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On Measuring the Nearness of Near-Moneys

By V. Karuppan Chetty*

Monetary economists have long been concerned about the substitutability of the liabilities of various financial institutions for money. Knowledge of the degree of substitutability of such liquid assets for money is essential for many reasons. For example, if these assets are close substitutes for money, then the financial intermediaries can, in principle, reduce the effectiveness of any given monetary action. This is, in fact, the position taken by Gurley and Shaw [11] [12] [13] [14]. They argue that the monetary authorities did not succeed in reducing the liquidity in the economy during the postwar period due to the rapid growth of liabilities of financial intermediaries. There has been some theoretical discussion about the relevance of Gurley and Shaw's arguments, but as pointed out by Johnson [16] and Cagan [5], in a slightly different context, this issue cannot be resolved by theoretical arguments. In order to determine whether consumers regard the various liquid assets as substitutes for money or not, one has to look at their market behavior. The question is essentially an empirical one.

Recently, Feige [9], Hamburger [15], and Lee [20] attempted to test empirically the validity of Gurley and Shaw's hypothesis. Not surprisingly, these econometric studies are not in agreement about the substitutability of liquid assets for money. Feige [9], using temporal cross-section data of liquid asset holdings by states in the United States for the period 1949–59, found that the yields on nonbank intermediary liabilities did not affect the demand for money, defined as demand deposits plus currency. Hence he concluded that these assets are not substitutes for money. Lee [20], using Feige's and other types of data, concluded that savings and loan association shares are much better substitutes for money than time deposits. Hamburger [15], using U.S. time series data, found that the predictive power of the demand function for money did not increase significantly when the definition of money was expanded to include other liquid assets. For reasons given in the next section, the methods used by Feige [9] and Lee [20] are better than that of Hamburger [15].

In order to determine whether the public regards various liquid assets as substitutes for money, one has to determine empirically the shape of consumers' indifference curves for money and other liquid assets. In the present paper, a utility function which generates a variety of indifference curves is used to estimate directly the elasticity of substitution between money and other liquid assets. In the past, monetary economists attempted to test substitutability hypotheses by estimating the various (cross) interest elasticities of demand for money. In this paper, the various elasticities of substitution are used to test the same hypothesis. In theory, one would expect the two methods to lead to the same conclusion. However, the empirical results of our paper differ to a great extent from

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the findings of others and seem to be more reasonable in terms of our a priori expectations.

Furthermore, knowledge of these elasticities of substitution will be useful in answering many other questions in monetary economics. For instance, suppose one finds, as Lee [20] does, that some liquid assets are substitutes for money. In what ways can a monetary theorist, interested in controlling the liquidity of the economy, use these findings for policy purposes? If, for example, the supply of these liquid assets increases, other things being equal, their prices will fall. Using the demand function for money, the monetary theorist will determine the amount by which the demand for money will go down and recommend an appropriate policy measure for reducing the quantity of money. Thus policy action is taken only after the effect of the increases in other liquid assets shows up in the yields of these assets, which, of course, takes some time. On the other hand, using the elasticity of substitution approach one can immediately find the money equivalent of the change in other liquid assets and determine the amount by which the money supply should be reduced to maintain the same level of liquidity in the economy. This will avoid some delay in taking appropriate monetary measures which is certainly desirable, since many economists in the past have argued that there is considerable lag between the time a policy measure is taken and the time its effect is realized.

Another related problem, which has attracted the attention of monetary economists for many years, is the definition of money. The commonly used definition classifies demand deposits and currency as money. Friedman and Meiselman [10] and Cagan [5] define money as demand deposits, currency, and time deposits in commercial banks. One of the reasons for inclusion of time deposits is that they can not be meaningfully separated from demand deposits until the 1930's. Friedman and Meiselman also argue that "they are such close substitutes for other monetary items that it is preferable to treat them as if they were *perfect substitutes* than to omit them."

