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MONEY GROWTH VARIABILITY AND MONEY SUPPLY INTERDEPENDENCE UNDER INTEREST RATE CONTROL: SOME EVIDENCE FOR CANADA

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ABSTRACT

Canada, like many countries, has recently experienced difficulties in achieving money growth stability and money supply independence. Based on the buffer-stock view of money-holding as well as the credit market approach to the money supply, this paper suggests that the problems have arisen from the Bank of Canada's use of an interest rate control mechanism. The paper argues that: (1) The short-run behavior of Canadian money growth is influenced by demand shifts in the Canadian credit market. (2) Movements in U.S. interest rates relative to the controlled Canadian interest rates are a key source of these shifts. The paper presents evidence on Canadian money supply and demand functions consistent with the foregoing explanation.

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MONEY GROWTH VARIABILITY AND MONEY SUPPLY INTERDEPENDENCE UNDER INTEREST RATE CONTROL: SOME EVIDENCE FOR CANADA

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I. Introduction

After the breakdown of the Bretton Woods system and the adoption of floating exchange rates by the major industrial countries in March 1973, it was widely believed that the new exchange system would allow each of these countries to insulate its money supply from foreign influences. The view that monetary independence was attainable may have encouraged some of the countries during the 1970s to pursue a policy of monetary targeting -- establishing a preannounced target growth rate, or band of growth rates, of some monetary aggregate.

Experience in the decade since floating exchange rates were adopted suggests that independence of national money supplies has not been achieved.[1] Moreover, a number of countries that adopted some form of monetary targeting have had considerable difficulties, especially in recent years, in achieving their targets.[2]

In this paper we consider the case of Canada whose experience under floating exchange rates provides an example of unanticipated monetary interdependence and disappointing performance in monetary growth targeting. Canada sought independence from the United States, even before the collapse of the Bretton Woods system, by allowing the exchange rate to float beginning May 1970. In November 1975 the Bank of Canada announced a

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policy of setting a specific target range for the rate of growth of M_1.[3]

In late 1979 -- about the time U.S. interest rates began to exhibit increased variability -- Canadian money growth began to fluctuate sharply relative to its behavior in the preceding few years (see figure 1a). Since late 1979, moreover, a pronounced positive relationship has existed between Canadian money growth and U.S. short-term interest rates (see figure 1b).[4] By late 1982, the problem of monetary control seemed so acute to the Bank of Canada that it abandoned money growth targets (see also figure 1b, which shows the behavior of the money stock relative to the target level). Another feature of the Canadian experience is that the regression for the short-run demand for M_1 -- of the type used by the Bank of Canada -- exhibits exceptionally large residuals since 1979 that appear to resemble deviations of money growth from the target rates of growth (compare figures 1a and 1c).

The Bank of Canada, like many central banks, has always used short-term interest rates as its principal mechanism in executing monetary policy. According to the conventional view of interest rate control that appears to underlie the Bank's approach, the money stock would be determined by money demand, which the Bank can influence by setting an appropriate interest rate. This view suggests two explanations of the erratic behavior of the Canadian money supply. One explanation links the behavior to the Bank's exchange rate policy. Concern with avoiding exchange rate fluctuations leads the Bank to respond to movements in U.S. interest rates in setting the Canadian interest rate. Thus large fluctuations in U.S. interest rates since late 1979[5] could have brought about variability in Canadian money growth through their positive effect on Canadian interest rates (through an interest rate policy reaction function) and then a negative effect on the money stock (through the money demand function). However, a problem with this explanation is that it implies a negative association between U.S. interest rates and Canadian money growth rather than the observed positive association.

A second explanation of the behavior of Canadian money growth -- one that the Bank of Canada itself has emphasized -- is that the demand for M_1 in Canada has become less stable since 1979.[6] One reason suggested for the instability during this period is the impact of financial innovations, possibly induced by high interest rates.[7] The instability in money demand could account for both large residuals in the demand equation as well as large fluctuations in money growth. However, this explanation does not account for the positive correlation between Canadian money growth and U.S. interest rates.

This paper proposes an alternative explanation of the triple incidence of money growth variability, the apparent money demand instability in Canada, and the positive dependence of Canadian money growth on U.S. interest rates. Our explanation is related to two strands in the literature: (1) Brunner and Meltzer's credit market approach to the money supply process (1976); and (2) the buffer stock view of money recently emphasized by Laidler (1984).[8] We argue that movements in U.S. interest rates cause shifts in the demand for domestic credit in Canada which, under interest rate control of the money supply process, produce changes in Canadian money growth. Changes in U.S. interest rates through this mechanism have a positive effect on Canadian money supply growth, providing a channel for monetary interdependence additional to the one arising from the

Bank of Canada's exchange rate management policy. According to the buffer stock view, money supply disturbances automatically affect money demand in the short run and thus these shocks appear as shifts of the money demand function.

The plan of the paper is as follows. In section II we discuss the Bank of Canada's approach to the determination of money growth under interest rate control. According to this approach, the money stock can deviate from its target value either because of unexpected changes in the demand for money or because the Bank occasionally places greater importance on other objectives, such as the exchange rate. Although both factors have been important sources of divergence of the money stock from its target values, our interpretation of the first factor differs from that of the Bank. In section III we present a framework of money growth under interest rate control that supplants the Bank's approach. We first develop a money supply process which highlights the role of the credit market and its sensitivity to foreign shocks as well as the Bank of Canada's intervention in the exchange market. We then discuss interaction between the money supply and money demand functions by incorporating the determinants of the money supply process into the short-run mechanism by which actual money balances adjust to desired money balances. Section IV presents evidence consistent with the money supply process we describe and supports the view that money supply disturbances, such as those produced by variability in foreign interest rates, exert an important influence on the short-run demand for money function. Section V summarizes the conclusions and implications of the paper.

II. Money Growth Under Interest Rate Control: The Bank of Canada's Approach

The Bank's approach is based on the conventional view that interest rate control implies a money supply function which is perfectly interest elastic at the fixed interest rate, and that the stock of money is determined where the money demand function intersects the elastic supply function.[9] According to this view, knowledge of the demand for money can be used to manipulate the interest rate in order to determine the behavior of the money stock. In this approach, the rate of money growth would deviate from the desired rate only to the extent that changes in money demand were unanticipated at the time the rate of interest was set. If the unanticipated changes are not large, interest rate control would be a viable method for money growth targeting in the sense that it would be technically feasible to keep money growth close to the target path. We discuss below how such a policy would be implemented and then examine to what extent the Bank has followed this policy.

