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TARGETS, INDICATORS, AND INSTRUMENTS OF MONETARY POLICY

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ABSTRACT

It has become increasingly evident that the Federal Reserve's official strategy of the past decade, involving the adherence to target paths for monetary aggregates, is not currently being utilized to any significant extent. While some commentators welcome and others deplore this development, most would agree that a need exists for a more explicit and coherent strategy for the conduct of monetary policy. The present paper seeks to advance the strategic discussion in several ways. One involves a comparative consideration of targets for nominal GNP and the price level, with emphasis on specificational robustness and implications for output variability. A second pertains to various "indicator" variables recently suggested by Fed officials and others. In this regard, it is necessary to be clear and specific about the role of potential indicators. Consequently, a careful review of the relevant conceptual distinctions--concerning instruments, targets, indicators, etc.--is required. Finally, the proposal that strategy should be conducted so as to place minimal reliance on quantity variables is given some attention, in the context of evidence concerning the merits of an interest rate instrument.

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Introduction

It has become increasingly evident that the Federal Reserve's official strategy of the past decade, involving the adherence to target paths for monetary aggregates with those paths designed gradually to eliminate inflation, is not actually being utilized to any significant extent. Recent Fed reports to Congress continue to discuss planned "ranges of growth for monetary and debt aggregates," but a careful reading indicates that these ranges do not constitute targets of policy, in the sense that actions will be taken to achieve the specified values. Instead, the stated ranges represent forecasts or predictions of what the aggregates' growth rates will turn out to be, in response to economic developments and policy actions determined in part by the behavior of other variables.[1] Additional evidence is provided by the appearance of proposals, put forth by various individuals and groups within the Federal Reserve system, for the adoption of new "indicator" variables that might be utilized in the policy process in some significant manner.[2]

While some commentators welcome and others deplore the Fed's non-adherence to monetary targets, most would agree that a need exists for a more explicit and coherent strategy for the conduct of monetary policy. Many would even subscribe to the recent contention by Friedman that "there is now a conceptual vacuum at the center of the U.S. monetary policymaking process." The foregoing quote is unusual, incidentally, as it seemingly could have as easily come from Milton Friedman as from its actual author.[3]

While Federal Reserve officials have been proposing a variety of new monetary indicators, quite different strategic proposals have been put forth by various academic analysts. Milton Friedman, to continue with our contrasting personalities, has suggested that the quantity of base money be frozen while, at the other extreme, Benjamin Friedman has called for the development of a strategy for "monetary policy without quantity variables."[4] A more representative position has been taken by a number of writers who have promoted the adoption of nominal GNP as an intermediate target variable,[5] while others have suggested that direct stabilization of the general price level would be preferable.[6] That a nominal GNP targeting strategy is feasible has been argued by the present writer, on the basis of studies indicating that an operational policy rule for adjusting the monetary base would result in nominal GNP values close to those specified by a steady (and non-inflationary) target path.[7]

The present paper seeks to advance the discussion of monetary policy strategy in several ways. One involves a comparative consideration of targets for nominal GNP and the price level, with emphasis on specificational robustness and implications for output variability. A second pertains to the various indicator variables suggested by Fed officials and others. In this regard, evidence is compiled relating to the predictive content of the proposed measures and consideration is given to the issue of whether this content could be useful in the policy process. To examine this last type of issue, it is necessary to be clear and specific about the role of indicator variables. Consequently, a careful review of the relevant conceptual distinctions--concerning instruments, targets, indicators, etc.--is required. Finally, the proposal for a strategy that places minimal reliance on quantity variables is given some attention, in the context of evidence concerning the merits of an interest rate instrument.

Organizationally, our review of conceptual distinctions comes first and is followed by the comparison of nominal income and price level targets. The third main section is devoted to an examination of potential indicator variables while the fourth focuses on alternative instruments. The paper also includes some brief concluding remarks and an appendix that describes models used in various places in the investigation.

Instruments, Indicators, Targets, and Goals

It will be useful before beginning our empirical analysis to review conceptual distinctions pertaining to four different roles that variables might play in the monetary policy process, namely, as instruments, indicators, targets, and goals. In addition, the potential usefulness of target and indicator variables will be reconsidered.

An instrument variable, according to the terminology introduced by Tinbergen,[8] is one that can be directly controlled by the relevant policy authority. In the context of U.S. monetary policy, the relevant authority is the Fed and the list of potential instruments would include various short-term interest rates and a number of alternative quantity measures such as total or non-borrowed bank reserves or the monetary base (i.e., total reserves plus currency in circulation).

At the other end of the spectrum are goal variables, which represent the ultimate objectives of policy and so may be thought of as arguments appearing in the policymaker's objective function.[9] In discussions of U.S. monetary policy, it is typically assumed that inflation prevention or price level stability is one goal and that a second involves some measure of real cyclical conditions, such as unemployment or real GNP (measured relative to its "capacity" or "normal" level).[10] Clearly, these are not variables that the Fed can directly or accurately control, and so are not potential instruments. Whether they are actually the main arguments of the Fed's objective function is difficult to determine, given that organization's well-known reluctance to be explicit about its objectives. But various types of evidence lend support to the notion that the behavior of inflation and unemployment (or real output) are indeed of predominant importance to the Fed.[11] There is also, I would suggest, considerable agreement that these variables represent the two main macroeconomic goals with which the Fed should be concerned.[12]

The third type of variable in our classification scheme--which is designed to reflect standard professional usage--is the intermediate target.[13] Such a variable is neither an instrument nor a goal, but one which serves as an operational guide to policy when the latter is conducted according to a two-stage process. Under such a process, the policy authority first chooses a time path for some target variable (or variables) that promises to lead to desirable outcomes for the goal variables. Then, in the second stage, policy efforts are focused on an attempt to achieve the designated path for the target variable. An example would be provided by a scheme whereby efforts are devoted to achievement of a target path for the M1 money stock, in the belief that this path will lead to a desirable combination of inflation and output realizations.[14] Other potential target variables include nominal GNP, as mentioned above, and the foreign exchange rate.[15] Whether there is any good analytical justification for any two-stage process, featuring an intermediate target variable, will be discussed below.

Finally, we have the category of indicator variables. These variables, like targets, are neither instruments nor goals, but are utilized in a different manner. In particular, the role of an indicator variable is not to serve as a stand-in to be aimed at but rather to provide information to the policymaker regarding the current state of the economy. The observation that an indicator variable currently has an unusually high (or low) value might, for example, be used to indicate that instrument settings should be reconsidered because they are apt to result in an undesirable outcome in terms of goals (or, perhaps, in terms of an intermediate target). Several examples of variables suggested for such a role are considered below, including raw commodity price indices and interest rate spreads.[16]

Before proceeding with a variety of empirical investigations relating to these roles, it will be useful at this point to consider an important argument concerning the advisability of two-stage procedures involving target variables. In particular, several writers[17] have questioned the desirability in principle of using target variables. The basic argument is that <u>any</u> intermediate target scheme must be undesirable, as it could be improved upon by a procedure that directly specifies instrument settings (as determined by prevailing information) that are optimal with respect to the ultimate goal variables. In such a process indicator variables might be useful, according to the argument, but the intrusion of an intermediate target could only be detrimental (or, at best, redundant) to the achievement of the actual objectives.

At the level of abstract principle, this anti-targeting argument is rather attractive. But at the level of actual policy implementation its force is weakened by the implicit assumption that the policy authority possesses a useful model that describes the relationships linking instrument variables to the ultimate goal variables that he seeks to influence. The poorer the model, the less compelling is the logic of the anti-targeting position.

In addition, the targeting critics' argument fails to take account of the suboptimality of "discretionary"--policymaking, i.e., period-by-period choices of instrument settings that are apparently optimal with respect to goal variables. In this regard, it is now agreed by most analysts that the implementation of period-by-period policy choices will not lead to a desirable sequence of outcomes when the monetary authority's goals pertain to real (e.g., output) as well as nominal (e.g., inflation) magnitudes. Instead, these outcomes will tend to feature an unnecessarily high average inflation rate with no additional output (or employment) in compensation.[18] Consequently, the basic anti-targeting argument is invalidated by the recognition of "discretionary" inefficiency.

