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TESTS FOR SEPARABILITY AND EXISTENCE OF CONSISTENT MONETARY AGGREGATES : THE KOREAN CASE

JEONG-HO HAHM* and WOON-GYU CHOI**

I. INTRODUCTION

Monetary theory and policy are inherently associated with the behavior of various monetary quantity and price aggregates. However, for such aggregates to be useful they must be consistent and theoretically meaningful.

The construction of theoretically meaningful monetary quantity and price aggregates are accompanied with some methodological questions such as the definition of money and the procedure employed to aggregate. Aggregation and index number theory provides theoretically consistent and unique answers to such questions as mentioned above.

On the one hand, aggregation theory provides a basis for identifying admissible (separable) component groups among various monetary assets so that economic aggregates can be constructed over such identified admissible component groups. These economic aggregates behave in a manner indistinguishable from elementary goods. They are treated as single goods in the consumer's preference : consumers are able to select their desired aggregate quantity without regard to its composition. In particular, an aggregate exists in aggregation theory if the aggregator function defined over the items of the aggregate and other items as well is weakly separable in the components of the aggregate. If this weak separability condition is violated, stable preferences cannot exist over the aggregate in the sense that varying the relative quantities of the elements within the aggregate while holding the aggregate level constant will affect consumer preferences over other assets or goods.

On the other hand, statistical index number theory provides parameter-free approximations to the exact economic aggregates which are provided by aggregation theory.

We have dual objectives in this paper : (1) We apply a system-wide approach to the demand for money on Korean data using a microtheoretical framework.

* Jeong-Ho Hahm is a senior economist in the Research Department of the Bank of Korea.
** Woon-Gyu Choi is an economist in the Research Department of the Bank of Korea. The views expressed in this paper are solely those of the authors and do not represent the views of the Bank.

Consumer's demand behavior for money and near-monies is analyzed based on the choice-theoretic framework. Price elasticities and elasticities of substitution are empirically estimated. As is well known, the degree of substitutability among monetary assets has been used explicitly or implicitly to provide a rationale for the appropriate definition of money. (2) Based on the aggregation-theoretic approach, we propose an explicit method for the construction of consistent monetary aggregates over which consumers can possess stable preferences. Specifically, we test for the appropriateness of aggregation assumption (weak separability) to find out if there exist any consistent monetary aggregates over some subsets of monetary assets. This also ensures the validity of the consistent two-stage optimization.

As the first step in applying a system-wide approach to the demand for money under a microtheoretical framework, we derive user costs for monetary assets which are viewed as durable goods yielding a flow of monetary services. Then we construct three types of Fisher Ideal monetary aggregates. An assumption of weak separability between consumer goods and monetary assets is not imposed, since this study treats consumption of consumer goods jointly with consumption of monetary services. Instead, this assumption is empirically tested. As the specifcation of the indirect utility function, a (homothetic) translog flexible functional form is utilized.

In recent years, empirical studies for money demand function under a macrotheoretical framework in Korea have been numerous and have been greatly advanced. However, empirical studies concerning consumer demand behavior for money and near-monies under a choice-theoretic framework based on the microeconomic demand theory have not been previously attempted because the proper price concept for monetary assets has not yet been established. We introduce a user cost, developed by Barnett (1978), as the price concept for monetary assets by viewing them as durable goods which provide a flow of monetary services. Considerable effort is made to derive a series of user costs for the thirty-one monetary assets which the Bank of Korea currently recognizes as sources of monetary services in the Korean economy since the derivation of user costs is essential to our task. It should, however, be noted that our study cannot be exhaustive or complete, but should be viewed as a preliminary to more detailed further research.

This paper is organized as follows : Section two presents a general model of the individual consumer's utility maximization that recognizes the interdependence between real and financial decisions. In section three, monetary aggregation theory and index number theory relevant to the construction of consistent monetary aggregates are briefly reviewed. Section four describes the specification of the demand system and data used in this study. In section five, the stochastic specification for the disturbance term and the method of estimations are discussed. This section also discusses the separability testing methods and the parameter restrictions on the separability test. Section six contains our empirical results and their interpretations. Section seven consists of a brief summary and tentative conclusions. It also includes some suggestions for further research.

II. THE MODEL

We assume that the conditions for the existence of a community utility function are satisfied.[1] And we suppose a representative consumer's direct utility function is weakly separable (a direct utility tree) of the form :

(1) $U = U[u(x), L]$,[2]

where x is a vector of the services of the consumer goods and monetary assets and L is leisure.[3]

It should be noted that even if monetary assets are not in consumer's elementary utility function, it has been proved in general equilibrium theory that each consumer has a derived utility function containing monetary assets along with consumer goods.[4] Recently, an alternative view has been developed that money should be treated "just like any other commodity", and money is held because of the utility it provides, i. e., the moneyness of money. And the degree of moneyness may be measured by the foregone income when a monetary asset is held instead of holding other assets with higher interest rates. This approach is enormously valuable since it makes possible to measure the flow of monetary services in terms of readily observable data, and also to capture the varying degrees of moneyness which various monetary assets possess.

It should also be observed that a two-stage budgeting decision process is implicit in the above utility tree structure. In the first stage the consumer allocates his expenditures among broad categories based on price indices for these categories, and in the second stage he allocates expenditures within each category. The particular two-level structure we wish to utilize can be expressed by the following classical consumer problem :

(2) $\max\ u(x)$ subject to $\pi' x = Y$,

where the utility (aggregator) function $u(x)$ is assumed to satisfy the usual regularity conditions. The total expenditures on the services of consumer goods and monetary assets is denoted by Y, and π is a vector of prices of consumer goods and user costs of monetary assets. In particular, the user cost of the ith monetary asset is given by

(3) $\pi_i = (R-r_i)/(1+R)$,

where r_i is the own rate of return on the ith asset, and R is the benchmark rate

1) Regarding aggregation over economic agents, see Gorman (1953) and Muellbauer (1975, 1976).
2) The subutility (aggregator) function $u(x)$ is assumed to be homogenous of degree one to ensure the consistency of the two-stage recursive budgeting decision process. See Strotz (1957, 1959), Gorman (1959), and Green (1964).
3) The utility-tree structure defined in (1) is treated as a maintained hypothesis in this study, although it is too restrictive since it implies the demand for consumer goods and monetary services is independent of the relative price change of leisure. This hypothesis is also testable, but this task is beyond the scope of this study.
4) See Arrow and Hahn (1971), and Quirk and Saposnick (1968).

of return, which represents the highest rate of return during the holding period. Thus the user cost of a monetary asset denotes income foregone or the opportunity cost by holding the ith monetary asset instead of other asset with the highest available yield. In this sense, the user cost of monetary asset is a price for the services the asset provides.[5]

Suppose further that the subutility functionu $u(x)$ is weakly separable in some subsets of monetary assets as follows :

$$(4) \qquad u(x) = u[u_1(x_1), x_2],$$

where x_1 is a vector of a subset of monetary assets, x_2 is a vector of consumer goods and the rest of monetary assets which are not in x_1. This utility structure implies that there exists a subfuntion and thus a consistent aggregate over some subsets of monetary assets alone. It is to be recalled that one of our principal objectives is to investigate whether there exist some consistent monetary aggregates over any subsets of monetary assets.[6]

This weak separability rationalizes the estimation of a monetary asset's demand system. However, the above utility tree structure defined in (4) relies on the assumption that the consumer is able to make a rational first-stage expenditure allocation among broad categories. For this to be possible, there must exist a set of consistent price indices corresponding to each broad category.

Gorman (1959) has shown that, given a weakly separable utility function with more than two categories, such consistent price aggregates exist if, and only if, the utility function is structured either as homothetically separable or as strongly separable with Gorman polar forms, or is a mixture of two structures. That is, homotheticity or quasi-homotheticity is a sufficient condition for the existence of utility trees and consistent two-stage optimization.

Moreover, homothetic or quasi-homothetic separability permits the separability hypothesis to be interpreted in terms of direct utility function rather than solely in terms of indirect utility function. In this connection, Blackorby, Primont and Russell (1974) have shown that if the direct utility function is strongly recursive separable with homothetic aggregator functions, then the indirect utility function will also be homothetically strongly recursive separable in normalized prices.

Homotheticity, however, has very strong implications for demand behavior, since it imposes unitary expenditure elasticities, i. e., the Engel curve is linear and passes through the origin. On the other hand, Gorman polar form has a linear Engel curve which need not pass through the origin.

As is the practice in the literature, by the duality theory, we can derive the direct demand system from the indirect utility specification without reference to direct utility

5) The user cost formula was first derived by Donovan (1978), and later by Barnett (1978) through an intertemporal consumption allocation model. For the rigorous mathematical derivation of user cost, see Barnett (1978).

6) We could use Hicksian aggregation to aggregate over monetary assets only if all the user costs move proportionately. However this is not typically the case for monetary assets.

function. An indirect utility function that is homogeneous of degree zero in income and prices can be expressed as a function of the ratios of prices (user costs) to total expenditures.

In section four, the specification of the indirect utility function and the derivation of the demand system from the indirect utility function are briefly described. In what follows, we want to briefly review the preference structure over monetary assets and monetary aggregation theory.

