Sources of Change in the Canadian Money Stock, 1955-65 (*)

The nominal stock of money (M) can be expressed as the product of a monetary or reserve base (B) determined by the monetary authorities and a money multiplier (m) whose terms reflect the asset preferences of the chartered banking system and the non-bank public. Thus, the nominal money stock can be written as:

$$[1] \qquad M = mB$$

The particular multiplier employed in this study is of the form:

$$[2] \qquad m = (1 + c + t)/(r + rt + c)$$

The derivation of m is found in Appendix B. The terms of the multiplier, its constituent ratios, are the currency ratio (c), the reserve ratio (r), and the savings deposit ratio (t) where c is the ratio of currency outside banks (C) to publicly-held demand deposits (D), t is the ratio of publicly-held personal savings deposits (T) to (D), and r is the ratio of total chartered bank reserves (R) to (D + T). It must be stressed that the reserve ratio is "actual" as opposed to "legal" and that all data used in calculations are "actual" as opposed to statutory (1).

(*) My thanks to T. J. Courchene and A. Murad for comments on earlier drafts of this paper.

(1) The data are on an Average of Wednesdays basis and were obtained from the Bank of Canada *Statistical Summary*. The money stock (M), which includes Float and excludes federal government chartered bank deposits, equals to C+D+T. Non-Personal Term and Notice deposits are included in Demand deposits, consistent with the practice of the Bank of Canada prior to March, 1962. Currency outside banks includes coin. The monetary base (B) includes currency outside banks, the vault cash of banks, and chartered bank deposits at the central bank. Bank reserves (R) include vault cash and deposits at the central bank, regardless of source.

In the following pages, we quantify the relative contributions of the multiplier and the base to changes in the Canadian money stock for the period 1955-65, and attribute to changes in the constituent ratios observed movements of the money multiplier.

A glance at Chart 1 reveals that, for 1955 to 1965, the major source of the substantial increase in the stock of money was a concomitant increase in the monetary base. During the same period, however, the impact of the rise in the monetary base on the money

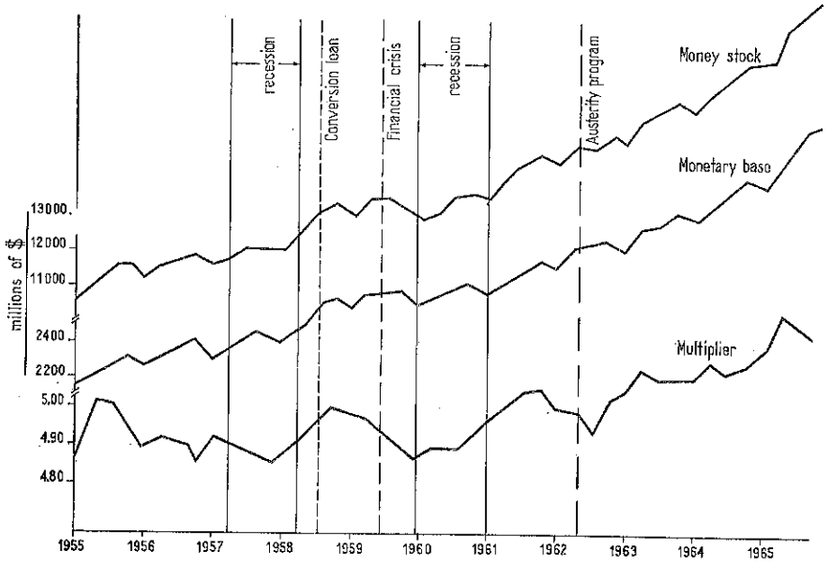

Chart 1.

stock was reinforced by a slight secular increase in the money multiplier. Chart 1 further suggests that, for a number of years, similar changes in the monetary base have had associated with them dissimilar changes in the stock of money due, of course, to changes in the money multiplier. Chart 1 is based upon "raw" data (not seasonally adjusted) and a strong seasonal pattern is evident in both the monetary base and the money stock but is not so evident in the behaviour of the multiplier. Because a graphical exposition is rather imprecise and unwieldy, we turn to numerical analysis for more information.

