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FOREWORD

This study analyzes U.S. consumer budget allocations among 11 aggregate commodity groups for the period 1948-78. Also budget allocations among four food groups are analyzed for this same period.

Several alternative model specifications are analyzed. Emphasis is given to the Deaton-Muellbauer (1980a) "almost ideal demand system." A dynamic version of their model is developed and quantified. Comparison of the static and dynamic formulations are compared with similar specifications of the "linear expenditure system." The predictive performance of these four models for the 11 commodity groups is tested for the sample period (1948-78) and for the years 1979-81.

The purpose of this study was to develop improved methods for analyzing demand relationships for food and other goods. The results for the dynamic or habit formation specifications appear promising, although no completely satisfactory results for all goods are claimed.

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CONTENTS

U.S. CONSUMER BEHAVIOR OVER THE POSTWAR PERIOD: AN ALMOST IDEAL DEMAND SYSTEM ANALYSIS

1. INTRODUCTION

The analysis of consumer allocation of personal consumption expenditures among goods and services is of continuing interest to economists (e.g., Houthakker and Taylor 1970). The study of expenditure patterns over time provides insights about important factors such as relative prices and income that will affect future consumption patterns. Food expenditures are the particular focus of this study, but it is argued that these expenditures should be analyzed within the framework of a demand system for major groups of expenditures. For other purposes, researchers often focus on detailed analyses of individual commodities or groups of commodities where both demand and supply aspects can be modeled, and where emphasis is on quantity rather than expenditure patterns.

Recently, Deaton and Muellbauer (1980a) developed the so-called almost ideal demand system (AIDS) which has several desirable properties to be noted in section 2. Their study of annual British data from 1954 to 1974 gave encouraging results using this demand system; however, they concluded that influences other than current prices and current total expenditures should be incorporated into the model. They suggested generalizing and improving their static model by adding dynamic elements. Ray (1980) extended the model to include family size in analyzing Indian budget data.

The objectives of this study are:

1. To develop a dynamic version of the Deaton-Muellbauer model.[1]
2. To estimate a demand system for U.S. consumer expenditures for an 11-aggregate commodity breakdown for 1948-78, and for a four commodity breakdown of food expenditures.
3. To compare the econometric properties of static and dynamic formulations of the AIDS model with the Linear Expenditure System (LES) model, considering both the price and income elasticities from each and their predictive performance for three years beyond the sample period.
4. To discuss the implications of these models and of alternative functional forms on price and income elasticities as budget shares change over time.

The outline of the report is as follows. the theoretical basis of various expenditure allocation models is given in section 2, with emphasis on such issues as aggregation, functional forms and hypothesis testing, and the development of a dynamic version of the almost ideal demand system. Section 3 summarizes estimation and testing procedures and outlines commodity classification and the data base. Analysis of aggregate consumer expenditures (11 commodity groups) is given in section 4, and analysis of consumer food expenditure (four commodity groups) is given in section 5. Summary and conclusions complete the report in section 6.

2. THEORETICAL EXPENDITURE ALLOCATION MODELS

A brief theoretical discussion of static and dynamic demand systems together with their properties will be presented in this section. Separability conditions that allow for aggregation across commodities, specific classes of preferences that allow consistent aggregation across consumers and a

[1]The use of the term dynamic needs some explanation. A completely dynamic specification would be a control-theoretic approach which would imply an optimal consumption path across time. A recent alternative dynamic approach embeds the steady-state or long-run solution into a more general dynamic specification; see, e.g., Anderson and Blundell (1982, 1983). In this paper we allow some of the model parameters to depend on previous consumption levels after the manner of Pollak and Wales (1969). Some researchers prefer the term habit formation to describe the model developed in this paper. For a recent treatment of the alternative dynamic approaches used in demand systems see, Johnson *et al.* (1985).

treatment of some dynamic aspects of consumer behavior will be discussed. After dealing with different functional forms and what they imply with respect to hypothesis testing, a description of the dynamic almost ideal demand system is given. Finally, the section ends with a treatment of the linear expenditure system (LES) which will be used as a benchmark to compare with the results from the almost ideal demand system, since the LES also allows for consistent aggregation across consumers and has been estimated on numerous occasions; see, e.g., Green, Hassan, and Johnson (1980) and the references therein.

Demand Systems

There exist several recent surveys and comprehensive treatments of demand systems; see, e.g., Barten (1977) and Blackorby, Primont, and Russell. However, some of the more recent developments are not included in these materials. Thus, a brief discussion of these latest developments will be given starting with the static individual consumer case.

Static Individual Consumer Case

Essentially there are two different approaches to the derivation of theoretically plausible demand systems. One approach starts with a well-behaved utility function that satisfies certain axioms of choice. Maximization of the utility function subject to the budget constraint yields a set of simultaneous demand functions. By specifying a particular utility function, a demand system is obtained from this optimization process. For example, the linear expenditure system (LES) is derived from the Klein-Rubin utility function; see, e.g., Powell (1974). An alternative approach starts with an arbitrary demand system and then imposes restrictions on the system of demand functions. Restrictions include the homogeneity conditions, Slutsky symmetry constraints, etc. Examples of this approach are given in Byron (1970), Court (1967), and more recently in Heien (1982, 1983).[2]

There are four properties that all theoretically plausible demand systems should satisfy. They are (1) adding up, (2) homogeneity, (3) symmetry, and (4) negativity. For completeness, a brief description of each will be given. For a more detailed discussion see, e.g., Deaton and Muellbauer (1980b), Phlips (1974), or Johnson, Hassan, and Green (1984).

The adding-up restriction states that the budget shares of both ordinary and compensated demand functions sum to one. Equivalently, the total value of ordinary and compensated demands sum to total expenditure. The homogeneity condition is that the quantity demanded remains unchanged if all prices and income increase by the same proportion. Restated, this says that there exists no money illusion. Slutsky's symmetry condition is that the compensated cross-price derivatives or elasticities are equal. The negativity restriction relates to the matrix of compensated price derivatives. It states that the matrix of substitution terms must be negative semidefinite. This, in turn, implies that the diagonal elements, compensated own-price derivatives, are nonpositive. This can alternatively be expressed by saying that the compensated demand curve is downward sloping, i.e., the "law of demand" holds. Some of the theoretically plausible demand systems automatically satisfy these conditions while the more flexible forms allow the demand analyst to test them. In the empirical section of this monograph, using the almost ideal demand system, we will test for the validity of some of these restrictions.

[2]Heien refers to his system as the almost complete system (ACS). His approach takes the restrictions from the S-branch utility system and imposes them on an arbitrary set of demand functions. In all of these latter approaches, the restrictions are only valid at a local point, usually at the means of the variables in the equations. It should also be noted that this approach relates to the well-known integrability problem: Given an arbitrary demand system, does a utility function exist that generates this particular demand system?

With the development and increased popularity of duality concepts, there now are four equivalent ways of representing consumer preferences; see, e.g., Blackorby, Primont, and Russell (1978).[3] The primary advantage of these duality relationships is that theoretically plausible demand systems can be obtained by relatively simple differentiation rather that by direct optimization techniques. In addition, desirable properties of the underlying preferences (and resultant demand systems) oftentimes can be obtained more easily by employing different representations other than the traditional direct utility function. More will be said about these issues when we discuss the derivation of the almost ideal demand system.

Static demand systems serve as a useful beginning in analyzing consumer expenditure allocation patterns. However, they ignore the effects of persistence in consumption behavior (habit formation), expectations of future prices and income, intertemporal optimization issues, etc. In order to more realistically capture these effects, some dynamic aspects of consumer behavior will be presented. However, before we deal with those issues, some important theoretical and applied properties of demand systems will be discussed.

Aggregation Across Commodities

The theory of consumer behavior is based on an individual consumer's preferences. However, data are usually only available for aggregate commodity groups and aggregate groups of consumers. What are the conditions that will allow us to consistently treat aggregate groups of commodities and consumers given that our theory is based on micro relationships? The first of these problems, aggregation across commodities, has been solved by using separability concepts. The latter problem will be discussed in the next subsection.

A direct utility function is weakly separable if and only if the marginal rate of substitution between any two commodities belonging to the same group is independent of the level of consumption of a third commodity in any other group, that is,

$$\frac{\partial\left(\frac{U_i}{U_j}\right)}{\partial q_k} = 0 \qquad \text{for } i, j \in I \text{ and } k \notin I \tag{1}$$

where U_i, U_j are marginal utilities associated with commodities i and j, respectively, belonging to group I, and q_k is the quantity of the k^{th} good, which does not belong to group I.[4] Strong separability implies that the marginal rate of substitution between two commodities is unaffected by the consumption of a third commodity which may belong to the same group of commodities as i and j. Closely related to the concept of strong separability is additive preferences (e.g., Phlips (1974)). Preferences are additive if the direct utility function, U, except for a monotonic transformation, can be written as the sum of different functions that can be expressed only in terms of the quantitites of commodities appearing in that particular group. That is,

$$U(q_1, q_2 \ldots, q_n) = \sum_{i=1}^{n} f_i(q_i) \tag{2}$$

where $f_i(\bullet)$ is a function whose arguments are the quantities of commodities appearing in the i^{th} group. The LES is an example of a demand system derived from additive preferences.

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[3]The four different ways of representing consumer preferences are the (1) direct utility function, (2) indirect utility function, (3) cost or expenditure function, and (4) transformation or distance function. Of course, the existence of these functions requires some regularity conditions. See Deaton and Muellbauer (1980b) for an excellent discussion of these methods.

[4]For a detailed discussion of separability concepts, see, e.g., Phlips (1974) and Deaton and Muellbauer (1980b).

What are the theoretical and empirical implications of assuming different forms of separability? First, separability assumptions usually result in the reduction of the number of unknown parameters to be estimated.[5] The demand analyst can concentrate on aggregate commodity groups. Weak separability is a necessary and sufficient condition; see, e.g., Deaton and Muellbauer (1980b, p. 124) for the *second* stage of two-stage budgeting. This allows, for example, one to focus on the demand for food items. The quantity or expenditures on food commodities can be expressed as a function of the prices of food items and total food expenditure. Price changes in other groups only affect the quantities demanded of food items through their impact on total food expenditure. However, separability restrictions are not imposed without some costs. Strong separability (additivity) implies, among other things, that there exists an approximate linear relationship between price and income elasticities, Deaton (1975a). This is a very serious limitation that runs counter to most empirical results. Thus, for highly disaggregate commodities such as food items, more flexible forms that do not impose additivity should be employed. The AIDS will be used in this monograph to analyze the demand for a four-food group classification. Some of the justifications will become more apparent later, but for now the AIDS does not imply additive preferences and the limitations that are associated with this class of preferences.

Aggregation Across Consumers

So much has been done concerning aggregation across commodities that it led Muellbauer (1975, p. 525) to conjecture "that probably no really new results remain to be discovered." However, the same cannot be said about the problem of aggregation across consumers. The usual approach has been to assume identical preferences across consumers, express variables in the demand function in per capita terms, and summarily invoke the "representative consumer" argument. More specifically, it is assumed that by expressing aggregate demand functions in per capita terms, the theoretically micro or individual results approximately carry over to the aggregate or market demand functions. But this line of argument has little theoretical foundation.

Muellbauer (1975, 1976) obtained conditions under which consistent aggregation across consumers is permitted. If preferences belong to a "price independent generalized linear" class (PIGL), then market demands can be represented as if they were the outcomes of decisions by a rational representative consumer (Deaton and Muellbauer 1980a, p. 313). Necessary and sufficient conditions that permit consistent aggregation across consumers can be stated in terms of the budget shares or expenditure (cost) functions. In terms of budget shares, $w_i = p_i q_i / x$, where p_i represents price, q_i represents the quantity demanded, and x is total expenditure, the individual budget share equations must have the "generalized linear" (GL) form:

$$w_{ih} = v_h(x_h, p)\, A_i(p) + B_i(p) + C_{ih}(p) \tag{3}$$

where h represents the h^{th} family, p denotes a price vector, and v_h, A_i, B_i, and C_i are functions satisfying $\sum_i A_i = \sum_i C_{ih} = \sum_h C_{ih} = 0$, and $\sum_i B_i = 1$ (Deaton and Muellbauer 1980a, p. 323). With respect to the expenditure or cost function, in order for individual behavior to be preference consistent it must take the form

$$\{c(u_h, p)/k_h\}^{\alpha} = (1 - u_h)\, \{a(p)\}^{\alpha} + u_h \{b(p)\}^{\alpha} \tag{4}$$

where c represents the cost function, u the utility level of the h^{th} family, k_h can represent family composition effects, and a(p) and b(p) are functions of the price vector p. When α approaches zero, we obtain the PIGLOG (price independent generalized logarithmic) form

$$\log \{c(u_h, p)/k_h\} = (1 - u_h) \log \{a(p)\} + u_h \log \{b(p)\} \tag{5}$$

where a(p) and b(p) are linear homogeneous concave functions. For particular forms for a(p) and b(p) and with k_h taken to be unity (because of lack of data on individual family compositions), the AIDS can be derived from this expenditure function. It can also be shown (see Deaton and Muellbauer

[5] An anonymous reviewer pointed out that the Tornquist system is not separable and has (n+1) parameters, while the LES is separable (and additive) and has (2n-1) unknown parameters.