Ⅲ. MONETARY AGGREGATION THEORY

Barnett (1981) developed demand-side Divisia monetary indices, which are a member of the superlative class of index numbers introduced by Diewert (1976). Barnett's construction of Divisia monetary aggregates involves both economic aggregation and statistical index number theory. First, economic aggregation theory is used to identify admissible (separable) component groups among monetary assets. Aggregation theory requires, in this case, weak separability of the utility or production function in the blocks of monetary components over which aggregation is performed.[7] Next, index number theory is used in order to compute parameter-free approximations to the exact economic aggregates provided by aggregation theory.

Aggregation of monetary assets can be approached both from the demand and the supply side of monetary assets. Since this study is concerned with aggregation from a consumer's point of view, the relevant aggregator function is a utilily function. In what follows, a brief discussion of demand-side monetary aggregation theory relevant to the construction of consistent monetary aggregates is in order.

1. Aggregation Theory

A. Blocking of the Utility Function

In order to facilitate the following discussion, let us suppose that the vector x contains a vector of consumer goods and monetary assets. And we partition the quantity vector x into two groups such that $x = (x_1, x_2)$, where x_1 is a vector of currency, demand deposits, and time & savings deposits, and x_2 is a vector of consumer goods and rest of monetary assets, which are not in x_1. We correspondingly partition the price vector π such that $\pi = (\pi_1, \pi_2)$, where π_1 is a vector of user costs of currency, demand deposits, and time & savings deposits, and π_2 is prices (user costs) of consumer goods and other monetary assets.

We seek to aggregate currency, demand deposits, and time & savings deposits, and we term this aggregate the total money stock (M_2). Since one of our primary concerns is to reveal the implications of monetary aggregation theory, we at this point assume that an aggregate M_2 over currency, demand deposits, and time & savings

7) For a detailed discussion of functional separability, see Goldman and Uzawa (1964), Berndt and Christensen (1973, 1974), Blackorby, Primont and Russell (1977, 1978) and Denny and Fuss (1977).

deposits exists.[8] In other words, the utility function defined by (4) is assumed to be weakly separable in the block of currency, demand deposits, and time & savings deposits. Aggregator function u_1 is assumed to be linearly homogeneous. As discussed below, these conditions are both necessary and sufficient for the existence of the economic monetary aggregate M_2 which we seek.

It is noted that we can establish a fully nested utilily-tree by nesting weakly separable blocks within weakly separable blocks. As a result, we can acquire a rational multistage budgeting procedure in which the subutility function itself defines the relevant theoretical quantity index at each stage, and duality theory defines the corresponding functional price index. In what follows, we elaborate on the two-stage budgeting properties of decision and the implications for quantity and price aggregation.

B. Two-Stage Budgeting Decision

The principle of the two-stage budgeting decision is that the consumer can solve his problem as defined in (2) either directly or in two stages as described below. We now decompose the consumer's utility maximization process defined by (2) into two stages : the first stage of the two-stage decision is, for some index of the aggregate monetary asset quantitiy $M_2 = u_1(x_1)$ and aggregate monetary asset price $\Pi_2 = \Pi_2(\pi_1)$, to select M_2 and x_2 to solve

(5) $\max\ u(M_2, x_2)$ subject to $\Pi_2 M_2 + \pi_2' x_2 = Y$.

From the solution of (5), the consumer determines the expenditure for the aggregate monetary services over currency, demand deposits, and time & savings deposits $\Pi_2 M_2$

In the second stage, the consumer allocates $\Pi_2 M_2$ over consumption of the services of each item which is component of M_2 by solving the following decision problem :

(6) $\max\ u_1(x_1)$ subject to $\pi_1' x_1 = \Pi_2 M_2$.

This two-stage budgeting decision is said to be consistent if the solution for x to the problem (2) is the same as the solution for x obtained from the two-stage decision of (5) and (6). According to Green (1964), the two-stage budgeting decision is consistent and there exist aggregate quantity index M_2 and aggregate price index Π_2 if and only if the utility function $u(x)$ is blockwise weakly separable in the block of x_1 and the aggregator function u_1 is linearly homogeneous in their arguments.

Of the above two conditions, the weak separability, often referred to as admissibility or existence condition, is the one of primary concerns in this study, which attempts to test a utililty function for weak separability in the block of monetary assets and other uses of money income. Clearly, such a test does provide a theoretically meaningful criterion for ascertaining the admissibility of aggregation over potential sources of monetary services.

8) This separability assumption is empirically testable and the hypothesis testing is systematically conducted below.

We call u_1 the quantity aggregator function, and Π_2 the user cost aggregator function. In general, the quantity aggregator function is the corresponding utility function.

This two-stage decision process is two-stage budgeting, and can be extended to n-stage budgeting for an n-level hierarchy of nested monetary aggregates,[9] simply by nesting weakly separable blocks within weakly separable blocks in an analogous manner. It should, however, be noted that the consumer acts as if actual aggregate goods existed. Also observe that quantity indices depend exclusively upon quantities, and that price indices depend exclusively upon prices. Furthermore, the budget constraint of problem (6) shows that the product of a dual price index and its corresponding quantity index always equals actual expenditure on the goods within the aggregates (Fisher's factor reversal test).[10]

2. Index Number Theory

Financial innovations and various regulatory policy changes since the 1970s in the United States have led to large fluctuations in the narrowly defined monetary aggregates M_1 due to the process of portfolio shifts from components of M_1 to other financial assets which are transaction-type assets with higher interest rates. This has resulted in serious problems associated with the interpretation of the existing monetary aggregates and the appropriateness of these aggregates as targets or indicators of monetary policy. Recently several researchers suggested that, in order to deal with this situation, more broadly defined high-level monetary aggregates, such as M_2, M_3 and L be used as targets or indicators of monetary policy. As a result, the U. S. Federal Reserve Board has redefined various level of monetary aggregates such as M_2 and M_3. With this movement, the appropriateness of the simple (unweighted) summation procedure, which is currently used for the purpose of constructing the official monetary aggregates has emerged as a controversial issue. All of the current official monetary aggregates are constructed from the simple summation of component monetary assets. This procedure, however, implies perfect substitutability among the monetary assets over which aggregation is performed and the equality of all own rates of return on them. Since these assumptions are not typically acceptable for monetary assets, the simple-sum monetary aggregates are expected to be distortive, especially at the higher level aggregation, such as M_2 or M_3, since the higher the level of aggregation, the less substitutable the monetary components of the aggregation become. In this context, Barnett's Divisia monetary aggregates, based on the exact aggregation theoretic approach and statistical index number theory, are widely recognized as practically viable, and theoretically meaningful alternatives to the flawed simple sum monetary aggregates.

9) For a detailed discussion of subaggregation of monetary assets and the construction of a hierarchy of exact monetary assets aggregates for a representative consumer, see Barnett (1981).

10) By Fisher's factor reversal test, the price (user cost) index dual to a functional quantity index must equal total expenditure on the aggregated assets divided by the indirect category utility function defined on those assets.

Since the middle of the nineteenth century, economists have recognized the need to measure price and quantity aggregates, and have been aware that neither simple summation totals nor averages can fill that need. Since 1964, aggregation theory has been sufficiently advanced to provide a consistent approach for the construction of theoretically meaningful monetary aggregates. However, it should be observed that the monetary quantity aggregate based on the aggregation theory depends on the component monetary asset quantities and the specification of the aggregator (utility) function. In order to use such an aggregate, it is necessary to specify a parameterized econometric functional form for the aggregator function and to estimate its parameters. Therefore, the estimation of aggregator functions and the exploration of their properties play an important role in the aggregation theory literature. However, the resulting aggregation-theoretic aggregates, called functional or exact aggregates,[11] are inappropriate for use and publication by governmental agencies due to the dependency on unknown (but estimable) parameters. Therefore, nonparametric approximations to the unknown aggregator functions are needed. The constuction of such nonparametric approximations is the subject of index number theory : this theory eliminates the need to estimate unknown parameters by using both prices and quantities simultaneously in order to approximate economic quantity aggregates, which depend only upon quantities and not prices. Similarly, index number theory uses both prices and quantities simultaneously in order to approximate economic price aggregates, which depend only upon prices and not quantities.

Barnett (1981) introduced the use of neoclassical aggregation and index number theory into monetary economics. Barnett's Divisia demand monetary aggregate produces a Diewert-superlative measure[12] of the economy's flow of monetary services perceived by the consumers of those monetary services. More recently, Barnett (1986) introduced the Divisia supply monetary aggregate based on supply-side aggregation theory with a monetary production model by the financial firm.[13] By using these results, the multiple outputs of financial firm, i. e., the monetary assets produced, can be aggregated in order to obtain a Divisia supply monetary aggregate. Divisia supply monetary aggregate produces a Diewert-superlative measure of the economy's flow of monetary services delivered by financial firms through financial intermediation.

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11) Economic indices are often referred to as functional, true or exact indices. On the other hand, statistical indexes are used to approximate such economic or functional indices. See Barnett (1981).

12) According to Diewert, an index number is said to be superlative if it is exact for a flexible aggregator functional form, which can provide a second-order approximation to an arbitrary function. See Diewert (1976).

