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MONETARY AGGREGATES AS TARGETS: SOME THEORETICAL ASPECTS

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ABSTRACT

In the mid-1970s the Bank of Canada, along with a number of other central banks, began to set explicit targets for monetary growth and to emphasize the long-run role of monetary aggregates in controlling the rapid upward trend of prices.

There are three distinct ways of viewing and interpreting a policy of setting growth targets for monetary aggregates. The first is associated with the work of William Poole, the second is derived from the reduced-form model initially developed at the Federal Reserve Bank of St. Louis, and the third, which the author has labelled the feedback-rule approach, is related to the techniques developed within central banks to implement the policy of monetary targeting. In this paper the author sets forth the logic and examines the implications of these three methods when the principal aim of policy is reducing the rate of inflation. He also examines the question of gradualist versus "cold-shower" policies and the criteria for selecting a monetary aggregate as a policy target.

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1 INTRODUCTION

In the mid-1970s the Bank of Canada, along with a number of other central banks, began to set explicit targets for monetary growth and to emphasize the long-run role of monetary aggregates in controlling the rapid upward trend of prices. The central banks were responding in large measure to a change in the environment in which economic policies were being formulated. Whereas for most of the postwar period policy had been concerned with unemployment and stabilization of the cycle, events of the late 1960s and early 1970s had brought inflation to the fore as the main economic challenge. The change in policy thrust was backed up by a great deal of theoretical and empirical work that provided both the rationale for the new policies and the confidence that they could be applied in a sensible fashion.[1]

In examining the research underlying the policy of setting monetary targets one finds three distinct ways of viewing and interpreting the rationale of such a policy. The first is associated with the work of Poole, the second is derived from the reduced-form model initially developed at the Federal Reserve Bank of St. Louis, and the third, which I have

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1. For a discussion of the Canadian approach to policy in the 1970s see Freeman (1978), Bank of Canada (1975, 1976, 1977, 1978, 1979), Courchene (1976, 1977), and the symposium on monetary policy in Canada in the November 1979 issue of the Canadian Journal of Economics by Courchene, Fortin, Sparks and White (1979). A brief overview of the U.S. approach to policy can be found in Friedman (1977a).

labelled the feedback-rule approach, is related to the techniques developed within central banks to implement the policy of monetary targeting. In this paper I set forth the logic and examine the implications of each of the approaches when the principal aim of policy is reducing the rate of inflation. Although the issues discussed will reflect the kinds of problems that have arisen in Canada in the mid- to late-1970s, the focus of the analysis will be theoretical; I will not attempt to assess the actual events and policies of this period.

I begin in Section 2 with the simple IS-LM model of the static economy that underlies at least some of the academic discussion of a monetary aggregates policy. Although useful as an expository device for introducing the three ways of interpreting an aggregates policy, this model has very severe limitations in that it does not allow for the existence of inflation. In Section 3 of the paper I therefore extend the model to include an augmented Phillips curve and inflationary expectations. Although still relatively simple and easy to manipulate, the extended model is sufficiently rich to allow us to derive the implications for output, unemployment, inflation rates and interest rates of a policy of gradual deceleration over time of monetary growth. Both theory and the results of simulating various empirical models are used in the analysis to investigate the nature of the time paths that arise from such an anti-inflationary policy.

Next, this model is used to analyze the three different ways of interpreting monetary aggregates in the context of an inflationary setting. I also examine the question of gradualist versus "cold-shower" policies and, in Section 4, suggest criteria for selecting the appropriate monetary aggregate. Although the model and the discussion assume a closed economy, the extension to an open economy with flexible exchange rates will be referred to in passing and in footnotes.[2]

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2. The important operational question of whether the central bank uses base control or interest rate control as its mechanism for affecting the growth of the monetary aggregate will not be addressed in this paper. See Freedman (1981) for an analysis of some of the implications of using the monetary base or bank reserves to control a monetary aggregate.

2 MONETARY POLICY IN A SIMPLE NON-INFLATIONARY MODEL

To date, research on the use of monetary aggregate targets as control mechanisms has followed three main routes of inquiry. These can be termed the Poole approach, the reduced-form approach, and the feedback-rule approach. To analyze these approaches I use in this section a simple model without inflation; in the next section the same three approaches will be analyzed in the context of a somewhat more complex model with inflation.

2.1 The Model

Begin with the following standard IS-LM model of a non-inflationary economy:

$$\ln Y(t) = a(t) - bR(t) + u(t) \tag{1}$$

$$\ln M(t) = c - dR(t) + e\ln Y(t) + v(t). \tag{2}$$

All coefficients throughout the paper are postulated to be positive. Equation (1), the IS curve, relates nominal income (Y), which is equivalent to real output in a world without inflation, to government expenditure (included in a(t)), nominal interest rates (R) and a non-observable random variable term (u). A non-logarithmic equation of this type can easily be derived from a simple Keynesian-style model of commodity demand with a consumption function, an investment function (with investment inversely related to the interest rate) and an income equilibrium condition in which income equals the sum of consumption, investment, and government expenditure. Since there is no inflation in the model, no distinction needs to be made between nominal and real rates of interest in the determination of real output. Equation (2) equates the supply of money (M) with the demand for money, which is a function of income, interest rates and a non-observable random variable (v). The demand for money can be derived from either a transaction approach as analyzed originally by Baumol (1952) and Tobin (1956) or a choice-theoretic approach as exposited by Friedman (1959).[3]

Equations (1) and (2) are the structural equations of the IS-LM framework. If the exogenous variables of the system are money and government expenditure then the reduced-form equations express Y and R as functions of a and M.

$$\ln Y(t) = \frac{1}{d+be} [da(t) - bc + b\ln M(t) - bv(t) + du(t)] \quad (3)$$

$$R(t) = \frac{1}{d+be} [ea(t) + c - \ln M(t) + v(t) + eu(t)]. \quad (4)$$

Alternatively, if the exogenous variables are interest rates and government expenditures, then the reduced-form equations express Y and M as functions of a and R:

$$\ln Y(t) = a(t) - bR(t) + u(t) \quad (5)$$

$$\ln M(t) = c + ea(t) - (d+be)R(t) + eu(t) + v(t). \quad (6)$$

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3. For an up-to-date survey of money demand equations see Laidler (1977).

Before proceeding to analyze this static IS-LM system, I set out the equations for a system with an identical economic structure in which the effect on left-hand-side variables of a change in right-hand-side variables occurs with a distributed lag. This system will prove useful later in the analysis. The easiest way to represent and solve such a system is via the use of lag operator notation.[4] In this notation,

$$L^k X = X(t-k)$$

$$B(L)R = (B_0 L^0 + B_1 L^1 + B_2 L^2 + \ldots + B_n L^n)R$$

$$= B_0 R(t) + B_1 R(t-1) + B_2 R(t-2) + \ldots + B_n R(t-n).$$

The sum of the coefficients in the distributed lag is represented by

$$B(1) = B_0 1^0 + B_1 1^1 + B_2 1^2 + \ldots + B_n 1^n$$

$$= B_0 + B_1 + B_2 + \ldots + B_n.$$

Equations (1) and (2) can be rewritten with lags as equations (1') and (2').[5]

$$\ln Y = A(L)a - B(L)R + u \qquad (1')$$

$$\ln M = c - D(L)R + E(L)\ln Y + v \qquad (2')$$

The reduced-form equations in which M and a are treated as exogenous variables are shown in (3') and (4').