In reality, the various liquid assets may not be regarded as perfect substitutes for money nor can they be treated as completely unrelated to money. Hence the all-or-nothing approach in defining money does not seem to be very useful. Gurley [11], in this context, points out, "If the degree of substitutability between each type of monetary asset and money were known, liquid assets could be weighted in such a way that the constancy of this weighted amount would imply constant interest rates, other things the same." For illustrative purposes, Gurley used a definition which assigned weights of one to currency and demand deposits and weights of one-half to other liquid assets. It has been pointed out by several writers that the "best" set of weights can be derived using canonical correlation techniques or the method of principal components. This will give the "best" definition of money in some statistical sense, like maximum correlation or maximum variance, but it is difficult to give economic interpretation to these weights. Instead, in this paper, we suggest a method of aggregating the liquid assets, using the elasticities of substitution and other economically meaningful parameters.

Another related and controversial issue in monetary theory is concerned with the choice of the appropriate interest rate or rates to explain the demand for money. Some economists, such as Eisner [8] and Latane [19] maintain, following the Keynesian tradition of relating income and investment to long rates, that the relevant rate is that on long-term bonds. Bronfenbrenner and Mayer [4], Laidler [17] and a few others advocate the use of short-term interest rates, since this reflects the opportunity cost of holding money. Gurley and Shaw [11] [12] [13] [14], naturally, argue for their candidate, the yield on nonbank intermediary liabilities. Lee [20] has recently presented empirical evidence for the superiority of the yield on saving and loan association shares over others but his conclusions are questionable for reasons pointed out in the sections that follow. Christ [6] and Lee [20] have used the relative quantities of these assets to form a weighted average of the various interest rates.

Regarding the choice of the interest rate, Turvey [22] remarked "Their relative importance depends upon the relative substitutability of long-term and short-term paper assets for money and upon their relative quantities. The former is unknown (hence all the argument), while the latter is measurable. . . . " Since the elasticities of substitution of various assets for money are estimated in the present paper, they are used to construct an index of interest rates as suggested by Turvey [22]. Since the demand for money in theory is a function of a number of highly correlated interest rates, it seems appropriate to use economically meaningful weights to come up with an average, rather than trying to choose *the* interest rate using some statistical criterion, like standard errors.

The plan of the paper is as follows. In Section I, the method of estimating the various elasticities of substitution, aggregation of the liquid assets, and construction of the interest rate index are discussed when assets are taken two at a time. Empirical estimates are presented for U.S. time series data for the period 1945–66. A more general method to handle all the assets simultaneously and the empirical results are presented in Section II. A new series based on the new definition of money and an index of interest rates are computed, and a velocity series based on the new definition of money is calculated and compared with other velocity series. Concluding remarks are made in Section III.

I. *A Model for Estimating the Elasticity of Substitution*

Throughout this paper, the term money (M) will be used to denote hand-to-hand currency plus demand deposits in commercial banks. To start with, it is assumed that there is one other financial asset, namely time deposits (T). Following the new approach to consumer demand theory, as developed by Becker [3] and Lancaster [18], let us assume that the consumer combines money and time deposits to produce various characteristics like liquidity, store of value, etc. We assume that the consumer combines M and T such that, for any given budget, he maximizes his satisfaction. The possibility of substituting T for M arises for two reasons: (1) M and T may have some common characteristics; (2) even if they have no characteristics in common, there may be substitution between different characteristics. The indifference curves between M and T may assume various possible shapes ranging from straight lines, in the case of perfect substitutes, to right angle curves, when they are consumed in fixed proportions. The degree of curvature of these indifference curves is a measure of substitutability of money and time deposits. To answer this question, we need a utility function, which generates a variety of indifference curves with different degrees of substitution and whose parameters can be estimated with the use of observed variables like quantities and prices. One such function which generates a variety of indifference curves, but has only few parameters, is the constant elasticity of substitution production function introduced by Arrow, *et al.* [2]. The CES function was introduced to study the degree of substitution between capital and labor, but we can make use of this function to study the substitutability of money and other financial assets. The utility function of the consumer can be written as

