Working Paper 8407

MONETARY POLICY REGIMES: A SYNTHESIS OF THE MONETARY CONTROL AND RATIONAL EXPECTATIONS LITERATURES

by James G. Hoehn

The author gratefully acknowledges useful comments on earlier drafts by Matthew Canzoneri, William Gavin, Kim Kowalewski, and David Lindsey. It is emphasized that these persons do not necessarily agree with the opinions expressed by the author. Kathy Begy and Laura Davis assisted in manuscript preparation.

December 1984

Federal Reserve Bank of Cleveland

Abstract

The monetary control literature has attempted to explore the effects of alternative policies without succeeding in incorporating rational expectations or in integrating analysis of the money supply sector into a complete macroeconomic framework. The rational expectations approach, while reserving a place for the monetary control issues under the concepts of instrument (Sargent and Wallace 19751, automatic stabilizers (McCallum and Whitaker 19791, and structural reforms (Dotsey and King 19831, has not provided the needed integration. Extending earlier work by Hoehn (1979, 1983b) and McCallum and Hoehn (1982, 19831, this paper attempts to provide a synthesis of the concepts from the rational expectations and monetary control literatures, in the context of a relatively complete, if ad hoc, macroeconomic model.

It is concluded that, under the most plausible assumptions concerning the availability and use of information of various types by private agents and the monetary authorities, the monetary regime--defined as the conjunction of the open-market strategy and the institutional and regulatory framework--does matter for the distribution of output, as well as of money, interest rates, and prices. On the other hand, the rational expectations approach raises a number of problems and ambiguities regarding policy effects that require further theoretical research. Some recent efforts along these lines are critically evaluated.

The literature on monetary control and rational expectations expanded rapidly in the 1970s and early 1980s, each spurred by the experience of stagflation and the ineffectiveness of postwar monetary policies. The term monetary control literature signifies the analyses of alternative money supply behaviors as influenced by the modus operandi of monetary policy and the institutional and regulatory framework. A basic premise of this literature is that these factors, which taken together shall be termed a regime, are important determinants of macroeconomic outcomes. This literature is seriously limited by its narrow focus on monetary control per se and by its lack of full integration with macroeconomic theory. The rational expectations literature, which has revolutionized macroeconomic theory, has exerted little influence on the monetary control literature (though it may be on the threshold of doing so). The reason for this may lie in the unrealistic concepts of policy in the rational expectations literature, which seem inadequate or simply inapplicable to real world phenomena. These concepts have been a continuing, albeit rather unjustified, source of skepticism regarding the policy implications of rational expectations--or, more generally, new classical--models and may help explain continued adherence to traditional policies and macroeconomic concepts.

The two literatures have advanced independently, reflecting the fallacious dichotomy between the broad macro and money market sectors of analytical models and previous literature and the infamous two-stage policy decision sequence. A reconciliation between these literatures will serve a number of purposes. First, where the two literatures differ in their concept of policy, an attempt at reconciliation forces careful reassessment. It will be seen that the monetary control literature has, in some important ways, modeled

policy more realistically. As the monetary control literature's valid contributions are incorporated into a rational expectations macromodel, some important loopholes in the policy ineffectiveness proposition will come to light.

The present paper can be regarded as an extension of previous efforts to reconcile rational expectations macroeconomics and the monetary control literature (by Hoehn 1979, 1983b). McCallum and Hoehn (1982, 1983), Goodfriend (1983), and Goodfriend et al. (1983) also deal with the narrower issues of monetary control per se using the rational expectations assumption in some way. Related work includes Sargent and Wallace (1975), McCallum (1981, 1984), Dotsey and King (1983), Canzoneri, Henderson, and Rogoff (1983), and Goodfriend (1984b). These latter papers largely concern macroeconomic issues beyond the normal scope of the monetary control literature.

I. The Monetary Policy Sector in Macroeconomic Models

Monetary policy plays an important role in macroeconomic theories, particularly theories of the business cycle. A monetary policy sector is necessary to complete a macroeconomic model. One of the most important advances in macroeconomics has been that policy behavior has been modeled more and more realistically.

In the simple Keynesian models the monetary policy sector sets the interest rate, which is treated as either fixed or as a choice parameter. IS-LM models, which include monetarist models as a special case, assign the monetary policy sector the role of setting the money stock. In these models, the money stock is either fixed or a choice parameter, invariant with respect to the state of the economy. Monetarists gave special attention to the role

of monetary policy, emphasizing the comparison of constant growth rules--which they advocated--versus randomized or state-dependent money supply behavior. Even though the monetarists warned of the dangers of fixing interest rates, they did not incorporate such policy behavior into their models.

The rational expectations theorists offered a significant advance by formally treating monetary policy as the choice of a feedback rule.' In their models, policy is typically characterized by the instrument and a rule for its behavior, stated as a function of state variables. Sargent and Wallace (1975) showed that, under rational expectations and certain assumptions regarding aggregate supply and demand behavior, the time path of output is invariant with respect to the feedback rule.[2] However, at the same time, the choice of the instrument does have implications for the distribution of output. Rational expectations theorists generally continued to assign monetary policy the role of setting the money stock, because the use of the interest rate as an instrument was believed to result in the indeterminacy of nominal variables. Like the monetarists, rational expectations theorists generally emphasized the dangers of fixing interest rates, and may therefore have preferred to construct models employing money supply behavior, the adoption of which they considered beneficial. In applying their models to the explanation of actual events, the rational expectations theorists, like the monetarists, may often have confused normative and positive economics. Another reason for specifying monetary policy as a rule for the money stock was analytical convenience.

So although the rational expectations theorists offered a significant advance over earlier modelbuilders in their treatment of the monetary policy sector, their earliest models were unequipped to explain or predict economic

events in the case in which the Federal Reserve did not use the money stock as the instrument. This was a serious limitation. Not only has the Federal Reserve employed the federal funds rate as the instrument during most of the period in which the rational expectations literature has expanded, but it is also infeasible for the Federal Reserve to adopt what can be regarded mathematically as a money stock rule unless radical institutional and regulatory changes take place. Indeed, even a total reserve or monetary base instrument is infeasible under current arrangements.

The major remaining barrier to incorporating both rational expectations and an adequate policy sector into macromodels is analytical and econometric intractability. A realistic rule for the federal funds rate or nonborrowed reserves as a function of either future expectations of goal variables or past observations on state variables raises the order of the system of difference equations that represent the structure of the economy beyond an order that permits derivation of analytical reduced forms corresponding to the observable reduced forms. Perhaps more research will overcome the analytical difficulties, but early success cannot be anticipated.

This discussion does not directly concern the identification and estimation of a structural probability model of the macroeconomy. However, an appropriate research strategy for building such a model must include the construction of a tractable and simple, yet adequate, monetary policy sector. There is obviously a need for great improvement in this area. Development of such a model is essential if the macroeconomic literature and the literature on monetary control are to be integrated. Without such an integration, the conclusions of the literature on monetary control are not secure. Benjamin Friedman (1975 and 1977) has shown that a failure to integrate the broad

macroeconomic analysis and the money market analysis can lead to potentially serious error (even in a conventional Keynesian model) in policy analysis.

II. A Reconsideration of the Instrument Concept

The problem of monetary policy is that of designing a rule--that is', a procedure for adjusting policy instruments--that responds to incoming information to minimize deviations of objective variables from their targets. The only rational approach to this design is to construct a complete structural probability model that links policy instruments to the ultimate objectives. In practice, the objectives have included stabilization of output, prices, money, and interest rates.

A policy instrument is a variable that the Federal Reserve can control directly and precisely. It must be immediately observable, or it cannot be controlled precisely. In the traditional use of the term, and in an ultimate sense, monetary policy instruments include open-market operations, all aspects of discount-window administration, reserve requirements, and various other regulations such as deposit-rate ceilings. But, of these, only open-market operations are flexible enough to employ on an essentially continual basis. In recent literature, the term instrument has been used to signify alternative criteria of open-market operations. The alternative instruments are essentially quantity-setting or interest-rate-setting rules of behavior. While in principle a relation between a quantity and a rate, similar to Poole's combination policy, can serve as the operational criterion of open-market operations, and in general should, analytical insights are often facilitated by contrasting polar cases of quantity versus rate-setting policy behavior (see Poole 1970). An additional reason for considering these polar

cases is that they have sometimes described actual policy.

The value of the instrument is kept constant only so long as it remains consistent with the ultimate objectives. When new information about deviations of target variables is received, the instrument should be reset, an action termed feedback. Information is, in principle, conveyed by observed movements in all of the observable variables, both exogenous and endogenous, that enter into the complete structural probability model. The model tells us how the instrument must be reset to be consistent with the objectives, conditional on the set of observed realizations. Feedback cannot be continuous or immediate, because most information is conveyed only at discrete intervals: there is an information lag. In addition, because some time is required to filter information and execute the appropriate instrument resetting, there is also a decision lag. In practice, the decision lag is lengthened by bureaucratic or committee behavior. Instrument resettings are often made only after a broad-based consensus develops among non-analytical policymakers that such a resetting is needed. The instrument issue exists precisely because feedback cannot be instantaneous and continuous. The Federal Reserve must have some criterion for actions between points of time at which new information becomes available, can be processed, and used to make a new decision. Policy cannot be asked to do nothing in the interval, unless doing nothing is defined.

The instrument problem and the feedback problem are complementary; in that together they make up the complete problem of policy design. Consequently, a correct conception of the instrument problem requires an understanding of feedback--in particular, we must have an accurate understanding of which information is available to the policymaker, with which lags.

This view of the policy problem suggests that the instrument issue has been widely misconceived in several respects. Most important, many economists have confounded the feedback and instrument problems. Many influential studies of the "instrument issue" implicitly or explicitly have sought a variable, which, if pegged without feedback, would more closely achieve the goals than if alternative variables were pegged permanently. This naturally led to an unwarranted bias against interest-rate-setting rules, because they require more feedback in a cyclical context. Instead, the instrument should be chosen strictly on its ability to insulate the goals from unknown disturbances. Past disturbances can be imputed from available data in conjunction with the model, and it is the proper role of feedback to offset the impact of known disturbances.

An associated misconception is of the time horizon relevant to the instrument choice problem. That horizon is the information (and decision) lag. Unfortunately, a practical separation between instrument and feedback issues is complicated by the different frequencies with which information becomes available. The instrument concept of recent literature is simply inapplicable without information or decision lags, for otherwise feedback can and should be continuous. The nature of the instrument choice problem depends as critically on the assumptions about information availability as it does on the other structural characteristics of the model.

Given the conception of the policy problem as that of responding to information, the reserve accounting period is a useful means of separating for information that is currently available and information that is available only with a lag. (The reserve accounting period also corresponds to the period of the traditional adjustment mechanism inherent in reserve requirements.)

