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**MONETARY BASE AND MONEY STOCK IN CANADA**

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## ABSTRACT

In this report, the authors consider some Canadian evidence related to the control of the money supply. At issue is the relative efficacy of monetary-base control versus a method of control wherein short-term interest rates are adjusted to keep the money supply on target. This study examines certain problems involved in the implementation of both types of money-supply control in the context of Canadian institutional arrangements. Two basic issues are investigated empirically: causality and stability. Finally, representative money-multiplier and money-demand equations are estimated for Canada and simulations are presented in order to compare their relative forecasting abilities.

# RESUME

Dans ce rapport, les auteurs étudient l'expérience canadienne en ce qui a trait au contrôle de la masse monétaire. Le principal problème qui retient leur attention est celui de l'efficacité du contrôle de la base monétaire comparativement à la méthode de contrôle qui utilise des ajustements des taux d'intérêt à court terme pour maintenir la masse monétaire dans les limites visées. Les auteurs examinent aussi certains problèmes soulevés par la mise en oeuvre de chacun de ces types de contrôle monétaire à l'intérieur du cadre institutionnel canadien. Ils analysent de façon empirique deux questions fondamentales, la causalité et la stabilité. L'étude comporte aussi une estimation des équations standard de multiplicateurs de la monnaie et de celles de la demande de monnaie et se termine par des simulations qui permettent de comparer les pouvoirs prédictifs de ces équations.

## INTRODUCTION AND CONCLUSIONS

A controversy has developed in recent years concerning control of the money supply. Monetarists contend that the most expedient way to obtain growth of the money supply at a specified rate is for the central bank to supply reserve assets at that rate, with modifications to take account of predictable movements in the bank deposit multiplier (e.g. Courchene, 1976b and Burger, 1972). Central banks on the other hand, notably the Bank of Canada and the Federal Reserve System, prefer a method of control that exploits the interest elasticity of the demand function for money: short-term interest rates are adjusted to keep money supply on target.

In this paper we consider Canadian evidence related to this issue. Monetarists believe (a) that changes in money supply are predominantly caused by changes in the base, and (b) that movements in the ratio of money to reserve assets (the multiplier) are relatively easy to predict. Thus there are two issues at stake, both of which can be investigated empirically: causality and stability. Once outside the confines of the textbook money multiplier, however, empirical testing presents some thorny conceptual problems.

First, a variety of definitions can be used for both money supply and the reserve base. In this study we concentrate on two definitions of the privately held money supply: M1 (currency in circulation plus privately held demand deposits excluding float) and M2C (currency plus total Canadian dollar privately held bank deposits). We also examine the behaviour of total Canadian dollar chartered bank deposits alone (i.e. M2C minus currency). The monetary base is defined as currency in circulation plus bank reserves minus reserves required against federal government deposits. The latter item is excluded for consistency with our money-supply definitions, all of which exclude federal government deposits. A narrower concept, net bank reserves, defined as bank reserves less reserves required against government deposits and against items in transit (float), is also analyzed. A second problem concerns the time horizon. We are concerned in this paper only with short-run control of the money stock. As a long-run proposition, controlling the rate of growth of money supply does in fact require the Bank of Canada to sustain growth in reserve assets at a rate approximately equal to the target money-growth rate[1], with due allowance made for trends in the multiplier. The Bank does not attempt to set an interest-rate target for anything beyond the very short run. The monetarist position, however, is that even in the short run the link is sufficiently tight to allow accurate control of money through manipulation of the base. This position is not made conditional on changed institutional arrangements, although a change to uniform contemporaneous reserve requirements is strongly favoured.

1. With the Bank of Canada's current operating procedure this would be a consequence of attaining target money-growth rates rather than the cause.

How stable the money multiplier might be in a reformed system is a matter for conjecture, not for empirical research since the data reflect response to existing legislation.

We reach several conclusions. First, that the relationship between base and money supply is much looser than the monetarists have implied. There is substantial variation in the multiplier over the short run for all definitions of money and reserve assets. Although it is true that it is the unpredictability rather than the variability of the money multiplier that hinders monetary control, the range of variation is such that it puts the burden of proof on those who contend that the movements are easily predictable. For example, over the period January 1970 to December 1976 the standard deviation of the difference between the annualized monthly growth rate of M1 and of the monetary base was approximately 22 percent; between M2C and the monetary base it was a little greater at 23 percent, and between total private Canadian dollar deposits and net reserves it was nearly 43 percent. Our second conclusion, evident from these growth-rate differentials, is that the relationship between broad money and the base is not significantly closer than that between narrow money and the base. In addition, these data show that if the Bank of Canada attempted to control M2C through bank reserves, passively accommodating changes in currency demand, a significant controllability problem would remain, given the looseness of the relation between total bank deposits (i.e. M2C minus currency) and bank reserves. There is therefore no evidence in favour of broad money as a monetary target on the grounds of more tightly controlling the money supply. Third, the findings contrary to the monetarist position are strongly enhanced by evidence that emphatically demonstrates causality running from money to the base. The historical association observed between the two arises primarily from the influence of deposits on bank reserves, not vice versa, so that the existing correlation, weak though it may be, could give an exaggerated impression of how well the money supply could be controlled via the base. Moreover, a change of regime towards base control would destroy the very process that underlies the correlation on which policy makers would supposedly rely.[2]

In view of our findings, it seems inevitable that any attempt to use the base to control the growth of a monetary aggregate would involve fine tuning of the base, with a day-to-day decision on the cash reserve setting - which is precisely what current operating procedures involve. The gains in simplicity or in information to the banking system, which seem to be a major virtue of the monetarist recommendation of an announced target for bank reserves couched in terms of its effect on monetary growth, would simply not materialize.

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2. Compare Lucas' critique (1976) of econometric models used to evaluate alternative policy rules.

## 1 MOVEMENTS IN MONEY MULTIPLIERS

To illustrate the relation between money and reserve assets, the ratios of M1 and M2C to the monetary base are plotted in Figure 1. Also plotted is the ratio of total private deposits to net bank reserves (the bank-deposit multiplier). Although it is evident that these ratios vary considerably over time, the variations, if they are predictable, need not impede control of the money supply.

A classic case is that of an exogenous withdrawal of deposits from the banking system by the public. Since central banks are concerned only with total money supply and not with its composition, the standard central bank response is to replenish bank reserves automatically. The problem that this poses for empirical testing is that the monetary base grows more rapidly than the money supply, giving the impression that the link between money and the base is loose. Yet the central bank has not allowed the currency drain to effect bank reserves in such a way as to push money off target, and its control over the money supply is maintained.[3] Thus the bank-deposit multiplier is possibly a more relevant measure of the potential accuracy of base control, because it is not affected by currency movements. It can be seen from Figure 1, however, that the bank-deposit multiplier is no less variable than the money multipliers.

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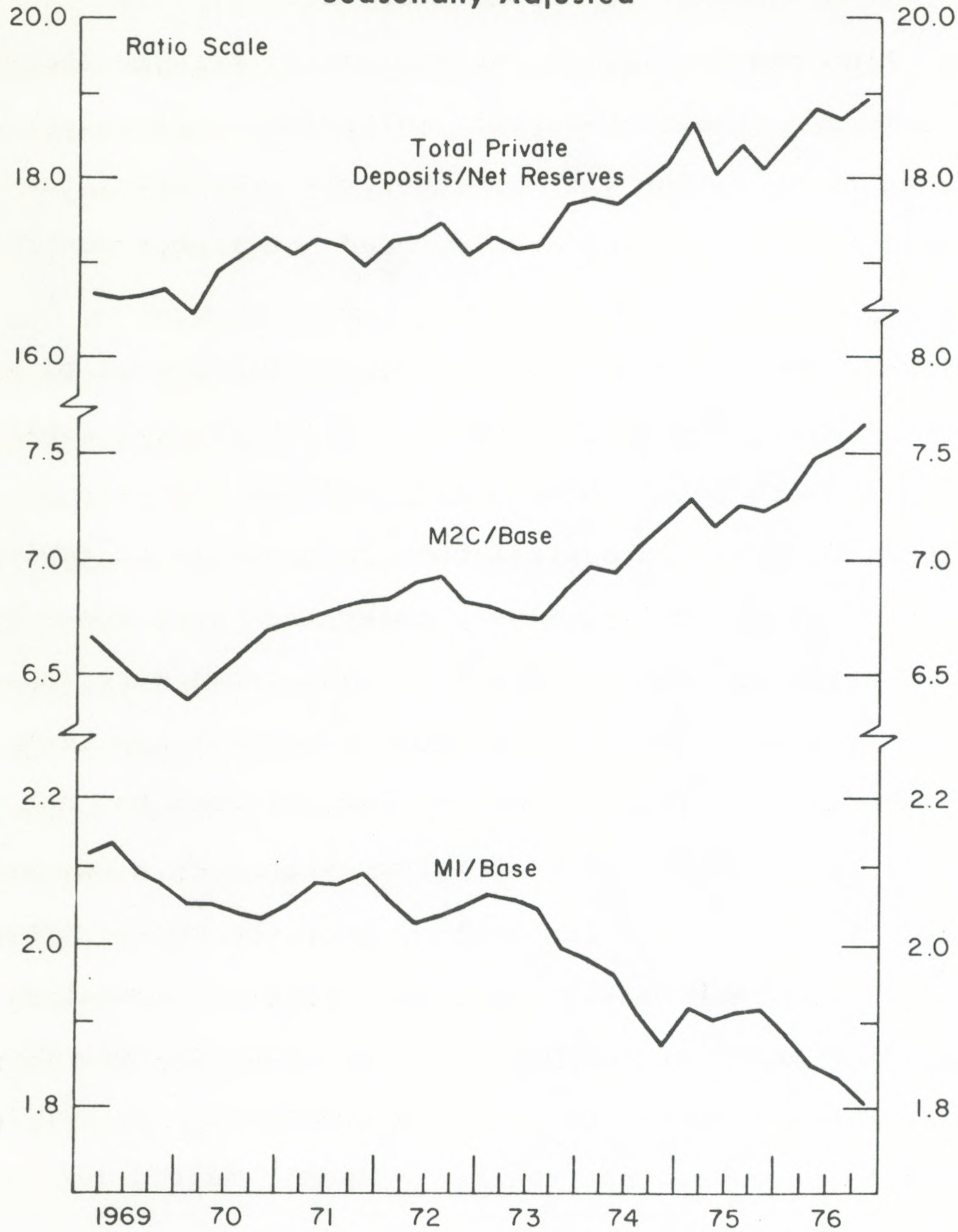
3. Notice that a strict rule for monetary policy defined in terms of growth of the monetary base would forbid this response, denying the central bank a role that since Bagehot (1873) has been widely accepted as one of its major functions.