An essential ingredient in the Bank's approach is an econometric estimate of the demand for money. Most of the empirical work on demand for M1 in Canada uses an equation which combines a long-run demand function with a real partial adjustment mechanism following Chow (1966).[10] A simple but representative form of the long-run demand function is

$$m_t^* = \alpha_0 + \alpha_1 y_t + \alpha_2 r_t + u_t, \quad \alpha_1 > 0, \ \alpha_2 < 0, \qquad (1)$$

where m^*, y and r represent logarithms of the desired real stock of money, real income, and the short-term interest rate, respectively; u is the error term. Adding the Chow mechanism, we have

$$m_t = \lambda m_t^* + (1 - \lambda)\, m_{t-1}, \quad 0 < \lambda < 1, \tag{2}$$

where m_t is the logarithm of the actual real stock of money.

The demand for money based on equations (1) and (2) can be rewritten as

$$M_t - M_{t-1} = (P_t - P_{t-1}) + \lambda(\alpha_0 + \alpha_1\, y_t + \alpha_2 r_t + u_t - m_{t-1}), \tag{3}$$

where M and P are the logarithms of the nominal money stock and the price level.

Let $\bar{M}_t$ represent the logarithm of the mid-value of the target money stock announced for period t.[11] Let $\bar{r}_t$ be the interest rate that would make the expected value of M_t equal to $\bar{M}_t$, According to the money demand function (3), $\bar{r}_t$ would satisfy

$$\bar{M}_t - M_{t-1} = (\hat{P}_t - P_{t-1}) + \lambda(\alpha_0 + \alpha_1\, \hat{y}_t + \alpha_2 \bar{r}_t + \hat{u}_t - m_{t-1}), \tag{4}$$

where $\hat{P}_t$, $\hat{y}_t$, and $\hat{u}_t$ represent the forecasts of P, y, and u, available to the Bank in period t.

When the Bank of Canada announced its targeting policy in 1975, it was assumed initially that the Bank would attempt to achieve its target by setting the interest rate at $\bar{r}$ in each period.[12] The Bank, however, made it clear later that money growth targets were not its sole concern and that it would be influenced by other considerations in determining the interest rate.[13] One special concern of the Bank has been preventing large movements in the exchange rate. For this reason the Bank may have been reacting to the U.S. interest rate to avoid letting a substantial differential develop between U.S. and Canadian interest rates.[14]

To explore the Bank of Canada interest rate reaction function, we consider the following model:

$$r_t^* = \Theta\bar{r}_t + (1 - \Theta)r_t^{us}, \quad 0 \leq \Theta \leq 1, \tag{5}$$

$$r_t - r_{t-1} = \mu(r^* - r_{t-1}) + X_t\Pi + v_t, \quad 0 < \mu < 1. \tag{6}$$

where r^* is the "desired" rate of interest in the long run, r^{us} the U.S. interest rate, X a vector representing other objectives (Π a corresponding vector of coefficients) and v an error term. The above model allows for the possibility that the desired long-run rate may equal $\bar{r}$ ($\Theta = 1$), r^{us} ($\theta = 0$), or a weighted average of the two rates. Moreover, the model permits the interest rate to be adjusted gradually towards the desired rate ($\mu < 1$) and for other objectives (included in X) to play a role in the short-run determination of the interest rate.

To estimate the model, we developed a measure of $\bar{r}$ as follows. First, the demand function for Canadian M_1, based on (1) and (2), was estimated for the floating exchange rate period, 1970III-1983I, using quarterly data; OLSQ estimates of the function are presented in row 1 of Table 1.[15] (As significant serial correlation of the error term is not indicated, the Cochrane-Orcutt adjustment is not used.) Next, values of $\hat{P}_t - P_{t-1}$ and $\hat{y}_t$ were generated from forecasting equations, developed according to a procedure suggested by Mishkin (1983).[16] Then $\bar{r}$ was calculated according to (4).

Making use of the above measure of $\bar{r}_t$, we estimated an interest-rate reaction function for the Bank of Canada, based on (5) and (6). The function was estimated for the floating exchange rate period 1970III-

1983I,[17] using a dummy variable to distinguish between subperiods with and without the targeting policy. Three variables -- the expected rate of inflation, the expected rate of unemployment, and the (actual) rate of exchange rate appreciation -- were considered as possible candidates to represent the set X.[18] None of these variables proved to be significant.[19] After dropping these variables from the reaction function, the regression estimates are as follows:

$$\begin{aligned} r_t - r_{t-1} = & \underset{(-.58)}{-.00} + \underset{(4.28)}{.01D} + \underset{(1.84)}{.07}\,(\bar{r}_t - r_{t-1})\,D + \underset{(7.72)}{.64}(r^{us} - r_{t-1}) \\ & \underset{(-1.39)}{-\ .14}(r_t^{us} - r_{t-1})D, \\ & \underset{(1.92)}{\rho = .14}, \ R^2 = .79,\ DW = 2.13,\ SEE = .0074, \qquad (7) \end{aligned}$$

where D is a dummy variable for the targeting period (equal to 1 for 1975III-1982III, equal to zero in the remaining period), and t-values are shown below the coefficients.

The regression equation shows that although $\bar{r}$ has exerted some influence on the Canadian interest rate, the effect of the U.S. interest rate has been much stronger.[20] The magnitude of the effect of the U.S. interest rate in the targeting period, moreover, has been less than but not significantly different from its effect in the nontarget period. The evidence suggests that the targeting policy had only a marginal influence on the Bank of Canada's reaction function.[21]

The reluctance of the Bank of Canada to follow a pure targeting strategy of setting $r = \bar{r}$ could account for the divergence of M_t from $\bar{M}_t$. However, even if r had been set exactly equal to $\bar{r}$ in each period, the money stock could still have diverged from its target value because of errors in forecasting inflation and output, and unforeseen shifts in money demand. To examine the relative importance of these factors, we subtracted (4) from (3) and let $\hat{u} = 0$ (based on the absence of serial correlation in our estimates of money demand) to get

$$M_t - \bar{M}_t = (P_t - \hat{P}_t) + \lambda\alpha_1(y_t - \hat{y}_t) + \lambda\alpha_2(r_t - \bar{r}_t) + \lambda u_t. \tag{8}$$

Using our estimate of $\hat{P}_t$ and $\hat{y}_t$ from the forecasting equations, of $\lambda\alpha_1$, $\lambda\alpha_2$, and λu_t from the demand for money equation, and our measure of $\bar{r}_t$, it is possible to decompose the variance of $M_t - \bar{M}_t$ into variances and covariances of the terms on the right-hand side of the equation. For the period 1975III-1982III during which the targeting policy was in force, we find that the sum of the first two terms accounted for only 6.8 percent of the variance of $M_t - \bar{M}_t$, while the third term was responsible for 46.0 and the last term for 59.5 percent of the variance.[22] (The sum of the covariance terms was thus equal to -12.3 percent of the variance.) According to these estimates, the deviation of r from $\bar{r}$ played an important role in causing the divergence of M_t from $\bar{M}_t$. However, money demand residuals were also a major source of the divergence. This evidence would appear to support the Bank of Canada's explanation that its difficulties with controlling money growth have arisen from money demand instability.