Information available with a lag includes observations on money, output, prices, and the family of reserve aggregates. It will be assumed here that the information lag on these variables is one or more reserve accounting periods. On the other hand, the Federal Reserve is assumed to have perfect current information on the securities in its portfolio (the open-market position) and on the federal funds rate. In addition, the policymaker has partial knowledge of the so-called uncontrollable factors affecting reserve supply (float, Treasury cash, currency, and so on), excess reserve demand, and borrowed reserve demand. The way the Federal Reserve uses immediately available information will be thought of here as an operating procedure, a concept related to the instrument but more descriptive.

The particular information structure assumed is a central feature of the analysis. Besides the obvious advantage of being explicit, the specific assumptions made will facilitate analysis of the effects of alternative operating procedures and regulatory factors on the control of money especially, but in a broader macro context in which the objectives involve the stability of interest rates, prices, and output.

III. An Analytical Framework

This section develops a model of the instrument issue that is dynamic and incorporates rational expectations of prices. Its dynamics are rather simple, exploiting the idea that lagged behavioral responses are more important for the feedback issue than for the instrument issue. While this notion facilitates analysis of instrument issues, it will be necessary to consider ways in which the instrument and feedback issues cannot be entirely separated in a rational expectations model. All variables are measured as deviations

from deterministic components, which has the effect of eliminating constants and polynomials in the time index.

A serious limitation of the model is that it does not account explicitly for changes in the "structural" parameters and disturbance variances that would occur as the policy regime is altered. In other words, the model is, like virtually every other analytically tractable model, subject to the well-known Lucas (1976) critique. Consequently, the sensitivity of results to likely changes in parameters should be assessed. In many relevant practical situations, this can probably be done, and illustrations will be given below. Quantitative simulations using existing money market models, while interesting and suggestive, do not lead to secure conclusions without this kind of sensitivity analysis.

Aggregate commodity demand is taken to be a negative function of the ex ante real rate of interest and is subject to a white-noise disturbance:

$$(1)\quad y_t = d\,[r_t - (E_{t-1}\,p_{t+1} - p_t)] + u_{1t}, \qquad d<0,$$

where

y = natural log of output,

r = federal funds rate,

p = natural log of the price level,

and t is a reserve accounting period time index.

Expectations of inflation are taken to be equal to the objective expectation of the next period's price level, conditioned on all lagged (t-1) realizations, minus the current (actual) price level. Later, the implications of allowing the public to form future price expectations based on current observations will be examined.

The aggregate supply function is that of Sargent and Wallace (1975):

$$(2)\quad y_t = s\,(p_t - E_{t-1}\,p_t) + u_{2t}, \quad s>0.$$

Output supply responds positively to price level surprises and is subject to a white-noise disturbance. There are at least three justifications for this aggregate supply function (see McCallum 1980, pp. 720-1). First, the accelerationist or expectations-augmented Phillips curve of Friedman, Phelps, and others; second, Lucas' island parable, if agents only know the current local price plus any lagged information; and third, as a single-equation representation of Keynesian econometric wage-markup price equations. [3]

The key contention here is that, for the issues addressed by the monetary control literature, the Sargent-Wallace supply function is more appropriate than available alternatives, such as those that begin with the Lucas island parable but allow agents to respond to information contained in the interest rate. The assumption that private agents either do not observe or do not respond to elements of the information set available to the Federal Reserve results in a preservation of the relevance of the monetary regime for output stabilization. Some rational expectations theorists, such as Barro (1976) and Dotsey and King (1983), have explicitly noted that superior information by the Federal Reserve can form a basis for output stabilization policy. These theorists, however, have been deliberately reluctant to make such an allowance of superior information in their analyses. This reluctance arises from the contentions that (a) the policy of releasing the superior information to the public is essentially equivalent to feedback in terms of stabilization effects, and that (b) in any case, such information hardly forms the basis for stabilization of the countercyclical type advocated by Keynesians or that

observed in postwar experience. Contention (b), while surely correct, seems irrelevant in the context of monetary control issues. But contention (a) must be carefully considered.

It might seem that prompt release of the Federal Reserve's fragmentary observations on reserve and deposit data would, by eliminating the Federal Reserve information advantage, render the monetary policy regime irrelevant. But that surely cannot be the case: the policy regime also influences what kind of information is generated and how it is processed. For example, the recent switch of reserve requirement accounting altered the kind of information flowing to the Federal Reserve from the banking system and sped it up. Regulatory issues such as this fall into the category of structural reform as conceived by Dotsey and King (1983). But the other aspects of the regime, the instrument and feedback rules, can reflect a more efficient processing of information than can be accomplished by private agents alone. It is probably not economic for private agents to index contracts fully to reflect all variations in, for example, float, Treasury cash balances, and currency flows. Yet each of these reserve supply factors can distort the information conveyed by the interest rate and other prices. There would appear to be economies of scale in processing information that can be exploited by the Federal Reserve. The benefits derived can be distributed widely by appropriate manipulation of interest rates. An interesting question not yet adequately addressed is whether such information processing is a public good. If not, there may be no justification on grounds of economic efficiency for a public monopoly.

The aggregate supply function, in conjunction with rational expectations and the aggregate demand equation, ensures that the familiar "policy

ineffectiveness" result of Sargent and Wallace (1975) will prevail: the behavior of output will be invariant with respect to policy feedback. However, operating procedures and regulatory factors can, by affecting the distribution of price level surprises, have implications for the behavior of output. Thus, Sargent and Wallace suggested, the instrument choice is generally consequential for output even if feedback is not. It will be shown later that the importance of the instrument, or, more broadly, of the policy regime, is robust with respect to a number of re-specifications of the aggregate supply equation.

The money demand equation is quite conventional, except that it is expressed as a first-order Taylor expansion or linear approximation:

$$(3)\quad m_t = a_1 r_t + a_2 y_t + a_3 p_t + e_t, \qquad a_1<0,\ a_2>0,\ a_3>0,$$

where

m = money (reservable deposits),

and e is a white-noise disturbance.

The linearity permits consistent use of the (linear) balance sheet identities in the money supply sector of the model.

The money supply sector provides a relation between the money stock and the interest rate that is needed to complete the model and determine output, price level, money stock, and interest rate. This relation can be termed a money supply function. In general it has the form:

$$(4)\quad m_t = \beta r_t + v_t,$$

where the slope, β, is a nonlinear function of the parameters in the money supply sector, and v_t is a linear function of the disturbances in the money supply sector.

The slope of the money supply function helps determine the way commodity market and money market disturbances affect output, the price level, the money stock, and the interest rate. All of Poole's (1970) qualitative results can be duplicated within this model, if an exact money supply rule replaces the money supply sector of the model. The use of (a) the real rate of interest in the aggregate demand function, (b) an aggregate supply function of the Sargent-Wallace type, and (c) rational expectations does not destroy Poole's qualitative results, at least in this model, as long as Poole's levels of variables are converted to one-period innovations. (The implications of aggregate supply disturbances, which Poole didn't examine, are essentially the same as aggregate demand disturbances, if output stabilization is the objective.)

In addition to making these improvements, the model here adopted facilitates analysis of the effects of alternative operating procedures, reserve requirement systems, and discount policies. These alternatives influence the slope and variability of the money supply function and the variances of y, p, m, and r. Hence, the framework of analysis allows an integration of the monetary control and macroeconomic aspects of analysis.

The money supply sector comprises four equations: two reserve demand equations, a rule for open-market operations, and a reserve identity. The demand for total reserves is the sum of required reserves, the fraction k_1 (reserve requirement ratio) of the money stock, plus a random term W_1^*, representing excess reserves:

(5) $TR_t = k_1 m_t + w^*_{1t}, \qquad 0 \leq k_1 < 1$

In the case of contemporaneous reserve requirements (CRR), it is assumed that k_1 is a positive fraction. In the case of lagged reserve requirements (LRR), it is assumed that the demand for total reserves is a function of the lagged money stock, as in:

(6) $TR_t = k_1 m_{t-1} + w^*_{1t}.$

Because the term in m_{t-1} will not appear in expressions for innovations in the endogenous variables, formal analysis of innovations can proceed most conveniently by setting $k_1 = 0$ under LRR. As emphasized elsewhere, the presence of lagged terms anywhere in the model merely affects the optimal feedback and is not relevant to the instrument issue.

Total reserve supply is defined as the sum of the open-market position, S_t, borrowed reserves, BR_t, and the so-called uncontrollable factors affecting reserve supply $(\lambda_t + \lambda^*_t)$.

(7) $TR^S_t = S_t + BR_t + \lambda_t + \lambda^*_t.$

The Federal Reserve is assumed to have some direct information on the uncontrollable factors, but not complete information. In particular, when the open-market program for the reserve accounting period is determined, the Federal Reserve knows the portion λ_t but does not know λ^*_t.

The borrowed reserve demand equation:

(8) $BR_t = k_2 r_t + w_{2t} + w^*_{2t}, \qquad k_2 > 0,$

makes borrowing a positive function of the funds rate, with random disturbance terms w_{2t} and w^*_{2t}.

The former is directly observable to the Federal Reserve before open-market operations are carried out, while the latter is not. The coefficient k_2 represents the response of borrowings to a change in the funds rate.

The Federal Reserve's information set includes S_t, r_t, λ_t, w_{2t}, and past realizations of all observable variables, including money, output, prices, and the family of reserve measures. The relevant general form of the policy rule is then:

$$(9) \quad S_t = c_1\lambda_t + c_2 w_{2t} + c_3 r_t,$$

ignoring the feedback terms on lagged observations. Policy can (only) choose a relation among the observable variables and can achieve that relation precisely by manipulating the open-market position. Different operating procedures can be represented by different values of the c_i's. A value of zero for c_3 characterizes the essentially quantity-setting policies, while an infinite value for c_3 characterizes the pure rate-setting case. These special cases are represented by:

$$(10) \quad S_t = c_1\lambda_t + c_2 w_{2t},$$

and

$$(11) \quad r_t = b_1\lambda_t + b_2 w_{2t},$$

respectively. These expressions will facilitate the analysis of alternative operating targets, which imply different values for the c_i's or b_i's.

A policy regime can generally be defined as a set of values for k_1, k_2, and c_1, c_2, and c_3, because policymakers ultimately exercise control over all of them. The values of the c_i characterize the operating procedure, while the values of k_i represent the reserve requirement system and discount policies.

Solving the four equations of the money supply sector (using the general form of the policy rule), we find the following alternative expressions for the money supply function:

$$(12)\quad m_t = k_1^{-1}(c_3+k_2)r_t + k_1^{-1}[(c_1+1)\lambda_t + (c_2+1)w_{2t} - w_{1t}^* + w_{2t}^* + \lambda_t^*] \quad \text{for } k_1 \neq 0,\ c_3 < \infty,$$

or

$$(13)\quad r_t = k_1(c_3+k_2)^{-1}m_t + (c_3+k_2)^{-1}[w_{1t}^* - w_{2t}^* - \lambda_t^* - (c_1+1)\lambda_t - (c_2+1)w_{2t}], \quad \text{for } (c_3+k_2) \neq 0.$$

The first expression makes explicit that the policy regime uniquely determines the slope of the money supply function (4):

$$(14)\quad \beta = k_1^{-1}(c_3+k_2).$$

In addition, k_1, c_1, and c_2 help determine the variance of the disturbance, v_t, in the money supply function. One immediate result is that the optimal value of both c_1 and c_2 is -1. This is seen by observing that such a value for c_1 and c_2 eliminates λ_t and w_{2t} from the money supply function.