13) For details of the theoretical derivation of the Divisia monetary index for the consumer, see Barnett (1981, 1986). For the theoretical derivation of the supply-side Divisia monetary index, see Barnett (1986), Hahm (1987).

Ⅳ. DEMAND SYSTEM SPECIFICATION AND DATA

1. Functional Forms

In recent years, demand modeling for consumer goods has moved towards the system-wide approach, where by the system of demand functions is jointly estimated subject to the constraints of microeconomic theory. In the system-wide approach, demand systems are usually derived, through duality theory, from a generating-function specification for tastes or technology, and the specification usually is a locally flexible functional form.[14] The translog is a locally flexible functional form for direct and indirect utility functions which presents a second-order local (Taylor series) approximation to an arbitrary twice differentiable direct or indirect utility function. In this study the approximate translog specification will be utilized.

The indirect utility function, dual to the direct utility function, is extended to allow for habit formation simply by introducing new parameters which can be interpreted as "committed quantities" or "subsistence levels of consumption."[15]

For ease of explanation, we start with the basic translog (BTL). A direct utility function has a corresponding reciprocal indirect utility function which can be approximated by the BTL form :

(7) $\ln V = \alpha_0 + \Sigma_i \alpha_i \ln v_i + (1/2)\Sigma_i \Sigma_j \beta_{ij} \ln v_i \ln v_j,$

where V is the reciprocal indirect utility function, $v_i = \pi_i / Y$, π_i = the price (user cost) of the ith good (monetaty service), Y = total expenditures on the services of consumer goods and monetary assets, and $\beta_{ij} = \beta_{ji}$. Then by the modified Roy's identity,[16] we have the following demand equations corresponding to (7) :

(8) $x_i = v_i^{-1} (\alpha_i + \Sigma_j \beta_{ij} \ln v_j) / (\Sigma_i \alpha_i + \Sigma_i \Sigma_j \beta_{ij} \ln v_j),$

where x_i is the quantity demanded of commodity i. Multiplying (8) by v_i yields the expenditure share equations :

(9) $s_i = (\alpha_i + \Sigma_j \beta_{ij} \ln v_j) / (\Sigma_i \alpha_i + \Sigma_i \Sigma_j \beta_{ij} \ln v_j),$

where $s_i = \pi_i x_i / Y$. Since the expenditure share equations are homogeneous of degree zero in parameters, a normalization of the parameters is required for estimation of (9). A convenient normalization is :

(10) $\Sigma_i \alpha_i = 1.$

The homothetic translog (HTL) flexible form can be derived by imposing the following restrictions :

(11) $\Sigma_i \beta_{ij} = 0$, for all j.

With the addition of restrictions (10) and (11), the HTL model's share equations become linear as follows :

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14) The class of locally flexible functional forms was defined by Diewert as being the class of functions that can attain, at an arbitrary point, arbitrary values of the function and its first and second derivatives. See Diewert (1974).

15) See Pollak and Wales (1980).

16) $x_i = [\partial V / \partial v_i] / [\Sigma_j v_j (\partial V / \partial v_j)].$

(12) $s_i = \alpha_i + \sum_j \beta_{ij} \ln v_j$.

In order to introduce the subsistence levels of consumption, we can, following Pollak and Wales (1980), generalize the BTL model by adding a constant term to the BTL demand equations of (8). We term this model the "generalized translog (GTL) flexible model" :

(13) $x_i = b_i + [z_i^{-1}(\alpha_i + \sum_j \beta_{ij} \ln z_j) / (\sum_i \alpha_i + \sum_i \sum_j \beta_{ij} \ln z_j)]$,

where (1) $z_i = \pi_i / Y^s$, (2) $Y^s = Y - \sum_k \pi_k b_k$ is "supernumerary" expenditure, and (3) $\sum_k \pi_k b_k$ represents the subsistence levels of consumption expenditure independent of market prices (opportunity costs).

The expenditure share equations derived from GTL are as follows :

(14) $s_i = b_i v_i + (Y^s / Y)[(\alpha_i + \sum_j \beta_{ij} \ln z_j) / (\sum_i \alpha_i + \sum_i \sum_j \beta_{ij} \ln z_j)]$.

Applying restrictions (10) and (11) to the GTL model yields a form which is not homothetic and whose share equations are not linear in parameters and variables :

(15) $s_i = b_i v_i + (Y^s / Y)[(\alpha_i + \sum_j \beta_{ij} \ln z_j)$.

This form, known as the linear translog (LTL),[17] has linear Engel curves which need not pass through the origin. As can be seen from (15), only if all values of b_i all equal to zero, does it reduce to the HTL, which has linear Engel curves passing through the origin.

As we see in the above, the generalized translog (GTL) fiexible form contains the nested pair of the basic translog (BTL), the linear translog (LTL), and the homothetic translog (HTL) all as special cases. The GTL is a relatively new demand system used by Pollak and Wales (1980) and Atrostic (1982). The share equations derived from GTL are, however, too complex to be estimated. The HTL model is simple to estimate since its share equations are linear but it has linear Engel curves passing through the origin. The LTL model has linear Engel curves which need not pass through the origin, but its share equations are not linear in parameters and variables.

It should be noted that we select a specification for the indirect utility function on the basis of a compromise between the conflicting criteria of a homothetic structure, which imposes unitary expenditure elasticities but is relatively simple to estimate, and a Gorman polar form, which has linear Engel curve without passing the origin but makes the demand system highly nonlinear. In this study, we have decided to use the homothetic indirect utility translog function and estimate demand system as defined in (12). This choice is primarily motivated by the empirical implementation mentioned above.

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17) This model is often called as the quasi-homothetic translog model, and has been estimated by Manser (1976) and Serletis (1986). Quasi-homotheticity is exploited extensively by Gorman (1961, 1976), Deaton and Muellbauer (1980), and Barnett (1983). A well-known example of quasi-homothetic function is the Stone-Geary utility function which is the quasi-homothetic version of the Cobb-Douglas utility function.

2. Data

The data used in our study consist of quarterly time series on expenditures and prices (user costs) of one block of consumer goods and three blocks of monetary assets for the period 1975. I —1987. IV

A. Data on the Consumer Goods

A block of consumer goods is constructed by aggregating expenditures for various consumer goods such as foods, durables and services. This necessarily implies that there exists a subfunction and thus an exact aggregate over various consumer goods. In reality, however, the aggregate is known to comprise a large number of elementary consumer goods. The validity of the above assumption is also an empirical one, which is testable. However, as is the case in all studies of the kind undertaken here, some measure of prior aggregation is rendered inevitable due to the limited data availability and methodology. In any event, the restrictiveness of the assumption of existence of an exact aggregate over consumer goods is to be kept in mind when the results are interpreted. In this study, constant (1980) consumption expenditure $\pi_{1,80} Q_{1t}$ is used as the aggregate consumption goods.[18] Then using current consumption expenditure $\pi_{1t} Q_{1t}$ and the identity $(\pi_{1t}/\pi_{1,80}) = (\pi_{1t} Q_{1t}/\pi_{1,80} Q_{1t})$, a time series on the price of the aggregate consumption good π_{1t} is generated.[19] Next per-capita consumption expenditure is computed. This is done by dividing the aggregate consumption expenditure during each time period (quarter) by the corresponding population size n_t. The resulting per-capita constant (1980) expenditure on the consumer goods in period t $(\pi_{1,80} Q_{1t}/n_t)$ corresponds to the per-capita quantity demanded of the consumer goods in the estimating model defined in (12).

B. Data on the Monetary Assets

Three blocks of monetary assets comprise the thirty-one assets which the Bank of Korea currently recognizes as sources of monetary services in the Korean economy. Data on the three blocks of monetary assets are not readily available. Thus they are constructed using available data on the stocks of the component monetary assets, their own rates of return, and a benchmark rate of return.

In order to construct time series on the three blocks of monetary assets, it is necessary to acquire data on the quantities and the rates of return to the component monetary assets. Table 1 shows a brief description of the thirty-one monetary assets along with their own rate series. According to BOK's latest classification scheme, the narrow money measure M_1 consists of the first four assets (1-4), total money stock M_2 consists of assets 1-15, and the broadest money measure M_3 consists of assets 1-31.[20] In this study, the thirty-one monetary assets are grouped into the three

18) Observe that this consumption expenditure value is Laspeyres quantity index.

19) See Barnett (1983), Fayyad (1986).

20) It should be noted that the assets in insurance institutions are not included due to nonavailability of data.