Table I contains percentage changes in the money stock, the money multiplier, and the monetary base for the years 1955-64, the relative contributions of changes in the base and the multiplier to changes in the money stock for those years, and the percentage contributions of the multiplier and the base to changes in the money stock for the period 1955.I to 1965.IV.

TABLE I

CONTRIBUTIONS OF THE MULTIPLIER AND THE MONETARY BASE TO CHANGES IN THE MONEY STOCK

Year	Change in M % (1)	Change in B % (2)	Change in m % (3)	(2÷1) % (4)	(3÷1) % (5)
1955	5.86	5.71	0.14	97.4	2.6
1956	3.04	2.44	0.58	80.2	19.8
1957	3.42	4.27	−0.83	124.8	− 24.8
1958	10.08	7.88	2.20	78.1	21.9
1959	− 1.94	0.52	−2.47	− 26.8	126.8
1960	5.55	3.16	2.39	56.9	43.1
1961	6.25	5.62	0.61	89.9	10.1
1962	4.56	3.42	1.14	75.0	25.0
1963	5.92	5.68	0.23	95.9	4.1
1964	8.02	6.46	1.55	80.5	19.5
Total Period	85.40	77.50	7.90	90.8	9.2

Over the total period, it is evident that, while the multiplier made a positive contribution to the increase in the stock of money (2), by far the largest role was played by the rise in the monetary base. The annual figures reveal that the role of the multiplier is enlarged for the shorter period: with the exceptions of 1955 and 1963, the annual contribution of changes in the multiplier to changes in the money stock far exceeds the contribution over the total period; indeed, on an annual basis changes in m have accounted for as much as 43% of the observed change in M. In 1957, the decline in the

(2) This is not to imply that the multiplier has some life of its own. Changes in (m) merely reflect decisions by the banks and the non-bank public to alter the composition of their portfolios.

multiplier reduced the impact of an increase in the monetary base while, for 1959, despite an increase in the base, a decline in the multiplier caused a decline in the stock of money. Finally, the reader is referred to Table I(A) (Appendix A) for data on the quarter-to-quarter contributions of changes in m and B to changes in the money stock: Table I(A) indicates that, on a quarterly basis, the multiplier has accounted for as much as three quarters of the observed change in the money stock. The inference to be drawn from the data is clear: while movements in the monetary base are predominant over long periods of time, over short periods, the impact of changes in the monetary base engineered by the monetary authorities on the money stock is apt to be less certain. A glance at Table I(A) reveals that for five quarters in which the percentage increase in the monetary base was between 1.81% and 1.88%, the percentage increase in the stock of money varied from 0.24% to 4.65%.

Sources of Change in the Multiplier

We have established that, for short periods of time, changes in the money multiplier constitute an important source of change in the stock of money. The source of change in the multiplier is, of course, changes in the constituent ratios of the multiplier.

Given the form of our money multiplier, we can express it in functional terms as:

$$[3] \qquad m = m(c, t, r)$$

Differentiating this expression totally yields:

$$[4] \qquad dm = \frac{\partial m}{\partial c} dc + \frac{\partial m}{\partial t} dt + \frac{\partial m}{\partial r} dr$$

Dividing through by (dm) yields:

$$[5] \qquad 1 = \frac{\partial m}{\partial c}\frac{dc}{dm} + \frac{\partial m}{\partial t}\frac{dt}{dm} + \frac{\partial m}{\partial r}\frac{dr}{dm}$$

which gives us the proportion of the change in the multiplier attributable to changes in the currency, savings deposit, and reserve ratios (c, t, and r) respectively. While equations [4] and [5] are in continuous terms, our data consist of discrete observations. We can rewrite equations [4] and [5] to account for this as follows:

$$[6] \qquad \Delta m = \frac{\partial m}{\partial c} \Delta c + \frac{\partial m}{\partial t} \Delta t + \frac{\partial m}{\partial r} \Delta r$$

$$[7] \qquad 1 = \frac{\partial m}{\partial c}\frac{\Delta c}{\Delta m} + \frac{\partial m}{\partial t}\frac{\Delta t}{\Delta m} + \frac{\partial m}{\partial r}\frac{\Delta r}{\Delta m}$$