This inefficiency would not result, according to the Kydland-Prescott analysis, if instrument choices were based on a maintained policy rule determined via optimization calculations that utilize the authority's true goals. But in the absence of any mechanism for precommittment of future choices, the authority will recalculate its "optimal" choices each period. In economies in which real variables depend on nominal surprises, moreover, the recalculated settings will differ from those specified by the optimal rule. The recalculated choices will be implemented and, in the class of economies under discussion, will result in the inefficient outcomes mentioned above.

But consider a two-stage strategy whereby the monetary authority attempts each period to hit an intermediate target, when the target values have been previously chosen so as to lead on average to desirable outcomes for goal variables. From our description of the approach it would appear that such a strategy might lead to instrument settings that yield sequences of outcomes that are superior, in terms of ultimate goals, to those that would be forthcoming under the approach recommended by the anti-targeting argument. This result would come about because adherence to the target path precludes period-by-period revisions designed to exploit surprises. That such is indeed possible is demonstrated in an insightful paper by Rogoff.[19] In particular, Rogoff shows that--in a model economy with realistic features--adherence to various intermediate target variables can enhance outcomes in terms of the policymaker's true goals. Thus it turns out that the anti-targeting argument, despite its intuitive appeal, is not conclusive even as a matter of theoretical principle. Instead, it appears that intermediate targeting of some nominal variable is likely to be useful in terms of the true objectives of monetary policy because it prevents attempts to generate surprises. We shall, accordingly, consider the attractiveness of some alternative target variables in the upcoming section.

Nominal Income and Price Level Targets

Traditionally, various measures of the money stock--especially the M1 and M2 measures--have been the main candidates for adoption as intermediate target variables. Recently, however, considerable academic attention has been given to nominal GNP or some other measure of nominal income.[20] There are three possible advantages for a nominal income target, relative to a money stock target, that tend to justify this change in orientation. First, the average rate of nominal income growth needed to yield a desired average inflation rate over extended spans of time can be more accurately determined. Thus it is highly probable that the average rate of growth of real income or output for the U.S. will be about 2½ or 3 percent per year over the next decade, so the achievement of a 2½ or 3 percent growth rate for nominal income will result in approximately zero inflation. By contrast, there is considerable uncertainty as to the average growth of M1 velocity and therefore to the growth rate of M1 that would yield zero inflation. Second, the maintenance of a steady growth rate for nominal income has better automatic stabilization properties in response to money-demand and saving-investment shocks. If these shocks are predominant, better cyclical behavior of the economy should result from a scheme that stabilizes nominal income rather than money around a smooth target path. Finally, regulatory change and technological innovation in the payments industry require revisions in operational measures of the money stock. It is possible, consequently, that any given measure would be less reliably related to instrument values than would nominal income.

An important issue is whether nominal income targeting is feasible, that is, whether targets can be accurately achieved by control of the instruments available to the monetary authority. A fairly extensive study of that issue has recently been conducted by the present author, with an encouraging outcome.[21] In particular, my study indicates that adoption of a certain quantitative rule for the growth of the monetary base would result in quarterly values for nominal GNP that are close to those specified by a steady (and non-inflationary) growth path. Because this study will be used as a starting point for several investigations to be conducted below, a brief review is in order.

Let b_t and x_t denote logarithms of the monetary base and nominal GNP, respectively, for quarter t. Also let target values for x_t be denoted as x_t^* and assume that these are specified to increase in value by 0.00739 each quarter, an amount that corresponds to an annual growth rate of 3 percent for nominal GNP. Then the operational rule examined in my previous study can be written as

$$(1)\quad \Delta b_t = 0.00739 - (1/16)(x_{t-1}-b_{t-1}-x_{t-17}+b_{t-17}) + \lambda(x^*_{t-1}-x_{t-1})$$

where λ is some non-negative parameter. Here the constant term is simply a 3 percent annual growth rate expressed in quarterly logarithmic units, while the second term subtracts the average growth rate of base velocity over the previous four years (to account for technological and regulatory change).

Table 1
RMSE Values for Nominal Income Target
Simulation Results, 1954.1-1985.4

Model	Value of λ in Policy Rule (1) 0.0	0.1	0.25	0.5
Vector Autoregression	.0429	.0216	.0220	.1656*
Real Business Cycle	.0281	.0200	.0160	.0132
Monetary Misperceptions	.0238	.0194	.0161	.0137
Phillips Curve	.0311	.0236	.0191	.0174

Note: Asterisk indicates explosive oscillations

Finally, the third term adds an adjustment in response to cyclical departures of GNP from its target path.

To determine whether this rule would in fact keep nominal GNP close to the 3% target growth path, given the existence of stochastic shocks of various types, one needs to conduct simulations incorporating such shocks in a system that includes the rule and an econometric model that describes the response of x_t to the generated values of b_t. The fundamental problem in this regard is that there is no agreed-upon model. Indeed, it is my contention that the macroeconomics profession does not possess a satisfactory model of the short-run dynamics of aggregate-supply or Phillips-curve behavior, governing the response of real variables to monetary stimuli, even at the qualitative level. In light of this problem, my method of investigation has been to determine whether policy rule (1) performs well in variety of different models. Thus far I have conducted simulations with a number of vector autoregression (VAR) systems and three small models that are intended to be structural, i.e., policy invariant. These three models are small in scale but are designed to represent three important competing theories concerning the interaction of nominal and real variables: the real business cycle (RBC) theory; the monetary-misperceptions theory of Lucas and Barro; and a more "Keynesian" theory patterned on the Phillips-curve or wage-price specification of the MPS model.[22]

Some results of these simulations are reported in Table 1 for the three structural models and one representative VAR model, a four-variable system in which the included variables are Δy_t, Δp_t, R_t, and Δb_t (where y_t = log of real GNP, p_t = log of GNP deflator, and R_t = Treasury bill interest rate). The models were estimated with quarterly seasonally-adjusted data for 1954.1 - 1985.4, and the simulations conducted over that same span with each quarter's residuals fed into the system as estimates of shock realizations. In the simulations, b_t values generated by rule (1) are used instead of actual historical values. For each model and several values of λ, ranging from 0.0 to 0.5, root-mean-square error (RMSE) magnitudes are calculated and reported in Table 1. Since x_t and x_t^* are logarithms, these RMSE values can be interpreted as percentage deviations, with (e.g.) 0.02 corresponding to 2.0 percent. From the reported figures it can be seen that rule (1) performs satisfactorily for intermediate values of λ, that is, values between 0.1 and 0.25. Despite the variety of models, x_t values are kept close to the x_t^* target path, thereby implying inflation rates close to zero for the period. Targeting errors are smaller than with $\lambda = 0$ in all cases, and with the VAR model they are much smaller than when $\lambda = 0.5$. This last-mentioned case provides an example of a clearly unsatisfactory performance: a time plot of the x_t values indicates the presence of explosive oscillations.

While there is room for skepticism and for additional study,[23] the reported results are strongly encouraging with regard to the feasibility of nominal income targeting. It is then worthwhile to consider some issues relating to the <u>desirability</u> of nominal GNP as the variable to be used in an intermediate targeting strategy. In particular, let us consider two classes of issues, the first concerning the extent of long-range price level uncertainty implied by steady growth of nominal GNP and the second pertaining to countercyclical stabilization properties.

The issue of long-range price level uncertainty has been raised by Haraf,[24] who has argued that (the log of) real GNP evolves over time in a non-trend-stationary fashion. For expositional simplicity, suppose that the process is a random walk with drift, although the argument would be much the same for any process with an autoregressive unit root. Then if nominal GNP is induced to grow steadily, the (log of the) price level p_t will evolve as a random walk. Its drift will equal zero if the correct trend rate is chosen for the nominal GNP target path, but confidence bands for p_t will nevertheless grow without bound as one looks into the distant future. Consequently, Haraf suggests that a target path for p_t rather than x_t would be preferable in terms of long-range performance.

With regard to this argument, it needs to be recognized that statistical tests are incapable, on the basis of available data, of distinguishing accurately between unit-root processes and trend-stationary processes with an autoregressive root close to unity (say, 0.98).[25] Thus the presumption on which Haraf's analysis is based may be counterfactual. It seems likely, nevertheless, that series such as real GNP may be mixtures of stationary and unit-root components, which would leave the argument with validity.