1980a, pp. 324-325) that the LES, the quadratic utility function, a weakly restricted form of the indirect translog and the AIDS are members of the PIGL class. Thus, these demand systems are derived from preferences that allow consistent aggregation across consumers. For a more complete treatment of some recent theoretical results with respect to the aggregation problem across consumers see, e.g., Johnson *et. al.* (1985).

The Dynamics of Consumer Behavior

Besides obeying certain theoretical restrictions and satisfying aggregation conditions, demand models should also explicitly incorporate or test for dynamic behavior of consumers. Thus the static demand models in the previous sections need to be extended. There exist several approaches to this problem; see, e.g., Johnson, Hassan, and Green (1984).

One ad hoc approach has been to add a time trend or lagged dependent variable to the ordinary demand function that includes prices and total expenditure. This approach can be justified on the basis of a partial adjustment process. Another approach has been Houthakker and Taylor's (1970) state adjustment model. They assume that habits can be accounted for by a state variable referred to as "psychological stock" of habits. By further assuming that over time the stock of habits change due to depreciation, they obtain, after proper substitutions, an observable demand relationship which can be empirically analyzed. This method has had a great deal of popularity. A third approach to consumer dynamics, and the one used in this monograph, is to assume that the parameters of the demand models are random. Pollak and Wales (1969) have published several articles describing this approach. For example, it is usually assumed that the minimum subsistence parameter in the LES depends upon previous consumption levels. This allows an explicit treatment of persistences or habit formations that are present in consumer behavior patterns. A fourth approach, but one which will not be considered in the empirical sections, it that of modeling an intertemporal demand system; see, e.g., Lluch (1974) and Klijn (1977). By casting the consumer optimization problem into a control theory framework, much more realism is gained at the expense of severe data requirements. Some interesting work has been done for the demand for durables using this approach; see, e.g., Diewert (1974), Muellbauer (1981), and Cooper and McLaren (1983) and MaCurdy (1983).

One of the important contributions of this monograph is to empirically evaluate a dynamic extension of Deaton and Muellbauer's AIDS. Some of the parameters of the system will be allowed to depend upon previous consumption levels. This method is referred to as "translating" by Pollak and Wales (1981).[6]

Functional Forms and Hypothesis Testing[7]

Traditional functional forms such as the double-log or LES have frequently been used to empirically analyze consumer expenditure patterns. However, they have some serious limitations. For example, the double-log form implies constant price and income elasticities over time. In addition, these fuctional forms imply a rigid relationship between quantities demanded and prices and income. To circumvent some of these problems, more flexible functional forms have been developed. Examples include: the direct and indirect translog, quadratic expenditure system, S-branch, Laurent, generalized Leontief, AIDS, and Fourier transformation equations. The first seven models are sometimes interpreted as providing (local) second-order approximations to arbitrary twice differentiable demand systems while the Fourier transforamtion has the capability in principle of providing global approximations to arbitrary demand systems (Gallant, 1981).

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[6]Pollak and Wales (1981) discuss five alternative methods of incorporating demographic variables in demand systems. One of the methods, translating, allows the "necessary" or "subsistence" parameters of a demand system to depend on the demographic variables. A more general application of this method would allow demand parameters to depend on previous consumption levels.

[7]For a general discussion of hypothesis testing and functional form, see King (1979) and Green and Hassan (1981). Also, for a more detailed treatment of the issues discussed in this section see the papers presented by Gallant (1984), Wohlgenant (1984), Chalfant (1984), King (1984), Weaver (1984), and Pope (1984) at the 1983 meetings of the Allied Social Science Association in San Francisco.

One major advantage of these flexible functional forms is that they allow for the testing of some of the theoretical restrictions such as symmetry, homogeneity, and negativity. Oftentimes, nonflexible forms automatically impose these restrictions. Another advantage of flexible functional demand equations is that they allow price and income elasticities to vary over time, thereby letting the data determine the empirical values. Also, flexible forms take on constant elasticities as special cases. For an example of the Box-Cox flexible form, see Pope, Green, and Eales (1980).[8]

While these so-called flexible forms have some distinct advantages over their more inflexible counterparts, there are some disadvantages. As an illustration consider the Box-Cox functional form. A Box-Cox transformed demand equation has the form:

$$q_{it}^{(\lambda)} = \beta_0 + \beta_1 p_{1t}^{(\lambda)} + \ldots + \beta_n p_{nt}^{(\lambda)} + \beta_{n+1} y_t^{(\lambda)} + u_{it} \tag{6}$$

$$i = 1, \ldots, n,\ t = 1, \ldots, T$$

where q_{it} is the per capita quantity demanded of the i^{th} commodity in time period t, p_{jt} is the corresponding price of the j^{th} commodity, y_t is per capita disposable income, and λ is the transformation parameter and u_{it} is a disturbance term. Estimation of this function may yield the maximum value of the likelihood function, give the best fit, and provide more flexible patterns for elasticity movements over time, but yet not make much sense from an economic viewpoint. What is the economic interpretation of a likelihood estimate of, say, $\hat{\lambda} = -3$? Such an estimate is not ruled out on *a priori* grounds and a value of this size may occur rather frequently.

How does the Fourier approximation compare with the AIDS and other flexible and nonflexible forms? The Fourier flexible form introduced in Gallant (1981) is given by:

$$p_i q_i / y = (x_i b_i - \sum_{\alpha=1}^{A} \{u_{0\alpha} x' k_\alpha + 2 \sum_{j=1}^{J} j[u_{j\alpha} \sin(jk'_\alpha x) + v_{j\alpha} \cos(jk'_\alpha x)\} k_{i\alpha} x_i)/$$

$$(b'x - \sum_{\alpha=1}^{A} \{u_{0\alpha} x' k_\alpha + 2 \sum_{j=1}^{J} j[u_{j\alpha} \sin(jk'_\alpha x) + v_{j\alpha} \cos(jk'_\alpha x)]\} k'_\alpha x)] \tag{7}$$

where $p_i q_i / y$ is the i^{th} expenditure share, x the income normalized prices, i.e., $x = p/y$ where p is price and y is income, the k's are multi-indexes and sin(•) and cos(•) are trigonometric functions. This system obviously has desirable flexibility properties, but it may introduce artificial cyclical effects due to the sine and cosine terms. However, statistical partial F-tests should indicate nonsignificant results in the absence of cyclical effects. Even if partial F-tests are statistically significant, the question still remains: "What are the economic factors associated with this type of change?" (King, 1984). Another disadvantage of this form is that it does not permit consistent aggregation across consumers.[9]

We think the choice of the preferred system remains an empirical issue since there are advantages and disadvantages for each system. The LES, quadratic system, a weak form of the translog, and the AIDS all permit consistent aggregation across consumers whereas the "Fourier" demand system does

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[8]The Box-Cox transformation is given by $X^{(\lambda)} = \dfrac{X_t^\lambda - 1}{\lambda}$ where λ is an unknown parameter to be estimated. The linear form ($\lambda = 1$) and logarithmic form ($\lambda = 0$) are special cases of the Box-Cox functional form, although the Box-Cox form is not a convex combination of the two.

[9]To prove that the Fourier flexible form is not derived from the PIGL class of preferences, it is necessary and sufficient to demonstrate that the budget share can be expressed in the form

$$w_i = v(y,p)A_i(p) + B_i(p);$$

see Muellbauer (1975, 1976). After several manipulations of the Fourier budget share form, it can be shown that it cannot be expressed in the form given by Muellbauer. Thus, the Fourier form does not belong to the PIGL class of preferences.

not. The Fourier series approximation on the other hand allows for global aproximation properties and more general relationships for the patterns of elasticiites over time.[10]

The "bottom line" of this discussion on flexible functional forms appears to be one of a tradeoff between imposing plausible economic restrictions versus possibly better data fitting with less economically plausible forms.

Concerning hypothesis testing and functional forms, it is well known that the test for the validity of restrictions also implicitly tests for the functional form. That is, the specific model chosen and the particular constraint being tested are confounded. Thus, it is important to allow for as much generality or flexibility in the underlying model as possible, *ceteris paribus,* in which to carry out the proposed tests. Some of the demand systems, as mentioned previously, do not allow for testing of some of the particular demand properties. They are automatically satisfied from the system's specification.

The Dynamic Almost Ideal Demand System

The Almost Ideal Demand System (AIDS)

The AIDS developed by Deaton and Muellbauer (1980a) builds on a model by Working (1943) and Leser (1963). Their model expresses the i^{th} budget share, w_i, as a function of log x, that is:

$$w_i = \alpha_i + \beta_i \log x \tag{7}$$

where w_i and x are the i^{th} budget share and total per capita expenditure, respectively. The Working-Leser model was extended by Deaton and Muellbauer to include the effect of prices. The resultant demand system was derived, by use of duality concepts, from a particular cost or expenditure function. The AIDS cost function is given by:

$$\log c(u,p) = \alpha_0 + \sum_k \alpha_k \log p_k + \tfrac{1}{2}\sum_k\sum_j \gamma^*_{kj} \log p_k \log p_j + u\beta_0 \prod_k p_k^{\beta_k} \tag{8}$$

where α_0, α_i, β_i and γ^*_{ij} are parameters, u is utility and p_j's are prices. Deaton and Muellbauer chose the particular cost function because it was flexible, it represented preferences that permit exact nonlinear aggregation over consumers, and it resulted in demand functions with desirable properties. By applying Shepard's Lemma, that is, by differentiating the cost function, after appropriate substitutions we obtain the AIDS in budget share form:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log (x/P) \tag{9}$$

where P is a price index defined by:[11]

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \tfrac{1}{2}\sum_k\sum_j \gamma^*_{kj} \log p_k \log p_j \tag{10}$$

As a linear approximation to this demand system Deaton and Muellbauer (1980a) utilize Stone's (1953) index ($\log P^* = \sum_k w_k \log p_k$), where $P \cong \xi P^*$; that is, P is assumed to be approximately proportional to P^*. They then applied ordinary least squares (OLS) to estimate the demand functions.[12] Thus, equation (9) is redefined as:

$$w_i = \alpha_i^* + \sum \gamma_{ij} \log p_j + \beta_i \log (x/P^*) \tag{11}$$

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[10]This result will be made more explicit in the next subsection.

[11]The term a_0 can be interpreted as the outlay required for a minimal standard of living when prices are equal to 1 as in a base year (Deaton and Muellbauer 1980a, p. 316).

[12]Note that Stone's index uses current period budget shares to compute P* although the budget shares (w_i) are the dependent variables in equation (11). Since budget shares do not change sharply from year to year, a price index based on budget shares lagged one period should give a good approximation.

where $\alpha_i^* = \alpha_i - \beta_i \log \xi$. This equation will be referred to as the linear approximate/almost ideal demand system (LA/AIDS) and may be a good first-order approximation to the complete AIDS system, equation (9).

In this form, with P as a price index, the coefficients are easily interpreted. The i^{th} budget share is expressed in terms of prices and real income or expenditures, x/P. The α_i is the intercept and represents the budget share when all logarithmic prices and real expenditures equal zero. The γ_{ij} is equivalent to the change in the i^{th} budget share with respect to a percentage change in the j^{th} price with real expenditures or income held constant; that is, $\gamma_{ij} = \partial w_i/\partial \log p_j$. The β_i represents the change in the i^{th} budget share with respect to a percentage change in real income or expenditures with prices held constant; that is, $\beta_i = \partial w_i/\partial \log (x/P)$.

The demand properties (commonly known as adding up, homogeneity, and Slutsky symmetry) can be shown to be satisfied for the AIDS. First, for adding up, the budget shares sum to 1 if $\sum_i \alpha_i = 1$, $\sum_i \gamma_{ij} = 0$, and $\sum_i \beta_i = 0$. Second, the homogeneity condition holds if $\sum_j \gamma_{ij} = 0$. And, finally, the symmetry restriction holds if $\gamma_{ij} = \gamma_{ji}$.

The Dynamic Almost Ideal Demand System

To reflect persistences in consumption patterns, the static AIDS was extended by specifying the α_i to be linear functions of previous consumption levels. That is,

$$\alpha_i = \alpha_i^* + \alpha_i^{**} q_{it-1}. \tag{12}$$

This linear "habit" scheme follows the approach of Pollak and Wales (1969). By substituting expression (12) into (9) we obtained what we refer to as the dynamic or "habit" version of the AIDS. More specifically, the dynamic AIDS becomes:

$$\begin{aligned} w_i = {} & \alpha_i^* + \alpha_i^{**} q_{it-1} + \sum_j \gamma_{ij} \log p_j + \beta_i \{\log x - \alpha_0 \\ & - \sum_j (\alpha_k^* + \alpha_k^{**} q_{kt-1}) \log p_k - \tfrac{1}{2} \sum_k \sum_j \gamma_{kj}^* \log p_k \bullet \log p_j\}. \end{aligned} \tag{13}$$

The dynamic AIDS is a theoretically-plausible demand system since it is derived from the cost or expenditure function

$$\log c = \alpha_0 + \sum_k (\alpha_k^* + \alpha_k^{**} q_{kt-1}) \log p_k + \tfrac{1}{2} \sum_k \sum_j \gamma_{kj}^* \log p_k \bullet \log p_j + u \beta_0 \prod_k p_k^{\beta_k}. \tag{14}$$

See Appendix 1 for a proof of this proposition.