4. For a good discussion of lag operators see Griliches (1967).

5. For the sake of simplicity u and v are introduced without distributed lags.

$$\ln Y = \frac{1}{D(L)+B(L)E(L)} [D(L)A(L)a - B(L)c + B(L)\ln M - B(L)v + D(L)u] \quad (3')$$

$$R = \frac{1}{D(L)+B(L)E(L)} [E(L)A(L)a + c - \ln M + v + E(L)u]. \quad (4')$$

Finally, for purposes of future discussion I take the first difference of equation (3') and present it as equation (3").

$$\Delta\ln Y = \frac{1}{D(L)+B(L)E(L)} [D(L)A(L)\Delta a + B(L)\Delta\ln M - B(L)\Delta v + D(L)\Delta u]. \quad (3")$$

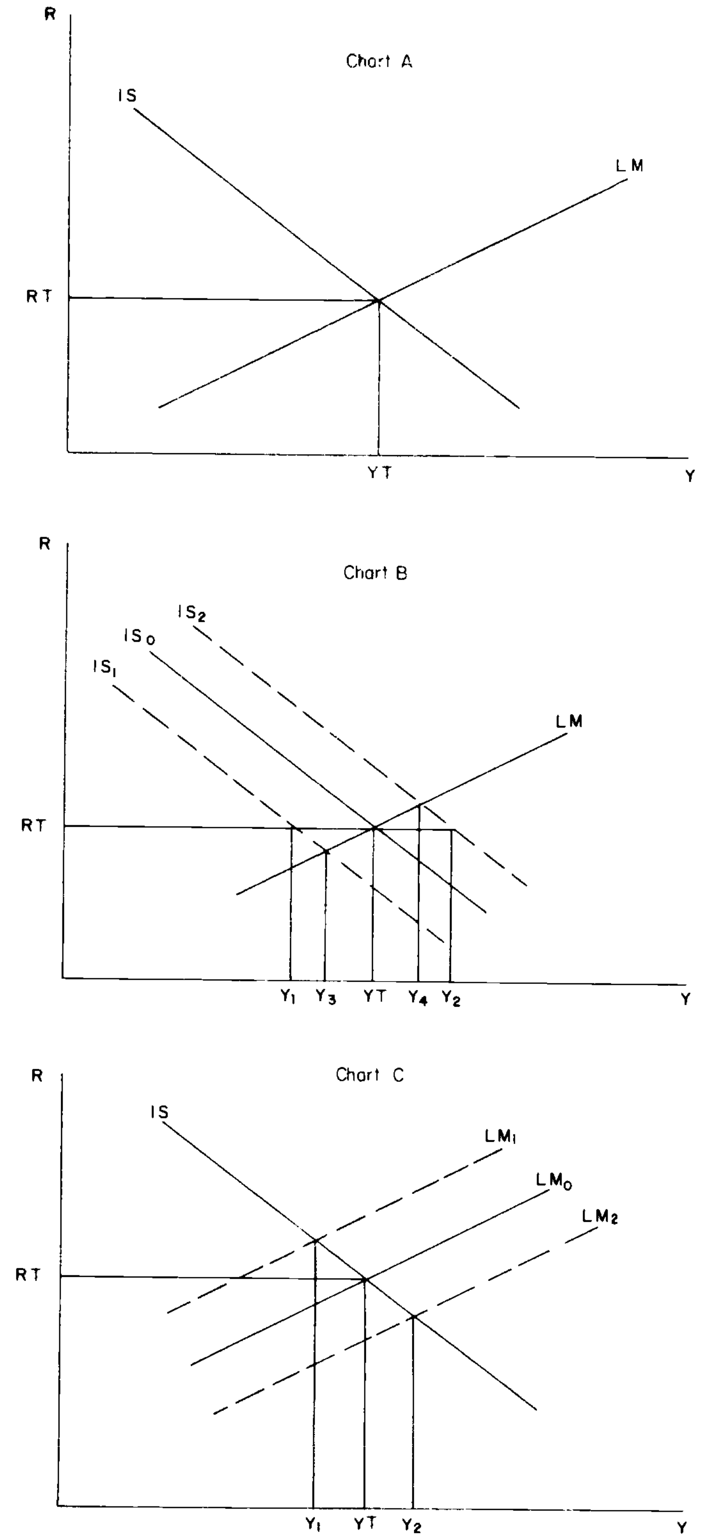
2.2 The Poole Approach

In a pair of pathbreaking articles, Poole (1970a, 1971) analyzed the question of whether the authorities should use the interest rate or the money supply as their instrument, given a target level of income, YT, and known parameters of equations (1) and (2).[6] It is easily shown that, if there were no random errors, then it would not matter in the least which one was used. As can be seen in Figure 1, Chart A, the appropriate setting of the interest rate (denoted as RT) is that which intersects the IS curve at YT; similarly the appropriate setting of the money supply is that which causes the LM curve to intersect the IS curve at YT.

6. For an analysis of policy setting when parameters are not known with certainty, see Brainard (1967).

Figure 1

POLICY INSTRUMENT: INTEREST RATE OR MONEY SUPPLY



However, when error terms are assumed to shift the IS curve and/or the LM curve in ways that cannot be directly observed, the choice of instrument will have substantive implications for the economy. This can be seen intuitively in the two polar cases usually focused on in this type of discussion.[7] In one the LM curve is stable ($v = 0$) and the IS curve shifts (Chart B); in the other the IS curve is stable ($u = 0$) and the LM curve shifts (Chart C). In Chart B the IS curve is assumed to shift between IS_1 and IS_2 and the LM curve is stable. If the authorities set R at RT, income will fluctuate between Y_1 and Y_2. On the other hand if M is set at MT (giving YT when IS is at its normal IS_0 position) then income will fluctuate only between Y_3 and Y_4. Obviously in this case the authorities should set M and let R fluctuate, and monetary policy will act as an automatic stabilizer of economic fluctuations.

