Estimation of Moneyness Weights of Financial Assets in Simple Macroeconomic Model: The Case of Japan*

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The basic idea is that various financial assets have different moneyness characteristics and that money can be empirically defined as weighted sum of these financial assets. A simple macroeconomic model is constructed for the purpose of estimating the moneyness weights of financial assets. We built two basic propositions of the modern quantity theory of money into the structure of the model. The model is nonlinear and contains cross-equation constraints. Nonlinear minimum distance estimator is applied to the system as a whole, for the case of Japan. The estimated results agree with the main assertions of the quantity theory and seem to indicate that we have to pay more attention to the broader definitions of money.

I. Introduction

The definition of money and the related problem of estimating moneyness weights of various financial assets have received much attention in the literature and still remain a live issue. The remarkable growth of liabilities of financial intermediaries during the postwar period and the rapid progress of financial innovations since the 1970s have stimulated intensive discussion concerning the choice of the appropriate monetary indicator and the substitutability of various financial assets.

The empirical approach to the definition of money can be classified into two broad categories. The most common and practical

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approach is to define money by classifying some assets as money, and others as non-money on the basis of empirical evidence. The most comprehensive analysis along this line is that of Friedman and Schwartz (1970). Friedman and Schwartz select financial assets to be included in money by the ability of these assets to explain nominal income statistically. They use two criteria for this purpose: i) the highest correlation of the sum of these assets with nominal income, and ii) the higher correlation of the sum of these financial assets with nominal income than of any of the components separately. According to this approach, financial assets, which are included in the money, have full unit weights of moneyness, while any other financial assets have zero moneyness weights.

The second approach applies the index number theory to the definition of money and derives an index of monetary aggregates. Divisia monetary aggregate is the most widely used index. This approach, developed by Barnett (1980), produces a measure of the monetary service flow that consumers receive from their monetary asset portfolio. When one compares the divisia monetary aggregate with the conventional monetary indicators, one can immediately notice two major differences. Firstly, conventional money supply is a stock concept, while the divisia index is a flow of monetary services. Secondly, the divisia index utilizes the user cost of financial assets as the weight attached to financial assets. The user cost of a financial asset is related to the interest rate. The user cost of money is defined as the cost incurred in order to obtain one unit of the flow of monetary services per unit of time. The user cost of each component of money is defined as the difference between its own rate of interest and the benchmark rate. The benchmark rate is usually defined as the rate of return on bond. The implicit assumption is that bond does not provide any flow of the monetary services and the difference of the benchmark rate and the own rate of return of a financial asset is the price paid for the flow of monetary services. As a result, the divisia index will vary when the interest rate structure changes, even if the quantity of all the financial assets remains constant.

The new approach, taken by this paper, is to estimate non-unit, but constant moneyness weights of financial assets and to derive a stock concept of money by the weighted sum of financial assets. The basic assumption is that each financial asset has a different degree of moneyness and that the moneyness weight is constant for the estimation period, even if the weight will gradually change over the longer period of time. Our definition of money, labelled "liquidity" for convenience, is

$$L = w_1FA1 + w_2FA2 + w_3FA3 \qquad (w_1 = 1)$$

where FA's represent financial assets and w's denote moneyness weights attached to financial assets. I have normalized the weights by assuming that the moneyness weight of the $FA1$ is equal to 1.

We have included three broad categories of financial assets in the study. They are currency plus demand deposits ($FA1 = M1$), quasi money plus certificates of deposits ($FA2 = M2 + CD - M1$) and deposits of quasi financial institutions ($FA3 = (M3 + CD) - (M2 + CD)$). "Quasi Money" represents the total of private deposits, public deposits and installments of Sogo Banks minus demand deposits with financial institutions surveyed. $FA3$ represents the deposits of Post Offices, Agricultural Cooperatives, Fishery Cooperatives, Labor Credit Unions (including Certificates of Deposits), and money trusts and loan trusts of all banks.

In section II, we will develop a simple macroeconomic model by which we can operationalize and measure the unobservable liquidity variable, L. In section III, the estimates of the model together with the simulation results of the model will be presented. A brief conclusion will follow in section IV.