$$U = (\beta_1 M^{-\rho} + \beta_2 T^{-\rho})^{-(1/\rho)}$$

where M and T represent money holdings and money value of time deposits in the next period respectively. Since this is a fairly general function, it can be assumed that it will provide an adequate approximation to the true utility function. Since only ordinal utility is used, β_1 can be assumed to be equal to 1 without loss of generality. This normalization is adopted throughout this paper. The implications of this normalization for the aggregation procedure are discussed later.

Suppose the consumer has cash holdings of M_0 dollars and wants to allocate them between M and T. If T represents the cash value of time deposits in the *next* period and if i is the rate of interest on time deposits of the current period, then the budget constraint of the consumer can be written as

$$M_0 = M + \frac{T}{1+i} \tag{1}$$

The slope of the budget line is $-(1+i)$. Hence $(1+i)$ can be considered as the ratio of the prices of money to time deposits.[1]

When the utility function is maximized subject to the budget constraint (1), the following marginal conditions are obtained:

$$\frac{\partial U}{\partial M} = \lambda \tag{2}$$

$$\frac{\partial U}{\partial T} = \lambda/(1+i) \tag{3}$$

$$M_0 = M + \frac{T}{(1+i)}, \tag{4}$$

where λ is the Lagrange multiplier. Dividing (2) by (3) we have

$$\frac{\beta_1}{\beta_2}\left(\frac{M}{T}\right)^{-\rho-1} = 1 + i$$

Taking logarithms on both sides, rearranging terms, and adding a disturbance term, we have the regression model

$$log \frac{M}{T} = -\frac{1}{1+\rho} log \frac{\beta_2}{\beta_1} + \frac{1}{1+\rho} log \frac{1}{1+i} + e \tag{5}$$

Using data relating to M, T, and i, and making the usual assumptions about the disturbance term, we can estimate $1/1+\rho$ and the intercept term using least squares methods. From the intercept term, an estimate of β_2/β_1 can be obtained, and using a normalization rule β_1 and β_2 can then be estimated. The elasticity of substitution between money and time deposits is given by $\sigma = 1/1+\rho$. Thus whether any particular financial asset is a substitute or not can be directly tested using this regression.

This model has some similarities to the one used by Christ [6], since he regressed ratios of various stocks on interest rates and income, but his regression equations were not derived from any specific model like the one set out in this paper.

In our model,[2] the ratio of prices of

[1] Alternatively, one can assume that the consumer maximizes $U[T(1+i), M]$, subject to the constraint $M+T=M$, where T now represents the amount of time deposits in the *current* period. In both cases, the marginal conditions are the same. Also if one assumes that the consumer maximizes $U(Ti, M)$ subject to $M+T=M$, one obtains very similar results empirically, since the form of U is quite general.

[2] Milton Friedman, in a personal communication, pointed out to me that the price ratio has units of time in it and hence the estimated elasticity substitution will depend on the arbitrary choice of the time unit. To get around this difficulty, we should maximize the utility function subject to one more constraint on the flow of income from these assets. Where we have three or more assets, this can be done. If μ is the lagrangean multiplier

