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THE DEMAND FOR MONEY AND THE MONETARY POLICY PROCESS IN CANADA*

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Abstract

The authors address a number of issues associated with interpreting the dynamics of standard demand-for-money regressions, and provide some illustrative empirical estimates using data for Canada. This leads to a discussion of the potential roles that monetary aggregates generally, and the demand-for-money equation more specifically, might play in the process of monetary policy formulation.

Résumé

Les auteurs examinent plusieurs questions liées à l'interprétation de la dynamique des fonctions types de demande de monnaie et présentent en guise d'illustration quelques estimations dérivées de données canadiennes. Ils analysent ensuite les rôles que les agrégats monétaires en général et l'équation de demande de monnaie en particulier sont susceptibles de jouer dans la formulation de la politique monétaire.

1. INTRODUCTION

The demand for money is a much-studied topic, and proposing to do new work in the area demands some justification. Interpreted broadly, the present paper may be seen as part of a larger, continuing effort at the Bank of Canada to determine whether there is a useful role for monetary aggregates in policy formulation. The research agenda grew out of some of the difficulties experienced with monetary targeting in Canada from 1975 to 1981. During that period, the narrow monetary aggregate M1 was the centrepiece of Canadian monetary policy, but its usefulness was gradually eroded by problems with its predictability, until it was officially dropped as a target in 1982. At the time, most of the difficulties with M1 were rooted in financial innovation, as households and firms took advantage of new instruments offered by financial institutions.

As the difficulties with M1 grew, efforts were devoted to the search for another monetary aggregate which could play the roles that M1 played in the 1975-81 period. Given the nature of the shifts in the demand for M1, this research focussed on broader, more inclusive monetary aggregates, thus raising important aggregation issues. In this context, Cockerline and Murray (1981) broadened the set of monetary measures under consideration to include superlative indices of monetary services, constructed by weighting individual monetary components according to estimates of their relative liquidity. However, the results of that study suggested that superlative aggregation could not, by itself, lead the way to a monetary aggregate able to play the policy role formerly held by M1.

Despite continuous research on this problem during 1982-84, a simple money-demand equation with desirable properties, including temporal stability, proved elusive. One reason was that, although for certain monetary aggregates (notably M2) it was possible to explain the data passably well using standard money-demand equations, the dynamic properties of these equations seemed inconsistent with traditional theoretical priors to a much greater extent than had been the case for M1. It was finally concluded that none of the available monetary aggregates could adequately perform the rigorous role of policy target.

At this point, the research turned to an investigation of monetary aggregates in the less demanding role of policy guide, which is essentially that of a leading or contemporaneous indicator of economic developments (see Crow, 1988). This involved testing for the information content of alternative aggregates with respect to key macroeconomic variables such as nominal spending, real output and inflation. Preliminary work by Cockerline and Murray (1981) was extended to a much wider array of monetary and credit aggregates and to several more years of data, and a more extensive array of tests was applied. The results of this research were reported in Hostland, Poloz and Storer (1987), Milton (1988), Freedman and Longworth (1988) and Muller (1989). It was found that:

(1) the conventional summation monetary aggregates tend to outperform the superlative indices in terms of information content;

(2) M2+ growth is the best contemporaneous indicator of the growth of nominal spending;

(3) M2 growth is the best leading indicator of inflation (two quarters ahead);

(4) real M1 growth is the best leading indicator of real output growth (two quarters ahead);

(5) a composite model, combining real M1 growth and M2 growth, is the best leading indicator of nominal GDP (two quarters ahead);

(6) the estimated relationships have been reasonably stable over time.

A full description of the research on credit aggregates is outside the scope of this paper. However, we should note here that monetary and credit aggregates were found to contain independent information.

Unlike the situation under explicit monetary targeting, the less demanding role of a policy guide does not require fully articulated structural demand equations for the monetary aggregates in question. However, a satisfactory economic explanation for the behaviour of a variable over time can increase confidence in its use, even though that use may be informal and subject to qualification. Therefore, the demand for money remains an important area of research at the Bank of Canada. Not surprisingly, given that the demand for M1 has been extensively studied in the past and has continued to shift during the 1980s, and given the prominence of M2 and M2+ in the information content results, recent money-demand research at the Bank has focussed principally on the M2 family of monetary aggregates.

One of the most prominent issues addressed in this research has been the question of money-demand dynamics. Specifically, demand-for-money equations for broad aggregates typically have exceptionally low estimated speeds of adjustment. This finding is difficult to reconcile with observed behaviour of financial markets. Thus, recent research at the Bank has been directed at finding whether alternative approaches to dynamic modelling, or alternative interpretations of previously estimated dynamics, will allow a well-grounded structural explanation of monetary aggregate behaviour.

This paper examines a number of issues regarding the dynamics of estimated demand-for-money equations and draws on empirical evidence for Canada to inform that examination and to explore potential roles for monetary aggregates in the policy process. Section 2 examines various interpretations that can be attached to the dynamic aspects of standard demand-for-money regressions. Section 3 empirically examines these issues, among others, using data for Canada. Section 4 then considers the import of the foregoing for the formulation of monetary policy in general, and discusses more specifically the role played by monetary aggregates in the policy process in Canada. Section 5 offers some concluding remarks.

2. ALTERNATIVE INTERPRETATIONS OF DEMAND-FOR-MONEY REGRESSIONS

Although the empirical work of Section 3 examines a wider range of specification issues relevant to money demand in Canada and to the particular measure of money we chose to work with, in the present section we focus on theoretical aspects of a single issue relevant to all empirical work on money demand - the interpretation of dynamics. Empirical demand-for-money equations based on quarterly data all need some form of dynamic structure. One form which enjoys widespread use is:

$$(m - p) = a_0 + a_1 y + a_2 R + a_3 (m - p)_{-1} + e \tag{2.1}$$

where lower-case letters denote natural logarithms, m denotes nominal money balances, p the price level, y real income, R the nominal interest rate, the a's represent regression coefficients, e the regression residual, and the subscript $_{-1}$ denotes a one-period lag. The coefficient a_3 is generally found to be rather close to unity, especially for broader measures of money, implying a high level of persistence in the data. Equation (2.1) is actually a restricted form of a more general dynamic specification; however, it explains the data well for a number of countries and a number of different sample periods, and it will suffice for the purposes of this section. Implicit in (2.1) is the so-called long-run demand-for-money equation:

$$(m - p) = b_0 + b_1 y + b_2 R + u \qquad (2.2)$$

where $b_1 = a_1/(1-a_3)$ and $b_2 = a_2/(1-a_3)$. Although one can argue that (2.2) excludes potentially important explanatory variables, and different functional forms may be more appropriate for some data sets, these issues will be dealt with in the next section.

A variety of explanations for the form (2.1) have appeared in the demand-for-money literature, based both on non-behavioural or statistical factors and on economic theories of individual or institutional behaviour. We do not attempt to provide an exhaustive survey here, but rather highlight those which seem most relevant for our purposes.

Non-Behavioural Interpretations of Money-Demand Dynamics

A non-behavioural interpretation of equation (2.1) has been developed by Goodfriend (1985), who suggests that measurement error in the explanatory variables of money demand may produce spurious adjustment lags. The analysis is an extension of the well-known argument that the real current income variable in empirical money-demand equations measures the true scale variable, real wealth, with error (e.g. Feige, 1967). In Goodfriend's formulation, output and the interest rate are assumed to be proxies for the true variables determining money demand, and are presumed to be autocorrelated. Under these circumstances the least-squares error term will be correlated with the explanatory variables and therefore the parameter estimates will be biased. Also, even though the "true" demand-for-money equation is assumed to contain no dynamics, adding lagged real balances to the regression will tend to reduce the sum of squared residuals. This is because - since the true explanatory variables are assumed to be positively autocorrelated - adding a lagged dependent variable helps to offset the over- and under-predictions of money demand created by the bias in the income and interest rate coefficients. In effect, according to Goodfriend's story, without the lagged dependent variable the regression residual would be autocorrelated, and the variable simply "cleans up" the regression. As such, no structural interpretation should be given to the estimated parameter on the lagged dependent variable.

A similar argument to that made by Goodfriend could be made in the case where equation (2.2) excludes an important explanatory variable. It is well known that exclusion of a significant explanatory variable will lead to least-squares bias in the remaining coefficients, unless it happens to be orthogonal to the remaining explanatory variables. By the same reasoning, provided that the excluded variable was positively autocorrelated, a lagged dependent variable might spuriously help to explain the data. A structural change leading to a permanent shift in, say, the constant term of equation (2.2) is one obvious example. Those who have worked with regressions such as (2.1) are well aware that finding an additional significant explanatory variable often produces a faster "speed of adjustment" (a smaller value for a_3), which lends credence to this interpretation.

Microeconomic Theories of Money-Demand Dynamics

The literature contains a number of hypotheses which are intended to justify the form of (2.1), and which may be used to interpret the parameter estimates that are obtained. The most frequently cited microeconomic basis for (2.1) is the partial-adjustment hypothesis (e.g. Chow, 1966). According to this hypothesis there are costs of adjusting one's level of cash balances to their equilibrium level, once the latter has been disturbed. Thus, a change in one of the determinants of money demand causes agents to respond gradually, by a constant proportion of the gap between desired and actual real money balances in each period. As a result, observed holdings of real balances consist of a linear combination of desired balances and the previous period's level of real balances. In this story the "speed of adjustment" corresponds to $(1-a_3)$ in equation (2.1), hence the oft-heard criticism that the data imply an unrealistically slow speed of adjustment when the equation is interpreted in this way.

Some have argued that it is unrealistic to suppose that agents adjust gradually to changes in some of the variables affecting money demand but immediately to innovations in the price level. This has led to the nominal partial-adjustment hypothesis, where the gap between nominal desired and actual balances is closed gradually. This formulation is the same as (2.1) except that the lagged dependent variable takes the form $[m_{-1} - p]$. A similar functional form may also be derived by assuming that money demand depends on permanent or expected income, and that the agent updates his estimate thereof using an error-learning or adaptive mechanism. Applying a Koyck transformation to such a model results in a form like (2.1) with the addition of the term R_{-1}, which might easily be approximated by (2.1) in estimation. Detailed surveys of these and other models are provided in Laidler (1985).