Now suppose instead that, as the demand for money shifts, the LM curve fluctuates between LM_1 and LM_2 and the IS curve is stable. As shown in Chart C, setting the money supply at MT will lead to shifts in income between Y_1 and Y_2. If the authorities set the interest rate at RT, income will remain unchanged at YT regardless of the movements of the LM curve. Thus the intuition to be gained from Poole is that the authorities should use the money supply as an instrument

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7. See Poole (1970a, 1971) and LeRoy and Lindsey (1978).

if the IS curve is volatile and the LM curve is stable, and the interest rate as an instrument if the demand for money is volatile and the IS curve is stable.[8]

Poole extends the analysis to deal with the more general case in which both curves shift and their shifts can be positively or negatively correlated with each other. One can use equations (3) and (5) to calculate the variance of income around its target level when M or R are set at MT or RT to achieve YT for u = v = 0. Minimization of income variance, the criterion for choice between M and R as instrument, involves comparing expressions that contain the variance of u, the variance of v, and the covariance between them as well as the coefficients d, b, and e. The amount of information required to implement this approach is thus rather substantial since one has to know the size of error variances and covariances and the crucial structural parameters of the system. Further, if this knowledge is available, one can carry out short-run fine tuning in response to any known shift in any of the exogenous variables of the system. For example, if the aggregate expenditure curve shifted upward (upward shift in a(t)), this model indicates that M should be reduced so as to offset the increase in Y that would occur if policy

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8. If the demand for money were volatile in the very short run, say over a week, but quite stable over the longer run, say over six months, the analysis would imply emphasis on interest rates in the very short run and on the money supply in the longer run.

were left unchanged. Similarly in the extension to a system with lags, a change in an exogenous variable whose effect was expected to persist for more than one period would likely entail a series of offsetting changes over time in the policy instrument, whether M or R.[9]

This activist element in the formal Poole approach can also be interpreted in terms of the indicator or information role of financial variables in the absence of complete information.[10] Suppose, for example, that both the money supply numbers and interest rate data are available with virtually no lag but that GNP data are available with only a substantial lag. One cannot use equations (1) and (2) to deduce the values of u or v in the period in which they occur because the value of Y is not available. The problem then becomes one of trying to use the information contained in movements of the financial variables M and R, as well as

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9. Poole himself clearly points out the implied activist nature of his model in the section entitled "A Dynamic Model" in Poole (1970a). It is rather curious that his approach has become associated with the notion of a passive setting of the instruments of policy, a result that holds only in the simple static version of the theory. The other element of the Poole approach that has usually been neglected in later discussions is the "combination policy" in which the central bank in effect calculates a money supply rule that is generally superior to the constant R or the constant M policy discussed above.

10. A formal analysis of the problem that has been couched in these terms can be found in Kareken, Muench and Wallace (1973) and in Friedman (1975). For a simple diagrammatic analysis of the role of the information variable, see Mitchell (1980).

knowledge of past behavioural and stochastic relationships, in order to act in such a way as to minimize the variance of Y over time. Thus, in an economy with a volatile IS curve and a stable demand for money, an incipient increase in M will inform the observer that the IS curve has shifted to the right and hence that monetary policy should be tightened (R up or M down). On the other hand, in an economy with a stable IS curve and a volatile money demand, an incipient increase in M will indicate a random increase in money demand and hence will entail an increase in money supply (i.e., R constant). With both IS and LM curves volatile, knowledge of past variances and covariance of the error terms u and v will be needed to deduce the optimal policy that will minimize the variance of income.[11]

The literature deriving from the Poole approach has branched in two directions. The first deals with the question of whether the authorities should use reserves or interest rates as their instrument in aiming at the money supply intermediate target.[12] This has in turn led to an examination of the logic of a two-stage procedure in which,

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11. Note the implicit assumption in this analysis that there can be substantial deleterious effects on income from not adjusting the policy settings over the period in which the income data are unavailable. There exists research in Canada indicating that a less-than-optimal setting of the instruments for short periods of time has only relatively small effects on the economy. See Duguay and Jenkins (1978).

12. See Pierce and Thomson (1972).

say, interest rates are used to aim at money and money to aim at income (Friedman (1975, 1977a)), and of the general role of information in setting policy (Kareken, Muench, and Wallace (1973), Friedman (1975)).[13] The second extension has been to add an external sector to the model and examine the role of exchange rates in the analysis (Henderson (1979), Boyer (1978), Sparks (1979)). Since exchange rate data are also available with virtually no lag, one can treat the exchange rate as a possible intermediate target or as an information variable.

2.3 The Reduced-Form Approach

The second approach to monetary targeting is based on the reduced-form analysis of the effects of the money supply on income. Equations (1) and (2) can be solved to give Y as a function of M as shown above in equation (3). However, since the reduced-form model has empirically been implemented in terms of a distributed lag model, it makes more sense to derive it in terms of equations (1') and (2') that allow for lags. As shown in equation (3'), Y can be written as a distributed lag on M, u and v, and in a more general model on any shift in a(t) caused by, for example, changes in taxes,

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13. This strand of the literature has shifted the focus of attention away from the optimal instrument towards the question of how new information should be used. One conclusion of these articles is that all available information should be looked at in the setting of policy.

government expenditures, or exports.[14] If equation (3') is first-differenced, we have the more usual St. Louis type of equation with nominal income growth written as a function of the growth of money as shown in equation (3").

An equation such as (3') is sometimes used as the basis for the argument that if the growth of money is held stable then the growth of income will be stable.[15] The emphasis on the reduced-form equation (3') rather than on the structural equations (1') and (2') derives from the belief that it is much more difficult empirically to capture the IS curve directly than it is to capture it indirectly via equation (3').[16] The reasons for this belief range from the difficulty of finding appropriate measures for all the interest rates entering into the determination of consumption and investment to the possibility that money has a direct effect on expenditure that cannot be encompassed easily in an equation such as (1') but whose effect on income will show up in a reduced-form equation.[17] It is worth noting in

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14. The seminal article on reduced-form models is Anderson and Jordan (1968). For the application of such models to Canada see Duguay (1978).

15. In a non-inflationary, non-growth world the argument would be couched in terms of levels of money and levels of income.

16. One of the conditions necessary for equation (3") to fit well is that Δv be small relative to $\Delta \ln M$, i.e., that the demand for money be reasonably well defined.

17. In Section 3.3 I discuss some empirical problems related to the estimation of reduced-form models.

connection with this approach that if equation (3') or (3") were really well specified one could implement a countercyclical activist policy in which changes in money growth rates were used to offset exogenous shifts in expenditure and other shocks to the system.[18] Despite the inherent logic of this point, believers in reduced-form models tend to oppose the use of monetary policy for countercyclical purposes.

2.4 The Feedback-Rule Approach

In a third approach[19] to monetary targeting, interest rates are set on the basis of a tendency of money growth to diverge from its target growth path.[20] Thus if money incipiently grows faster than desired, the authorities will raise interest rates and this will push money back down to its

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18. See White (1978).

19. Although I treat the feedback rule as a separate approach, one might consider it as an offshoot of the Poole approach to policy in which attention is focused on the polar case in which, over the medium run, the LM curve is relatively stable and the IS curve is volatile. The principal additional elements in this approach are (a) the assumption that the authorities do not know the parameters of the IS curve and hence cannot implement an activist policy and (b) the attention paid to practical problems such as the means of avoiding instrument instability.