[Table 1] A Taxonomy of Monetary Assets and Interest Rate Series

Group	Component	Monetary Asset Description	Own Rate
MONEY (M_1)	1	Currency	r_1 : No Interest (Zero)
	2	Checking Deposits	r_2 : No Interest (Zero)
	3	Household Checking Deposits	r_3 : Interest Rate on Household Checking Deposits
	4	Ordinary and Other Demand Deposits	r_4 : Interest Rate on Ordinary Deposits
TIME AND SAVINGS DEPOSITS	5	Time Deposits	r_5 : Interest Rate on Time Deposits (1-year or more)
	6	Saving Deposits	r_6 : Interest Rate on Saving Deposits
	7	Notice Deposits	r_7 : Interest Rate on Notice Deposits
	8	Liberal Saving Deposits	r_8 : Interest Rate on Liberal Saving Deposits (3-month or more)
	9	Other Time and Saving Deposits	r_9 : r_5
	10	Foreign Currency Deposits	r_{10} : Interest Rate on Time Deposits (3-month or more)
	11	Installment Saving Deposits	r_{11} : Interest Rate on Installment Saving Deposits (2-year)
	12	Mutual Installments	r_{12} : Interest Rate on Mutual Installments (3-year)
	13	Housing Installments	r_{13} : Interest Rate on Housing Installments (3-year)
	14	Workman's Property Formation Deposits	r_{14} : Interest Rate on Workman's Property Formation Deposits (3-year)
	15	Household Installment Savings	r_{15} : Interest Rate on Household installment Savings (3-year)
	16	CD (Certificates of Deposits)	r_{16} : Interest Rate on CD
NONMONETARY INSTITUTIONS DEPOSITS		〈Development Institutions〉	
	17	Demand, Time & Savings Deposits	r_{17} : $(r_2+r_5)/2$
		〈Investment Institutions〉	
	18	Bills Issued	r_{18} : Interest Rate on Bills Issued (60-day or more)
	19	CMA (Cash Management Accounts)	r_{19} : Interest Rate on CMA (180-day)

Group	Component	Monetary Asset Description	Own Rate
	20	Beneficial Certificates	r_{20} : Yield on Government and Public Bond
	21	Securities Investment Savings	r_{21} : r_{18}
	22	Securities Finance Co. Deposits	r_{22} : Interest Rate on Securities Finance Liabilities Certificates (60-day)
	23	Merchant Banking Co. Deposits	r_{23} : $(r_{18}+r_{19})/2$
		〈Savings Institutions〉	
	24	Trust Accounts of Banks	r_{24} : Interest Rate on Development Trust (3-year)
	25	Mutual Savings and Finance Company Deposits	r_{25} : Interest Rate on Mutual Credit (18-month) and Mutual Installments (20-month)
	26	Mutual Savings and Finance Company Borrowings	r_{26} : Interest Rate on Borrowings (1-year or more)
	27	Mutual Credit Co. Deposits	r_{27} : Average of Interest Rates on Mutual Credit Time Deposits and Mutual Credit Installment Savings
	28	Credit Unions Deposits	r_{28} : r_{27}
	29	Postal Savings Deposits	r_{29} : Average of Interest Rates on Postal Savings and Time Deposits
		〈Other Financial Assets〉	
	30	Debentures Issued	r_{30} : Yield on Industrial Finance Debentures
	31	Commercial Bills Issued	r_{31} : Yield on Commercial Bills Issued (60-day)

Note : 1. The data for quantities for the components (including CD) of monetary institutions are three-month average data based on the month-end balances data. However, the data for items of non-bank financial institutions are two-quarter moving averages of two consecutive quarters from the quarter-end balances data due to the data availability. 2. All own rates are average quarterly data. They are after-tax rates obtained by considering the types of interest payment (issuance or circulation) and tax rates. For example, suppose that the annual rate of the ith component is k_i and the interest is paid by the three-month basis with tax rate τ. Then the after-tax rate of return of the ith component is $r_i = [1+(k_i/4)*(1-\tau)]^4-1$.

blocks of x_2, x_3 and x_4. The components of x_2 (1-4) are included in the M_1 monetary aggregate. The components of x_3(5-16)[21] are those of the M_2 monetary aggregate net of x_2. The components of x_4(17-31) are those of the M_3 monetary aggregate net of x_2 and x_3. We aggregated, using the Fisher Ideal Index,[22] each group of x_2, x_3 and x_4 to obtain three monetaty aggregates of Q_2, Q_3 and Q_4, respectively.

We decided to use the Fisher Ideal Index, because this index perfectly satisfies Fisher's factor reversal test and can immediately reflect the introduction of new assets into the index.[23] In any event, as Diewert (1976) pointed out, the choice between these two indices is of little importance, since the Divisia Tornqvist-Theil index and the Fisher Ideal index both belong to the class of Diewert-superlative index numbers and these indices move very closely together.

The data for quantities for the components (including CDs) of monetary institutions are three-month average data based on the month-end balances data. However, the data for the items of non-bank financial institutions are two-quarter moving averages of two consecutive quarters from the quarter-end balances data due to the data availability. The computation of Fisher Ideal monetaty aggregates requires knowledge of the user costs of the component monetary assets. The derivation of the user costs defined in (3) in turn requires knowledge of the own rate of return to each component and a benchmark rate of return. A representative rate[24] among several after-tax rates of return for the different holding periods is selected as the own rate of return to each monetary component.[25] As an alternative, we may use the yield-curve adjusted rate for the different holding periods.[26] However, we do not use this method because the yield curve is not available yet.

Next, the benchmark rate R_t, according to Barnett and Spindt (1982), is defined as follows :

$$R_t = \max\ [r_{gt}, r_{it}\ (i=1, 2, \cdots, 31)],$$

where R_t is the benchmark rate of return for the period t, r_{gt} is the yield on government and public bonds, and r_{it} is the own rate of the ith monetary component.

Several comments concerning data adjustment are in order : First, X-11 ARIMA method is applied for all the data which are suspected of having seasonality in order to eliminate this. Second, each monetary asset is divided by population to get per-capita series since the theoretical model is based on individual decision making problem. Next, each asset is divided by the consumption expenditure deflator to con-

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21) Observe that CD is included in x_3.

22) Fisher Ideal index is defined as the geometric mean of Laspeyres index and Paasche index. $Q_t = Q_{t-1}[\{(\Sigma_i \pi_{i,t-1} m_{it})(\Sigma_i \pi_{it} m_{it})\}/\{(\Sigma_i \pi_{i,t-1} m_{i,t-1})(\Sigma_i \pi_{it} m_{i,t-1})\}]^{1/2}$, π_{it} is the user cost of the ith asset for the period t. See Diewert (1976), Barnett (1981), and Hahm (1987).

23) See Diewert (1976).

24) The selection is based on the volume size of each component asset corresponding to the different holding periods.

25) As the own rate of return for demand deposits, implicity interest rate concept may be used. See Klein (1974), Offenbacher (1979), Mitchell (1979), Barnett (1981), and Ewis and Fisher (1984).

26) For example, all the own rates with a maturity greater than three months can be yield curve adjusted to a three-month rate for time deposits.

vert nominal balances to real terms. Third, the aggregate user costs corresponding to the three aggregate monetary quantities are derived using Fisher's factor reversal test. Fourth, no attempt is made to disaggregate by sector due to the data availability. This would require construction of two sets of monetary aggregates : one for consumers and another for business. Fifth, the main reason why we have constructed only one block of consumer goods and three blocks of monetary assets is for the empirical implementation of separability tests. When we have more than four arguments, it would be quite complicated to impose the parameter restrictions for separability tests. Finally, prior estimation, the price (user cost) indices are all scaled to equal 1.0 in 1981. I. To ensure that the products of price and quantity indices $\pi_{it}Q_{it}$ remain unchanged by the rescaling, the quantity series are rescaled accordingly, so that the expenditure share for each item is not changed.

V. ESTIMATION AND HYPOTHESIS TESTING

1. Stochastic Specification and the Method of Estimations

In order to estimate the expenditure share equation systems given by (12), we must specify a stochastic disturbance term for each share equation. Following conventional practice, we specify classical additive disturbance terms in share equations and assume that they are normally distributed with zero mean and constant covariance. Thus, we can write the stochastic version of the model as :

(16) $s_t = f_t(x_t, \theta) + u_t,$

where s_t is the vector of observed expenditure shares at time t, x_t is the vector of exogenous variables, θ is the vector of unknown parameters, and u_t represents a classical disturbance term with the following properties :

(17) $E(u_t) = 0, \ E(u_t, u_t') = \Omega$ for all s, t,

where Ω is a variance-covariance matrix.

Here u_t is assumed to be a first-order autoregressive process such that

(18) $u_t = Ru_{t-1} + e_t$

where $R = [R_{ij}]$ is a matrix of unknown parameters and e_t is the vector of a non-autocorrelated disturbance term defined as :

(19) $E(e_t) = 0, \ E(e_t, e_t') = \Sigma,$

where Σ is a symmetric and positive semi-definite covariance matrix.

The disturbance term specification given in (17) allows both contemporaneous and non-contemporaneous disturbance terms to be correlated.

Since the sum of the expenditure shares equals one ($\Sigma_i s_i = 1$), it follows that the covariance matrix is singular due to the singularity of the system. If autocorrelation in the disturbances is absent, Barten (1969) has shown that full information maximum likelihood estimates of the parameters can be obtained by

arbitrarily deleting an equation in such a system, and that the resulting estimates are invariant with respect to the equation deleted. If, however, autocorrelation is present as assumed above, Berndt and Savin (1975) have shown that the adding up property of a singular system imposes additional restrictions on the parameters of the autoregressive process. When these restrictions are not imposed, any estimations and thus hypothesis testings are conditional on the equation deleted.

In this study, we assumed no autocorrelation across the equations (i. e., R is diagonal). As a result, the autoregressive coefficients have been restricted to being the same for all equations.