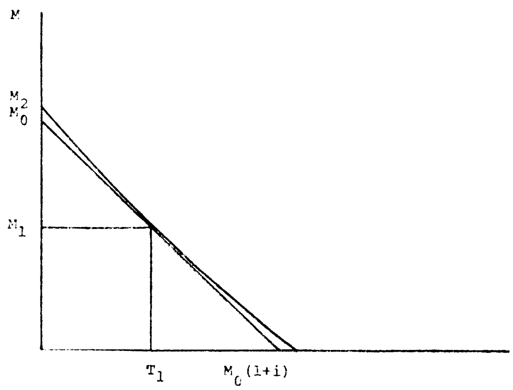

FIGURE 1. INDIFFERENCE CURVE BETWEEN M AND T

M and T is $1+i$. There are alternative ways of specifying the price of holding a dollar of M or T. If one takes the alternative cost approach, the price of holding a dollar of M will be the alternative income forgone. If, for example, the interest rate on corporate bonds, i_β, represents the alternative income, then the price ratio of T and M is given by $(i_\beta - i_T)/i_\beta = 1 - i_T/i_\beta$, where i_T is the interest rate on time deposits. If this price ratio is used in equation (5) this would imply that M/T will not change for a given percentage change in both i_T and i_β. This does not seem reasonable.

The empirically determined indifference curves can now be used to aggregate money and time deposits. The aggregation procedure is illustrated in Figure 1. For a given set of M_1 and T_1, we find the indifference curve that passes through that point. This is the maximum satisfaction that can be produced with this combination. From the same figure, we also find that the same satisfaction can be produced by using M_2 units of money alone. Hence adding T_1 units of time deposits to M_1 is equivalent to adding $(M_2 - M_1)$ units of money to M_1. Determination of such an M_2 is possible whenever the indifference curves intersect or are tangent to the M-axis. This measure of aggregate liquid assets *is exactly* the normalized utility function with $\beta_1 = 1$.

Friedman and Meiselman [10], in this context, point out that one should find out the moneyness of other liquid assets and use that to give an extended definition of money. Our aggregation procedure is along the same lines. In order to use this procedure, one need not determine completely the indifference curve that passes through a given M or T. Instead, if we assume that $\beta_1 = 1$, then the adjusted money, (M_a), is given by

$$M_a = (M^{-\rho} + \beta_2 T^{-\rho})^{-1/\rho}$$

after determining the degree of substitution between M and T. Our interest is to define the aggregate money. For this purpose, it seems quite natural to adopt the normalization rule, $\beta_1 = 1$.

If money and time deposits are identical commodities, then it follows that $\beta_2 = 1$ and $\rho = -1$. Then, $M_a = (M+T)$. Thus, the simple addition of M and T is justified, when M and T are identical. Of course, we do not have to make use of a CES function to reach this obvious conclusion. The fact, however, that the aggregation procedure reduces to a reasonable method under simple conditions increases our confidence in the procedure.

The methods discussed above were used to estimate the elasticity of substitution between money and commercial bank time deposits using time series data for the United States for the period 1945–66.[3]

for the new constraint, then the regressions will be of the form $\log M/T = a + b \log(1 + \mu i/\lambda)$. μi is now independent of the units of time. Here T is the amount of time deposits in the current period. Since μ/λ is the same for all regressions, b will be affected in the same manner in all regressions when i is small. Hence we can still run the same regression. Discussions with Gary Becker on this point have been very useful.

[3] The money stock and time deposits in commercial banks are from various issues of the *Federal Reserve Bulletin* (*FRB*). Interest rates on time deposits are from Cagan [5], for 1945–60 and from various issues of the *FRB* for 1961–66. Current income figures are from various issues of *Survey of Current Business*.

$$\log M/T = 1.510 + 34.69 \log 1/(1 + i)$$
$$(1.569)$$

$$R^2 = .981$$

$$D.W. = .57$$

The elasticity of substitution between money and time deposits is significantly different from zero at the 5 percent level and considerably large. Hence we can treat M and T as very good substitutes for each other. Since there is evidence of autocorrelation among the disturbances, the standard error has been corrected using Wold's [24] method. When the logarithm of the current income is used as an additional explanatory variable, it turned out to be insignificant at the conventional levels. This is in agreement with our theoretical formulation, since our utility function implies that M/T will not depend on M_0 or income for given i. The implied estimate of β_2 is found to be

$$\beta_2 = \exp(-1.510/34.69) = .957.$$

The adjusted stock of money is given by

$$M_a = (M^{.971} + .957T^{.971})^{1.03}$$

An indifference curve between M and T is shown in Figure 1. This looks almost like a straight line, supporting Friedman's hypothesis that M and T are perfect substitutes.