These latter equations are, of course, approximations to equations [4] and [5] (3). We can give these expressions empirical content by substituting into equations [6] and [7] the partial derivatives of equation [2] with respect to c, t, and r. For equation [6] this yields the following:

$$[8] \qquad \Delta m = \left[\frac{(1+t)(r-1)}{(r+rt+c)^2}\right]\Delta c + \left[\frac{c(1-r)}{(r+rt+c)^2}\right]\Delta t - \left[\frac{(1+c+t)(1+t)}{(r+rt+c)^2}\right]\Delta r$$

The partial derivatives of m with respect to c, t, and r are negative, positive, and negative respectively. This approach has been used by Friedman and Schwartz (4), and Ahrensdorf and Kanesathasan (5), but both the details of the method and the multipliers investigated differ from ours.

We have calculated the terms of equation [8] for quarterly data (unadjusted), annual data, and for the total period. The quarterly unadjusted figures are found in Table II while the annual and total period figures are contained in Table III.

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(3) See: R. G. D. Allen, *Mathematical Analysis for Economists*, London, Macmillan, 1964, pp. 328-9.

(4) Milton Friedman, Anna J. Schwartz, *A Monetary History of the United States*, Princeton University Press, 1963, Appendix B.

(5) J. Ahrensdorf, S. Kanesathasan, "Variations in the Money Multiplier and Their Implications for Central Banking", *IMF Staff Papers*, November, 1960, p. 134.

TABLE II

SOURCES OF CHANGE IN THE MULTIPLIER
(quarterly data, not seasonally adjusted)

		Δm Actual	Δm Estimated (1)	$\frac{\partial m}{\partial c}\Delta c$ (2)	$\frac{\partial m}{\partial r}\Delta r$ (3)	$\frac{\partial m}{\partial t}\Delta t$ (4)	(2)÷(1)	(3)÷(1)	(4)÷(1)
1955	1	—	—	—	—	—	—	—	—
	2	.140	.146	.114	.088	−.056	0.78	0.60	− 0.38
	3	−.012	−.011	.022	−.019	−.015	− 1.94	1.65	1.28
	4	−.078	−.076	−.058	−.025	.007	0.76	0.33	− 0.09
1956	1	−.043	−.042	−.114	−.024	.096	2.71	0.56	− 2.27
	2	.027	.027	.027	.006	−.007	1.01	0.24	− 0.25
	3	−.018	−.017	−.026	.021	−.013	1.50	− 1.25	0.74
	4	−.047	−.046	−.058	−.008	.020	1.24	0.19	− 0.43
1957	1	.067	.067	−.083	.040	.109	− 1.23	0.60	1.63
	2	−.023	−.023	.009	−.024	−.008	− 0.38	1.03	0.35
	3	−.039	−.038	−.064	.014	.012	1.69	− 0.37	− 0.32
	4	−.007	−.008	.084	.018	−.110	−10.26	− 2.22	13.75
1958	1	.028	.027	−.025	−.016	.069	− 0.94	− 0.62	2.56
	2	.051	.052	.058	.010	−.016	1.11	0.20	− 0.31
	3	.041	.042	.103	−.020	−.041	2.45	− 0.47	− 0.97
	4	.043	.044	.084	.016	−.056	1.92	0.36	− 1.28
1959	1	−.026	−.026	−.126	−.029	.129	4.77	1.10	− 4.87
	2	−.012	−.011	−.044	.002	.031	3.98	− 0.19	− 2.78
	3	−.043	−.042	−.084	.017	.024	2.01	− 0.41	− 0.59
	4	−.054	−.054	.000*	−.015	−.039	− 0.02	0.29	0.71
1960	1	−.013	−.013	−.066	−.024	.077	4.92	1.85	− 5.78
	2	.012	.012	−.014	.032	−.005	− 1.12	2.53	− 0.41
	3	.005	.004	.004	.015	−.015	0.96	3.42	− 3.39
	4	.045	.046	.086	.017	−.057	1.86	0.36	− 1.22
1961	1	.056	.055	.011	−.007	.051	0.21	− 0.14	0.93
	2	.043	.044	.056	.006	−.018	1.27	0.15	− 0.42
	3	.027	.026	.079	.024	−.077	2.97	0.90	− 2.88
	4	.010	.010	.082	−.009	−.062	7.83	− 0.86	− 5.96
1962	1	−.049	−.048	−.090	−.061	.103	1.85	1.26	− 2.12
	2	−.024	−.024	.001	−.027	.001	− 0.05	1.12	− 0.06
	3	−.072	−.069	−.095	−.001	.028	1.38	0.02	− 0.40
	4	.105	.108	.122	.086	−.101	1.13	0.80	− 0.93
1963	1	.049	.047	.026	−.022	.043	0.56	− 0.47	0.90
	2	.051	.052	.069	.015	−.033	1.33	0.29	− 0.63
	3	−.037	−.036	−.035	−.012	.012	0.98	0.35	− 0.34
	4	.000	.000	.047	−.003	−.044	−94.59	0.64	89.13
1964	1	−.002	−.002	−.004	−.032	.034	2.14	16.12	−17.26
	2	.050	.050	.049	.029	−.028	0.98	0.58	− 0.56
	3	−.044	−.042	−.029	−.004	−.008	0.68	0.11	0.20
	4	.034	.033	.070	.021	−.058	2.10	0.65	− 1.76
1965	1	.040	.040	.052	−.025	.013	1.30	− 0.63	0.33
	2	.111	.116	.167	.047	−.098	1.43	0.40	− 0.84
	3	−.031	−.031	.037	−.022	−.046	− 1.16	0.71	1.45
	4	−.019	−.018	−.010	−.003	−.004	0.57	0.18	0.24