An alternative branch of the literature uses aggregation stories to justify (2.1). For example, Barrett, Gray and Parkin (1975) assume that agents review their portfolios at different times and so aggregation produces the form of (2.1). In the context of a model of optimal portfolio behaviour, the authors suggest that in a given period a proportion $(1-a_3)$ of agents review their portfolios and adjust completely to any discrepancy between desired and actual positions. The remainder, equal to proportion a_3, leave their portfolios untouched. Assuming that cash balances are among their financial assets, one can suppose that aggregation across all agents, some of whom have adjusted completely and the remainder of whom have not adjusted at all, will produce an aggregate relation resembling equation (2.1). However, in this case, the parameter $(1-a_3)$ could no longer be interpreted as a speed of adjustment of an individual, although it might approximate the speed of adjustment of the economy as a whole.

An alternative justification based on aggregation has been offered by Smith (1986), who develops a dynamic Baumol-Tobin model of money demand using the Miller-Orr target-threshold model with lump-sum adjustment costs. In his model, net cash disbursements follow a diffusion process with a deterministic part and a stochastic part. As a result, cash balances this period are equal to cash balances the previous period, less the deterministic part of disbursements, plus the stochastic disbursement, provided that the upper and lower thresholds are not breached. This implies that when cash balances are between the lower and upper thresholds they follow a random walk with negative drift. However, in a given period there is a non-zero probability of reaching a threshold, in which case adjustment to target balances (intermediate between upper and lower thresholds) is full and immediate. Aggregation across agents and across time produces average cash-balance behaviour which is a linear combination of lagged balances (in proportion a_3, say) and of optimal target holdings (in proportion $1-a_3$). Thus, an equation such as (2.1) may fit the data; however, the proportion $(1-a_3)$ represents the fraction of agents that cross a threshold in a typical period. In this model the proportion $(1-a_3)$ is an endogenous variable depending on the mean and variance of net disbursements. Smith also shows that for "accumulators" (agents with positive drift rather than negative drift) the adjustment parameter depends on interest rates and the size of transfer costs.

Exogenous Money, Buffer Stocks and Simultaneity

It has been argued that various microeconomic theories leading to (2.1), while appearing to be reasonable descriptions of individual behaviour, cannot describe aggregate demand behaviour if the aggregate money stock is presumed to be exogenously given by the monetary authorities (Laidler, 1985, 110-113). If it can be assumed that the money stock is exogenous in this sense, whatever quantity of money exists must be held by someone, so the economy as a whole cannot adjust gradually to its preferred holdings of money balances. Consequently, by aggregating over individuals behaving according to one of the reasonable microeconomic stories outlined above, one obtains an unreasonable description of aggregate behaviour. As well, equations such as (2.1) imply implausible dynamic responses to monetary shocks under the assumption of exogenous money. In particular, an increase in money consistent with (2.1) causes the interest rate to jump initially beyond its long-run equilibrium value, behaviour which seems at odds with the notion of partial adjustment.

The empirical relevance of this argument, of course, hinges on the key assumption that the money stock is exogenous. For present purposes it is useful to distinguish between "logical exogeneity" and "econometric exogeneity." By "logically exogenous" we mean a variable that can be controlled in a causal sense. Therefore, it is difficult to accept the notion of a logically exogenous supply of money whenever the measure of money under consideration includes an "inside" component that is determined by the interaction between decisions of financial institutions and the private sector. Most monetary aggregates for which demand equations have been estimated fall into this category. In contrast, the concept of "econometric exogeneity," which corresponds to the "weak exogeneity" condition defined by Engle, Hendry and Richard (1983), refers to the relationship between a set of parameters and the explanatory variables in the equation. A set of parameters can be considered "econometrically exogenous" with respect to the explanatory variables in a regression if there is no significant simultaneity bias. Although logical exogeneity probably can be ruled out for most monetary aggregates, theories based on logically exogenous money might nevertheless provide useful insights into empirical work on money demand. This is because it is possible for the measured money stock to be determined simultaneously with other variables in the money-demand function, and therefore for the explanatory variables to be correlated with the equation's error term. This possibility might arise in periods when the money stock represents a policy objective for the monetary authorities, in which case its behaviour over time could approximate that of a predetermined variable. Such behaviour on the part of the monetary authorities, if sufficiently rigorously implemented, could therefore produce a time path for the money supply with econometric implications similar to those predicted by theories based on a logically exogenous money assumption. The empirical relevance of the resulting simultaneity would depend on the degree of control exercised by the authorities over the monetary aggregate in question. This idea is developed more fully below.

(1) Exogenous money and sticky prices

Laidler (1988) has developed a theory with exogenous money which results in an equation for real balances resembling (2.1). Laidler's model is based on a simple, new-classical framework, in which the standard assumption that agents do not have contemporaneous access to information about the general price level is replaced by a price-stickiness story. Specifically, Laidler supposes that the economy consists of two types of firms: "fix-price" firms, which set their prices for this period at the end of the previous period, and therefore adjust to demand fluctuations in the current period by changing output, and not prices; and "flex-price" firms, which can vary both price and output in the current period. In this economy an unexpected increase in the money supply will lead to higher prices in the case of flex-price firms, but to more output in the case of fix-price firms. Hence prices will rise by less than one for one with the money supply, and real balances will rise. In Laidler's model the solution for real money balances can be written with a lagged dependent variable. This is because the solution for real balances is a combination of those for nominal money and the price level, with the latter adjusting slowly in response to monetary shocks.

(2) Buffer-stock money

Closely related to this theory is the so-called buffer-stock literature (see Laidler, 1984). In the buffer-stock story, when there is an exogenous increase in the money supply, agents do not immediately attempt to unload the excess money but rather allow above-desired levels of cash balances to accumulate in a "buffer" and then work them off gradually.[1] The buffer-stock

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[1] It is important not to confuse the buffer-stock view of money demand with standard theories of the precautionary demand for money. In the latter, agents are seen as holding a cushion of transactions balances in addition to their anticipated needs as a contingency against unforeseen expenditures. In contrast, the buffer-stock literature is concerned with unexpected movements in the aggregate money supply which are absorbed by individuals, in some sense unwillingly, until they decide what to do in response.

literature attempts to reconcile equations like (2.1) with an exogenous money supply by adding a term representing the "money surprise" in each period:

$$(m - p) = a_0 + a_1y + a_2R + a_3(m - p)_{-1} + a_4(m - m^e) + e' \qquad (2.3)$$

where $(m - m^e)$ represents the unexpected addition to the money stock. The empirical buffer-stock literature is surveyed critically by Milbourne (1987, 1988). He notes that if m is interpreted as an endogenous variable then it will be correlated with e′, and there will be positive correlation between $(m - m^e)$ and e′ which must be dealt with during estimation. In the literature he surveyed, attempts to produce unbiased estimates of a_4 have generally been unable to reject the hypothesis that a_4=0. If one instead interprets m as exogenous, then equation (2.3) should be renormalized prior to estimation, but various attempts to do so have not generally been supported by the data either. Milbourne concludes on the basis of his survey that the buffer-stock notion cannot be tested in a single-equation framework, but rather should be tested in the context of a complete model.

A possible interpretation of the apparent failure of buffer-stock models to win substantial empirical support is that it is the result of the dichotomous way in which they have been tested. Specifically, by assuming that the money stock is either purely exogenous, or purely endogenous, when in fact the degree of simultaneity between money and the explanatory variables might vary over time, the tests that have been performed may have weak discriminatory power. In the following subsection we consider the implications of adopting an intermediate assumption concerning the determination of the measured money stock.

(3) Monetary policy and simultaneity

As suggested earlier, although logical exogeneity probably can be ruled out for most monetary aggregates, econometrically the behaviour of the aggregate will depend on how the monetary authorities behave towards it, or towards one or more of its components, and over what horizon. Typically, monetary targets have been expressed as a range of growth rates, and have been pursued using the rate of interest or bank reserves as the instrument of policy. Nevertheless, depending on the rigour with which the target is pursued in practice, on average there might be a significant feedback from movements in money to the arguments of the money-demand equation, and the strength of these feedbacks might be higher in some periods than in others. The potential implications for money-demand estimations may be illustrated in the following highly stylized model of a small open economy:

$$y = b_0 - b_1(R - p^e_{+1} + p) + b_2(s + p^* - p) + u_1 \qquad (2.4)$$

$$p = b_3(y - y^N) + p^e + u_2 \qquad (2.5)$$

$$m = p + b_4y - b_5R + u_3 \qquad (2.6)$$

$$R = R^* + (s^e_{+1} - s) + u_4 \qquad (2.7)$$

where: all variables are dated at the current period (t), except those bearing the subscript '+1', which denotes period (t+1);
lower-case letters denote logarithms;
y = real output, and superscript 'N' denotes its natural level;
p = domestic price level;
s = nominal domestic price of foreign exchange;
R = nominal domestic rate of interest;
m = domestic money stock;
$*$ denotes a foreign variable;
^{e} denotes a rational expectation taken in period t-1;
u_i= exogenous shocks.

Equation (2.4) is a standard open-economy IS equation, with real output related negatively to the real rate of interest and positively to the real domestic price of foreign exchange. Equation (2.5) is a Lucas aggregate supply function, which embodies the natural-rate hypothesis. Equation (2.6) is a semi-logarithmic demand-for-money equation, and equation (2.7) represents uncovered interest parity. Each equation contains a stochastic shock assumed to be independently normally distributed with a zero mean.

