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I. INTRODUCTION

Financial innovations, to large extent, have dominated the debate over and implementation of monetary policy since 1981. The nationwide introduction of NOW accounts that year, supplemented by MMDAs in December 1982 and Super NOWs in January 1983, raised a variety of questions concerning which monetary aggregate should be targeted, whether the new accounts were responsible for slower observed velocity growth in 1982-83 and if the historical link between M1 and GNP has been broken. In short, the new accounts beg the question of whether they possess the characteristics of "money" and should be treated as such in the conduct of monetary policy.

The empirical evidence on this question comes primarily from estimates of reduced-form GNP equations or money demand equations based on ad hoc adjustments to official measures of the money stock. These studies, however, have not dealt with the more recent introduction of MMDAs and Super NOWs. Moreover, while the voluminous work of Barnett and his colleagues on Divisia monetary aggregates offers strong theoretical and empirical criticism of the weighting scheme of official aggregates, it has not yet considered the question of which financial assets can be grouped into a collection that represents "money." Stated differently, deciding on the collection of assets to be included in a superlative index of the money stock is at least as important as determining asset weights.

This paper offers empirical evidence on the "moneyness" of the new interest-bearing checking accounts. We follow an approach to product definition often employed in antitrust disputes. This strategy involves specifying a benchmark product and estimating elasticities of substitution between it and the alleged competing (or non-competing) products. In the current case, if one assumes that currency and demand deposits are assets that embody the set of characteristics associated with money, consumer demand theory suggests estimated elasticities of substitution between them and the new interest-bearing checking deposits as indicators of moneyness. Our particular interest is in isolating significantly positive elasticities of substitution between currency or demand deposits and balances in NOWs and Money Market Mutual Funds (MMMFs). Insufficient data, for the time being, precludes consideration of MMDAs and Super NOWs.

We estimate these relationships by applying the Almost Ideal Demand System (AIDS) to aggregate budget shares for these asset groups. Using a sample of monthly data for June 1981-February 1985, we find NOWs to be a complement to currency and demand deposits while MMMFs are a substitute for these balances. These results indicate that M1 presently includes one asset that is not a good substitute for money and does not include another that is a good substitute. Our results extend those of Barnett by showing that the composition of current monetary aggregates--as well as their fixed weights--cannot be supported by the data.

II. FINANCIAL INNOVATIONS AND THE CONDUCT OF MONETARY POLICY

That uncertainty about the effects of financial innovations on measured money growth dominated policy discussions in 1983 can be seen from a casual look at the record. The record of the meeting of the Federal Open Market Committee held February 8-9, 1983, states, for example:

> "Committee members' views varied considerably on the weight to attach to M1 ... the performance of that aggregate had been subject over the past year or more to substantial uncertainties related to the growing role of NOW accounts and an apparent shift in the behavior of its income velocity ... Only modest allowance was made for the possibility that the new Super NOW accounts would draw funds into M1 from other sources."
>
> [Bulletin, April 1983, pp. 288-89]

Two months later, in a statement to Congress, Chairman Volcker reported:

> "To some extent--but it cannot be measured with any degree of certainty--the decreases in "velocity" may reflect the changing nature of M1; with interest-bearing NOW and Super NOW accounts making up an increasingly large proportion of M1, this aggregate may be influenced by "savings" behavior as well as "transactions" motives. That

> is a longer-term factor, and the growth in M1 over the shorter-run may have been affected by the reduced level of market rates--particularly relative to interest-bearing NOW accounts--and slowing inflation as well. The range of uncertainty on these points is substantial (emphasis added) and has led the Federal Open Market Committee to place less emphasis on M1 in the implementation of policy over the short term."
>
> [Bulletin, May 1983, p. 338]

Clearly, these and other official statements indicate that considerable uncertainty has existed concerning how interest-bearing checking accounts are being used and how their use might affect the behavior of the monetary aggregates generally and the behavior of M1 velocity specifically. The uncertainty about whether these accounts were held as savings or transactions balances is really uncertainty about the characteristics of alternative assets and the degree to which they are used as substitutes. Knowing the degree of substitutability, of course, is necessary to measuring the economy's monetary service flow.

III. FINANCIAL INNOVATIONS AS MONEY SUBSTITUTES: THE CURRENT EVIDENCE

The existing work on the moneyness of different assets and the effects of financial innovations follows three distinct paths. Much of this work, however, predates the introduction of NOW accounts.