Another possible counterargument questions the quantitative importance of random-walk behavior of the price level, provided that the drift term is (approximately) zero. A non-zero average inflation rate is socially undesirable,[26] of course, and quarter-to-quarter or year-to-year forecast errors lead to resource misallocation. But the possibility that the price level might, with low probability, drift far away from its present value seems a matter of less concern. Such an occurrence would have a sizeable impact on parties to long-term debt contracts denominated in monetary units, but there is nothing to keep these parties from contracting in real (indexed) terms. Indeed, it would seem that an economy in which the price level obeyed a process of the form

(2) $\Delta p_t = \varepsilon_t$,

where ϵ_t is white noise with zero mean and σ_ϵ equal to about 0.005 for quarterly time periods, would be highly fortunate in that regard.[27]

The second class of issues regarding the desirability of nominal income targeting has to do with cyclical properties of real variables. As mentioned above, one desirable feature is the automatic countercyclical response to demand shocks, which will tend to stabilize output movements if prices are sticky. In response to supply shocks, however, the automatic policy responses may be counterproductive.[28] It is unclear, then, whether nominal GNP stabilization would be preferable to stabilization of the price level--or some other variable--under the assumption that prices are not fully flexible and shocks of various types occur. (If prices are <u>fully</u> flexible, monetary policy will be essentially irrelevant to the cyclical behavior of real variables and only long-range price level stabilization will be relevant).

It is accordingly of interest to determine whether a policy rule comparable to (1) can be devised that will be effective over a wide range of models in promoting a smooth and non-inflationary path for the price level--that is, a constant value for p_t. A natural candidate rule is provided by a modified version of (1) in which the final cyclical adjustment term $\lambda(x^*_{t-1}-x_{t-1})$ is replaced with a counterpart that pertains to the price level. Thus we consider the following rule, in which the p^*_t target values are understood to be constant over time:

$$(3)\quad \Delta b_t = 0.00739 - (1/16)(x_{t-1}-x_{t-17}-b_{t-1}+b_{t-17}) + \lambda(p^*_{t-1}-p_{t-1}).$$

Using rule (3) in conjunction with the same four models of the economy as described above, simulations have been conducted that are the exact counterpart of those summarized in Table 1--the estimated models and shocks

Table 2
RMSE Values for Price Level Target
Simulation Results, 1954.1 - 1985.4

Model	Value of λ in Policy Rule (3) 0.0	0.1	0.25	0.5
Vector Autoregression	.0629	.0316	.0230	.0175
Real Business Cycle	.0501	.0258	.0150	.0096
Monetary Misperceptions	.0508	.0229	.0137	.0097
Phillips Curve	.0971	.0699	.0965*	.2332*

Note: Asterisk indicates explosive oscillations.

Table 3
RMSE Values for Price Level Target
Simulation Results, 1954.1 - 1985.4

Model	Value of λ in Policy Rule (4) 0.0	0.1	0.25	0.5
Vector Autoregression	.0748	.0339	.0362	.0282*
Real Business Cycle	.0371	.0266	.0174	.0112
Monetary Misperceptions	.0314	.0208	.0140	.0098
Phillips Curve	.0889	.4715*	1.6692*	4.4310*

Note: Asterisk indicates explosive oscillations.

are the same. Based on these simulations, Table 2 reports RMSE statistics for p_t that are the counterparts of those for x_t given in Table 1. From the figures in Table 2 it can be seen that successful stabilization of p_t is obtained with the VAR, RBC, and Lucas-Barro models. The RMSE values are quite large with the Phillips Curve model, however, and explosive oscillations are encountered with λ values equal to 0.25 or greater.[29]

Consequently, the following modification of policy rule (2) was also investigated:

$$(4)\quad \Delta b_t = -(1/16)(p_{t-1}-p_{t-17}-b_{t-1}+b_{t-17}) + \lambda(p^*_{t-1}-p_{t-1}).$$

Here the zero constant term aims directly for a zero rate of growth in the price level, while the first included term subtracts the average growth rate over the previous four years of the ratio of the price level to the monetary base. For the target variable p_t, then, rule (4) is analogous to rule (1) for the variable x_t. As it transpires, however, rule (4) yields results that are less satisfactory than rule (3). These results are reported in Table 3, where it can be seen that explosive oscillations are more severe than before with the Phillips Curve model and also occur in the VAR system when the feedback coefficient λ is set at the value 0.5.

The results in Tables 1, 2, and 3 shed light only on the feasibility of direct income or price level stabilization, which requires the absence of explosive oscillations. In particular, they provide no indication of the cyclical effects on real variables provided by the alternative intermediate targeting strategies. Some results relevant to this consideration are reported in Table 4. There RMSE values for real GNP, calculated relative to a fitted trend, are reported for the three policy rules (1), (3), and (4) in

Table 4
RMSE Values for Real GNP[1]
Simulation Results, 1954.1 - 1985.4

Model	Value of λ	Nominal GNP Rule (1)	Price Level Rule (3)	Price Level Rule (4)
VAR4	0.1	.0348	.0394	.0405
RBC	0.1	.0397	.0397	.0397
MM	0.1	.0444	.0444	.0444
PC	0.1	.0382	.0841	.6293*
VAR4	0.25	.0347	.0409	.0440
RBC	0.25	.0397	.0397	.0397
MM	0.25	.0444	.0444	.0444
PC	0.25	.0373	.1786*	2.7484*

Note: asterisk indicates explosive oscillations.

combination with each of the four models. In Table 4, RMSE figures are given only for the two intermediate values of λ, 0.1 and 0.25, as they provide the most attractive possibilities.

According to the RBC model, monetary policy has no effect on the evolution of real output, so the RMSE values are the same for all three policy rules (and both values of λ). The monetary misperceptions (Lucas-Barro) theory presumes that monetary actions can have real effects, but only if unanticipated. As each of the three rules is deterministic, each gives rise to no monetary surprises and thus to no output movements. Consequently, the same RMSE values prevail for all three rules (and both λ values) in this model, as well. The invariance of real GNP behavior with respect to nominal target paths in the RBC and Lucas-Barro models shows up clearly in the relevant entries in Table 4.

In the VAR and Phillips-Curve models, by contrast, the different policy rules yield different simulation paths for real GNP. In the VAR system, the RMSE values are slightly smaller with the nominal income target rule (1) than with rules (3) or (4), but the difference is too small to be considered of importance. With the Phillips-curve model, however, real GNP variability is small with rule (1) but very large with rule (3) and enormous under rule (4).

These unsatisfactory results with price level rules in the Phillips-curve model suggest an extra experiment. As estimated, the model's parameters do not imply invariance of real variables to different steady inflation rates. Accordingly, the equations were re-estimated with constraints imposed to guarantee steady-state invariance. The behavior of the system in simulations with the re-estimated model was, however, worse than before--explosive oscillations were even more severe than those reported in Table 4.

The main conclusion to be drawn from these experiments is that the price level targeting rules (3) and (4) do not possess the robustness to model specification that is a feature of the nominal income rule (1). Given that non-trend-stationarity of the price level is a fairly minor disadvantage, provided that drift is absent, it would seem that a non-inflationary target path for nominal income would represent a more attractive possibility than a constant price level target, in the context of a two-stage policy strategy.

The Role of Indicator Variables

In this section we switch our attention to the notion that indicator variables, as distinct from targets, could be useful in the monetary policy process. As mentioned above, the basic idea is that observations on these variables could be useful to the policy authority in terms of information provided about recent or current economic conditions. In the discussion that follows, an attempt will be made to evaluate the validity of that idea by means of empirical investigations involving five potential indicator variables that have been proposed in recent writings and one additional measure that is of traditional significance.

Of these six variables, the first two are price indices for groups of commodities in the narrow sense of that term: products of the agricultural and mineral sectors of the economy. Specifically, these variables are the spot-price index compiled by the Commodity Research Bureau and the materials price index of the Journal of Commerce. In this section the logarithms of these two indices will be denoted pc_t and pf_t, respectively. Our third measure, denoted spr_t, is an interest rate spread. Following the lead of Laurent,[30] the specific measure utilized is the yield on 20-year U. S. Treasury notes minus the Federal Funds rate. Next comes a foreign exchange rate, namely, the Federal Reserve's trade-weighted index of the foreign exchange value of the U. S. dollar,[31] whose logarithm is here denoted s_t. Fifth on our list of measures is the real (i.e., deflated) magnitude of the M2 money stock, a measure emphasized in a widely-noted letter by Michael Darby.[32] The log of this measure is denoted $m2_t$. Finally, for the sake of comparison our list includes the index of "eleven leading indicators" compiled and published by the Department of Commerce. Its log is here denoted li_t.