The series relating to M, $M+T$, and M_a are shown in Table 1. It can be seen from columns (2) and (3) that there is not much difference between $M+T$ and M_a. Hence if we are interested in including T, we can simply add T to M.

Similar regressions were run to estimate the elasticities of substitution between money and the liabilities of savings and loan association (SL) and deposits in mutual savings banks (MS) for the period 1945–66.[4] The estimated equations are

Table 1—Adjusted Money Stock Based on M and T

M	$M+T$	M_a
102.3	132.4	133.5
110.0	143.8	145.0
113.6	148.8	150.1
111.6	147.4	148.6
111.2	147.3	148.5
117.7	154.0	155.3
124.5	162.0	163.8
129.0	169.7	171.2
130.5	174.2	175.8
134.4	181.2	182.9
138.2	186.6	188.4
139.7	190.3	192.4
138.6	194.7	196.9
144.2	207.4	209.8
145.6	212.2	214.8
144.7	216.8	219.7
149.4	212.2	214.4
151.6	248.3	252.1
157.3	268.3	272.6
164.0	289.2	294.0
172.0	317.2	322.8
175.8	335.4	341.9

$$\log M/SL = 4.612 + 101.851 \log 1/(1 + i_{SL})$$
$$(8.900)$$

$$\bar{R}^2 = .946, \quad D.W. = .510$$

$$\log M/MS = 2.297 + 27.637 \log 1/(1 + i_{MS})$$
$$(1.354)$$

$$\bar{R}^2 = .980, \quad D.W. = .829$$

i_{SL} and i_{MS} are yields on SL and MS respectively. The elasticity of substitution between M and SL is 101.851, the highest among the three assets. These findings strongly support Gurley and Shaw's [14] hypothesis and the findings of Lee [20], that savings and loan association shares are good substitutes for money. Hence we join Lee [20] in rejecting the conclusion of Feige [9] and Hamburger [15]. Feige, in fact, found that savings and loan shares are likely to be complementary to money.

Lee also found that, in the presence of the yield on nonbank intermediary liabilities, the yields on other assets, like time deposits, turn out to be statistically insignificant explanatory variables in the demand function for money. Hence this

[4] Savings and loan association shares and time deposits in mutual savings banks and their yields are from the *Savings and Loan Fact Book*, 1967.

implies that time deposits are not substitutes for money while savings and loan association shares are. This conclusion is somewhat questionable because the yields on various assets are highly correlated and hence the standard errors become unreliable. So one cannot conclude on the basis of "t" values which asset is a substitute and which is not.[5] Also Hamburger [15] reports that inclusion of other financial assets in M does not increase the R^2, but sometimes decreases it. But this is small wonder because the variance of $(M+T)$ is different from the variance of M. Since the dependent variables are different in the two regressions, R^2 can not be reliably used as a basis of comparison.

A weakness in our approach in estimating the degree of substitution is that we consider only one asset, in addition to M, at a time. The movements of M/T may reflect a shift between M and T or between one of them and other financial assets. Hence our estimates of the coefficients are likely to be biased. To remove this difficulty, we have to introduce all the assets simultaneously in our model and estimate the parameters. This is done in the next section. Briefly the results are: (1) The elasticity of substitution between T and M remains the same as before. (2) The substitutability of savings and loan association shares becomes somewhat weaker than before, but still they remain substitutes for money. (3) Deposits in mutual savings banks are also substitutes for money.