II. Basic Structures of the Model

We start with two basic propositions of the modern quantity theory of money. One is that the supply of money determines the level of prices in the long-run. The other is that a change in the conditions of demand and supply of money affects real income in the short-run. We accept these two propositions as a maintained hypothesis and build a simple model to incorporate these propositions and operationalize the liquidity. The model is specified for the purpose of estimating moneyness weights of financial assets.

The model has the following structure:

Main Block

$$C = c_1 + c_2Y + c_3C_{-1} + c_4EL_{-k} + u_c \tag{1}$$

$$I = i_1 + i_2Y + i_3DC + i_4I_{-1} + i_5EL_{-k} + u_i \tag{2}$$

$$Y = C + I + G + X \tag{3}$$

$$P = p_1 + p_j AL^s_{-j} + p_{j+1} AL^s_{-(j+1)} + u_p \tag{4}$$

Supplementary Equations

$$y_t^p = bY_t + (1-b)(1+a)Y_{t-1}^p \tag{5}$$

$$EL = L^s - L^d \tag{6}$$

$$L^s = GRFA1 + w_2 GRFA2 + w_3 GRFA3 \tag{7}$$

$$GRFA1 = \frac{FA1}{e^{g1t}} \frac{1}{P} \tag{8}$$

$$GRFA2 = \frac{FA2}{e^{g2t}} \frac{1}{P} \tag{9}$$

$$GRFA3 = \frac{FA3}{e^{g3t}} \frac{1}{P} \tag{10}$$

$$L^d = mY^p \tag{11}$$

$$AL^s = AGFA1 + w_2 AGFA2 + w_3 AGFA3 \tag{12}$$

$$AGFA1 = \frac{FA1}{e^{(a+g_1)t}} \tag{13}$$

$$AGFA2 = \frac{FA2}{e^{(a+g_2)t}} \tag{14}$$

$$AGFA3 = \frac{FA3}{e^{(a+g_3)t}} \tag{15}$$

where Y = real GNP
C = real consumption expenditure
I = real gross investment
G = real government expenditure
X = real net exports
DC = changes in real consumption expenditure
P = GNP deflator
Y^p = real permanent income
$FA1 = M1$ = currency plus demand deposits
$FA2 = (M2 + CD) - M1$ = quasi money plus certificates of deposits
$FA3 = (M3 + CD) - (M2 + CD)$ = deposits of quasi financial institutions

EL = real excess liquidity
L^s = real supply of adjusted liquidity
L^d = real demand for adjusted liquidity
AL^s = supply of adjusted liquidity

All real variables are in 1980 constant yen. And all the series are seasonally adjusted quarterly data.

Several distinctive characteristics of the model need some explanation. Firstly, to operationalize the proposition that the conditions of the money market will affect real income in the short-run, we introduced the excess liquidity term into the consumption function and the investment function. The idea is that the disequilibrium of the monetary sector will have some effect on real consumption and real investment. Excess liquidity is defined as the difference of the supply of liquidity and the long-run or desired demand of liquidity. In order to capture the long-run demand, we introduced permanent income as an explanatory variable of the demand function. Excess liquidity term can be interpreted as a kind of monetarist transmission mechanism from the money market to the real sector. Suppose that the quantity of money that people hold at a particular moment of time happens to be larger than the quantity they wish to hold from the long-run consideration. Individuals will then seek to dispose of what they regard as their excess money balances and that will raise the volume of expenditures and receipts. This is the rationale for including excess liquidity in the consumption function and the investment function.

We have deliberately omitted the interest rate variable from the specification of the model. We presumed that it would be an extremely unreliable method to measure the quantity of liquidity from the interest rate. Besides, if we introduce the interest rate in the demand for liquidity function, the demand and supply would be in the short-run equilibrium and it would not be possible to capture excess liquidity term.

Secondly, in the price equation, we are implementing the proposition that the supply of money determines the level of prices in the long-run. It should be noted that explanatory variables in the price equation are adjusted liquidities instead of the liquidity variable itself. Some part of the increase in liquidity is used to accommodate the secular increase in real income. And this part of the liquidity would not play any role in determining the level of prices. Therefore, the correct liquidity variable in the price equation has to be adjusted liquidity, which we derive by taking this secular growth factor into account and discounting it.