20. In the implementation of this approach, the authorities are likely to use a fan or band around the target growth path and change interest rates only when money moves outside the fan or the band. However, for expositional purposes I ignore the subtleties connected with the use of a fan or band.

target.[21] Conversely, when money incipiently grows more slowly than desired, the authorities will reduce interest rates and this will tend to raise money back to its target.

There are two variants of this approach. In the first and less interesting the authorities act to hold M equal to its target regardless of whether the source of the increase in money demand is a random shift in money demand or an undesired increase in income. In the second variant the authorities set target money growth equal to target income growth ($\Delta \ln YT$)[22] times the appropriate elasticity plus (less) any random increase (decrease) in money demanded that can be identified. Hence it is only undesired increases in income that give rise to interest rate changes.

In the simple static model described above, this approach can be formalized by setting money supply at its target level, MT, in equation (2), first-differencing, and transposing terms. This gives

$$\Delta R = \frac{1}{d} [e\Delta \ln Y + \Delta v - \Delta \ln MT]. \qquad (7)$$

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21. Note that there is no independent role for the money supply in this approach. The authorities use interest rate changes to move along the money demand curve and money demand is assumed always to equal money supply. In the very short run the authorities use the setting of excess cash reserves at the chartered banks to influence short-term interest rates. See Dingle, Sparks, and Walker (1972) and White and Poloz (1980) for a detailed discussion of the technique of setting excess cash reserves by the Bank of Canada.

22. This would be zero in a completely static model.

The formalization of the second variant of the policy rule discussed in the preceding paragraph is shown as equation (8).

$$\Delta \ln MT = e \Delta \ln YT + \Delta v. \tag{8}$$

Substituting (8) into (7) we have

$$\Delta R = \frac{e}{d} [\Delta \ln Y - \Delta \ln YT]. \tag{9}$$

Thus the money rule can be shown to be formally equivalent to a feedback rule on income growth. When income grows faster than desired, interest rates are increased and when income grows more slowly than desired, interest rates are decreased.[23] This policy can be treated as a form of

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23. Given the formal equivalence of a feedback rule on money growth and another on income growth, one might wonder why the authorities do not dispense with the intermediate money target and focus solely on a nominal income target. Indeed, this approach has been suggested by Tobin (1980). There are, however, good reasons for continuing to use an intermediate money target. In a world with lags the change in interest rates resulting from the movement of income away from its target will cause income to return to its target but only with a long lag. The same change in interest rates is likely to cause money to return to its target much more quickly especially if the intermediate target is a narrow monetary aggregate, because both the movement of income back to its target and, as a separate factor, the change in interest rates, act in the same direction on money growth. The argument has often been made that it is important, both from the standpoint of the credibility of the authorities and as a means of ensuring their accountability, to choose a target that can be achieved within a reasonable horizon. Money fulfils this role whereas nominal income does not. An additional factor in reducing the usefulness of nominal income as a target is the large revisions that have taken place over the years between the preliminary national accounts data and the final numbers.

proportional stabilization rule of the sort discussed by Phillips (1954) in his classic article. Note that for the policy to make sense one must assume that there exists an IS equation such as that depicted in equation (1) in which an increase in interest rates tends to reduce the demand for goods but that the authorities do not know the values of the parameters of this equation.[24] Hence the authorities do not have sufficient knowledge to carry out an activist countercyclical policy in the face of an exogenous shift in the demand for goods.

In implementing the feedback policy the authorities are continually faced with the question of whether an increase in actual money has been caused by an increase in Y (the data for which are unavailable because of the lag in producing the numbers) or by a random movement in the demand for money, v. In the first case interest rates should be raised; in the second, they should not be raised and the money supply target should be adjusted to accommodate the random movement. All available information, both real and financial, should be brought to bear in order to distinguish between the two hypotheses.

In the case of lags in the economic system, as depicted by equations (1') and (2'), there is a distinct possibility

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24. Similarly, the authorities either do not possess or do not believe in estimated reduced-form equations of the sort shown in equations (3') or (3").

that attempts to respond to increases in Y by forcing M back to target in the very short run will lead to substantial interest rate volatility and possibly to the explosive oscillation in interest rates that has been termed instrument instability (Holbrook (1972)). This can be shown by using (2'), the LM curve with lags, to solve for the feedback rule.

$$\Delta R = \frac{1}{d_0} [E(L)\Delta \ln Y + \Delta v - \Delta \ln MT - D^*(L)\Delta R]. \qquad (7')$$

Here d_0 is the lead coefficient in D(L), i.e., the coefficient on current R, and D*(L) is the rest of the distributed lag with d_0 omitted. The movement of R in response to an increase in income growth is thus determined by this nth order difference equation in ΔR. If d_0 is small relative to the coefficients in the rest of D(L), there is likely to be substantial volatility in interest rate movements when income starts to grow faster than desired.[25]

25. The pattern will also depend on the lag structure of E(L). Empirically the mean lag on income can be estimated to be smaller than the mean lag on interest rates. In these circumstances the assertion in the text about volatility will hold true. It is worth pointing out that the implied volatility in interest rates is the result of the lag structure of the money demand equation and not of the choice of interest rates rather than money as the instrument. If the authorities held money constant in the face of an increase in income the same interest rate pattern would result as that indicated by equation (7'). Diagrammatically, this can be shown by the movement of the short-run LM curve in response to past interest rate changes in the presence of long lags. See Meyer (1974).

The way out of this difficulty is to use interest rates to bring the money supply back to its target level, not each period (e.g., month) but at the end of a period of, say, six months (White (1976)). This will result in the money supply being away from its target for a period of time; however, the interest rates will always be acting in the direction of moving it back towards the target.

2.5 Summary

The above analysis of the three approaches to setting targets for monetary aggregates can be summarized as follows. The formal Poole approach and most of its offshoots require knowledge of the parameters and error variances and covariances of both the IS and LM curves. The approach focuses on the period when information on income is unavailable, indicates the way in which information can be used, and implies short-run fine tuning as information becomes available. The reduced-form approach requires knowledge of the reduced-form equation in which nominal income is a function of money but does not require knowledge of the underlying structural equations. Logically, it can be used to justify fine tuning in response to shifts in exogenous expenditures. The feedback-rule approach, which can be treated as an extension of one of the polar cases of the Poole approach, requires knowledge of the parameters of the LM curve but not the parameters of the IS curve. It gives the authorities a rule for changing interest rates as money moves away from target but requires a judgment as to whether the source of the change in money is a random shift in the demand curve for money or an increase in income. It does not entail an activist monetary policy since the information is not available to implement such a policy.