On pre-1980 data, Barnett (1980), Offenbacher (1979, 1980) and Ewis and Fisher (1984a, b) apply consumer demand theory to estimate elasticities of substitution between M1A and other assets, such as savings balances. The general conclusion of this work is that few assets appear to be good substitutes for money but the sample considered does not include any of the financial innovations currently of interest. While this consensus differs from Chetty's (1969) finding that many assets were close substitutes for money, Boughton (1981) and Husted and Rush (1984) correct errors in Chetty's analysis and report low substitutability between money and other assets.

A second line of work deals with the effects of NOW accounts on the money-GNP relationship but is based on ad hoc adjustments to M1. Hafer (1984), for example, cites turnover data on NOW accounts as evidence that they are used as savings balances. After subtracting other checkable deposits from M1, results from money demand and reduced-form GNP equations indicate that this adjusted measure of M1 is more closely related to aggregate spending and explains a large portion of the 1982-83 velocity decline. Similar practices, with varying conclusions, are found in Wenninger (1984). Turnover data for one institution also have been used by Stern, Supel and Quah (1984) to argue that MMMFs do not behave like money.

The final line of work related to financial innovations includes the research on Divisia monetary aggregates by Barnett and his colleagues [Barnett (1980, 1981, 1982, 1983, 1984; Barnett, Offenbacher and Spindt (1981, 1984); and Barnett and Spindt (1982)]. The motivation for this work is that official simple-sum aggregates give equal weight in M1 to currency, demand deposits, NOWs and Super NOWs even though each asset has a separate and distinct set of characteristics. For example, whereas each asset can be used directly in transactions, balances in Super NOWs earn interest and are subject to minimum balance requirements and check fees. The Barnett studies provide theoretical and empirical support for the intuitive notion that dollars held in different ways do not provide the same value of monetary services and should not be given equal weight in a monetary aggregate.

The Divisia studies, however, do not question the current composition of the official aggregates; instead, only the weights given to existing components are changed. For example, while it is clear that currency and NOWs should (probably) receive different weights in M1, it is not clear that NOWs belong in M1 as a close substitute for currency. Similarly, it is not clear that MMMFs, currently in M2, do not provide monetary services similar to the services of M1 balances. More generally, the studies involving Divisia aggregates have not investigated whether the new interest-bearing checking accounts possess the set of characteristics and provide the set of services typically associated with money.

IV. ASSESSING THE "MONEYNESS" OF THE NEW ACCOUNTS

One approach to identifying assets that are used as substitutes is based on the idea that individuals hold different assets for each asset's particular characteristics and that modelling the demand for a characteristic (e.g., the liquidity of an asset) is different from the standard problem of modelling the demand for a physical good itself (e.g., the demand for money).[1/] As Barnett (1981) points out, this distinction is particularly relevant to quantifying the effects of financial innovations since the demand for the liquidity and other characteristics of different assets may not have changed in recent years but the introduction of new deposit accounts and new production technology may have reduced the cost of producing particular assets that provide these characteristics. Put this way, our study of the moneyness of alternative asset groups is better viewed as a study of the demand for the characteristics of money after the structural changes associated with new technologies (e.g., MMDAs and NOWs) have been accounted for.

Assumptions Regarding Multi-Step Budgeting and Separability

To generate substitution relationships between asset pairs we specify a set of demand equations derived from the consumer problem of minimizing expenditures on all commodities subject to achieving some specified level of utility. It is assumed that, because the characteristics of various assets provide utility for individuals, holdings of real financial assets can be entered as arguments in the utility function of a representative individual. By taking this approach, financial assets are treated in the same manner as other commodities that provide utility--such as food and clothing. Although this treatment of money as a commodity that provides utility directly has many precedents, it should be noted that some economists object to this specification on the grounds that money merely augments the production of goods that generate consumer utility and does not have distinct characteristics that provide utility directly.[2/]

In anticipation of another potential criticism concerning the application of a model of flow demands to the holdings of financial assets (wealth), which normally are considered to be a stock concept, it is important to note that the budget constraint is expressed in expenditure (i.e., flow) terms. This transformation is possible because the stock expressions for the quantities of various financial assets are multiplied by their user costs before they are entered into the model. By noting that user costs are the rental prices of the services provided by durable goods and assuming that services are proportional to stocks, multiplying stock holdings of financial assets by their respective user costs produces a flow measure of expenditures on the services of the stocks.[3/] When transformed in this manner, it is appropriate to apply a flow demand model to explain the determination of expenditures on the transactions services of alternative financial assets. Moreover, stating the problem in terms of expenditures on monetary services is consistent with a two-stage budgeting process (i.e., weak separability).

