Contributions of the Determinants to the Rate of Change in the Money Stock: The Case of Korea

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I. Introduction

Monetary authorities control the issue of assets that banks use as reserves for their monetary liabilities. Such assets are called high-powered money (H) to signify that they can serve as the base for a multiple expansion of bank deposits. When currency is held by the public (C), the same term is used in recognition of its potential use by banks to expand the money stock. Given the quantity of high-powered money, the public and commercial banks jointly determine its division between public holdings and bank reserves (R). The public determines the fraction of total money balance it wants to hold in the form of high-powered money. This can be done by simply converting currency into bank deposits and vice versa.

The banking system determines the volume of monetary liabilities it is willing to create through loans and investment per unit of high-powered money it holds. When banks reduce their holdings of high-powered money by making loans and thereby reduce their reserve ratio, they increase the money supply assuming that the public maintains the same currency-money ratio (c). Similarly, the public can affect the quantity of money when it changes its holding of high-powered money in relation to deposits, or shifts deposits between demand (Dd) and time accounts (Dt).

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The relation of the amount of money supplied to the behavior of the three sectors can be seen in the following equations.

$$M_2 = C + D \tag{1.1}$$

$$H = C + R \tag{1.2}$$

$$C = c_2 M_2 \tag{1.3}$$

$$D = (1 - c_2) M_2 \tag{1.4}$$

$$R = r_2 D = r_2 (1 - c_2) M_2 \tag{1.5}$$

Divide both sides of equation (1.2) by M_2

$$\frac{H}{M_2} = \frac{C}{M_2} + \frac{R}{M_2} \tag{1.6}$$

Substitute both equations (1.3) and (1.5) into (1.6)

$$M_2 = \frac{H}{c_2 + r_2 (1 - c_2)} \tag{1.7}$$

Obviously, the value of currency-money ratio (c) and reserve deposit ratio (r) differs depending upon the definition of the money supply. However, we can still use the M_2 reserve ratio (r_2) in the M_1 money supply, provided that the variable which indicates shifts between demand and time deposits is separately treated. Let

$t = Dt/Dd$, $C = c_1 M_1$ and $Dd = (1 - c_1) M_1$.

Then equation (1.5) becomes

$$R = r_2 (Dd + t\,Dd)$$

$$= r_2 (1 + t)\, Dd = r_2 (1 + t)(1 - c_1) M_1 \tag{1.8}$$

Dividing equation (1.2) by M_1 and substituting equation (1.8) yields

$$M_1 = \frac{H}{c_1 + r_2 (1 + t)(1 - c_1)} \tag{1.9}$$

Equations (1.7) and (1.9) express the total money stock in terms of the quantity of high-powered money, the currency-money ratio (or the currency ratio), the reserve deposit ratio (or the reserve ratio), and the time-demand deposit ratio. These four variables will be referred to as the determinants of the money supply. The quantity of money is jointly determined by these four variables.

The quantity of high-powered money, unlike the other three determinants of the money supply is measured in the nominal currency unit, and the real value of a given nominal quantity is inversely proportional to price. The other three determinants, on the other hand, are measured as pure numbers and cannot be mean-

ingfully deflated by an index of prices. The currency ratio and reserve ratio, at most, vary from zero to unity.

In following section, an attempt will be made to estimate the relative contribution of each determinant to the rate of changes in the money stock in the case of Korea from 1954 to 1969.

II. Contributions of the Determinants to the Rate of Change in the Money Stock

The four proximate determinants of the money stock reflect the behaviour of the three sectors of the economy: high-powered money, the behaviour of the government, mainly; the currency ratio, of the public; the reserve ratio, of banking institutions; and shifts between demand and time deposits, of the public.

The rate of change directly attributable to changes in each of the four determinants can be derived from the identity equations of the money supply developed previously.