Another obvious result is that k_2 and c_3 appear additively. Open-market

operations (c_3) and discount-window administration (k_2) can both be employed as policy tools, but one of them is redundant. An implication is that "reforms" of the discount window--for example, those that would result in a zero value for k_2--need not influence the determination of money, the interest rate, output, or prices, if the rule of open-market operations is changed in an offsetting manner. Reserve requirements (given by the ratio k_1) and open-market operations (implied by c_3) are distinct policy tools, however.

The semi-reduced-form solutions for the endogenous variables in the model are given below for the general case of the policy rule. A wide variety of regime changes or reforms can be analyzed using these equations:

$$(15)\quad m_t = [1-k_1(a_1(s-d)+(a_2s+a_3)d)J]e_t-(a_2s+a_3)(k_2+c_3)Ju_{1t}$$
$$+(a_2d+a_3)(k_2+c_3)Ju_{2t}$$
$$+[a_1(s-d)+(a_2s+a_3)d]J[v_{2t}-w^*_{1t}+(1+c_2)w_{2t}+w^*_{2t}+(1+c_1)\lambda_t+\lambda^*_t],$$

$$(16)\quad r_t = -(s-d)k_1Je_t-(a_2s+a_3)k_1Ju_{1t}+(a_2d+a_3)k_1Ju_{2t}$$
$$+(s-d)J[v_{2t}-w^*_{1t}+(1+c_2)w_{2t}+w^*_{2t}+(1+c_1)\lambda_t+\lambda^*_t],$$

$$(17)\quad y_t = -sdk_1Je_t+s(a_1k_1-k_2-c_3)Ju_{1t}-d(a_1k_1-k_2-c_3-a_3k_1)Ju_{2t}$$
$$+dsJ[v_{2t}-w^*_{1t}+(1+c_2)w_{2t}+w^*_{2t}+(1+c_1)\lambda_t+\lambda^*_t],$$

$$(18)\quad p_t = -dk_1Je_t+(a_1k_1-k_2-c_3)Ju_{1t}-(a_1k_1-k_2-c_3+a_2dk_1)Ju_{2t}$$
$$+dJ[v_{2t}-w^*_{1t}+(1+c_2)w_{2t}+w^*_{2t}+(1+c_1)\lambda_t+\lambda^*_t],$$

$$(19)\quad S_t = -c_3(s-d)k_1Je_t-c_3(a_2s+a_3)k_1Ju_{1t}+c_3(a_2d+a_3)k_1Ju_{2t}$$
$$+[c_3(s-d)J+1]v_{2t}-c_3(s-d)Jw^*_{1t}+[c_3(1+c_2)(s-d)J+c_2]w_{2t}$$
$$+c_3(s-d)Jw^*_{2t}+[c_3(1+c_1)(s-d)J+c_1]\lambda_t+c_3(s-d)J\lambda^*_t,$$

$$(20)\ TR_t = k_1[1-k_1(a_1(s-d)+(a_2s+a_3)d)J]e_t$$
$$-k_1(a_2s+a_3)(k_2+c_3)Ju_{1t}$$
$$+k_1(a_2d+a_3)(k_2+c_3)Ju_{2t}$$
$$+k_1[a_1(s-d)+(a_2s+a_3)d]J[v_{2t}+(1+c_2)w_{2t}+w^*_{2t}+(1+c_1)\lambda_t+\lambda^*_t]$$
$$-(c_3+k_2)(s-d)Jw^*_{1t},$$

and

$$(21)\ BR_t = -k_2(s-d)k_1Je_t-k_2(a_2s+a_3)k_1Ju_{1t}+k_2(a_2d+a_3)k_1Ju_{2t}$$
$$+k_2(s-d)J[v_{2t}-w^*_{1t}+(1+c_1)\lambda_t+\lambda^*_t]$$
$$+[k_2(1+c_2)(s-d)J+1]w_{2t}+[k_2(s-d)J+1]w^*_{2t},$$

where

$$J = [(s-d)(a_1k_1-k_2-c_3)+dk_1(a_2s+a_3)]^{-1}.$$

Determinacy of Nominal Magnitudes

Perhaps one reason that an analysis of operating procedures was not performed in the context of a rational expectations model was that most economists accepted the Sargent and Wallace (1975) argument: within such a model, nominal magnitudes are indeterminate under an interest-rate rule, regardless of feedback.[4] Economists of different views toward rational expectations responded differently to the Sargent and Wallace argument. Some of those opposed regarded it as a cause for skepticism about either rational expectations or the Sargent and Wallace model, since it was well known that the Federal Reserve in practice operated by fixing the funds rate. The notion seemed to be that if the price level were indeterminate, it should have behaved more wildly than it did. On the other hand, proponents of rational

expectations, as well as many monetarists, regarded the Sargent and Wallace indeterminancy result as a strong argument in favor of quantity-setting policy behavior. Some of these proponents either dismissed as impossible that the Federal Reserve used the funds rate as the instrument, or concluded that the Federal Reserve policy was responsible for observed price instability.

Nevertheless, the Sargent and Wallace argument should never have been understood to imply that a pure quantity-setting rule is optimal. It merely suggests that the Federal Reserve should adopt a policy regime that results in some slope to the money supply function. Even a very slight positive or negative slope brings determinacy. In terms of the analysis of Sargent and Wallace, β of equation (4) must be finite, or the money supply function is a pure rate-setting equation that is not sufficient to determine money or prices in a rational expectations model. The coefficient β does not have to equal zero.

McCallum (1981) upset the Sargent and Wallace result by showing that if the feedback rule reflected some degree of concern over the money stock in some future period--a case that seems relevant--then nominal magnitudes are determinate after all. McCallum's result can be generalized, so that feedback that reflects any degree of concern for any nominal variable-- prices in particular--yields determinacy. Hence, the view that the Federal Reserve must be concerned about money per se, or any other nominal intermediate target, to achieve determinacy is not correct. Nevertheless, the determinacy issue gives us an interesting example of how the instrument and feedback issues cannot always be analyzed independently in a rational expectations model.

In the interpretation made here, a proviso is required that in cases where the policy regime results in a perfectly elastic money supply function, the

policy rule's feedback reflects a degree of concern--no matter how small--for some current value of at least one of the nominal variables: either money or prices. Interestingly, a funds rate-setting regime is only one of several in which indeterminacy arises in the absence of this proviso. As will be shown below, regimes with LRR or a borrowed reserve target will also yield a perfectly elastic money supply function.

Before discussing some implications of the model, it is useful to look at some generalizations that can be made without affecting results, as well as some of the model's limitations.

Behavioral Lags

All of the results derived with this model for the innovations in y, p, m, and r would be unaffected if any terms involving lagged realizations of variables were added to the equations. In the innovation form of the model--sometimes referred to as a mapping into expectations space--which recasts the variables as deviations from prior expectations, all of these lagged terms drop out. Hence, the LRR case can be handled by simply setting k_1 equal to zero. That lagged terms can be ignored greatly facilitates analysis of the instrument question in contexts where the feedback problem is very complicated. It is the role of feedback to deal with lagged terms or disturbance autocorrelations. A similar result is derived if the disturbances are replaced with moving average processes.

Alternative Aggregate Supply and Aggregate Demand Specifications

Because the appropriate specifications for aggregate supply and aggregate demand are the subject of considerable controversy, it is useful to assess how

sensitive are results to be derived with respect to a number of possible changes in specification.

The innovation form of the aggregate supply function is:

$$(22)\quad y_t = sp_t + u_{2t}.$$

The aggregate supply equation can handle a fixed-output assumption, by setting $s = u_{2t} = 0$. It can also handle supply behavior that sets the price level inflexibly one period in advance by taking the limit of reduced form solutions as the elasticity of aggregate supply, s, approaches infinity. Most relevant implications of different policy regimes are qualitatively similar in these cases, although solution expressions for the endogenous variables are considerably simplified. A so-called Keynesian supply function, in which the prior expectation of p_t is eliminated from the expression, results in exactly the same innovation form for aggregate supply. The Sargent and Wallace supply function is not critical in analyzing the instrument question in this model. Any supply behavior that makes output innovations a function of innovations in the price level yields the same qualitative results--in particular, it does not matter whether the so-called long-run Phillips curve is vertical or not, or even whether the more restrictive rational expectations or natural rate hypotheses are accepted. Of course, these latter hypotheses have powerful implications regarding the effects of feedback.

The aggregate demand equation's innovation form is:

$$(23)\quad y_t = d(r_t + p_t) + u_{1t}.$$

A simpler innovation form obtains if the operator E_{t-1} is placed in front of

p_t, representing a case in which current information is not available about the current price level when inflation expectations (which go into the calculation of the ex ante real rate) are formed. In this case, p_t is eliminated from the innovation form of the aggregate demand equation. The zero-inflation case that Poole studied, or one in which prices are predetermined one period in advance, results in the same exclusion of p_t from the innovation form. Solutions then become considerably simpler, but results for the innovations of y, m, and r under alternative instruments or operating procedures are, in many important ways, qualitatively similar.

The results derived from the model are sensitive to the specification of the aggregate demand equation in one respect: if expectations of the future price level are formed with any current information on p, y, m, or r, the innovation form of the aggregate demand equation involves the innovation in the expectation of future prices $(E_t p_{t+1} - E_{t-1} p_{t+1})$, which is not generally zero (McCallum and Hoehn 1982, 1983). This expression generally depends on the feedback rule and other lagged terms throughout the structural equations, and the neat analytical separation between the instrument problem and the feedback problem cannot generally be made. A wide variety of special cases and curious results then becomes possible--and has appeared in the literature--but none has much generality.

The bothersome expression can be eliminated if the expectation of the future price level is invariant with respect to current observations. Goodfriend (1984b) characterizes this restriction as trend-stationarity, and, in formal analysis, links it to the absence of base drift in money. However, trend-stationarity, as defined by Nelson and Plosser (1982), requires merely

that a variable eventually return to a predetermined trend. This definition is less restrictive than the condition that the future expectation be a fixed target-- that is, that the price level tends to return immediately to a predetermined trend. If the restrictive condition is met, the expectation of the price level at time $t+1$, formed at time $t-1$, will not be revised at time t. Thus, the bothersome term is identically zero and does not appear in the innovation form as before.

There are other ways to get rid of the bothersome term. If the only current information going into future price level expectations is the interest rate (a reasonably plausible case, and one of those examined by Canzoneri, Henderson, and Rogoff (1983), the term will then vanish if the interest rate does not actually convey any information about the future price level. That will occur if the money supply function is horizontal and nonstochastic: if the rate is fixed by a policy rule, then its innovation is zero, and it cannot relay any information. If the policy regime results in a stochastic, horizontal money supply curve (such as under LRR or a borrowed reserve operating target, as currently employed), then interest-rate innovations reflect self-reversing disturbances to the reserve market. One might be tempted to conclude that, once again, the current interest rate conveys no useful information about the future price level. However, this conclusion is not warranted. Funds rate innovations due to reserve market shocks destabilize p, y, and m and therefore relay information about current values of those variables. Unless the feedback in the policy rule implies fixed future expectations of prices, that information will, in general, affect future expectations of the price level.