After writing a general utility function that includes money and other commodities, we assume that this function is weakly separable in financial assets. Stated most simply, this assumption implies that individuals follow a multi-step budgeting process in which, subject to their expenditure constraints and group price indices, they first allocate budget shares across broad commodity groups, such as "food", "shelter," and "financial assets." Once broad decisions are made to allocate, for example, 20 percent of the budget to food and 40 percent to the services of financial holdings, further budgeting decisions are made concerning how these broad shares will be allocated among specific commodities within each commodity group.

A model consistent with the assumptions of this budgeting process is Almost Ideal Demand System of Deaton and Muellbauer (1980). A representative consumer is assumed to allocate the utility maximizing value of expenditures on the services of all financial assets among competing asset groups based on his real expenditures on financial asset services and the user costs (rental prices) of all competing assets. The representative equation for expenditures on asset i as a share of total expenditures on

financial assets in month t can be written:

$$(1) \quad S_{it} = \alpha_i + \sum_j \gamma_{ij} \ln P_{jt} + \beta_i \ln E_t + \sum_k \delta Q_k + \xi T + \varepsilon_{it}$$

where:

S_{it} = nominal expenditures on financial asset i ÷ total nominal expenditures on all financial assets;

P_{it} = the user cost of financial asset i in month t; 4/

E_t = real expenditures on the financial assets commodity group; 5/

Q_k = three quarterly dummy variables;

T = a time trend;

ε_{it} = an error term $\sim N(0, \sigma^2)$.

For the present problem, there are five equations like (1).

In demand studies that use time series data, the presence of autocorrelated errors is likely. Thus, we replace the assumption that ε_{it} is iid with:

$$(2) \quad \varepsilon_{it} = \rho_1 \varepsilon_{i,t-1} + \rho_2 \varepsilon_{i,t-2} + \cdots + \rho_p \varepsilon_{i,t-p} + v_t$$

so that ε_{it} is an AR(p) process. Estimation of the p coefficients is accomplished by the inclusion of error terms in the model specification; p is selected by overfitting and testing restrictions to smaller p.

We study the demand for NOWs and MMMFs relative to two benchmarks: currency and demand deposits (money). Only four equations of the demand system were estimated, however, because the budget shares used as dependent variables sum to one in each period and, therefore, imply a singular system unless one share equation is deleted. The estimation period includes monthly data from June 1981-February 1985.[6/] The system was estimated by iterated seemingly unrelated regressions with savings deleted. Symmetry and homogeneity were imposed and autocorrelation coefficients were restricted to be the same across equations (see Appendices).[7/] Descriptive statistics for shares and user costs are reported in Table 1. Properties of the demand model and derivations of elasticities of substitution are provided in Appendices A and B.

V. RESULTS

Coefficients of the estimated demand system appear in Table 2. It was necessary to constrain the γ_{ii} coefficients to satisfy negativity of own elasticities of substitution. This was imposed by replacing γ_{ii} with $(smin_i - \sigma_i^2)$ in the estimated equations, where $smin_i$ is the minimum share for asset i. This blunt instrument is likely to be a stronger restriction than necessary and sufficient restrictions given by Gallant and Golub (1984) or Barzilla and Kopp (1985). Also, as mentioned earlier, the presence of autocorrelation was detected and eventually ε_{it} was determined to follow an AR(2) process. In the interest of space, the 12 coefficients for the quarterly dummies and the four time trend coefficients are not reported.

From the estimated coefficients in Table 2 we calculated elasticities of substitution between NOWs and MMMFs, respectively, relative to our money benchmarks, currency and demand deposits. These elasticity estimates consider simultaneously the relative--and potentially offsetting--effects of changes in the user costs of individual assets and of overall real expenditures on the services used of financial assets. Compared with simple Marshallian cross-price elasticities, the elasticity of substitution differs in that the former may indicate two assets are gross complements, while with the latter, adding the effects of changes in real expenditures to this relationship, the assets might really be substitutes.[8/]

Although the model permits estimation of elasticities and their standard errors at each data point, we only report elasticities and standard errors estimated at mean values for the independent variables.[9/] These values are representative of values for individual data points.