Figure 1

**RATIOS OF MONETARY AGGREGATES TO RESERVE ASSETS**

**Seasonally Adjusted**



Other changes in the mix of financial assets can also disturb the multiplier. Changes in the money multiplier can be attributed to changes in any of five ratios: (1) time to demand deposits (due to different reserve requirements); (2) statutory to current deposits[4] (it is the latter that the Bank seeks to control but reserves are required only against the former); (3) excess reserves to deposits; (4) float to deposit; and (5) currency to deposits. Whatever the source, instability in the multiplier does not of itself render precise control of the money supply through the base impossible. If changes are anticipated, an offsetting manipulation of bank reserves can contain them as in the example of the currency drain. However, the magnitude of the variations in Figure 1 is sufficient to raise doubts about their predictability, a point worth emphasizing. This is especially true given the tendency among monetarists to regard targets expressed in terms of base and M2C as virtually coterminous,[5] so that the multiplier for broad money is asserted to be either stable in value or at least to have a stable trend rather than merely a stable function of readily observed variables. Since, on the basis of this assertion, monetarists make strong policy recommendations regarding the ease and desirability of controlling money exactly to a predetermined course, it is worth while to look

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4. Statutory deposits are lagged actual deposits, equal to the average of deposits on the four Wednesdays ending with the second last Wednesday of the preceding month. Current monthly deposits are simply the average of Wednesdays' deposits in this month.
5. Courchene (Dec. 1976, p. 48).

at the information contained in Figure 1 in terms of growth-rate differentials between money and base. This is done in Table 1, which gives the growth rate of the base itself, the differences in the growth rates of broad and narrow money from that of the base and also the difference in growth between total privately held deposits and net bank reserves. With a stable trend in the multiplier these differentials would be approximately constant from one year to another - in the limit zero for a stable multiplier. It is immediately obvious that they are neither constant over time nor zero. Thus the data refute that a policy of constant growth in the base could have produced constant growth in money over the past decade. The difference between private deposits and net reserves shows this to be true even if the effects of changes in currency and float were perfectly offset by reserve management. To illustrate the degree of imprecision, assume that the trend in the value of the multiplier is perfectly predictable (i.e. a negative trend for M1, positive for M2C), so that only the variance of the growth-rate differentials around their means is liable to produce unintended movements in money. Then with, for example, the broad definition of money the standard deviation of 2.1 percent implies that after allowing for the trend in the value of the multiplier a confidence interval[6] of $\pm$ 4.2 percent at the minimum surrounds the likely outcome of growth in M2C in a year, given growth in the base.

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6. If the conventional two times standard deviation approximation to the .95 probability level is used. We emphasize here that conditional statements of this kind are not really valid given results presented below which show that base is not exogenous with respect to money.

Table 1 PERCENTAGE GROWTH RATES OF RESERVE ASSETS AND MONETARY AGGREGATES - ANNUAL DATA - 1970-76*

| | Growth rate of base | Differences in rates of growth | | |
|---|---|---|---|---|
| | | M1 and base | M2C and base | Privately held deposits and net bank reserves |
| 1970 | 5.5 | -3.2 | 0.0 | 1.9 |
| 1971 | 11.0 | 1.8 | 3.5 | 1.0 |
| 1972 | 15.8 | -1.9 | 1.7 | 0.8 |
| 1973 | 14.6 | -0.2 | -1.2 | 0.3 |
| 1974 | 15.6 | -5.9 | 4.4 | 3.4 |
| 1975 | 14.5 | -0.7 | 3.0 | 2.6 |
| 1976 | 12.8 | -4.9 | 4.2 | 2.5 |
| Root mean squared difference | | 3.5 | 3.1 | 2.1 |
| Standard deviation | | 2.7 | 2.1 | 1.1 |
| | | Monthly data Jan. 1970 - Dec. 1976 | | |
| Mean | | -1.8 | 2.4 | 1.0 |
| Root mean squared difference | | 22.1 | 23.3 | 42.8 |
| Standard deviation | | 22.0 | 23.2 | 42.7 |

* Average of Wednesdays data used throughout. Growth rate of the reserve asset is subtracted from growth rate of the monetary aggregate.

Over periods of less than a year the annualized growth rates are even more divergent. Given the growth in the base, the monthly results produce a confidence interval about M1 of at least ± 44 percent (at annual rates) on a monthly basis, and ± 46 percent for M2C. The confidence interval for private deposits, given growth in net reserves, is even larger. Thus, aside from the more fundamental issue of causality, taken up later in this paper, two things should already be clear: (1) If you believe in a monetary rule, in selecting a target you have to choose between money and base - you cannot have both. If a monetary aggregate such as M1 or M2C is used to define the target growth rate, then an attempt to control it via the base would require fine tuning of the base to offset changes in the public's desired asset ratios. This would require close monitoring of the weekly behaviour of the mutiplier. (2) In the absence of an empirical demonstration that the variations can be predicted _ex ante_, it must be provisionally concluded that precise month-to-month control of any monetary aggregate using the base as policy instrument is unlikely to be possible.

There are implications in this discussion for the question of whether narrow or broad money is the more appropriate target for the Bank of Canada. An important deciding factor is controllability, and it has been argued that, with the monetary base used as an instrument, M2C is more easily controlled than M1. As Courchene (April 1976, p. 250) puts it, "Controlling M2 essentially involves controlling chartered bank cash reserves ...

Since the public determines how it will allocate its assets among the various types of chartered bank deposits, M1 is not under direct Bank control, at least not under present Bank Act legislation."

The view that there is a marked distinction between M2C, which is potentially under direct Bank control, and M1, which is not, is surely incorrect. In principle the base could be fine-tuned for either aggregate to achieve target growth rates, and it is an empirical question as to which aggregate bears the more stable relation to the base. It does not logically follow from the fact that reserves are required against all Canadian dollar deposits that the multiplier is more stable when money is broadly defined. All that can be inferred is that the multiplier effect of a given change in reserves will be larger on M2C than on M1. The evidence in Table 1 is mixed, but in the short run it does not reveal a tighter empirical link between broad money (or total private deposits) and reserve assets, and the residual variance is large enough to refute the idea that control of reserves is equivalent to direct control of broad money.[7]

As a framework in which to organize the data for a more detailed analysis of the behaviour of the money multiplier, a scheme similar to that used by Friedman and Schwartz (1963)[8] is

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7. This result is not peculiar to Canada. Andersen (1971) found the M2 multiplier to be less stable than the M1 multiplier in the United States.
8. Appendix B. For a more recent reference see Frost (1977).

useful. The following definitions are used:

| | |
|---|---|
| C | is currency in circulation. |
| DD | is demand deposits excluding Government of Canada deposits and private sector float. |
| TD | is time deposits. |
| STATD | is statutory time deposits. |
| STADD | is statutory demand deposits excluding statutory Government of Canada deposits and statutory float. |
| BKRES | is bank reserves excluding reserves against Government of Canada deposits and reserves against float (i.e. net reserves as defined previously). |
| EXR | is excess reserves. |

To simplify notation it is also useful to define the following ratios:

$a = C/DD$

$b = TD/DD$

$c = STADD/DD$

$g = STATD/DD$

$e = EXR/DD$

$f = 0.12c + 0.04g+e$

The ratios a, b, c, e and g, and the variable BKRES, can be regarded as the proximate determinants of the money stock in an accounting (as distinct from a causal) sense. It is useful to organize the data in terms of these ratios. An increase in a, the ratio of currency to demand deposits, clearly increases the money stock given bank reserves, but an increase in b, the ratio of time to demand deposits increases only broad money, leaving narrow money unchanged. (By contrast, in a system of contemporaneous reserve requirements an increase in b would cause M1 to decline since more reserves would be absorbed by time deposits). Increases in c or g imply a deceleration of deposit growth since they are ratios of statutory (i.e. lagged) to current deposits. Finally, an increase in the excess reserve ratio, e, clearly implies lower deposits given reserves. A much more precise statement can be made about these accounting relationships if the definitions for the money supply are differentiated with respect to time.

Using our narrow definition, the money supply is:

$$M1 = C + DD \qquad (1)$$

which can be rewritten as:

$$M1 = k_1 \cdot BKRES \tag{2}$$

where

$k_1 = (1+a)/f$ constitutes the narrow money multiplier.