In cases other than these, a feedback rule that permits the price level to

be non-trend-stationary will, under the modification of the way expectations and the real rate are determined, lead to a rather intractable analytical problem if there are lagged terms in the model. The results of the Federal Reserve adopting feedback that permits non-trend-stationary behavior for nominal magnitudes is an important topic of current research, and it is possible that some results derived from the model will be upset for the case in which private agents use current information sets. It is quite possible that the direct results and intuitions we have from Poole's analysis will not prove relevant in a dynamic rational expectations framework.

Recent theoretical and empirical results suggest that this trend-stationarity restriction of the model is a potentially serious one if private agents use current information sets. Goodfriend (1984b) argues that tension between objectives of price-level and interest-rate stabilization can create a strong motive for non-trend-stationary policy rules. The analysis of a non-trend-stationary model requires great simplicity. Goodfriend manages it by reducing the number of disturbances to two and the number of structural parameters to four, two of which characterize policy. However, Goodfriend's analysis has some unsatisfying aspects. A sufficiently high degree of interest-rate smoothing will always require a negative kind of base drift in money and prices; that is, to keep nominal interest rates stable, this period's accommodative increases in money will have to be followed by larger decreases in money in the next period. This seems empirically implausible as well as counterintuitive. But it may be a result of the assumption that the real rate is exogenous, or, equivalently, that output is fixed despite aggregate demand fluctuations. McCallum (1984) notes, in a discussion of Goodfriend, that the inability of contemporaneous accommodation to achieve

smoothing under a pure base drift policy depends critically on this output exogeneity assumption. Despite these limitations and troubling implications of the model, Goodfriend illustrates the point that intuitive and seemingly sensible results can be overturned in rational expectations models if (a) the public exploits current information sets, and (b) the Federal Reserve allows drift in the price level from a predetermined trend path. Empirical results of Nelson and Plosser (1982) suggest that the price level has not been trend-stationary, at least in the sense of a straight-1ine trend.

In principle, one can escape this problem by adopting a trend-stationary money-supply rule. In practice, however, this will not achieve the necessary trend-stationarity of prices unless money velocity is also trend-stationary. Financial innovation appears to render velocity non-trend-stationary, and Nelson and Plosser find velocity cannot be regarded as having a linear trend.

Given the theoretical ambiguities, it is tempting to suggest running experiments on the economy to answer seemingly intractable analytical questions. Yet, opinions vary about whether meaningful experiments (such as the one beginning in October 1979) have actually been run, and about how to interpret the results. The varying views spring from theoretical disagreements and ambiguities. Hence, it seems unlikely that experimentation alone will solve the analytical problems. As further support for this contention, consider the skepticism among many--the refusal to face the fact--that the Federal Reserve was really using a funds rate instrument in the 1970s, given the (mistaken) theoretical belief that such a policy was either impossible or extremely ill-advised! Only McCallum's modification of the Sargent and Wallace indeterminacy argument cleared the disbelief among some.

IV. Some Implications for Recent Policy Regimes and Reform Proposals

The remainder of this paper considers particular issues of the monetary control literature within the context of the complete rational expectations macroeconomic framework.

A first result is that, in the case of a pure rate-setting rule, the policy rule is the money supply function. None of the other money supply sector equations is needed to determine the money supply function, and hence play no part in determining p, y, m, or r. They merely determine various reserve quantities given the equilibrium values of those variables. The values of k_1 and k_2 (and their real-world variability) and variances of money supply sector disturbances are inconsequential. Issues related to LRR versus CRR, the Depository Institutions Deregulation and Monetary Control Act of 1980, discount-window administration, and float are irrelevant to the behavior of the variables of real concern. The switch in 1979 to a quantity-setting policy rule made these issues relevant.

A second result of generality, noted earlier, is that the optimal value of both c_1 and c_2 is -1. Obviously, open-market operations should act to offset known disturbances to the reserve market arising from fluctuations in borrowed reserve demand and the uncontrollables. The optimal combination policy will establish as the criterion for open-market operations the condition:

$$(24) \quad S_t + \lambda_t + w_{2t} - c_3 r_t = 0,$$

where c_3 is the optimal response of the open-market position to r. As intuitions derived from Poole's analysis suggest, the optimal value of c_3 depends on the objective function and all of the structural parameters and

disturbance variances. (For example, if output stabilization is the objective, c_3 should be larger, the larger money demand and reserve market disturbances are relative to aggregate demand and aggregate supply disturbances, and so forth. Such results are too familiar to repeat here.) One can, in principle, find the optimal value of c_3 for any objective function defined on the variance of innovations in p, y, m, and r.

The relevant comparison between pure quantity- and rate-setting rules is between:

$$(25)\quad S_t + \lambda_t + w_{2t} = 0,$$

and

$$(26)\quad r_t = 0.$$

A limitation--not so much of the model itself, but rather of the analysis conducted here with it--is that the opportunity the Federal Reserve has in pursuing a reserve operating target of extracting information about unobserved reserve market shocks from the observed federal funds rate will not be considered. In practice, the Federal Reserve should, and apparently does, use such information (see Wallich 1984, p. 27). To illustrate with a simple case, suppose the reserve measure serving as an operating target is R_t, and its demand is:

$$(27)\quad R_t^d = fr_t + e_t,$$

where $f>0$ and e_t is an unobserved disturbance term. Let the supply be the

sum of the open-market position, S_t, and an unobserved disturbance, v_t, representing uncontrollable factors affecting supply:

$$(28) \quad R_t^s = S_t + v_t.$$

The Federal Reserve observes S_t and r_t, but not R_t, whose control it seeks. Consider first the pure quantity-setting rule:

$$(29) \quad S_t = 0.$$

In this case:

$$(30) \quad R_t = v_t,$$

with variance σ_v^2. On the other hand, with a reserve supply rule of form:

$$(31) \quad S_t = gr_t,$$

then

$$(32) \quad R_t = f\,(f-g)^{-1}v_t - g\,(f-g)^{-1}e_t,$$

with variance

$$(33) \quad VAR(R) = f^2\,(f-g)^{-2}\sigma_v^2 + g^2\,(f-g)^{-2}\sigma_e^2,$$

assuming e_t and v_t are uncorrelated. The optimal value of g is:

$$(34) \quad g = -f^{-1}\sigma_v^2 (\sigma_e^2)^{-1}.$$

Hence, the policy rule that achieves closest control of the reserve operating target is actually a combination policy.

In the context of the complete model, the reserve market cannot be isolated as in the above illustration. The reduced form reserve demand equation represents the simultaneous interaction of all the parameters and disturbances in the model. The choice of g to stabilize R becomes analytically intractable in the general case. More importantly, incorporating this into the analysis of operating targets blurs the useful distinction between essentially rate-setting versus essentially quantity-setting policy behavior. In any case, an application of Occam's razor is needed somewhere. It would be desirable to trace the analysis to its most elementary nuts and bolts; the Federal Reserve ought to do so. However, the structure of information flows to the Federal Reserve cannot be adequately known to an "outsider" such as this writer. It must be conceded that this can become a serious problem in the analysis of alternative policy regimes, particularly to the extent that regime changes are associated with changes in the structure of information flows available to the Federal Reserve.

In descriptions of decisionmaking at the Federal Reserve, it is often said that the Federal Reserve takes part of the adjustment to information, seeming to imply that c_1 and c_2 are something less than unity in absolute magnitude. Alternatively, this could be interpreted as a different use of the term information than used here. The Federal Reserve may have noisy data

(which it calls "information") that it filters to get information (which constitutes the "adjustment" to the reserve path).

Now we consider some alternative operating procedures that have recently been in effect or proposed. As will become clear, none of the popular proposals considered for particular operating procedures is optimal; each involves discarding information. This result implies that an optimal policy system will not permit a simple description and partly explains why confusion over the open-market policies actually employed has been widespread.

Total reserve operating target. If the Federal Reserve attempts to control total reserves, it sets:

$$E[TR_t \mid I_t] = 0, \tag{35}$$

where

I_t includes S_t, r_t, λ_t, w_{2t}. This is achieved by setting:

$c_1 = c_2 = -1$, and

$c_3 = -k_2$, or

$$S_t + \lambda_t + w_{2t} + k_2 r_t = 0. \tag{36}$$

This rule has the term in r_t only because changes in the funds rate raise (observed) borrowed reserves to prevent known fluctuations in borrowings from affecting total reserves; the open-market position must be adjusted by an offsetting amount.

The result, assuming $k_1 \neq 0$ (CRR), is a strictly supply-determined money

stock. Innovations in money arise strictly from reserve market disturbances:

$$(37)\quad m_t = k_1^{-1}(-w_{1t}^* + w_{2t}^* + \lambda_t^*).$$

This policy has the desirable property that known fluctuations in the uncontrollables (λ_t) and in borrowed reserve demand ($k_2 r_t + w_{2t}$) are offset. But the policy is not optimal, unless by chance the optimal $c_3 = -k_2 < 0$. This is a possibility, but is not very likely, even if monetary control is the sole objective, because it gives full force to the reserve market disturbances w_{1t}^*, w_{2t}^*, and λ_t^*.

If $k_1 = 0$ (LRR), then a total reserve operating target results in an undefined money supply function. Yet many monetarists were calling for such a target, even without conditioning it on a return to CRR! If their advice had been taken, p, y, m, and r would have been indeterminate. This is a different kind of indeterminacy than nominal indeterminacy, because real variables would also be indeterminate, and because it does not depend on the nature of feedback. It must be admitted, however, that such an extreme policy would make some loopholes in the argument important. These loopholes relate to reserve carryover provisions, as of adjustments, and the timing of borrowing. These loopholes involve palliative actions by bank reserve management that "lean against" interest-rate movements. It seems clear that they can only mitigate and not eliminate the magnified interest rate and other instabilities arising from a poorly designed policy regime. As proof of this proposition, it suffices to consider that if the instabilities were completely eliminated by bank behavior, there would be no incentives for such actions by the banks.

Nonborrowed reserve operating target. A nonborrowed reserve operating

target would set:

$$(38)\quad E[(TR_t - BR_t) \mid I_t] = 0,$$

which requires $c_1 = -1$ and $c_2 = c_3 = 0$, or

$$(39)\quad S_t + \lambda_t = 0.$$

This is inefficient because it ignores known shifts in borrowed reserve demand (w_{2t}). The resulting money supply function is an upward-sloping (assuming $k_1 \neq 0$) and stochastic relation between m_t and r_t:

$$(40)\quad r_t = k_1 k_2^{-1} m_t + k_2^{-1}(w_{1t}^* - w_{2t} - w_{2t}^* - \lambda_t^*), \quad \text{for } k_2 \neq 0.$$

But if $k_1 = 0$ (LRR), the money supply function becomes a horizontal, yet still stochastic, relation:

$$(41)\quad r_t = k_2^{-1}(w_{1t}^* - w_{2t} - w_{2t}^* - \lambda_t^*). \quad \text{for } k_2 \neq 0.$$

Hence, under LRR, a nonborrowed reserve operating target is equivalent to a stochastic funds rate peg.