The identity equation for the M_1 money supply was written as

$$M_1 = \frac{H}{c_1 + r_2 (1 + t)(1 - c_1)}$$

Taking logarithms and differentiating with respect to time

$$\frac{\dot{M}_1}{M_1} = \frac{\dot{H}}{H} - \frac{c_1 (1 - r_2 (1+t))}{c_1 + r_2 (1+t)(1-c_1)} \frac{\dot{c}_1}{c_1} - \frac{r_2 (1+t)(1-c_1)}{c_1 + r_2 (1+t)(1-c_1)} \frac{\dot{r}_2}{r_2} - \frac{t r_2 (1-c_1)}{c_1 + r_2 (1+t)(1-c_1)} \frac{\dot{t}}{t} \qquad (2.1)$$

Finally making suitable substitutions

$$\frac{\dot{M}_1}{M_1} = \frac{\dot{H}}{H} + \left(1 - \frac{r_2 (1+t) M_1}{H}\right)\left(-\frac{\dot{c}_1}{c_1}\right) + \left(1 - \frac{c_1 M_1}{H}\right)\left(-\frac{\dot{r}_2}{r_2}\right) + \left(1 - \frac{((1-r_2) c_1 + r_2) M_1}{H}\right)\left(-\frac{\dot{t}}{t}\right) \qquad (2.2)$$

The left-hand side of the equation represents the rate of change of the M_1 money supply. The four terms on the right-hand side give the contributions to that rate of change by high-powered money, the currency ratio, the reserve ratio, and shifts between demand and time deposits respectively. Since the data exist only for discrete points in time, the instantaneous rates in formula (2.2)

must be approximated by average rate over a period.[1] Approximating the terms in this way, however, introduces an error or "interaction" term and thereby destroys the equality. The error is usually small and can be ignored.

The formula for the rate of change in the M_2 money stock attributable to changes in each of the three determinants can be derived in a similar manner.

$$M_2 = \frac{H}{c_2 + r_2 (1 - c_2)}$$

$$\frac{\dot{M}_2}{M_2} = \frac{\dot{H}}{H} + \frac{c_2 M (1 - r_2)}{H} \left(-\frac{\dot{c}_2}{c_2}\right) + \frac{r_2 M (1 - c_2)}{H} \left(-\frac{\dot{r}_2}{r_2}\right) \quad (2.3)$$

Tables 1 and 2 show the semi-annual contributions of each determinant to the rate of change in M_1 and M_2 money stocks. Tables 3 and 4 present average contributions in percentages rates for the entire period and two subperiods as well as in relative contributions. For the relatives, the contribution of each determinant was divided by the average rate of change of the money stock. When the contributions of all determinants do not have the same sign, some determinants make a negative relative contribution. For example, from equation (2.2) the contribution of high-powered money is $\dot{H}/H$. If $\dot{H}/H$ were negative and $\dot{M}/M$ were positive, high-powered money makes a negative relative contribution, the money supply increases despite a decrease in high-powered money. The relative measures therefore indicate the degree of association between the contribution of each determinant.

The dominant role of high-powered money in the long-run growth of the money stock is indicated by Tables 1 -- 4. For the entire period, the increase in high-powered money was slightly greater than that of the M_1 money supply so the relative contribution of high-powered money is more than 100 percent. The relative contribution of high-powered money to the M_2 money supply was approximately 80 percent. Before the first period of 1965, the large growth of high-powered money occurred chiefly because of government deficit financing. After the first period of 1965, the main source of the increase in high-powered money was the net acquisition of foreign assets.

The relative contribution of the currency ratio was not systematic, both positive and negative contributions occurring. For

1 For ease of computation, we used the values of beginning period for the calculations of M, H, r,c, and t in the equation 2.2.

Table 1

THE RATE OF CHANGES IN THE M_1 MONEY SUPPLY AND CONTRIBUTIONS BY DETERMINANTS (PERCENT)

Period		Total[a]	High-powered Money	Currency Ratio	Reserve Ratio	Time Deposit Ratio
1954	2	34.12	34.44	-0.22	0.21	-0.73
1955	1	10.87	3.81	4.40	2.17	-0.58
	2	25.75	34.00	-0.10	-6.04	-0.26
1956	1	26.88	17.55	6.77	0.50	-0.02
	2	12.89	15.54	-1.86	-0.06	-0.45
1957	1	8.65	2.16	2.62	2.45	0.80
	2	8.54	6.80	-1.12	3.13	-0.40
1958	1	17.21	11.87	4.12	0.09	0.32
	2	10.43	14.35	-3.23	0.18	-0.52
1959	1	27.64	17.85	7.29	-0.08	0.41
	2	2.81	3.91	-1.28	0.82	-0.63
1960	1	9.54	8.88	-1.14	2.30	-0.59
	2	-3.27	1.98	-5.19	-0.44	0.18
1961	1	8.29	3.67	4.08	-0.10	0.27
	2	25.26	25.08	1.18	-0.43	-0.59
1962	1	14.83	20.51	5.76	-6.43	-2.56
	2	9.76	6.57	-0.06	4.95	-2.34
1963	1	2.26	-9.75	4.86	6.40	-0.05
	2	3.40	10.37	-4.69	-0.79	-1.69
1964	1	3.69	0.06	-1.08	3.27	1.92
	2	10.74	14.28	-5.65	3.10	-0.54
1965	1	10.09	7.28	1.54	0.75	0.22
	2	14.10	19.87	-0.11	-2.65	-1.98
1966	1	15.05	37.02	2.17	-13.74	-4.13
	2	13.51	26.04	-2.26	-1.67	-7.69
1967	1	20.53	25.07	-0.78	-1.28	-3.02
	2	16.25	15.32	0.04	4.80	-4.85
1968	1	19.48	28.06	-0.01	-3.29	-6.43
	2	9.23	23.55	-0.65	2.33	-9.46
1969	1	10.94	13.79	0.37	1.85	-9.09
	2	27.31	31.53	0.27	2.12	-3.17