Closing the model requires that one specify the policy rule followed by the monetary authorities. For illustrative purposes the authorities are assumed to have targets for the money stock, (m^T), and the nominal exchange rate, (s^T), which are consistent with one another *ex ante* in the sense of the *ex ante* model solution that is implied. Divergences from these targets are weighted arbitrarily in using a policy-conditioning parameter; we can think of the authorities as targeting the money stock but being willing to deviate from that target (while staying within a target range) when the exchange rate deviates from its target, as follows:

$$m = m^T - b_6(s - s^T) + u_5 \qquad (2.8)$$

where u_5 is a stochastic error taken to proxy the degree of error associated with policymakers' control over the money supply. Implicit in this policy rule is the assumption that the period over which the money stock is measured is long enough to allow the authorities to react to movements in the exchange rate - which is observed continuously - and to have some influence on the average level of the money stock for that period. *A priori* it seems plausible that such feedback effects, which are recursive in real time, might appear to be contemporaneous in quarterly data. Thus, as the conditioning parameter b_6 tended towards zero, the behaviour of the money stock would become econometrically exogenous, and the exchange rate would become purely endogenous; as b_6 approached infinity, the exchange rate would become econometrically exogenous and the money stock would become a purely endogenous variable. For intermediate values of b_6, policy might be described as "conditional," and the behaviour of both the money supply and the exchange rate would be influenced by their respective targets.

In deriving the rational expectations solution, it is assumed that the exogenous variables of the model are expected to be constant, which implies that $p^e = p^e_{+1} = p^e_{+2}$, and so on. This results in some simplification of the solutions, which are expressed here as deviations from expected equilibrium values:

$$y = y^N + k(b_5+b_6)u_1 - k(b_1+b_2)(1+b_5+b_6)u_2 - k(b_1+b_2)(u_3 - u_5) + k(b_2b_5-b_1b_6)(R^* - R^{*e} + u_4) + kb_2(b_5+b_6)(p^* - p^{*e})$$

$$p = p^e + kb_3(b_5+b_6)u_1 + [1 - kb_3(b_1+b_2)(1+b_5+b_6)]u_2 - kb_3(b_1+b_2)(u_3 - u_5) + kb_3(b_2b_5-b_1b_6)(R^* - R^{*e} + u_4) + kb_3b_2(b_5+b_6)(p^* - p^{*e})$$

$$R = R^e + k(b_3+b_4)u_1 - (b_5+b_6)^{-1}[k(b_1+b_2)(1+b_5+b_6)(b_3+b_4) - 1]u_2 - (b_5+b_6)^{-1}[k(b_1+b_2)(b_3+b_4) - 1](u_3 - u_5) + (b_5+b_6)^{-1}[k(b_2b_5-b_1b_6)(b_3+b_4) + b_6](R^* - R^{*e} + u_4) + kb_2(b_3+b_4)(p^* - p^{*e}) \qquad (2.9)$$

where:

$$k = \{b_5+b_6+(b_1+b_2)[b_4 + b_3(1+b_5+b_6)]\}^{-1} > 0$$

From these solutions for y, p and R, it is immediately apparent that in a standard money-demand equation these variables will be correlated with the error term of the equation, u_3, unless it happens that u_3 and u_5 are perfectly offsetting. It is easily demonstrated that the correlation between the error term and explanatory variables of the estimated demand-for-money equation will rise as b_6 declines. That is, as the authorities attempt to control the money supply more closely and leave the exchange rate to be determined endogenously, the degree of simultaneous equations bias in standard least-squares estimates of the demand for money will rise.

One implication of this model is that the conventional least-squares estimates of the parameters of the demand-for-money equation will not be invariant to the orientation of monetary policy. Changes in the policy rule over time, proxied here by changes in b_6, will result in changes in the degree of simultaneity, and therefore in the amount of simultaneous equations bias that exists in a particular set of ordinary least-squares estimates, and hence lead to perceived shifts in the equation. This point was made first in Poloz (1980)[2] and later in Gordon (1984). Another implication is that, since the magnitude of simultaneity bias might vary over a particular estimation period, tests of its statistical significance over an entire sample period may lead to incorrect inferences as to its economic importance.

Notice also that the correlations between the money-demand residual and the arguments of the money-demand equation that result from the interaction

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[2] Although Poloz found that estimates of simultaneous equations bias in an equation for M1 for Canada followed an interesting pattern over time, the extent of the bias was found to be very small.

with the policy reaction function will have empirical implications similar to those of measurement error or omitted variables, as discussed above. If least-squares estimates of the parameters of equation (2.2) contain simultaneous equations bias, and output and/or interest rates exhibit positive autocorrelation, then by the same reasoning presented by Goodfriend (1985) we would expect a lagged dependent variable to be significant in a money-demand regression. Thus, the estimated "speed of adjustment" from simple equations like (2.1) can also be influenced by the orientation of monetary policy relevant to the estimation period.

As noted earlier, a key assumption of the buffer-stock money literature is that the money supply is logically exogenous. If this assumption were valid, based on the above analysis one would expect that parameter estimates of a standard demand-for-money equation would contain significant simultaneity bias. Thus, an indication of the potential empirical relevance of theories based on an assumed exogenous money supply can be obtained simply by testing for simultaneity bias in a standard demand-for-money equation. Two qualifications should be noted, however. First, the generality of the alternative hypothesis implicit in diagnostic tests for simultaneity produces statistics of relatively low power against specific alternatives. Thus, such tests cannot support inferences regarding the validity of specific buffer-stock models, the testing of which would require the development of a maintained hypothesis that suggested a specific role for buffer-stock money. In short, it would be possible to find, for the same data set, no simultaneity bias in a money-demand equation, yet evidence consistent with a particular buffer-stock model. Second, it is theoretically possible that an exogenous money-supply shock might, in the first period, affect buffer-stock holdings exclusively and that those buffer stocks would be worked off gradually in subsequent periods, in which case the error term and explanatory variables in a money-demand equation need not be contemporaneously correlated. In other words, it is theoretically possible for money to be logically exogenous while finding no evidence of simultaneity bias. We would discount this possibility in the context of a quarterly model, however, given the ease with which portfolios can be adjusted in modern financial systems.

In this paper our objective is to make inferences concerning the demand-for-money function, and tests of particular buffer-stock models are not undertaken. Under the maintained hypothesis that money is not logically exogenous, estimating the parameters of money demand requires that one take all possible precautions to avoid an omitted-variables problem and to correct for possible simultaneity bias; remaining persistence in the data must then be accepted for what it is. However, the above discussion implies that there will be several plausible interpretations of the estimated dynamics, both behavioural and non-behavioural. Thus, one probably should not reject a particular model on the grounds that it has an implausibly slow "speed of adjustment."

In the empirical work to follow we allow for a very general dynamic form and test for the presence of simultaneity as a matter of course. However, it is necessary to consider first a range of more fundamental specification questions so that a reasonable maintained hypothesis can be developed against which the simultaneity issue may be examined.

3. EMPIRICAL EVIDENCE: THE DEMAND FOR M2+ IN CANADA

Most previous empirical research on the demand for money in Canada has focussed on the narrow monetary aggregate M1, which consists of currency and demand deposits at banks. Prior to the late 1970s, equations modelling the demand for M1 were found to be reasonably well specified. However, a number of institutional developments beginning in the late 1970s and continuing into the 1980s have significantly affected the demand for M1. The introduction of new deposits has resulted in shifts between non-interest-bearing demand deposits included in M1 and interest-bearing, savings-type deposits outside M1. In addition, there has been an economization of cash balances as banks extended cash management facilities to smaller corporations. Given the ongoing nature of these shifts, the demand for M1 has been quite unstable, making it difficult to model over the recent period.[3] Although the gradual nature of these shifts has tended to preserve the indicator properties of the growth of M1, we chose not to deal with its demand function in this paper, except to use estimates of its parameters based on the 1970s as a standard for comparison.

The empirical work to follow focusses on the monetary aggregate M2+, which consists of M2 (M1 plus personal savings and personal fixed-term deposits, and non-personal notice deposits at chartered banks), plus deposits held at other, non-bank, financial institutions. M2+ is of particular interest for a number of reasons. First, as noted above, M2+ emerged from the work on alternative monetary indicators as having the strongest historical relationship

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[3] See Freedman (1983) and Boothe and Poloz (1988). Boothe and Poloz estimate that the cumulative downward shift in M1 amounted to about 40 per cent of the 1985Q4 stock of M1 between 1976 and the end of 1985.

with nominal spending. Second, M2+ internalizes many of the shifts due to financial innovation that affected M1, and those that are not internalized (specifically, the outright economization of transactions balances) represent a much smaller proportion of M2+ simply because it is a much larger aggregate. Third, M2+ internalizes the important margin of substitution between similar bank and non-bank deposits. These advantages bode well for the empirical performance of a demand equation for M2+.

One major difference between modelling M1 and M2 or M2+ is that the broader aggregates have a relatively higher proportion of savings-type rather than transactions-type deposits.[4] Consequently, the store-of-value motive for holding money will be relatively more important than the transactions motive in analyzing movements in broad aggregates. For this reason, we expect that modelling the demand for M2 or M2+ will involve different specification issues from those encountered in modelling the demand for M1.

In this section of the paper we discuss various specification issues encountered in modelling the demand for M2+. Our objectives are twofold. One objective is to identify which empirical issues are most important in modelling the demand for M2+. We present estimates of various M2+ equations to summarize some of the ongoing research at the Bank of Canada and compare these results to the previous research on the demand for M1. A second objective is to provide additional evidence relating to the dynamic issues discussed in the preceding section. The empirical work is based on quarterly data; definitions and sources

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4 For instance, the M1 component of M2 has declined from 37 per cent in 1968 to 18 per cent in 1988. Since a considerable part of M1 does not pay interest, another way of expressing this development is that the interest-bearing component of M2 has risen from about two-thirds to over four-fifths in the past two decades.

of the variables are provided in Appendix 1.

Modelling Strategy

A fairly eclectic modelling strategy is used to meet these objectives. A general-to-specific search procedure is applied throughout the analysis, beginning with several lags on each explanatory variable and testing down to obtain a number of reasonably well-specified alternative models for M2+. Rather than attempting to isolate one particular money-demand function, we focus on specification issues themselves. Given the importance of stationarity assumptions underlying the demand-for-money function and our inability to discriminate between alternative hypotheses on statistical grounds, we consider two approaches to modelling M2+. One approach, based on error correction, results in level specifications. The other approach, based on the unit root hypothesis, results in specifications in differenced form. We also examine alternative measures of the scale variable and the opportunity-cost variable in the equations. Various M2+ equations are then used to provide some insight into the empirical issues discussed in the previous section relating to measurement error, simultaneity bias and the estimated dynamics.