Finally, writing equation (16) for the period t-1, multiplying by R, and subtracting it from (16) yields the final model to be estimated in our study.[27]

(20) $$s_t = f_t(x_t, \theta) - Rf_{t-1}(x_{t-1}, \theta) + Rs_{t-1} + e_t .$$

2. Hypothesis Testing

A. Preference Structure over Monetary Assets

Once the model is estimated, the structure of preferences can be investigated by testing for weak separability. We are primarily interested in the existence of consistent monetary aggregates in the consumer's preference. We wish to test preferences for blockwise weak separability in the monetary assets. It is to recalled that monetary assests are grouped into three groups, while consumer goods are grouped into one group. It is implicitly assumed that there exists a consistent aggregate of consumer goods.[28] Specifically, we use an aggregate consumer good which has been aggregated from three categories of various commodity groups such as food, nondurables, durables, and services. In this study, the aggregate consumer good and three blocks of monetary assets constructed as such indices in the manner outlined above are assumed to be exact economic aggregates in the sense that each is assumed to behave as if it were an elementary good.

Suppose, as section three, that a monetary aggregate M_2 exists in the consumer's preference and the monetary aggregate contains only currency, demand deposits, and time & savings deposits. Then this means there exists a subutility (aggregator) function over currency, demand deposits, and time & savings deposits. This implies that the block of currency, demand deposits, and time & savings deposits is weakly separable from the aggregate consumer good and other monetary assets, so the admissibility of aggregation over currency, demand deposits, and time & savings deposits is satisfied. At the level of the consumer, he must be able to select his desired aggregate quantity of M_2 without regard to its composition. Varying the relative quantities of currency, demand deposits, and time & savings deposits within M_2 while

27) For this work, the system has been estimated with the deletion of last share equation. In order to check invariance of maximum likelihood parameter estimates with respect to the equation deleted, we have estimated the model more than once, deleting a different equation each time.

28) Grouping the consumer goods into only one block implies that preferences are weakly separable in that block. This is done mainly due to the direct availability of aggregate data for the consumer goods.

holding the aggregate level of M_2 constant must not affect the consumer's preferences over any other goods (assets). If this condition is satisfied, consumers can possess stable preferences over M_2 and other goods (assets). If M_2 is not a good in this fundamental sense, then consumer preference over M_2 and other goods will appear to shift whenever the relative proportions of the M_2 change.

B. Separability Testing Methods

The conventional separability tests (with Leontief separability conditions) fall into two categories.[29] One type is the exact test, where it is implicitly assumed that the function used exactly represents the true underlying utility or production function, and the null hypothesis of separability is imposed globally for all possible values of the exogenous variables. The second type is the appoximate test, where the function used is a second-order approximation to some unknown arbitrary function, and thus the nulll huypothesis is imposed only at a point of approximation. Berndt and Christensen used the exact test, while Denny and Fuss used the approximate test. The exact test would be preferable if no additional constraints were imposed, since a single reject/non-reject decision is globally applicable. Unfortunately, with second-order expansion and the conventional Leontief separability conditions, this is not the case. Blackorby, Primont and Russell (1977) and Denny and Fuss (1977) have shown that the restriction of global weak separability using the Leontief separability conditions implies either strong separability within the partitioned subaggreagates, or strong separability between aggregates.

The Berndt and Christensen exact test is a test for global separability (at all points of the untility surface) while the Denny-Fuss approximate test is a test for local separability (only at the point of expansion). Denny and Fuss (1977), and Blackorby, Primont and Russell (1977) have shown that the Berndt and Christensen exact test is a joint test of weak sparability and hometheticity of the aggregator function (homethetic weak separability) and that this test is nested in the approximate test. The tests we carry out for the separability conditions are based on the Denny-Fuss framework.

Exact Separability Tests[30] : Let $F : \Omega^n \rightarrow R$ be a twice differentiable function with image $F(x) = F(x^1, \cdots, x^n)$, where Ω^n is the non-negative Euclidean n-orthant and R

29) Most empirical separability tests are performed to test for the existence of consistent input aggregates in the manufacturing firm's production technology. See Burgess (1974), Denny and Pinto (1978), Woodland (1978), Blackorby, Schworm and Fisher (1986). However, on the one hand, Hancock (1986) and Hahm (1987) performed separability tests to investigate the existence of consistent monetary aggregator functions for the financial firm. Hancock used the translog variable profit function, while Hahm utilized the generalized symmetric Barnett variable profit function. On the other hand, Fayyad (1986) and Serletis (1987) performed separability tests to investigate the existence of consistent monetary aggregator functions on the demand side. Fayyad used the absolute price version of Rotterdam model, while Serletis utilized the linear translog model.

30) For more detailed discussions of the definition of separability and the functional separability, see Goldman and Uzawa (1964), Berndt and Christensen (1973), and Blackorby, Primont and Russell (1977, 1978).

is the real line. Let $I^0 = \{I^1, \cdots, I^n\}$ be a partition of the set of variable indices, $I = \{1, 2, \cdots, n\}$. Then the vector x has the decomposition $x = (x^1, x^2, \cdots, x^n)$ and has the Cartesian decomposition $\Omega^n = \Omega^1 \times \Omega^2 \times \cdots \times \Omega^n$. Hence $K \in I^r$ means that x_k is a component of $x^r \in \Omega^r$.

The ith and jth variables are separable from the kth variable if and only if

$$(21) \qquad \partial (F_i(x)/F_j(x))/\partial x_k = 0$$

where $F_i(x) = \partial F(x)/\partial x_i$. This is the so called Leontief separability condition.

Suppose the image of general quadratic flexible functional form can be expressed as

$$(22) \qquad F(x)_{i \in I} = \Sigma \alpha_i f_i(x_i)_{i \in I, j \in I} + \Sigma\Sigma \beta_{ij} f_i(x_i) f_j(x_j),$$

where $\beta_{ij} = \beta_{ji}$, $(i, j) \in |x|$.

Using (21) and (22), it can be shown that the ith and jth variables are separable from the kth variable if and only if

$$(23) \qquad \alpha_j \beta_{ik} - \alpha_i \beta_{jk} + 2\Sigma_l (\beta_{jl}\beta_{ik} - \beta_{il}\beta_{jk}) f_l(x_l) = 0.$$

Equation (23) holds for all values of x in any neighborhood if and only if

$$(24) \qquad \alpha_j \beta_{ik} - \alpha_i \beta_{jk} = 0,$$

and

$$(25) \qquad \beta_{jl}\beta_{ik} - \beta_{il}\beta_{jk} = 0.$$

Thus the satisfaction of (24) and (25) is equivalent to weak separability of the pair $\{i, j\}$ from k. However, the restrictions (24) and (25) require either strong separability within the partitioned subaggregates or strong separability between aggregates.[31]

Appoximated Separability Tests : For the Translog sepecification, with $f_l(x_l) = \log x_l$ equation (23) becomes

$$(26) \qquad \alpha_j \beta_{ik} - \alpha_i \beta_{jk} + 2\Sigma_l (\beta_{jl}\beta_{ik} - \beta_{il}\beta_{jk}) \log x_l = 0.$$

Thus the satisfaction of (24) and (25) is also equivalent to weak separability of $\{i, j\}$ from k for the Translong function. Similarly, the imposition of the above Leontief separability conditions on the Translog functional form requires either strong separability within the partitioned subaggreates or strong separability between aggregates. In other words, the test of weak separability with the Translog flexible functional form becomes the joint test of weak separability and homotheticity of aggregator function.[32] When the null hypothesis of weak separability has been rejected by the data, the rejection of the null hypothesis may be a result of rejecting the hometheticity of the aggregator function. Furthermore, once the restriction of weak separability has been imposed, neither the aggregator function nor the function of

31) This property applies to all functions that have a general quadratic flexible form including the Translog and the generalized Leontief functional forms. See Blackorby, Primont and Russell (1977).

32) See Blackorby, Primont and Russell (1977). See also the Appendix in Denny and Fuss (1977).

aggregates is any longer capable of providing an arbitrary second-order approximation. Thus, testing the null hypothesis of weak separability using the Leontief separability condition (the exact test) may not be appropriate, because imposing parametric restrictions for (24) and (25) is too strong to serve as a test for weak sepabrability, since it introduces unwanted structure. This problem has long been recognized; the most frequently suggested solution is to treat the specified function as an approximation to the true underlying function, rather than as an exact function.