[a] Lines do not add exactly to total because of rounding and approximation error.

Table 2

THE RATE OF CHANGE IN THE M_2 MONEY SUPPLY AND CONTRIBUTIONS BY DETERMINANTS (PERCENT)

Period		Total[a]	High-powered Money	Currency Ratio	Reserve Ratio
1954	2	37.08	34.44	1.22	0.69
1955	1	13.67	3.81	6.17	2.17
	2	27.02	34.00	0.60	-6.02
1956	1	29.09	17.55	8.34	0.50
	2	13.54	15.54	-1.70	-0.06
1957	1	7.24	2.16	2.19	2.45
	2	9.40	6.80	-0.71	3.13
1958	1	16.94	11.87	4.24	0.09
	2	11.35	14.35	-2.87	0.18
1959	1	27.74	17.85	7.83	-0.08
	2	4.27	3.91	-0.47	0.82
1960	1	11.05	8.88	-0.34	2.30
	2	-4.75	1.98	-6.67	-0.44
1961	1	8.20	3.67	4.30	-0.10
	2	27.70	25.08	2.50	-0.43
1962	1	25.41	20.51	11.16	-6.43
	2	15.11	6.57	2.34	4.95
1963	1	-4.33	-0.75	6.70	6.41
	2	5.27	10.37	-4.08	-0.79
1964	1	-1.07	9.06	-4.27	3.24
	2	10.50	14.28	-6.38	3.10
1965	1	9.74	7.28	1.48	0.75
	2	22.40	19.87	4.81	-2.65
1966	1	31.52	37.02	10.67	-13.74
	2	27.52	26.44	2.55	-1.67
1967	1	29.16	25.07	4.50	-1.28
	2	25.72	15.32	3.35	4.80
1968	1	29.73	28.06	4.68	-3.29
	2	28.68	23.55	1.63	2.33
1969	1	30.35	13.79	10.73	1.85
	2	29.23	31.53	-3.87	2.12

[a] Lines do not add exactly to total because of rounding and approximation error.

Table 3

THE RATE OF CHANGE IN THE M_1 MONEY SUPPLY AND CONTRIBUTIONS BY DETERMINANTS FOR SELECTED PERIODS (PERCENT)

Period	Total[a]	High-powered Money	Currency Ratio	Reserve Ratio	Time Deposit Ratio
All years	13.3	14.7	0.6	0.1	-1.90
	(100)	(110.5)	(4.5)	(0.9)	(-14)
1954 I — 1965 I	12.6	11.5	0.8	0.7	-0.4
	(100)	(91.3)	(7.0)	(6.0)	(-3.9)
1965 II — 1969 II	16.7	24.9	0.1	-1.10	-5.90
	(100)	(114.8)	(0.6)	(-6.6)	(-35.7)

Note: Figures in parenthese are relative contributions [a]Lines do not add exactly to total because of rounding and approximation error.

Table 4

THE RATE OF CHANGE IN THE M_2 MONEY SUPPLY AND CONTRIBUTIONS BY DETERMINANTS FOR SELECTED PERIODS (PERCENT)

Period	Total[a]	High-Powered Money	Currency Ratio	Reserve Ratio
All years	17.6	14.7	2.2	0.2
	(100)	(83.52)	(12.40)	(1.1)
1954 I — 1965 I	14.4	11.5	1.4	0.7
	(100)	(82.10)	(10.00)	(5.0)
1965 II — 1969 II	29.0	25.1	4.3	-1.10
	(100)	(86.55)	(14.83)	(-4.4)

Note: Figures in parentheses are relative contributions [a]Lines do not add exactly to total because of rounding and approximation error.

this reason, the long-run contribution of the currency ratio is quite small, particularly in the case of M_1. However, the contribution of the M_2 currency ratio was 12.5 percent. The figure is somewhat higher in the latter period (15 percent) than earlier period (10 percent). This largely reflects the upward movement of per capita real income and interest rates, which were the two most important variables explaining the declining currency-money ratio. Be sure that a declining currency-money ratio makes a positive contribution to the money supply.