3 MONETARY POLICY IN A MODEL WITH INFLATION

In this section I examine the logic of a monetary aggregates target and the implications of implementing a policy of reducing the rate of growth of the monetary aggregate in a model of a world with inflation. The model used in this section of the paper, although still very simple, represents in a not unreasonable way the thinking of many mainstream economists about the inflationary process. Although the model reflects a closed economy, extension to an open economy is not difficult and will be discussed in footnotes.

3.1 The Model

The model has four equations: the income-expenditure relation (IS), the money market equilibrium (LM), the augmented Phillips curve with a natural rate interpretation, and the expectations-formation equation:

$$\ln Q = A(L)a - B(L)(R-(\Delta \ln P)^{e}) + u \tag{10}$$

$$\ln M = c - D(L)R + E(L)\ln Q + F(L)\ln P + v \tag{11}$$

$$\Delta \ln P = (\Delta \ln P)^{e} + G(L)(\ln Q-\ln QF) + w \tag{12}$$

$$(\Delta \ln P)^{e} = H(L)\Delta \ln P + z. \tag{13}$$

Equation (10) relates real output (Q) to the real interest rate defined as the nominal interest rate minus the expected rate of inflation.[26] In equation (11) the demand for money is a function of real output, the price level and the nominal interest rate. For both theoretical and empirical reasons, I assume F(1) = 1; i.e., in the long run a doubling of the price level leads to a doubling of the quantity of money demanded. In equation (12), the augmented Phillips curve,[27] the rate of inflation is equal to the expected rate of inflation plus a function of the difference between output and full-employment output (QF). This equation is equivalent to the usual relationship between inflation, unemployment, and expected inflation since ln(Q/QF) is linearly related to the difference between actual unemployment and the natural rate. In the way it has been specified, the equation implies a linear relation between unemployment and inflation whereas many empirical studies have found a non-linear relationship.[28] For analytical convenience I will use the linear formulation but will point out in passing the circumstances where the non-linearity would make a difference to the analysis. Finally, equation (13) relates the expected rate of

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26. In a more sophisticated model one might use a long-term interest rate in equation (10) and a short-term rate in equation (11).

27. Usually the Phillips curve is defined in terms of wages. If one assumes that prices are determined by marking up wages (or standard unit labour costs) one can easily derive equation (12) by solving out the wage Phillips curve and the mark-up equation.

28. See, for example, Freedman (1976).

inflation to past rates of inflation. This formulation rules out both rational expectations[29] and the possibility that the announcement of policy may have a direct effect on expectations.[30] In equation (13) it is assumed that $H(1) = 1$;[31] this assumption is necessary for the model to have long-run natural rate properties.[32]

Before I go on to analyze the properties of the above model, I present the reduced-form equations that can be derived from equations (10) to (13). The three that are needed for future analysis show the relationship between money supply growth and the rate of inflation, the rate of growth of output, and the growth of nominal income.

$$\Delta \ln P = [J(L)]^{-1} \left[\frac{B(L)}{D(L)} \Delta \ln M + A(L) \Delta a\right] + \text{error terms} \tag{14}$$

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29. See, however, Friedman (1979) for discussion of the possibility that truly rational expectations are really adaptive after all.

30. See footnote 41 for further discussion of this point.

31. Note, however, the arguments against this hypothesis in Sargent (1971).

32. A simple way of introducing the exchange rate into the above model is to postulate that the level of the exchange rate is a function of the level of prices in Canada vis-à-vis the level of prices in foreign countries, especially the United States, and of the differential in the real interest rate between Canada and foreign countries. A more realistic analysis of the determinants of the Canadian dollar can be found in Haas and Alexander (1979) or Freedman (1979).

where

$$J(L) = \frac{B(L)F(L)}{D(L)} + [\frac{1-H(L)}{G(L)} + \frac{B(L)E(L)(1-H(L))}{D(L)G(L)} - B(L)H(L)](1-L)$$

$$\Delta lnQ = (1-H(L))(1-L)[J(L)]^{-1}[\frac{B(L)}{D(L)}\Delta lnM + A(L)\Delta a] + \text{error terms} \quad (15)$$

$$\Delta lnY = \Delta lnP + \Delta lnQ$$
$$= (1+(1-H(L))(1-L))[J(L)]^{-1}[\frac{B(L)}{D(L)}\Delta lnM + A(L)\Delta a] + \text{error terms.} \quad (16)$$

Given that F(1) and H(1) are assumed to equal 1 the sum of the coefficients in J(L) can be calculated as $J(1) = \frac{B(1)}{D(1)}$. Hence in long-run equilibrium

$$\Delta lnP = \Delta lnM + \frac{D(1)}{B(1)}A(1)\Delta a$$

$$\Delta lnQ = 0$$

$$\Delta lnY = \Delta lnM + \frac{D(1)}{B(1)}A(1)\Delta a.$$

Thus in the long run the rate of inflation and the rate of growth of nominal income will be equal to the rate of growth of money. The role of the exogenous expenditure term, a, is easy to interpret in economic terms. Only if the real value of automonous expenditures rises continually can it have a permanent effect on inflation. But in a non-growth model with QF constant it is impossible to envisage such a situation occurring.

3.2 Effects of a Deceleration in Money Supply Growth

I begin the analysis of the above model by assuming that the economy is experiencing a persistently high rate of inflation (say 8 per cent) and that priority is given to bringing down the rate of inflation to a much lower rate (say 2 per cent). There are two main types of decelerationary paths that might be considered: (1) a gradual reduction in the targeted rate of growth of money (instrument gradualism); (2) a sharp reduction in the targeted rate of growth of money (instrument cold shower).[33] If the preferred policy is to be one of gradualism, it is also necessary to specify how gradual the policy is to be, i.e., how many years will be required to achieve the final target of 2 per cent growth in the money supply. The choice among the options will depend in large part on the movements of output, prices, and interest rates (also the exchange rate) that are expected to result from the policy implemented by the authorities. The movement of these variables is basically an empirical question and hence one must have recourse to empirical models in order to get some feel for the kinds of results that can be expected from different policies. I first examine the results of implementing a policy of gradual deceleration of the money

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33. One might also consider a gradual reduction in the rate of inflation (goal gradualism) and a sharp reduction in the rate of inflation (goal cold shower). See Poole (1970b) and Freedman (1978b) for a discussion of these concepts.

supply (instrument gradualism) in an economy of the sort depicted by structural equations (10) to (13), given plausible estimates of the coefficients and lag structures, and then turn briefly to the policy of a sharp reduction in the rate of growth of money.[34]

Suppose one starts from a growth rate of money of, say, 8 per cent, and reduces this growth rate by 1 percentage point per annum for six years until it reaches a rate of 2 per cent, consistent with the desired 2 per cent inflation. The results of such a deceleration are shown in Figure 2 for interest rates, price inflation, real output and nominal income growth.[35] Clearly gradualism in bringing down the instrument (money) leads to a cyclical pattern in all the endogenous variables of the system. Nonetheless, the underlying movement of all the nominal variables is downward; i.e., despite the cyclical nature of the outcome, there is a clear downward trend over time. The time paths portrayed in Figure 2 indicate, however, that a policy of instrument gradualism