On the other hand, if CRR were in effect, and the discount rate were tied

to r_t, k_2 would equal zero, and the money supply function would be:

$$(42)\quad m_t = k_1^{-1}(-w_{1t}^* + w_{2t} + w_{2t}^* + \lambda_t^*),$$
$$\text{for } k_1 \neq 0.$$

This money supply function is vertical, but subject to greater stochastic influences than under the total reserve operating target, because known borrowed reserve demand shifts (w_{2t}) are ignored. If both k_2 and k_1 are zero (LRR and a tied, or penalty, discount rate), then prices, output, money, and the interest rate are indeterminate (their variance is indefinitely large).

Another feature of the nonborrowed reserve operating target is that it inefficiently ignores any information about excess reserve demand. Although the model assumes, for simplicity, that the Federal Reserve has no such information, in practice it often has.

Borrowed reserve target. A borrowed reserve target is equivalent to the condition:

$$(43)\quad k_2 r_t + w_{2t} = 0.$$

By renormalizing this condition, we arrive at the money supply function:

$$(44)\quad r_t = -k_2^{-1} w_{2t},$$
$$\text{for } k_2 \neq 0.$$

This is equivalent to the special case of the "pure" funds rate rule with $b_2 = -k_2^{-1}$. This target is obviously inefficient, because it permits the funds rate to fluctuate in response to known disturbances in borrowed reserve demand. It also obviously does not "lean against" commodity market or

money demand disturbances to stabilize prices, output, or money. The borrowing target delivers a money supply function that is horizontal and stochastic--a "dirty" funds rate policy.

Under LRR, the borrowed reserve target is less inefficient than a nonborrowed reserve target. The borrowed reserve target, unlike the nonborrowed reserve target, insulates the money supply function from unobserved fluctuations in excess reserves, uncontrollable factors affecting reserve supply, and borrowed reserve demand. Under CRR, these advantages of a borrowing target must be weighed against the "leaning against" properties of the nonborrowed reserve target.

Free reserve operating target. A free reserve operating target is identical to a borrowed reserve target, in the (assumed) absence of any information about fluctuations in excess reserves. Hence, like a borrowing target, it is less inefficient than a nonborrowed reserve target under LRR, and may be more or less inefficient than a nonborrowed reserve target under CRR.

The October 1979 Regime Change

The regime change that occurred in October 1979 involved two major elements. First, the operating procedure shifted from a federal funds rate rule to a quantity-setting rule. Second, the nature of the feedback was fundamentally altered. Our model is best suited to analyze the former.

In terms of the instrument issue, the 1979 shift was highly

inappropriate. As shown above, the pure funds rate rule is optimal under lagged reserve requirements. The regime change altered the policy rule from:

(45) $r_t = 0$,

to

(46) $S_t + \lambda_t + w_{2t} = 0$,

where the latter reflects the attempt by the Federal Reserve to offset known changes in uncontrollables and borrowed reserve demand (Levin and Meek 1981). The money supply function then became:

(47) $r_t = k_2^{-1}(w_{1t}^* - w_{2t}^* - \lambda_t^*)$.

A comparison of equation (47) with equation (45) yields an immediate conclusion. The adoption of a quantity rule under LRR ushered in a regime that offered inferior potential control of money, relative to the funds rate regime and, in addition, increased the variance of innovations in interest rates. Empirically, the change in operating procedures was associated with at least a doubling of the coefficient of variation in the entire maturity spectrum of interest rates (Hoehn 1982). The standard deviation of monthly percentage growth rates in M1, adjusted for shifts to negotiable order of withdrawal (NOW) accounts, rose by about one-third (Hoehn 1983b), as shown in table 1.

A similar conclusion holds for the variances of innovations in output and the price level: they should have increased, regardless of the objective the

policy rule was intended to satisfy. That is because under LRR, the optimal value of c_3 is infinity for any objective function defined on the variances of y, p, m, and r. The reason can be explained quite simply: under LRR, the money supply function is horizontal. Macroeconomic events cannot affect the interest rate without delay, as they would under CRR. They do so under CRR (given a fixed open-market position) by, for example, raising the quantity of money, in turn raising the demand for reserves, and thus raising the funds rate. This link was delayed under LRR for two weeks, by which time appropriate feedback could be administered in any case. On the other hand, reserve market disturbances create fluctuations in the interest rate. The result is a money supply curve that is horizontal and therefore cannot "lean against" macro disturbances, yet the position of that curve is disturbed by the reserve market shocks. It would be unambiguously better, given that the money supply curve is horizontal, to fix the rate to prevent it from fluctuating unhelpfully in response to reserve market disturbances. This explains why the optimal combination policy has c_3 equal to infinity-- a pure rate-setting rule after all. This result obtains regard1ess of the objective function.

Some went so far as to argue that, under LRR, there was no money supply function at all. According to Porter, Lindsey, and Laufenberg (1975):

> ... under lagged reserve accounting, the textbook supply of demand deposits function does not exist: there is no independent avenue for reserve injections to affect the equilibrium level of deposits in the same week other than by operating through interest rates and deposit demand. Marshall's scissors has lost one of its blades (p. 4).
>
> ... no relation.. .exists.. .to relate the current week's demand deposits, nonborrowed reserves, and interest rates that is not dependent on the demand deposit function (p. 40).

Certainly it is true that, under LRR, the textbook money supply function does not exist, essentially because one cannot renormalize the reserve demand equation to express the current quantity of money as a function of the current level of reserves.[5] But the apparent suggestion is that under LRR, the money stock is strictly demand-determined. This is incorrect. The money demand function gives us a relation between the money stock and the interest rate, but is not sufficient to determine the quantity of money. If the interest rate is given by the horizontal money supply function of LRR, then money demand and supply jointly can determine the quantity. If the horizontal money supply function is affected by reserve market shocks, then the supply curve is doing as much cutting as the demand curve. In the model, the only case in which the money stock is strictly determined by either demand or supply occurs when the money supply curve is vertical, as in the case of CRR and a total reserve operating target. Then the money stock would be strictly supply-determined, and the rate would be determined by both supply and demand.

Laurent (1984) suggests that one need not suppose the existence of a money demand function at all to understand how the quantity of money is determined. Laurent's model has not been formalized, but appears to lack an adequate number of equations to determine equilibrium in the money market and the quantity of money. Inclusion of a money demand equation would complete the model. On the other hand, Kopecky (1984), in an exchange with Laurent, seems to propound the notion that the concept of money supply is not a useful analytical concept. His model is quite explicit, but his use of the concept of money demand seems confined to the determination of the currency-to-demand deposit and time deposit-to-demand deposit ratios in

familiar models such as that of Burger (1971), who considers his a "money supply" model! Indeed, there does not appear to be any fundamental difference between Kopecky's and Burger's models.

It must be confessed that, in a model in which the public can hold money in the form of currency and different deposits with different reserve requirement ratios, the distinction between demand and supply becomes problematic. If the model were expanded to incorporate this heterogeneity in money, the distinction drawn between demand and supply sectors would be blurred. However, qualitatively similar results could be derived. The inclusion of currency, coupled with lagged vault cash accounting, creates somewhat more troubling analytical problems. Neither of these issues seems critical to consider to understand the essential nature of equilibrium.

A source of confusion in the literature and financial press was the supposition that increased interest-rate volatility per se would be associated with more precise monetary control. Greater interest-rate volatility may be associated with tighter money control, yet simply increasing the volatility of the funds rate does not necessarily improve the control of money. Such a result depends on the nature of the interest-rate volatility. The increased range of movement in interest rates improves money control if it represents greater responses to deviations of money from its target path. But if the increased variability of interest rates is unrelated to money demand shifts, as in the case of a reserve market disturbance affecting the funds rate, then the increased variability worsens money control. A similar kind of argument against interest-rate volatility per se can be made if the objective is price or output stabilization. What the 1979 policy did, from the standpoint of the instrument issue, was simply to randomize funds rate innovations, rather than set up a mechanism for "leaning against" money demand or commodity market

disturbances.

It was possible to predict that the 1979 policy would be accompanied by a reduction in the elasticity of borrowed reserve demand, k_2, under given administrative guidelines for the discount window. As the variance of the funds rate increased, banks spread their limited borrowing privileges over a wider range of funds rates. A given rise in the funds rate (relative to the discount rate) led to less of an increase in borrowings. While this suggestion represents only an informal motivation for expecting a lower elasticity, a more rigorous analysis has been offered by Goodfriend (1983) that seems to imply the same result. Furthermore, empirical observation seems to suggest that the elasticity did decline (see charts 1, 2, and 3).

This kind of structural change worsened monetary control beyond what would have been expected from a fixed-parameter model. Given LRR, the only way excess supplies or demands for reserves due to reserve market disturbances could be eliminated (barring any elasticity in excess reserves) was by changes in borrowing induced by fluctuations in the funds rate. Just how far the funds rate must move to clear the market depended on the magnitude of k_2. As borrowed reserve demand becomes less elastic, the funds rate moves further. What also apparently happened was that the borrowed reserve demand's disturbance term increased in variance. These two structural changes are strongly suggested by the observed relation between borrowings and the spread between the funds rate and the discount rate. These changes in the structure of the model, brought about by the change in operating procedures, suggest that simulations based on fixed-parameter models that try to assess the impact of alternative instruments may lead to quantitatively quite inaccurate results. Work on the microfoundations of reserve demand behavior is another

field for research that would enable us to predict more accurately the effects of alternative operating procedures. However, it will be exceedingly' difficult to integrate fully such analysis into a complete structural probability model. We may have to resort to ad hoc "patchups," accounting as best we can for likely changes in parameters and variances.

One direct implication of this discussion is that, under LRR, any so-called reform of the discount window that reduced the magnitude of k_2 would not only destabilize p, y, and interest rates, but would also reduce monetary control. In fact, a regime in which k_2 were zero would lead to indeterminacy of p, y, m, and r. This is a different kind of indeterminacy than occurs under a funds rate peg without feedback, for not only are nominal magnitudes indeterminate, but so are real variables. The indeterminacy now results from the inability of any funds rate to clear the reserve market. Consequently, the money supply function is undefined. The discount window is the only safety valve for reserve market disturbances under LRR with a quantity-setting rule. A discount rate tied to the funds rate or closure of the window altogether would each constitute such a regime in which K_2 equaled zero. The monetarists should not have advocated such so-called reforms without predicating them on a return to CRR.