Two theoretical questions remain with respect to the dynamic AIDS being a valid demand system. First, does the above cost (expenditure) function satisfy the theoretical properties of a cost function? Second, does the above dynamic AIDS satisfy the adding-up condition?[13] The properties of the cost function will be addressed first followed by a discussion of the adding-up constraint.

Deaton and Muellbauer (1980, p. 39) list five properties of a cost function: (1) the cost function is homogeneous of degree one in *current* prices, (2) the cost function is increasing in u, nondecreasing in p and increasing in at least one price, (3) the cost function is concave in *current* prices, (4) the cost function is continuous in p with first and second derivatives with respect to p existing, and (5) the partial derivatives of the cost function with respect to prices are Hicksian demand functions. We will only consider the first property here.

The dynamic cost function is homogeneous of degree one in *current* prices if

$$c(u, \theta p) = \theta c(u, p) \tag{15}$$

[13]It is not valid to test for the adding-up property in a system that automatically imposes it. More specifically, the left hand side of the AIDS is w_i, thus $\sum_i w_i = 1$ by construction.

where θ is any positive parameter. In logarithmic form equation (15) implies

$$\log c(u, \theta p) = \log \theta + \log c(u, p). \tag{16}$$

In Appendix 2 it is shown that the conditions for the dynamic cost function to be linearly homogeneous of degree one in current prices are $\sum_k \beta_k = \sum_k \gamma^*_{kj} = 0$ and $\sum_k (\alpha_k{}^* + \alpha_k{}^{**} q_{kt-1}) = 1$. The latter condition can be imposed at specified values for q_{kt-1}, i.e., at a local point. Thus, the cost function in (14) is only locally valid, i.e., at points where the above restrictions hold.

An alternative dynamic cost function, and one which is globally homogeneous of degree one in current prices is given by Ray (1984)

$$\log c = \alpha_0{}^* + \sum_k \alpha_k{}^{**} q_{kt-1} + \sum_k \alpha_k{}^* \log p_k + \tfrac{1}{2}\sum_k\sum_j \gamma^*_{kj} \log p_k \log p_j + u\beta_0 \,\pi p_k{}^{\beta_k}. \tag{17}$$

It can be shown to be linearly homogeneous if the conditions $\sum_k \alpha_k{}^* = 1$ and $\sum_k \gamma^*{}_{kj} = \sum_k \beta_k = 0$. The proof, omitted here, is similar to that contained in Appendix 2 for the other dynamic cost function.

Consider the second question, i.e., does the dynamic AIDS satisfy the adding-up property? Given the dynamic AIDS in equation (13), it is shown in Appendix 3 that it obeys the adding-up condition if $\sum_i \alpha_i{}^* = 1$ and $\sum_i \gamma_{ij} = \sum_i \beta_i = \sum_i \alpha_i{}^{**} q_{it-1} = 0$. Again the last equality can be imposed at specified values of q_{it-1}. Thus, it only obtains at local points.

Alternatively, given the dynamic cost function in equation (17), it can be shown that it gives rise to the following AIDS:

$$w_i = \alpha_i{}^* + \sum_j \gamma_{ij} \log p_j + \beta_i \{\log x - \alpha_0{}^* - \sum_k \alpha_k{}^{**} q_{kt-1} - \sum_k \alpha_k{}^* \log p_k$$

$$- \tfrac{1}{2}\sum_k\sum_j \gamma_{kj}{}^* \log p_k \log p_j\}. \tag{18}$$

The adding-up condition is satisfied if

$$\sum_k \alpha_i{}^* = 1 \text{ and} \sum_i \gamma_{ij} = \sum_i \beta_i = 0.$$

Thus, these dynamic AIDS systems satisfy the adding-up condition globally. In this sense it is more attractive than the former dynamic AIDS given in equation (13). However, this manner of introducing habit effects is not entirely satisfactory because it implies that the only way in which habits shift the ordinary demand function is through its influence on the price "index," log P, i.e., through an income effect.[14]

The Linear Expenditure System (LES)

The LES, which can be derived from the Stone-Geary utility function in budget share form, is given by:

$$w_i = p_i\gamma_i/x + \beta_i(1 - \sum_k p_k\gamma_k/x) \qquad \text{for } i, k = 1, \ldots, n \tag{19}$$

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[14]Three methods of incorporating habits can be summarized as follows: (1) Replace the coefficients $\alpha_1, \alpha_2, \ldots, \alpha_n$ in equation (8) with $\alpha_i = \alpha_i{}^* + \alpha_i{}^{**} q_{it-1}$, i = 1, .., N which yields the cost function (14) and the demand system (13). The problem with this method is that the restrictions only hold locally. (2) Replace the coefficient α_0 in equation (8) with $\alpha_0 = \alpha_0{}^* + \sum_{i=1}^{n} \alpha_i{}^{**} q_{it-1}$ which yields the cost function (17) and the demand function (18). A limitation of this approach, as pointed out in the text, is that habits influence the demand function only through an income effect. (3) Replace $\alpha_1, \alpha_2, \ldots a_n$ in equation (8) with $\alpha_i = \alpha_i{}^* + \theta w_{it-1}$ where $\alpha_1{}^* + \alpha_2{}^* + \ldots \alpha_n{}^* = (1-\theta)$, a restriction that can readily be imposed. A problem with this formulation is that it assumes a common coefficient, θ, across commodities. (4) Replace $\alpha_1, \alpha_2, \ldots, \alpha_n$ in equation (8) with $\alpha_i = \alpha_i{}^* + \alpha_i{}^{**} w_{it-1}$. This habit scheme has the same problem as specification (1), i.e., it is only locally valid. We appreciate an anonymous reviewer for pointing out some of these relationships.

where the w_i's are budget shares, the p_i's are prices, the γ_k's are interpreted as minimum required subsistence quantities, the β's are marginal budget shares, and x is total expenditure (income). It can be shown that the LES globally satisfies the adding-up, homogeneity, and symmetry restrictions; see, e.g., Goldberger (1967). The LES is also described as an additive system because it is derived from an additive utility function.

In addition to being a theoretically plausible demand system (that is, derived from a utility maximization process), having an intuitive economic interpretation, and being relatively easy to estimate, the LES has performed well in terms of goodness of fit, prediction, and so forth in comparison with nonadditve systems; see, e.g., Hassan, Johnson, and Green (1977).

A Comparison of the LES and AIDS

A brief comparison of the theoretical properties of the elasticites of the LES and AIDS will be given in order to better evaluate the empirical results that are presented in section 4.

The expenditure and uncompensated own-price elasticities for the LES are:

$$\eta_i = \beta_i / w_i \tag{20}$$

and

$$\varepsilon_{ii} = -1 + (1 - \beta_i)\gamma_i / q_i \tag{21}$$

respectively. For the AIDS, the expenditure and uncompensated own-price elasticities are given by:

$$\eta_i = 1 + \beta_i / w_i \tag{22}$$

and

$$\varepsilon_{ii} = -1 + [\gamma_{ii} - \beta_i(\alpha_i + \sum_k \gamma_{ik} \log p_k)] / w_i \tag{23}$$

respectively. With regard to changes in the expenditure elasticities corresponding to changes in the i^{th} budget share, the LES possesses the property that as the i^{th} budget share decreases, the income elasticity increases; that is, $\partial\eta_i/\partial w_i = -\beta_i/w_i^2 < 0$, as marginal budget shares are always restricted to be positive. The implication is that as the budget share for a necessary commodity, such as food, decreases (which it has over time), its expenditure elasticity increases (assuming no inferior goods). This hypothesis seems unrealistic. However, the AIDS and the LA/AIDS—as neither restricts marginal budget shares to be positively valued—allow the expenditure elasticity to decrease with respect to a decrease in the budget shares for necessities ($\beta_i < 0$). Mathematically, $\partial\eta_i/\partial w_i = -\beta_i/w_i^2 > 0$ for $\beta_i < 0$. Thus, in this situation, the AIDS and LA/AIDS possess a more desirable property than the LES.[15] Concerning the properties of the own-price elasticities with respect to a change in w_i, in the LES, $\partial\varepsilon_{ii}/\partial w_i = -(1 - \beta_i)p_i\gamma_i/w_i^2 x < 0$, assuming $0 < \beta_i < 1$ and $\gamma_i > 0$. Thus, as the i^{th} budget share decreases, the own-price elasticity becomes more inelastic, as expected. In the AIDS, the sign of $\partial\varepsilon_{ii}/\partial w_i$ depends on the relative magnitudes of γ_{ii} and $\beta_i(\alpha_i + \sum_k \gamma_{ik} \log p_k)$. *A priori,* it is difficult to assign a positive or negative value to the change in ε_{ii} with respect to a change in the budget share, w_i.

[15] The Fourier transformation demand system is even more flexible in this regard than the AIDS; see, e.g., Wohlgenant (1984).

3. DATA AND ESTIMATION PROCEDURES

The theory presented in section 2 provides a framework in which the data can be organized and interpreted. The data and estimations are important in that they allow us to analyze the usefulness of the theory by moving us from theoretical abstraction to empirical reality. In any economic analysis, numerous problems related to data manipulation and methods of estimation arise. The empirical issues encountered in this study and the method of their resolution are presented here.

This section describes the data and the methods utilized to derive the estimates that will be discussed in section 4. Data were collected for 11 aggregate categories and four food groups. Estimations were performed using the linear expenditure system (LES), linear approximate almost ideal demand system (LA/AIDS), and the almost ideal demand system (AIDS) in both static and habit versions of these models. Full information maximum likelihood (FIML) estimation was employed except for the special case of the LA/AIDS, for which ordinary least squares (OLS) and seemingly unrelated (SUR) methods were used. For the static models the same explanatory variables appear on the right-hand side of each equation, thus, OLS estimators are equivalent to using seemingly unrelated regression methods. For the dynamic LA/AIDS seemingly unrelated estimation techniques are used to obtain more efficient estimators. The LES and the LA/AIDS for the 11 aggregate commodity groups were the only two models estimated. The AIDS, whose parameters increase multiplicatively as the number of commodities increases, could not be estimated for the aggregate commodity groups given the available number of observations. Because of an interest in closely examining the food group parameters, the AIDS, LES, and LA/AIDS were all estimated using the data for the four food commodity groups. This removed the estimability problem resulting from having a large number of commodity groups (11 compared to four). In addition, the four food group estimations of the LES serve as a benchmark to evaluate the estimates from the AIDS.

The Data

Eleven Aggregate Commodity Groups

Annual time series (1947-78) data on personal consumption expenditures (PCE) and prices were used in estimating the parameters required for the LES and the LA/AIDS. Current dollar and constant (1972) dollar PCE data were obtained from a computer tape provided by the U.S. Department of Commerce (USDOC).[16] The annual PCE estimates are available on a continuous basis from 1929 to date and provide detailed information on the composition of consumers' expenditures. The time period, 1948 to 1978, was selected for analysis. Data for 1947 were included in the dynamic specifications since lagged values were involved, leaving 31 usable observations. It should be noted that, in general, estimation of demand systems assumes very restrictive supply conditions. The underlying assumption is that either supply is perfectly elastic at given prices or supply is fixed and prices are given. The usual assumptions were presumed to hold in this analysis.

For purposes of estimation these data[17] were aggregated into 11 categories: (1) food, (2) alcohol plus tobacco, (3) clothing, (4) housing, (5) utilities, (6) transportation, (7) medical care, (8) durable goods, (9) other nondurable goods, (10) other services, and (11) other miscellaneous goods. Table 3.1 contains a detailed description of each category. These categories were first described in Mann (1980). They do not correspond to the commodity groups delineated in most other complete demand system studies and, because of the flexibility provided by the detailed information, do not correspond to the standard group headings of the Survey of Current Business where the expenditure data are commonly published. Note that the food component combined food at home and food away from home; alcohol was excluded from the food category; medical care expenses were defined separately; and automobile expenditures were included in the durable goods classification and not in the transportation category. Unlike the other commodities estimated at the dollar value of their retail sale, expenditures for

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[16]The PCE data are available from Computer Systems and Services Division, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C.