II. *Some Extensions of the Model*

We now assume that there are more than two financial assets. Let the utility function be

$$U = f(X_1, X_2, X_3 \cdots X_n),$$

where $X_1, X_2, \cdots, X_n$ are the various assets. We must now specify the form of the utility function. The purpose of our study will be defeated if we use the CES function for n inputs as generalized by Uzawa [23], since the partial elasticity of substitution between any two inputs is the same. The generalized CES function of Mukerjee [21] and Dhrymes and Kurz [7] does not assume that the partial elasticities are the same. Hence we assume that the utility function is given by (8). We assume that the budget constraint is given by (9) where Y is income and the r's are the yields on the various assets.

If the utility function is maximized subject to (9), we have the following first order conditions.

$$\frac{\partial U}{\partial M} - \lambda = 0 \tag{10}$$

$$\frac{\partial U}{\partial X_j} - \lambda/(1 + r_j) = 0 \tag{11}$$

$$(j = 1, 2, \cdots, n),$$

where λ is a Lagrangian multiplier.

The parameters of the utility function can be estimated using these conditions along the lines suggested by Dhrymes and Kurz [7]. Dividing (10) by (11) and manipulating as before, we have equation (12). If we substitute (12) in (9), we get an implicit relation between the interest rates, M, and Y. This relation can now be solved for M. Let the explicit relation between M, interest rates, and Y be given by

$$M = f(r_1, r_2, \cdots, r_n, Y).$$

Assuming log M has a valid Taylor series

[5] Lee has used the differentials between yields on liquid assets and the yield on money in his regressions to avoid the problem of collinearity. Michael J. Hamburger told me that when he recomputed the regressions after introducing the yield on money explicitly, instead of using the differentials, the interest elasticities for SL go down considerably.

(8) $$U = (\beta M^{-\rho} + \beta_1 X_1^{-\rho_1} + \beta_2 X_2^{-\rho_2} \cdots + \beta_n X_n^{-\rho_n})^{-1/\rho}$$

(9) $$M_0 = f(Y, r_1, r_2, \cdots, r_n) = M + \frac{X_1}{1 + r_1} + \frac{X_2}{1 + r_2} + \frac{X_n}{1 + r_n}$$

(12) $$\log X_j = \frac{-1}{\rho_j + 1} \log \frac{\beta\rho}{\beta_j\rho_j} - \frac{1}{\rho_j + 1} \log \frac{1}{1+r_j} + \frac{\rho + 1}{\rho_j + 1} \log M,$$

(13) $$\log M = a_0 + \sum_{j=1}^{n} a_j \log (1 + r_j) + a_{n+1} \log Y.$$

expansion in terms of log r_j and log Y, we can write this expansion as equation (13). When the disturbance terms are introduced in equations (12) and (13), the parameters of the system can be estimated using two-stage least squares. First, log M is estimated as a function of Y and the r_j's, which are assumed to be exogenous. The estimate of log M is then inserted in (12) and each equation is estimated individually. The estimates obtained in the second stage are consistent and can be used to determine the implied estimates of the parameters of the production function. Also the asymptotic variances of these estimates can be calculated using standard methods of large sample distribution theory.[6] These estimates can then be used to calculate the partial elasticity of substitution between M and other assets defined as:

(14) $$\sigma_{M,X_j} = \frac{d \log (M/X_j)}{d \log \left(\dfrac{\partial U/\partial M}{\partial U/\partial X_j}\right)} = \frac{1}{(1+\rho)+(\rho_j-\rho) \Big/ \left[1+ \dfrac{\beta_j\rho_j X_j^{-\rho_j}}{\beta\rho M^{-\rho}}\right]}$$

This is the Hicks-Allen [1] direct partial elasticity of substitution.

Here income and interest rates may not be strictly exogenous variables[7] and hence the two-stage least squares may not be consistent for equation (12). Thus the ordinary least squares may be no worse than the two-stage least squares as far as the inconsistency is concerned. Using the least squares method, one can simply estimate (12) and omit equation (13) and the Taylor series approximation altogether. Both the methods were tried in estimating the regression. Since the estimates of the parameters were almost identical, only the ordinary least squares estimates are given below.