Walsh (1984) suggested that the increase in interest-rate volatility would also be associated with a decrease in the elasticity of money demand. Such a change would, it seems, reduce the control errors arising from reserve market disturbances and associated interest-rate changes. On the other hand, it would, given large self-reversing money demand function shifts, create further instability in interest rates, prices, and output. Hence, such a decline in the elasticity of money demand would probably be unhelpful, unless monetary

control were desired for its own sake.

Walsh's results, however, appear to depend critically on the absence in his model of a nonmoney asset with a positive and certain rate of return. This feature is crucial, because, in his model, money is essentially held for portfolio rather than transactions reasons. Furthermore, a decline in money demand elasticity was not empirically observed after 1979. While it would be surprising if the money demand function were entirely invariant with respect to policy, it is very difficult to model the demand for transactions media in a completely adequate analytical fashion, from first principles rather than starting from curves.

Although the October 1979 policy was not promising in terms of the instrument issue, its feedback properties were more promising. By using the level of nonborrowed reserves rather than the funds rate as the benchmark for feedback decisions from one reserve period to the next, feedback apparently allowed far less scope for base drift in the money stock. Hoehn (1983a) found evidence that the Federal Reserve's feedback implied a faster response of the funds rate to fluctuations in money growth. This result was anticipated in a timely and prescient article by Judd and Scadding (1979). Borrowed or free reserves also became more closely related to changes in money growth.

The overall assessment of the 1979 procedure, then, is that the Federal Reserve tried harder through stronger feedback to keep the money stock on its annual target path after initial money deviations took place, but the procedure permitted larger initial deviations to occur. It is hard to judge whether the new procedure was a net improvement, despite improved feedback. (Money and other variables became more unstable, but one can argue that other causes were at work.)

In any case, it is the role of economists to suggest better means of accomplishing given objectives, and there was much in the 1979 modus operandi to criticize on technical grounds. An important unanswered question about the 1979 procedure is whether appropriate feedback could have been delivered without adopting a regime that had extremely poor operating characteristics. To the extent that the Federal Open Market Committee (FOMC) tends to confuse instruments and targets in the way suggested by Judd and Scadding (1979), appropriate feedback depends on choosing an instrument that proxies for the target as closely as possible over cyclical and secular timeframes. But to the extent that the FOMC's continuing confusion merely reflects the continuing confusion among economists of the feedback and instrument issues, it will become possible to design and adopt policy regimes with appropriate feedback without the problems associated with the 1979 procedure, as economists come to make clearer distinctions.

Another critical issue is whether some types of feedback are really more appropriate than others, or in what sense they are more appropriate. In the formal model, the kind of (lagged) feedback is of consequence to neither output nor innovations in any endogenous variables. In more Keynesian models--for example, with multiperiod contracts as in Fischer (1977) or Taylor (1979)--the type of feedback will be important for output stabilization.

V. More Recent Operating Procedures and the Imposition of Partially Contemporaneous Reserve Requirements

The procedure in effect from the fall of 1982 until the institution of partially contemporaneous reserve requirements in February 1984 apparently

adopted borrowed reserves as the benchmark for feedback, but used nonborrowed reserves as the operating target. The nonborrowed reserve target implied that the criterion of open-market operations was:

$$(48) \quad S_t + \lambda_t = 0.$$

Under LRR, this resulted in money supply behavior that determined the rate according to:

$$(49) \quad r_t = k_2^{-1}(w_{1t}^* - w_{2t} - w_{2t}^* - \lambda_t^*),$$

which allows the funds rate to vary with reserve market shocks, but not in response to commodity market or money market shocks. This is another variant of the "dirty" funds rate peg.

When CRR was adopted, the Federal Reserve announced its intention to maintain unchanged operating procedures. But the anticipated uncertainty among banks regarding their reserve positions during the first few reserve periods was expected to increase both the level and the variance of excess reserves. It was appropriate to adopt a procedure for offsetting expected fluctuations in excess reserves. As shown in equations (43) and (44), a borrowed reserve operating target, as opposed to a nonborrowed reserve operating target, has this property. In addition, it automatically offsets any unexpected but observed or known current fluctuations in excess reserves. Hence, the anticipated problems of the transition to CRR may have prompted reconsideration of the nonborrowed reserve operating target. Apparently the Federal Reserve in fact moved to a borrowed reserve operating target after the

reimposition of CRR, even beyond the initial transition period. The properties of such a regime have been analyzed above: it is equivalent to a "dirty" funds rate rule, with the funds rate target dependent upon known disturbances in borrowed reserve demand. Obviously, since such a dependence is unhelpful, a pure funds rate rule would constitute a better operating procedure. But a comparison of equations (44) and (49) makes clear that the borrowed reserve target (under either LRR or CRR) is an improvement over the nonborrowed reserve target under LRR. And furthermore, the switch from a nonborrowed reserve to a borrowed reserve operating target as CRR was instituted may have been an improvement over maintenance of the nonborrowed reserve operating procedure. This contention will appear paradoxical, since it has been contended above that the October 1979 regime, which incorporated a nonborrowed reserve operating target, would have been improved upon by a reimposition of CRR.

To explore this paradox, it is useful to suppose the nonborrowed reserve operating target had been maintained as CRR was imposed. With CRR reinstituted, the same operating procedure would have implied an upward slope to the one-period money supply curve:

$$(50) \quad r_t = k_2^{-1}k_1 m_t + k_2^{-1}(w_{1t}^* - w_{2t} - w_{2t}^* - \lambda_t^*).$$

A clear implication is that the character or distribution of sources of interest-rate fluctuations would have been quite different than under LRR, despite continued employment of the nonborrowed reserve operating target. With this money supply sector, r is exposed to all the disturbances in the model, whereas it was exposed only to reserve market shocks before. The response of r to reserve market shocks will be muted, however, because in

addition to the safety valve of the window, the familiar textbook adjustment mechanism involving changes in required reserves also comes into play. Nevertheless, it seems likely that the overall effect on the variance of r would have been an increase. At least this would have been true if the only change had been to unlag reserve requirements.

One implication of the new upward slope in the money supply function would have been that the variance of one-period innovations in the money stock would have been reduced in this model, given a preponderance of money demand shocks relative to money supply shocks. And it might appear that, by giving money supply an upward slope, reintroduction of CRR would have brought an improvement, whether our objective were to stabilize p, y, or m, because r would lean against commodity market and money demand shifts. But there are at least three reasons for doubting this, as follows:

First, assuming borrowed reserves continued to serve as the benchmark for feedback from one period to the next, any response of r to macroeconomic disturbances would have been reversed in the subsequent reserve period. So reinstitution of CRR under the same operating procedures would essentially have just increased the range of self-reversing fluctuations in the funds rate. For example, a shift in aggregate demand, aggregate supply, or money demand, whether temporary or permanent, would have affected the rate only for the current reserve period (the rate would have had a memory of only one period) unless the borrowed reserve benchmark were systematically altered. In this context, the favorable conclusion derived from our model seems especially dependent on the exclusion of the current interest rate from the public's information set in forming inflation expectations. That exclusion is once again of no consequence if the price level fluctuates randomly around a stationary trend, but the assumption is quite implausible when borrowed

reserves are used as the benchmark for feedback adjustment to the nonborrowed reserve operating target. The trend-stationarity assumption would be more plausible if nonborrowed reserves or total reserves were used as the feedback benchmark, as in the 1979 procedure.

The consequences of relaxing the trend-stationarity assumption are impossible to establish with certainty. A conjecture is that the increase in self-reserving fluctuations would reduce the information content of the interest rate, and lead to greater instability in prices, output, and money.

Second, the recent change in reserve regulations did considerably more than simply unlag reserve requirements. It also doubled the reserve period, preserved a two-day lag, allowed expanded carryover privileges, changed the flow and timing of deposit and other information available to the policymaker, and so on. It is harder to assess the overall impact of all of these changes taken together. Reserve requirements (k_1) were also changed at the same time.

Goodfriend (1984a) notes that the two-day lag between computation and maintenance periods under the current system of so-called contemporaneous reserve requirements can, under certain open-market policies, completely eliminate the potential advantages of CRR. If the Federal Reserve stabilizes the funds rate or otherwise abandons its reserve targeting in the last two days of the maintenance periods, banks will engage in intertemporal arbitrage in the reserve market so that the funds rate will be determined strictly by banks' expectations of the Federal Reserve's funds rate target in these two days. An interesting implication is that if the Federal Reserve interpreted the funds rate's level in the first 12 days as conveying information from the market, and then stabilized the rate in some degree in the last 2 days, the

Federal Reserve would be engaging in self-deception. Rather than looking at the rest of the world through a window, the Federal Reserve would be seeing itself in a mirror--albeit a "funny-house" mirror. The reflection would be distorted by the market's inability to comprehend fully where the Federal Reserve's funds rate target is.

Third, the nonborrowed reserve operating target would probably have too much current-period response of interest rates to money movements, given the current economic environment. If income or price level stabilization is the objective, and if money demand is volatile and therefore serves as a poor proxy for the unobserved price and output level, exposing the interest rate to fluctuations caused by money demand shifts in the manner implied by current operating procedures might increase instability in p and y. Under LRR, funds rate innovations were unaffected by disturbances to aggregate demand and supply or money demand. Under CRR, funds rate innovations will reflect all such disturbances. The exposure to money demand disturbances is obviously unhelpful, although it cannot be avoided, if responses to aggregate demand and supply shocks are to be allowed. This writer's intuition is that the degree of responsiveness of the interest rate to the three shocks taken together will be too large relative to the optimal response. In other words, because money demand innovations are relatively large, the optimal combination policy will be one in which c_3 is very high--although finite, under CRR--so the interest rate should respond very little. The nonborrowed reserve operating target will allow too much one-period response.

The restoration of CRR has the effect of reducing the optimal value of c_3 from infinity to some finite number. Given the recent environment in which aggregate demand and supply shocks (essentially, inflation uncertainty) seemed small, and money demand uncertainty was great, the optimal value of c_3 was

probably very high. But in an environment of accelerating inflation, in which aggregate demand and supply disturbances are larger relative to money demand disturbances, c_3 should be lower. The restoration of CRR, together with the Monetary Control Act and reductions in the variance of float, reduces the optimal value of c_3 and will render a policy like that of 1979 more attractive in an environment of inflation uncertainty.

VI. Concluding Remarks on Recent Operating Procedures

This discussion has emphasized how theoretical analysis of operating procedures can be very misleading if it ignores regulatory and institutional factors. Casual empiricism can also lead one to the wrong conclusions, if the interactions of operating procedures, regulatory and institutional factors, and the scope and nature of feedback (both "discretionary" and "automatic") are overlooked. For example:

(1) The 1979 policy procedure was not a fair test of how well a reserve-based procedure can control money without excessive interest-rate volatility, because it was conducted without benefit of reforms since instituted. Those who concluded from the experience that a reserve-based policy cannot improve monetary control are ignoring the interaction of operating procedures and the regulatory and institutional factors.