[17]Data are available in Appendix 5.

housing are estimated at the rental value of the space. Total expenditure is the sum of current dollar expenditures. As is commonly done in this type of analysis, "total expenditure" and "income" were considered to be equivalent. Quantities were represented by per capita constant dollar PCE. Prices were implicit prices created for each category by dividing the current dollar expenditure series by its constant (1972) dollar counterpart. This ensured that price times quantity equal expenditure. The population data used to obtain per capita variables were for the midyear (July 1) U.S. resident population obtained from the USDOC Bureau of the Census (1979). Budget shares for each item represent the portion of total expenditure allocated to that commodity. Each share is a nonnegative amount and all shares add up to one. The budget shares for the 11 expenditure categories for 1947 to 1981 appear in Appendix Table 5.A.4. The budget share of food declined from about 25 percent in 1947 to about 17 percent in 1978 (and in 1981). The food consumed away from home portion changed by a very small amount during that time so that food consumed at home accounted for most of this decline. The alcohol and tobacco share decreased throughout this period. The portion of the budget spent on clothing fell steadily to about half the 14 percent share of 1947. The housing share nearly doubled from 8.7 percent to 14.6 percent in 1978 and 14.8 percent in 1981. Both utilities and transportation increased by a small amount. The share of medical care expenses more than doubled from about 4.2 percent to about 9.5 percent. The other nondurable goods' share stayed about the same over this period while the share spent on durable goods and other services increased slightly. The other miscellaneous goods category share decreased by a small amount.

Four Food Groups

Data necessary to estimate the parameters for the food commodity demand functions were similar to those needed for the aggregate categories. They included per capita food consumption, per capita income, and prices. No official time series on PCE for major types of foods are available from the USDOC. Consumer expenditures for domestic farm products bought by civilians in the United States were obtained from the U.S. Department of Agriculture (USDA) Agricultural Economics Report No. 138 (AER-138, USDA 1968), Table 111 and the USDA Statistical Bulletin No. 656 (SB-656, USDA 1981), Table 88. A comparison of the PCE for all food (the aggregate of the PCE for food at home plus the PCE for food away from home) compiled by the USDOC[18] and the civilian expenditures for U.S. farm produced foods estimated by USDA[19] revealed some dissimilarities (see Appendix Table 5.A.5), since these series were compiled using conceptually different methods.

The USDOC PCE for food is a summary measure used in the National Income and Product Accounts. This PCE series for food consists of food purchased for off-premise consumption excluding alcoholic beverages. It represents transactions or purchases of food at market value by individuals. The valuation of the level of PCE involves indirect estimation of consumer commodity purchases from business records. In census years the value of food production at the manufacturing level is derived in conjunction with the input-output accounts. This value is distributed among food sales to other manufacturing industries; off-premise food use; personal purchases of meals and snacks; food supplied to employees; food produced and consumed on farms; food consumed while traveling on business; food purchased in connection with entertainment and for gifts; and other categories, which include food purchased by airlines, hospitals, and other institutions, utilizing the "commodity flow" method developed by S. Kuznets.[20] Briefly, between census years data are collected on manufacturers' shipments for home goods and consumer staples, omitting exports of agricultural products and including imports, and excluding the retail changes in inventories. This provides a "control total" of retail food sales. The percentage change in this "control total" from the census year is then applied to the census year value.

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[18]For more information, see U.S. Department of Commerce (1954).

[19] The estimation methods for this series are more fully described in U.S. Department of Agriculture (1970).

[20]See pp. 85-94 of U.S. Department of Commerce (1954).

Table 3.1. Description of Expenditure Items Included in Each Aggregate Group: Eleven Commodities

Commodity Group (i)	Description
(1) Food	Food is the aggregate of food at home plus food away from home. Food at home includes food purchased for off-premise consumption excluding alcohol. Food away from home includes purchased meals and beverages.
(2) Alcohol plus tobacco	This group includes alcoholic beverages plus tobacco products.
(3) Clothing	Clothing includes shoes and other footwear; shoe cleaning and repair; clothing and accessories except footwear; cleaning, laundering, dyeing, pressing, alteration, storage, and repair of garments; jewelry and watches.
(4) Housing	Housing includes owner occupied nonfarm dwellings; tenant-occupied nonfarm dwellings. Both are estimated at the rental value of the space.
(5) Utilities	Utilities include electricity, gas, fuel oil, and coal.
(6) Transportation	Transportation includes tires, tubes, accessories, and other parts; repair, greasing, washing, parking, storage, and rental; gasoline and oil; bridge, tunnel, ferry, and toll roads; insurance premiums less claims paid; purchased local transportation; purchased intercity transportation.
(7) Medical care	Medical care expenses include drug preparation and sundries; physicians, dentists, other professional services; privately controlled hospitals and sanitariums; medical care and hospitalization insurance; income loss insurance; workmen's compensation insurance.
(8) Durable goods	Durable goods include furniture, mattresses, and bedsprings; kitchen and other household appliances; china, glassware, tableware, and utensils; other durable house furnishings; books and maps; wheel goods, durable toys, sports equipment, boats and pleasure aircrafts; radio and television receivers, new autos, net purchases of used autos; other motor vehicles.
(9) Other nondurable goods	Other nondurable goods include toilet articles and preparations; semidurable household furnishings; cleaning and polishing preparations; miscellaneous household supplies and paper products; stationery and writing supplies; magazines, newspapers, and sheet music; nondurable toys and sport supplies; flowers, seeds, and potted plants.
(10) Other services	Other services include personal business expenditures; barbershops, beauty shops, and baths; water and other sanitary services; telephone and telegraph; domestic service; other household operations; radio and television repair; admissions to spectator amusements; clubs and fraternal organization; paramutual net receipts; other recreation; commercial participant amusements.
(11) Other miscellaneous goods	Other miscellaneous goods include private education and research; religious and welfare activities; net foreign travel; food furnished employees; food produced and consumed on farms; clothing furnished military; rental value of farm dwellings; other housing; opthalmic products and orthopedic appliances.

The PCE series does not include food furnished to the military or to government or commercial employees and food produced and consumed on farms since this does not enter the marketing system. It also excludes food consumed during business travel, for purposes of entertainment, or as gifts; and food purchased (consumed) by other users such as airlines, hospitals, and other institutions. The food expenditure series of the USDA represents the market value of foods originating on U.S. farms and purchased for civilian consumption. The USDA series includes the value of foods purchased in retail stores and in restaurants and other away-from-home eating establishments, including sales tax and tips. It also includes the value of food served by schools, hospitals, and other institutions, and of food furnished to civilian employees. Like the USDOC series, it excludes food furnished to the military and to government employees and food produced and consumed on farms. In addition, it excludes expenditures for food not originating on U.S. farms, fish,[21] and alcoholic and nonalcoholic beverages.

The food data from Table 111 in the AER-138 (USDA 1981) are available for the years 1947 to 1960, and from Table 88 in the SB-656 (USDA 1981) for 1961 to 1978 for seven commodity groups: meat products, poultry and eggs, dairy products, fruits and vegetables, grain mill products, bakery products and miscellaneous. Coffee, tea, and cocoa and other imported foods and beverages are excluded. For estimation purposes these food data were aggregated into four commodity groups: (1) meats, (2) fruits and vegetables, (3) cereal and bakery products, and (4) miscellaneous foods. Table 3.2 contains a description of each category.

Table 3.2. Description of Expenditure Items Included in Each Food Group: Four Commodities

Commodity Group (i)	Description
(1) Meats	Meats include beef and veal (m_1), pork (m_2), fish (m_3) (fresh, frozen, canned, and cured), and poultry (m_4) (chicken and turkey).
(2) Fruits and vegetables	Fruits and vegetables include all fruit and vegetable items.
(3) Cereal and bakery products	Cereal and bakery products include grain mill products plus bakery products.
(4) Miscellaneous foods	Miscellaneous foods include dairy products, eggs, imported sugar (refined equivalent), miscellaneous foods (USDA designation), and a meat adjustment accounting for the differences in the USDA series and the series calculated as described in section 3.

The Meat Data. The meats food group was reconstructed according to the method used by Christensen and Manser (in Terleckyj 1976). It contains the expenditures for beef and veal (m_1), pork (m_2), fish (m_3), and poultry (m_4). This meat series differs from the meat product category in the USDA sources noted above (Table 111 and Table 88) since it includes fish (m_3) and poultry (m_4). Quantity per capita data for each of these meat items are available in the AER-138 (USDA 1968) and the SB-656 (USDA 1981). Beef plus veal (m_1) and pork (m_2) were obtained from Table 8 (USDA 1968) and Table 4 (USDA 1981). Fish (m_3), fresh and frozen plus canned and cured, was obtained from Table 9 (USDA 1968) and Table 5 (USDA 1981). Poultry (m_4), chicken plus turkey, was obtained from Table 10 (USDA 1968) and Table 6 (USDA 1981). Table 97 (USDA 1968 and 1979) and Table 77 (USDA 1981) were utilized for the U.S. Bureau of Labor Statistics (USBLS) retail price indexes corresponding to these four items entering the meat group. These price data, available for the 1957-59 and 1967 base periods, were converted to a 1972 base period to be consistent with the base for the broad group

[21]Fish is not included in the U.S. Department of Agriculture food expenditure data, but is included in the analysis by reconstruction of the meats category.

categories. The price indexes and per capita consumption for meat items are presented in Appendix 5. Constant dollar expenditures were obtained by multiplying these quantities per capita by the USBLS average retail price index for 1972. Current dollar expenditures were obtained by multiplying the constant dollar expenditures by the retail price indexes for each year. Current per capita meat expenditures for each item and for the aggregate are presented in Appendix Table 5.A.8. The implicit price deflator for the meat category is defined in the same manner as for the aggregate categories (current dollar amounts divided by constant dollar amounts). The population data used to obtain per capita amounts are for the midyear (July 1) U.S. resident civilian population from Table 118 (USDA 1968) and Table 89 (USDA 1981).

The Other Food Groups. Fruits and vegetables, cereal and bakery products, and miscellaneous foods were defined in a similar fashion to that of Manser (1976). The expenditure series for fruits and vegetables was taken directly from Table 111 (USDA 1968) and Table 88 (USDA 1981). The cereal and bakery products series combined the bakery goods and grain mill product series from Table 111 (USDA 1968) and Table 88 (USDA 1981). In both these categories, imports are a very small, almost negligible, component. For the miscellaneous foods category, the expenditure series for dairy products and other foods from Table 111 (USDA 1968) and Table 88 (USDA 1981) were utilized. In addition, an expenditure series for eggs and data on sugar imports were added to this category. The egg expenditure series was constructed by multiplying the USDA quantity series for eggs from Table 10 (USDA 1968) and Table 6 (USDA 1981) by the price of eggs from the USBLS. The expenditure for sugar imports was constructed by converting raw sugar import data from Table 86 (USDA 1968) and Table 72 (USDA 1981) to a refined sugar equivalent and then multiplying by the price of sugar (only) from the USBLS. The addition of expenditures on fish to the meats group and the imports of sugar to the miscellaneous foods group was made in an attempt to reconcile the USDA and the USDOC series. Admittedly, this reconciliation was rather arbitrary and imprecise but it was as elaborate as possible given the available data. This new aggregate series is presented in Appendix Table 5.A.5.

The price series are the consumer price indexes for meat, poultry, and fish; fruits and vegetables; and cereal and bakery products from the USBLS. An implicit price deflator was created for the meats group by dividing the current dollar expenditures by their constant (1972) dollar counterpart. A comparison of these prices with the consumer price index for meat, poultry, and fish showed a high degree of correspondence (refer to Appendix Table 5.A.9). Therefore, the published USBLS series was used for this analysis.

A price index for miscellaneous foods was constructed in a similar fashion. Current dollar and constant dollar expenditure series were generated for miscellaneous foods. And, as before, an implicit price deflator was calculated from these. An attempt was made to construct a price index for miscellaneous foods using a procedure as close as possible to that used by the USBLS in constructing the consumer price index but this proved unsatisfactory.[22]

Estimation Procedures

Full information maximum likelihood (FIML) estimation was used for the LES and the AIDS. Ordinary least squares (OLS) and seemingly unrelated estimation techniques were utilized for the LA/AIDS. The estimated OLS values from the LA/AIDS were used as initial parameter values in the estimation of the AIDS using FIML. The FIML technique provides estimates for the entire system of equations simultaneously by using all the information available for each of the equations of the system. FIML estimates are derived for all the structural parameters of a system while maximizing the likelihood function and while utilizing a wide range of *a priori* information pertaining to all the equations simultaneously. This information involves the constraints on the coefficients and certain restrictions on the error structure. FIML estimates are values associated with a local maximum point. The FIML estimates are consistent, asymptotically efficient, and asymptotically normally distributed. Analytical small sample properties of simultaneous equation estimators in the presence of

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[22]Food data used in the analysis are found in Appendix 5.

nonlinearities are virtually unknown.[23] However, in this analysis, there were 31 x 11 = 341 total observations for the major categories and 31 x 4 = 124 observations for the food categories.[24] Due to the aggregation relationships for the data, that is, $\sum_i w_i = 1$ or $\sum_i p_i q_i = x$, there were actually only 310 and 93 observations, respectively. The number of degrees of freedom for such a system are not those for a small sample in the usual sense. The large sample properties of FIML estimators include consistency and asymptotic efficiency as mentioned above.