Similarly, our broad definition of the money supply, M2C, can be written in terms of a broad money multiplier $k_2 = (1+a+b)/f$

$$M2C = k_2 \cdot BKRES. \tag{3}$$

The following are derivatives of these identities with respect to time:

$$\frac{1}{M1}\frac{d(M1)}{d(t)} = \frac{1}{BKRES}\frac{d(BKRES)}{d(t)} + \frac{1}{1+a}\frac{d(a)}{d(t)} - \frac{.12}{f}\frac{d(c)}{d(t)} - \frac{.04}{f}\frac{d(g)}{d(t)} - \frac{1}{f}\frac{d(e)}{d(t)} \tag{4}$$

$$\frac{1}{M2C}\frac{d(M2C)}{d(t)} = \frac{1}{BKRES}\frac{d(BKRES)}{d(t)} + \frac{1}{1+a+b}\frac{d(a)}{d(t)} + \frac{1}{1+a+b}\frac{d(b)}{d(t)} - \frac{.12}{f}\frac{d(c)}{d(t)} - \frac{.04}{f}\frac{d(g)}{d(t)} - \frac{1}{f}\frac{d(e)}{d(t)}. \tag{5}$$

The relative contributions of the determinants of the growth rate of the money supply (both definitions) over the period 1970-76 are given in Table 2. Seasonally unadjusted monthly data are used, annual rates are obtained by averaging the monthly

Table 2 DECOMPOSITION OF THE RATE OF GROWTH OF THE MONEY SUPPLY 1970-76

| | | | | Components of the M1 money multiplier | | | |
|---|---|---|---|---|---|---|---|
| | M1 | BKRES | $k_1$ | $\frac{1}{1+a}\frac{d(a)}{d(t)}$ | $\frac{-.12}{f}\frac{d(c)}{d(t)}$ | $\frac{-.04}{f}\frac{d(g)}{d(t)}$ | $\frac{-1}{f}\frac{d(e)}{d(t)}$ |
| 1970* | 5.24 | 5.95 | - 0.71 | 0.44 | 1.54 | - 3.37 | 0.80 |
| 1971 | 16.21 | 18.46 | - 2.25 | -2.79 | -1.07 | 2.50 | -0.31 |
| 1972 | 12.42 | 17.19 | - 4.77 | 0.41 | -0.66 | - 2.01 | 0.29 |
| 1973 | 11.22 | 9.81 | 1.42 | 1.86 | 0.93 | - 3.36 | -0.57 |
| 1974 | 5.77 | 16.32 | -10.55 | 3.57 | -2.14 | -11.86 | -0.15 |
| 1975 | 17.99 | 17.10 | 0.90 | -1.61 | -1.63 | 3.11 | 0.56 |
| 1976 | 4.06 | 9.43 | - 5.36 | 1.78 | 2.46 | -10.28 | 0.16 |
| Mean | 10.42 | 13.46 | - 3.05 | 0.52 | -0.08 | - 3.61 | 0.11 |
| Standard deviation** | 23.80 (5.55) | 40.58 (4.94) | 42.40 (4.21) | 8.35 (2.17) | 18.85 (1.74) | 16.05 (5.74) | 4.10 (0.49) |

| | | | | Components of the M2C money multiplier | | | | |
|---|---|---|---|---|---|---|---|---|
| | M2C | BKRES | $k_2$ | $\frac{1}{1+a+b}\frac{d(a)}{d(t)}$ | $\frac{1}{1+a+b}\frac{d(b)}{d(t)}$ | $\frac{-.12}{f}\frac{d(c)}{d(t)}$ | $\frac{-.04}{f}\frac{d(g)}{d(t)}$ | $\frac{-1}{f}\frac{d(e)}{d(t)}$ |
| 1970 | 10.34 | 5.95 | 4.39 | 0.13 | 5.21 | 1.54 | - 3.37 | 0.80 |
| 1971 | 13.88 | 18.46 | - 4.57 | -0.88 | -4.59 | -1.07 | 2.50 | -0.31 |
| 1972 | 17.71 | 17.19 | - 2.48 | 0.12 | 2.11 | -0.66 | - 2.01 | 0.29 |
| 1973 | 16.84 | 9.81 | 7.03 | 0.54 | 6.61 | -0.93 | - 3.36 | -0.57 |
| 1974 | 15.49 | 16.32 | - 0.83 | 0.96 | 11.94 | - 2.14 | -11.86 | -0.15 |
| 1975 | 15.46 | 17.10 | - 1.64 | -0.41 | -3.87 | - 1.63 | 3.11 | 0.56 |
| 1976 | 16.74 | 9.43 | 7.31 | 0.43 | 13.62 | 2.46 | -10.28 | 0.16 |
| Mean | 14.78 | 13.46 | 1.32 | 0.13 | 4.43 | - 0.08 | - 3.61 | 0.11 |
| Standard deviation | 10.74 (2.22) | 40.58 (4.94) | 42.51 (4.84) | 2.39 (0.61) | 26.06 (7.09) | 18.85 (1.74) | 16.05 (5.74) | 4.10 (0.49) |

* Annual growth rates are obtained by summing monthly growth rates for the year.

** Standard deviation is calculated using annualized monthly growth rates; the standard deviation in parenthesis is calculated using average annual growth rates.

rates. With the exception of the excess reserve ratio,[9] considerable variation exists, even at the annual level, in the contribution of all the component ratios to monetary growth. This suggests that an explanation of the behaviour of the multiplier would require sophisticated structural modelling of these components, negating the supposed simplicity of the monetarist recommendation.

In the case of both money multipliers the variance around trend dominates the trend itself. Thus, while the mean rate of growth of the narrow money multiplier, $k_1$, is -3.05 percent over the period (a manifestation of the positive trend in the ratio of statutory time deposits to demand deposits) the standard deviation on both a monthly and yearly basis is extremely large, 42.40 and 4.21 percent respectively. If $k_1$ is broken down into its components, it is clear that the main source of change, both trend and short-run variance, is the ratio of statutory time deposits to demand deposits. The negative mean growth in $k_1$ is mitigated somewhat by the positive growth in the ratio of currency to demand deposits. If seasonally adjusted data were used, one would expect the data to attribute considerable variability in M1 growth to variability in the ratio of statutory demand deposits to demand deposits at the monthly level, but a surprisingly high proportion of variance arises from this ratio at the annual level also.

9. The lack of variation in the excess reserve ratio might be expected with month-average data. See Dingle, Sparks and Walker (1972).

Over-all, the magnitude and pattern of the variability in the growth rates of the component ratios support our conclusion that movements in the $k_1$ multiplier are difficult to forecast.

For the same reason that the trend of the narrow multiplier is negative, the trend in the broad money multiplier is positive, and the contributions of component ratios to its changes are roughly parallel. As in the case of the M1 multiplier, the large variance in the M2C multiplier implies that reserve control of the money supply would require elaborate structural forecasting of the components of the multiplier.

## 2 CAUSALITY

The preceding discussion leaves open the fundamental question of whether changes in the base or in bank reserves cause changes in the money supply. Thus, the statistics presented so far suggest, but do not conclusively prove, that a policy of control via the base would be unsuccessful. However, conditional statements about the growth of money supply given the growth in base are valid only if there is a causal link from base to money.

Under the institutional circumstances prevailing in Canada we do not feel it appropriate to assume that the base is an exogenous variable. There are two reasons for this: (1) Historically the Bank of Canada has been concerned with the control of variables such as M1, interest rates, and at times the exchange rate. Neither bank reserves nor monetary base have been used as proximate targets of policy on a month-to-month basis; they have instead responded to the requirements of these other objectives. (2) Reserves are required not against the current month's deposits but against lagged deposits. In practice the chartered banks hold very low levels of excess reserves, this means that at month end reserves are determined by lagged deposits not vice versa. This does not imply that the Bank of Canada passively ratifies any rate of asset acquisition determined by the chartered banks, but rather that it is in general impossible to infer from month-average reserve data whether policy has been expansionary or contractionary. Typically the interplay between demand for and supply of excess reserves, which determines changes in the money supply, short-term interest rates, and so on, takes place within the month.[10] Under current operating procedures, the interest rate is the policy instrument used to control M1, and its short-term setting is intended to produce growth in M1 within an announced target range. An illustration demonstrates the problem involved. Suppose for example the Bank were to embark upon a more expansionary policy. Initially, the chartered banks would be confronted with an excess supply of cash reserves. In their efforts to eliminate the excess they would buy assets, causing interest rates to decline and the money supply to increase, just as in the familiar textbook credit multiplier. However, because of the lagged reserve requirement, expansion of the banking system

10. Dingle, Sparks and Walker (1972) provide a detailed description of this process.

does not bring about a reduction in excess reserves. Thus, there is no definite limit on the expansion of the system that will follow from a given increase in excess reserves. As long as an excess supply remains in the system a disequilibrium persists and the banks continue to expand. Analytically the problem is that if the demand for excess reserves is not a function of the level of this month's deposits or interest rates[11] then the demand for total reserves is a predetermined function of lagged deposits, and the supply of reserves is given by monetary policy. Equilibrium thus requires the mutual coincidence of two predetermined variables and the system is overdetermined. In practice the process is typically brought to a halt not by a self-equilibriating market mechanism but by the central bank itself withdrawing the excess, having achieved its desired effect on short-term interest rates or some other proximate target. The point to note is that at the end of the month the level of bank reserves will not necessarily indicate an expansionary policy. An expansionary policy will, however, be correctly indicated by interest rates and, to some extent, by the money supply. Only in the next month will movements in bank reserves (and monetary base) reflect this month's expansionary policy. Thus the monetary base is a poor indicator of the short-run stance of monetary policy -

11. Current deposits and interest rates fail to show up as significant explanatory variables in estimates of chartered bank demand functions for excess reserves using post-1967 data.

it is a lagging rather than a leading indicator.

This view of the system can be tested against the alternative view that base causes money supply, because Granger's definition (1969) of bivariate causality applies directly. A Sims' test (1972) can be used to discriminate among causality from base to money, causality from money to base, simultaneity, or independence.

Our prior expectations of the test results are as follows. Clear-cut results showing causality running from money to base should hold when the data correspond closely to statutory reserve requirements. That is, if (a) "money" is defined as privately held bank deposits, (b) the base concept is limited to net bank reserves, and (c) monthly data are used, we expect rejection of the hypothesis that base causes money and acceptance of the hypothesis that money causes base.

As we move away from correspondence with legal requirements we expect the results to become more ambiguous. For example, we might find statistical independence in the relationship between M1 and the monetary base because variations in the ratios of currency to bank reserves, of demand deposits to total deposits and excess reserves spoil the clean statutory link.