Thirdly, there is one more factor, which we called Goldsmith factor, that has to be taken into account in calculating the adjusted liquidity. Goldsmith (1969) showed that in the course of economic growth a rapid accumulation of financial assets follows. As a result, the financial interrelations ratio has a tendency to increase. We calculated relative accumulation speed of financial assets, compared to the speed of growth of nominal income. The rationale for adjusting this factor is that the part of the liquidity, which is accumulated by this Goldsmith process, would not affect the price level directly.

Fourthly, the effects of the liquidity on the price level and real income have different lag structures. In the price equation, we used two consecutive lagged terms of the adjusted liquidity as explanatory variables. The purpose of the price equation is to capture the long-run trend of the price, rather than to explain the short-term variations of price accurately. Therefore, we omitted all the other variables, which can affect the short-term price movements away from this trend. The lag structures will be determined during the estimation of model by the goodness of fit criterion.

The model assumes that the supply of all financial assets are exogenous. The supply of liquidity is defined by equation (12). This definition is an integral part of the model. In effect we are imbedding the definition of the unobservable variable, L, in the structure of the model. By introducing the liquidity into the model in this way, we would be able to get the estimate of the liquidity, only after we obtain the estimates of the entire model; not vice versa.

III. Estimation of the Model and Its Simulation

The most important characteristics of the model from the point of view of the estimation are that it is nonlinear in terms of parameters and that there are several cross-equation constraints. The cross-equation constraints dictate a nonlinear system method for the estimation of the model. The model was estimated for the period of 1975 I-1988 IV, using the seasonally adjusted quarterly data. These new characteristics of the model will become clear after some substitutions and rearrangements. Identities have to be substituted out and some parameters that can be estimated independently of the main block of the model have to be replaced by their estimates.

We will briefly describe the estimation of the supplementary equations before the final estimation of the main block. The real income growth factor, a, was estimated by regressing $\ln Y$ on a constant term and a time trend.

$$\begin{aligned} \ln Y &= 12.01 + 0.0104t \\ &\quad (2879.8) \quad (108.7) \\ R^2 &= 0.9954, \ S.E. = 0.012, \ D.W. = 0.33 \end{aligned} \tag{16}$$

The Goldsmith factors were calculated as the difference between the quarterly growth rate of each financial asset and the quarterly growth rate of the nominal income. The calculated factors for $FA1$, $FA2$ and $FA3$ are -0.0016, 0.0089 and 0.0119 respectively. We adopted adaptive expectations type of permanent income. Permanent income was defined by

$$Y_t^p = bY_t + (1-b)(1+a)Y_{t-1}^p \tag{17}$$

where a is the exponential growth factor of real income and b is the adaptation parameter. For the value of the parameter b, we have used 0.1. Utilizing the supplementary equations described above, the main block of the model, after some substitution and rearrangement, can be written as follows. As one can see from the equation system of (18) to (20), the system is nonlinear in parameters and, besides, there are cross-equation constraints.

$$\begin{aligned} C = c_1 &+ c_2 Y + c_3 C_{-1} \\ &+ c_4(GRFA1_{-k} + w_2 GRFA2_{-k} \\ &+ w_3 GRFA3_{-k} - mY_{-k}^p) + u_c \end{aligned} \tag{18}$$

$$\begin{aligned} I = i_1 &+ i_2 Y + i_3 DC + i_4 I_{-1} \\ &+ i_5(GRFA1_{-1} + w_2 GRFA2_{-1} \\ &+ w_3 GRFA3_{-1} - mY_{-1}^p) + u_i \end{aligned} \tag{19}$$

$$\begin{aligned} P = p_1 &+ p_j(AGFA1_{-j} + w_2 AGFA2_{-j} + w_3 AGFA3_{-j}) \\ &+ p_{j+1}(AGFA1_{-(j+1)} + w_2 AGFA2_{-(j+1)} \\ &+ w_3 AGFA3_{-(j+1)}) + u_p \end{aligned} \tag{20}$$