The procedure for estimating the LES demand parameters for the U.S. data utilized *A Fortran Program for Nonlinear Multivariate Regression* abbreviated as GCM (Snella 1979).[25] Since the methods employed in the program are essentially the same as those developed by Deaton (1975b), the derivations will be omitted. As discussed in section 2, a demand system based on utility theory is desirable from a theoretical viewpoint and has several advantages in its empirical applications. A complete set of demand functions can be estimated efficiently by making use of *a priori* restrictions on the behavioral parameters available from demand theory. Such demand systems assure that all expenditures on individual commodities aggregate to total consumption. The LES is a complete set of demand relations that automatically satisfies the properties of demand theory while the AIDS requires the imposition of additional restrictions.

For estimation of the AIDS and the LA/AIDS, the FIML and OLS procedures of the *Time Series Processor* (TSP) program of Hall and Hall (1978) were utilized. Because some noneconomic factors other than price and income influence consumer demand and since these elements are not explicitly introduced in the demand equations, the demand systems are incomplete. It is assumed that these random errors or structural disturbance terms enter additively into equations explaining expenditures and budget shares. This is done to account for any errors of omission and to aid in empirical implementation. For estimation purposes, the t^{th} observation for the LES, the AIDS, and the linear approximate AIDS is written in the form

$$w_{it} = p_{it}\gamma_i/x_t + \beta_i(1 - \sum_k p_{kt}\gamma_k/x_t) + \varepsilon_{it} \tag{24}$$

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \log p_{jt} + \beta_i(\log x_t - \alpha_0 - \sum_k \alpha_k \log p_{kt} - \tfrac{1}{2}\sum_k\sum_j \gamma^*_{kj} \log p_{kt} \log p_{jt}) + \varepsilon_{it} \tag{25}$$

and

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \log p_{jt} + \beta_i \log (x_t/P_t) + \varepsilon_{it} \tag{26}$$

respectively.

To estimate the dynamic AIDS, an error term ε_{it} is added to each equation. The stochastic assumptions are that $E(\varepsilon_t) = 0$ and $E(\varepsilon_t\varepsilon_t') = \delta_{tt}'\Omega$ where ε_t is an n x 1 vector and δ_{tt}' is the Kronecker product. That is, the error term is assumed to have expectation zero, to be temporally uncorrelated and have a contemporaneous variance-covariance matrix Ω.

Since the sum of the budget shares equals one, it follows that the contemporaneous covariance matrix is singular. If autocorrelation in the disturbances does not exist, Barten (1969) has shown that full information maximum likelihood estimates of the parameters can be obtained by arbitrarily deleting an equation. The resultant estimates are invariant with respect to the equation deleted. If, however, autocorrelation is present, i.e.,

$$\varepsilon_t = R\varepsilon_{t-1} + v_t \tag{27}$$

[23]See Section 11.9 of Intriligator (1978).

[24]See pp. 22-23, Barten (1969).

[25]An attempt to use this program for the AIDS estimation was unsuccessful.

for $t = 2, \ldots, T$ and where $v_2, \ldots, v_T$ are independently, identically distributed normal random vectors with mean zero and contemporaneous covariance matrix Σ, then a result developed by Berndt and Savin (1975) can be used. The variables in the system can be replaced by their first-order transforms, i.e., if Y_t is the original variable, then replace it by $Y_t - \rho Y_{t-1}$ where ρ is the autocorrelation parameter. Assuming no autocorrelation across equations, i.e., R is diagonal, Berndt and Savin (1975) have shown that the autocorrelation coefficients for the equations must be identical. This condition holds any time the sum of the regressand across commodities equals the value of one of the regressors (in our case, $\sum_i w_i = 1$).

Given these stochastic assumptions, a program developed by Hall and Hall (1978) and discussed in Berndt *et al.* (1974) was used to obtain FIML estimators of the parameters of the system. For the 11-commodity case a simplification discussed by Deaton and Muellbauer (1980a) was made to obtain the parameter estimates. In equation (10) log P was replaced by an index developed by Stone (1953). The index is $\log P^* = \Sigma w_k \log p_k$. If this is an adequate approximation to log P, then the static AIDS can be estimated by OLS. This version, termed the linear approximate almost ideal demand system, was used for the 11-commodity case. However, the FIML procedure was employed for the four-food commodity groups.

In this section the data, estimation procedures, stochastic framework, and testing procedures for the equations used in the empirical analysis were described. They provide the link to the application of the theory. The interpretation of the results of this application will be synthesized in the next sections.

4. ANALYSIS OF TOTAL CONSUMER EXPENDITURES (11 COMMODITY GROUPS)

Empirical estimates are presented here for the linear approximate almost ideal demand system based on the static Deaton-Muellbauer (1980a) model and the dynamic version developed in Section 2. Tests of the homogeneity assumption are given for both models. Also, the static and dynamic linear expenditure systems are presented as examples of restrictive additive preference models which are used as a basis of comparison of the indirectly nonadditive preference scheme of the AIDS model. The data set is from 1948 to 1978, with the years 1979 to 1981 used to test the predictive ability of the models.

The Static Linear Approximate AIDS

Here we present empirical estimates for the LA/AIDS, and test the homogeneity assumption. Symmetry is not imposed, but the models satisfy the adding-up property of allocation models, i.e., the sum of the expenditure coefficients (β_i) equals zero as does each column of price coefficients (γ_{ij}). Also, the sum of the intercept terms α_i^* equals one. When homogeneity is imposed, the sum of the γ_{ij} for each row equals zero.

The Nonhomogeneous LA/AIDS Results

The model relates budget shares as a function of real expenditures and real prices. The intercept terms a_i^* have no economic content but are required for calculations of the budget shares at average real income and prices.

Expenditure Coefficients (β_i). These coefficients measure 100 times the effect on the i^{th} budget share of a 1 percent increase in real expenditures. Coefficients automatically sum to zero, are negative for necessities and are positive for luxuries.

Results in Table 4.1 suggest that food and eight other commodity groups are necessities and two commodities (durable goods and other nondurable goods) are luxuries.

Table 4.1

The Linear Approximate Almost Ideal Demand System (Nonhomogeneous and Nonsymmetric):
Estimates for Eleven Aggregate Commodity Groups

		Estimated Coefficients[a]													
Commodity group i		α_i^*	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	γ_{i9}	γ_{i10}	γ_{i11}	$\sum_j \gamma_{ij}$
Food	(1)	1.225 (4.5)[b]	-0.129 (-3.9)	0.1185 (2.5)	-0.0236 (-0.4)	0.0185 (0.4)	-0.0057 (-0.1)	-0.0608 (-1.7)	0.0351 (0.9)	0.0701 (1.3)	-0.0290 (-0.5)	0.0649 (1.0)	-0.0870 (-2.8)	-0.0697 (-1.1)	0.0312 (1.1)[c]
Alcohol plus tobacco	(2)	0.377 (8.9)	-0.041 (-7.9)	-0.0061 (-0.8)	0.0320 (3.7)	-0.0096 (-1.2)	-0.0252 (-3.8)	0.0067 (1.2)	-0.0148 (-2.4)	0.0112 (1.3)	0.0160 (1.8)	-0.0425 (-4.0)	-0.0052 (-1.1)	0.0280 (2.7)	-0.0094 (-2.1)
Clothing	(3)	0.173 (1.4)	-0.010 (-0.7)	0.0167 (0.8)	0.0227 (0.9)	0.0535 (2.4)	-0.0102 (-0.5)	0.0324 (2.0)	-0.0642 (-3.6)	0.0349 (1.4)	-0.0274 (-1.0)	-0.0281 (-0.9)	-0.0491 (-3.5)	-0.0079 (-0.3)	-0.0268 (-2.1)
Housing	(4)	0.907 (6.2)	-0.093 (-5.3)	-0.0720 (-2.8)	-0.0480 (-1.6)	-0.1081 (-4.1)	0.0945 (4.1)	-0.0741 (-3.9)	0.0435 (2.1)	0.0025 (0.1)	-0.0440 (-1.4)	0.0170 (0.5)	0.0974 (5.8)	0.1174 (3.3)	0.0260 (1.7)
Utilities	(5)	0.132 (2.9)	-0.012 (-2.2)	0.0025 (0.3)	-0.0251 (-2.7)	0.0015 (0.2)	0.0167 (2.4)	0.0138 (2.4)	-0.0058 (-0.9)	0.0015 (0.2)	-0.0166 (-1.7)	0.0348 (3.1)	0.0078 (1.5)	-0.0172 (-1.6)	0.0140 (2.9)
Transportation	(6)	0.392 (7.1)	-0.039 (-5.7)	-0.0139 (-1.4)	-0.0071 (-0.6)	0.0413 (4.2)	-0.0434 (-5.0)	0.0245 (3.4)	0.0257 (3.2)	0.0065 (0.6)	0.0116 (1.0)	-0.0584 (-4.3)	0.0362 (5.8)	-0.0007 (-0.1)	0.0222 (3.8)
Medical Care	(7)	0.174 (1.3)	-0.011 (-0.7)	-0.0302 (-1.3)	0.0250 (0.9)	-0.0377 (-1.6)	-0.0085 (-0.4)	-0.0054 (-0.3)	-0.0198 (-1.0)	0.0062 (0.2)	-0.0269 (-1.0)	0.0309 (0.9)	0.0495 (3.3)	0.0453 (1.4)	0.0284 (2.0)
Durable Goods	(8)	-2.848 (-7.6)	0.365 (8.0)	0.0184 (0.3)	0.0806 (1.0)	0.0974 (1.4)	0.1343 (2.3)	0.1476 (3.0)	-0.0613 (-1.1)	-0.2032 (-2.7)	0.1039 (1.3)	0.0007 (0.0)	-0.1313 (-3.1)	-0.2018 (-2.2)	-0.0147 (-0.4)
Other nondurable goods	(9)	-0.122 (-1.4)	0.022 (2.0)	-0.0002 (-0.0)	-0.0084 (-0.5)	-0.0175 (-1.1)	-0.0505 (-3.6)	-0.0109 (-0.9)	0.0077 (0.6)	-0.0151 (-0.8)	0.0079 (0.4)	-0.0133 (-0.6)	0.0316 (3.1)	0.0356 (1.6)	-0.0331 (-3.5)
Other services	(10)	0.283 (2.1)	-0.021 (-1.3)	-0.0294 (-1.2)	-0.0545 (-2.0)	-0.0185 (-0.8)	-0.0904 (-4.3)	-0.0147 (-0.8)	0.0090 (0.5)	0.0699 (2.6)	0.0033 (0.1)	-0.0095 (-0.3)	0.0817 (5.3)	0.0154 (0.5)	-0.0378 (-2.7)
Other miscellaneous goods	(11)	0.307 (3.4)	-0.031 (-2.8)	-0.0042 (-0.3)	0.0063 (0.3)	-0.0207 (-1.3)	-0.0117 (-0.8)	-0.0590 (-5.0)	0.0448 (3.4)	0.0156 (0.9)	0.0012 (0.1)	0.0036 (0.2)	-0.0315 (-3.0)	0.0556 (2.5)	0.000 (0.0)

[a]Coefficients are based on United States data for the years 1948 to 1978. Data are given in Appendix 5.

[b]Values in parentheses are t-statistics.

[c]Calculated as the square root of the F-ratios obtained from comparing the residual sum of squares of the LA/AIDS without and with homogeneity imposed.

The durable goods income coefficient differs significantly from zero (critical t = 2.1 at the 5 percent level) and the "other nondurable goods" income coefficient has a t value of 2.0. For necessities, food and five other commodity group income coefficients are statistically significant at the 5 percent level, whereas three other group income coefficients are not (clothing, medical care, and other services). Thus, seven of 11 coefficients are significant.

In the Deaton-Muellbauer (1980a) study of nondurables in the United Kingdom for 1954 to 1974, five of eight expenditure coefficients had t values of 2.0 or higher. Food and housing were classified as necessities and others were luxury goods.

Direct and Cross Price Coefficients. These coefficients measure 100 times the effect on the i^{th} budget share of a 1 percent increase in the j^{th} real price with real expenditure held constant. Of the 11 direct-price coefficients (γ_{ii}), ten have the expected positive sign. The exception is "other nondurable goods" where the coefficient is not statistically significant at the 5 percent level. Eight of the ten correctly signed coefficients are statistically significant. Deaton and Muellbauer found seven of eight coefficients to be positive, with four coefficients statistically significant.

There are 110 cross-price coefficients in this study of which 34 are statistically significant. (In the Deaton-Muellbauer study, 18 of 56 coefficients had $t > 2.0$.) Positive coefficients indicate substitute goods (51 of 110); negative values indicate complements (59 of 110). The "other services" price variable was significant in nine of 11 equations, whereas the durable goods price variable was significant in none of the equations. It is difficult to obtain meaningful cross-price elasticities in large models, as reflected in the results noted here. Discussion of the estimated elasticities is given after consideration of homogeneity.

Tests for Homogeneity

The LA/AIDS was also estimated with homogeneity imposed (i.e., $\sum_j \gamma_{ij} = 0$). The estimated coefficients, shown in Table 4.2, retain much the same pattern and levels of significance as for the unrestricted case.