In order to avoid the above problems, Denny and Fuss (1977) used the approximate test using Translong flexible functional form. The Translog function used is considered to be a second-order approximation to the true frunction, and the null hypothesis is imposed only at a point of approximation. When a weakly separable Translog function is approximated by a second-order Taylor series expansion about the point of approximation $x = (1, 1, \cdots, 1)$, the second part in equation (23) vanishes, hence the satisfaction only of (24) is equivalent to weak separability of $\{i, j\}$ from k.[33]

3. Parameter Restrictions for Separability Tests

In order to conduct our approximate tests for weak separability, we consider the separability restrictions associated with restrictions on the functional from. With four variables there are three separability patterns : the separability of two variables from the other two variables; the symmetric separability of two variables from the other two variables; and the separability of three variables from the other variable. There are in all thirteen possibilities. These possibilities and corresponding parametric restricitions are shown in Table 2.[34]

Ⅵ. EMPIRICAL RESULTS

1. Parameter Estimation

The homothetic translog model has been estimated by the method of maximum likelihood. The maximum likelihood estimates[35] of unknown parameters for the model are presented in Table 3. Most of the parameter estimates are statistically significant and have signs that would be expected from the economic theory. Among the first-order coefficients, the α_i's, which represent average expenditure shares of the aggregate consumer good and each aggregated monetary asset, all have positive signs, as expected from theory, and have appropriate magnitudes and fairly high

33) However, the approximate test has also some problems. See Woodland (1978), Blackorby, Schworm and Fisher (1986).

34) For the derivation of these restrictions, see Denny and Fuss (1977). We should express the restrictions for weak separability in terms of the free parameters of the model. Under each separability type, we must be able to eliminate a number of free parameters equal to the number of independent parametric restrictions corresponding to that separability type.

35) These estimates are obtained using FIML program on the TSP econometric package at the Bank of Korea.

[Table 2] Parametric Restrictions for Approximate Weak Separability

Hypothesis	Parametric Restrictions	# of independent Parametric Restrictions
[(1, 2), 3, 4]	$\alpha_1/\alpha_2=\beta_{13}/\beta_{23}=\beta_{14}/\beta_{24}$	2
[(1, 3), 2, 4]	$\alpha_1/\alpha_3=\beta_{12}/\beta_{23}=\beta_{14}/\beta_{34}$	2
[(1, 4), 2, 3]	$\alpha_1/\alpha_4=\beta_{12}/\beta_{24}=\beta_{13}/\beta_{34}$	2
[(2, 3), 1, 4]	$\alpha_2/\alpha_3=\beta_{12}/\beta_{13}=\beta_{24}/\beta_{34}$	2
[(2, 4), 1, 3]	$\alpha_2/\alpha_4=\beta_{12}/\beta_{14}=\beta_{23}/\beta_{34}$	2
[(3, 4), 1, 2]	$\alpha_3/\alpha_4=\beta_{13}/\beta_{14}=\beta_{23}/\beta_{24}$	2
[(1, 2), (3, 4)]	$\alpha_1/\alpha_2=\beta_{13}/\beta_{23}=\beta_{14}/\beta_{24}$ $\alpha_3/\alpha_4=\beta_{13}/\beta_{14}=\beta_{23}/\beta_{24}$	3
[(1, 3), (2, 4)]	$\alpha_1/\alpha_3=\beta_{12}/\beta_{23}=\beta_{14}/\beta_{34}$ $\alpha_2/\alpha_4=\beta_{12}/\beta_{14}=\beta_{23}/\beta_{34}$	3
[(1, 4), (2, 3)]	$\alpha_1/\alpha_4=\beta_{12}/\beta_{24}=\beta_{13}/\beta_{34}$ $\alpha_2/\alpha_3=\beta_{12}/\beta_{13}=\beta_{24}/\beta_{34}$	3
[(1, 2, 3), 4]	$\alpha_1/\alpha_2=\beta_{14}/\beta_{24}$ $\alpha_1/\alpha_3=\beta_{14}/\beta_{34}$ $\alpha_2/\alpha_3=\beta_{24}/\beta_{34}$	2
[(2, 3, 4), 1]	$\alpha_2/\alpha_3=\beta_{12}/\beta_{13}$ $\alpha_2/\alpha_4=\beta_{12}/\beta_{14}$ $\alpha_3/\alpha_4=\beta_{13}/\beta_{14}$	2
[(1, 2, 4), 3]	$\alpha_1/\alpha_2=\beta_{13}/\beta_{23}$ $\alpha_1/\alpha_4=\beta_{13}/\beta_{34}$ $\alpha_2/\alpha_4=\beta_{23}/\beta_{34}$	2
[(1, 3, 4), 2]	$\alpha_1/\alpha_3=\beta_{12}/\beta_{23}$ $\alpha_1/\alpha_4=\beta_{12}/\beta_{24}$ $\alpha_3/\alpha_4=\beta_{23}/\beta_{24}$	2

Note : The subscripts are ; $1=Q_1$ (consumer good), $2=Q_2(M_1)$, $3=Q_3$ (Time & savings deposits), and $4=Q_4$ (Nonmonetary institutions deposits).

[Table 3] Parameter Estimates of the Translog Model
(Unrestricted)

Assets i	Parameter Estimates					DW	R
	α_i	β_{i1}	β_{i2}	β_{i3}	β_{i4}		
Q_1	0. 5409 (4. 2970)	0. 1411 (11. 8778)	-0. 0470 (-5. 7756)	-0. 0683 (-10. 7331)	-0. 0258 (-7. 5432)	1. 79	0. 986
Q_2	0. 1421 (3. 6557)	-0. 0470 (-5. 7756)	0. 0421 (5. 1518)	0. 0046 (0. 5352)	0. 0003 (0. 0964)	2. 18	
Q_3	0. 2099 (3. 1074)	-0. 0683 (-10. 7331)	0. 0046 (0. 5352)	0. 0631 (8. 4738)	0. 0005 (0. 1771)	1. 58	
Q_4	0. 1069 (3. 2081)	-0. 0258 (-7. 5432)	0. 0003 (0. 0964)	0. 0005 (0. 1771)	0. 0249 (28. 9322)	2. 07	

Note : 1. t-ratios are in parentheses. 2. The subscripts are : 1= Q_1 (Consumer good), 2= Q_2 (M_1), 3= Q_3 (Time & savings deposits), and 4= Q_4 (Nonmonetary institutions deposits). 3. Prices of all goods (assets) are normalized by the price of $Q3$. 4. Convergence criterion value is 1. 0E-6. 5. Loglikelihood value = 694. 690.

precisions. All estimates of the own-price coefficients β_{ii}'s are positive with high precisions. This implies that, as own prices rise, the expenditure share increases and thus own-price elasticities are all inelastic. Cross-price coefficients are all negative except β_{23}, β_{24}, and β_{34}, which have very low precisions.

2. Regularity Conditions

Before proceeding to hypothesis testings concerning the existence of consistent monetary aggregates in the consumer's preference, we want to check to see whether the estimated homothetic translog model satisfies some regularity conditions, i. e., nonnegativity, monotonicity and quasiconvexity. The nonnegativity condition requries that the values of the fitted demand functions be nonnegative. The condition simply means that all demands for consumer good and monetary assets are predicted to be positive by Roy's identity, and this can be easily checked by investigating the signs of the estimated average expenditure shares. The monotonicity condition requires that the indirect utility function be monotonically decreasing in prices (user costs), and this can also be checked by the average shares. Finally, the curvature condition requires quasiconvexity of the indirect utility function, and may be checked, provided the monotonicity condition holds, by direct computation of the Hessian matrix $[\partial^2 V/\partial v_i \partial v_j]$. The Hessian matrix is required to have at most one eigenvalue negative with all others being positive or zero. This condition may also be checked by the matrix of Allen-Uzawa partial elasticities of substitution. The matrix must be negative semidefinite. A necessary, but not sufficient, condition for curvature restriction is that the own elasticities of substitution must be all nonpositive.[36]

The estimated homothetic translog model satisfies nonnegativity and monotonicity conditions at all observations. As for quasi-convexity, it fails to satisfy the curvature condition at some of the observations. However, at the sample mean (the approximation point), the estimated model satisfies the curvature condtions.[37] The satisfaction of all appropriate regularity conditions implies that the estimated translog model is consisitent with consumer's utility maximizing behavior underlying the model, and that estimates of parameters will also produce proper elasticities of substitution and price elasticities.

3. Elasticities of Demand and Substitution

In this subsection, we will consider price elasticities of demand and elasticities of substitution since direct parameter estimates do not provide an adequate source of information. For the homothetic translog model, the uncompensated price elasticities of demand and Allen-Uzawa partial elasticities of substitution can be derived by the following formulae.[38]

36) See Ewis and Fisher (1984) and Diewert (1977).
37) It should be observed that our hypothesis testings are based on the Denny-Fuss approximate test.
38) See Ewis and Fisher (1984) and Serletis and Robb (1986).

The own-price elasticities :

(27) $e_{ii} = -1 + \partial \ln s_i / \partial \ln p_i = -1 + \beta_{ii} / s_i.$

The cross-price elasticities :

(28) $e_{ij} = \partial \ln s_i / \partial \ln p_i = \beta_{ij} / s_i.$

The Allen-Uzawa partial elasticities of substitution : [39]

(29) $\sigma_{ij} = [e_{ij} / s_j] + \eta_i,$

where η_i is income elasticities and $\eta_i = 1$ for the homothetic translog model employed here.

In our study, all own- and cross-price elasticities and Allen-Uzawa elasticities of substitution are calculated at the sample mean (the approximation point).