The analysis is conducted in the conventional framework using a long-run aggregate demand-for-money function represented by:

$$m - p = a_0 + a_y y + a_r R + a_c(csb - p) + e \qquad (3.1)$$

All variables except interest rates are measured in logarithms. In the long run, the demand for M2+ is assumed to be determined by the price level (p), the level of real income (y), a variable measuring the opportunity cost of holding money (R), the value of the outstanding stock of Canada Savings Bonds (csb), and e, a random disturbance term. The variable csb is intended to capture substitution between such bonds and personal savings and term deposits. CSBs are non-marketable securities issued by the federal government once a year at a fixed rate of return. Since CSBs can be redeemed before maturity without a penalty, they can be used as an option to hedge against future increases in interest rates. This option value makes it difficult to measure the relative rates of return on CSBs and deposits within M2+, and attempts to do so in previous empirical work have generally been unsuccessful. To circumvent this problem, we try to capture substitution between M2+ and CSBs directly, using the outstanding stock of CSBs. Equation (3.1) attributes a constant proportion of changes in CSBs to offsetting changes in deposits within M2+. Although including the stock of CSBs in the equation may involve introducing another element of simultaneity bias (since CSBs and other deposits may be determined jointly in a single portfolio allocation decision), this specification allows us to identify a highly significant CSB effect that is quite robust across alternative M2+ specifications.

As noted above, we consider two alternative approaches to modelling the stochastic process, e, underlying the demand for money. One approach assumes that e is a stationary process. This assumption implies that in the presence of stochastic shocks the model will converge to a long-run stock equilibrium represented by (3.1). An alternative approach assumes that e is a non-stationary stochastic process. This assumption introduces a unit root into the equation so that velocity is modelled as having a stochastic trend component. It is difficult to choose between these alternative models using available statistical techniques. Unit root tests with the data used here are unable to reject the unit root hypothesis. However, since these tests have been shown to have low power, we are unable to discriminate between the alternative hypotheses with a reasonable degree of confidence. For this reason, we prefer to conduct our analysis using both models as if there is a "near unit root" in the data.

The first approach corresponds to the notion of cointegration advanced by Engle and Granger (1987). The Granger Representation Theorem ensures that under the assumption that e is a stationary process there exists an error-correction model that is consistent with the cointegration vector represented by the long-run demand-for-money equation (3.1). To identify error-correction dynamics that can generate this stock equilibrium, we apply a specification search procedure in the context of an unrestricted autoregressive distributed lag (ADL) specification given by:

$$m = A(L)m_{-1} + B(L)p + C(L)y + D(L)R + E(L)csb + u \qquad (3.2)$$

where A(L), B(L), C(L), D(L) and E(L) represent lag operators.

The second approach corresponds to the unit root hypothesis. We can capture a dynamic adjustment mechanism consistent with generating equation (3.1), where e has a unit root, by using an ADL specification with variables expressed in growth-rate form:

$$\Delta m = A(L)\Delta m_{-1} + B(L)\Delta p + C(L)\Delta y + D(L)\Delta R + E(L)\Delta csb + v \qquad (3.3)$$

The random disturbance term, v, in the growth-rate equation is characterized as having a permanent effect on the level of M2+. The unit root process can be thought of as capturing permanent shifts in the demand for M2+ arising from stochastic technology shocks or, possibly, from an omitted trended variable that may be difficult to identify over the historical period.

Given the difficulty in discriminating between unit roots and "near unit roots," our interest is not primarily in determining whether the equation has a unit root. We are more interested in examining the importance of stationarity assumptions on the empirical properties of the money-demand equation. Recent advances in econometric theory suggest that violations of stationarity conditions can have serious implications for statistical inference. For example, equations specified in level form run the risk of producing spurious parameter estimates when the error term is non-stationary. On the other hand, if the cointegration hypothesis underlying level equations is valid, then equations specified in growth-rate form impose invalid restrictions on the data.

A number of M2+ equations were specified using a general-to-specific search procedure. This involved isolating parsimonious dynamic representations of equations (3.2) and (3.3) starting from the unrestricted level and growth-rate ADL specifications and testing down for optimal lag lengths. A single lag of the dependent variable was found to be highly significant in both the level and growth-rate specifications. This conveniently enables us to focus on the "speed-of-adjustment" parameter, equal to one minus the estimated coefficient on the lagged dependent variable, to summarize the dynamic adjustment of the equations. For convenience, in the discussion to follow we will continue to refer to this parameter as the "speed of adjustment," while bearing in mind that this interpretation is subject to the various qualifications raised in Section 2.

Preliminary work indicated that the scale variable was most informative in level and growth-rate equations with real income measured as final sales, which subtracts inventory movements from real GDP. The contemporaneous value and three lags of final sales were found to be statistically significant. Smoothness priors were imposed on the lag structure of final sales using a four-quarter moving average. This restriction simplified our presentation of the model and could not be rejected by the data. Lags of the price level were found to be statistically insignificant in level specifications, and lags of the inflation rate were found to be statistically insignificant in growth-rate specifications. Thus, in both classes of models, the dynamic adjustment of money in response to price shocks appears to be adequately captured by a geometric lag structure.

The opportunity-cost variable, R, was constructed using the yield on 90-day corporate paper (R90) as the substitute rate and the rate of return on savings deposits at banks (RSDB) as the own rate for interest-bearing deposits.[5] The interest rate differential, (R90-RSDB), was used to proxy the opportunity cost of interest-bearing deposits and R90 was used to proxy the opportunity cost of non-interest-bearing deposits. Both variables were included in the level and growth-rate specifications and freely estimated. The

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5 These choices reflect the results of previous work with the M2 and M2+ equations. We have examined other proxies of the own rate (such as the rate on 90-day fixed-term deposits) and RSDB has been found to have the best fit in M2+ equations.

specification search indicated that the contemporaneous values of R90 and (R90-RSDB) were most significant in level specifications, whereas the contemporaneous and lagged values were preferred in growth-rate specifications.

Modelling M2+ in the Pre-1981 Period

Earlier research has suggested that the relationship between M2+ and nominal spending changed in the 1980s relative to the 1970s. The velocity of M2+ exhibited a downward trend throughout the 1970s, rose sharply in 1982-84, and then resumed its downward trend from a higher level (see Figures 1 and 2 in Appendix 1). One interpretation of this development, supported by anecdotal evidence, is that there was a decline in intermediation in the early 1980s, as households and firms used liquid assets to reduce outstanding debts during this period.[6] To examine the importance of this velocity movement in the context of the demand for money, we first specified M2+ equations over the 1971Q1-80Q4 subperiod, before the sharp increase in interest rates in 1981, and then extended the analysis to the full sample period, 1971Q1-88Q4.

The general-to-specific search procedure applied to the M2+ equation over the pre-1981 subperiod resulted in the following error-correction model:

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[6] Although this interpretation is supported by anecdotal evidence, so far it has not been possible to demonstrate its relevance empirically. For example, McPhail and Caramazza (1989) included the spread between the five-year mortgage rate and the five-year term deposit rate at banks and at near-banks as proxies for the cost of intermediation in M2 and M2+ equations, without success.

M2+ Equation: OLS 1971Q1-80Q4

$$\Delta m2+ = \underset{(.258)}{-0.532} + \underset{(.035)}{0.119}\,[1.107p + \underset{(0.090)}{1.40}\, y^{a} + \underset{(.507)}{0.165}\, R90 \underset{(1.010)}{-0.460}\,(R90\text{-}RSDB) - m2+_{-1}]$$

$$\underset{(.023)}{-0.107}\,(csb - .881\, csb_{-1})$$

$$R^2 = 0.542 \quad SER = .453\% \quad DW = 1.76 \qquad (3.4)$$

Standard errors are given in parentheses. The scale variable, y^a, represents the smoothed final sales series referred to above. We chose to report the above error-correction parameterization of the model to focus on the long-run elasticities (given in square brackets) and on the speed-of-adjustment parameter (the coefficient in front of the square brackets). CSBs are constrained to have a permanent instantaneous effect on M2+. This restriction could not be rejected by the data. Long-run price homogeneity is imposed by constraining the long-run price elasticity to one minus the CSB elasticity. This ensures that real M2+ balances will be proportional to the outstanding stock of real CSBs in steady state. A likelihood ratio test indicates that the long-run price homogeneity restriction cannot be rejected (with a Marginal Significance Level (MSL) of 0.20).

It is useful to compare the estimates of the above M2+ equation to estimates of an equation for M1, obtained using an analogous specification search procedure:

M1 Equation: OLS 1971Q1-80Q4

$$\Delta m1 = \Delta p \underset{(.535)}{- 0.017} + \underset{(.047)}{0.198} [p_{-1} \underset{(.222)}{+ 0.849 y} - \underset{(0.920)}{3.390 R90} - \underset{(.041)}{0.084 SHIFT} - m1_{-1}]$$

$$R^2 = .471 \quad SER = 1.089\% \quad DW = 2.27 \qquad (3.5)$$

Equation (3.5) is simply a partial adjustment model for real M1 balances. SHIFT represents a dummy variable capturing a gradual shift in M1 demand beginning in 1976 due to financial innovation (see Freedman, 1983).

There are four differences worth noting between the estimated M1 and M2+ equations. First, the M2+ equation has a speed of adjustment of just over 10 per cent per quarter, about half that estimated for the M1 equation. Second, in the case of the M2+ equation the data support a nominal adjustment mechanism whereas for M1 a real adjustment mechanism is preferred; this results in the appearance of the term p_{-1} inside the square brackets in the M1 equation, as opposed to p in the case of M2+. This implies that M1 reacts instantaneously to price shocks, whereas M2+ follows a dynamic adjustment process. Third, M2+ has a much higher estimated long-run income elasticity (1.40) than M1 (0.85). Fourth, M2+ is much less interest-sensitive than M1. M1 has a mean interest rate elasticity of about -0.34 (with respect to R90) whereas both R90 and (R90-RSDB) are statistically insignificant in the M2+ equation.