The estimated regression equations for time deposits, savings and loan associa-

[6] Dhrymes and Kurz [7] suggest a method of constructing the confidence interval for ρ_i, given the confidence interval for $1/(\rho_i-1)$. This is incorrect because if $1/(\rho_i-1)$ has a "t" distribution, the moments of ρ_i will not in general exist for finite samples. Hence only asymptotic variance can be used. Also in this case, the distribution of $1/(\rho_i-1)$, a two-stage least squares estimate, is not known for finite samples.

[7] This was pointed out to me by a referee.

$$(15)\quad \begin{cases} \log T = .118 - \underset{(2.69)}{40.384} \log P_T + \underset{(.19)}{.649} \log M & \bar{R}^2 = .991, \quad D.W. = .87 \\ \log SL = -15.398 - \underset{(10.25)}{52.346} \log P_{SL} + \underset{(.49)}{3.517} \log M & \bar{R}^2 = .983, \quad D.W. = .49 \\ \log MS = -3.517 - \underset{(3.32)}{24.105} \log P_{MS} + \underset{(.197)}{1.217} \log M & \bar{R}^2 = .992, \quad D.W. = .84 \end{cases}$$

$$(16)\quad M_a = [M^{.954} + 1.020T^{.975} + .880MS^{.959} + .616SL^{.981}]^{1.026}$$

tion shares, and mutual savings bank deposits are given in equation (15), where $P_j = 1/(1+r_j)$.

The partial elasticities of substitution between M and other assets at their mean values are calculated using (14). We have the following results:

$$\sigma_{M,T} = 30.864$$
$$\sigma_{M,SL} = 35.461$$
$$\sigma_{M,MS} = 23.310$$

The partial elasticities of substitution, σ_{MT} and $\sigma_{M,MS}$ are similar to those obtained in the previous section. The partial elasticity of substitution between M and SL is 35.461, compared to 101.851 obtained before. Our second estimate of $\sigma_{M,SL} = 35.461$ seems more reasonable than 101.851, since the former is close to $\sigma_{M,T}$ and $\sigma_{M,MS}$. Also it is free from the bias due to the single equation approach mentioned earlier. There is no reason why $\sigma_{M,SL}$ alone should be considerably different from those of other financial assets. Also in view of the larger standard errors associated with the regression equation relating to SL, one can not conclude that the liabilities of savings and loan association are the best substitutes for money. The conclusion that can be drawn from these regressions is that T, SL, and MS are all good substitutes for money. Thus, we have provided empirical evidence for Gurley and Shaw's hypothesis.

Also the utility function in (8) can be used to determine the adjusted money stock as before. The adjusted stock of money in this case is given by equation (16). It is interesting to observe that all the exponents are very close to one. Also the coefficient of time deposits is approximately 1, which again supports Friedman's definition. Approximately we can write M as

$$M_a' = M + T + .880MS + .615SL$$

On the basis of the coefficients of various assets we can probably rank the assets in the decreasing order of closeness to money as follows: T, MS, and SL. Thus our conclusions are different from those of Lee [20].

It is comforting to find that the weights for T, MS, and SL are in the range (0, 1). Since the estimates are derived from a least squares regression with the unrestricted coefficients, the results are really amazing. We believe it is only fair to remark that it is not a very common event in econometrics to find the estimated coefficients within the relevant range. The weight for T is slightly greater than 1; but in view of the standard error of the coefficients of the regression relating to T and M, this is not bad. Also, if T is almost as good as

TABLE 2—ADJUSTED MONEY STOCK BASED ON M, T, SL AND MS.