We do not agree with this explanation. We present in the next section a framework alternative to the one the Bank has adopted that we believe is a more accurate analysis of the dynamics of interest rate control of money growth. In the following section we present an interpretation of the results from the first regression in Table 1 that suggests that the observed residuals in the money demand regression reflect an inadequacy in the conventional specification of the short-run adjustment mechanism rather than instability in the long run demand for money.

III. Money Supply and Demand Under Interest Rate Control: An Alternative View

In this section we first present a view of how the stock of money is determined under interest rate control that differs from the Bank's view, and then go on to discuss the interaction between money supply and demand.

Under interest rate control, the central bank attempts to fix the yield on (a certain class of) government securities by being ready to absorb any excess demand or supply at the fixed price. This policy amounts to making the supply of central bank domestic credit (assets of the central bank excluding international reserves) perfectly interest elastic. In addition, interest rate control generally provides commercial banks free access to reserves at a fixed interest rate.[23] If banks can freely vary their reserves, commercial bank credit (assets of banks excluding bank reserves) would also become perfectly interest elastic.[24] In this case, the entire banking sector could be viewed as willing to accommodate the demand for domestic credit (defined as the sum of commercial bank and central bank domestic credit) by the nonbanking public at the fixed rate. A change in the demand for domestic credit would then automatically produce a change in the money supply as a result of the nonbanking public's transactions with the banking sector. A change in the demand for domestic credit, moreover, need not produce a matching change in money demand. Thus if, according to the buffer stock approach, the money market does not clear instantaneously, then the stock of money would not be demand-determined and the conventional view would be undermined. The view we present below is one in which the stock of money is determined largely by the demand for domestic credit.[25]

The demand for domestic credit depends on the rates of return on alternative assets.[26] If these alternatives are very good substitutes for assets included in domestic credit, the demand for domestic credit would be sensitive to changes in rates of return on the substitutes and thus not likely to be very stable. Instability in the demand for domestic credit for this reason may produce considerable volatility in money supply under interest rate control.

For a country like Canada whose financial markets are well integrated with U.S. markets, movements in the foreign rate relative to the controlled domestic rate can trigger large changes in the demand for domestic credit. To highlight the role of shifts between domestic and foreign securities, consider a simple framework which abstracts from differences in securities due to risk, term of maturity, and other characteristics. Assume that all interest-bearing assets take the form of a riskless one period bond. Let r and r^{us} represent the yields on domestic and U.S. bonds, respectively. Also, let σ be the expected rate of change in the exchange rate (the price of U.S. dollars) so that $r^{us} + \sigma$ is the expected rate of return on the U.S. bond (in terms of domestic currency). In this simple framework, domestic credit (DC) would equal (for simplicity, we omit the time subscripts from equations (9) through (13) below)

$$DC = B - B^{n}, \qquad (9)$$

where B represents the total stock of domestic bonds and B^{n} is the stock held by the nonbank public.

As the money supply (MS) would equal the sum of domestic credit and international reserves (IR), we can express the rate of money growth as[27]

$$\Delta MS/MS = \Delta DC/MS + \Delta IR/MS. \tag{10}$$

Under interest rate control, ΔDC would equal the change in the demand for domestic credit. According to (9), moreover, the change in domestic credit would equal the difference between the change in the total supply of domestic bonds (ΔB) and that in the demand by the nonbank public (ΔB^n). While the flow of public and private borrowing would determine ΔB, shifts between domestic bonds and other assets, especially foreign bonds, would affect ΔB^n.

We present below a simple relationship explaining the change in domestic credit (divided by the money stock). Our purpose is to highlight the sensitivity of domestic credit to rates of return on domestic and foreign bonds. We expect an increase in $r^{us} + \sigma$ to cause a shift from domestic to foreign bonds and induce the sale of domestic bonds to the banking sector by the nonbank public and thus lead to a decrease in B^n. Similarly, an increase in r would be expected to cause an increase in B^n. Assuming that ΔB^n dominates the behavior of ΔDC, we posit the following relationship:

$$\Delta DC/MS = \delta_0 + \delta_1 (r^{us} + \sigma) + \delta_2 r + w_1 , \qquad \delta_1 > 0,\ \delta_2 < 0, \tag{11}$$

where w_1 is an error term representing the influence of other factors.[28]

Changes in international reserves (divided by the money stock) also represent another source of money growth. These changes would arise because of exchange-market intervention by the Bank of Canada. The primary objective of the Bank's intervention activity appears to be to smooth movements in the exchange rate.[29] Thus, we expect changes in international reserves to be inversely related to changes in the exchange rate. The amount of exchange market intervention may also depend on other objectives such as inflation or unemployment. As discussed above, movements in $r^{us} + \sigma$ relative to r would induce shifts between domestic and foreign bonds and thus put pressure on the exchange rate to move. The change in the exchange rate due to this source may be perceived by the Bank to be temporary, since according to the Bank's interest rate reaction function, r would be adjusted to r^{us} almost completely in the long run. The Bank therefore may intervene in the exchange market in response to movements in $r^{us} + \sigma$ and r (in addition to its response to the actual exchange rate change).

We thus consider an intervention function of the following form:

$$\Delta IR/MS = \Phi_0 + \Phi_1 (r^{us} + \sigma) + \Phi_2 r + X\Omega + w_2, \qquad (12)$$

$$\Phi_1 < 0, \ \Phi_2 > 0,$$

where X is a vector (identical with that in the interest-rate reaction function (6)) representing other objective variables including the rate of change of the exchange rate, Ω a vector of coefficients, and w_2 the error term in the relationship. Adding (11) and (12), we get the following "money supply" function:

$$\Delta MS/MS = \kappa_0 + \kappa_1(r^{us} + \sigma) + \kappa_2 r + X\Omega + \bar{w},$$
$$\kappa_1 = \alpha_1 + \Phi_1 > 0,\ k_2 = \alpha_2 + \Phi_2 < 0, \tag{13}$$

where $\bar{w} = w_1 + w_2$. Note that $r^{us} + \sigma$ exerts a positive effect on money growth through the domestic credit function, but a negative effect through the intervention function. On the other hand, r would exert a negative effect on money growth through the domestic credit function and a positive effect through the intervention function. Under a managed float, we would expect the net effect of $r^{us} + \sigma$ to be positive, while that of r to be negative, so that κ_1 would be positive and κ_2 negative. To explain these signs, consider, for instance, an increase in r^{us} that causes an excess supply of domestic bonds and a matching excess demand for foreign bonds.[30] Under interest rate control, the excess supply of domestic bonds would be fully accommodated and lead to an equal increase in DC. The extra demand for foreign exchange (arising from the excess demand for foreign bonds) would also equal the change in DC, but under a managed float would not be fully accommodated. In this case, the change in IR would be less (in absolute value) than the change in DC and thus intervention would provide a partial offset to the effect of domestic credit.