If quarterly (or longer-run) data were available simultaneity might become apparent, not just for the technical reason that the data are further removed from a statutory basis but for an important behavioural reason too. At the quarterly level it is no longer correct to say that money determines the base that the Bank is constrained to supply. This is because the growth of bank credit and monetary aggregates have long been regarded as important indicators by the Bank, and it has responded to unwelcome movements in their levels by changing its interest-rate setting. Because quarterly data aggregate over periods long enough that the Bank's short-run interest-rate target is influenced by money growth, they are contaminated by policy feedback and could, consistent with our view of the process, reject a causal chain going from money to base in favour of simultaneity or independence.[12]

To characterize the Sims' causality test more formally, consider two time series, denoted by M and R, which are covariant stationary stochastic processes. If the M series is statistically independent of the R series, then forecasts of M1 that are conditioned on an information set that includes the past history of both variables should not be superior, in a mean predictive error sense, to forecasts conditioned solely on past values of only the M variable. In other words, defining

$\sigma^2(M_t-E_{t-1}(M_t|\phi_{t-1}))$ as the minimum[13]

predictive error variance of M conditional on information

12. This is analogous to the general point that aggregation over time will give a truly recursive system the appearance of simultaneity cf. Wold (1964).
13. This implies that $E_{t-1}(M_t|M_{t-1}, M_{t-2},...)$

is the optimal linear predictor of M given the information set $(\Phi_{t-1})$; $E_{t-1}$ is the expectation operator at time t-1.

on information available at the time of forecast, $\phi_{t-1}$, we can categorize four possible causal relationships between the two series (Granger, 1969). Unidirectional causality running from M to R is indicated if

$$\sigma^2(R_t - E_{t-1}(R_t | R_{t-1}, R_{t-2}, \ldots, M_{t-1}, M_{t-2}, \ldots)) < \sigma^2(R_t - E_{t-1}(R_t | R_{t-1}, R_{t-2}, \ldots)) \quad (6)$$

and

$$\sigma^2(M_t - E_{t-1}(M_t | M_{t-1}, M_{t-2}, \ldots)) = \sigma^2(M_t - E_{t-1}(M_t | M_{t-1}, M_{t-2}, \ldots, R_{t-1}, R_{t-2}, \ldots)) . \quad (7)$$

Conversely, M is uniquely caused by R if

$$\sigma^2(M_t - E_{t-1}(M_t | M_{t-1}, M_{t-2}, \ldots, R_{t-1}, R_{t-2}, \ldots)) < \sigma^2(M_t - E_{t-1}(M_t | M_{t-1}, M_{t-2}, \ldots)) \quad (8)$$

and

$$\sigma^2(R_t - E_{t-1}(R_t | R_{t-1}, R_{t-2}, \ldots)) = \sigma^2(R_t - E_{t-1}(R_t | R_{t-1}, R_{t-2}, \ldots, M_{t-1}, M_{t-2}, \ldots)). \quad (9)$$

Feedback, or bidirectional causality, is indicated when conditions

(6) and (8) both hold. The series are independent in a causal sense, although a contemporaneous relationship may exist, if both equations (7) and (9) occur.

Sims' method of testing these causal patterns employs estimates of a pair of two-sided, distributed-lag equations of the following form:

$$M_t = \alpha_0 + \sum_{i=-d_1}^{d_2} \alpha_{1i} R_{t+i} + v_t \qquad (10)$$

$$R_t = \beta_0 + \sum_{i=-d_1}^{d_2} \beta_{1i} M_{t+i} + u_t \qquad (11)$$

where

$u_t$ and $v_t$ are the error terms and

$d_2$ and $d_1$ are, respectively, the length of the lead and the length of the lag on the regressor.

The absence of causality from R to M is equivalent to accepting, using an F-test, the null hypothesis that the lead coefficients are not significantly different from zero in a least squares regression of equation (11). Unidirectional causality from M to R requires both acceptance of the null hypothesis in equation (11) and rejection of the null hypothesis that the lead coefficients are not significantly different from zero in a comparable regression with equation (10). The other Granger causal patterns can be similarly interpreted in the context of lead coefficients in equations (10) and (11).

The existing causal relationships were examined using the Sims' test on our definitions of the monetary aggregate and the reserve aggregate. In keeping with the bivariate structure of this test, seasonally adjusted monthly and quarterly data were used.[14] As F-tests are generally highly sensitive to autocorrelation in the residuals the data were initially filtered by a first difference of the logarithms of the series. Although this procedure adequately removes autocorrelation in the residuals of equation (10) one would expect, a priori, that statutory averaging would generate a moving-average process in the residuals of a regression of bank reserves on bank deposits. As a result, a generalized least squares estimation procedure is applied when bank reserves are the dependent variable.

It is necessary to specify the lead and lag lengths for the regressor in the Sims' test. Econometric theory suggests that specifying long lead and lag lengths reduces the danger of omitting a relevant variable. However, the problem is alleviated somewhat by knowledge of the statutory lead-lag relationship between the variables. In the reported tests, a 6 lag-3 lead regression model was used for monthly data, while the quarterly regressions were specified with 2 lags and 2 leads. Longer

14. Dummy variables for the mail strikes were also avoided by using an ARIMA forecasting strike option in theX-11-ARIMA program to modify the values of money and base for the 1974 and 1975 mail strikes.

lengths did not affect the results.

For the Sims' test of the causal relationships between money and base, Table 3 presents the pairs of F-statistics required to test the statistical significance of the future values of the right-hand side variable in the regressions.

Table 3 F-RATIOS FOR TESTS OF SIGNIFICANCE OF FUTURE VALUES OF EXPLANATORY VARIABLES*

| | Monthly data | | Quarterly data | |
|---|---|---|---|---|
| | F .95 (3,74)=2.73<br>6 lags and 3 leads. Range:<br>Jan. 1970 to Dec. 1976<br>Reserve aggregate | | F .95 (2,27)=3.35<br>2 lags and 2 leads. Range:<br>1Q69 to 4Q76<br>Reserve aggregate | |
| | Monetary base (BASE) | Net reserves (BKRES) | Monetary base | Net reserves |
| M1A | 3.57**<br>(2.59) | 2.87**<br>(1.18) | 1.74<br>(1.02) | 0.54<br>(1.08) |
| M2C | 4.51**<br>(0.06) | 9.84**<br>(0.07) | 4.96**<br>(0.50) | 10.13**<br>(1.18) |
| Total private deposits (TPDEP) | | 8.56**<br>(0.07) | | 10.35**<br>(1.17) |

* Upper statistic is for a regression of a monetary aggregate on a reserve aggregate; lower statistic (in parentheses) is for the reverse regression.
** Significant at the .95 level.

Our prior views on causality are strongly confirmed. Only the upper statistics in Table 3 are significant.[15] There is unambiguous unidirectional causality from the monetary aggregate to the reserve aggregate with the single exception of the quarterly results for M1. The tests indicate that the quarterly M1 series and the reserve aggregate (any definition) are independent, although they may be related contemporaneously. As expected, the results are more conclusive as the variable definitions approach statutory definitions in the sense that the F-statistics for leading values of the base increase in the money regressions while they diminish for leading values of money in the inverse regressions.

Sims (1972) points out that both the statistical significance and the absolute size of the lead coefficients are important. Coefficients on the future values of the regressor, taken as a group, may be statistically insignificant, but large individual coefficients would cast some doubt on the absence of causality. Further, the lead coefficients should be positive for the money regression to be consistent with the expected causality. The lead coefficients for a representative selection of cases where unidirectional causality is indicated are listed in Table 4: they give no cause for concern about our interpretation of the results.

15. Feige and McGee (1977), using weekly data on U.S. M1 and total bank reserves, found a similar causal pattern for the post-1968 period (i.e. after the change to lagged reserve accounting in the United States).

Table 4 ESTIMATED LEAD PROFILES FOR VARIOUS REGRESSIONS

| Dependent variable | Independent variable | Coefficients Monthly data Lead 1 | Lead 2 | Lead 3 | Quarterly data Lead 1 | Lead 2 |
|---|---|---|---|---|---|---|
| M1 | BASE | .64 | .35 | .05 | .58 | -.02 |
| BASE | M1 | .14 | -.06 | -.06 | .11 | -.04 |
| M2C | BASE | .42 | .30 | -.04 | .74 | -.12 |
| BASE | M2C | .00 | .03 | -.02 | .07 | .01 |
| TPDEP | BKRES | .31 | .24 | .11 | .52 | .04 |
| BKRES | TPDEP | -.08 | .03 | .05 | .11 | .18 |

A natural question arises from these findings regarding the causal links between money and base: if money is not caused by base then what does cause money? In our view money is generated by a demand function, responding to transactions requirements and interest rates.[16]

Given this money-demand function, the Bank of Canada sets short-term interest rates to control M1, thereby setting up a series of interest-rate adjustments and asset substitutions that

16. There is no way to test this proposition because the Sims' test cannot be applied beyond a bivariate context, and no satisfactory specification of the demand for money can be derived with a single explanatory variable. Thus we do not regard tests of causality between money and GNP as a resolution to the question. Indeed the very meaning of causality is unclear outside the bivariate model. In any event Barth and Bennett (1974) have applied the test, finding bidirectional causality between GNP and two measures of the money supply, but unidirectional causality from the index of industrial production to narrow money.

impinge on broad money. One piece of evidence in support of this view is the identification of a causal pattern running from M1 to M2C, although this result is only indicative of the time ordering of responses by M1 and M2C to exogenous impulses.[17] Another piece of evidence comes from tests of the relative *ex post* forecasting performance of money-multiplier versus money-demand specifications. Although the causality tests discussed above render regressions of broad money on the lagged monetary base invalid, for M1 the test results are less clear: with monthly data they do indicate that M1 causes base money but with quarterly data there is no evidence of unidirectional causality.

## 3 A COMPARISON OF DEMAND AND SUPPLY SPECIFICATIONS OF MONEY

In this section we report the results of a study comparing the accuracy of two alternative schemes for forecasting narrow money: the first is based on a conventional demand-for-money function, the second on a money multiplier. This evidence on the *ex post* forecasting record of the equations stemming from the competing approaches relates directly to the question of what causes money. Given the ambiguous causality between the reserve base and M1, we regard a failure of the base (money-multiplier

17. A Sims' test was used to determine the direction of causality between M1 and M2C. The F-statistic on the lead coefficients with M2C as the independent variable was 5.90; the F-statistic on the lead coefficients with M1 as the independent variable was 1.87.

specification vs. money-supply specification) to provide a superior forecasting performance as damaging to the arguments for base control and encouraging for the current control procedures of the Bank of Canada.