Our particular interest is whether elasticities of substitution between either currency or demand deposits (used as the benchmark) and other assets are significantly different from zero. Viewing currency and demand deposits as assets that are undoubtedly money, high and significantly positive values indicate which assets are substitutes for money and, therefore, which assets represent conceptually satisfying candidates for inclusion in monetary aggregate. Conversely, a significantly negative elasticity of substitution would indicate that the assets in question are complements. A value not significantly different from zero would suggest that the two assets are used in fixed proportions; that is, they are neither substitutes nor complements.

The results indicate that NOWs are a complement to demand deposits and used in fixed proportions relative to currency, whereas MMMFs are a substitute for both currency and demand deposits. Moreover, demand deposits and currency are shown to be substitutes, as expected.[10/] Overall, these results indicate that the current composition of M1 can be criticized on the grounds that it includes some balances that do not embody the characteristics of money while it excludes other balances that apparently do.

IV. CONCLUSIONS

Uncertainty about the impact of interest-bearing checking deposits on the targeted monetary aggregates has received much discussion but alternative points of view have been based on little empirical evidence. The evidence that does exist is based on data ending prior to the new financial innovations or *ad hoc* adjustments to money demand regressions.

We report in this study a consistent approach to estimating the effects of interest-bearing checking deposits and other innovations on the composition of the monetary aggregates. Based on consumer demand and duality theory, we establish an optimization problem for asset holders and derive a set of asset demand equations that include the user costs of all competing assets and total expenditures on monetary services.

The results indicate that NOWs are complements to demand deposits whereas MMMFs are substitutes for currency and demand deposits. For policy purposes, these results indicate that NOWs are not money and should not be included in M1 whereas MMMFs, currently in M2, possess the characteristics of money typically associated with assets in M1. When considered with the work on Divisia aggregates, the results indicate that the composition of current monetary aggregates, as well as their weighting schemes, is in need of revision.

The primary limitation of the study is that limited time series data for MMDAs and Super NOWs do not yet permit estimating similar relationships for these new assets, which have been thought to distort the behavior of official monetary aggregates. Within the near future, however, it should be possible to apply a similar model to these assets to determine whether official aggregates accurately represent the economy's monetary service flow and to suggest an alternative asset collection as a replacement.

FOOTNOTES

*Michael T. Belongia is a senior economist at the Federal Reserve Bank of St. Louis. James A. Chalfant is assistant professor of Agricultural and Resource Economics at the University of California, Berkeley. John G. Schulte and Jude Naes provided research assistance.

1/ See, for example, Becker (1965) and Lancaster (1976).

2/ Supporters of the view that money can be treated as a commodity and entered into the utility function directly include Samuelson (1947), Friedman (1959) and Patinkin (1965).

3/ See Donovan (1978); Barnett (1981), p. 197; and Barnett and Spindt, pp. 5-6.

4/ This is based on Barnett's (1978) user cost formula. He derives the expression:

$$P_{it} = \frac{P^*_t \; (R_t - r_{it})(1-M)}{1+R_t \; (1-M)}$$

where P* is a true cost of living index, R_t is some benchmark rate of return, r_{it} is the observed nominal own rate of return on asset i and M is the marginal tax rate. For purposes of this study P^*_t is the geometric mean of the CPI and the GNP deflator and R_t is the Baa corporate bond rate. The own rate of interest (r_{it}) on currency is assumed to be zero. The implicit own rate on demand deposits is estimated by Klein's (1974) formula, which is written $r_D = r_I(1-R/D)$ where r_I is the return on bank investments (proxied by the three-month commercial paper rate) and R/D is the marginal reserve to deposit ratio. The user cost for the combined currency-demand deposit aggregate is a weighted average of their individual costs:

$$P_{C,DD} = \frac{S_C * P_C + S_{DD} * P_{DD}}{S_C + S_{DD}},$$

where S_C and S_{DD} are the shares represented by currency and demand deposits.

The Baa corporate bond rate was chosen as our benchmark (R_t) because it was greater than all own-rates of interest (r_{it}) on other assets; this is a necessary condition to make user costs positive. Barnett and Spindt have found their experiments with Divisia Indices to be robust with respect to choice of R_t.

5/Real expenditures allocated to financial assets actually is nominal expenditures on the services of this commodity group deflated by the geometric mean of the user costs associated with the five assets. See Deaton and Muellbauer (1980).