The test for homogeneity is given in the seventh column of Table 4.3. Homogeneity is rejected ($F > 4.41$) for five commodities and is not rejected for six commodities including food.

Deaton and Muellbauer (1980a) reject homogeneity for four of their eight commodity groups. They observe that imposition of homogeneity seems to result in induced autocorrelation, with a *drop* in the Durbin-Watson statistic for *all* commodities but especially for commodities where homogeneity is rejected. Our results are more interesting. The d statisitc is *lowered* for the five cases where homogeneity is rejected and also for groups 3 and 7 where the F values (4.24 and 4.19, respectively) approach the critical value of 4.41. However, the d statistic is *raised* (improved) for three groups where homogeneity is *not* rejected (groups 1, 4, and 8) and remains unchanged for group 11 where the F value is zero.

The above result has intuitive appeal in that autocorrelated errors usually indicate misspecified equations. Thus, if one were not working with a demand system, it would be appropriate to correct seven equations for autocorrelation and to accept the homogeneous equations for four groups.

But this argument cannot be pushed too far, as the evidence on positive autocorrelation is inconclusive for all equations except for the unrestricted equation for utilities. Here, the hypothesis of positive autocorrelation is rejectd at the 5 percent significance level (using Savin and White's (1977) tables for $n = 31$, $k' = 12$ with values of $d_L = 0.608$ and $d_u = 2.553$). Judge *et al.* (1980, p. 223) recommend the use of a much higher significance level, such as 40 percent and, although tables are not available to us, we expect that results would suggest the advisability of correction for autocorrelation.

Table 4.2

The Linear Approximate Almost Ideal Demand System (Homogeneous and Nonsymmetric): Estimates for Eleven Aggregate Commodity Groups

Commodity group i		Estimated Coefficients[ab]												
		α_i^*	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	γ_{i9}	γ_{i10}	γ_{i11}
Food	(1)	1.245 (4.6)[c]	−0.131 (−4.0)	0.0985 (2.2)	−0.0443 (−0.8)	0.0088 (0.2)	−0.0227 (−0.6)	−0.0650 (−1.9)	0.0548 (1.6)	0.0852 (1.6)	−0.0630 (−1.3)	0.0628 (0.9)	−0.0821 (−2.7)	−0.0328 (−0.2)
Alcohol plus tobacco	(2)	0.371 (8.1)	−0.040 (−7.1)	−0.0000 (−0.0)	0.0382 (4.3)	−0.0067 (−0.8)	−0.0201 (−3.0)	0.0079 (1.3)	−0.0207 (−3.5)	0.0067 (0.7)	0.0263 (3.1)	−0.0419 (−3.7)	−0.0066 (−1.3)	0.0168 (0.5)
Clothing	(3)	0.156 (1.2)	−0.008 (−0.5)	0.0339 (1.6)	0.0404 (1.6)	0.0618 (2.6)	0.0044 (0.2)	0.0360 (2.1)	−0.0811 (−4.7)	0.0220 (0.8)	0.0018 (0.1)	−0.0263 (−0.8)	−0.0533 (−3.5)	−0.0400 (−1.1)
Housing	(4)	0.924 (6.1)	−0.095 (−5.1)	−0.0888 (−3.6)	−0.0652 (−2.2)	−0.1162 (−4.3)	0.0803 (3.6)	−0.0776 (−4.0)	0.0600 (3.1)	0.0151 (0.5)	−0.0724 (−2.6)	0.0152 (0.4)	0.1015 (5.9)	0.1482 (1.3)
Utilities	(5)	0.141 (2.6)	−0.013 (−2.0)	−0.0065 (−0.7)	−0.0344 (−3.3)	−0.0029 (−0.3)	0.0091 (1.2)	0.0120 (1.7)	0.0031 (0.4)	0.0082 (0.8)	−0.0319 (−3.3)	0.0338 (2.5)	0.0100 (1.6)	−0.0006 (−0.0)
Transportation	(6)	0.406 (5.7)	−0.40 (−4.6)	−0.0282 (−2.4)	−0.0218 (−1.6)	0.0344 (2.7)	−0.0555 (−5.3)	0.0215 (2.3)	0.0397 (4.3)	0.0172 (1.2)	−0.0126 (−1.0)	−0.0599 (−3.3)	0.0397 (4.9)	0.0255 (0.5)
Medical Care	(7)	0.192 (1.4)	−0.014 (−0.8)	−0.0485 (−2.1)	0.0062 (0.2)	−0.0465 (−1.8)	−0.0239 (−1.2)	−0.0093 (−.05)	−0.0019 (−0.1)	0.0199 (0.7)	−0.0579 (−2.2)	0.0290 (0.8)	0.0539 (3.3)	0.0788 (0.8)
Durable Goods	(8)	−2.857 (−7.8)	0.366 (8.2)	0.0279 (0.5)	0.0904 (1.3)	0.1020 (1.6)	0.1424 (2.7)	0.1496 (3.2)	−0.0706 (−1.5)	−0.2103 (−3.0)	0.1199 (1.8)	0.0017 (0.0)	−0.1336 (−3.2)	−0.2192 (−0.8)
Other nondurable goods	(9)	−0.143 (−1.3)	0.024 (1.8)	0.0211 (1.1)	0.0135 (0.6)	−0.0072 (−0.4)	−0.0324 (−2.0)	−0.0065 (−0.4)	−0.0132 (−0.9)	−0.0310 (−1.4)	0.0439 (2.1)	−0.0110 (−0.4)	0.0264 (2.1)	−0.0035 (−0.0)
Other services	(10)	0.258 (1.7)	−0.018 (−0.9)	−0.0051 (−0.2)	−0.0295 (−1.0)	−0.0067 (−0.2)	−0.0698 (−3.1)	−0.0096 (−0.5)	−0.0149 (−0.8)	0.0516 (1.7)	0.0445 (1.6)	−0.0070 (−0.2)	0.0757 (4.3)	−0.0293 (−0.3)
Other miscellaneous goods	(11)	0.307 (3.5)	−0.031 (−2.9)	−0.0042 (−0.3)	0.0063 (0.4)	−0.0207 (−1.3)	−0.0117 (−0.9)	−0.0590 (−5.2)	0.0449 (4.0)	0.0156 (0.9)	0.0012 (0.1)	0.0036 (0.2)	−0.0315 (−3.1)	0.0556 (2.4)

[a] Coefficients are based on United States data for the years 1948 to 1978. Data are given in Appendix 5.

[b] $\sum_j \gamma_{ij} = 0$ indicates homogeneity.

[c] Values in parentheses are t-statistics.

Table 4.3

A Comparison of the Linear Approximate Almost Ideal Demand System with Homogeneity (H) and without Homogeneity (NH) Imposed.[a]

Commodity group i		Summary statistics						Test for[b] Homogeneity	Elasticities[c]			
		SSE(10^{-2})		R^2		DW			Expenditure		Own-Price	
		H	NH	H	NH	H	NH	(F value)	H	NH	H	NH
Food	(1)	0.271	0.269	0.990	0.990	1.628	1.585	1.20	0.35	0.36	-0.51	-0.42
Alcohol plus tobacco	(2)	0.046	0.042	0.998	0.999	2.074	2.432	4.43*	0.22	0.20	-0.25	-0.38
Clothing	(3)	0.133	0.123	0.995	0.996	1.546	1.776	4.24	0.92	0.90	-0.38	-0.47
Housing	(4)	0.152	0.145	0.994	0.995	1.460	1.413	2.88	0.28	0.30	-0.39	-0.29
Utilities	(5)	0.053	0.045	0.971	0.981	2.117	2.833	8.69*	0.64	0.67	-0.67	-0.62
Transportation	(6)	0.072	0.055	0.979	0.989	1.148	1.360	14.67*	0.47	0.48	-0.47	-0.66
Medical care	(7)	0.141	0.131	0.995	0.996	1.441	1.785	4.19	0.79	0.83	-0.70	-0.91
Durable goods	(8)	0.364	0.372	0.869	0.870	2.535	2.519	0.14	3.93	3.92	-0.04	-0.17
Other nondurable goods	(9)	0.113	0.089	0.930	0.958	1.334	1.369	12.20*	1.46	1.42	-1.21	-1.26
Other services	(10)	0.154	0.133	0.980	0.986	1.721	2.098	7.15*	0.83	0.80	-0.28	-0.22
Other miscellaneous goods	(11)	0.088	0.090	0.934	0.934	1.621	1.621	0.00	0.42	0.42	0.03	0.03

[a]Homogeneous model results (denoted as H) are given in Table 4.2 and nonhomogeneous results (denoted as NH) are given in Table 4.1.

[b]F value for (1, 18) = 4.41. The asterisk indicates rejection of the assumption of homogeneity for certain commodity groups.

[c]Formulas are given in Section 2. Per capita expenditures in the reference year 1972 are valued at $3,520. Calculated at mean (1948-1978) values.

Elasticity Estimates

Expenditure elasticity estimates at mean values are practically identical for the unrestricted and homogeneous LA/AIDS models, as would be expected due to the stable values for the β_i's in the two models. Direct price elasticities vary between the two models to a greater extent than the expenditure elasticities.

One characteristic of AIDS elasticities should be noted; namely, that the elasticities will change over the period as budget shares change. The formulas for expenditure and price elasticities (equations 22 and 23) are as follows:

$$\eta = 1 + \beta_i / w_i$$

$$e_{ii} = -1 + [\gamma_{ii} - \beta_i (\alpha_i + \sum_k \gamma_{kj} \log p_k)] / w_i$$

For necessities, the value of β_i is negative. The budget share for food was .244 in 1948 and .174 in 1978. Given the β_i value of about -.130, the expenditure elasticity thus would be .46 in 1948 and .25 in 1978.

Food price elasticities vary from -0.48 in 1948 to -0.30 in 1978. The cross-price elasticities must balance the changes in the expenditure and direct price elasticity when homogeneity is imposed.

The Dynamic Linear Approximate AIDS

The dynamic linear approximate almost ideal demand system is similar to the static counterpart in that budget shares are related to real prices and expenditure. It differs in that past consumption is an added variable to reflect habits in expenditure. However, since the lagged consumption variable differs by equation, we do not have a pure allocation model which requires the same independent variables for all equations; thus, the adding-up property is not automatically satisfied with OLS estimation procedures used.[26] The dynamic linear approximate AIDS models (with and without homogenity imposed) were also estimated using the seemingly unrelated regression model. These results, reported in Appendix Table 6.1 and 6.2, had somewhat higher root mean square errors than the OLS results and thus are relegated to the appendix.

In this section, results are presented first for the dynamic LA/AIDS model which is unrestricted (i.e., nonhomogenous, nonsymmetric, and not meeting the adding-up condition). These results will then be compared with the same model where homogeneity is imposed.

The Unrestricted D/LA/AIDS Results

The estimated parameters are shown in Table 4.4. The intercept term, α_i^*, is a random element without economic content except as needed for calculation of elasticity values. The coefficient α_i^{**}, associated with past consumption q_{it-1}, measures the effect of habits. If all α_i^{**} were equal to zero, the static and dynamic versions would be equivalent.

Habit Effects. For this model, three commoditity groups show statistically significant (5 percent level) positive α_i^{**} coefficients; namely, housing, medical care, and other nondurable goods. This reflects persistence in budget share allocations. Food, other services, and transportation coefficients are positive and significant at a level somewhat above 5 percent.

The durable goods coefficient is negative and significant at the 10 percent level. Its negative sign implies that past purchases tend to lower current budget share allocations (similar to an inventory effect). The other commodity groups have relatively low t-values.

Expenditure Coefficients (β_i). Estimates suggest that two commodity groups are luxuries (durable and other nondurable goods) while food and the other eight goods are necessities ($\beta_i < 1$). This classificaiton is the same as for the static models. Nine of 11 coefficients are statistically significant at the 5 percent level.

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[26]The FIML method used to estimate the dynamic AIDS for four food groups does incorporate the adding up condition. But limited degrees of freedom made it impossible to use FIML in the 11-commodity case.