Modelling M2+ Over the Full Sample Period Using Error Correction

The regressions reported in Table 1 illustrate some of the important empirical issues encountered in specifying a level equation for M2+ over the 1971Q1-88Q4 period. All equations are estimated while imposing long-run price homogeneity, although we find that in the extended sample period this restriction is consistently rejected by the data. We prefer to interpret this rejection as evidence of model misspecification rather than as a rejection of price homogeneity *per se*. Diagnostic tests were performed on the estimated equations to provide further evidence of model misspecification and possibly to isolate the source of the misspecification. Marginal significance levels of these tests are reported in Table 2.

In regression [1] reported in Table 1, both R90 and (R90-RSDB) are statistically significant. However, in Table 2 there is considerable evidence of model misspecification. Long-run price homogeneity can be easily rejected (at the 0.001 level). There is evidence of serial correlation in the residuals (at the 0.006 level) and evidence of structural instability in the early 1980s. This misspecification may be due to the downward shift in intermediation thought to have occurred in the early 1980s. A dynamic simulation showed that the equation is unable to explain the permanent shift in the level of M2+ over the 1981Q1-84Q2 period. At this stage in our research, it is difficult to say much about the nature of the apparent shift in M2+ with a reasonable level of confidence. For now, we simply use a dummy variable to capture a permanent shift in the constant term.[7]

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[7] The shift variable is constructed as a time trend in the level equation and a zero/one binary variable in the growth-rate equation to capture the permanent shift in M2+ over the 1981Q1-84Q2 period.

TABLE 1

M2+ Level Specifications

(Sample: 1971Q1-88Q4; standard errors given in parentheses)

Error-Correction Model:

$$\Delta m = a_0 + d((1-e_{csb})p + e_y y - m_{-1}) + e_r R90 + e_{rd}(R90-RSDB)$$
$$+ e_{csb}(csb - (1-d)csb_{-1}) + e_{sh}(DSH - (1-d)DSH_{-1})$$

	OLS: [1]	[2]	[3]	[4]	2SLS
Constant (a_0)	-1.22 (0.26)	-.729 (.234)	-.559 (.130)	-.728 (.233)	-.602 (.245)
Adjustment Parameter (d)	.220 (.036)	.122 (.030)	.100 (.016)	.122 (.030)	.106 (.030)
Long-Run Income Elasticity (e_y)	1.500 (.037)	1.512 (.056)	1.477 (.048)	1.510 (.051)	1.488 (.067)
R90 Semi-Elasticity:					
Impact (e_r)	-.089 (.036)	-.029 (.034)	--	-.029 (.033)	-.011 (.037)
Long Run:	-.405 (.131)	-.238 (.239)	--	-.241 (.232)	-.100 (.328)
(R90-RSDB) Semi-Elasticity:					
Impact (e_{rd})	-.194 (.102)	-.007 (.097)	--	--	--
CSB Effect (e_{csb})	-.126 (.013)	-.085 (.014)	-.080 (.012)	-.085 (.013)	-.082 (.013)
Long-Run Shift (e_{sh})	--	-.098 (.023)	-.115 (.020)	-.099 (.024)	-.111 (.027)
R^2	.738	.807	.805	.807	.806
SER	.552%	.477%	.472%	.474%	.474%
DW	1.35	1.69	1.72	1.69	1.72

TABLE 2

Diagnostic Tests on M2+ Level Specifications

(Marginal Significance Levels)

Equation:	[1]	[2]	[3]	[4]
1. Price Homogeneity	.001	.077	.031	.042
2. Serial Correlation	.006	.210	.266	.212
3. ARCH	.393	.102	.099	.095
4. RESET	.973	.742	.684	.748
5. Kurtosis	.691	.550	.557	.552
6. Skewness	.976	.912	.915	.909
7. Structural Stability:				
1981Q1 Breakpoint	.002	.366	.245	.274
1982Q3 Breakpoint	.005	.024	.963	.027
8. Simultaneity Bias	.943	.638	.374	.550

Notes for Diagnostic Tests Reported in Tables 2 and 4

1. LR test of long-run price homogeneity restriction.
2. LM test for first-order serial correlation.
3. LM test for first-order autoregressive conditional heteroscedasticity.
4. Ramsey's (1969) misspecification test.
5. LM test for excess kurtosis in the residuals.
6. LM test for skewness of the residuals.
7. LR test for structural stability of regression coefficients (with long-run price homogeneity imposed and the adjustment parameter held constant over subperiods).
8. Hausman's misspecification test for simultaneity bias.

Regression [2] of Table 1, which includes this dummy variable, indicates that there was a downward shift in the level of M2+ of about 10 per cent over the 1981Q1-84Q2 period.[8] Furthermore, the estimated speed of adjustment is lowered considerably, from 22 per cent (per quarter) to 12 per cent. This result is puzzling because we expect, as argued in Section 2 above, an excluded shift variable to be picked up by the lagged dependent variable, resulting in slower estimated dynamics. Also note that the coefficients on (R90-RSDB) and on R90 are statistically insignificant when the shift variable is included in the equation. This may indicate that R90 or (R90-RSDB) is correlated with the structural shift. Regressions [3] and [4] show that excluding R90 and RSDB from the specification has little effect on the estimates. The shift variable reduces the serial correlation in the residuals (as indicated in Table 2) but does not completely alleviate the problem with long-run price homogeneity and structural instability. The long-run price homogeneity restriction can be rejected at the 0.03 to 0.07 level in the three regressions. Specifications which include R90 (i.e. regressions [2] and [4]) are found to be structurally unstable around a 1982Q3 breakpoint. This may be an indication that the velocity shifts in M2+ thought to have occurred in the early 1980s may not be adequately captured by the constructed dummy variable.

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[8] Although the estimated effect of the shift appears to be highly significant (with a MSL of 0.001), the construction of the variable entails considerable pre-test bias and, hence, it is difficult to give the confidence levels associated with our inferences a meaningful interpretation.

Modelling M2+ Over the Full Sample Period Assuming A Unit Root Hypothesis

Estimates of M2+ growth-rate equations are reported in Table 3. Results of diagnostic tests performed on these estimated equations are reported in Table 4. Regression [1] shows that the M2+ growth-rate equation is well-specified over the full sample period even without a shift variable. Regression [2] shows that the shift variable is statistically insignificant (with a MSL of 0.12). Regression [4] shows that when (R90-RSDB) is excluded from the specification, the shift variable becomes statistically significant (at the .03 level) and is estimated to be about 10 per cent of M2+, which is similar to the estimate obtained from the level equation. Thus, in the growth-rate equations, (R90-RSDB) seems better able to explain velocity movements in M2+ than the constructed shift variable.

As for the level equations, the growth-rate equations are generally inconsistent with long-run price homogeneity (see Table 4). This is not altered by including a shift in the equation. A likelihood ratio test rejects long-run price homogeneity at the 0.03 level with the shift excluded (regression [1]) and at the 0.01 level with the shift included. However, when both the shift variable and (R90-RSDB) are excluded (regression [3]), long-run price homogeneity cannot be rejected (with a MSL of 0.08). These results are generally consistent with our earlier conjecture that rejections of long-run price homogeneity reflect misspecification of the model. In particular, it may be that the crude form of the shift dummy does not adequately explain events over 1981-1984. Another contributing factor might be misspecification of the opportunity-cost variable, (R90-RSDB). There is some concern that the differential might not be a good proxy for relative rates of return on M2+

TABLE 3
M2+ Growth-Rate Specifications
(Sample: 1971Q1-88Q4; standard errors given in parentheses)

Growth-Rate Model:

$$\Delta m = a_0 + d((1-e_{csb})\Delta p + e_y \Delta y) + (1-d)\Delta m_{-1}$$
$$+ e_{r1}\Delta R90 + e_{r2}\Delta R90_{-1} + e_{rd1}(\Delta R90 - \Delta RSDB) + e_{rd2}(\Delta R90_{-1} + \Delta RSDB_{-1})$$
$$+ e_{csb}(\Delta csb - (1-d)\Delta csb_{-1}) + e_{sh}(\Delta DSH - (1-d)\Delta DSH_{-1})$$

	OLS: [1]	[2]	[3]	[4]	2SLS
Constant (a_0)	0.44%	1.31%	0.46%	1.68%	2.95%
	(0.67)	(0.90)	(0.69)	(0.94)	(1.31)
Adjustment Parameter (d)	.410	.444	.405	.456	.703
	(.082)	(.085)	(.086)	(.087)	(.130)
Long-Run Income Elasticity (e_y)	1.277	0.896	1.212	0.700	0.587
	(.375)	(.407)	(.387)	(.396)	(.367)
R90 Semi-Elasticities:					
e_{r1}	.076	.076	-.061	-.042	-.087
	(.075)	(.075)	(.060)	(.059)	(.083)
e_{r2}	-.171	-.163	-.143	-.129	-.146
	(.071)	(.073)	(.051)	(.050)	(.055)
Long Run:	-.231	-.195	-.502	-.378	-.332
	(.204)	(.188)	(.187)	(.167)	(.145)
(R90-RSDB) Semi-Elasticities:					
e_{rd1}	-.385	-.349	--	--	--
	(.153)	(.153)			
e_{rd2}	-.182	-.150	--	--	--
	(.136)	(.136)			

TABLE 3 (Continued)

OLS:	[1]	[2]	[3]	[4]	2SLS
CSB Effect (a_5)	-.064 (.016)	-.061 (.016)	-.064 (.017)	-.060 (.016)	-.068 (.020)
Long-Run Shift (a_6)	--	-.078 (.050)	--	-.107 (.050)	-.107 (.048)
R^2	.764	.772	.730	.747	.713
SER	.532%	.527%	.560%	.546%	.582%
DW	2.40	2.42	2.24	2.28	2.00

TABLE 4
Diagnostic Tests on M2+ Growth-Rate Specifications
(Marginal Significance Levels)

Equation:	[1]	[2]	[3]	[4]
1. Price Homogeneity	.029	.010	.084	.024
2. Serial Correlation	.128	.098	.333	.244
3. ARCH	.153	.218	.120	.178
4. RESET	.130	.099	.234	.147
5. Kurtosis	.590	.623	.605	.564
6. Skewness	.945	.877	.961	.878
7. Structural Stability:				
1981Q1 Breakpoint	.423	.695	.959	.301
1982Q3 Breakpoint	.812	.595	.783	.698
8. Simultaneity Bias	.065	.031	.181	.061

Note: See notes to Table 2.

deposits and competing financial assets, since there have been a number of innovations in deposits offered by banks and a corresponding decline in the relevance of RSDB over time. Although the likelihood ratio tests are invalid under the maintained cointegration hypothesis underlying the error-correction specifications (see Phillips and Durlauf, 1986), the same qualification cannot be made with respect to the growth-rate equations under test here. Moreover, unconstrained estimates of the long-run price elasticity are found to be in the 0.7 to 0.8 range, significantly below unity, in both the level and growth-rate models.