We now consider the interaction between the foregoing money supply function and the demand for money function discussed earlier. According to the buffer stock view, excess money balances would be run down gradually over time. On an individual level, one reason for the slow adjustment may be that in the presence of uncertainty, it is economical to take some time to search for information relevant to portfolio and spending decisions.[31] However, while individuals can reduce their money balances, the community as a whole cannot. The aggregate demand for money can adjust but the adjustment may be slow if the arguments of the demand for money change sluggishly. Although inertia in the price level and, to a lesser extent, in output is generally recognized, the critics of the buffer stock view argue that the interest rate would adjust rapidly to clear the money market. Under interest rate control, however, even this variable is temporarily fixed and cannot be relied on to eliminate excess money balances rapidly.[32]

Although the conventional specification of short-run money demand includes a partial adjustment mechanism, the mechanism does not adequately represent the buffer stock view. The basic problem is that while the partial adjustment mechanism incorporates gradual adjustment in the desired real stock of money to changes in the arguments of money demand, it does not allow for such adjustment in response to changes in money supply.[33] Carr and Darby (1981) have suggested that money supply shocks (unanticipated money) should be included in the partial adjustment mechanism. One problem with that approach, however, is that even some anticipated money may be held temporarily if the price level does not adjust fully to anticipated changes. Another issue is that unanticipated money would be correlated with the residual in money demand, which would make it difficult to obtain unbiased and consistent estimates of the effect of money supply shocks.[34]

As an alternative approach, we introduce the determinants of the money supply function (13) into the partial adjustment mechanism and rewrite this mechanism as:

$$m_t = \lambda m_t^* + (1 - \lambda)m_{t-1} + \beta_1(r^{us} + \sigma_t) + \beta_2 r_t + z_t,$$
$$\beta_1 > 0, \beta_2 < 0, \qquad (14)$$

where z is an error term which we expect to be correlated with $\bar{w}$, the error term in the money supply function. Note that β_1 has the same sign as κ_1 and β_2 the same sign as κ_2.[35]

To examine the implications of the modified partial adjustment mechanism for the short-term demand for money, we combine (14) with (1) and get

$$m_t = \gamma_0 + \gamma_1 y_t + \gamma_2 r_t + \gamma_3(r_t^{us} + \sigma_t) + \gamma_4 m_{t-1} + e_t,$$
$$\gamma_1 = \lambda\alpha_1, \gamma_2 = \lambda\alpha_2 + \beta_2, \gamma_3 = \beta_1, \gamma_4 = 1 - \lambda, e_t = \lambda u_t + z_t. \qquad (15)$$

As (15) shows, the term e_t would now reflect the error term in the demand for money as well as that in the supply function.[36] Moreover, the effect of r_t in (15) represents its influence through both the demand and supply functions. Finally, one interesting testable implication of (15) is that $(r^{us} + \sigma)$ would exert a positive effect on m_t.

The portfolio balance approach to the demand for money in an open economy suggests that the variables r^{us} and σ may also influence the desired stock of real balances. However, as explained below, the direction of the possible effect of r^{us} and σ via the demand for money would be opposite to that via the supply side. The long-run demand for money, according to the open-economy portfolio balance approach, can be written as (see Cuddington 1983):

$$m_t^* = \alpha_0 + \alpha_1 y_t + \alpha_2 r_t + \alpha_3(r_t^{us} + \sigma_t) + \alpha_4\sigma_t + u_t,$$
$$\alpha_1 > 0, \alpha_2 < 0, \alpha_3 \leq 0, \alpha_4 \leq 0. \qquad (16)$$

In (16), α_3 would be negative if foreign bonds and domestic money are gross substitutes and equal zero if there is no direct substitution between these assets. Similarly, α_4 would be negative if currency substitution is present and equal zero otherwise. Now, if we combine (14) with (16), we can rewrite short-run money demand as

$$m_t = \gamma_0 + \gamma_1 y_t + \gamma_2 r_t + \gamma_3^{'} r_t^{us} + \gamma_3^{''}\sigma + \gamma_4 m_{t-1} + e_t, \qquad (17)$$

$$\gamma_3^{'} = \lambda\alpha_3 + \beta_1, \ \gamma_3^{''} = \lambda(\alpha_3 + \alpha_4) + \beta_1,$$

where γ_1, γ_2, γ_4 and e_t are the same as in (15). Thus, estmation of the short-short-run money demand function would provide a clear-cut test of the presence of r^{us} and σ on the supply side, regardless of whether the true form of the function is given by (15) or (17). If $\beta_1 = 0$, $\gamma_3 = 0$ in (15) while $\gamma_3^{'} < 0$ and $\gamma^{''} < 0$, according to (17).[37]

IV. Empirical Evidence on the Money Supply Process and the Short-Run Demand for Money

In this section we present evidence on supply functions explaining money growth and its components, and on the short-run demand for money incorporating the modified partial adjustment mechanism.

Each equation is initially estimated, using OLS. To avoid simultaneous equation bias, the key equations are reestimated using a two-stage least squares procedure. The instruments used in this procedure were based on the model of the Bank's reaction function discussed in section II above.

One problem with estimating both the supply and demand functions for money is that no reliable measure of σ is available. As a proxy for σ, we used f-s where f and s denote, respectively, the logarithms of forward and spot exchange rates. As is well recognized, this measure would be subject to error in the presence of a risk premium. Thus, when using this measure, the coefficient of σ was not constrained to be equal to that of r^{us}.[38] Another potential difficulty with the use of f-s along with r and r^{us} is that interest rate arbitrage would lead to a high degree of multicollinearity among these variables. This problem, however, was not severe in the data set we used. The simple correlation between r and (r^{us} + f-s) was .91, and thus not very close to a perfect linear relationship.[39]

Table 2 presents the supply side regressions for the flexible exchange rate period 1970III-1983I. Row 1 of the table shows OLS estimates of the domestic credit equation (11). All variables in this equation are highly significant and have the expected signs. In estimating the intervention function, we first tried a conventional form in which $\Delta IR/MS$ depends only on the X variables, representing the expected rate of inflation, the rate of change in the spot exchange rate and the expected unemployment rate.[40] Of these only the first two variables, $\Delta\hat{P}$ and Δs, were significant, and the estimated equation including these variables is shown in row 3 of the table. Then we estimated an extended intervention function according to (12), which also includes r^{us}, r, and f-s.[41] As shown in row 4 of the table, the additional variables are significant and have signs opposite to those in the domestic credit equation.