Table 4.4

The Dynamic Linear Approximate Almost Ideal Demand System (Nonhomogeneous and Nonsymmetric): Estimates for Eleven Aggregate Commodity Groups

Commodity group i		Estimated Coefficients[a]														
		α_i^*	α_i^{**}	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	γ_{i9}	γ_{i10}	γ_{i11}	$\sum_j \gamma_{ij}$
Food	(1)	1.133	0.110	−0.126	0.1301	0.0160	−0.0190	−0.0059	−0.0492	0.0407	0.0021	−0.0442	0.1046	−0.0786	−0.0730	0.024
		(4.3)[b]	(1.7)	(−4.0)	(2.8)	(0.3)	(−0.4)	(−0.1)	(−1.4)	(1.1)	(0.0)	(−0.8)	(1.5)	(−2.6)	(−1.2)	(0.9)[c]
Alcohol plus tobacco	(2)	0.389	−0.029	−0.042	−0.0067	0.0310	−0.0107	−0.0279	0.0058	−0.0134	0.0136	0.0147	−0.0435	−0.0054	0.0317	−0.011
		(8.1)	(−0.6)	(−7.5)	(−0.9)	(3.4)	(−1.3)	(−3.4)	(1.0)	(−2.0)	(1.4)	(1.5)	(−4.0)	(−1.1)	(2.6)	(−2.1)
Clothing	(3)	0.236	0.063	−0.020	0.0132	0.0335	0.0416	0.0025	0.0279	−0.0682	0.0189	−0.0267	−0.0157	−0.0423	−0.0065	−0.022
		(1.7)	(1.0)	(−1.1)	(0.6)	(1.2)	(1.6)	(0.1)	(1.7)	(−3.7)	(0.6)	(−1.0)	(−0.5)	(−2.7)	(−0.2)	(−1.6)
Housing	(4)	1.246	0.367	−0.157	−0.0797	−0.0706	−0.0415	0.0872	−0.0524	0.0396	−0.0301	−0.0352	0.0039	0.0650	0.0700	−0.044
		(13.2)	(6.6)	(−11.4)	(−5.7)	(−4.2)	(−2.4)	(7.0)	(−4.8)	(3.4)	(−1.8)	(−2.1)	(0.2)	(6.3)	(3.4)	(−3.2)
Utilities	(5)	0.130	−0.014	−0.012	0.0025	−0.0258	0.0027	0.0160	0.0141	−0.0058	0.0018	−0.0166	0.0336	0.0089	−0.0170	0.014
		(2.8)	(−0.2)	(−2.0)	(0.3)	(−2.6)	(0.3)	(2.0)	(2.3)	(−0.9)	(0.2)	(−1.7)	(2.7)	(1.3)	(−1.5)	(2.8)
Transportation	(6)	0.385	0.068	−0.040	−0.0169	−0.0093	0.0311	−0.0331	0.0178	0.0327	0.0007	0.0109	−0.0431	0.0289	−0.0023	0.017
		(7.3)	(1.6)	(−6.1)	(−1.8)	(−0.9)	(2.7)	(−3.1)	(2.2)	(3.7)	(0.1)	(1.0)	(−2.6)	(3.8)	(−0.2)	(2.8)
Medical Care	(7)	0.355	0.198	0.040	−0.0301	−0.0068	−0.0071	−0.0034	−0.0092	−0.0170	0.0302	−0.0012	0.0222	0.0284	0.0120	0.018
		(2.9)	(3.1)	(2.5)	(1.6)	(−0.3)	(−0.3)	(−0.2)	(−0.7)	(−1.1)	(1.3)	(−0.0)	(0.8)	(2.0)	(0.4)	(1.5)
Durable Goods	(8)	−3.314	−0.099	0.427	0.0465	0.0109	0.1888	0.1481	0.1614	−0.0571	−0.1940	0.1073	−0.0447	−0.1478	−0.2225	−0.003
		(−7.8)	(−1.9)	(8.0)	(0.7)	(0.1)	(2.4)	(2.7)	(3.5)	(−1.1)	(−2.8)	(1.4)	(−0.5)	(−3.6)	(−2.6)	(−0.1)
Other nondurable goods	(9)	−0.037	0.129	0.008	−0.0179	−0.0101	−0.0268	−0.0212	−0.0082	−0.0042	−0.0099	0.0188	−0.0005	0.0160	0.0315	−0.027
		(−0.5)	(3.3)	(0.9)	(−1.0)	(−0.7)	(−2.0)	(−1.5)	(−0.9)	(−0.4)	(−0.7)	(1.2)	(−0.0)	(1.7)	(1.8)	(−3.5)
Other services	(10)	0.381	0.109	−0.038	−0.0273	−0.0414	−0.0358	−0.0612	−0.0138	0.0067	0.0426	−0.0170	0.0076	0.0877	0.0103	−0.042
		(2.9)	(2.0)	(−2.2)	(−1.3)	(−1.6)	(−1.5)	(−2.5)	(−0.9)	(0.4)	(1.5)	(−0.6)	(0.2)	(6.0)	(0.3)	(−3.2)
Other miscellaneous goods	(11)	0.311	0.063	−0.033	−0.0046	0.0079	−0.0291	−0.0084	−0.0544	0.0401	0.0090	−0.0003	0.0124	−0.0305	0.0566	−0.001
		(3.3)	(0.5)	(−2.8)	(−0.3)	(0.4)	(−1.2)	(−0.5)	(−3.6)	(2.5)	(0.4)	(−0.0)	(0.4)	(−2.8)	(2.5)	(−0.1)

[a]Coefficients are based on United States data for the years 1948 to 1978. Data are given in Appendix 5.

[b]Values in parentheses are t-statistics.

[c]Calculated as the square root of the F-ratios obtained from comparing the residual sum of squares of the D/LA/AIDS without and with homogeneity imposed.

Direct and Cross-Price Coefficients. Ten of the eleven direct-price coefficients had the expected positive sign. As in the static models, the exception is "other nondurable goods" where the coefficient is not statistically significant. Seven of the ten positive values are statistically significant at the 5 percent level (eight of ten for the static models).

Of the 110 cross-price coefficients, 30 are statistically significant at the 5 percent level (34 for the static case).

Test for Homogeneity

The dynamic model was estimated also by imposing homogeneity (see Table 4.5). A comparison of the unrestricted and homogeneous models is given in Table 4.6. There are five groups where homogeneity is rejected; namely, housing, utilities, transportaiton, other nondurable goods and other services. Here, homogeneity is rejected in housing expenditures, whereas, in the static model, "alcohol plus tobacco" was the fifth group rejected. In both static and dynamic models homogeneity is not rejected for six groups including food.

The dynamic model includes lagged consumption as an explanatory variable, and, although it is not the lagged value of the dependent variable (budget share), the Durbin-Watson d statistic is somewhat suspect. However, it provides an interesting basis of comparison with the static model.

Where homogeneity is rejected (groups 4, 5, 6, 9, and 10) the d statistic is *lowered* in four of the five cases but is increased for transportation. Recall that for the static model the d statistic was *lowered* for all five cases. Here again, the d statistic is lowered for the marginal case (group 2).

Where homogeneity is not rejected (groups 1, 3, 7, 8, and 11), the d statistic is *increased* in two of the five groups, 1 and 8. Thus, our evidence raises doubts about the general validity of the Deaton-Muellbauer claim about induced autocorrelation for equations where homogeneity is not rejected. We must note that the dynamic models do *not* impose adding up and this aspect may contribute to the findings. Further testing with additivity imposed might clarify this issue.

Elasticity Estimates

Expenditure elasticities are similar for the two dynamic models (see Table 4.6). The values are similar to those for the static models (Table 4.3) for five groups (1, 2, 5, 6, and 11); the dynamic model results are somewhat lower for five (3, 4, 7, 8, and 10) and somewhat higher for durable goods (group 8).

Direct price elasticites also are similar for the two dynamic models and are roughly comparable between static and dynamic models.

A more interesting comparison of elasticity estimates is given next where the additive preference LES models are compared with the LA/AIDS models.

Static and Dynamic Linear Expenditure Systems

This section presents the empirical estimates of the static and dynamic linear expenditure systems. The limitations of the static model are well recognized. Here we present the dynamic linear expenditure system as one improvement over the static model that has been suggested and analyzed. Other more flexible systems include the static model corrected for autocorrelation, the dynamic LES model (Green, Hassan, and Johnson, (1980)), the Houthakker-Taylor model (1970), the Brown-Heien (1972) S-Branch model, and the Christensen-Manser (1976) model on nonadditive preference structures. The static model, in a sense, provides a benchmark by which other models may be compared.

Table 4.5

The Dynamic Linear Approximate Almost Ideal Demand System (Homogeneous and Nonsymmetric): Estimates for Eleven Aggregate Commodity Groups

	Estimated Coefficients[a]													
Commodity group i	α_i^{*}	α_i^{**}	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	γ_{i9}	γ_{i10}	γ_{i11}
Food (1)	1.140 (4.4)c	0.119 (1.9)	−0.127 (−4.1)	0.1162 (2.7)	0.0038 (0.1)	−0.0292 (−0.6)	−0.0185 (−0.5)	−0.0514 (−1.5)	0.0558 (1.7)	0.0078 (0.1)	−0.0707 (−1.5)	0.1062 (1.6)	−0.0742 (−2.5)	−0.0459 (−0.2)
Alcohol plus tobacco (2)	0.362 (7.2)	0.025 (0.5)	−0.039 (−6.7)	−0.0004 (−0.1)	0.0383 (4.2)	−0.0061 (−0.7)	−0.0185 (−2.5)	0.0085 (2.4)	−0.0211 (−3.5)	0.0053 (0.6)	0.0261 (3.0)	−0.0411 (−3.5)	−0.0062 (−1.1)	0.0152 (0.4)
Clothing (3)	0.260 (1.8)	0.099 (1.6)	−0.025 (−1.3)	0.0234 (1.1)	0.0524 (2.0)	0.0407 (1.5)	0.0202 (1.0)	0.0179 (1.6)	−0.0826 (−5.0)	0.0004 (0.0)	−0.0054 (−0.2)	−0.0073 (−0.2)	−0.0414 (−2.5)	−0.0283 (−0.3)
Housing (4)	1.103 (10.6)	0.225 (5.3)	−0.131 (−9.5)	−0.0659 (−4.0)	−0.0507 (−2.6)	−0.0621 (−3.1)	0.0992 (6.7)	−0.0586 (−4.4)	0.0305 (2.2)	−0.0255 (−1.2)	−0.0203 (−1.0)	0.0101 (0.4)	0.0749 (6.1)	0.0685 (0.9)
Utilities (5)	0.143 (2.6)	0.034 (0.5)	−0.014 (−2.0)	−0.0058 (−0.6)	−0.0322 (−2.8)	−0.0056 (−0.5)	0.013 (1.2)	0.0114 (1.6)	0.0027 (0.4)	0.0071 (0.7)	−0.0311 (−3.1)	0.0367 (2.5)	0.0074 (0.9)	−0.0018 (0.0)
Transportation (6)	0.387 (6.3)	0.124 (2.8)	−0.042 (−5.6)	−0.0280 (−2.8)	−0.0201 (−1.7)	0.0185 (1.5)	−0.0319 (−2.6)	0.0104 (1.2)	0.0471 (5.6)	0.0025 (0.2)	−0.0044 (−0.4)	−0.034 (−1.7)	0.0249 (2.8)	0.0125 (0.2)
Medical Care (7)	0.390 (3.1)	0.225 (3.6)	−0.045 (−2.8)	−0.0408 (−2.2)	−0.0222 (−1.0)	−0.0081 (0.4)	−0.0118 (−0.7)	−0.0119 (−0.8)	−0.0061 (−0.4)	0.0415 (1.8)	−0.0158 (−0.7)	0.0199 (0.7)	0.0282 (1.9)	0.0271 (0.3)
Durable Goods (8)	−3.319 (−8.2)	−0.099 (−2.0)	0.428 (8.3)	0.0487 (0.9)	0.0124 (0.2)	0.1904 (2.6)	0.1499 (3.0)	0.1619 (3.7)	−0.0590 (−1.3)	−0.1955 (−3.0)	0.1106 (1.8)	−0.0448 (−0.5)	−0.1484 (−3.8)	−0.2262 (−0.9)
Other nondurable goods (9)	−0.034 (−0.3)	0.160 (3.3)	0.007 (0.6)	0.0009 (0.1)	0.0068 (0.4)	−0.0209 (−1.2)	−0.0001 (−0.0)	−0.0040 (−0.3)	−0.0234 (−1.9)	−0.0213 (−1.2)	0.0498 (3.0)	0.0042 (0.2)	0.0082 (0.7)	−0.0002 (−0.0)
Other services (10	0.334 (2.1)	0.085 (1.3)	−0.031 (−1.5)	−0.0016 (−0.1)	−0.0172 (−0.6)	−0.0193 (−0.7)	−0.0453 (−1.6)	−0.0085 (−0.4)	−0.0186 (−0.9)	0.0289 (0.8)	0.0318 (1.1)	0.0066 (0.2)	0.0800 (4.6)	−0.0368 (−0.3)
Other miscellaneous goods (11	0.310 (3.4)	0.060 (0.5)	−0.033 (−2.9)	−0.0039 (−0.3)	0.0085 (0.5)	−0.0283 (−1.3)	−0.0080 (−0.5)	−0.0545 (−3.8)	0.0397 (2.6)	0.0088 (0.4)	0.0010 (0.1)	0.0120 (0.4)	−0.0307 (−3.0)	0.0553 (2.4)

[a]Coefficients are based on United States data for the years 1948 to 1978. Data are given in Appendix 5.

[b]$\sum_j \gamma_{ij} = 0$ indicates homogeneity.

[c]Values in parentheses are t-statistics.