(2) The recent switch to CRR under current operating procedures is not likely to result in any improvement in monetary control or stability of the macroeconomy. Undoubtedly, some will conclude that the switch to CRR is inconsequential. Once again, this conclusion would ignore the interaction between operating procedures and regulatory and institutional factors. A complete structural analysis of the type made here suggests that CRR can only

improve matters--the potential minimum variance of p, y, or m is strictly lower for the optimal combination policy under CRR than the minimum under LRR--except in the special case where the optimal policy is a pure rate-setting rule. In short, CRR improves the operating characteristics of optimally designed policy rules--perhaps not in a dramatic way, but in relation to benefits that are economy-wide--on a $3 trillion base--almost certainly greater than the few millions it costs.

Footnotes

1. Optimal control theorists of the Keynesian school had earlier employed the concept of the feedback rule. Unfortunately, their work apparently received limited attention in the economic profession at large, despite the high quality of analysis. Much of this work, as applied to monetary policy, took place in the Special Studies section of the Board of Governors' Division of Research and Statistics, under the mentoring of Peter Tinsley, John Kalchbrenner, and others. These analyses are, of course, subject to the well-known "Lucas critique." Nevertheless, they can be seen as quite prescient and provocative.

2. It was widely thought at the time that the invariance of the output path with respect to the feedback rule arose strictly from the particular kind of supply behavior Sargent and Wallace posited. It has more recently been recognized that this invariance result is sensitive to demand behavior. For the most lucid treatment of this point, see Canzoneri, Henderson, and Rogoff (1983).

3. The Sargent and Wallace supply function also generates essentially the same results with regard to the instrument issue as does supply behavior under Fischer (1977) or Taylor (1979) wage-contract models. This statement would not necessarily hold true, however, if private agents used current information sets in forming future price-level expectations as discussed in a subsequent section. These wage-contract models also have different optimal feedback characteristics and have been used to upset the policy ineffectiveness proposition.

4. Apparently, Hoehn (1979, 1983b) and McCallum and Hoehn (1982, 1983) performed the first such analysis for operating procedures in the context of a rational expectations model.

5. See Burger (1971) for an example of the textbook money supply function.

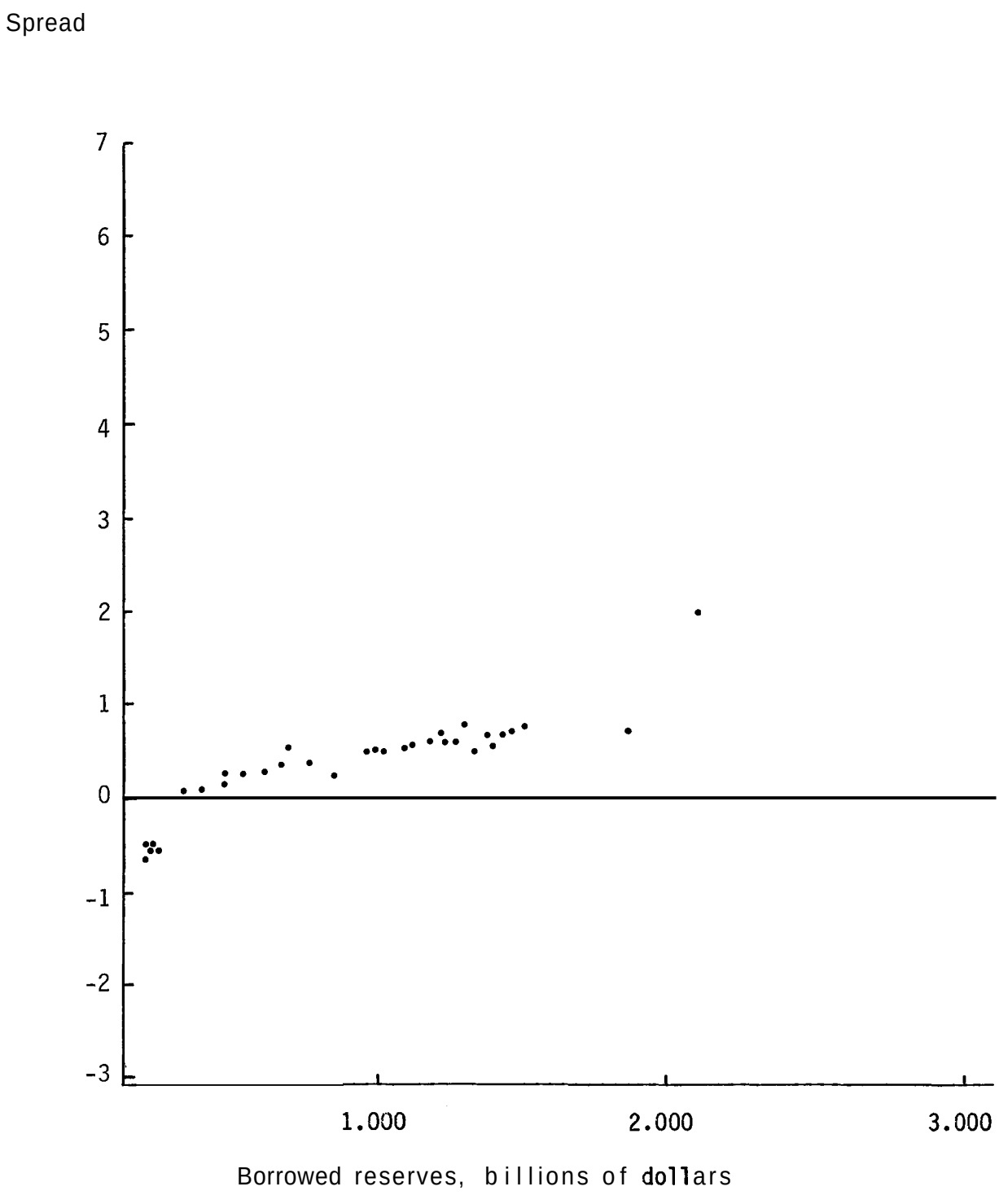
Table 1 Money Variability Under the 1979 Policy Procedure

Intra-year M1-B variability using original seasonal adjustment factors, in standard deviation of annualized percent growth rates

Fiscal year(s)	Monthly	Quarterly
1971-79 average	6.1	3.0
1979	7.6	3.8
1980	9.6	6.4
1981	8.9	5.5
1982	7.6	3.3

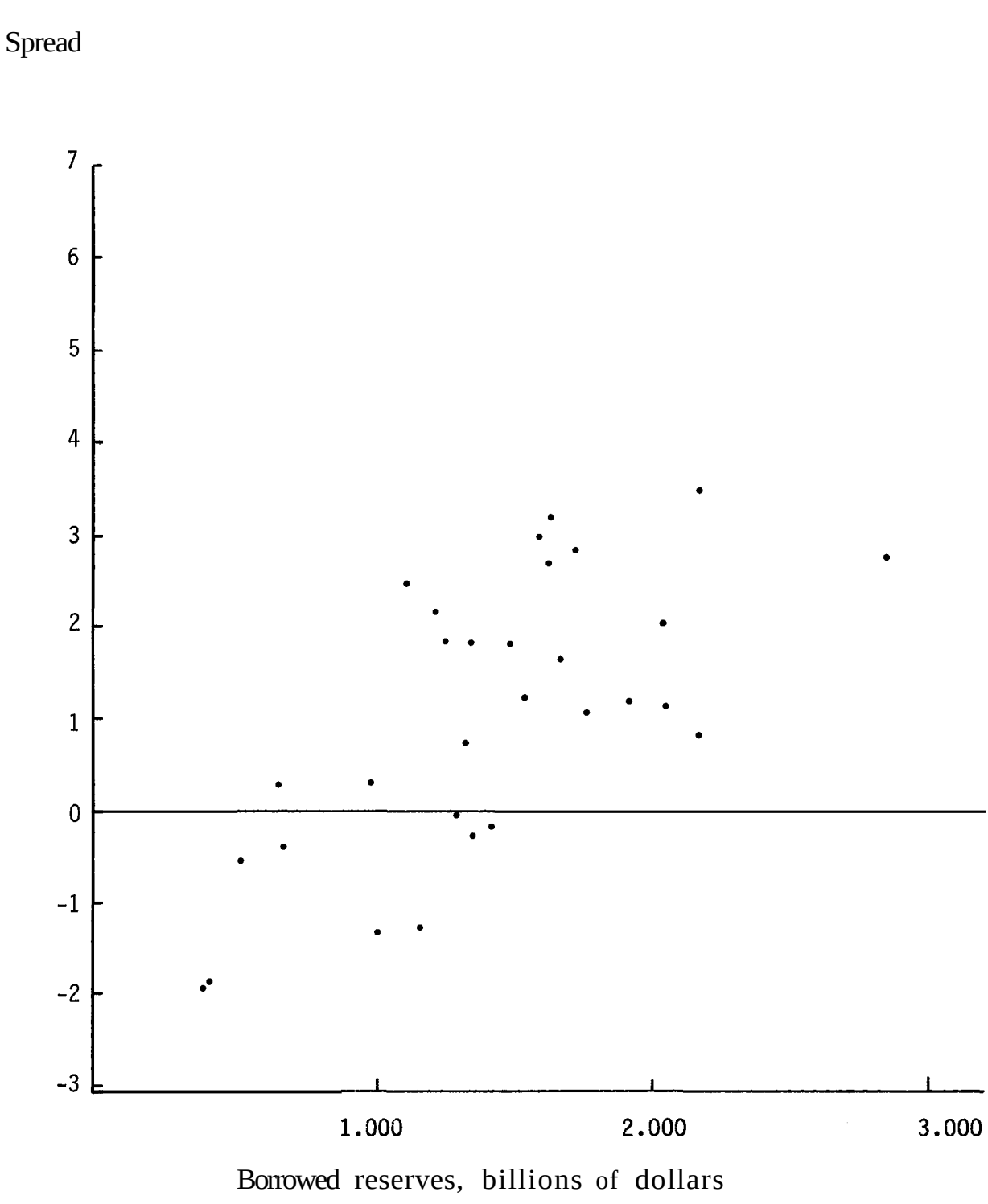
SOURCES: Lindsey et al., "Monetary Control Experience Under the New Operating Procedures, "New Monetary Control Procedures - Volume II, Federal Reserve Staff Study, Board of Governors of the Federal Reserve System, February 1981; Federal Reserve System, February 1981; Federal Reserve Statistical Releases H.6, dated November 30, 1981, April 23, 1982, October 29, 1982, and November 29. 1982: Board of Governors of the Federal Reserve System; and Annual statistical Digest, 1980, Board of Governors of the Federal Reserve System, table 13. p. 31.