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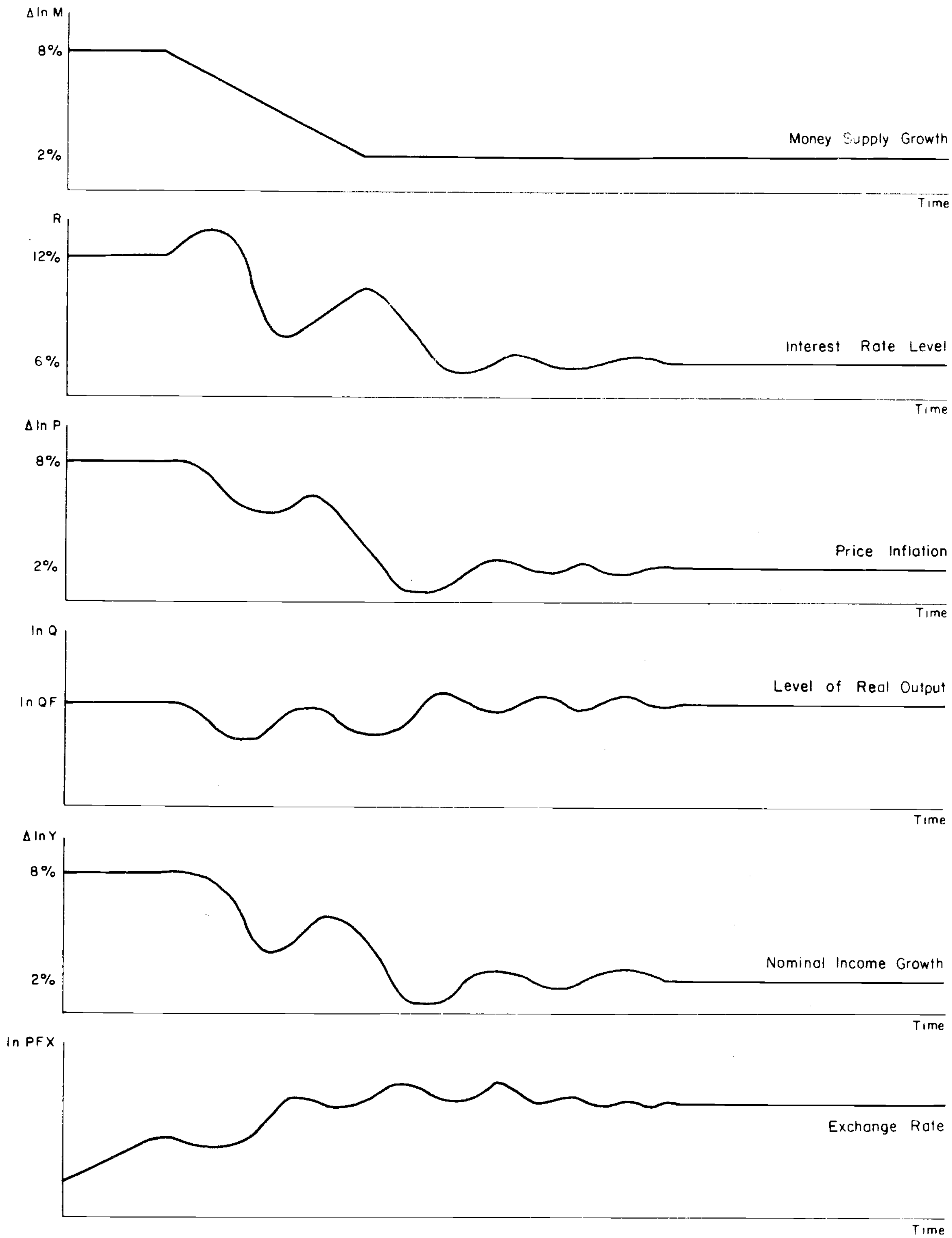
34. A somewhat more complex model with an external sector was developed in Freedman (1978a). This model, along with some others, was subjected to a policy of decelerating money supply growth in Freedman (1978b) and the results reported in that paper are the basis for the analysis of this section. A similar analysis using an even simpler model can be found in Tobin (1974). For a more recent exercise of this sort see Meyer and Rasche (1980).

35. I also graph lnPFX, the exchange rate, based on the equation sketched out in footnote 32. I assume that the foreign inflation rate is constant at 2 per cent throughout the entire period.

Figure 2

EFFECTS OF A GRADUAL REDUCTION IN MONEY SUPPLY GROWTH



requires patience since the decline in inflation rates is initially rather small and some time is required before the effects on inflation of the deceleration policy become sizable.

What are the economics underlying these results? Given the 8 per cent inflation rate, the decline in the rate of growth of the money supply initially leads to a rise in interest rates. With price inflation continuing at 8 per cent this rise in nominal rates also implies a rise in real rates of interest, which brings about a decline in real expenditure.[36] This in turn leads to a decline in output, an increase in unemployment above the natural rate, and a decrease in both wage and price inflation. The decrease in price inflation feeds gradually into expected inflation, putting further downward pressure on wage inflation, and so on. In the course of the downward movement nominal interest rates begin to fall after their initial rise; this occurs first as a result of the decline in real income and later as a result of the slowdown in the rate of price inflation. The

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36. For a large model such as RDX2, which has an external sector, the explanation can be expanded in a number of directions. The most important ones are the multifaceted effect of real interest rates on expenditure via real fixed investment, consumption, and housing, and the effect of a rise in interest rates on the exchange rate. The implied appreciation of the Canadian dollar leads to a reduction of the real current account balance, thereby accentuating the effects on real expenditure of the rise in interest rates and also has a direct downward effect on Canadian prices via its effect on the Canadian dollar prices of traded goods. See Freedman and Longworth (1975) for a detailed analysis of the monetary policy mechanism in RDX2.

interest rate finally settles at a new lower level that reflects the reduced rate of inflation. Thus the model gives rise to the three classic effects of a money supply decline on the nominal rate of interest as discussed, for example, by Friedman (1968): the liquidity effect (the initial rise in the nominal interest rate), the income effect (the subsequent decline as income falls) and the inflationary effect (to the new level consistent with the lower rate of inflation).