The matter to be investigated is whether these potential indicator variables provide information about the state of the economy that would be useful in conducting monetary policy. Of particular concern is whether they help in predicting future movements in macroeconomic goal variables. In approaching that question, it is important to keep in mind that it is incremental predictive content that is relevant. The issue, for example, is not whether price level movements are often preceded by changes in pc_t, but whether such changes regularly provide extra information in addition to that which would be utilized by the policymaker or policy analyst in the absence of pc_t data. The information content of a potential indicator variable should be gauged, in other words, in relation to information that would be utilized in the normal course of affairs. In what follows it is assumed that routinely-utilized information consists of the four variables included in the VAR system explored above. It is assumed, then, that information proved by four lagged values of Δy_t, Δp_t, Δb_t, and R_t would be routinely possessed by the policy analyst.

To determine whether any of the six indicator variables listed above are informative in the relevant sense, two sets of least-squares regression results have been obtained. The first of these is summarized in Table 5, where statistics are reported pertaining to predictions of Δy_t and Δp_t in

Table 5
Predictive Contribution of Potential Indicator Variables in VAR-Type Regression Equations

Indicator Variable[2]	Sample Period	Standard Errors Without and With Indicator Variables Included[1] Δy_t Equation Without	Δy_t Equation With[3]	Δp_t Equation Without	Δp_t Equation With[3]
Δpc_t	1954.1-1985.4	.00899	.00900	.00403	.00398
Δpf_t	1954.1-1985.4	.00899	.00885	.00403	.00396
spr_t	1956.3-1985.4	.00892	.00860*	.00396	.00393
Δs_t	1954.1-1985.4	.00899	.00905	.00403	.00396
Δs_t	1972.3-1985.4	.00995	.00972	.00389	.00363
$\Delta m2_t$	1960.2-1985.4	.00876	.00846*	.00404	.00399
Δli_t	1954.1-1985.4	.00899	.00859*	.00403	.00406

[1]Four lags each included for Δy_t, Δp_t, Δb_t, R_t, and indicator variable (where relevant)

[2]pc=log of Commodity Research Bureau spot price index; pf = log of Journal of Commerce materials price index; spr = interest rate spread; s = log of spot exchange rate; m2 = log of deflated M2 money stock; li = log of leading indicator index.

[3]Asterisk means explanatory power added by indicator is statistically significant at 0.05 level.

the context of a VAR system of the relevant specification. In particular, these regressions have either Δy_t or Δp_t as the dependent variable and regressors including four lags of Δy_t, Δp_t, Δb_t, and R_t. Each such equation is estimated with and without four lagged values of the relevant indicator variable (for each of these candidates). Calculated "standard error" values, reflecting estimates of the standard deviation of the residual disturbance term, are tabulated for each case so that comparisons can be made.

The relevant comparisons can be exemplified by the final pair of values in the first row of Table 5. These indicate that the residual standard error when Δp_t is the dependent variable is 0.00403 without indicator values and falls to 0.00398 when Δpc_{t-1}, Δpc_{t-2}, Δpc_{t-3}, and Δpc_{t-4} are included. In this particular case the potential indicator clearly provides very little incremental explanatory power in both absolute and relative terms. It therefore provides very little predictive power from a policy perspective.

As it happens, examination of Table 5 shows that the same can be said for all six potential indicators and both dependent variables. The extent to which the indicator variables provide incremental predictive power, over and above that provided by past values of Δy_t, Δp_t, Δb_t, and R_t, is extremely small. In three cases, to be sure, the amount of incremental power is enough to imply formal rejection of the statistical hypothesis that zero additional power is provided,[33] but from a practical perspective the increment would appear to be quite unimportant even in these cases. Quantitatively similar results are obtained, moreover, when the regressions are estimated using log-levels in place of differences for the variables that appear in first-differenced form in Table 5.[34]

One possibility not recognized in the Table 5 results is that contemporaneous values of the indicator variables might be important. From a

Table 6
Explanatory Contribution of Potential Indicator Variables in Regression Equations with Contemporaneous Values of Interest Rate and Indicator

Indicator Variable	Sample Period	Standard Errors Without and With Indicator Variable Included[1]			
		Δy_t Equation		Δp_t Equation	
		Without	With	Without	With
Δpc_t	1954.1-1985.4	.00875	.00874	.00401	.00398
Δpf_t	1954.1-1985.4	.00875	.00863	.00401	.00397
spr_t	1956.3-1985.4	.00861	.00811*	.00394	.00391
Δs_t	1954.1-1985.4	.00875	.00880	.00401	.00398
Δs_t	1972.3-1985.4	.00945	.00945	.00386	.00367
li_t	1954.1-1985.4	.00875	.00746*	.00401	.00403

[1]Four lags each included for Δy_t, Δp_t, Δb_t, R_t, and indicator variable (where relevant) plus current values of R_t and indicator (where relevant).

[2]See Table 5.

[3]See Table 5.

practical perspective it is necessary that policy actions be taken somewhat before their effects are desired, but in the context of an analysis with quarterly data it is possible to justify the inclusion of the contemporaneous value of (e.g.) Δpc_t, if observations on that variable are available more promptly than for the basic macroeconomic variables of the VAR system. But while this is certainly the case in comparison with GNP and price level values, it is quite clearly not the case with respect to interest rates, which are observable almost continuously.[35] Consequently, Table 6 reports results that are analogous to those of Table 5 but with current-quarter values of R_t and the various indicators included in the regressions (in addition to the four lagged values of each included variable).[36]

Once again it will be seen that very little incremental explanatory power is provided by the potential indicator variables, even though the contemporaneous observation is included. In only two of the Table 6 cases is the explanatory power of the five values of an indicator variable different from zero at the 0.05 significance level, and in neither of these cases is the additional information content of the indicator variable of clear quantitative importance from a policy viewpoint.[37]

The foregoing results pertain to the predictive or explanatory information content of potential indicator variables, relative to a basic information set that includes observations on y_t, p_t, b_t, and R_t. A different way of gauging the potential usefulness of a candidate variable would be to determine the magnitude of improvement that its use would make possible <u>in the context of</u> a specific and well-defined procedure for conducting policy. To make such a determination, one must have at hand, of course, a well-defined procedure. Very few are present in the literature, but three such procedures -- i.e., specific and operational policy rules -- have been described in the

Table 7
Control Error Reduction of Potential Indicator Variables
Nominal GNP Target; Policy Rule (3) with $\lambda = 0.25$

Indicator Variable	Sample Period	R^2 Value in Regression of Simulation Control Errors on Four Lagged Values of Indicator			
		VAR Model	RBC Model	MM Model	PC Model
Δpc_t	1954.1-1985.4	.071	.099	.115	.120
Δpf_t	1954.1-1985.4	.137	.152	.164	.178
spr_t	1956.3-1985.4	.223	.246	.320	.321
Δs_t	1954.1-1985.4	.044	.102	.126	.118
Δs_t	1972.3-1985.4	.075	.215	.258	.231
$\Delta m2_t$	1960.2-1985.4	.130	.147	.215	.216
Δli_t	1954.1-1985.4	.326	.209	.322	.260

previous section of this paper. There it was suggested that rule (1), involving a smooth and non-inflationary target path for nominal GNP, was somewhat more attractive than the other two. Consequently, rule (1) provides a natural framework for investigation of the issue of indicator usefulness according to this alternative criterion.

Evidence relevant to this criterion is given in Table 7, which reports coefficient of determination (R^2) values for regressions in which simulated targeting errors -- discrepancies between x_t and x_t^* -- are regressed on four lagged values of each of the potential indicators (considered in turn).[38] By their nature the R^2 statistics for these regressions measure the fraction of target-error variability that could in principle be eliminated by making the policy rule suitably contingent upon past values of the indicator variable.[39] Such statistics are reported for each of the four models of the economy discussed previously and with the value 0.25 used for λ in policy rule (1).