In Table 4, we tabulate the price elasticities of demand for the consumer good and monetary assets along with their approximated t values. [40] It is not required that $e_{ij} = e_{ji}$ since their respective shares may differ. It can be shown from the table that the price elasticities reveal a pattern consistent with the demand theory. All own-price elasticities have negative signs as expected in theory and are inelastic, i. e., $|e_{ii}| < 1$. Cross-price elasticities e_{ij} vary between positive and negative and are also all inelastic. In the table, each column represents the percentage change in quantities for each good of four goods, given a unit percentage price change of a given good. From the first column, it can be seen that an increase in the price of the consumer good results in a decrease in all three monetary assets. From the second column, an increase in the user cost of M_1 (Q_2) results in a decrease in the consumer good and an increase in the other two monetary assets Q_3, Q_4. Similarly, from the third column, an increase in the user cost of time & savings deposits (Q_3) results in a decrease in the consumer good and an increase in the other two monetary assets Q_2, Q_4. Finally, from the fourth column, an increase in the user cost of nonmonetary institutions deposits (Q_4) results in a decrease in the consumer good and an increase in the other two monetary assets Q_2, Q_3. From the above, a conclusion can be drawn that the consumer good and all three monetary assets are all gross complements for each other, and that all monetary assets are gross substitutes for each other. [41]

It seems that the above conclusion is quite reasonable. Suppose that the price of the consumer good rises. Then any rational consumer would reduce the demand for monetary services when he is forced to curtail consumption of the consumer good due to its price rise. On the other hand, suppose the user cost of a given monetary asset rises while the price of the consumer good is held constant. In this case, first, the demand for the given monetary asset would be reduced. The consumer, however, will substitute for other monetary assets in order to maintain some level of monetary services.

39) The Slutsky equation in elasticity form is $e_{ij} = s_j(\sigma_{ij} - \eta_i)$.

40) The standard errors are calculated as linear approximations. See Kmenta (1971 : 444). This may be carried out using the ANALYZ command in TSP.

41) This gross concept in Marshallian sense contains the income effect along with the substitution effect.

The estimated elasticities of substitution along with their approximate t values are listed in Table 5. These elasticities measure the responsiveness in the change of demand when relative prices (user costs) are changed. As can be seen from the table, all own elasticities of substitution are negative, so the necessary condition of curvature is satisfied. The off-diagonal terms measure the degree of substitutability and complementarity between two goods (or assets). If $\sigma_{ij} > 0$, two goods are substitutes, while if $\sigma_{ij} \leqq 0$, they are complements. As we can see from the table, the estimated elasticities of substitution, however, show somewhat different patterns of substitution from the uncompensated price elasticities, i.e., all goods (assets) are revealed to be Hicks-Allen substitutes for one another. As for the elasticities of substitution between the consumer good and each monetary asset, they are very small with very high precision. An interesting observation is that the elasticity of substitution between the consumer good and time & savings deposits (Q_3) or nonmonetary institutions deposits (Q_4) (which have both transaction and investment services) is greater than that between consumer good and M_1 (Q_2) which has mainly transaction services. As for the elasticities of substitution between monetary assets,[42] the elasticity of substitution between monetrary assets is relatively greater than that between the consumer good and monetary assets. From the table, the elasticity of substitution (1.1549) between M_1 (Q_2) and time & savings deposits (Q_3) is relatively greater than that (1.0206) between M_1 (Q_2) and nonmonetary institutions deposits (Q_4), but the two elasticities are quite similar. The elasticity of substitution (1.0235) between time & savings deposits (Q_3) and nonmonetary institutions deposits (Q_4) is relatively greater than that (1.0206) between M_1 (Q_2) and nonmonetary institutions deposits (Q_4).

From the above, we may draw the following conclusions. First, the likely monetary assets have higher substitutability than distant assets. Second, the monetary assets produced from nonbank financial institutions which are not included in official monetary aggregate M_2 also have a much higher substitutability for M_1. This suggests that some assets (with high liquidity) in Q_4 (nonmonetary institutions deposits) should be included as components of M_2. And third, there appears to be no evidence of strong substitutability among monetary assets. This means that a simple sum monetary aggregation, which requires infinite elasticity of substitution, would be an inappropriate method for the construction of monetary aggregates. Nor can our current simple sum monetary aggregates be consistent monetary aggregate variables for monetary theory and policy since they cannot measure the proper flow of monetary services in the economy. The above information concerning the degree of substitutability among monetary assets suggests that our current method of construction of official monetary aggregates is inappropriate and, hence, should be reviewed.

4. Hypothesis Testing Results

One of our principal objectives is to discover the structure of consumer's preferences over monetary assets. More specifically, we wish to find out whether

42) For comprehensive explanations concerning the elasticities of substitution between monetary assets and their implications for monetary policy in Korea, see Hahm and Choi (1988).

[Table 4] Price Elasticities of Demand
(at the approximation point)

E_{ij}	Q_1	Q_2	Q_3	Q_4
Q_1	-0. 7391 (-11. 9384)	-0. 0869 (-3. 6446)	-0. 1262 (-4. 2253)	-0. 0477 (-4. 2970)
Q_2	-0. 3308 (-3. 5125)	-0. 7039 (-7. 2532)	0. 0325 (0. 5485)	0. 0022 (3. 6557)
Q_3	-0. 3253 (-2. 9175)	0. 0220 (0. 5103)	-0. 6992 (-6. 9179)	0. 0025 (3. 1074)
Q_4	-0. 2413 (-3. 2584)	0. 0029 (0. 9702)	0. 0049 (3. 2081)	-0. 7666 (-9. 8069)

Note : 1. t-ratios are in parentheses. 2. The subscripts are : 1= Q_1 (Consumer good), 2= Q_2 (M_1), 3= Q_3 (Time & savings deposits), and 4= Q_4 (Nonmonetary institutions deposits).

[Table 5] Allen Partial Elasticities of Substitution
(at the approximation point)

σ_{ij}	Q_1	Q_2	Q_3	Q_4
Q_1	-0. 3663 (-1. 7064)	0. 3885 (3. 7589)	0. 3987 (4. 5218)	0. 5539 (5. 3371)
Q_2	0. 3885 (3. 7589)	-3. 9519 (-4. 3916)	1. 1549 (3. 8385)	1. 0206 (181. 082)
Q_3	0. 3987 (4. 5218)	1. 1549 (3. 8385)	-2. 3309 (-3. 6221)	1. 0235 (135. 595)
Q_4	0. 5539 (5. 3371)	1. 0206 (181. 082)	1. 0235 (135. 595)	-6. 1681 (-4. 0934)

Note : 1. t-ratios are in parentheses. 2. The subscripts are : 1= Q_1 (Consumer good), 2= Q_2 (M_1), 3= Q_3 (Time & savings deposits), and 4= Q_4 (Nonmonetary institutions deposits).

there exist any consistent monetary aggregates over some subsets of the monetary assets on the consumer's preferences. For this, we empirically test for the appropriateness of the monetary aggregation assumptions that underlie the various money measures. As mentioned above, a necessary condition for the existence of a consistent aggregate is that the utility (aggregator) function, defined over the components of the aggregate and other items as well, be blockwise weakly separable in the components of the aggregate. It should also be recalled that the tests we utilize for the weak separability conditions are based on the Denny-Fuss framework.[43]

Now we consider hypothesis tests for the existence of monetary aggregates. Thirteen null hypotheses are considered. Each null hypothesis is tested using the asymptotic likelihood ratio. As is well known, the negative of twice the difference between the log of the likelihood function under the maintained hypothesis and the null hypothesis is asymptotically distributed as Chi-square with degrees of freedom equal to the number of parameter restricitions imposed under the null hypothesis.

The calculated Chi-square statistics for the hypothesis tests and selected critical values are presented in Table 6. Among total thirteen hypotheses, based on our testing method and data, for only three cases we cannot rule out the admissibility of aggregation over the component monetary assets at the 1 percent significance level. That is, we find that the three types [(2, 3), 1, 4], [(2, 4), 1, 3] and [(3, 4), 1, 2] of weak separability are consistent with our data. The test statistics decisively reject all the other possible separability types by the data at any reasonable level of significance except [(1, 2), 3, 4] and [(2, 3, 4), 1].

Specifically, as can be seen from the table, the null hypothesis that there exists a monetary aggregator function over currency, demand deposits, and time & savings deposits (M_2) cannot be rejected statistically at the 5 percent level of significance. When the null hyupothesis is imposed, the log value of the likelihood function is 694.487, while the unrestricted value of the likelihood function is 694.690. The calculated Chi-square value for the likelihood ratio test of the null hypothesis is $\chi^2=0.41$. This is less than the critical Chi-square value with 2 degrees of freedom at the 5 percent level of significance, which is $\chi^2=5.99$. This result strongly supports the assertion that there exists a monetary aggregator function over currency, demand deposits, and time & savings deposits (M_2). Similarly, the null hypothesis that there exists a monetary aggregator function over time & savings deposits and other monetary assets produced by the nonbank finanical institutions cannot also be rejected statistically at the 1 percent level of significance. When the null hypothesis is imposed, the log value of the likelihood function is 690.160, while the log value of the unrestricted likelihood function is 694.690. Thus calculated Chi-square value for the likelihood ratio test of the null hyupothesis is $\chi^2=9.06$. This is less than the critical Chi-square value with 2 degrees of freedom at the 1 percent level of significance, which is $\chi^2=9.21$. This result statistically supports the assertion that there exists a consistent monetary aggregator function over time & savings deposits and other

43) See the discussions in section three and section five.