The existence of cycles on the downward path follows from the lags inherent in the system described in the structural equations (10) to (12) and those in the expectations formation equation (13). But what are the main determinants of the characteristics of the cycles resulting from the deceleration in the rate of growth of money? What determines peak unemployment rates and speeds of response of inflation and other variables? Experiments carried out with a relatively simple model that incorporates the characteristics of equations (10) to (13) but also has an international sector (Freedman (1978a)) indicate that the characteristics of the wage-price sector are the most significant elements in the development of the cyclical response of the economy.[37] The two crucial parameters are the size and speed of the response of prices to the product gap (or of wages to the unemployment

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37. The magnitude of the semi-elasticity of the demand for money with respect to the interest rate also plays a role in determining whether or not the model is stable.

gap) and the mean lag in expectations formation. The greater the response of inflation to economic slack and the shorter the mean lag on expectations formation, the smaller the peak unemployment rate associated with any given path of money supply deceleration. It is interesting to note that it is not so much the path of inflation that changes when coefficients are altered as the paths of real output and employment. These move in such a way as to bring about the price deceleration consistent with the deceleration of the rate of growth of the money supply.[38]

There is a further important characteristic of the decelerationary path that is worth stressing at this point. Since the nominal rate of interest will decline eventually in response to the decline in the rate of inflation, there will be an increase in the demand for real money balances. To satisfy this increase, the rate of price inflation must decelerate somewhat faster on average than the rate of nominal money supply growth. For example, consider a case in which the money supply growth rate was reduced 1 percentage point per year for six years (from 8 per cent to 2 per cent) and interest rates fell from 12 per cent to 6 per cent over this same period. If the semi-elasticity of demand for money

38. See Freedman (1978b) for the analysis summarized in this paragraph. The importance of the two coefficients is also emphasized in Freedman (1977).

with respect to interest rates (the coefficient d in equation (2)) was about 0.02,[39] real balances would have to rise by [(12-6) x 0.02] or 12 per cent over the period. To achieve this rise, the average rate of inflation would have to be 2 per cent less than the average rate of growth of the money supply over the six-year period. Since initially the growth of the money supply falls more than does price inflation (implying an initial fall in real money balances), at some later point in the cycle price inflation would have to be decelerating substantially faster than the money supply in order to permit the necessary growth of real money balances. Without such an "overshoot" of inflation rates, the amount of real money balances at the end of the six-year period of money supply deceleration would be lower than needed in long-run equilibrium. This insufficiency would result in higher interest rates and thus lead to the onset of secondary cycles despite the fact that the money growth rate had stopped declining. To prevent such a situation from arising, policy might allow for an increase in the level of money balances once and for all (but not in their rate of growth) in order to supply the economy with the real balances demanded at

39. This would correspond to an elasticity of 0.24 at 12 per cent interest rates and 0.12 at 6 per cent interest rates.

the new equilibrium lower rates of interest.[40]

The system of equations under discussion can also be used to compare the merits of instrument gradualism and instrument cold shower as a policy response to inflationary conditions. Because of the lags in the economic system, both types of policy give rise to cyclical movements in the key economic variables. But a cold-shower policy involving a sharp decline in the rate of growth of the money supply (say a permanent decline from 8 per cent to 2 per cent in one year) would lead to a much sharper initial cycle than that portrayed in Figure 2.[41] The far sharper initial increases in interest rates and unemployment rates that would result from such a policy might be considered a less desirable outcome than that

40. A detailed theoretical discussion of this point can be found in Freedman (1978c).

41. If the announcement of a cold-shower policy had direct effects on expectations this conclusion would be substantially modified. Fellner (1976, 1979) has enunciated the credibility hypothesis in which he argues that the expectations that enter into the decision making of the private sector can be strongly affected by the policy announced by the authorities, to the extent that the authorities have gained credibility by achieving previously announced targets. Fellner argues that estimated lags overstate the true lags in such a case and hence give an overly pessimistic picture of the difficulty in bringing down the rate of inflation. There may be some merit to the argument offered by Fellner although very little empirical evidence has been presented to support the approach. Lucas (1976) has also argued that estimated structural coefficients will change in response to a change in policy and that simulated time paths in response to policy shocks should take this into account, thereby modifying the conclusions. The practical importance of these points remains an open question.

achieved by a gradualist policy in spite of the more rapid decline in inflation.[42]

Furthermore, and perhaps more important, empirically wages and prices have generally been found to be more closely related to the reciprocal of the unemployment rate than to its level. This implies that the increase in the unemployment rate resulting from a sharp cold-shower decline in the rate of growth of the money supply would be larger than that implied by a cold-shower policy in a system with a linear Phillips curve. The reason for this result is that with a non-linear Phillips curve the extra deflationary effect on prices arising from a given increase in unemployment is less, the higher the unemployment rate; hence, to get an extra 1 percentage point decline in the rate of inflation requires a larger increase in the unemployment rate. Thus the argument against cold-shower policies, which rests on the resulting excessively large movements of interest rates and the unemployment rate (also the exchange rate), gains added strength if the Phillips curve is non-linear.

The principle underlying the choice of an appropriate period of time over which to implement a policy of

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42. A further element that is important in the real world but not in the model is the existence of long-term contracts. If many people have locked themselves into such contracts it will be more costly to bring down the rate of inflation very quickly. For example, long-term borrowers who are paying high nominal rates of interest would incur a substantial loss if the rate of inflation fell dramatically as a result of a cold-shower policy.

deceleration is not very different from that underlying the choice between instrument gradualism and instrument cold shower. The shorter the period chosen, i.e., the greater the rate of deceleration of the money supply, the sharper (at least initially) will be the movements of the interest rate and the unemployment rate (and also the exchange rate). On the other hand, the decline in the rate of price inflation will also be more rapid in the case of a more rapid rate of deceleration of the money supply. Views regarding the desired speed of deceleration would be based on judgments of the desirability of the implied paths of inflation, unemployment, etc., of the sort that have been presented above.

3.3 The Three Interpretations of a Money Supply Rule

In the light of the above discussion I now return to the three approaches to monetary targeting of Section 2 and analyze them in terms of implementing an anti-inflationary policy.

The Poole approach, which focuses on the short-run unobservable shifts in IS and LM curves, cannot deal with strategic problems such as the appropriate rate of deceleration of the money supply. It can help only in dealing with tactical problems that arise on the deceleration path, such as the use of money and interest rates as information variables that indicate the growth of nominal income in the period before the income data become available.

By way of contrast, both the reduced-form approach and the feedback-rule approach can be used to address the strategic questions that arise in the course of implementing an anti-inflationary monetary policy. In the reduced-form model (equations (14) to (16)) one solves for the growth of real output, inflation, and nominal income as distributed lags on past growth of the money supply as well as other variables. The estimated coefficients that appear in regressions based on these kinds of equations for Canada tend to imply relatively small output cycles and a fairly rapid decline in price inflation in response to a deceleration in the growth rate of money.[43] Given this result even cold-shower policies or a policy of very rapid deceleration of money can be justified in that the unemployment rate needed to put downward pressure on inflation rates is not very large. Moreover, virtually no secondary cycles appear in the simulation of reduced-form models, in contrast with simulation results from the system of structural equations.[44]

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43. See Anderson and Jordan (1968) and Duguay (1978) for standard reduced-form models explaining nominal income and Selden (1977) for an equation explaining the rate of inflation. See Freedman (1978b) for the paths of variables such as unemployment and inflation that arise from a deceleration of money in the Duguay model and in a simple reduced-form equation for inflation.