To facilitate a comparison between the international reserve and the domestic credit equations, we also introduce $\Delta\hat{P}$ and Δs into the latter equation in row 2 of the table. As the estimates show, although these additional variables are insignificant, their effect on $\Delta DC/MS$ is of the opposite sign and about the same magnitude as that on $\Delta IR/MS$. Comparing rows 2 and 4, it is also clear that the coefficients of the three variables, r, r^{us}, and f-s are all larger, in terms of their absolute values, in the domestic credit than in the international reserve equation. The results confirm the hypothesis that under a managed float, the effects of r, r^{us}, and $f-s$ operating through the domestic credit function would dominate the money supply process.

The estimates of the money growth equation with the same variables as in rows 2 and 4 are shown in row 6 of the table. As discussed above, the net effect of $\Delta\hat{P}$ and Δs on money growth is close to zero. The money growth equation excluding these variables is shown in row 5. As r and $f-s$ are endogenous variables, we also estimate this equation using two-stage least squares and present the estimates in row 7 of the table. The instrumental variables used to obtain these estimates represent the variables entering the Canadian interest rate reaction function (r_{t-1}, r^{us}, $\bar{r}$, and D) and the lagged value of $f-s$.[42] The effect of r and r^{us} now becomes larger (in absolute value) and remains significant. The effect of $f-s$, however, is not significant. This result may reflect the measurement error problem mentioned above.

Next we examine the role of the supply side factors in the demand for money. In table 1 we present estimates of the short-run money demand equation of the form (15) in rows 2 and 3, using the ordinary least squares and two-stage least squares procedures, respectively. As y represents an additional endogenous variable in the money demand relationship, the list of instrumental variables now includes additional variables relevant to predicting y. The additional variables represent y^{us} (U.S. output measured in logarithms) as well as the lagged values of certain Canadian variables used in the forecasting equation developed in section II to measure $\bar{r}$.[43]

The results reported in table 1 support the view that supply-side considerations matter in the adjustment mechanism. As the results show, r^{us} exerts a positive and significant effect on the real stock of money. This evidence is inconsistent with the conventional closed-economy formulation in which r^{us} would be absent from the money demand function. It is also inconsistent with the conventional open-economy variant where r^{us} would have a negative effect on the demand for money. The f-s variable which did not survive the two-stage money supply regression was also found not significant in the two-stage money demand regression. Finally, it is interesting to note that the introduction of r^{us} in the money demand regression increases the absolute value of the coefficient of r. In the two-stage regression, this coefficient is equal to -1.33. In the absence of supply side factors in the adjustment mechanism ($\beta_1 = \beta_2 = 0$), such a value would imply a long-run interest elasticity equal to -1.23 (at the average value of the interest rate over the the given period).[44] This estimate of the long-run elasticity would appear to be too large in relation to previous estimates.[45] If the modified adjustment mechanism is used, however, the coefficient of r would also include the supply side effect (recall $\gamma_2 = \gamma\alpha_2 + \beta_2$) and the implied long-run interest elasticity could be considerably lower.

V. Conclusions and Implications

Three conclusions emerge from the study of the Bank of Canada's use of an interest rate control procedure to determine monetary growth. The first conclusion is that under the interest rate procedure, for an open economy such as Canada, foreign shocks cause disturbances to the money supply through the domestic credit market. Canada's use of an interest rate as its policy instrument for controlling money growth thus leads to a hitherto unrecognized channel of interdependence. When interest rates rise in the United States, the Canadian nonbank public will switch from domestic to foreign bonds. Under interest rate control, the authorities and the banking sector will buy all domestic bonds that are offered by the public, with expansionary effects on money growth. This effect represents a channel that is additional to the Bank of Canada's direct response to changes in U.S. interest rates through a domestic interest rate reaction function -- a well understood channel of interdependence.

A second conclusion is that variability in money growth attributable to foreign shocks can easily be misinterpreted as instability in the demand for money. The reason for the misinterpretation is that the conventional specification of the short-run mechanism by which actual real money balances adjust to desired real money balances is inadequate. We argue in the paper that money supply disturbances should be included in the adjustment mechanism, and that these disturbances could account for apparent shifts in the demand for money.

A final conclusion is that use of an interest rate as the policy instrument is a mechanism that may be incompatible with the objective of stable money growth. The basic problem is that the demand function in the credit market is likely to be very sensitive to the differential between the rate the authorities set and the rate of return on close substitutes. Movements in rates of return on substitutes relative to the controlled interest rate would shift the demand function for credit and change the money stock. In an open economy, foreign securities are a close substitute for domestic credit and changes in rates of return on foreign assets are an important source of monetary variability.

The foregoing considerations suggest that a policy of money growth targeting through the use of an interest rate control procedure is doomed to failure even if there is no conflict with other objectives. Even if the central bank takes into account the role of domestic credit in the determination of money growth, large movements in money growth could still occur because of large unanticipated changes in the demand for domestic credit in response to changes in the rate of return on alternative assets.

This paper implies that the behavior of money growth would be different under reserve control. Suppose that the Bank's money supply procedure were based on reserve control. It would provide the banks the reserves that would be adequate to support the growth rate of the money supply that it deemed appropriate. If it ignored the movements in U.S. interest rates, Canadian nationals might still choose to switch from domestic to foreign bonds with initially higher U.S. interest rates, but the nonbank public would not find ready buyers in the banking sector for their domestic bonds. The yields on domestic bonds would therefore rise to match the U.S. interest rate, and money supply growth would be unaffected.

Again, under reserve control, the effect of exchange rate management on the money supply could be completely sterilized, but the Canadian interest rate would have to move to clear the credit market.[46] In those circumstances, there would be no link between U.S. interest rates and Canadian money growth. With exchange market intervention not fully sterilized, reserve control would be weakened.

All things considered, in our judgment if the objective of the Canadian monetary authorities is to achieve control of the money supply process, the interest rate procedure is a self-defeating means. For an open economy, that procedure will heighten interdependence.

APPENDIX: Data and Sources

D: A dummy variable equal to 1 for the money targeting period 1975III-1982III, and zero for the remaining period.

DC: Domestic credit, billions of Canadian dollars, defined as MS-IR.

f: Natural logarithm of the forward Canadian dollar exchange rate, average of monthly figures. Source: IFS Financial Statistics.