[Table 6] Log Likelihood - Ratio Test Results

Hypothesis	Log Likelihood Value	Test Statistics[a] $2(L^U-L^R)$	D. F.	Critical Values $\chi^2(0.05)$	$\chi^2(0.01)$
Unconstrained	694.690				
[(1, 2), 3, 4]	690.055	9.27	2	5.99	9.21
[(1, 3), 2, 4]	688.626	12.13	2	5.99	9.21
[(1, 4), 2, 3]	678.526	24.33	2	5.99	9.21
[(2, 3), 1, 4]	694.487	0.41***	2	5.99	9.21
[(2, 4), 1, 3]	693.128	3.12***	2	5.99	9.21
[(3, 4), 1, 2]	690.160	9.06*	2	5.99	9.21
[(1, 2), (3, 4)]	686.049	17.28	3	7.82	11.34
[(1, 3), (2, 4)]	687.936	13.51	3	7.82	11.34
[(1, 4), (2, 3)]	686.322	16.74	3	7.82	11.34
[(1, 2, 3), 4]	656.880	75.62	2	5.99	9.21
[(2, 3, 4), 1]	689.515	10.35	2	5.99	9.21
[(1, 2, 4), 3]	687.205	14.97	2	5.99	9.21
[(1, 3, 4), 2]	688.830	11.72	2	5.99	9.21

Notes : a. The test statistic is calculated as $2(L^U-L^R)$ and is distributed as χ^2, where L^U and L^R are the values of the unconstrained and constrained likelihood functions, respectively. b. *** : Cannot reject the null hypothesis at the 5 percent level of significance, * : Cannot reject the null hypothesis at the 1 percent level of significance. c. The subscripts are : $1=Q_1$(Consumer good), $2=Q_2(M_1)$, $3=Q_3$(Time & savings deposits), and $4=Q_4$(Nonmonetary institutions deposits).

monetary assets produced by the non-bank financial institutions. One interesting point is that it has been observed that we cannot rule out the admissibility of aggregation over currency, demand deposits and other monetary assets produced by the non-bank financial institutions.

The above results indicate that for some subsets of monetary assets consistent

two-stage optimization is valid. In particular, there exists a consistent monetary aggregate over currency, demand deposits, and time & savings deposits (M_2). Although the aggregation theory indicates that aggregation over currency, demand deposits, and time & savings deposits is possible (admissible) in light of the consumer's preference structure, it does not tell us how to aggregate these monetary components included in the aggregate. However, it should be recalled that the information concerning substitutability among monetary assets suggests that the simple summation method is inappropriate for constructing monetary aggregates and it would be better to depend on a more scientific method such as the Divisia monetary index based on aggregation and index number theory.

One more important comment : There is a growing literature on money demand system analysis based on consumer theory in both theoretical and empirical frameworks. Such system-wide studies of demand for monetary assets have typically assumed weak separability between consumer goods and monetary assets.[44] This assumption involves the traditional "money-nonmoney" dichotomy, and implies that we can formulate a subutility (aggregator) function over monetary assets alone. However, this assumption is empirically testable. The task involves the testing of preferences for weak separability in the block of monetary assets. Our testing result indicates that this hypothesis is rejected by the data at the margin. That is, it is rejected at the 1 percnet level of significance, but we cannot reject the possibility of the traditional money - nonmoney dichotomy at the 0.5 percent level of significance. This, in any event, remains to be a matter which merits further investigation. It should be noted that there is some empirical evidence in support of the weak separability between monetary assets and other consumer goods and services.[45]

Ⅶ. SUMMARY AND CONCLUDING REMARKS

This paper lays out a system-wide approach to the demand for money on Korean data under a microtheoretical framework. Its primary objective is to propose an explicit method for the construction of consistent monetary aggregates in the sense that consumers can possess stable preferences over the aggregates. Specifically, consumer's demand behavior for money is analyzed based on the choice-theoretic framework. We estimate price and substitution elasticities of monetary assets. As is well known, the degree of substitutability among monetary assets has been used explicitly or implicitly to provide a rationale for the appropriate definiton of money. We then test for the appropriateness of aggregation assumption (weak separability) underlying various money measures. This ensures the validity of the consistent two-stage optimization.

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44) See Chetty (1969), Donovan (1978), Offenbacher (1979), Barnett (1980), Ewis and Fisher (1984, 1985), and Serletis and Robb (1986, 1988).

45) See Fayyad (1986), Hancock (1986).

In order to apply a system-wide approach to the demand for money under a microtheoretical framework, as a first step, we derive user costs for monetary assets. Then, we construct three types of Fisher Ideal monetary aggregates. An assumption of weak separability between consumer goods and monetary assets is not imposed since this study treats consumpiton of consumer goods jointly with consumption of monetary services. Instead, this assumption is tested empirically.

Although much work has to be done, we may draw the following interesting, though tentative, conclusions based on our results.

(1) All the monetary assets are found to be own-price inelastic. This may give some information on the change of demand for monetary services due to the change of interest rate.

(2) A very interesting observation is that the consumer good and monetary assets appeared to be gross complements for one another, while monetary assets are all gross substitutes for each other. However, in terms of the Allen elasticities of substitution, all goods (assets) are revaealed to be Hicks-Allen substitutes for one another.

(3) One more interesting observation is that the elasticity of substitution between the consumer good and time & savings deposits or other monetary assets produced by non-bank financial institutions (which have both transaction and investment services) is greater than that between consumer good and narrow money M_1 (which has mainly transaction services).

(4) The elasticity of substitution between M_1 and time & savings deposits is relatively greater than between M_1 and other monetary assets produced by non-bank financial institutions. The elasticity of substitution between time & savings deposits and other monetary assets produced by non-bank financial institutions is relatively greater than that between M_1 and other monetary assets produced by non-bank financial institutions. The likely monetary assets have higher substitutability than distant assets. The monetary assets produced from non-bank financial institutions is relatively greater than that between M_1 and other monetary assets produced by non-bank financial institutions. The likely monetary assets have higher substitutability than distant assets. The monetary assets produced form non-bank financial institutions which are not included in official monetary aggregate M_2 also have a much higher substitutability for M_1.

(5) There appears to be no evidence of strong substitutability among monetary assets. This means that the simple sum monetary aggregation, which requires infinite elasticity of substitution, would be inappropriate for the construction of monetary aggregates. Hence our current simple sum monetary aggregates cannot be consistent monetary aggregate variables for monetary theory and policy since they cannot measure the proper flow of monetary services in the economy.

(6) There appears to exist some consistent monetary aggregates over some subsets of monetary assets. This also ensures the validity of two-stage recursive optimization process. In particular, our current official total money stock (M_2) is found

to be a consistent monetary aggregate in the sense that consumers have stable preference over M_2.

As is the case for all the empirical studies, the study carried out above cannot, in any event, be exhaustive or conclusive, but rather should be viewed as a first step toward shedding some light on the construction of consistent monetary aggregates in Korea. Further research is clearly needed in this area.

Some areas of research which can be profitably expanded are as follows :

(1) Since there exists some evidence for the appropriateness of two-stage recursive optimization process, we may construct a subutility function over monetary assets only. Substantial benefits can be expected from the estimation of money demand system with more disaggregated monetary data. It would be very instructive to investigate the appropriateness of monetary aggregation over various subsets of monetary assets to obtain consistent money measures.

(2) In this study, we use homothetic utility function throughout. While its use greatly simplifies the estimation of demand system and hypothesis testings, it imposes unitary expenditure elasticities. Weakening the homotheticity assumption is clearly an area for productive future research.[46]

(3) Since the translog flexible functional form basically provides only a local approximation, it would be constructive to utilize other flexible functional forms which have global property such as the Fourier flexible functional form (Gallant (1981)), the Laurent flexible functional form (Barnett (1983)), or the normalized quadratic semiflexible functional form (Diewert (1988)).

(4) The estimating demand system can be expanded by allowing a dynamic formulation to accommodate short-run disequilibrium situations (including lagged endogeneous and exogenous variables as regressors).[47]

(5) Once various levels of consistent monetary aggregates over which consumers possess stable preference are constructed theoretically or practically, the next step should be to investigate their empirical performance in terms of various macroeconomic policy criteria such as causality and stability of money demand function in order to select the most appropriate monetary aggregates as an intermediate target.

(6) As the above results indicate, the simple-sum monetary aggregation is inappropriate for construction of economic monetary aggregates. If Divisia or Fisher Ideal monetary aggregates, which can properly capture the flow of monetary services in the economy, are constructed and used as an indicator, then an enormous amount of information as a monetary indicator can be expected from them.[48]

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46) As a practical alternative, a quasi-homothetic translog model (LTL), or a generalized translog model (GTL), or a basic translog model (BTL) can be utilized.

47) See Anderson and Blundell (1982).

48) An empirical analysis concerning the performance of the Fisher Ideal monetary aggregates in Korea appears in Hahm and Choi (1988). They report that all levels of the Fisher Ideal monetary aggregates are found to be superior to simple sum monetary aggregates in terms of velocity, demand function, and lagged correlation analysis.

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