The semi-elasticity of M2+ with respect to a general increase in interest rates, measured using R90, is quite sensitive to the specification of the equation. For example, when the shift variable and (R90-RSDB) are excluded from the growth-rate equation, the absolute value of the estimated long-run interest semi-elasticity increases from 0.23 to 0.50. A similar result holds for the level equations. Consequently, our inferences on the interest sensitivity of M2+ are conditional on the appropriate measure of the opportunity cost of M2+ and the possibility of a shift in the equation.

It is also worth noting the relationship between time trends and the estimated income elasticities in the M2+ equations. In the growth-rate equations, the estimated constant term implies that the <u>level</u> of M2+ has a deterministic log-linear trend component. The scale variable then captures cyclical movements of the velocity of M2+ around this trend. This decomposition of velocity into a trend and cyclical component is found to be quite sensitive to alternative specifications. For example, in growth-rate equations without a shift (regression [1], Table 3), M2+ has an estimated long-run income elasticity of 1.28, and the constant term implies a steady-state (annualized) growth rate of about 0.44 per cent. Adding the shift variable to the equation reduces the long-run income elasticity to 0.896 and increases the implied steady-state (annualized) growth rate due to the constant term to 1.31 per cent. Thus, including the shift variable in the equation gives the fitted velocity of M2+ a stronger trend component with relatively less cyclical movement around its trend.

This relationship between the linear time trend and the scale variable reconciles the estimates of the income elasticities in level and growth-rate equations. Incorporating a linear time trend into level M2+ equations results in estimates of the long-run income elasticity that are consistent with growth-rate equations. For example, including a time trend in regression [2] in Table 1 reduces the estimated long-run income elasticity from 1.51 to 0.88 which is fairly close to the estimate from the corresponding growth-rate equation (.896 in the regression reported in Table 2). Thus it is the absence of a time trend and not the unit root hypothesis that accounts for the high income elasticities in level equations. It is interesting to note that a linear time trend is statistically insignificant in error-correction specifications for M2+. This provides some additional support for the cointegration hypothesis, which implies that the trend in the price level, income and CSBs adequately accounts for the trend in M2+.

Although its interpretation is clouded by various issues raised in Section 2, another striking difference between the level and growth-rate equations is the estimated "speed-of-adjustment" parameter. In level regressions, the speed-of-adjustment parameter is about 0.10, implying that after a year, less than 50 per cent of the adjustment is complete. In contrast, the speed-of-adjustment parameter in growth-rate equations is in the 0.41 to 0.45 range, implying that after a year 67-78 per cent of the adjustment is complete. This suggests that the unit root hypothesis may be a useful assumption for helping to identify the dynamics underlying the demand for M2+.

We should note that we are not directly addressing the question of whether the M2+ equation actually has a unit root. Our interest in the unit root hypothesis has more to do with other specification issues. Consider the possibility of misspecification bias mentioned in Section 2 above. Suppose that the estimated parameter on the lagged dependent variable is biased upward because of simultaneity, measurement error or an omitted variable. Differencing the data may reduce the bias arising from these sources of misspecification. It would therefore be misleading to interpret the resulting "faster speed of adjustment" from estimates of growth-rate equations as evidence that velocity has a stochastic trend component (i.e. a unit root in the M2+ equation). Alternatively, the differencing filter can be considered a technique for alleviating certain misspecification problems.[9] From this point of view, characterizing the velocity of M2+ as if it has a stochastic trend component may be considered as a useful working hypothesis insofar as it improves the simulation properties of the equation.

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[9] This is the view taken by Nelson and Plosser (1982) who suggest that the implications of overdifferencing are less serious than those resulting from underdifferencing. The general validity of this approach has yet to be established. For example, cointegrated systems described by Engle and Granger (1987) imply that overdifferencing can result in serious misspecification problems as well.

Simultaneity Bias in Estimated M2+ Equations

As noted above in Section 2, there is no strong prior case for expecting a significant simultaneity problem in the M2+ demand equation, since the Bank of Canada has not used M2+ as an explicit target over the sample period. However, M1, which is a component of M2+, played such a role during 1975-81, making it possible in theory for M2+ to contain an element of simultaneity. In addition, it might simply be the case that money, prices, output and interest rates are simultaneously determined. In the absence of an explicit structural model of the linkages between these variables, reduced-form equations may be useful as a diagnostic tool for detecting simultaneous equations bias that may arise regardless of the actual monetary policy pursued over the historical period. We should also emphasize that this diagnostic approach does not represent a direct test of the buffer-stock hypothesis. Formally testing for simultaneity arising specifically from buffer-stock effects would involve specifying an explicit structural role for buffer-stock money, which is beyond the scope of this paper.

The empirical importance of simultaneity bias in the M2+ equations can be examined by comparing the OLS estimates to system or 2SLS estimates. In estimating by 2SLS we treated prices, output and interest rates as potentially endogenous variables. In specifying a reduced-form equation for interest rates, we initially divided our sample into subperiods and attempted to estimate separate reaction functions for each period. This approach, however, did not produce reaction functions with sensible properties, so we instead characterized the policy regime as being constant across the entire period. We then took a fairly eclectic approach to specifying the three reduced forms, with exogenous shocks arising from movements in world commodity and oil prices, foreign output and foreign real interest rates prominent among the explanatory variables (estimates of these reduced forms are given in Appendix 2). Fitted values from the reduced-form equations were then used as instruments for the price level, output and the interest rate in 2SLS estimates of the M2+ equation.

In general, the 2SLS estimates were found to be very similar to those obtained using OLS -- see the last column of Tables 1 and 3. In the level equation, the 2SLS estimates are virtually identical to the OLS estimates. The long-run interest semi-elasticity declines somewhat (in absolute value) from 0.24 to 0.10 when 2SLS is used but remains statistically insignificant. The estimated speed of adjustment declines slightly from 0.122 per cent to 0.106 per cent. Thus, there is little evidence that the slow dynamics in level M2+ equations can be attributed to simultaneity bias. Moreover, a Hausman test does not detect evidence of misspecification arising from simultaneity bias in any of the four regressions (see Table 2).

In growth-rate equations, the 2SLS estimates imply higher speeds of adjustment. For example, in equation [4] in Table 3 the estimated speed of adjustment increases from 0.456 with OLS to 0.703 with 2SLS. A Hausman test provides some evidence of misspecification arising from simultaneity bias in this equation (at the 0.06 level). Thus, the 2SLS estimates provide some evidence that the estimated adjustment speed of the M2+ growth-rate equations is biased downward by simultaneity. It is clear from a comparison of the results, however, that simultaneity cannot account for the much greater differences in speeds of adjustment between level and growth-rate equations.

Short-Run Dynamics and the Long-Run Demand for M2+

Research on empirical money-demand functions has for the most part concentrated on "short-run" specifications. The generally poor empirical performance of these specifications has led some to conclude that so little is known about the short-run dynamics of money demand that the research agenda should focus on estimates of long-run elasticities rather than adjustment speeds. Lucas (1988), Poole (1988), and Hoffman and Rasche (1989) report evidence on the existence of a stable long-run relationship between the levels of real balances (M1), real income and interest rates for the United States, while Duck (1988) finds for a group of 33 countries that the long-run real demand for money (the rate of growth of real M1 and M2) is explained quite well by a small number of variables, mainly real income and interest rates. The long-run interest elasticities obtained from money-demand equations estimated with annual data, however, can differ markedly from those estimated with quarterly or monthly data (Rasche (1987), Poole (1988)).[10]

These findings are to some extent corroborated by the above analysis of the demand for M2+ in Canada. We find the long-run parameter estimates to be more robust than estimates of short-run dynamics. Specifically, although sensitive to the inclusion of a time trend in the equations, our estimates of the long-run income elasticity are similar in level and growth-rate specifications. In addition, long-run estimates of the CSB effect and the shift over the 1981Q1-84Q2 period are approximately equal across the alternative

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[10] Hoffman and Rasche (1989) find that the estimated interest elasticities are statistically significantly different depending on whether short-term or long-term interest rates are used, but the difference is not of economic importance.

specifications, and unconstrained estimates of the long-run price elasticity fall consistently into the 0.7 to 0.8 range, rejecting the hypothesis of long-run price homogeneity. On the other hand, our results are inconclusive with respect to short-run dynamic issues. In particular, the estimated speed of adjustment is quite sensitive to the stationarity assumption underlying the equation. This is also the case for the estimated interest sensitivity of M2+, which is found to be statistically insignificant in level regressions but statistically significant in growth-rate regressions.

The statistical properties of long-run estimates have recently become an important area of econometric research. On the one hand, Phillips' (1986) analysis of the spurious regression problem shows that ignoring a unit root in the error term of the equation results in long-run estimates that lack meaningful statistical interpretations. On the other hand, Engle and Granger's (1987) analysis of cointegration shows that ignoring long-run relationships between levels of variables also results in serious misspecification problems. Consequently, stationarity issues should be an important concern in the analysis of the long-run demand for money.