6/Observations for January-May 1981 were not used because the initial large inflow of funds to NOWs was likely to provide misleading evidence on substitution relationships among assets. The sample used in estimation covers a period over which the growth of MMMF and NOW balances was stable.

7/An iterative procedure was employed because the two-step procedure suggested by Zellner (1962) is not invariant to the choice of the equation deleted from the system. That is, estimated coefficient values will vary if different share equations are deleted. The iterative procedure produces the same set of coefficient estimates regardless of which share equation is deleted.

8/ Let S_j = asset share j; E_i = income elasticity for asset i; η_{ij} = cross-price elasticity between assets i and j; σ_{ij} = elasticity of substitution between assets i and j. We can write

(1) $\eta_{ij} = S_j (\sigma_{ij} - E_i)$ and

(2) $\sigma_{ij} = (\eta_{ij}/S_j) + E_i$.

It is clear from these equations that the cross-price elasticities and the elasticity of substitution give the same sign only if the substitution effect is larger than the expenditure effect ($\sigma_{ij} > E_i$); the magnitudes will differ in any case.

9/ Standard errors are approximated by $(\frac{\hat{\gamma}_{ij}}{s_i s_j})$. Computation of exact standard errors is not yet tractable [see Ewis and Fisher (1984b)].

10/ Lack of data prevented consideration of MMDAs and Super NOWs in a complete model. Preliminary work with a smaller demand system, however, offers some suggestive evidence that MMDAs are a substitute for currency and demand deposits whereas Super NOWs are used in fixed proportions. These supplemental results, if confirmed by further investigation, would indicate a monetary aggregate composed of currency, demand deposits, MMDAs and MMMFs. In other words, these results offer some evidence that current M1 should include some M2 balances and delete its current other checkable deposits category.

Table 1
Descriptive Statistics for Shares and User Costs, June 1981-February 1985

	Mean	Standard Deviation	Minimum	Maximum
Shares				
Currency	0.24	0.02	0.21	0.28
Demand Deposits	0.18	0.02	0.13	0.22
NOWs	0.10	0.01	0.09	0.11
MMMFs	0.11	0.04	0.03	0.16
Savings	0.37	0.06	0.27	0.50
User Costs				
Currency	2.06	0.08	1.91	2.17
Demand Deposits	0.90	0.16	0.57	1.16
NOWs	1.33	0.06	1.22	1.42
MMMFs	0.64	0.21	0.18	0.89
Savings	1.32	0.06	1.22	1.42

Table 2
Results from a Five-Asset AIDS Model Based on Equation (1)

	Coefficient Estimate	Standard Error
ρ_1	1.066*	0.094
ρ_2	-0.229*	0.094
α_1	1.676*	0.148
θ_{11}	0.246*	0.037
γ_{12}	-0.020*	0.003
γ_{13}	0.005	0.019
γ_{14}	0.000	0.002
β_1	-0.223*	0.021
α_2	1.117*	0.444
θ_{22}	-0.005	2.147
γ_{23}	-0.030*	0.004
γ_{24}	-0.004	0.007
β_2	-0.123*	0.064
α_3	-0.702*	0.154
θ_{33}	-0.200	0.123
γ_{34}	-0.016*	0.002
β_3	0.113*	0.022
α_4	-1.218	0.635
θ_{44}	-0.014	0.364
β_4	0.199*	0.092

An asterisk denotes significance at the 0.05 level.

Table 3
Estimated Elasticities of Substitution[1/]

	Currency	Demand Deposits
Demand Deposits	0.567 (0.07)	
NOWs	1.184 (0.79)	-0.598 (0.19)
MMMFs	1.019 (0.09)	0.804 (0.33)

1/ Elasticities are estimated at the data means. Estimated standard errors in parentheses are approximate.

APPENDIX A

The Almost Ideal Demand System

Recent advances in demand analysis have led to the increased use of systems of demand equations. In contrast to most early studies of the demand for money (surveyed by Feige and Pearce (1977)), these are derived in a manner consistent with the theory of consumer behavior. This permits theoretical properties of demand curves to be incorporated into estimating equations. In addition, statistical testing of these properties is made possible.