In the estimation of the model we imposed a kind of long-run equilibrium condition of the monetary sector. As one can see by the excess liquidity term, the monetary sector is not in equilibrium in the short-run. Since the monetary sector would be in equilibrium in the long-run, it has been assumed that the sum of the excess liquidity term for the entire sample period would be equal to zero, that is, $\sum_{t=1}^{t} EL_t = 0$. The implementation of this assumption puts a restriction on the value of the parameter, m. From the definition,

$$
\begin{aligned}
\sum_{t=1}^{t} EL_t &= \sum_{t=1}^{t} L_t^s - \sum_{t=1}^{t} L_t^d \\
&= \sum_{t=1}^{t} GRFA1 + \sum_{t=1}^{t} w_2 GRFA2 \qquad (21) \\
&\quad + \sum_{t=1}^{t} w_3 GRFA3 - m \sum_{t=1}^{t} Y_t^p = 0
\end{aligned}
$$

therefore,

$$
\begin{aligned}
m &= \frac{\sum_{t=1}^{t} GRFA1}{\sum_{t=1}^{t} Y_t^p} + w_2 \frac{\sum_{t=1}^{t} GRFA2}{\sum_{t=1}^{t} Y_t^p t_p} + w_3 \frac{\sum_{t=1}^{t} GRFA3}{\sum_{t=1}^{t} Y_t^p} \qquad (22) \\
&= 0.219 + 0.440 w_2 + 0.335 w_3
\end{aligned}
$$

For the estimation of the main block, we have used Malinvaud's nonlinear minimum distance estimator. The objective function can be written as

$$Q(b) = e(b)'(S^{-1} \otimes I_T) e(b)$$

where $e(b)$ is the vector of stacked residuals (a function of the parameters b), S is an estimated covariance matrix of the disturbances and I_T is the identity matrix of order of the number of observations. Estimates of the model are reported in Table 1.

In the estimation of the model, we dropped the excess liquidity term from the investment function. When we tried excess liquidity terms in both consumption function and investment function, we had some trouble in obtaining convergence of the model and estimates of other parameters were badly affected. Besides, the excess liquidity term of the consumption function had been more significant than the excess liquidity term of the investment function in most cases. One of the possible reasons for this phenomenon is that it is hard to explain investment behavior for some period immediately after the second oil crisis by our model.

As for the lag structure, excess liquidity term in the consumption function performed slightly better with no time lag. For the price equation, the lags of 8 to 9 quarters were chosen by the maximum likelihood function of the model. We have also presented the result

TABLE 1
RESULTS OF ESTIMATION FOR ALTERNATIVE LAG STRUCTURES OF PRICE EQUATION

Parameters	6 and 7 Quarter Lags		7 and 8 Quarter Lags		8 and 9 Quarter Lags	
	Est. Coef.	Stan. Err.	Est. Coef.	Stan. Err.	Est. Coef.	Stan. Err.
c_1	6.92	1.78	7.02	1.72	7.23	1.71
c_2	0.021	0.030	0.031	0.028	0.038	0.026
c_3	0.80	0.056	0.79	0.056	0.78	0.057
c_4	0.067	0.025	0.079	0.027	0.088	0.028
i_1	−4.18	1.46	−4.24	1.48	−4.21	1.48
i_2	0.025	0.017	0.028	0.017	0.030	0.017
i_3	1.43	0.24	1.49	0.24	1.48	0.24
i_4	0.96	0.053	0.95	0.053	0.95	0.053
p_1	27.24	1.80	29.41	2.09	32.67	2.29
p_6	0.022	0.014				
p_7	0.015	0.016	0.024	0.016		
p_8			0.020	0.018	0.017	0.016
p_9					0.032	0.018
w_2	1.23	0.36	0.87	0.22	0.70	0.17
w_3	0.94	0.38	0.70	0.31	0.61	0.30
log of likelihood function	(−1,018.32)		(−1,018.55)		(−1,017.85)	

for 7 and 8 lags, together with the result for 6 and 7 lags as supplementary estimates of the model. In terms of the original equations of the model, estimated results can be arranged as follows. The asymptotic t-values for the coefficients are reported in the parenthesis below the estimated coefficients.