Stationarity issues have implications for the analysis of measurement error and simultaneity bias of Section 2 above. The errors-in-variables analysis of Goodfriend (1985), as well as the analysis of simultaneity bias arising from the orientation of monetary policy, are conducted under the implicit assumption that the variables in the money-demand function are stationary processes. This stationarity assumption seems inconsistent with the observed time-series properties of some of the variables typically used in estimating money-demand equations. In particular, the price level and income are highly trended and, hence, may be better characterized as integrated (non-stationary) processes. Properties of estimates involving integrated regressors are thus more appropriately analyzed in the context of cointegration theory.

Recent developments in cointegration theory show that regressions involving integrated regressors have different asymptotic properties from regressions involving stationary regressors. In particular, estimates of long-run elasticities on integrated regressors are "super-consistent" in the sense that they converge at faster rates than estimates involving stationary regressors (see Stock, 1987 and Engle and Granger). Furthermore, Phillips and Durlauf (1986) and Engle and Granger (1987) show that OLS estimates of long-run coefficients of integrated regressors in multivariate regressions are consistent even in the presence of measurement error and simultaneity. This implies that under the maintained hypothesis of simultaneity and/or measurement error, long-run estimates of price and income elasticities are more likely to be consistent in error-correction models, while estimates of the short-run elasticities and the speed of adjustment are more likely to be biased.

Our empirical analysis indicates that, contrary to econometric theory, the long-run parameter estimates are robust to alternative stationarity assumptions. However, it should be kept in mind that the relevant econometric theory is asymptotic, and therefore perhaps not applicable to samples of typical size, including that used above. Our estimates of short-run dynamics and of the interest rate sensitivity of M2+ are found to be quite sensitive to the alternative specifications. The results are therefore encouraging with respect to our ability to model the long-run demand for M2+ even though the short-run dynamics may be misspecified.

4. THE ROLE OF MONETARY AGGREGATES IN THE CONDUCT OF MONETARY POLICY

The role of monetary aggregates in monetary policy has been a subject of renewed interest in recent years. Some, notably Benjamin Friedman (1988a, b), have argued that there is no role for monetary aggregates and that there is a vacuum at the centre of the policy process. Friedman's argument is that the difficulty facing policymakers is not merely the instability of the short-run demand-for-money function, but more generally the collapse of the longer-run relationship between money and income and prices, so that the empirical basis for the (systematic) role of money in the monetary policy process no longer exists.

Although shifts in the money-stock/money-income relationship stemming from financial innovation and deregulation have led monetary authorities to de-emphasize or abandon money-stock targets and to rely more on a broader set of indicators, there remains - at least from a Canadian perspective - an important role for monetary aggregates in the policy process (see Crow, 1988). The nature of this role depends on the use of monetary aggregates in the attainment of the goals of monetary policy. Here the main issue is whether the monetary aggregates are to serve as intermediate targets or whether they are to serve, less rigidly, as policy guides. The distinction between the two is one of degree: in both cases the essential role of the monetary aggregates is to help prevent cumulative one-way policy errors (Freedman, 1989b).

The research outlined in the preceding section suggests a number of points related to the potential role for monetary aggregates in policy formulation. First, although the broader monetary aggregates have tended to be more stable than the narrower aggregates, they are not necessarily free of unpredictable shifts. For instance, the downward shift in M2+ (and M2) over the 1981-84 period is difficult to explain even after the event.[11] Thus, if in late 1982, when the Bank of Canada abandoned target growth ranges for M1, it had adopted targets for M2+ or M2 in the belief that these aggregates were free of shifts, actual money growth would have persistently fallen short of target during 1982-84, suggesting an easing of monetary policy that would have ultimately been judged inappropriate.[12]

Second, although temporary shifts in money demand are not as much of a problem as permanent shifts for the use of monitoring or target ranges, they would nevertheless be important were the authorities to adjust interest rates in response to movements in monetary aggregates relative to their bands. The percentage dynamic confidence intervals for M2+ are smaller than for M1, but they are sufficiently large that, were the authorities to consider establishing formal or informal monitoring ranges for M2+, the ranges would have to be rather

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[11] Our preferred explanation is that the fear of continuing high real interest rates and the uncertainty over income and employment prospects engendered by the 1981-82 recession prompted households and firms to reduce their indebtedness substantially; one means of doing so was to use existing liquid assets to pay off debts, a process which resulted in a downscaling of both the asset and liability sides of their balance sheets, as well as of the balance sheets of financial institutions.

[12] Shifts in monetary aggregates do not necessarily preclude the adoption of target ranges for monetary aggregates, since the authorities could adjust the target ranges to take these shifts into account. Often, however, one does not know how much the target ranges should be adjusted until it is too late for policy purposes. Furthermore, as Freedman (1989a) points out, the usefulness of monetary targets in the conduct of policy or in enhancing the credibility of the monetary authorities would soon be eroded if they had to be adjusted often.

wide if one wished to avoid the need to react to movements due simply to random errors in money demand. On the other hand, the ranges would have to be sufficiently narrow so that what may be considered typical movements in nominal spending (e.g. 2 percentage points) would justify a response in policy stance on the basis of movements in the monetary aggregate. This condition may hold for the level specification of M2+[13], but the same could not be said of the growth-rate equation, since in that case the confidence interval would be wider, and the income elasticity would be somewhat smaller. Another concern relates to the issue of base drift. The growth-rate specification implies that random disturbances to M2+ demand have a permanent effect on the level of M2+. Hence, in the context of monetary targeting, the growth-rate specification would argue in favour of allowing base drift in the level of M2+, in order to prevent base drift in nominal spending.

Third, CSBs are close substitutes for personal savings deposits.[14] At times this can complicate the interpretation of underlying movements in M2+ and M2, as unusually large (small) CSB sales reduce (raise) the level and, temporarily, the growth rate of these aggregates considerably. Furthermore, target ranges would have to be adjusted for CSB-induced shifts in the path of M2+ and M2. As an illustration of the importance of the CSB effect consider the recent experience. Using a CSBs coefficient of -0.085 (see Tables 1 and 3), the above-average 1987 CSB sales campaign of $12.4 billion reduced the level of

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13 For the levels specification of M2+ the 95 per cent dynamic confidence interval after one year is ±1.6 per cent. Since this is based on an equation that contains dummy variables for past unpredicted money-demand shifts, the true *ex ante* confidence band is wider.

14 As shown in Section 3, the real stock of CSBs is a highly significant variable in M2+ and M2 equations, but not in M1 equations.

M2+ in November of that year by an estimated $1.8 billion, or 0.55 percentage points, below what it would have been for an average sales campaign of about $9 billion.[15] In contrast, the below-average 1988 CSB sales campaign of $4.2 billion raised the level of M2+ in November by $2.4 billion, or 0.67 percentage points, above what it would have been for an average campaign. This suggests that the monetary authorities should perhaps focus on CSB-adjusted M2+ and M2. However, these adjusted aggregates were found to be inferior to M2+ or M2 as indicators of nominal spending and inflation.

Fourth, the interest sensitivity of M2+ (in specifications where it is statistically significant) is usually quite low.[16] The influence of monetary policy actions on M2+ is thus mostly indirect, through the influence of interest rates on output and prices. If M2+ (or M2) were to serve as an intermediate target, very large changes in interest rates would be required to return the aggregate to its target path over a relatively short time span following deviations from that path. This suggests that the return to the target path should perhaps be somewhat more gradual for the broader aggregates than for M1. Prolonged deviations, however, could prevent reaping the benefits in terms of credibility that would presumably be conferred by successful targeting. From the perspective of an indicator, on the other hand, the low interest rate elasticity may be a desirable property since, in the absence of random shocks

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[15] CSB sales are concentrated in November of each year. CSBs became a more important source of government financing in the 1980s. From 1981 to 1988 CSB annual net sales averaged about $9 billion, whereas from 1970 to 1980 they averaged approximately $2 billion.

[16] Interpretation of the effects of interest rate movements on M2+ is clouded by the potential for accompanying changes in the rate of redemption of CSBs.

to M2+ demand, movements in M2+ reflect mainly movements in nominal spending. Given the very low interest elasticity, using M2 and M2+ as guides to policy would in theory not differ greatly from using nominal spending directly. In practice, of course, the monetary aggregates, especially M2, offer a marked advantage in terms of timing of information.[17] This advantage, however, is tempered by the rather wide confidence intervals of the estimated money-demand equations.

Fifth, and last, our research to date has not allowed us to conclude definitely in favour of either a levels specification or a growth-rate specification of money demand. Since the two formulations indicate considerably different adjustment dynamics, resolution of this issue would be useful for making informed assessments of current and prospective developments. Also, although the equations presented in Section 3 explain the data well and have performed well in post-sample prediction, the persistent rejection of long-run price homogeneity suggests that potentially important elements of misspecification remain.

Thus, uncertainties about adjustment dynamics, the possibility of unpredictable shifts, and issues of controllability have led to the conclusion that the broad monetary aggregates cannot bear the weight of being formal intermediate policy targets. Nevertheless, they still contain valuable information which can be used to further the medium-term goal of price stability (see Crow, 1988 and Freedman, 1989a).

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[17] The portion of M2+ held at non-bank financial institutions is reported with a longer lag than are M2 data. In practice this does not pose a serious problem, however, since M2 and M2+ are very highly correlated and the former may be used to construct preliminary estimates of the latter.

As one possible example, suppose that the authorities have in mind a desired deceleration of inflation to reach price stability. Corresponding to this, given an assumption about potential real growth, there will be an implied path of nominal spending and a path for interest rates. Corresponding to these paths will be a predicted path for the monetary aggregates consistent with their estimated demand equations. Since M2 and M2+ are observed more frequently than nominal spending, these aggregates have a potentially useful role to play. In particular, for a given path of nominal spending and interest rates, the money-demand equations can be used to analyze deviations of M2 and M2+ from their predicted path in terms of a shock to nominal spending or a disturbance to the money-demand equation. The contemporaneous and leading indicator properties of M2+ and M2 with respect to nominal spending and inflation complement the information from the demand functions and from the analysis of other economic indicators in assessing current and prospective developments, and in guiding the authorities in adjusting the policy stance. At times, of course, the indicator models and the money-demand functions may give seemingly conflicting interpretations of economic developments.