The starting point in demand analysis is to hypothesize a utility function

$$U = U(x_1, x_2, \ldots, x_n)$$

which gives a measure of the level of satisfaction (utility) derived from the consumption of n goods, whose quantities are denoted by $(x_1, x_2, \ldots, x_n)$. The consumer's goal is assumed to be the maximization of U, subject to an income constraint which limits expenditures to available income:

$$E = \sum_{i=1}^{n} p_i x_i .$$

It is straightforward to include goods which are not actually purchased, such as leisure, by using the opportunity costs of consuming these goods (or their services), some implicit rental rate, as the price of the goods (p_i). In the case of leisure, the market wage rate is a natural choice. The measure of income must be extended--available spending power on a daily basis would be property income plus 24 times the hourly wage rate. The conventional income measure is then less than this amount by the amount of leisure "purchased."

In the case of financial assets, balances held in a particular form have an opportunity cost, measured by the rate of return foregone by not holding a different asset. The "expenditures" on financial assets' services would then be calculated in the same manner as the cost of leisure:

$$\text{Monetary Expenditures} = \sum_{i=1}^{\text{Number of Assets}} \left(\text{Price of Asset } i\right) \left(\text{Quantity of Asset } i\right)$$

In principle, the maximization of utility subject to the income constraint produces, after some algebra, a set of demand curves. These give the optimal (utility-maximizing) value for each x_i, as functions of all prices and the level of expenditures, so that

$$x_i = \psi_i\ (p_1,\ p_2,\ \ldots\ p_n,\ m) \quad i=1,\ldots,A,$$

where A is the number of assets. Often, it is sufficient to assume a particular form for ψ_i; ad hoc specifications will suffice when only one commodity is of interest, perhaps, or when the theoretical restrictions from consumer theory are deemed unimportant. (The latter could be argued persuasively for the present application to aggregate data, although Deaton and Muellbauer (1980) have argued that this particular demand system aggregates perfectly over consumers.

In practice, a set of demand equations cannot be obtained in closed form, unless U(.) takes some fairly simple form.

This limits the types of behavior which can be modeled, as it is necessary to assume either a simple functional form for U(.) or an ad hoc specification for each $\psi_i(.)$.

It is possible, however, to utilize an alternative approach to the problem of utility maximization, provided by duality theory. Conceiving of the original problem of utility maximization as the primal, a dual problem would be to minimize total outlays, subject to a constraint that utility be no less than a particular value. It is easy to see that the two problems yield the same optimal values for each x_i. (At least, this is true if certain regularity conditions are met; see Diewert's (1974) survey or Deaton and Muellbauer (1980b)).

The result of the solution to the dual problem is an expenditure function, $C(u,p_1, p_2, \ldots, p_n)$, which relates the consumer's expenditures to the level of utility (u) and the set of prices. This function contains the same set of information about preferences for each good as does the utility function. For empirical studies, however, it has some advantages over the utility function; most important is that, regardless of the form of C(.), demand equations are obtained as first derivatives of C(.). So long as these can be found, the difficulties of the primal approach are bypassed, yet consistency with underlying theory is maintained.

Based on previous work on aggregation by Muellbauer (1975, 1976), Deaton and Muellbauer (1980a, b) suggest that a linear expenditure function $c(u,p) = a(p) + b(p)*u$ will suffice. Since the parameters are price-dependent, a wide range of preferences can be represented by different choices for a(p) and b(p).

A number of desirable properties are obtained by the choices for a(p) and b(p) which lead to the Almost Ideal Demand System (Deaton and Muellbauer (1980a, b). Of particular interest are its ease of estimation and its ability to represent a wide range of consumer preferences. A complete discussion and derivation may be found in either of those references, or in the application to U.S. food demand by Blanciforti and Green (1983). We present here only the estimating equations.

The expressions for budget shares (obtained by multiplying each x_i by (p_i/E)), are

$$S_i = \alpha_i + \sum_j \gamma_{ij} \log P_j + \beta_i \ln \left(\frac{E}{P}\right) \qquad i=1,\ldots,A,$$

where P denotes a price index. In this study, P has been obtained using Stone's (1953) price index

$$P = \prod_{j=1}^{n} P_j^{S_j}$$

as suggested as an approximation by Deaton and Muellbauer (1980a, page 316). Blanciforti and Green (1983) referred to the resulting demand system as the Linear Approximate Almost Ideal Demand System. They also note in a footnote that the inclusion of budget shares on the right-hand side of the equation rules out the exogeneity of P and, strictly speaking, ordinary least squares techniques. Following both Deaton and Muellbauer and Blanciforti and Green, we ignore this problem.