Narrow money is chosen as the object of study for three reasons: (1) It can be explained using a simple, widely accepted demand function. Broader definitions require interest-rate differentials and wealth for a satisfactory explanation and raise serious aggregation problems. (2) Our causality tests render regressions of broad money on the lagged monetary base invalid. Quarterly data are used in this study. (3) M1 is the aggregate actually used in the formulation of monetary policy. We hasten to add that our choice of M1 does not involve an intrinsic bias against the money multiplier, since forecasts of M2 (currency plus privately held Canadian dollar deposits at chartered banks) using money-multiplier equations are no more accurate than those of M1.

Two forecasting equations for M1 are specified: the first containing GNE, its price deflator (PGNE) and the short-term interest rate (R90) as explanatory variables: the second containing the monetary base and the short-term interest rate; distributed lags are employed where warranted empirically. These specifications might be interpreted as being based respectively on a demand function and a supply function, although our results in the preceding section deny that the regression of money on the base is a valid equation for making conditional statements about growth in money given growth in the base. That is, the data cannot demonstrate how closely money could be regulated using the base as the control instrument.[18] It is only the usefulness of the regression of money on base as a device for making unconditional forecasts that we are assessing.

Quarterly data, not adjusted for seasonality, are used for the test, and the estimation period is 1Q60-4Q76. Both equations are estimated using actual values of the relevant variables, but only information available in the current period is used in testing their forecasting ability.[19] Naive forecasts of the unknowns on the right-hand side of the equations are used. Thus forecasts that employ the demand-for-money function use naive forecasts for GNE and the implicit price deflator[20] and the actual short-term paper rate, while forecasts based on the money-multiplier equation use the actual value of the base and a naive forecast for R90 (its most recently observed level,

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18. Indeed, as Lucas (1976) has demonstrated, a change in the policy regime affects all reduced-form relationships, and hence a policy shift to base control would potentially void all current correlations.
19. This procedure follows Burger's analysis in spirit but not in detail.
20. Each series was decomposed into a trend component and a cyclical component. The cyclical component was forecast by linear regression of detrended data on three lagged dependent values and added back to the trend component to obtain a forecast for the variable. Seasonality was handled using quarterly dummy variables.

$R90_{-1}$). These substitutions are meant to reflect the different control procedures involved in the two approaches. In the demand-function approach to the control of M1, the policy instrument is the short-term interest rate; its value can therefore be treated as known in the current quarter, whereas in the alternative approach it is the base that is known.

### 3.1 The Money-Multiplier Equation

When the forecasting accuracy of a money-multiplier equation for M1 is tested a regression of money on the base will yield a spuriously low estimate of error variance because the two variables are related by an identity. Currency held by the public is a major component of M1 (34 percent) and of the base (59 percent). To gauge the accuracy of money-multiplier forecasts this simultaneity must be removed from the equation. Our procedure is to use bank reserves, excluding reserves held against federal government deposits[21] (BKRES), as the explanatory variable in equations for both M1 and demand deposits (DD). In judging the stability of the M1 multiplier either M1 itself or demand deposits can be regarded as the appropriate dependent variable. The results of the comparisons with the respective demand functions are exactly the same.

A consistent data series for reserves, which allows for the

21. Hereafter referred to as bank reserves.

effects of the 1967 change in reserve requirements,[22] is needed for the money-multiplier equation. An adjusted series is constructed such that its pre-1967 value is equal to what it would have been had post-1967 legislation prevailed. Adjusted bank reserves (BKRESA) are calculated from BKRES as follows:[23]

$$BKRESA = BKRES - (RRQCASH1 - .12)\ STADD - (RRQCASH2 - .04)\ STATD$$

where

STADD is privately held statutory demand deposits

STATD is other statutory deposits

RRQCASH1 is the required reserve ratio on demand deposits

RRQCASH2 is the required reserve ratio on other deposits.

A specification to allow the multiplier to change over time is employed because there are not only long-run trends in its value but also significant short-run variations. These movements are captured primarily by using the lagged value of the multiplier, $MULT_{-1}$, multiplied by the current base to form a

22. From a flat 8 percent to 12 percent on demand deposits and 4 percent on other deposits. Only Canadian dollar deposits are subject to reserve requirements.

23. This calculation is unrealistic to the extent that the pre-1967 mix of deposits probably would not have been the same if reserve requirements were different. We present the series for statutory float, statutory government deposits, statutory demand and other deposits in the Appendix.

composite explanatory variable $MULT_{-1}$ (BKRESA). A further source of change in the multiplier is allowed through the short-term interest rate. The estimated money-multiplier equations are:

$$\underset{}{M1} = \underset{(0.3)}{-\,27} + (\underset{(53.1)}{1.02}\ MULT_{-1} - \underset{(2.2)}{.018}\ R90)\ BKRESA + \underset{(0.0)}{5.24}\ STRIKE74$$

$$+ \underset{(3.4)}{459}\ STRIKE75 + \text{seasonals} \qquad (12)$$

see = 188. RB2 = .998 dw = 2.24

where
$MULT_{-1} = M1_{-1}/BKRESA_{-1}$.

$$DD = \underset{(0.1)}{-\,46} + (\underset{(48.8)}{1.03}\ MULT_{-1} - \underset{(62.5)}{.013}\ R90)\ BKRESA - \underset{(1.1)}{163}\ STRIKE74$$

$$+ \underset{(0.6)}{82}\ STRIKE75 + \text{seasonals} \qquad (13)$$

see = 132 RB2 = .997 dw = 2.20

where
$MULT_{-1} = DD_{-1}/BKRESA_{-1}$.

The form of the equation is the same for both dependent variables. It includes dummy variables for seasonal variation and for the postal strikes of 1974 and 1975 (STRIKE74 = 1 in 2Q74, 0 elsewhere; STRIKE75 = 1 in 4Q75, 0 elsewhere). Lagged values of the explanatory variables are found to be not significant, a result consistent with our earlier work which did not find a causal sequence from base to money. In essential characteristics these equations follow the monetarist forecasting schemes used by Burger and others. As expected, the coefficient on $MULT_{-1}$ is close to unity (with a constant multiplier it would be precisely unity). However, the significant negative coefficient on R90 is not consistent with the usual derivation of the multiplier model as a money-supply function - in the standard money-supply model the interest rate has a positive sign, reflecting the banks' economizing on excess reserves (and increased use of borrowed reserves as in the U.S. system) as the opportunity cost rises.[24] Of course, what this coefficient is picking up is not the behaviour of the banking system but the behaviour of the public whose holdings of Ml vary inversely with the interest rate. Thus this equation embodies demand-side as well as supply-side factors.

### 3.2 The Money-Demand Equation

In contrast to the base-multiplier equation, the task of specifying an adequate demand equation is simple given the existing extensive empirical research on this problem (e.g. Clinton, 1973; Goldfeld, 1973; and White, 1976). We estimate a loglinear demand for real money balances (Ml/PGNE) as a function of real income (RGNE) and the 90-day finance company paper rate (R90). The equation is estimated in a stock-adjustment form[25] by the method of ordinary least squares. As before,

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24. See Boorman and Havrilesky (1972, Chapter 1) for an exposition of the paradigm.
25. More complex rational lag functions were inferior empirically.

the equation includes dummy variables for seasonal variation and for the postal strikes of 1974 and 1975. The estimated money-demand equation is:[26]

$$\begin{aligned} LOG(M1/PGNE) = {} & \underset{(2.34)}{0.5200} + \underset{(3.05)}{0.0520}\ STRIKE74 \\ & + \underset{(4.21)}{0.0686}\ STRIKE75 + \underset{(5.49)}{0.2182}\ LOG(RGNE) \\ & - \underset{(7.23)}{0.0107}\ R90 + \underset{(11.46)}{0.7167}\ LOG(M1_{-1}/PGNE_{-1}) \\ & + \text{seasonals.} \end{aligned} \qquad (14)$$

see = .00154 RB2 = 0.990 dw = 2.02

To provide a comparison for the base-multiplier equation that uses demand deposits as the dependent variable, a demand function was estimated for DDEP:[27]

26. This equation, besides yielding plausible parameter values, fits the data quite well. The long-run real income elasticity is 0.770 and the long-run coefficient on interest-rate is -0.0378.
27. As expected, the coefficients on the strike dummies were larger for demand deposits than for M1. The long-run real income elasticity of 0.788 is not statistically different than our estimate for M1, while the partial adjustment of 0.227 is lower. Furthermore, as might be expected, in the long-run the implied interest-rate elasticity of demand deposits, -0.060, is larger than that of M1.