* This entry is the result of truncating at three decimal places.

TABLE III

SOURCES OF CHANGE IN THE MULTIPLIER
(annual data)

Year	Δm (1)	$\frac{\partial m}{\partial c}\Delta c$ (2)	$\frac{\partial m}{\partial r}\Delta r$ (3)	$\frac{\partial m}{\partial t}\Delta t$ (4)	(2)÷(1)	(3)÷(1)	(4)÷(1)
1955	0.007	−0.045	0.016	0.036	−6.260	2.209	5.051
1956	0.031	−0.139	0.060	0.110	−4.512	1.953	3.560
1957	−0.041	0.000	−0.007	−0.033	0.003	0.190	0.806
1958	0.110	0.113	−0.022	0.020	1.023	−0.206	0.183
1959	−0.114	−0.186	−0.021	0.093	1.627	0.191	−0.818
1960	0.122	0.088	0.059	−0.026	0.724	0.490	−0.214
1961	0.033	0.120	−0.040	−0.047	3.619	−1.200	−1.419
1962	0.058	0.046	0.035	−0.024	0.804	0.618	−0.422
1963	0.012	0.072	−0.048	−0.011	5.811	−3.897	−0.914
1964	0.083	0.144	0.022	−0.082	1.728	0.263	−0.991
1965	0.071	0.150	0.000	−0.079	2.109	0.000	−1.107
Total Period . .	0.296	0.191	0.057	0.047	0.645	0.195	0.159

To assist the reader in assessing the contributions of the constituent ratios to changes in the multiplier, the ratios and the multiplier (for unadjusted data) are charted in Chart 2.

On both a quarterly and an annual basis, Tables II and III indicate that the predominant source of change in the money multiplier is changes in the currency ratio (c). The savings deposit and reserve ratios, on the basis of Tables II and III, appear to make roughly equal contributions to changes in the multiplier but neither is as powerful as the currency ratio. The average annual absolute values (1955-65) of the ratios $\frac{\partial m}{\partial c}\Delta c$, $\frac{\partial m}{\partial r}\Delta r$, and $\frac{\partial m}{\partial t}\Delta t$ to Δm are 2.565, 1.019, and 1.407 respectively, indicating a somewhat smaller role for the reserve ratio vis-à-vis the savings deposit ratio.

Further evidence on the relative importance of the individual constituent ratios to changes in the multiplier is obtained from the elasticities and weighted regression coefficients derived from the following regression equation:

$$[9] \quad m_t = -7.41c_t + 1.05t_t - 22.4r_t + 7.99 \quad R^2 = 0.9940$$
$$(t) \qquad (84.7) \quad (45.8) \quad (23.4) \quad (99.4) \quad D.W = 0.40$$

Equation [9] was estimated with quarterly, unadjusted data. Re-estimation of equation [9] after the application of a Durbin

procedure to the time series lowered the t-values but did not materially alter the regression coefficients.