In order to simplify the share equations to a manageable number of variables, restrictions are placed on the preferences of the consumer. Generally, it is assumed that preferences are intertemporally weakly separable, so that this period's allocation of total expenditures is independent of prices and expenditures in all other periods. In addition, it is assumed that separability with respect to a set of commodities is appropriate. In this study, weak separability is assumed for the financial assets studied, so that

$$U = U[V(x_1, x_2, \ldots, x_A), x_{A+1}, \ldots, x_n],$$

where $x_1 \ldots x_A$ denotes the relevant set of financial assets. The "sub-utility function," $V(.)$, governs the allocation of expenditures to the various assets, after the total expenditure on these assets has been determined. This is assumed to be the result of a "first-stage" budgeting process, in which total expenditures are allocated to groups such as financial assets, all food items, etc.

This budgeting process makes clear the distinction between wealth, as measured by the stock of financial assets, and the flow of expenditures on monetary services. The consumer decides to carry some amount of current wealth forward to the next period and, because of the desirability of monetary services, some of this wealth will be held as financial assets. The moneyholder incurs the cost of slower growth in future wealth due to the lower rates of return on monetary goods. This is the cost, or expenditure, on the services of money.

The implication of this weak separability is that budget shares of the financial assets then depend only on the user costs of each asset and total expenditures on the group of assets. The substantial reduction in the number of parameters required in estimation makes separability an appealing restriction. For discussions of the mechanics and implications of separability, see either Barnett (1981) or Deaton and Muellbauer (1980b); in addition, Ewis and Fisher (1984a, 1984b) discuss the separability assumptions as they relate to the present problem, the demand for money and near-monies.

Estimation of the Almost Ideal Demand System is accomplished by the Iterated Seemingly Unrelated Regressions Technique, a variant of Zellner's (1962) two-step procedure which has been shown to be equivalent to maximum-likelihood (Kmenta and Gilbert (1968)). With one equation of the form

$$S_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \log (E/P)$$

for each asset, a system of six equations is obtained. Since any one equation is redundant because the shares always sum to one, it is customary to delete one equation. Barten (1969) showed maximum-likelihood results to be invariant to the choice of equation for deletion; Berndt and Savin (1975) later extended his result to the case of share equation systems with first-order autocorrelation. Green, Hassan, and Johnson (1978) and Capps (1983) provide examples and discussion of the technique as applied to the Linear Expenditure System.

Each share equation is assumed to include an additive error term, e_i. Because the n-1 assets are jointly selected in the consumer's budgeting decision, it is likely that these error terms will be correlated. That is,

$$E(e_{it}\, e_{jt}) = \alpha_{ij} \neq 0;\ i,j = 1, \ldots, n.$$

In Zellner's original paper, as well as in Barten's, it is assumed that there are contemporaneous correlations but serial independence. That is,

$$E(e_{it}\, e_{js}) = 0 \text{ for each } i,\ j \text{ and } t \neq s.$$

It is likely with time series data, however, that autocorrelation also will be present. Berndt and Savin suggest several autocorrelation filters that can be assumed. The most common, and the assumption in this study, is that the same first-order autocorrelation coefficient is present in each equation. Thus, each share equation, $S_i = f_i(\underline{P},E)$ is estimated in the transformed version,

$$S_{it} = \rho\, S_{i,t-1} + f_{it}(\underline{P},E) - \rho\, f_{i,t-1}\,(\underline{P},E),$$

where ρ is the autocorrelation coefficient. See Ewis and Fisher (1984a, b) for an example.

The coefficients of the deleted equation can be recovered by using estimated coefficients of other equations and restrictions from demand theory. These restrictions include: "adding-up,"

$$\sum_{i=1}^{A} \alpha_i = 1, \quad \sum_{i=1}^{A} \gamma_{ij} = 0, \quad \sum_{i=1}^{A} \beta_i = 0;$$

homogeneity,

$$\sum_{j=i}^{n} \gamma_{it} = 0;$$

and symmetry,

$$\gamma_{ij} = \gamma_{ji}.$$

These restrictions and a negativity constraint were imposed on the estimated coefficients. The negativity restriction ensures that the compensated demand curves are downward sloping.

These restrictions from consumer theory, which correspond to assumptions made about the utility function, reduce the number of coefficients to be estimated, thus conserving degrees of freedom. Deaton and Muellbauer (1980a, b) or Johnson, Hassan and Green (1984) provide detailed derivations and interpretations of these restrictions.