Chart 1 Borrowed Reserve Demand: October 1976 to September 1979



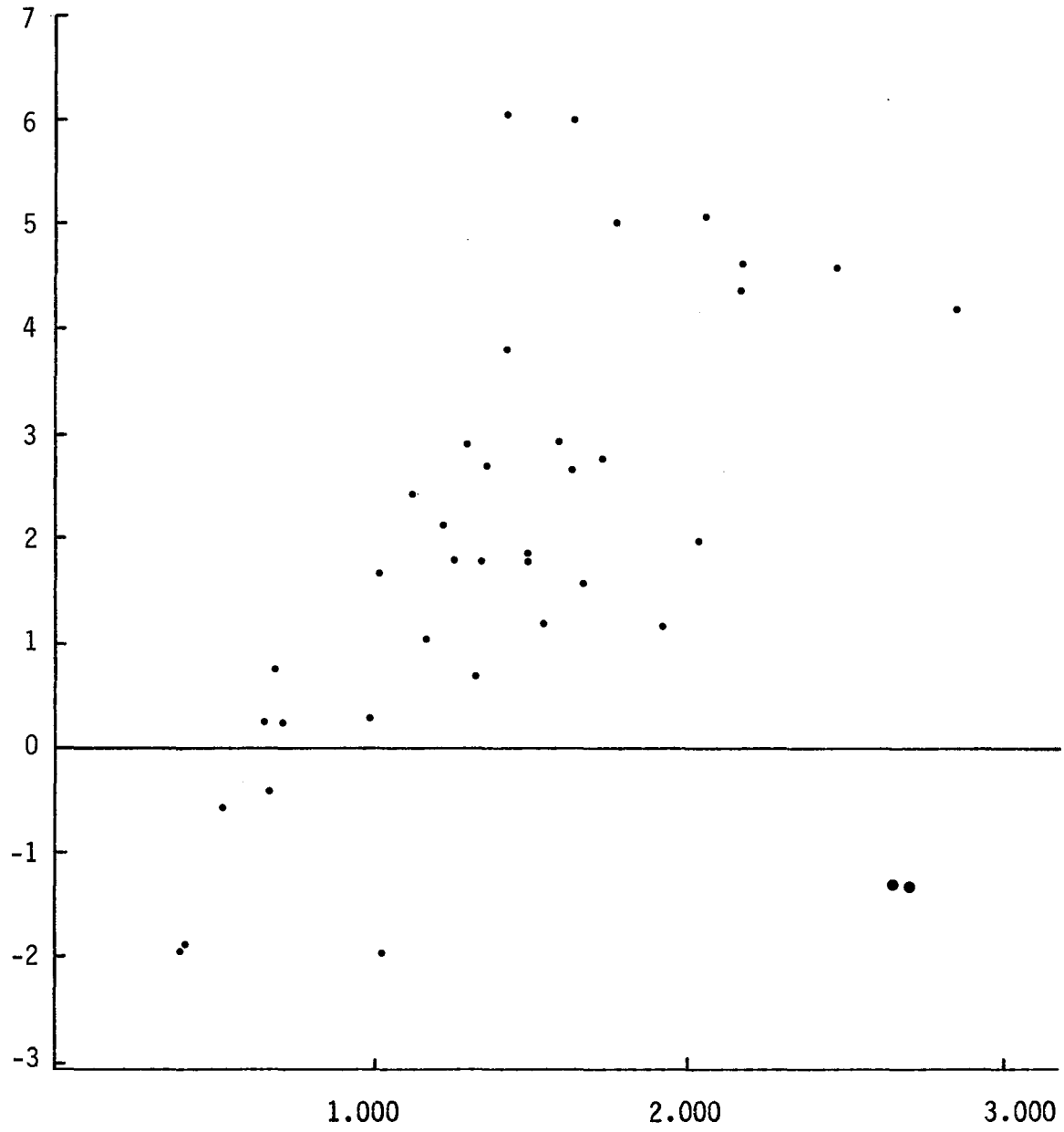
SOURCE: Board of Governors of the Federal Reserve System.

Chart 2 Borrowed Reserve Demand: October 1979 to September 1982



SOURCE: Board of Governors of the Federal Reserve System.

Chart 3 Borrowed Reserve Demand October 1979 to September 1982
Adjusted for Surcharge



SOURCE: Board of Governors of the Federal Reserve System.

References

Barro, Robert J. 1976. "Rational Expectations and the Role of Monetary Policy," Journal of Monetary Economics, vol. 2, no. 1 (January,) pp. 1-32.

Burger, Albert E. 1971. The Money Supply Process, Belmont, CA: Wadsworth Publishing Company, Inc.

Canzoneri, Matthew R., Dale W. Henderson, and Kenneth S. Rogoff. 1983. "The Information Content of the Interest Rate and Optimal Monetary Policy," Quarterly Journal of Economics, vol. 98, no. 4 (November), pp. 545-66.

Dotsey, Michael, and Robert G. King. 1983. "Monetary Instruments and Policy Rules in a Rational Expectations Environment," Journal of Monetary Economics, vol. 12, pp. 357-82.

Fischer, Stanley. 1977. "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule," Journal of Political Economy, vol. 85, no. 1 (February), pp. 191-205.

Friedman, Benjamin M. 1977. "The Inefficiency of Short-Run Monetary Targets," Brookings Papers on Economic Activity, No. 2, pp. 293-335.

_____. 1975. "Targets, Instruments, and Indicators of Monetary Policy," Journal of Monetary Economics, vol. 1, no. 4 (October), pp. 443-73.

Goodfriend, Marvin. 1984a. "The Promises and Pitfalls of Contemporaneous Reserve Requirements for the Implementation of Monetary Policy," Economic Review, Federal Reserve Bank of Richmond, vol. 70, no. 3 (May/June), pp. 3-12.

_____. 1984b. "Rational Expectations, Interest Rate Smoothing, and the—'Optimality' of a Non-Trend-Stationary Money Supply Rule," Working Paper Federal Reserve Bank of Richmond, (February).

_____, et al. 1983. "A Weekly Perfect Foresight Model of the Nonborrowed Reserve Operating Procedure," December 8, Unpublished manuscript.

_____. 1983. "Discount Window Borrowing, Monetary Policy, and the Post-October 6, 1979 Federal Reserve Operating Procedure," Journal of Monetary Economics, vol. 12, no. 3 (September), pp. 343-56.

Hoehn, James G. 1983a. "Recent Monetary Control Procedures and the Response of Interest Rates to Fluctuations in Money Growth," Federal Reserve Bank of Dallas Economic Review (September), pp. 1-10.

_____. 1983b. "The Monetary Instrument and Lagged Reserve Accounting," University of Virginia, Ph.D. dissertation (August).

_____. 1982. "Recent Interest Rate Behavior in Perspective: Some Descriptive Statistics," Working Paper No. 8301, Federal Reserve Bank of Dallas, (December).

_____. 1979. "The Choice of Optimal Monetary Policy Instrument: With Applications to Lagged Reserve Requirements and Rational Expectations," Paper prepared for Macro/Money Workshop, Economics Department of Pennsylvania State University (September 26).

Judd, John P., and John L. Scadding. 1979. "Conducting Effective Monetary Policy: The Role of Operating Instruments," Economic Review, Federal Reserve Bank of San Francisco, (Fall), pp. 23-31.

King, Robert G. 1983. "Interest Rates, Aggregate Information, and Monetary Policy," Journal of Monetary Economics, vol. 12, no. 2 (August), pp. 199-234.

Kopecky, Kenneth J. 1984. "Monetary Control under Reverse Lag and Contemporaneous Reserve Accounting: A Comparison," Journal of Money, Credit and Banking, vol. 16, no. 1 (February), pp. 87-92.

_____, Darrel W. Parke., and Richard D. Porter. 1983. "A Framework for Analyzing Money Stock Control under the Monetary Control Act," Journal of Economics and Business, 35 (June), pp. 139-57.

Laurent, Robert D. 1984. "A Reply," Journal of Money, Credit and Banking, vol. 16, no. 1 (February), pp. 89-92.

Levin, Fred J., and Paul Meek. 1981. "Implementing the New Operating Procedures: The View from the Trading Desk," Federal Reserve Staff Study - Volume II: New Monetary Control Procedures, Board of Governors of the Federal Reserve System (February), pp. 1-A5.

Lindsey, David, et. al. 1981. "Monetary Control Experience under the New Operating Procedures, "Federal Reserve Staff Study--Volume II: New Monetary Control Procedures, Board of Governors of the Federal Reserve System (February), pp. 1-102.

Lucas, Robert E. Jr. 1976. "Econometric Policy Evaluation: A Critique," Journal of Monetary Economics, Supplementary Series, vol. 1, pp. 19-46.

_____. 1973. "Some International Evidence On Output-Inflation Tradeoffs," American Economic Review, vol. 63, no. 3 (June), pp. 326-34.

McCallum, Bennett T. 1984. "Some Issues Concerning Interest Rate Pegging, Price Level Determinacy, and the Real Bills Doctrine," Working Paper No. 1294, National Bureau of Economic Research (March).

_____, and James G. Hoehn. 1983. "Instrument Choice for Money Stock Control with Contemporaneous and Lagged Reserve Requirements," Journal of Money, Credit and Banking, vol. 15, no. 1 (February), pp. 96-101.

_____. 1982. "Money Stock Control with Reserve and Interest Rate Instruments under Rational Expectations," National Bureau of Economic Research, Working Paper No. 893, (May).

_____. 1981. "Price Level Determinacy with an Interest Rate Policy Rule and Rational Expectaations," Journal of Monetary Economics, vol. 8, no. 3 (November), pp. 319–29.

_____. 1980. "Rational Expectations and Macroeconomic Stablization Policy: An Overview," Journal of Money, Credit and Banking, vol. 12, no. 4 (November, part 2), pp. 716–46.

_____, and John K. Whitaker, 1979. "The Effectiveness of Fiscal Feedback and Automatic Stabilizers under Rational Expectations," Journal of Monetary Economics, (April), pp. 171–86.

Nelson, Charles R., and Charles I. Plosser. 1982. "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications," Journal of Monetary Economics, vol. 10, no. 2 (September), pp. 139–62.

Phelps, Edmund S. 1967. "Phillips Curves, Expectations of Inflation, and Optimal Unemployment over Time," Economica, 34 (August), pp. 254–81.

Poole, William. 1970. "Optimal Choice of Monetary Policy Instruments in a Simple Macro Model," Quarterly Journal of Economics, vol. 84 (May), pp. 197–216.

Porter, Richard, David Lindsey, and Daniel Laufenberg. 1975. "Estimation and Simulation of Simple Equations Relating Reserve Aggregates and Monetary Aggregates," Unpublished manuscript, Board of Governors of the Federal Reserve System.

Sargent, Thomas J., and Neil Wallace. 1982. "The Real-Bills Doctrine versus the Quantity Theory: A Reconsideration," Journal of Political Economy, vol. 90, no. 6 (December), pp. 1212–36.

_____. 1975. " 'Rational' Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule," Journal of Political Economy, vol. 83, no. 2 (April), pp. 241–54.

Taylor, John B. 1979. "Staggered Wage Setting in a Macro Model," American Economic Review, vol. 69, no. 2 (May), pp. 108–13.

Wallich, Henry C. 1984. "Recent Techniques of Monetary Policy," Economic Review, Federal Reserve Bank of Kansas City (May), pp. 21–30.

Walsh, Carl E. 1984. "Interest Rate Volatility and Monetary Policy," Journal of Money, Credit and Banking, vol. 16, no. 2 (May), pp. 133–50.