$$\begin{aligned} C &= 7.23 + 0.038Y + 0.78C_{-1} + 0.088EL \\ &\quad (4.23) \quad (1.45) \quad (13.78) \quad (3.09) \\ R^2 &= 0.9985,\ S.E. = 0.77,\ D.W. = 1.68 \end{aligned} \tag{23}$$

$$\begin{aligned} I &= -4.2 + 0.030Y + 1.48DC_{-1} + 0.95I_{-1} \\ &\quad (-2.85) \quad (1.75) \quad (6.26) \quad (17.68) \\ R^2 &= 0.9945,\ S.E. = 1.80,\ D.W. = 1.95 \end{aligned} \tag{24}$$

$$\begin{aligned} P &= 32.67 + 0.017AL_{-8} + 0.032AL_{-9} \\ &\quad (14.25) \quad (1.01) \quad (1.79) \end{aligned} \tag{25}$$

$$R^2 = 0.9902, \quad S.E. = 1.01, \quad D.W. = 0.30$$

$$L^s = GRFA1 + \underset{(4.09)}{0.70}GRFA2 + \underset{(2.01)}{0.61}GRFA3$$

The key parameters of the model are w_2 and w_3. The estimates of w_2 and w_3 are 0.70 and 0.61 respectively for the model with 8 and 9 quarters in the price equation. That is, the moneyness weight of quasi money and certificates of deposits is 0.70 and the weight of deposits of quasi financial institutions is 0.61.

On the other hand, those estimates for the lags of 7 and 8 quarters are 0.87 and 0.70 respectively and those for the lags of 6 and 7 quarters are 1.23 and 0.94 respectively. As one can see, the estimates of w's are rather sensitive to the choice of the lag structure. This is one of the shortcomings of the approach taken in this paper.

In order to evaluate the model as a unit and to evaluate whether the model is adequate for the purpose of estimating the liquidity, simulation of the model has been performed. We performed dynamic simulation of the model for the estimation period of 1975 I-1988 IV. The summary results of dynamic simulation for the model are given in Table 2. The Table 2 contains various measures of the

TABLE 2
SUMMARY OF DYNAMIC SIMULATIONS
(1975 I～1988 IV)

	Consumption	Investment	Real GNP	GNP Deflator
Correlation Coefficient	0.9956	0.9580	0.9907	0.9951
Root Mean Squared Error	1.89	5.33	6.73	1.01
Mean Absolute Error	1.49	4.56	5.66	0.82
$\frac{\text{Mean Absolute Error}}{\text{Actual Mean Value}} \times 100$ (%)	1.01	5.54	2.23	0.82
Mean Value				
Actual	147.12	82.28	254.37	100.34
Simulated	146.93	82.06	253.97	100.34
Standard Deviation				
Actual	20.17	14.58	42.81	10.23
Simulated	20.28	17.34	45.87	10.17

goodness of fit. Considering the fact that the model is a kind of long-run model, it seems that the model tends to track the movements of the endogenous variables reasonably well for the most of the period.

IV. Conclusions

The central purpose of the paper was to estimate the moneyness weights of financial assets. We built two basic propositions of the modern quantity theory of money into the structure of the simple macroeconomic model. By estimating the model as a whole by nonlinear minimum distance estimator, we obtained the moneyness weights of financial assets from the estimates of the model. General findings of the paper agree with the main assertions of the quantity theory. The moneyness weight for quasi money plus certificates of deposits is 0.70, and that for deposits of quasi financial institutions is 0.61. The liquidity is estimated to be $FA1\,(=M1)+0.70FA2\,(=M2-M1+CD)+0.61FA3\,(=M3-M2)$. The time lag between the supply of the liquidity and the price levle (roughly speaking, from 6 to 9 quarters) estimated in this paper using the log of likelihood function of the model seems to be consistent with the findings of Friedman and others. The effect of excess liquidity on consumption had a very short time lag.

As for the general magnitudes of the moneyness weights, w_2 and w_3, the estimated results seem to suggest that we have to pay more attention to broader definitions of money. This seems to be consistent with the historical trend towards more broader definitions of money. Unfortunately, the estimates of moneyness weights are rather too sensitive for the choice of the lag structure. A further investigation along the line seems to be necessary before we can obtain a more accurate estimate.

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