The contributions of the reserve ratio also largely offset each other over the entire period and within each subperiod. This ratio tended to move in different directions so its contribution was absolutely smaller for the entire period than either subperiod, as Tables 3 and 4 indicate. For example, the contribution of the reserve ratio to the rate of change in the money stock was initially marginally positive and negative subsequently, so the combined effect was even smaller.

Finally, the negative contribution of shifts from demand to time deposits is an important element in explaining the change in the M_1 money stock. The ratio of time to total deposits rose throughout much of the first period. This rising trend was partially offset by declines in a few periods, so that the over-all contribution of shifts between demand and time deposits, while negative, was small in the earlier period. However, after 1965 the ratio of time to total deposits rose rapidly. This large increase in the ratio is reflected in a substantial negative contribution to the rate of change of the M_1 money stock.

High-powered money dominated long run movement in the rate of change in the money stock. How stable are the contributions of the determinants? Table 5 and 6 show the standard deviation and the coefficient of variation of the contributions of each determinant to the rate of change in the money stock. In other words, Tables 5 and 6 show the standard deviation of the columns in Tables 1 and 2 respectively, and the standard deviation divided by the mean. The coefficient of variation indicates relative variability of a determinant.

The standard deviation of the contribution of high-powered money is larger than that of other determinants. For example, the standard deviation of the contribution of high-powered money to the rate of change in the M_1 money stock during the entire period is 10.87, while that of the currency ratio is 3.20. But this is to be expected as the value of the contribution of high-powered money

Table 5

THE STANDARD DEVIATION AND COEFFICIENT OF VARIATION OF THE CONTRIBUTION OF DETERMINANTS (M_1)

Period	High-Powered Money	Currency Ratio	Reserve Ratio	Time Deposit Ratio
All years	10.87	3.20	4.00	3.12
	(0.74)	(5.33)	(20.00)	(-1.64)
1954 I —	10.67	4.36	2.93	6.32
1965 I	(0.93)	(5.45)	(4.19)	(-15.8)
1965 II —	7.28	1.13	5.74	3.38
1969 II	(0.29)	(11.27)	(5.20)	(-1.58)

Note: Figures in parentheses are the coefficient of variation.

Table 6

THE STANDARD DEVIATION AND COEFFICIENT OF VARIATION OF THE CONTRIBUTION OF DETERMINANTS (M_2)

Period	High-Powered Money	Currency Ratio	Reserve Ratio
All Years	10.87	4.73	3.76
	(0.74)	(2.15)	(18.5)
1954 I—1965 I	10.67	4.80	2.93
	(0.93)	(3.43)	(4.18)
1965 II—1969 II	7.28	4.21	5.08
	(0.29)	(0.98)	(-4.62)

Note: Figures in parentheses are the coefficient of variation.

far exceeds the value of other contributions. Next, let us consider the coefficient of variation, which provides a measure of relative variability for the contribution of a determinant. On the whole, high-powered money shows the smallest coefficient of variation

and hence the greatest relative stability. The coefficients of the other determinants show considerably greater relative variability. Although the high variability of the contribution of the reserve ratio is largely explained by the monetary authorities policies, this is not the case for the currency ratio and time deposit ratio. The changing effects of the currency ratio and the time-deposit ratio on the money supply, unlike changes in bank reserve ratios or issues of the central bank money, are not subject to the direct control of the monetary authorities. The variability of the contribution of the currency ratio, for example, indicates that the currency ratio has a greater effect in explaining short-run variability of the money supply than long-run behavior of the money supply. Because of this variability, the authorities' ability to control the money supply by manipulating either high-powered money or the reserve ratio may be substantially hampered in the short run.

In the monetary management of Korea, all the attention has focused on the discussion of high-powered money and the reserve ratio even in the short run, while the currency ratio has received little attention. One reason may be the fact that sources of variation in the currency ratio involve actions of innumerable holders of money and are difficult to explain. The present analysis reveals the importance of the currency ratio and the time deposit ratio in controlling the money supply at least in the short run.