APPENDIX B

Derivations of Price and Income Elasticities for the Linear Approximate Almost Ideal Demand System

Changes in the budget shares of particular assets can be related to price and income changes through convenient elasticity measures. In the current model, prices are user costs as derived by Barnett (1978) and income is actually the expenditures on all the services of all assets in the monetary assets group. The expression for the budget share of the ith good is

$$s_i = \alpha_i + \sum_j \gamma_{ij} \log P_j + \beta_i \log (x/p).$$

Using Stone's (1953) price index

$$\log P = \Sigma\, s_j \log P_j$$

we find that

$$s_i = \frac{P_i Q_i}{x} = \alpha_1 + \sum_j \gamma_{ij} \log P_j + \beta_i \log x - \beta_i \log P$$

$$= \alpha_i + \sum_j \gamma_{ij} \log P_j + \beta_i \log x - \beta_i \Sigma s_j \log P_j.$$

An expression for Q_i is then easily derived

$$Q_i = \frac{x}{P_i}[\alpha_i + \sum_j \gamma_{ij} \log P_j + \beta_i \log x - \beta_i \Sigma s_j \log P_j]$$

The three derivatives of interest are

$$\frac{dQi}{dPi} = \frac{-x}{Pi^2} [\,.\,] + \frac{x}{Pi} [\frac{\gamma ii}{Pi} - \beta i \frac{si}{Pi}]$$

$$\frac{dQi}{dPj} = \frac{x}{Pi} [\frac{\gamma ij}{Pj} - \beta i \frac{sj}{Pj}]$$

$$\frac{dQi}{dx} = \frac{1}{Pi}[\,.\,] + \frac{x}{Pi} \frac{\beta i}{x} = \frac{1}{Pi}[\,.\,] + \frac{\beta i}{Pi}$$

By multiplication of these three derivatives by the appropriate variable and division by Qi (to convert to elasticity form according to

$$\eta_{x,y} = \frac{dx}{dy} \cdot \frac{y}{x})$$

we find

$$\eta_{Qi,Pi} = \frac{Pi}{Qi} \quad \frac{-x[.]}{Pi^2} + \frac{x}{Pi}[\frac{\gamma ii}{Pi} - \beta i \frac{si}{Pi}]$$

$$= -1 + \frac{\gamma ii}{si} - \beta i$$

$$\eta_{Qi,Pj} = \frac{Pj}{Qi} \cdot \frac{x}{Pi} [\frac{\gamma ij}{Pj} - \beta i \frac{sj}{Pj}]$$

$$= \frac{\gamma ij}{si} - \beta i \frac{sj}{si}$$

$$\eta_{Qi,x} = \frac{x}{Qi} \cdot [\frac{1}{Pi} [.] + \frac{1}{Pi} \beta i]$$

$$= 1 + \frac{\beta i}{si}$$

The expressions above then were used to derive the elasticities of substitution reported in the article. An asset's own elasticity of substitution, which must be negative to meet the negativity and curvature restrictions of demand theory, can be written:

$$\sigma_{ij} = \frac{\eta_{QiPi}}{S_i} = [\frac{\gamma_{ii}}{s_i} - 1 - \beta_i + s_i \eta_i] \div s_i$$

$$= \frac{\gamma_{ii}}{s_i^2} - \frac{1 + \beta_i}{s_i} + \eta_i$$

$$= \frac{\gamma_{ii}}{s_i^2} - \frac{1}{s_i} - \frac{\beta_i}{s_i} + (1 + \frac{\beta_i}{s_i})$$

$$= 1 + \frac{\gamma_{ii}}{s_i^2} - \frac{1}{s_i}.$$

Estimates of values for this expression are the diagonal elements of Table 2.

Similarly, the elasticity of substitution between assets i and j can be derived from:

$$\sigma_{ij} = \frac{\eta_{Qi}P_j}{s_j} = [\frac{\gamma_{ij}}{s_i} - \beta_i \frac{s_j}{s_i} + s_j\eta_i] \div s_j$$

$$= \frac{\gamma_{ij}}{s_i s_j} - \frac{\beta_i}{s_i} + \eta_i$$

$$= 1 + \frac{\gamma_{ij}}{s_i s_j}.$$

Estimates for this expression are the off-diagonal elements of Table 3.

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