Of the 28 coefficients of determination reported in Table 7, only four exceed 0.30 in magnitude, with the majority falling in the range 0.10 - 0.25. While many of the values are significantly different from zero at the conventional 0.05 level, the striking fact about Table 7 is that the values are as small as they are. This is rather remarkable, given the simplicity of the policy rule (1) and its reliance on only two variables (namely, x_t and b_t). Thus the message provided by Table 7 would seem to be that only minor improvements in the performance of rule (1) could be obtained by use of any of the recently proposed indicator variables.

This message receives some reinforcement by a comparison of simulated performance under rule (1) with actual historical performance. The main discrepancy between actual values of nominal GNP, x_t, and the target values,

x_t^*, has not involved variablility of growth rates but rather their average value. Simply put, nominal GNP has (on average) grown much more rapidly than the rate (3% per year) that would yield price level stability. Thus the actual historical RMSE -- i.e., the value of $[(1/128)\sum(x_t-x_t^*)^2]^{\frac{1}{2}}$ for 128 quarters starting with 1954.1 -- amounts to 0.771. By reducing that value to 0.020-0.030 range reported in Table 1, the policy rule (1) would accomplish most of what it attempts. Thus the additional RMSE reduction made possible by the use of the potential indicator variables would be at most about 0.004, according to Table 7. For example, the RMSE value for 1954.1-1985.4 with the VAR model and $\lambda = 0.25$ in rule (1) is 0.0220 -- see Table 1. By making use of four lagged values of the Commerce Department's index of leading indicators (li_t), this figure could be reduced to about 0.0184. And for the recently proposed indicators including pc_t and spr_t, the potential improvement is even smaller.

The foregoing discussion has proceeded under the maintained assumption that achievement of x_t^* target values is an appropriate objective of monetary policy. That assumption can, of course, be questioned. But there is little reason to doubt that keeping x_t close to x_t^* would keep average inflation rates quite close to zero. The evidence suggests that this outcome could be accomplished by means of policy rule (1). Thus we see that to eliminate inflation it is not necessary to rely upon recently-proposed indicator variables. Furthermore, it is unclear that they could be of major importance in preventing undesirable swings in real activity.

An Alternative Instrument

Our final main topic concerns the choice of a variable to be used as the operating instrument for monetary policy, that is, the variable to be manipulated more or less directly by the central bank. In the foregoing discussion involving policy rules (1), (3), and (4) it was presumed that the monetary base would be used as the instrument; here we shall briefly consider an alternative possibility.

In his comment on my "Robustness Properties" paper, Benjamin Friedman has suggested that the monetary base is likely to be an unsuitable instrument.[40] A point emphasized by Friedman is that the base is largely composed of currency in the hands of the nonbank public, much of which is used "for purposes like tax evasion and drug trafficking" and as "the standard medium of exchange in black markets around the world." Furthermore, the Fed has "never even pretended to limit the amount of currency in circulation, but instead has explicitly acted to accommodate fluctuations in the public's demand for currency." But with the base set so as to control a target such as nominal GNP, sizeable changes in bank reserves would be required in response to shifts in the public's desired currency/deposit ratio. Together, Friedman suggests, these facts make "the monetary base an odd candidate to serve as the practical focus of monetary policy."[41]

In evaluating this suggestion, it is important to distinguish carefully between targets and instruments, a step that is rendered more difficult by the common but unfortunate practice of using the word "targeting" in conjunction with the Fed's instrument variable.[42] Properly speaking, once a target variable is chosen the only function of the instrument is to expedite attainment of the specified target values. To be concerned with the path of the selected instrument per se or that of some other variable--unless it is of value as an indicator--is to implicitly assign target status to this variable, thereby muddling the basic framework for policy. In the context of the policy strategy represented by rule (1), for example, it is inappropriate to be concerned with the behavior of bank reserves per se; if base settings result in satisfactory values for nominal GNP then the base should be judged a satisfactory instrument. It is of course possible to question the desirability of a nominal GNP target, but that is a different matter.

For the sake of analytical clarity, then, it will be useful to settle provisionally on x_t as an intermediate target variable and consider whether an instrument other than the base would permit more accurate attainment of the 3 percent target path. For the alternative instrument it is natural to consider a short term interest rate, in part because of the Fed's traditional emphasis on such rates and in part to permit exploration of the possibility of conducting policy "without quantity variables." The remainder of this section, consequently, will be devoted to an empirical comparison between an interest rate and the monetary base as instruments for control of nominal GNP as an intermediate target. Specifically, we will experiment with analogues to rule (1) that feature R_t, rather than b_t, as the manipulated variable. In doing so we will continue to use the 90-day Treasury bill rate as our operational measure of R_t, even though the Fed actually focusses on the federal funds rate. Doing so will facilitate comparisons and permit a longer sample period to be investigated, without distorting the results in any obvious way.

In attempting to design a policy rule for control of x_t by means of an R_t instrument, an immediate difficulty is created by the nature of the dynamic relationship between (nominal) interest rates and inflation. In particular, while it is usually presumed that "high" interest rates have the effect of reducing demand and thereby reducing inflationary pressures, it is also widely agreed that from a longer-term perspective it is the case that high nominal interest rates are the consequence of rapid inflation. This difficulty may be expressed by the aphorism that "to achieve low interest rates it is necessary to raise the rate of interest." Despite that difficulty, however, it should be possible to find a rule with some stabilizing properties provided that an increase in R_t will have a temporary but significant contractionary effect on the level of aggregate demand.

Proceeding under that assumption, a starting point is provided by the simple rule specified in equation (6):

$$(6) \qquad R_t = R_{t-1} - \lambda_1(x^*_{t-1} - x_{t-1}).$$

Here the policy coefficient λ_1 is positive, so the rule calls for an increase in the interest rate instrument, relative to its previous value, whenever nominal income exceeds its target value (i.e., whenever $x_{t-1} > x^*_{t-1}$). To determine the efficacy of rule (6) in keeping x_t close to the x^*_t target path, simulations have been conducted in a system consisting of (6)--with different trial values for λ_1-- and the Δy_t, Δp_t, and Δb_t equations from the four-variable VAR model described above.[43] These simulations differ from those reported above in two ways: not only is (6) now used as the policy rule, but also it replaces the VAR equation with R_t (rather than Δb_t) as the dependent variable. As before, however, the simulation period is 1954.1-1985.4 and the VAR residuals are fed into the system each period as estimates of shock realizations.

In simulations with policy rule (6), the performance of the R_t instrument is poor. The best λ_1 value seems to be in the vicinity of 0.03, which results in a RMSE value of 0.0695--much larger than the best RMSE figures reported for the b_t instrument in Table 1. If λ_1 is reduced substantially below 0.03, rule (6) applies insufficient corrective stimulus and fails to keep x_t close to x_t^*. (With $\lambda_1 = 0.01$, for example, the RMSE value is 0.1572.) And if, on the other hand, λ_1 is raised much above 0.03, then explosive oscillations occur. (With $\lambda_1 = 0.05$, RMSE = 0.1303 while with $\lambda_1 = 0.08$, RMSE = 0.4362.)

Nominal income stabilization performance is much better, however, when a second lagged target error term is included in the R_t policy rule. In this case we have

$$(7) \qquad R_t = R_{t-1} - \lambda_1(x^*_{t-1}-x_{t-1}) + \lambda_2(x^*_{t-2}-x_{t-2})$$

$$= R_{t-1} - (\lambda_1-\lambda_2)(x^*_{t-1}-x_{t-1}) - \lambda_2(\Delta x^*_{t-1}-\Delta x_{t-1}),$$

so that ΔR_t is subject to "derivative" as well as "proportional" feedback stimuli. Some resulting RMSE values with rule (7) are reported in Table 8. There it can be seen that with coefficients in the vicinity of $\lambda_1 = 1.00$ and $\lambda_2 = 0.90$, the stabilizing performance of (7) is entirely respectable. This result is, at its face value, distinctly encouraging with respect to the possibility of using an interest rate instrument to achieve target values of nominal GNP.