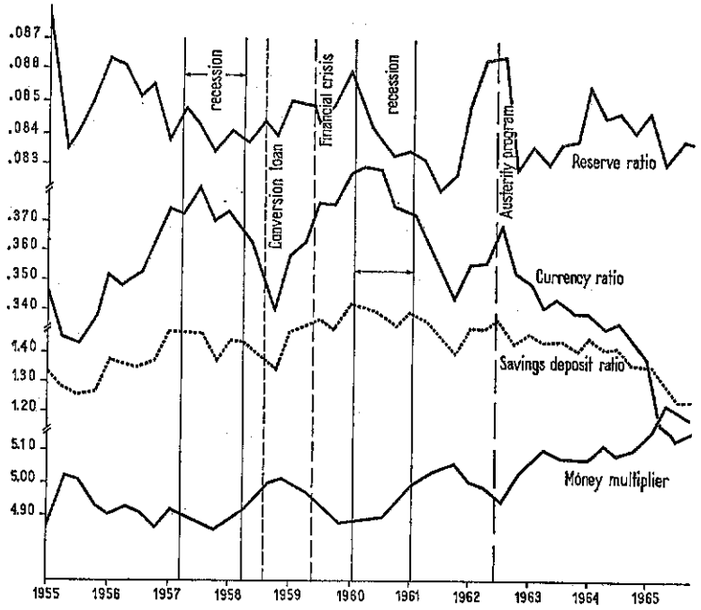

Chart 2.

The elasticities (mean) calculated from equation [9] are as follows:

Elasticity of m with respect to:

Currency Ratio	—.5187
Savings Deposit Ratio . . .	+.2940
Reserve Ratio	—.3584

Weighting the regression coefficients of equation [9] by the correlation between the dependent and relevant independent variable (scaled by the coefficient of determination) yields values of 1.29, —0.37, and 0.08 for the currency, savings deposit, and reserve ratios respectively (the weighted coefficients sum to unity when the weighted coefficient for the constant is included) (6). While the above

(6) This technique is presented in: A. Goldberger, *Econometric Theory*, New York, John Wiley, 1963, pp. 197-198.

elasticities suggest that changes in the reserve ratio are more powerful than changes in the savings deposit ratio, the weighted coefficients indicate that the reserve ratio is the least systematic contributor to changes in the multiplier on a quarterly basis.

Implications

The data indicate that while changes in the monetary base are the predominant source of change in the money stock for long periods of time, for periods as short as a year or a quarter, changes in the money multiplier play a large role in changes in the money stock and may occasionally overshadow changes in the base. These findings cast doubt on the ability of the central bank to pursue an effective short-term monetary policy since, for short periods, much of the control of the money stock (and interest rates) lies with the banking system and the non-bank public (7).

The major source of change in the money multiplier is change in the currency ratio (c). A rise in (c) leads to a decline in the multiplier, *ceteris paribus*, because it entails a redistribution of the monetary base that goes against the banking system. In other words, the banks suffer a net loss of reserves. This explanation of the impact of changes in (c) upon the multiplier might be adequate for monthly or quarterly data; for annual data it is inadequate. On a monthly or quarterly basis, a rise in (c) will reduce the multiplier if the reserve loss is not offset by the central bank. The Porter Commission suggests that the Bank of Canada does not normally allow changes in public note demand to affect "credit conditions" and that it takes the necessary offsetting action (8). It appears that the Bank of Canada does not completely offset changes in public note demand on a quarterly basis but nearly so (9). The impact of the currency ratio on the multiplier on an annual or longer basis requires a more subtle analysis. Specifically, it requires that we view changes

(7) Unless, of course, changes in the money multiplier are predicted accurately by the central bank. We submit that the Bank of Canada's description of reserve management as a process of successive approximation is inconsistent with accurate prediction. See: Bank of Canada, *Submission to the Royal Commission on Banking and Finance*, Ottawa, 1962, p. 19.

(8) Royal Commission on Banking and Finance, *Report*, Ottawa, Queen's Printer, 1964, p. 460 n.