III. The Problem of Interdependence Among the Determinants

The above calculations of the contributions were based on the assumption of independence among the determinants. As we know high-powered money, the currency ratio, the time deposit ratio, and the reserve ratio are "not rigidly linked together through institutional or accounting arrangements by which currency and deposits are issued. None of the determinants responds automatically to changes in the others. However, they may be related either through some economic or political effect of one on the others or through the common effect of other factors."[2] In other to ascertain such interrelations, we prepared Tables 7 and 8. The tables show the correlation coefficients between the contribution of the determinants. The correlation coefficients are insignifi-

2 Cagan (1965, p. 35). For example, an increase in the time deposit ratio, *ceteris paribus*, reduces the reserve ratio because of the reserve requirement differential. However, since the reserve ratio is also a function of other variables, in particular legal reserve requirements and interest rates, the time deposit ratio and reserve ratios are not automatically linked together.

Table 7

CORRELATIONS BETWEEN THE CONTRIBUTIONS OF THE DETERMINANTS IN THE RATE OF CHANGE IN THE M_1 MONEY STOCK

	Rhc	Rhr	Rht	Rrc	Rrt	Rtc
All years	.025	-.657(S)	-.251	.103	-.151	-.150
1954 I—1965 I	.003	-.669(S)	-.293	.091	-.257	-.105
1965 II—1969 II	.407	-.670(S)	.435	.531	.247	-.585

S: significantly different from zero at the .05 level.

Table 8

CORRELATIONS BETWEEN THE CONTRIBUTIONS OF THE DETERMINANTS IN THE RATE OF CHANGE IN THE M_2 MONEY STOCK

	Rhc	Rhr	Rcr
All Years	.203	-.609(S)	.348
1954 I—1965 I	.102	-.655(S)	.179
1965 II—1969 II	-.144	-.650(S)	.534

S: significantly different from zero at the .05 level.

cant except for the negative correlation between the reserve ratio and high-powered money. Since the contribution of the reserve ratio to the rate of change in the money supply is inverse to its first differences, the negative correlation indicates a tendency for high-powered money to move in parallel with the reserve ratio.

Two possibilities may explain the interdependence between the reserve ratio and high-powered money in Korea. An increase in the required reserve ratio may lead to increased bank borrowings from the Bank of Korea, when the spread between the market interest rate and rediscount rate is wide. High-powered money responds positively to bank borrowings. Even under the direct rediscount

ceiling system of the 1950's, on several occasions the Monetary Board relaxed the rediscount ceilings on the grounds that high reserve requirements impaired the profit position of banking institutions. The "reverse causation" is a second possibility, that is, an increase in high-powered money directly or indirectly causes the reserve ratio to rise. In 1961-1962 high-powered money increased greatly partly due to the unprecedented fiscal deficit and the increase in the domestic currency value of foreign exchange. To mop up the increase in high-powered money and reduce the inflationary potential, reserve requirements are raised. Moreover, particularly when high-powered money is increasing sharply, the reserve ratio rises, even if legal requirements are unchanged, because at least in the short run banks cannot expand earning assets. High-powered money and reserve ratio are also indirectly related through the interest rate. An increase in high-powered money reduces interest rates, at least initially, and the reserve ratio is positively related to interest rates.

Covariation among the determinants means that some of their contributions to the rate of change in the money stock were under or overestimated, offset, and, in a sense, not contributions at all. For example, if the negative correlation between the reserve ratio and high-powered money was explained by the former causing the latter, we could add to the relative contribution of the reserve ratio and subtract from the relative contribution of high-powered money. On the other hand the second possibility, high-powered money causing reserve ratio increases, suggest a subtraction from the relative contribution of the reserve ratio and addition to the contribution of high-powered money. Unfortunately, there is no satisfactory way to ascertain cause and effect, and we doubt that any adjustment would alter the conclusions materially.

IV. Conclusion

In order to describe mainly the long run movements in the money stock simple formulas which allocate changes in the money stock to the part contributed by each of these determinants were developed, and their contributions to the rate of changes in the money stock were calculated. A change in the money stock can be attributed to the sum of the contributions so long as they are largely independent. We found a negative relationship between high-powered money and the reserve ratio but our conclusions on the contributions of the determinants to the rate of change in the money stock are unlikely to be affected by this relation. We also

found high variability of the contribution of the currency ratio, which suggests the importance of the currency ratio in controlling the money supply at least in the short run.

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