5. CONCLUDING REMARKS

We began by noting that monetary aggregates have fallen into some disrepute in terms of their usefulness in the conduct of monetary policy. While many of the problems that have been encountered were due to financial innovation, demand-for-money equations for broader aggregates that are less susceptible to such problems are often found to have unsatisfactory dynamic properties. Section 2 sought to clarify the implications of various empirical questions for the observed dynamic properties of estimated money-demand equations and suggested that interpretation of those dynamics hinges on a number of possible factors that are difficult to isolate. In particular, the orientation of monetary policy over the sample period, and changes in that orientation, might influence the estimated dynamics through simultaneity bias. The absence of simultaneity can therefore be used to eliminate a range of possible explanations for money-demand dynamics, but can leave several other explanations on an equally plausible footing. Furthermore, there are enough possible reasons to expect estimates of dynamics to reflect other phenomena that rejecting equations on the basis of slow estimated speeds of adjustment will often be unjustified.

Section 3 examined these issues, among others, using the broad monetary aggregate M2+ in Canada over the 1971-88 period. While the estimated speed of adjustment and the estimated interest rate sensitivity of M2+ were found to be quite sensitive to alternative specifications, particularly with respect to alternative stationarity assumptions, estimates of the long-run demand for M2+ were much more robust. Moreover, there was little evidence that simultaneity bias has played an empirically important role in the demand for M2+ for our sample period. A number of questions remain, however, concerning the behaviour of M2+ in the post-1981 period. Further research is needed to improve our understanding of the apparent shift in M2+ beginning in 1981 and to explain why long-run price homogeneity could be rejected in most of the specifications reported in this paper.

Despite a number of shortcomings, the evidence accumulated thus far suggests that estimated demand-for-money models can play a useful role in the monetary policy process in Canada. In part this positive assessment is a product of the more modest set of demands envisaged for these variables, based on the lessons of the 1970s and early 1980s (see Freedman, 1989b). In any case, the monetary aggregates in Canada are viewed as useful indicators of economic developments, and the estimated demand equations - regardless of their various imperfections - are essential to an economic interpretation of their movements.

One last point to note is the potential role of monetary aggregates in explaining policy actions to the public, provided that their behaviour relative to the aggregate economy is reasonably stable. As a key nominal macro variable, a monetary aggregate can help provide an anchor for private-sector expectations over the medium term, even if it is used only to indicate the longer-term intentions of the monetary authorities. Furthermore, although at times the behaviour of such variables may not conform to expectations, focussing attention on one or more monetary aggregates on a fairly continuous basis sets up a sort of informal accounting framework that prompts fuller and more frequent discussion of the policy process with the public than might otherwise be the case.

APPENDIX 1
Data Sources and Definitions

M1	=	currency and demand deposits held by the public at chartered banks, seasonally adjusted (CANSIM series: B1627)
M2	=	M1 plus personal savings deposits and non-personal notice deposits at chartered banks, seasonally adjusted (CANSIM series: B1630)
M2+	=	M2 plus deposits at near-banks, seasonally adjusted (CANSIM series: B1633)
UGDP	=	GDP at constant prices, seasonally adjusted (CANSIM series: D20031)
UFS	=	final sales at constant prices, seasonally adjusted (UGDP less value of physical change in inventories -- CANSIM series: D20031 - D20042 - D20043)
PGDP	=	GDP implicit price deflator, seasonally adjusted (CANSIM series: D20337)
R90	=	rate on 90-day prime corporate paper (CANSIM series: B14017)
RSDB	=	rate on non-chequable savings deposits (CANSIM series: B14019)
CSB	=	value of outstanding Canada Savings Bonds held by the public (CANSIM series: B2406), seasonally adjusted using ARIMA X-11
SHIFT	=	binary variable having a value of 1 after 1975Q4 and 0 before
DSH	=	trended dummy variable having a value of 0 before 1981Q1, a linear time trend over the 1981Q1-84Q2 period, and a value of 14 after 1984Q2

Figure 1
Four-Quarter Growth Rates of YGDP and M2+

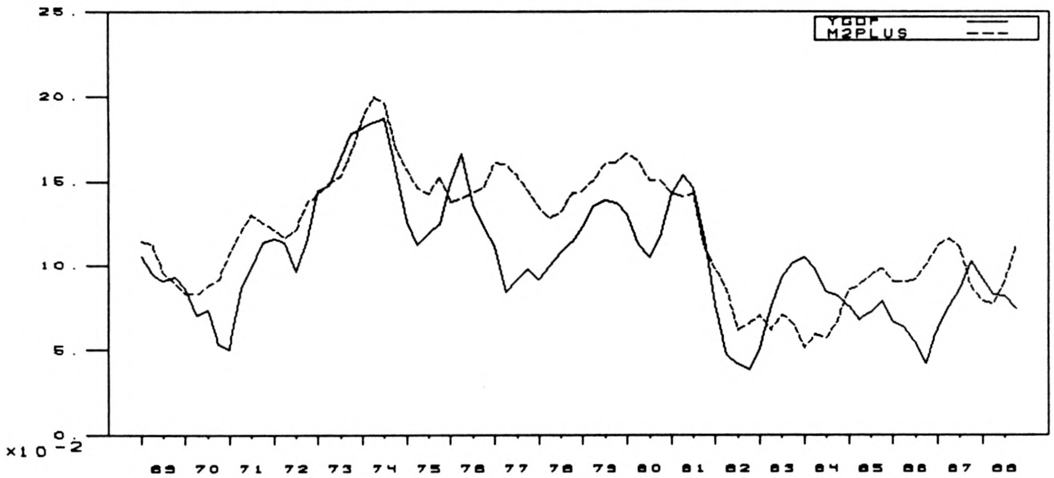
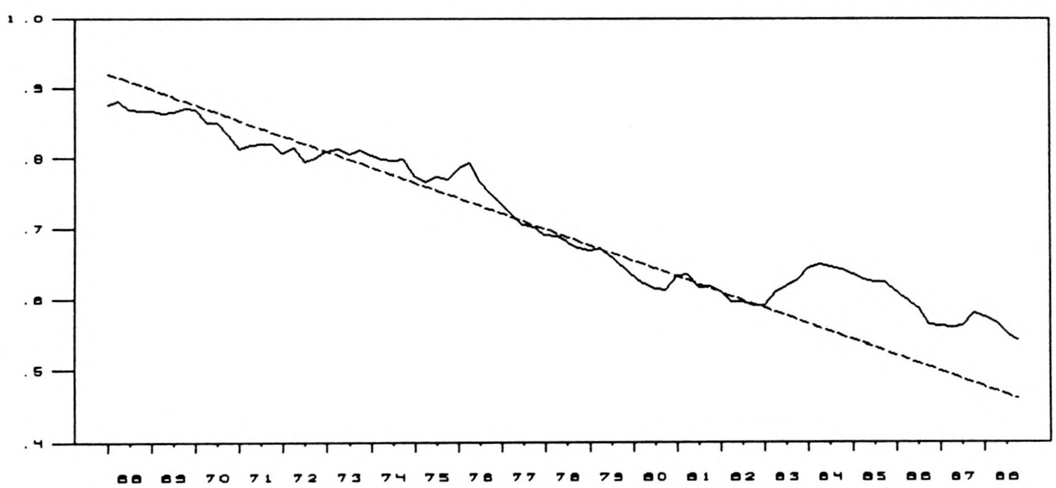


Figure 2
Velocity of M2+ and Time Trend Fitted over 1971Q1-80Q4 Period



APPENDIX 2
Reduced-Form Estimates For Two-Stage Least Square Procedure
(Sample: 1971Q1-88Q4)

1. The Price Level

$$\Delta p = \underset{(.0017)}{.0044} + \underset{(.111)}{.343}\Delta p_{-1} + \underset{(.106)}{.399}\Delta p_{-2} + \underset{(.035)}{.067}(y-yt)_{-1}$$

$$+ \underset{(.005)}{.014}\Delta rpoil + \underset{(.040)}{.021}\Delta rpcom + \underset{(.040)}{.045}\Delta rpcom_{-1} + \underset{(.041)}{.051}*\Delta s_{-1}$$

$R^2 = .682$ SER = .536% DW = 2.17

2. Real Income

$$\Delta y = \underset{(.0023)}{.0083} - \underset{(.046)}{.065}(r* - \Delta p^{*e}) + \underset{(.015)}{.021}(q_{-1}) + \underset{(.025)}{.042}rpcom$$

$$+ \underset{(.111)}{.189}\Delta y* + \underset{(.107)}{.119}\Delta y*_{-1} - \underset{(.077)}{.217}(y_{-1} - yt_{-1})$$

$R^2 = .215$ SER = .925 DW = 2.26

3. The Nominal Interest Rate

$$\Delta r = \underset{(.0013)}{.0041} + \underset{(.060)}{.453}\Delta r* - \underset{(.063)}{.507}(r_{-1} - r*_{-1}) + \underset{(.199)}{.525}(\Delta p^e - \Delta p*^e)$$

$$+ \underset{(.093)}{.404}\Delta y* + \underset{(.048)}{.252}(y_{-1} - yt_{-1}) - \underset{(.050)}{.125}\Delta rpcom$$

$R^2 = .776$ SER = .694 DW = 1.80

where p = the domestic GDP price deflator
Δp^e = expected domestic inflation (fitted values from a second-order autoregressive model)
$\Delta p*^e$ = expected foreign inflation (fitted values from a second-order autoregressive model)
$p*$ = a weighted GDP price deflator for the G7 countries
y = real final sales (i.e. real GDP less changes in inventories)
yt = fitted polynomial trend for y
$y*$ = U.S. real GDP
r = the domestic short-term interest rate (R90)
$r*$ = the foreign short-term interest rate
s = the Canadian-G7 effective exchange rate
q = the Canadian-G7 real effective exchange rate
rpcom = the real price of commodities
rpoil = the real world price of crude oil

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