It needs to be emphasized, however, that the Table 8 results are somewhat deceptive. Examination of the p_t and y_t paths that are generated in the $\lambda_1 = 1.00$, $\lambda_2 = 0.90$ case reveals that the approximately 3 percent (annual) growth rate of nominal GNP attained in this simulation is the consequence of almost zero growth in real output together with inflation of nearly 3 percent per year. So rule (7) does not succeed in generating long-term price level stability, as rule (1) does in the $\lambda = 0.1$ or $\lambda = 0.25$ simulations reported in Table 1. This result does not, in the opinion of the author, indicate that

Table 8
RMSE Values for Nominal Income
With VAR Model and Policy Rule (7)

Value of λ_2 in Rule (7)	Value of λ_1 in Rule (7) 0.50	1.00	1.50
0.30	.6509*		
0.40	.0435		
0.45	.0483		
0.80		.0879*	
0.90		.0283	
0.95		.0326	
0.98			.4049*
1.30			.1030*
1.45			.0814

Note: Asterisk denotes explosive oscillations.

a smooth 3 percent growth path for GNP is undesirable, but rather that the VAR model is in this case misleading. The basis of that conclusion is as follows: it is implausible that any maintained monetary policy rule would keep real output growth well below 3 percent over such a long span of years. Such a consequence would involve violation of the natural rate hypothesis, one of the few propositions that commands widespread support among macroeconomic researchers.

Even neglecting that implausibility, moreover, the results in Table 8 do not constitute evidence comparable to that presented in Table 1 for the b_t instrument. The point is that policy rule (1) has been found to be effective in simulations conducted with a wide variety of models. As there is no professional consensus regarding proper model specification, this type of robustness is extremely important. The question arises, then, whether rule (7) can be shown to possess similar robustness. How would it perform, for example, in the three structural models utilized above?

In the case of the Phillips-curve model this issue can be studied by appending a base-money demand function, specifying base demand as dependent upon the interest rate (as well as a transaction variable), and using policy rule (7) in place of (1). Doing so with the demand function (A6) described in the appendix, and trying rule (7) with the same coefficients as in Table 8, yields distinctly positive results. In particular, the RMSE values reported in Table 9 are more favorable than in Table 8 for the coefficient pair $\lambda_1 = 1.0$ and $\lambda_2 = 0.9$, and sensitivity to the coefficient magnitudes is considerably less.

What about performance with the RBC and monetary misperception models? In both of these cases a difficulty arises. In the RBC model, output is exogenously determined; so with government purchases also treated as

Table 9
RMSE Values for Nominal GNP
With PC Model and Policy Rule (7)

Value of λ_2 in Rule (7)	Value of λ_1 in Rule (7) 0.50	1.00	1.50
0.30	.0271		
0.40	.0377		
0.45	.0520		
0.80		.0293	
0.90		.0332	
0.95		.0481	
1.30			.0255
1.40			.0312
1.45			.0434

exogenous, the aggregate demand function determines the level of real base-money demand. But that same variable is also determined by the money demand equation in response to exogenous output (transactions) and the policy rule for R_t. Thus the price level is not determined, while two (typically different) values are generated for the monetary base. This does not mean that the price level is literally indeterminant in a RBC model, for reasons that have become fairly well known.[44] But its determination is dependent upon rather subtle expectational phenomena that are neglected in my very small and simple version of the RBC model.

Much the same is true, moreover, for the monetary misperceptions model. Consequently, we are unable to obtain results analogous to those of Tables 8 and 9 for the two structural models that are "classical" in their properties.

Our findings regarding use of R_t as a policy instrument are then somewhat inconclusive. In the two "sticky price" models under study, effective control of nominal GNP is provided by a reasonably simple policy rule with two feedback terms. In one of these cases, price level performance is poor but that suggests that the VAR model is not a reliable guide in the case at hand. In the two flexible-price models, empirical results are not obtainable because price-level (and nominal GNP) determinacy depends upon expectational considerations not included in the specification. That the nature of the interaction between R_t and other variables is so different in these two pairs of models might lead one to conjecture that robustness would not be found if the relevant expectational considerations were incorporated in the flexible-price models.

Concluding Remarks

The empirical results and analytical arguments of this paper have suggested that an intermediate target path for a nominal variable can, objections notwithstanding, play a constructive role in the context of a systematic strategy for monetary policy. With regard to the choice of a target variable, there are some reasons for believing that nominal income would be superior (in that capacity) to the price level, even though inflation prevention is an ultimate goal. In particular, the performance of price level targeting rules appears to be somewhat less robust to model specification while price level targets seem to provide a smaller degree of stabilizing influence on real output.

With regard to recently proposed indicator variables, the evidence rather strongly indicates that these could be useful in the policy process to only a minor extent. The proposed variables provide only a small amount of information that is not reflected in other variables that enter the policy process in the normal course of affairs. The main failure of U.S. monetary policy in the postwar era has been the generation, or facilitation, of excessive (i.e., inflationary) growth on average of nominal variables: monetary aggregates, nominal income, and aggregate price indices. Timely observation of special indicators can have little to do with the reduction of trend growth rates of nominal magnitudes.

Finally, with regard to alternative instruments, it appears that policy rules using the monetary base are somewhat more robust to model specification than ones that use a short-term interest rate, but the latter variable appears to function moderately well in models with price level stickiness. A point not mentioned above, but worth emphasis, is that interest rate smoothing--dampening of period-to-period movements--is an activity that is quite distinct from the use of an interest rate as an instrument. Indeed, smoothing of any variable tends to impair its effective use as an instrument, which may require sharp period-to-period adjustments.

Appendix

Here the object is briefly to describe the three "structural" models referred to in Tables 1-4. These models are structural in the sense that they pertain to specific alternative theories concerning the nature of business cycle fluctuations. They are extremely small in scale and are not here rationalized by explicit maximizing analysis, but are specified so as to represent the principal characteristics of three important, and competing, theoretical positions: the real business cycle position, the monetary misperceptions position, and one of a more Keynesian slant.[45]

As suggested in the body of the paper, the main difference among these theories concerns the aggregate-supply or Phillips-curve portion of the macroeconomic system. Consequently, the same specification is used in all three cases for the aggregate demand portion of the model--i.e., for the relation describing the quantity of output that would be demanded at a given price level for consumption, investment, and government purposes together. In order to keep the model small, a single aggregate demand relation is used instead of sectoral relations for consumption of nondurables, consumption of services, investment in fixed plant and equipment, investment in inventories, and so on. The principal determinants of demand quantities in such a relationship are typically taken to be real M1 balances and government purchases (g_t). In the context of policy rules (1), (3), and (4) it is appropriate to utilize real quantities of the monetary base instead of the former variable, thereby implicitly incorporating banking sector relations between M1 and the monetary base. The resulting relation is estimated in first-differenced logarithmic form, with one lag of each variable included to reflect dynamics. Least squares estimates for the sample period 1954.1 - 1985.4 are as follows:

$$\text{(A1)} \qquad \Delta y_t = \underset{(.001)}{0.0045} + \underset{(.083)}{0.2591}\,\Delta y_{t-1} + \underset{(.127)}{0.2795}\,(\Delta b_t - \Delta p_t)$$

$$+ \underset{(.131)}{0.2731}\,(\Delta b_{t-1} - \Delta p_{t-1}) + \underset{(.061)}{0.1476}\,\Delta g_t - \underset{(.062)}{0.1675}\,\Delta g_{t-1} + e_{1t}$$

$$R^2 = 0.276 \qquad SE = 0.00916 \qquad DW = 2.07.$$

The point estimates in (A1) were adopted for use in all simulations described in this section, with the residuals e_{1t} being used as estimates of shocks to aggregate demand.

Next consider the aggregate supply portion of the three competing theories. In the case of the RBC approach it is not necessary to estimate any relations in addition to (A1). That convenient property stems from the exogeneity postulated by the RBC hypothesis of real variables with respect to nominal variables--and therefore to monetary policy actions--plus the assumption that any fiscal effects on output work through an intermediate impact on nominal aggregate demand. Thus we take real output movements to be exogenous, which implies that the role of (A1) is simply to determine the price level. Since previous results indicate that different treatments regarding Δg_t have little quantitative importance, we also take Δg_t values to be exogenous.