$$\underset{}{LOG(DDEP/PGNE)} = \underset{(1.37)}{0.3219} + \underset{(3.39)}{0.0724}\ STRIKE74 + \underset{(4.07)}{0.0832}\ STRIKE75$$

$$+ \underset{(4.99)}{0.1786}\ LOG(RGNE) - \underset{(7.33)}{0.0136}\ R90$$

$$+ \underset{(12.81)}{0.7734}\ LOG(DDEP_{-1}/PGNE_{-1}) \qquad (15)$$

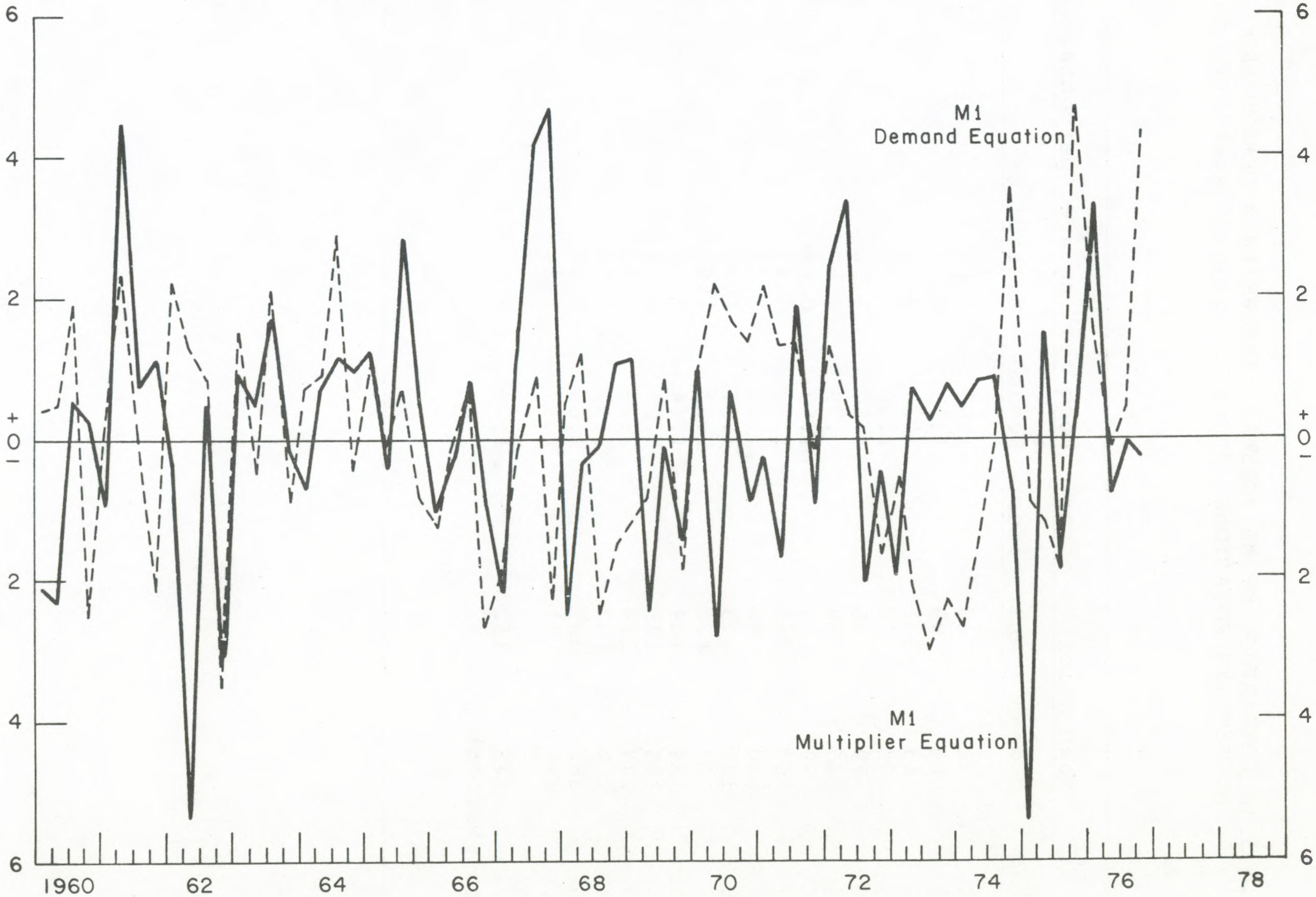
see = 0.0193 RB2 = 0.981 dw = 1.91

### 3.3 Relative Forecasting Performance of the Two Approaches

In Table 5 ex post forecast results are summarized. Static forecasts are used, i.e. lagged dependent variables are given their actual values, because for control purposes we need no more than a one-period-ahead forecast. A comparison of the supply-side approach with the demand-side approach for either aggregate, M1 or demand deposits, leads to the conclusion that the two approaches are almost exactly equal in their forecasting accuracy. For all equations the RMS errors from the forecast simulation are a bit larger than the standard error of estimate of the equations, reflecting the substitution of $R90_{-1}$ for R90 in the multiplier equation and of forecast values for actual values of RGNE and PGNE in the money-demand equation. The mean absolute errors, over the full period 1Q60-4Q76, are just over 10 percent greater for the demand equation than for the multiplier equation, but when the RMS percentage errors are compared the former equation comes out fractionally ahead. Moreover, as is evident from the M1 residuals plotted in Figure 2, the forecasting errors are randomly distributed in both cases. There is thus a

Figure 1

**M1 FORECAST ERRORS - FORECAST MINUS ACTUAL**



negligible difference in forecasting accuracy.

Table 5 A COMPARISON OF M1 FORECAST ERRORS FROM DEMAND AND MULTIPLIER EQUATIONS (Annual average of quarterly data)

(i) M1

| | Mean absolute error | | Root mean squared percentage error | |
|---|---|---|---|---|
| Period | Demand | Multiplier | Demand | Multiplier |
| 1960 | 70 | 68 | 1.60 | 1.62 |
| 1961 | 65 | 99 | 1.59 | 2.38 |
| 1962 | 113 | 132 | 2.22 | 3.11 |
| 1963 | 75 | 50 | 1.39 | 1.02 |
| 1964 | 79 | 56 | 1.56 | 0.90 |
| 1965 | 47 | 84 | 0.79 | 1.57 |
| 1966 | 89 | 57 | 1.52 | 0.84 |
| 1967 | 107 | 252 | 1.60 | 3.41 |
| 1968 | 120 | 82 | 1.60 | 1.38 |
| 1969 | 107 | 113 | 1.27 | 1.54 |
| 1970 | 142 | 120 | 1.62 | 1.60 |
| 1971 | 124 | 124 | 1.44 | 1.36 |
| 1972 | 105 | 138 | 1.09 | 2.34 |
| 1973 | 273 | 119 | 2.18 | 1.12 |
| 1974 | 289 | 107 | 2.37 | 0.74 |
| 1975 | 382 | 351 | 2.65 | 2.94 |
| 1976 | 296 | 191 | 2.31 | 1.70 |
| Average (Total Period) | 146 | 132 | 1.76 | 1.91 |

(ii) Demand Deposits

| | Mean absolute error | | Root mean squared percentage error | |
|---|---|---|---|---|
| Period | Demand | Multiplier | Demand | Multiplier |
| 1960 | 63 | 55 | 2.03 | 1.84 |
| 1961 | 55 | 55 | 2.01 | 2.44 |
| 1962 | 116 | 120 | 3.28 | 3.75 |
| 1963 | 65 | 49 | 1.76 | 1.41 |
| 1964 | 56 | 41 | 1.92 | 1.23 |
| 1965 | 35 | 74 | 0.80 | 1.92 |
| 1966 | 90 | 54 | 2.30 | 1.20 |
| 1967 | 107 | 188 | 2.32 | 3.79 |
| 1968 | 107 | 56 | 2.35 | 1.11 |
| 1969 | 84 | 105 | 1.47 | 1.86 |
| 1970 | 90 | 98 | 1.61 | 1.88 |
| 1971 | 69 | 113 | 1.31 | 1.89 |
| 1972 | 89 | 199 | 1.42 | 2.91 |
| 1973 | 162 | 89 | 2.14 | 1.13 |
| 1974 | 235 | 55 | 2.91 | 0.75 |
| 1975 | 300 | 243 | 3.06 | 3.41 |
| 1976 | 234 | 56 | 2.93 | 0.88 |
| Average (Total Period) | 115 | 100 | 2.19 | 2.20 |

Given the ambiguous causality between the reserve base and M1, we regard the failure of the base to provide a superior forecasting performance as damaging to the arguments for base control.[28] Because it is not supported by a remarkably good forecasting record, the case for controlling money directly through cash reserves must either be made on other grounds or must be supplemented by recommendations for institutional reform to tighten the link between reserves and deposits.

## 4 BASE VERSUS INTEREST-RATE CONTROL OF THE MONEY STOCK

The empirical tests reject the notion that there is a "direct" link between bank reserves and bank deposits and that changes in bank reserves cause changes in bank deposits. Given various statements by the Bank of Canada[29] that it has sought to control money not through the base but by means of a short-run, short-term interest-rate setting, this is an important result: a contrary finding would show its strategy to be based on an

28. This conclusion is, we conjecture, reinforced by possible changes in behaviour of the banks that could likely arise from a switch to base control. Since the authorities would no longer ensure that the system had a supply of reserves at a non-penal interest cost to match its requirements, banks would hold on average a greater and more variable quantity of excess reserves, further weakening the link between base and money.
29. See, for example, the Annual Report of the Governor for 1976 and 1977.

elementary misconception. The tests do in fact confirm that money and reserve assets behave in a manner consistent with the Bank's stated control procedure.

Now consider the possible implementation of a policy of control of money via the base: it might be implemented in the following way. The Bank of Canada might announce that for the coming year the growth in bank reserves is to be such as to cause M2C to grow at a smooth rate of 10 percent for the next 12 months. If the banking system expands too rapidly then it would be forced to borrow at penal rates to get its required reserves, and if it expands too slowly excess reserves would be pushed into the system.

For the banking system the major change from current operating procedures is the lack of assurance that it will get the reserves required by statute at non-penal rates every month. A model to explain the money supply might thus be set up in which "unborrowed" bank reserves are exogenous and the chartered banks' total purchases of assets depend on their expectations of the supply of reserves next month.[30] But such an approach has two serious flaws: (1) Only monopoly banks need be constrained in their asset expansion by their expectations of reserves to be supplied to the system in the month ahead. Their constraint, just

30. This was the approach taken by Johnson and Winder (1962) and criticized by Marsh (1964) for its omission of the fact that an individual bank adjusts cash by moving between cash and other assets, not by changing total deposits.

as now, is the current availability of excess reserves. If a bank finds itself with an excess it will buy liquid assets without being concerned about the consequence that this creates deposits (and a future reserve requirement) in the system as a whole. This, after all, is the familiar textbook-multiplier story: each bank lends out only excess reserves, unaware of the implications for the entire system, while for the banking system there is a multiple expansion of deposits that eliminates the excess. For an individual bank, reserves are endogenous: they can be increased by selling assets and/or by bidding more aggressively for deposits. Ignoring this point leads to a fallacy of composition. Consider the view (Courchene, 1977, p. 110) that with base control banks would no longer find it worthwhile to use liability management to cope with reserve deficiencies. The argument is that banks will not bid for wholesale deposits this period if they know this will cause an increased reserve requirement, and therefore a reserve deficiency, next period. The flaw in this argument is that, for any individual bank, a deposit inflow does increase actual excess reserves both in the current month and, if maintained, in future months. If this were not true then the bank's response, on the liability side, to an expected reserve deficiency would be to reduce its deposit rates, which is absurd. Any benefits in controlling broader aggregates through a policy of strict reserve growth would derive not so much from a change in liability management as from a change in asset management. Confronted with definite limits on the future availability of reserves, the banks might vary the prime loan rate more actively to control loan growth. Then if a reserve shortage were expected, banks would be more inclined to reduce their lending, rather than to sell time deposits in a tight market next month, bringing total asset (and total liability) growth into line with announced reserve expansion. This strategy hinges on reducing the stickiness of prime rate, which in the past has been the cause of "perverse" movements in broad monetary aggregates during periods of tight money, rather than on reserve control *per se*. A more flexible prime rate would likewise improve the efficacy of control via interest rates. (2) The proposed strategy is vacuous in that it would not give the banks any foreknowledge of the quantity of unborrowed reserves to be supplied even to the system as a whole, since this would depend on the behaviour of the multiplier. In practice it would give banks no more information about the future availability of reserves than does the present system. Both regimes require the banks to adapt to a reserve setting chosen by the central bank day-by-day to achieve proximate goals.