IR: Total reserves minus gold, determined as the product of the IFS series expressed in U.S. dollars with the Canadian spot dollar exchange rate. Billions of Canadian dollars, average of monthly figures. Source: IFS Financial Statistics.

MS: Money supply M1, billions of Canadian dollars, seasonally adjusted. Source: Federal Reserve Bank of St. Louis.

M Natural logarithm of MS.

$\bar{M}$ Natural logarithm of the mid-value of the target money stock calculated according to the procedure outlined in note 11, converting the Bank's announcements to a quarterly basis. Source: Bank of Canada Review, various issues, for the announcement of money growth targets.

m: Natural logarithm of real cash balances, defined as M-P.

P: Natural logarithm of the Canadian Implicit Price Deflator (1971 base). Source: Federal Reserve Bank of St. Louis.

r: Short-term Canadian interest rate, average of monthly figures. Morgan-Guaranty representative money market rates. Source: Federal Reserve Bank of St. Louis.

r^{us}: idem for the U.S.

s: Natural logarithm of the spot Canadian dollar exchange rate. Average of monthly figures. Source: IFS Financial Statistics.

UN: Canadian unemployment rate. Source: OECD Main Economic Indicators.

y: Natural logarithm of Real Gross National Product (billions of Canadian dollars), seasonally adjusted. Source: Federal Reserve Bank of St. Louis.

Footnotes

[1]According to DeGrauwe and Fratianni (1984, Table 5), for example, correlations of the average annual growth rates of M1 of 7 major countries increased in 1971-81 compared to 1960-70. Also see McKinnon (1982, 1984), and Dornbusch and Fischer (1984).

[2]Some examples are Canada, Germany and the U.K. See Federal Reserve Bank of New York (1983), pp. 102-4, 22-4, 54-9.

[3]The Bank of Canada announced: "It would not seem appropriate for the time being to have an underlying rate of monetary growth below 10 per cent per year, but that on the other hand, an underlying rate of 15 per cent would be too high" (statement by Governor Bouey in testimony before the House of Commons Standing Committee on Finance, Trade and Economic Affairs, November 6, 1975). Courchene (1977), p. 27. Subsequent announcements gradually lowered the average target rate to 6% by February 1981. The target range was also narrowed from 5 to 4 percentage points.

[4]The simple correlation of quarterly Canadian M_1 money growth with U.S. short-term interest rates is .58 for 1979IV to 1983I.

[5]The standard deviation of the quarterly rate of change of the U.S. 3-month T-bill rate increased from .012 1970III - 1979III to .029 1979IV - 1983I. In October 1979, the Federal Reserve System changed its monetary control variable, substituting nonborrowed reserves for the Federal funds rate. It is widely believed that this change in the monetary control variable is responsible for wider variability in both U.S. money growth and interest rates. (See Friedman (1984), Mascaro and Meltzer (1983).

[6]See, for instance the Governor's Remarks (Bank of Canada Review,

September 1982):

"Notwithstanding the contribution of monetary targeting in getting monetary policy to a better track, practical problems have emerged in Canada, and I expect other countries as well, which have reduced the usefulness of these targets as policy guides... ...Perhaps the most troublesome problem in Canada is that the relationship between our target monetary aggregate--M1--and the level of spending has not turned out to be as stable as it appeared in the mid-1970's."

[7]See e.g. Lucas (1984).

[8]See Carr and Darby (1981) for a related shock-absorber view of money. See also Judd and Scadding (1981) and White (1981).

[9]See, for instance, White (1979) for such an interpretation.

[10]See, for instance, Clinton (1973), Gregory and Mackinnon (1980), Poloz (1980), Bordo and Choudhri (1982).

[11]The Bank actually announced target rates of growth measured with reference to a specified base period. It is possible, however, to calculate $\bar{M}_t$ as follows: $\bar{M}_t = M_{t-n} + \bar{g}n$, where M_{t-n} is the logarithm of the money stock in the base period t - n and $\bar{g}$ is the mid value of the announced target range.

[12]See Parkin (1981). Also see Courchene's (1979) discussion of the Bank's approach.

[13]According to the Bank (1982a, p. 27), "The Bank thus never regarded its M1 target system as some sort of automatic pilot for monetary policy. In the short run it was something to be taken into account along with other considerations."

[14]Since the Bank of Canada believes that it "can exert a substantial degree of influence over interest rates at the short end of the maturity spectrum" (Federal Reserve Bank of New York, 1983, p. 100), in our empirical work we use a representative short-term interest rate -- the same rate that we use in the demand for money regressions below. Representative short-term rates include the Treasury bill rate, the rate on 90-day finance company paper, and the call money rate.

[15]To test the possibility that postal strikes during this period had a significant impact on the demand for money, we reestimated the demand for money regressions with dummy variables for major postal strikes. Although some postal strike dummies were significant, they did not affect the results much. We have omitted them from the regression equations shown in the table to simplify the presentation.

[16]In the forecasting equations, we used first differences of quarterly P and y. ΔP and Δy were both regressed on their own four lagged values as well as four lagged values of a number of Canadian macro variables. In addition to ΔP and Δy, we included Δr, ΔM, Δs and ΔU, where s is the logarithm of the spot exchange rate and U the unemployment rate. The four lagged values of these variables were retained in the forecasting equation only if they were jointly significant at the 5% level. (The forecasting equation for Δy included lagged values of ΔM and ΔU in addition to own lagged values. The equation for ΔP, however, did not retain any variable except own lagged values.) The predicted value of y_t is defined as y_{t-1} plus the predicted value of Δy_t.

[17]We used quarterly data because the estimates of the money demand func-

tion discussed above are quarterly.

[18]We assume that while the exchange rate is observed immediately, the information on the rates of inflation and unemployment becomes available to the Bank with a lag. The expected rates of inflation and unemployment, however, were estimated according to the procedure discussed in note 16 which assumes a one quarter information lag. As the actual information lag may have been shorter, we also introduced unexpected rates of these variables in the regression but found these to be insignificant.

[19]Expected changes in the unemployment rate as well as the inflation rate were also tried but turned out to be insignificant.

[20]Our measure of $\bar{r}$ would, of course, not be exactly the same as the $\bar{r}$ that the Bank may have utilized. In some respects, we may have assumed that too little information was available to the Bank, but in other respects, too much. Information lags, on the one hand, may be considerably less than one quarter, but on the other hand, the estimates of money demand that we used are based on the data for the whole period. It is also possible that rather than basing r on $\bar{r}$, the Bank may have followed a policy simply of reacting to the last-period deviation of the money stock from its target value (see Courchene 1979). In an alternative version of the reaction function, we replaced $(\bar{r}_t - r_{t-1})$ by $(M_{t-1} - \bar{M}_{t-1})$ but found that the latter target variable produced similar results.