The second of the three structural models is designed to represent the monetary misperceptions theory, developed by Lucas.[46] As the leading attempts to implement this approach empirically are those of Barro,[47] our formulation is based to a considerable extent on his. In particular, money-growth surprises--measured empirically as residuals from an equation designed to explain fluctuations in money growth rates--are taken to be an important determinant of real output. For present purposes it is useful to use surprise movements in the monetary base, instead of the M1 money stock considered by Barro. For the first-step regression used to represent the systematic component of base growth, the following autoregression was adopted:

$$\text{(A2)} \qquad \Delta b_t = \underset{(.001)}{0.0016} + \underset{(.082)}{0.4679}\, \Delta b_{t-1} + \underset{(.093)}{0.0426}\, \Delta b_{t-2} + \underset{(.083)}{0.3372}\, \Delta b_{t-3} + \tilde{\Delta} b_t$$

$$R^2 = 0.651 \qquad SE = 0.00463 \qquad DW = 2.07$$

Residuals from (A2), denoted $\tilde{\Delta} b_t$, were then employed as explanatory variables in the "aggregate supply" equation with estimates as follows:

$$\text{(A3)} \qquad \Delta y_t = \underset{(.001)}{0.0048} + \underset{(.193)}{0.3028}\, \tilde{\Delta} b_t + \underset{(.191)}{0.3776}\, \tilde{\Delta} b_{t-1} + \underset{(.083)}{0.3281}\, \Delta y_{t-1} + e_{3t}$$

$$R^2 = 0.150 \qquad SE = 0.00978 \qquad DW = 2.10$$

In the latter, it should be emphasized, standard errors associated with the coefficients attached to Δb_t values are larger than in Barro's work for technical reasons. Thus the y_t variable appears in first-differenced form and the specification includes Δy_{t-1} as an explanatory variable, thereby tending to attribute less explanatory power to the monetary surprises. These surprises continue to have sizeable coefficients, however, so a considerable influence of Δb_t irregularity on output is implied by (A3). Since the investigated policy rules are deterministic, there are of course no surprises occurring in the simulation exercises.

Finally, we turn to our specification more representative of Keynesian views. In particular, this specification was designed to represent--in simplified form--the wage-price portion of the well-known MPS econometric model. In that model, nominal wage changes are dependent (via an expectational Phillips relation) on a measure of capacity utilization and a measure of expected inflation. Prices then adjust gradually toward values implied by the prevailing level of wages and "normal" labor productivity growth. In our implementation, the first of these two relations is represented by the following equation estimated by least squares over 1954.1-1985.4:

$$\text{(A4)} \quad \Delta w_t = \underset{(.001)}{0.0048} + \underset{(.042)}{0.1838}\,(y_t-\bar{y}_t) - \underset{(.042)}{0.1327}\,(y_{t-1}-\bar{y}_{t-1}) + \underset{(.072)}{0.7594}\,\Delta p_t^e + e_{4t}$$

$$R^2 = 0.545 \qquad SE = 0.00479 \qquad DW = 1.81$$

Here w_t denotes the log of the nominal wage in manufacturing while $y_t - \bar{y}_t$ is the logarithmetic deviation of real GNP from a fitted trend and the expected inflation rate Δp_t^e is proxied by actual inflation rates averaged over the previous eight quarters. As the coefficient on Δp_t^e is significantly less than 1.0, the specification does not possess the natural-rate property of steady-state independence between inflation and $y_t - \bar{y}_t$. This makes the model more "Keynesian," and perhaps more favorable to an activist strategy, than if the coefficient equalled unity.

The second new equation in this model is the MPS-style price adjustment equation. Our version was estimated in first differenced form--in principle obviating the need for a trend term to reflect productivity changes--as follows:

$$\text{(A5)} \qquad \Delta p_t = \underset{(.0007)}{0.0003} + \underset{(.064)}{0.4929}\,\Delta w_t + \underset{(.063)}{0.4108}\,\Delta p_{t-1} + e_{5t}$$

$$R^2 = 0.692 \qquad SE = 0.00388 \qquad DW = 2.43$$

As with (A4), a slight departure from steady-state neutrality is implied by the point estimates. This motivates the constrained versions of (A4) and (A5) referred to in the body of the paper.

The experiment in which the Treasury bill rate, R_t, is used as an instrument necessitates that the foregoing model be augmented with a monetary base demand function. Estimates were found to be more satisfactory when lagged values of the transaction (y_t) and opportunity cost (R_t) variables were included, as well as a lagged dependent variable. The utilized version is as follows:

$$\text{(A6)} \quad \Delta b_t - \Delta p_t = \underset{(.0007)}{-0.0009} + \underset{(.054)}{0.1436}\,\Delta y_t + \underset{(.056)}{0.0371}\,\Delta y_{t-1}$$

$$+ \underset{(.074)}{0.1273}\,\Delta y_{t-2} - \underset{(.061)}{0.0717}\,\Delta R_t - \underset{(.061)}{0.3788}\,\Delta R_{t-1} + \underset{(.074)}{0.3912}\,(\Delta b_{t-1} - \Delta p_{t-1}) + e_{6t}$$

$$R^2 = 0.458 \qquad SE = 0.00562 \qquad DW = 2.19$$

NOTES

[1]The report delivered in February 1988, for example, describes developments during 1987 in part as follows: "Such factors as the pace of business expansion, the strength of inflation and inflation expectations, and developments in exchange markets played a major role in governing the System's actions, and in light of the behavior of these other factors, growth in the targeted aggregates, M2 and M3, was permitted to run at or below the established ranges." See "Monetary Policy Report to the Congress," Federal Reserve Bulletin 74 (March 1988), 151-164.

[2]Prominent examples are provided by Wayne D. Angell, "A Commodity Price Guide to Monetary Aggregate Targeting," December 1987; Manuel H. Johnson, "Current Perspectives on Monetary Policy," February 1988; and Robert D. Laurent, "An Interest Rate-Based Indicator of Monetary Policy," Economic Perspectives 12 (January/February 1988), 3-14. It is widely reported that the Federal Reserve Bank of St. Louis has presented a proposal involving targets (!) for the monetary base, but I have not seen any written descriptions.

[3]Benjamin M. Friedman, "Lessons on Monetary Policy from the 1980s," Journal of Economic Perspectives 2 (Summer 1988), 51-72.

[4]See Milton Friedman, "Monetary Policy for the 1980s," in To Promote Prosperity, ed. J. H. Moore. Stanford, CA: Hoover Institution Press, 1984, and Benjamin M. Friedman, "Monetary Policy Without Quantity Variables," American Economic Review Papers and Proceedings 78 (May 1988), 440-445.

[5]See, among others, Robert E. Hall, "Macroeconomic Policy Under Structural Change," in Industrial Change and Public Policy, Federal Reserve Bank of Kansas City, 1983; Robert J. Gordon, "The Conduct of Domestic Monetary Policy," in Monetary Policy in Our Times, ed. by A. Ando, E. Eguchi, R. Farmer, and Y. Suzuki. Cambridge, MA: The MIT Press, 1985; John B. Taylor, "What Would Nominal GNP Targeting Do to the Business Cycle?" Carnegie-Rochester Conference Series on Public Policy 22 (Spring 1985), 61-84.

[6]See Robert J. Barro, "Recent Developments in the Theory of Rules versus Discretion," Economic Journal 96 (Supplement 1986), 23-37, William S. Haraf, "Monetary Velocity and Monetary Rules," Cato Journal 6 (Fall 1986), 641-662, and Peter K. Clark, "Comment," Journal of Money, Credit, and Banking 20 (August 1988, part 2), 476-478.

[7]Bennett T. McCallum, "Robustness Properties of a Rule for Monetary Policy," Carnegie-Rochester Conference Series 29 (Autumn 1988), 173-203.

[8]Jan Tinbergen, On the Theory of Economic Policy. Amsterdam: North-Holland Pub. Co., 1952.

[9]Here the objective function is being conceived of as pertaining to public goals, involving the welfare of society, rather than the private goals of policy-making individuals or groups. It is important to recognize the existence of private goals when designing institutional arrangements, but such considerations are not the topic of the present paper.

[10]Notable studies that presume such goals include Finn Kydland and Edward C. Prescott, "Rules Rather than Discretion: The Inconsistency of Optimal Plans," Journal of Political Economy 85 (June 1977), 473-491, and Robert J. Barro and David B. Gordon, "A Positive Theory of Monetary Policy in a Natural Rate Model," Journal of Political Economy 91 (August 1983), 589-610.

[11]See, for a dated but interesting example, James L. Pierce, "Quantitative Analysis for Decisions at the Federal Reserve," Annals of Economic and Social Measurements 3 (1974), 11-19. A recent statement from the Fed says that the "ultimate objective of Federal Reserve Policy is to foster economic growth in a framework of price stability." See H. Robert Heller, "Implementing Monetary Policy," Federal Reserve Bulletin 74 (July 1988), 419-429.