	M_a	M'_a	$V_1=Y/M$	$V_2=$ $Y/M+T$	$V_3=Y/Ma$	i (percent)
1945	144.75	150.42	2.09	1.61	1.47	1.56
1946	157.67	163.81	1.92	1.47	1.33	1.48
1947	164.16	170.49	2.06	1.57	1.42	1.48
1948	164.38	170.36	2.32	1.76	1.57	1.53
1949	160.20	171.97	2.32	1.75	1.55	1.59
1950	173.91	180.21	2.42	1.85	1.63	1.66
1951	183.96	190.69	2.64	2.03	1.78	1.74
1952	194.69	201.40	2.69	2.04	1.78	1.94
1953	203.33	209.69	2.80	2.10	1.79	2.03
1954	215.01	221.22	2.70	2.00	1.68	2.13
1955	225.02	231.16	2.88	2.13	1.68	2.19
1956	233.78	239.52	3.00	2.20	1.78	2.36
1957	243.53	248.36	3.18	2.26	1.80	2.67
1958	262.37	266.84	3.07	2.13	1.68	2.76
1959	272.71	276.58	3.32	2.27	1.76	2.96
1960	284.23	286.94	3.47	2.31	1.76	3.20
1961	306.57	308.51	3.47	2.24	1.68	3.32
1962	333.52	333.97	3.76	2.26	1.67	3.62
1963	364.39	363.70	3.73	2.28	1.60	3.76
1964	396.45	394.81	3.86	2.19	1.58	3.85
1965	433.73	431.15	3.98	2.16	1.56	4.00
1966	457.43	453.85	4.23	2.22	1.60	4.34
Mean velocity			$\bar{V}_1=2.99$	$\bar{V}_2=2.03$	$\bar{V}_3=1.65$	
Coefficient of Variation			21.77	12.1	7.6	

money, as Friedman and others suspect, we would even expect the weight to be slightly greater than 1, since it yields a positive rate of return.

Since we have estimates of substitution and other parameters, we can define an index of interest rates. The exponents in the equation for M_a are very close to 1, and we will just use the marginal rates of substitution between M and other assets, namely 1, .88, and .615. Hence the interest rate index is given by

$$i_a = (i_T + .88 i_a + .615 i_{SL}) \div (1 + .88 + .615)$$

The adjusted money stock series M_a and M'_a, the interest index, i_a, and velocities based on various definitions of money are given in Table 2. It can be seen that there is not much difference between M_a and M'_a. The correlation coefficient beween M_a and $M+T$ is .999. This does not mean that one definition is as good as the other for all purposes. The mean and standard deviation of $M+T$ are 202.67 and 57.73 respectively, while the mean and standard deviation of M_a, are respectively, 253.72 and 93.07. There is considerable difference between the standard deviations. Hence for purposes of controlling or explaining money supply or demand, the two series will have different implications. But if one is using money stock to predict some other variable, say national income, then $M+T$ is as good as M'_a, or for that matter as M.

Also it can be seen from Table 2 that velocity based on M'_a is virtually a constant, while the other velocities vary to a considerable extent. The coefficient of variation is about one-third of that based on the traditional definition of money and about one-half of that based on Friedman's definition of money. Thus, as Gurley and Shaw and others have argued, we can attribute the postwar rise in velocity (based on the traditional definition of money) to the increased availability of money substitutes.

III. *Summary*

In this paper, some methods of estimating the degree of substitution between money and other financial assets are set out and used to test the substitution hypothesis of Gurley and Shaw using U.S. time series data for the period 1945–66. Also a method of aggregating the various liquid assets and interest rates using the elasticities of substitution and other economically meaningful parameters is presented. The empirical findings of this paper are: (1) Time deposits and savings and loan association shares are also very good substitutes for money and can be ranked in decreasing or order of closeness to money as follows: T, MS, and SL. (2) Our empirical results lead to the following definition of money:

$$M'_a = M + T + .880MS + .615SL$$

(3) Velocity, based on the new definition of money, has been virtually a constant since 1951.

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