[21]See also Gregory and Reynauld (1985) who reach similar conclusons using a different form of the reaction function.

[22]The relative importance of the money demand residual in explaining the deviation of M_t from $\bar{M}_t$ is very similar in the period since late 1979. For

the period 1979IV to 1982III, the variance of λu_t accounts for 58% of the total variance of $M_t - \bar{M}_t$ as compared to 44% for the third term and 8% for the sum of the first two terms in (8).

[23]In the Canadian system, less emphasis is placed on open market operations than in the United States. The Bank of Canada sets Bank Rate at which recognized money market dealers -- as in the United Kingdom -- can borrow from the central bank. The Bank can alter bank reserves by the use of government deposit transfers, augmenting reserves by transfers of the deposits to chartered banks, diminishing reserves by transfers of the deposits to the Bank. With fewer than a dozen chartered banks, the Bank can also rely on moral suasion. Chartered banks are subject to a fixed 12% primary reserve ratio on demand Canadian dollar liabilities and 4% on savings deposits. A secondary reserve ratio -- the ratio of the sum of Treasury bills, call loans, and cash in excess of the primary reserve requirement to total Canadian dollar liabilities -- to which the chartered banks are subject, may be varied by the Bank from 0% to 12%. If actual reserves of the chartered banks fell short of the reserves provided by the Bank, the chartered banks could reduce their call loans and force the money market dealers to borrow from the Bank. The chartered banks could also buy Treasury bills in the open market to meet any secondary reserve deficiency. See Courchene (1976, pp. 11-31).

[24]The term commercial bank credit is sometimes used to refer to bank loans. Here we do not emphasize the distinction between bank loans and other earning assets of commercial banks.

[25]See Laidler (1980) who refers to the conventional view as the money-market view and the alternative view as the credit-market view.

[26]Alternative assets refer to financial assets other than those included in the balance sheets of the consolidated banking sector. These alternatives would include equities and would represent foreign as well as domestic assets.

[27]In the empirical work discussed below, MS is defined as narrow money. Time deposits are thus being aggregated with other interest-bearing assets.

[28]As our main concern is with the role of r and $r^{us} + \sigma$ in the domestic credit function, we did not explore, in our empirical estimation of (11) below, the possible influence of other variables such as an index of wealth. We did, however, consider the possibility that if the adjustment of actual to the desired stock of domestic credit is completed in each period, the change in the demand for domestic credit may depend on first differences rather than levels of the rates of return. We tried a domestic credit function with $\Delta(r^{us} + \sigma)$ and Δr as the arguments, but found that this variant did not perform as well as (11) above.

[29]See Canada. Department of Finance (1982), and Federal Reserve Bank of New York (1983, p. 103), for a discussion of the Bank of Canada's reaction to movements in the Canadian exchange rate relative to the U.S. dollar.

[30]We exclude from this simple example a shift from domestic money or equities into foreign bonds.

[31]It has been argued that while there may be significant transactions costs of switching from broad money to other assets, these costs are low for shifts between narrow money and time deposits. See, for example, Goodfriend (1984).

[32]As Laidler (1984) suggested, even if the interest rate is flexible, it

could clear the credit market but need not imply clearing of the money market, if some other market, such as the capital goods market, does not clear rapidly and is therefore characterized by excess demand or supply.

[33]An alternative interpretation of the partial adjustment mechanism, suggested by Goodfriend (1984), is that the mechanism could represent errors in the measurement of the arguments in the demand for money.

[34]See McKinnon and Milbourne (1984).

[35]We expect, however, that $\beta_1 < \kappa_1$ and $|\beta_2| < |\kappa_2|$. As discussed in the next section, X variables in (13) did not turn out to be significant and thus we have not included them in (14).

[36]Note that the residuals in the regression equation in row 1 of table 1 would now represent not only e_t but also the effect of the omitted term $r^{us} + \sigma$.

[37]A positive effect of r^{us} on m_t would also be implied by currency-substitution models which assume $r-r^{us}$ to be a measure of σ. For instance, in the special case of perfect interest arbitrage and zero risk premium, $r-r^{us}$ would exactly equal σ. Substituting $\sigma = r-r^{us}$ in (17) and rearranging, the coefficient of r^{us} would equal: $\gamma_3' - \gamma_3'' = -\lambda\alpha_4$, which would be positive with $\alpha_4 < 0$. However, if there are departures from the above special case, the currency-substitution model can be discriminated from the supply-side effects by estimating the money demand function of the form (17), which includes σ as well as r and r^{us}. In this form, the coefficient of r^{us} must be negative or zero according to the currency-substitution model when the supply-side effect is absent. Also see note 38 below.

[38]Note that if f-s is a poor proxy for σ because of the presence of the

risk premium, $(r-r^{us})$ would also be a poor proxy for σ. For instance, let $f-s = \sigma+\rho$, and $r-r^{us} = f-s+\varepsilon$, where ρ is the risk premium and ε represents departures from perfect interest rate arbitrage. It follows that $r-r^{us} = \sigma+\rho+\varepsilon$. As there is no reason to suspect a systematic negative association between ρ and ε, $r-r^{us}$ in fact would provide a noisier signal on σ than f-s.

[39]The implied departure from interest rate arbitrage may be due to transactions costs. There may also be measurement errors in that the reported data for f and s may not represent the true transaction values.

[40]The expected values were estimated using the procedure discussed in note 16. Because of the caveat discussed in note 18, unexpected rates of inflation and unemployment were also considered as additional variables in the regressions but these variables were not significant.

[41]The coefficients of the reaction function were stable betwen subperiods with and without the target policy, according to the F-test at the 5% level.

[42]The lagged value of f-s was significant in a regression of f-s on r and r^{us}.

[43]The complete list of instrumental variables for this regression includes r_t^{us}, r_t, D, $(f-s)_{t-1}$, y^{us}, y_{t-1}, and four lagged values of ΔU_t, ΔM_t, and Δy_t.

[44]In the semilog money demand function that we use, the long-run elasticity at r_0 would equal $\alpha_2 r_0$. From (15) (with $\beta_2 = 0$), $\alpha_2 = \gamma_2/\lambda$. The value of the interest elasticity in the text is calculated using estimates of γ_2 and λ from regression 3 in table 1 and letting $r_0 = .097$ (the average value of r over the period).

[45]Previous studies tend to find the long-run elasticity of money demand (defined as a positive value) considerably less than one. See, for example, Laidler (1977).

[46]It is interesting to note, however, that under interest rate control, exchange rate management may not be inferior on grounds of money growth variability, since in the absence of such a policy, the differential between Canadian and U.S. interest rates might be greater leading to greater monetary variability.