[12]Recently there has been much emphasis in the literature on the Fed's manifest concern for interest rate behavior. See, for example, Marvin Goodfriend, "Interest Rate Smoothing and Price Level Trend-Stationarity," Journal of Monetary Economics 19 (May 1987), 335-348 and Carl E. Walsh, "The Impact of Monetary Targeting in the United States, 1976-1984," NBER Working Paper No. 2384, September 1987. In my opinion, that concern does not contradict the discussion in the body of the paper: the Fed interprets interest rate fluctuations as movements in the real rate, which makes the interest rate an alternative measure of real cyclical conditions. That argument does not pertain to the interpretation of the nominal interest rate as a tax, as suggested by Robert J. Barro, "Interest Rate Smoothing," NBER Working Paper No. 2581, May 1988. In my opinion the evidence does not support the hypothesis that Fed behavior is significantly influenced by tax-smoothing considerations.

[13]Some authors use "targets" to refer to ultimate goals and "intermediate targets" to refer to the role under discussion. To avoid possible confusion, the work "target" is here used only in the latter sense but the qualifier "intermediate" is occasionally appended, nevertheless, as a reminder.

[14]The official Fed strategy of 1979-1982 was approximately of this type. There are many analysts, of course, who doubt that actual efforts were concentrated solely on the achievement of the specified M1 target values.

[15]Recently there has been considerable interest in the exchange rate as a target variable. The rationale for such a choice is unclear.

[16]It should be noted that the meaning given here to the term "indicator" is quite different from that proposed in the 1960s by Brunner and Meltzer, who had in mind a measure of the "thrust" of policy, not the state of the economy. See Karl Brunner and Allan H. Meltzer, "The Meaning of Monetary Indicators," in _Monetary Process and Policy_, ed. by G. Horwich. Homewood IL: Richard D. Irwin, 1967.

[17]These include John H. Kareken, Thomas Muench, and Neil Wallace, "Optimal Open Market Strategy: The Use of Information Variables," _American Economic Review_ 63 (March 1973), 156-172; Benjamin M. Friedman, "Targets, Instruments, and Indicators of Monetary Policy," _Journal of Monetary Economics_ 1 (October 1975), 443-473; and Ralph C. Bryant, _Controlling Money: The Federal Reserve and its Critics_. Washington, D.C.: Brookings Institution, 1983. A recent review is provided by Friedman, "Targets and Instruments of Monetary Policy," NBER Working Paper No. 2668, July 1988.

[18]The argument was developed by Kydland and Prescott, "Rules Rather than Discretion," and elaborated by Barro and Gordon, "A Positive Theory."

[19]Kenneth S. Rogoff, "The Optimal Degree of Commitment to an Intermediate Monetary Target," Quarterly Journal of Economics 100 (November 1985), 1169-1189.

[20]For references, see note 5.

[21]See McCallum, "Robustness Properties."

[22]Since the main disagreement among schools of thought concerns the aggregate-supply or Phillips-curve portion of the model, the same aggregate demand specification is utilized in all three models. A brief description of these is provided in the appendix to the present paper.

[23]The main source of skepticism is each model's vulnerability to the Lucas critique. My strategy's defense is to consider a wide variety of models in the hope that one will be reasonably well specified and therefore relatively immune to this critique. As a related matter, one might inquire about robustness with respect to the sample period studied. The relevant question, however, is not whether model parameter estimates are insensitive to sample periods but whether good rule performance is. Some encouraging preliminary results have been obtained by Robert P. Flood and Peter Isard of the International Monetary Fund. Robustness across countries, moreover, is being studied by Thomas E. Hall, "McCallum's Base Growth Rule: Results From the United States, West Germany, Japan, and Canada," Working Paper, Bureau of Economics and Business Affairs, U.S. Department of State, October, 1988.

[24]Haraf, "Monetary Velocity and Monetary Rules."

[25]This argument was presented earlier in Bennett T. McCallum, "On 'Real' and 'Sticky-Price' Theories of the Business Cycle," Journal of Money, Credit, and Banking 18 (November 1986), 397-414. Analytical support has recently been provided by Christopher A. Sims, "Bayesian Skepticism on Unit Root Econometrics," Discussion Paper 3, Institute for Empirical Macroeconomics, May 1988.

[26]This exposition simply assumes that zero is the socially-optimal inflation rate. The analysis could easily be modified in an obvious fashion to accommodate other values.

[27]Here 0.005 is an assumed value that represents the approximate quarterly standard error of forecast for the U.S. inflation rate. (In Table 5 below, for example, the values are about 0.004.)

[28]An increase in productive capacity that brings about a temporary spurt in output growth will induce a monetary tightening even though none is needed to keep the price level from rising. If prices are sticky, the tightening might cause output subsequently to fall below its capacity level.

[29]That explosive oscillations can result when policy feedback responses are too strong for the system is well known. Even with the small models here utilized, the dynamics are too complex for me to be able to say exactly why instability occurs in the cases in which it does.

[30]See note 2 for reference to the Laurent paper.

[31]The Fed's index is reported only for periods since the start of 1967. In order to permit calculations for earlier periods, figures for 1954-1966 were constructed by the present author from series pertaining to bilateral exchange rates for the United States with Belgium, Canada, Italy, the Netherlands, and the United Kingdom. For details, see McCallum, "Robustness Properties."

[32]Darby's letter is reproduced in Committee on Banking, Finance, and Urban Affairs, U. S. House of Representatives, Report on the Conduct of Monetary Policy. Washington: U. S. Government Printing Office, 1988.

[33]This statement is based on values of the statistic $[(SSE^0-SSE)/SSE](T-H)$, where SSE^0 and SSE are sums of squared residuals with the indicator variable excluded and included, respectively, while T-H is the number of observations minus the number of parameters estimated in the inclusive case. Under the null hypothesis, of no incremental explanatory power, the statistic is asymptotically distributed as a chi-squared random variable with K degrees of freedom. (Here K denotes the number of restrictions imposed in the exclusive case, four in the present example).

[34]With this specification, a trend term is also included in all regressions. There are more formal rejections of the hypothesis of zero incremental explanatory power for the indicator variables, but again that power is of no practical importance.

[35]In principle the monetary base could be observed daily, but it is not under current conditions.

[36]The real M2 variable is not considered in Table 6 because observations would not become available in practice more quickly than for Δy_t and Δp_t.

[37]This finding is qualitatively similar to those of two very recent studies that also emphasize the requirement that an indicator must, to be useful, provide incremental information. See Richard T. Baillie, "Commodity Prices and Aggregate Inflation: Would a Commodity Price Rule be Worthwhile?" Working Paper, Michigan State University, October 1988, and Roy H. Webb, "Commodity Prices as Predictors of Aggregate Price Change," Working Paper, Federal Reserve Bank of Richmond, October, 1988.

[38]These discrepancies are those for which RMSE statistics are reported in Table 1.

[39]Strictly speaking, this statement presumes that the Δb_t instrument in (1) would be made <u>linearly</u> dependent upon indicator values such as $\Delta pc_{t-1}, \ldots, \Delta pc_{t-4}$.

[40]see Benjamin M. Friedman, "Conducting Monetary Policy by Controlling Currency Plus Noise," <u>Carnegie-Rochester Conference Series on Public Policy</u> 29 (Autumn 1988), 205-212.

[41]Friedman, "Conducting Monetary Policy," p.205.

[42] I have in mind language of the type that would refer to the 1979-82 policy regime as one of "nonborrowed reserves targeting."

[43] This is the only model of the four described above that includes the interest rate as an explicit variable.

[44] Bennett T. McCallum, "Price Level Determinacy with an Interest Rate Policy Rule and Rational Expectations," Journal of Monetary Economics 8 (November 1981), 319-329. Also see Benjamin Friedman, "Targets and Instruments of Monetary Policy."

[45] The following presentation is adapted from McCallum, "Robustness Properties."

[46] Robert E. Lucas, Jr., "Expectations and the Neutrality of Money," Journal of Economic Theory 4 (April 1972), 103-124.

[47] Robert J. Barro, "Unanticipated Money Growth and Unemployment in the United States," American Economic Review 67 (March 1977), 101-115, and "Unanticipated Money, Output, and the Price Level in the United States," Journal of Political Economy 86 (August 1978), 549-580.