A declared target of reserve expansion based on a target rate of growth of money would therefore have behavioural implications less favourable than might at first be apparent. It does not guarantee to the system, let alone to a particular bank, a known quantity of reserves in the months ahead, and there is no strong *a priori* case that moving to a system of base control would cause behavioural changes leading to a more easily controlled money supply. To the extent that the system is no longer assured that its over-all demand for reserves will be satisfied, it is probable that there would be larger average, and more variable, holdings of excess reserves and more use of Bank of Canada rediscounting facilities. This would mean weaker statistical correlation between "unborrowed" base and money than is not observed, since there would be an additional source of variance in the multiplier.

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## APPENDIX

Data Series for Statutory Deposits:
Government Deposits, Float, Net Demand
Deposits, and Notice Deposits (1955-76)

Table A-1 STATUTORY GOVERNMENT DEPOSITS

| | | | | | |
|---|---|---|---|---|---|
| 1955 | 1 | 382. | 138. | 175. | 182. |
| | 5 | 89. | 95. | 173. | 177. |
| | 9 | 105. | 175. | 112. | 418. |
| 1956 | 1 | 546. | 500. | 495. | 533. |
| | 5 | 397. | 427. | 488. | 343. |
| | 9 | 309. | 313. | 192. | 308. |
| 1957 | 1 | 372. | 238. | 313. | 416. |
| | 5 | 339. | 336. | 287. | 187. |
| | 9 | 162. | 141. | 152. | 219. |
| 1958 | 1 | 444. | 478. | 544. | 414. |
| | 5 | 175. | 378. | 336. | 350. |
| | 9 | 439. | 321. | 182. | 275. |
| 1959 | 1 | 418. | 461. | 504. | 512. |
| | 5 | 380. | 350. | 429. | 385. |
| | 9 | 366. | 179. | 102. | 214. |
| 1960 | 1 | 524. | 516. | 524. | 482. |
| | 5 | 395. | 365. | 443. | 401. |
| | 9 | 203. | 114. | 190. | 411. |
| 1961 | 1 | 631. | 508. | 460. | 395. |
| | 5 | 272. | 195. | 222. | 203. |
| | 9 | 262. | 155. | 157. | 240. |
| 1962 | 1 | 642. | 729. | 779. | 873. |
| | 5 | 719. | 900. | 891. | 850. |
| | 9 | 505. | 239. | 116. | 287. |
| 1963 | 1 | 597. | 545. | 576. | 543. |
| | 5 | 268. | 142. | 420. | 482. |
| | 9 | 456. | 288. | 427. | 584. |
| 1964 | 1 | 970. | 960. | 984. | 807. |
| | 5 | 689. | 668. | 801. | 920. |
| | 9 | 891. | 632. | 378. | 495. |
| 1965 | 1 | 827. | 838. | 875. | 793. |
| | 5 | 599. | 611. | 645. | 777. |
| | 9 | 802. | 577. | 571. | 562. |

Continued

| | | | | | |
|---|---|---|---|---|---|
| 1966 | 1 | 908. | 875. | 823. | 774. |
| | 5 | 608. | 578. | 561. | 650. |
| | 9 | 615. | 475. | 505. | 688. |
| 1967 | 1 | 988. | 911. | 923. | 981. |
| | 5 | 967. | 867. | 754. | 731. |
| | 9 | 718. | 596. | 243. | 136. |
| 1968 | 1 | 632. | 694. | 972. | 1047. |
| | 5 | 914. | 412. | 336. | 338. |
| | 9 | 357. | 362. | 289. | 615. |
| 1969 | 1 | 948. | 741. | 708. | 670. |
| | 5 | 673. | 646. | 799. | 886. |
| | 9 | 833. | 698. | 558. | 662. |
| 1970 | 1 | 1470. | 1452. | 1406. | 1193. |
| | 5 | 840. | 484. | 402. | 329. |
| | 9 | 368. | 242. | 357. | 633. |
| 1971 | 1 | 1321. | 1475. | 1470. | 1348. |
| | 5 | 1362. | 1481. | 1415. | 1431. |
| | 9 | 1411. | 1128. | 1114. | 1429. |
| 1972 | 1 | 2599. | 2552. | 2371. | 1974. |
| | 5 | 1559. | 1545. | 1169. | 1022. |
| | 9 | 946. | 818. | 638. | 1192. |
| 1973 | 1 | 2407. | 2667. | 2502. | 2286. |
| | 5 | 2089. | 2278. | 2402. | 2220. |
| | 9 | 2174. | 2083. | 1778. | 1658. |
| 1974 | 1 | 2116. | 2204. | 1925. | 1401. |
| | 5 | 888. | 617. | 706. | 942. |
| | 9 | 1052. | 1099. | 1133. | 2081. |
| 1975 | 1 | 4956. | 4744. | 4536. | 3877. |
| | 5 | 3255. | 3513. | 3239. | 2643. |
| | 9 | 2401. | 1978. | 1366. | 2254. |
| 1976 | 1 | 4166. | 3901. | 3951. | 3586. |
| | 5 | 2519. | 2410. | 2219. | 2207. |
| | 9 | 2593. | 2155. | 2130. | 2237. |

Table A-2 STATUTORY FLOAT

| | | | | | |
|---|---|---|---|---|---|
| 1955 | 1 | 563. | 438. | 423. | 505. |
| | 5 | 464. | 487. | 559. | 535. |
| | 9 | 471. | 513. | 550. | 527. |
| 1956 | 1 | 600. | 606. | 529. | 533. |
| | 5 | 591. | 662. | 614. | 719. |
| | 9 | 618. | 645. | 662. | 739. |
| 1957 | 1 | 714. | 733. | 589. | 639. |
| | 5 | 646. | 788. | 713. | 786. |
| | 9 | 713. | 694. | 768. | 713. |
| 1958 | 1 | 687. | 771. | 584. | 615. |
| | 5 | 621. | 739. | 688. | 768. |
| | 9 | 657. | 682. | 737. | 697. |
| 1959 | 1 | 775. | 781. | 605. | 648. |
| | 5 | 757. | 773. | 714. | 830. |
| | 9 | 585. | 619. | 689. | 635. |
| 1960 | 1 | 706. | 581. | 548. | 552. |
| | 5 | 546. | 576. | 602. | 638. |
| | 9 | 590. | 580. | 560. | 561. |
| 1961 | 1 | 611. | 571. | 484. | 496. |
| | 5 | 525. | 569. | 585. | 555. |
| | 9 | 566. | 559. | 578. | 560. |
| 1962 | 1 | 598. | 537. | 520. | 535. |
| | 5 | 442. | 616. | 508. | 618. |
| | 9 | 535. | 468. | 515. | 519. |
| 1963 | 1 | 545. | 547. | 399. | 483. |
| | 5 | 470. | 577. | 422. | 620. |
| | 9 | 535. | 499. | 526. | 493. |
| 1964 | 1 | 557. | 609. | 407. | 415. |
| | 5 | 544. | 527. | 473. | 631. |
| | 9 | 507. | 608. | 633. | 487. |
| 1965 | 1 | 690. | 533. | 464. | 494. |
| | 5 | 608. | 609. | 586. | 643. |
| | 9 | 578. | 708. | 574. | 546. |

Continued

| | | | | | |
|---|---|---|---|---|---|
| 1966 | 1 | 770. | 649. | 516. | 559. |
| | 5 | 507. | 647. | 654. | 686. |
| | 9 | 622. | 686. | 655. | 721. |
| 1967 | 1 | 761. | 766. | 590. | 578. |
| | 5 | 497. | 613. | 571. | 691. |
| | 9 | 602. | 606. | 657. | 798. |
| 1968 | 1 | 689. | 599. | 559. | 466. |
| | 5 | 498. | 803. | 630. | 720. |
| | 9 | 674. | 740. | 674. | 725. |
| 1969 | 1 | 842. | 944. | 628. | 605. |
| | 5 | 528. | 852. | 697. | 843. |
| | 9 | 701. | 750. | 793. | 800. |
| 1970 | 1 | 967. | 867. | 617. | 615. |
| | 5 | 719. | 772. | 751. | 881. |
| | 9 | 770. | 878. | 766. | 663. |
| 1971 | 1 | 806. | 641. | 499. | 567. |
| | 5 | 676. | 679. | 622. | 901. |
| | 9 | 699. | 653. | 693. | 459. |
| 1972 | 1 | 893. | 841. | 700. | 854. |
| | 5 | 759. | 932. | 875. | 1061. |
| | 9 | 770. | 884. | 889. | 897. |
| 1973 | 1 | 961. | 891. | 794. | 857. |
| | 5 | 744. | 1043. | 967. | 1228. |
| | 9 | 1101. | 1107. | 1154. | 1360. |
| 1974 | 1 | 1269. | 1287. | 909. | 1071. |
| | 5 | 965. | 1915. | 1274. | 1507. |
| | 9 | 1487. | 1432. | 1408. | 1225. |
| 1975 | 1 | 1505. | 1587. | 1172. | 1135. |
| | 5 | 1242. | 1686. | 1306. | 1750. |
| | 9 | 1346. | 1486. | 1369. | 809. |
| 1976 | 1 | 1981. | 1736. | 1265. | 1106. |
| | 5 | 1458. | 1552. | 1382. | 1730. |
| | 9 | 1292. | 1401. | 1353. | 1457. |