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Table 1

The Canadian Short-Run Demand for Money, Quarterly Data, 1970III - 1983I

	Constant	y	r	r^{us}	f-s	m_{t-1}	R^2	DW	h	SEE
1.	.01 (.06)	.06 (1.69)	-.53* (-4.79)			.90* (24.04)	.947	2.24	-.88	.0176
2.	-.05 (-.34)	.08* (2.15)	-1.09 (-4.85)	.59* (2.81)	.23 (1.66)	.88* (24.72)	.955	2.20	-.73	.0165
3.[a]	-.12 (-.77)	.10* (2.53)	-1.33* (-4.79)	.78* (2.91)	.30 (1.38)	.87* (23.62)	.954	2.12	-.45	.0168

Note: The dependent variable is m_t. * indicates significance at 5% level. See appendix for data and sources.

[a] Represents two-stage least squares estimates. See footnote 44 for the list of instrument variables.

Table 2

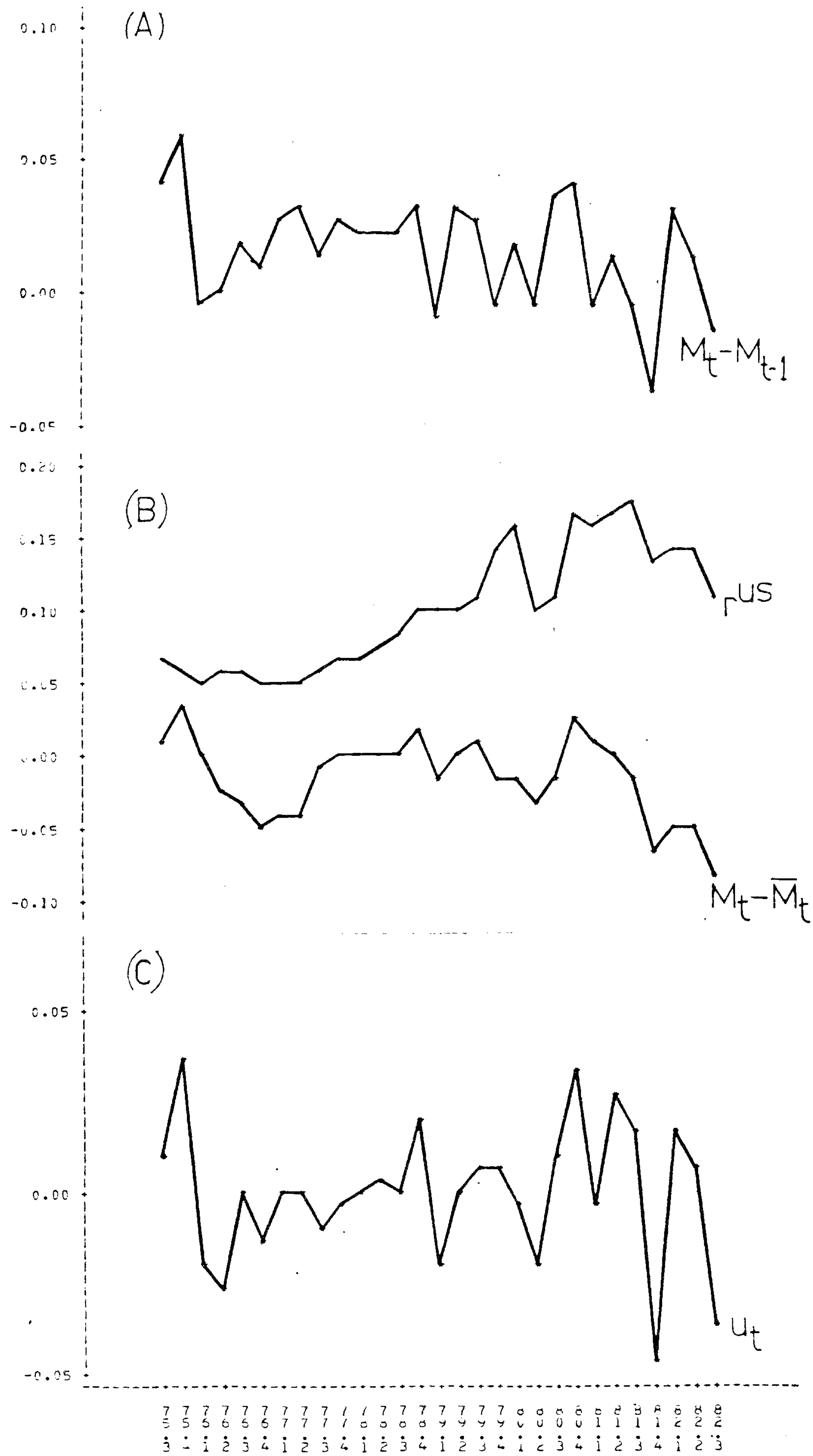
Equations Explaining Growth of Canadian Money Supply and its Components
Quarterly Data, 1970III - 1983I

	Dependent Variable	Const.	r^{us}	f-s	r	ΔP	Δs	R^2	DW	SEE
1.	ΔDC/MS	.03* (3.25)	1.31* (4.45)	.79* (3.97)	-1.35* (-4.92)			.35	1.66	.0235
2.	ΔDC/MS	.02 (1.27)	1.19* (3.92)	.69* (3.22)	-1.32* (-4.64)	.98 (1.36)	.31 (1.35)	.41	1.89	.0230
3.	ΔIR/MS	.02* (2.60)				-.95* (-2.26)	-.48* (-3.21)	.26	2.40	.0164
4.	ΔIR/MS	.03* (3.30)	-.61* (-3.06)	-.44* (-3.16)	.55* (2.95)	-1.04* (-2.20)	-.28 (-1.88)	.41	1.92	.0152
5.	ΔMS/MS	.04* (7.09)	.59* (2.83)	.25 (1.82)	-.78* (-4.07)			.38	2.13	.0165
6.	ΔMS/MS	.05* (4.70)	.58* (2.59)	.24 (1.56)	-.77* (-3.68)	-.06 (-.12)	.03 (.16)	.38	2.13	.0169
7.[a]	ΔMS/MS	.04* (6.53)	.84* (2.32)	.46 (1.35)	-1.03* (-3.04)			.35	2.06	.0169

Note: MS represents the average of the current and the lagged value of the money stock.
* indicates significance at 5%. See appendix for data and sources.

[a]Represents two-stage least squares estimates, using r_{t-1}, r^{us}, $\bar{r}$ and D as instruments.

Figure 1: The Behavior of Canadian $M_t - M_{t-1}$, r^{us}, $M_t - \bar{M}_t$, u_t, 1975III - 1982III



Note: See Appendix for definitions.