(9) We have estimated that, for quarterly data, the Bank of Canada offsets each dollar of currency drained from the banks by 78 cents.

in the currency ratio as altering the deposit expansion plans of the banks. This approach sees (c) for what it really is — a constraint on the banking system perceived by the banking system and not a behavioural ratio of the non-bank public (10). If the central bank confines its attention to changes in note demand rather than to the behaviour of the currency ratio, even with faultless offsetting it may find the response of the money stock to changes in the monetary base altering over time. For reserve ratio calculation purposes, the movement of bank cash is the relevant variable; for predicting the response of money and interest rates to changes in central bank liabilities, the currency ratio is the relevant variable.

A rise in the savings deposit ratio (t) increases the multiplier and, *ceteris paribus*, the money stock (11). The positive relationship between (t) and the money multiplier follows from our assumption that there is no currency drain against savings deposits (see Appendix B) (12). While there is in fact a currency drain from savings accounts, data on deposit turnover velocities suggest that our assumption is useful (13). A shift in public asset preferences away from demand deposits to savings deposits reduces the possibility of reserve losses from the banks as deposits expand (14). This suggests that induced changes in (t) may render uncertain the response of the money stock and interest rates to changes in the monetary base engineered by the central bank; this is especially possible under the provisions of the Bank Act of 1967 which established a lower legal reserve ratio for savings deposits than for demand deposits.

Our data indicate considerable variation in the non-statutory reserve ratio over the period studied; an examination of published values of the statutory reserve ratio (15) reveals that the former varies

(10) The usual textbook exposition of deposit expansion subject to a currency drain obscures this distinction.

(11) The most important *ceteris paribus* condition is that the actual reserve ratio is unchanged. If a rise in t creates excess reserves, the positive impact of a rise in (t) is lost.

(12) This assumption is forced by a lack of data on currency drains against the two classes of deposits. It would be unnecessary if we did not distinguish between demand and savings deposits.

(13) The turnover velocity of demand deposits is at least forty times as great as that of notice deposits. See: Canadian Bankers' Association, "Submissions to the Royal Commission on Banking and Finance". *The Canadian Banker*, Supplement, Spring, 1963, p. 41.

(14) Through inter-bank clearings.

(15) By "statutory reserve ratio" we mean the ratio of reserves to deposits calculated in accordance with statutory provisions. That is, the terms of the ratio do not enter the ratio simultaneously as they do for the non-statutory ratio.

considerably more than the latter (16). Furthermore, changes in the non-statutory ratio, while potent in terms of elasticity, are the least systematic source of change in the money multiplier.

The greater variability of the non-statutory reserve ratio vis-à-vis the statutory ratio reflects little more than the peculiarities of the legal reserve ratio calculation method used in Canada: since bank reserves and deposits do not enter the reserve ratio simultaneously, on a current basis reserves and deposits are somewhat independent (17). This means that banks can increase current deposits in the knowledge that reserves must be forthcoming to support them (18) and that open market changes in reserves affect deposits not directly but by altering bankers' expectations of future reserves (19).

Finally, a comment on money supply theory. Our results indicate that determination of the nominal stock of money rests, to a great extent, with the public and, to a lesser extent, with the banking system. Although the central bank controls the monetary base, this does not give it control of the stock of money. Rather, the central bank's control of the monetary base, coupled with the legal reserve ratio, gives it only the power to set an upper limit to the money stock. Whether the upper limit is reached depends only on the public, if we assume that banks shun excess reserves. In other words, the nominal stock of money is determined by the demand for money, constrained by the monetary base, and a theory of the supply of money may be redundant.

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(16) While our values for the reserve ratio exceed 8% this does not necessarily indicate excess reserves. The values for (r) would be lower had we deflated total reserves by reserves held against federal government bank deposits. Whatever the values for (r), we cannot say that excess reserves do or do not exist. Only by comparing actual to desired reserves could we make such a judgement. Of course, published reserves ratios tell us nothing about excess reserves. For data on the legal reserve ratio, see: Bank of Canada, *Statistical Summary*.

(17) This is not entirely correct. The vault cash component of reserves, about one-third of total reserves, enters the ratio simultaneously with bank deposits.

(18) "Must" is perhaps too strong a word but the reserve ratio calculation method does place an obligation on the central bank to not force the chartered banks into breaking the law.