Table A-3 STATUTORY NET DEMAND DEPOSITS (DSTATP)

| | | | | | |
|---|---|---|---|---|---|
| 1955 | 1 | 4318. | 4114. | 4097. | 4198. |
| | 5 | 4193. | 4325. | 4527. | 4636. |
| | 9 | 4600. | 4598. | 4617. | 4821. |
| 1956 | 1 | 4909. | 4805. | 4623. | 4614. |
| | 5 | 4600. | 4730. | 4749. | 4758. |
| | 9 | 4644. | 4645. | 4557. | 4676. |
| 1957 | 1 | 4700. | 4534. | 4326. | 4396. |
| | 5 | 4387. | 4518. | 4488. | 4465. |
| | 9 | 4299. | 4311. | 4596. | 4596. |
| 1958 | 1 | 4811. | 4915. | 4729. | 4624. |
| | 5 | 4558. | 4877. | 4871. | 5087. |
| | 9 | 5210. | 5222. | 5333. | 5304. |
| 1959 | 1 | 5467. | 5494. | 5183. | 5151. |
| | 5 | 5131. | 5121. | 5121. | 5240. |
| | 9 | 4998. | 4828. | 4841. | 4926. |
| 1960 | 1 | 5221. | 5123. | 4927. | 4842. |
| | 5 | 4852. | 4867. | 5009. | 5009. |
| | 9 | 4785. | 4950. | 5016. | 5223. |
| 1961 | 1 | 5466. | 5364. | 5143. | 5142. |
| | 5 | 5100. | 5004. | 5178. | 5277. |
| | 9 | 5518. | 5490. | 5525. | 5715. |
| 1962 | 1 | 6153. | 6094. | 5405. | 5022. |
| | 5 | 4874. | 5210. | 5122. | 5181. |
| | 9 | 4672. | 4522. | 4614. | 4861. |
| 1963 | 1 | 5185. | 5120. | 4817. | 4814. |
| | 5 | 4712. | 4776. | 4934. | 5209. |
| | 9 | 5018. | 4896. | 5177. | 5331. |
| 1964 | 1 | 5749. | 5865. | 5466. | 5332. |
| | 5 | 5469. | 5452. | 5549. | 5818. |
| | 9 | 5670. | 5520. | 5409. | 5433. |
| 1965 | 1 | 6001. | 5869. | 5613. | 5546. |
| | 5 | 5637. | 5710. | 5732. | 5998. |
| | 9 | 6053. | 5877. | 5812. | 5861. |

Continued

| | | | | | |
|---|---|---|---|---|---|
| 1966 | 1 | 6426. | 6307. | 5957. | 5908. |
| | 5 | 5825. | 5953. | 5953. | 6156. |
| | 9 | 6074. | 6092. | 6197. | 6573. |
| 1967 | 1 | 6877. | 6911. | 6620. | 6698. |
| | 5 | 6727. | 6718. | 6558. | 6739. |
| | 9 | 6618. | 6620. | 6447. | 6439. |
| 1968 | 1 | 6826. | 6845. | 6699. | 6605. |
| | 5 | 6599. | 6409. | 6144. | 6486. |
| | 9 | 6768. | 6825. | 6737. | 7168. |
| 1969 | 1 | 7622. | 7644. | 6871. | 6831. |
| | 5 | 7072. | 7266. | 7292. | 7655. |
| | 9 | 7262. | 7242. | 7278. | 7438. |
| 1970 | 1 | 8342. | 8174. | 7569. | 7315. |
| | 5 | 7265. | 6858. | 6834. | 7108. |
| | 9 | 6978. | 6968. | 7091. | 7320. |
| 1971 | 1 | 8322. | 8326. | 7897. | 7886. |
| | 5 | 8295. | 8515. | 8666. | 9076. |
| | 9 | 8849. | 8838. | 8816. | 9272. |
| 1972 | 1 | 10923. | 10844. | 10086. | 9773. |
| | 5 | 9505. | 9627. | 9374. | 9709. |
| | 9 | 9454. | 9556. | 9558. | 10474. |
| 1973 | 1 | 11698. | 11975. | 11305. | 11147. |
| | 5 | 11172. | 11889. | 11857. | 12308. |
| | 9 | 12228. | 12183. | 11969. | 11971. |
| 1974 | 1 | 12518. | 12726. | 11607. | 11212. |
| | 5 | 11188. | 12228. | 11334. | 11929. |
| | 9 | 11829. | 11859. | 11853. | 12853. |
| 1975 | 1 | 15860. | 15952. | 15122. | 14810. |
| | 5 | 14515. | 15108. | 14753. | 15076. |
| | 9 | 14523. | 14331. | 13916. | 15089. |
| 1976 | 1 | 18066. | 17270. | 16133. | 15316. |
| | 5 | 14636. | 14784. | 14747. | 15400. |
| | 9 | 15331. | 15092. | 14954. | 15188. |

Table A-4 STATUTORY NOTICE DEPOSITS (DSTAT2)

| | | | | | |
|---|---|---|---|---|---|
| 1955 | 1 | 5166. | 5229. | 5301. | 5388. |
| | 5 | 5439. | 5496. | 5522. | 5586. |
| | 9 | 5664. | 5716. | 5766. | 5666. |
| 1956 | 1 | 5606. | 5643. | 5662. | 5743. |
| | 5 | 5809. | 5867. | 5859. | 5891. |
| | 9 | 5919. | 5962. | 6034. | 6028. |
| 1957 | 1 | 5960. | 5991. | 6045. | 6093. |
| | 5 | 6141. | 6176. | 6159. | 6203. |
| | 9 | 6244. | 6279. | 6167. | 6140. |
| 1958 | 1 | 6042. | 6091. | 6174. | 6268. |
| | 5 | 6369. | 6456. | 6499. | 6589. |
| | 9 | 6729. | 6847. | 6924. | 6890. |
| 1959 | 1 | 6787. | 6826. | 6919. | 7011. |
| | 5 | 7107. | 7144. | 7129. | 7149. |
| | 9 | 7199. | 7225. | 7182. | 7068. |
| 1960 | 1 | 6852. | 6862. | 6940. | 7005. |
| | 5 | 7058. | 7090. | 7085. | 7108. |
| | 9 | 7198. | 7083. | 7287. | 7229. |
| 1961 | 1 | 7146. | 7192. | 7302. | 7406. |
| | 5 | 7460. | 7619. | 7501. | 7513. |
| | 9 | 7604. | 7638. | 7701. | 7641. |
| 1962 | 1 | 7540. | 7602. | 8179. | 8717. |
| | 5 | 8893. | 9034. | 9013. | 8983. |
| | 9 | 9010. | 9002. | 9064. | 8973. |
| 1963 | 1 | 8830. | 8948. | 9141. | 9275. |
| | 5 | 9384. | 9523. | 9476. | 9460. |
| | 9 | 9638. | 9660. | 9761. | 9713. |
| 1964 | 1 | 9575. | 9600. | 9701. | 9840. |
| | 5 | 9978. | 10055. | 10070. | 10148. |
| | 9 | 10194. | 10329. | 10455. | 10497. |
| 1965 | 1 | 10326. | 10484. | 10747. | 10984. |
| | 5 | 11280. | 11410. | 11452. | 11636. |
| | 9 | 11845. | 12034. | 12144. | 12177. |

Continued

| | | | | | |
|---|---|---|---|---|---|
| 1966 | 1 | 11962. | 11948. | 12054. | 12265. |
| | 5 | 12455. | 12492. | 12499. | 12629. |
| | 9 | 12784. | 12858. | 12952. | 12923. |
| 1967 | 1 | 12653. | 12756. | 13149. | 13359. |
| | 5 | 13534. | 13777. | 13932. | 14188. |
| | 9 | 14585. | 14934. | 15389. | 15785. |
| 1968 | 1 | 15383. | 15225. | 15427. | 15696. |
| | 5 | 16074. | 16587. | 16908. | 17356. |
| | 9 | 17469. | 17700. | 17938. | 17897. |
| 1969 | 1 | 17858. | 17960. | 18482. | 18849. |
| | 5 | 18813. | 18756. | 18686. | 18595. |
| | 9 | 18709. | 18821. | 18972. | 19007. |
| 1970 | 1 | 18501. | 18463. | 18626. | 18852. |
| | 5 | 19251. | 19693. | 19935. | 20304. |
| | 9 | 20495. | 20713. | 20866. | 21270. |
| 1971 | 1 | 21103. | 21063. | 21408. | 22137. |
| | 5 | 22356. | 22587. | 22849. | 23219. |
| | 9 | 23564. | 24057. | 24386. | 24459. |
| 1972 | 1 | 23868. | 24491. | 25173. | 26043. |
| | 5 | 26781. | 27656. | 28158. | 27987. |
| | 9 | 28410. | 28455. | 28833. | 28676. |
| 1973 | 1 | 28081. | 28116. | 28860. | 29550. |
| | 5 | 29909. | 30261. | 30525. | 30943. |
| | 9 | 31388. | 31615. | 32502. | 33504. |
| 1974 | 1 | 33865. | 34374. | 35322. | 36429. |
| | 5 | 37003. | 37353. | 37752. | 38799. |
| | 9 | 39828. | 40361. | 41404. | 42147. |
| 1975 | 1 | 41161. | 42438. | 43181. | 43799. |
| | 5 | 44550. | 44652. | 45254. | 46331. |
| | 9 | 46929. | 47694. | 49137. | 48524. |
| 1976 | 1 | 47339. | 48668. | 50450. | 51339. |
| | 5 | 53600. | 54844. | 55455. | 55877. |
| | 9 | 56457. | 57438. | 58185. | 58939. |

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