44. See Meyer and Rasche (1980) for a similar comparison of structural and reduced form models in the United States. Dewald (1980) finds substantially higher unemployment rates along the decelerationary path in his version of the St. Louis model.

The reduced-form type of analysis, however, does have two main drawbacks. First, there is a long literature on the empirical problems inherent in estimating the reduced-form model that at the very least suggests caution about the conclusions.[45] Second, the empirical results in virtually all estimated reduced-form models are inconsistent with the underlying building block of a stable demand-for-money function. This point is closely related to the argument made above that if the rate of growth of the money supply is reduced by one percentage point, not only does inflation eventually have to fall by one percentage point in the long run, but at some intermediate point the rate of inflation must temporarily fall by more than one percentage point to permit real money balances to rise by the amount needed to satisfy demand at the lower nominal interest rate in the new equilibrium. It can be shown[46] that for this result to occur, the coefficients on the distributed lag in the regressions of inflation and of nominal income growth on money growth must fulfil two conditions. The sum of the coefficients must be one, and the mean lag must be equal to the value of the semi-elasticity of the demand for money with respect to interest rates, i.e. -D(1). This in turn entails that a series of negative coefficients follow the positive

45. See, for example, Davis (1969), Friedman (1977b), Modigliani and Ando (1976), and Wurzburger (1978).

46. See Freedman (1978c).

coefficients in the distributed lag. Whether because of the empirical difficulty of finding such a pattern, or because of the tendency to truncate distributed lags too early, or because of the fact that it was not obvious to researchers that such negative coefficients are required for theoretical reasons, one does not typically find such patterns in the empirical literature. Hence the reduced-form models as estimated are not consistent with the standard demand-for-money equation and this throws some doubt on the usefulness of the results.

The feedback rule once again assumes that one can place more confidence in the estimates of the demand-for-money equation than in the empirical estimates of the other equations. It is further assumed that one believes firmly in the existence of the relationships expressed in equations (10), (12) and (13) without being confident of the magnitude of the coefficients and lags or the exact specification of the equations. Thus one can make statements with some degree of confidence about the long run--such as that a decelerating path for money will eventually reduce the rate of price inflation--without necessarily being clear in advance about the time paths of the variables that are of interest over the short to intermediate run.

The argument for gradualism in this context is in the main based on the view that knowledge about the detailed structure of the economy is rather limited. In implementing a policy of gradually reducing the rate of growth of the money supply, a relatively rapid decline in prices might be achieved with only a small decrease in output if the coefficients in G(L) were large and if the mean lags on G(L) and H(L) were small. The same policy would lead to a rather sharp decline in output and only slow progress initially on price inflation if these conditions did not hold. A reasonably cautious approach to policy would therefore suggest a fairly gradual deceleration with periodic reexamination of the results to see if the outcome is roughly consistent with one's prior beliefs about the non-monetary side of the economy. For example, if unemployment rose substantially more (less) than expected and inflation fell less (more) than expected this would imply, other things being equal, that the coefficients in G(L) and H(L) were less (more) favourable to a rapid decline in inflation than originally believed. This in turn would suggest a slower (faster) rate of deceleration of the money supply than originally intended or accepting higher (lower) amounts of economic slack than originally intended. The logic of a periodic retargeting rather than an initial announcement of the entire money supply path thus derives mainly from the uncertainty regarding the non-financial side of the economy and the need to take into account in setting policy any new information that becomes available regarding the response of the economy to the changes in financial variables brought about by the monetary deceleration.

4 SELECTION OF A MONETARY AGGREGATE

There has been much debate in the past five years over the question of which monetary aggregate the central bank ought to use for targeting purposes.[47] It is worth emphasizing that the criteria for choice differ according to the approach to monetary aggregates one is taking.

In the reduced-form approach, the preferred aggregate is the one whose movements best explain future movements in nominal income.[48] Duguay (1978) has shown that in the case of Canada M1 is the preferred measure from this point of view. If one adopts the feedback-rule approach to policy, then the best aggregate is the one that gives rise to the most desirable movements of output, interest rates, exchange rates, etc.[49] White (1979) has argued strongly that M1 is the preferred monetary aggregate from this standpoint also. The arguments for targeting on the narrow monetary aggregate in Canada are buttressed by the fact that M1 is at least as stable as the broader aggregates and less susceptible to shifts arising from unpredictable movements among financial

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47. See, for example, Courchene (1976, 1979) and White (1979).

48. It is also necessary to take account of the controllability of the money supply in choosing among the aggregates.

49. The notion of most desirable movements should take into account the desirability of avoiding the secondary cycles discussed in Section 3.2.

instruments. Furthermore, the broader monetary aggregates would return to a target path at about the same rate as would nominal income following a shock to spending because of their very low interest rate elasticity. In contrast, M1 would return to its target path much more quickly than income because of its relatively high interest rate elasticity. As discussed above,[50] the argument has often been made that this is a desirable characteristic for a monetary target from the standpoint of both the credibility and the accountability of the authorities.

Using the Poole approach in a simple static model, one can show that if the demand for money is perfectly stable the authorities should set policy in terms of the monetary aggregate that implies a vertical LM curve (i.e., that has zero interest rate elasticity of demand); in such a case shifts of the IS curve would not result in any change of income. It would thus appear that a broader aggregate ought to be preferred to M1. However, even in a simple static model, Poole has shown that if the demand-for-money equation has any stochastic error attached to it "a small amount of interest sensitivity is better than none" (Poole (1970a), page 206). Furthermore, once lags are added to the system one must be concerned with the nature of the resulting time paths of

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50. See footnote 23.

the endogenous variables. For example, if interest rates affect the real economy only with a one-period lag (i.e., the IS curve is vertical in the short run), then implementation of a money target using an aggregate with zero interest rate elasticity implies that no equilibrium exists in the short run. Even if the IS curve had a negative slope in the short run, adhering to a constant money supply target using an aggregate with zero interest rate elasticity might imply explosive oscillations in the interest rate if lagged interest rates had a substantially larger effect on real expenditure than did current interest rates.

The extension of the Poole approach to the question of the information content of different economic variables suggests that the authorities ought to pay most attention to the aggregate that yields the most information about current movements of income for which data are as yet not available. It does not follow, however, that targets should be set in terms of this or any other monetary aggregate (Friedman (1975)).

As White (1979) has pointed out, many criteria have been suggested as a basis of choice among monetary aggregates. The various criteria reflect differences in the approaches to policy. The choice of a monetary aggregate presupposes a priori selection of one of the approaches to policy as the preferred approach, or at least a weighting of the usefulness of the three approaches. Many of the arguments regarding the choice of a monetary aggregate are at cross purposes because the protagonists are implicitly or explicitly using different policy approaches as the basis for analysis.

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