(19) H. G. Johnson and J. W. L. Winder suggest that the method of calculating the legal reserve ratio predisposes the system to misunderstandings between the central bank and the chartered banks: *Lags in the Effects of Monetary Policy in Canada*, a study for the Royal Commission on Banking and Finance, November, 1962, p. 141.

APPENDIX A

TABLE I (A)

CONTRIBUTIONS OF THE MULTIPLIER AND THE BASE TO CHANGES IN THE MONEY STOCK
(quarterly data, unadjusted)

		Δ ln M %	Δ ln B %	Δ ln m %	Δ ln m / Δ ln M %	Δ ln B / Δ ln M %
1955	1	—	—	—	—	—
	2	4.65	1.82	2.81	60.6	39.1
	3	3.48	3.72	−0.23	− 6.8	106.7
	4	0.24	1.81	−1.56	−646.3	747.7
1956	1	−2.51	−1.63	−0.87	34.6	64.9
	2	2.70	2.14	0.54	20.3	79.5
	3	1.99	2.35	−0.36	− 18.3	117.8
	4	0.71	1.68	−0.96	−134.3	235.8
1957	1	−2.36	−3.74	1.36	− 57.7	158.0
	2	1.99	2.46	−0.46	− 23.4	124.1
	3	1.33	2.12	−0.79	− 59.6	159.9
	4	0.86	1.00	−0.14	− 16.7	117.0
1958	1	−0.75	−1.33	0.57	− 76.2	176.8
	2	4.28	3.23	1.03	24.2	75.5
	3	5.24	4.42	0.82	15.7	84.3
	4	3.16	2.30	0.85	27.1	72.8
1959	1	−2.60	−2.08	−0.51	19.8	79.7
	2	1.88	2.11	−0.24	− 12.7	112.1
	3	0.66	1.53	−0.86	−129.6	229.2
	4	1.51	−0.39	−1.09	72.6	26.3
1960	1	−2.99	−2.72	−0.26	8.8	91.0
	2	2.15	1.88	0.24	11.4	87.8
	3	1.94	1.85	0.10	52.5	49.1
	4	1.82	0.89	0.91	50.2	49.1
1961	1	−0.36	−1.47	1.12	−312.0	407.4
	2	2.73	1.86	0.85	31.3	68.1
	3	3.22	2.69	0.53	16.5	83.6
	4	2.04	1.84	0.19	9.6	90.4
1962	1	−1.74	−0.78	−0.97	55.5	44.8
	2	2.80	3.29	−0.47	− 17.0	117.6
	3	0.43	1.86	−1.45	−332.9	429.0
	4	1.78	−0.32	2.10	118.3	− 18.2
1963	1	−0.46	−1.41	0.96	−210.4	306.5
	2	3.62	2.60	0.99	27.6	72.2
	3	1.64	2.35	−0.72	− 44.0	143.4
	4	1.48	1.49	−0.01	—	100.0
1964	1	−0.81	−0.77	−0.04	4.8	95.1
	2	3.01	2.03	0.97	32.3	67.6
	3	2.13	2.98	−0.85	− 40.2	139.8
	4	2.24	1.59	0.66	29.5	70.7
1965	1	0.62	−0.14	0.77	123.3	− 23.2
	2	5.35	3.22	2.12	39.6	60.2
	3	3.55	4.16	−0.58	− 16.5	117.0
	4	2.04	2.39	−0.36	− 17.7	117.0

APPENDIX B

[1] $M = C + D + T$
[2] $T = tD$
[3] $C = cD$

Using [2] and [3], we can rewrite [1] as:

[4] $M = D(1 + c + t)$

The monetary base (B) is the sum of all chartered bank reserves (R) and currency in the hands of the public (C):

[5] $B = R + C$

Reserves (R) are a fraction (r) of the sum of (D) and (T):

[6] $R = r(D + T)$

Using [2], [3], and [6], we can rewrite ([5] as:

[7] $B = D(r + rt + c)$ or:
[8] $D = B/(r + rt + c)$

Substituting [8] into [4] yields:

[9] $M = B(1 + c + t)/(r + rt + c)$ or:
[10] $M = mB$

A. K. K.