Table 4.6

A Comparison of the Dynamic Linear Approximate Demand System with Homogeneity (H) and without Homogeneity (NH) Imposed[a]

Commodity group i		Summary statistics						Test for[b] Homogeneity (F value)	Elasticities[c]			
		SSE(10^{-2})		R^2		DW			Expenditure		Own-Price	
		H	NH	H	NH	H	NH		H	NH	H	NH
Food	(1)	0.254	0.256	0.991	0.992	1.876	1.786	0.70	0.37	0.38	-0.43	-0.36
Alcohol plus tobacco	(2)	0.047	0.043	0.998	0.999	2.168	2.401	4.26	0.24	0.18	-0.25	-0.40
Clothing	(3)	0.128	0.123	0.996	0.996	1.935	1.984	2.47	0.75	0.80	-0.59	-0.58
Housing	(4)	0.098	0.079	0.998	0.998	1.540	2.278	10.52*	0.01	-0.19	-0.25	-0.34
Utilities	(5)	0.054	0.046	0.972	0.981	2.218	2.804	7.95*	0.62	0.67	-0.69	-0.61
Transportation	(6)	0.061	0.052	0.986	0.990	1.709	1.570	7.62*	0.44	0.47	-0.38	-0.57
Medical care	(7)	0.111	0.100	0.997	0.997	1.965	2.100	2.31	0.31	0.39	-0.37	-0.54
Durable goods	(8)	0.337	0.347	0.893	0.893	2.543	2.533	0.01	4.42	4.41	-0.12	-0.14
Other nondurable goods	(9)	0.092	0.072	0.956	0.974	1.700	1.907	12.31*	1.13	1.15	-0.92	-1.01
Other services	(10)	0.151	0.123	0.982	0.989	1.641	2.137	9.94*	0.71	0.64	-0.24	-0.17
Other miscellaneous goods	(11)	0.090	0.092	0.935	0.935	1.728	1.747	0.01	0.39	0.39	0.03	0.05

[a]Homogeneous model results (denoted as H) are given in Table 4.5 and nonhomogeneous model (denoted as NH) are given in Table 4.4.
[b]F value for (1, 17) = 4.45. The asterisk indicates rejection of the assumption of homogeneity for certain commodity groups.
[c]Formulas are given in Section 2. Per capita expenditures in the reference year 1972 are valued at $3,520. Elasticities are calculated at mean (1948–1978) values.

We present first the static LES results with perhaps excessive detail. However, these results are then compared with the static AIDS model to illustrate the dramatic changes in elasticities associated with the changes in model specification. Next, the dynamic LES is presented and compared with the static LES, the AIDS, and the dynamic AIDS. The purpose of this exercise is to stress the advantages of more flexible forms. The static and dynamic LES models were estimated by FIML methods (Fortran Program for Multivariate Nonlinear Regression-GCM-by Snella (1979)). The comparisons with the AIDS model are linear approximations and are subject to the adding up conditions as mentioned previously.

Static LES Results

The estimated marginal budget shares (β_i) and minimum subsistence levels (γ_i) are well-defined statistically as shown in Table 4.7. The marginal budget shares add to one. The minimum subsistence levels, expressed in terms of deflated 1972 expenditure units, range from \$65.60 for utilities to \$493.86 for food. These values should be less than expenditures for any year; however, since the restriction that $q_{it} > \gamma_i$ was not imposed, the usual condition is violated for the earlier years. These results correspond with those obtained by others; see, e.g., Pollak and Wales (1969). However, all commodities have $q_{it} > \gamma_i$ for 1963 to 1978.

Expenditure elasticiites. The LES results indicate six commodiites are luxuries ($\eta_i > 1$) which does not agree with the AIDS models or the dynamic LES model where only durables and "other nondurable goods" are so classified.

Expenditure elasticities by definition vary inversely with the budget share ($\eta_i = \beta_i / w_i$) where β_i is restricted to be positive for all goods. Food budget shares decreased during the period, resulting in higher expenditure elasticities, whereas the converse holds for durable goods where budget shares increased. Note that for AIDS, the expenditure elasticities vary inversely with budget shares for luxuries and directly for necessities.

Direct elasticities. Recall that the direct price elasticity formula for the LES is:

$$e_{ii} = -1 + (1 - \beta_i)\gamma_i / q_i. \tag{21}$$

Since β_i and γ_i are nonnegative, $q_{it} > \gamma_i$ (for the years 1963 to 1978) and $0 < \beta_i < 1$, the direct price elasticity is limited to a value between -1.0 and 0. Price elasticities are less than one ($|e_{ii}|$) indicating inelastic demand, and in these cases $\eta_i > |e_{ii}|$.

The absolute values of the direct price elasticities vary directly with changes in the quantity consumed. Thus, since expenditures increased for all groups between 1963 and 1978 and with positive β_i and γ_i values, commodities show more price responsiveness in the later period, but are limited to be less than -1. Though not presented here, all cross-price elasticities are positive indicating net substitutes— a well known property of the LES.

Flexibility of money. The Frisch coefficient for the LES is -3.0, compared with a value of -1.0 associated with the AIDS system (see Appendix 4). Bieri and de Janvry (1972, p. 44) report values for the flexibility of money ranging from 0.61 for high income countries to 3.90 for low income countries.

Relationship between expenditure and price elasticities. Deaton (1975b) pointed out the approximate proportional relationship between price and expenditure elasticities for the LES, i.e.,

$$\varepsilon_{ii} \cong \phi \eta_i. \tag{28}$$

where ϕ is the inverse of Frisch's flexibility of money coefficient.

Table 4.7

The Linear Expenditure System (Homogeneous and Symmetric): Estimates for Eleven Aggregate Commodity Groups

Commodity group i	Estimated Coefficients[a]: Marginal budget share β_i	Estimated Coefficients[a]: Minimum subsistence level γ_i	Elasticities[b]: Expenditure (Calculated at mean values)	Elasticities[b]: Own-price (Calculated at mean values)	Elasticities[b]: Expenditure 1963	Elasticities[b]: Expenditure 1978	Elasticities[b]: Own-Price 1963	Elasticities[b]: Own-Price 1978	Pigou Relationship[c]	Related Data: Budget Share (1948-1978 Average values)	Related Data: Quantity (1948-1978 Average values)	Related Data: Budget Share 1963	Related Data: Budget Share 1978	Related Data: Quantity 1963	Related Data: Quantity 1978
Food (1)	0.0882 (23.6)[d]	493.86 (102.)	0.43	−0.21	0.45	0.51	−0.16	−0.30	0.49	0.203	558.31	0.196	0.174	537.61	643.90
Alcohol plus tobacco (2)	0.0110 (9.6)	140.54 (133.7)	0.22	−0.08	0.21	0.30	−0.05	−0.18	0.36	0.051	149.58	0.052	0.036	145.98	168.98
Clothing (3)	0.0576 (20.7)	230.94 (71.6)	0.58	−0.24	0.61	0.72	−0.13	−0.44	0.41	0.100	276.43	0.094	0.080	249.51	387.18
Housing (4)	0.2072 (35.2)	225.10 (24.0)	1.57	−0.57	1.44	1.42	−0.50	−0.73	0.36	0.132	382.68	0.144	0.146	359.12	656.57
Utilities (5)	0.0426 (35.1)	65.60 (35.9)	1.17	−0.38	1.15	1.02	−0.30	−0.52	0.32	0.036	94.50	0.037	0.042	89.43	131.59
Transportation (6)	0.0818 (40.3)	156.42 (36.8)	1.09	−0.38	1.09	1.00	−0.27	−0.54	0.35	0.075	216.89	0.075	0.082	197.74	314.31
Medical care (7)	0.1304 (43.0)	108.73 (13.8)	1.99	−0.61	2.02	1.37	−0.51	−0.73	0.31	0.066	210.16	0.065	0.095	192.26	354.41
Durable goods (8)	0.1738 (28.2)	209.31 (25.2)	1.39	−0.52	1.44	1.32	−0.39	−0.71	0.37	0.125	339.03	0.121	0.132	281.29	595.50
Other nondurable goods (9)	0.0723 (37.7)	91.07 (27.1)	1.39	−0.45	1.37	1.38	−0.36	−0.60	0.32	0.052	144.24	0.053	0.052	132.25	213.47
Other Services (10)	0.1009 (35.7)	262.63 (39.3)	0.96	−0.36	0.92	0.90	−0.27	−0.52	0.38	0.105	344.70	0.110	0.112	322.34	486.98
Other miscellaneous goods (11)	0.0343 (16.3)	131.77 (54.4)	0.64	−0.22	0.65	0.70	−0.17	−0.28	0.34	0.054	157.62	0.053	0.049	152.50	178.01

[a]Coefficients based on United States data for years 1948-1978. Data are given in Appendix 5.

[b]Elasticity formulas are given in Section 2.

[c]The ϕ coefficient is calculated as the absolute value of the own-price elasticity divided by the relevant expenditure elasticity. The average value is .33 and its related money flexibility is the reciprocal of ϕ or −3.0.

[d]Values in parentheses are t statistics.

Static LES versus LA/AIDS. A comparison of elasticities under these two models is given in Table 4.8. The LES results show the close relationship between the ratio of expenditure and own-price elasticities which average -0.33 (the reciprocal of the money flexibility coefficient is -3.0). The LA/AIDS results differ from LES in several aspects. First, the proportional relationship between expenditure and price elasticities shows much more variability than for LES, although there is a clustering of values about 1.0 (the Deaton Muellbauer results did not have this clustering). Second, expenditure elasticities decrease when LA/AIDS is used (in seven of eleven cases), whereas the absolute value price elasticities increase (in seven of eleven cases). These results are evident in Figure 4.1. We find the LA/AIDS to be preferable to the LES in most aspects.

Dynamic LES Results

The dynamic LES incorporates the idea that subsistence levels change over time. Minimum required levels γ_{it} are specified as linearly related to past consumption q_{it-1}, or

$$\gamma_{it} = \gamma_i^* + \alpha_i^{**} q_{it-1}. \tag{29}$$

Pollak (1970) interprets γ_i^* as the "physiologically" necessary component and $\alpha_i^{**} q_{it-1}$ as the "psychologically" necessary component of the minimum subsistence level.

The dynamic version includes a habit parameter (α_i^{**}) in addition to the marginal budget share variable (β_i).

This section compares the results of the D/LES with the D/LA/AIDS. The following section evaluates the overall findings of the six models used to analyze total consumption expenditures.

Marginal Budget Shares. These coefficients add to one, and all are statistically significant (See Table 4.9). There are changes in the values from those in the static model, particularly for housing expenditures where the habit coefficient is important.

Habit Parameters. All commodities except food reflect the importance of past consumption on budget shares.

D/LES versus D/LA/AIDS/H. A comparison of elasticities under these two models is given in Table 4.10. As with the comparison of the static models (Table 4.8), the D/LES results show a close relationship between ratio of expenditure and own-price elasticities, whereas this is not true for the dynamic AIDS model. The expenditure elasticities decrease in value for D/LA/AIDS/H when compared with D/LES (for nine of 11 comodity groups). The own-price elasticities likewise increase for nine of the 11 commodity groups.

The Predictive Accuracy of Four Models

The measure used here to appraise the predictive accuracy of the four models is the root mean square percentage error, or

$$\text{RMS percentage error} = \sqrt{\frac{1}{N} \Sigma \left(\frac{A_t - P_t}{A_t}\right)^2} \tag{30}$$

where

A_t = actual budget share; and

P_t = predicted budget share.

These values are given in Table 4.11 for each of the 11 commodity groups and for the four models: the static and dynamic linear approximate almost ideal demand systems (LA/AIDS, D/LA/AIDS) and the static and dynamic linear expenditure systems (LES, D/LES).

Table 4.8

A Comparison of Elasticities for the Static Linear Expenditure System and the Linear Approximate Almost Ideal Demand System with Homogeneity Imposed: Estimates for Eleven Aggregate Commodity Groups

Commodity group i		LES			LA/AIDS/H			Direction of Change From LES to LA/AIDS/H	
		Elasticities		Pigou Relationship[b]	Elasticities		Pigou Relationship[b]	Elasticities[a]	
		Expenditure	Own-price	ϕ	Expenditure	Own-Price	ϕ	Expenditure	Own-price
Food	(1)	0.43	-0.21	0.49	0.35	-0.51	1.46	–	+
Alcohol plus tobacco	(2)	0.22	-0.08	0.36	0.22	-0.25	1.14	~	+
Clothing	(3)	0.58	-0.24	0.41	0.92	-0.38	0.41	+	+
Housing	(4)	1.57	-0.57	0.36	0.28	-0.39	1.39	–	–
Utilities	(5)	1.17	-0.38	0.32	0.64	-0.67	1.05	–	+
Transportation	(6)	1.09	-0.38	0.35	0.47	-0.47	1.00	–	+
Medical care	(7)	1.99	-0.61	0.31	0.79	-0.70	0.88	–	+
Durable goods	(8)	1.39	-0.52	0.37	3.93	-0.04	0.01	+	–
Other nondurable goods	(9)	1.39	-0.45	0.32	1.46	-1.21	0.83	+	+
Other Services	(10)	0.96	-0.36	0.38	0.83	-0.28	0.34	–	–
Other miscellaneous goods	(11)	0.64	-0.22	0.34	0.42	0.03	0.07	–	–

[a]Based on the absolute value of the own-price elasticity. ~ indicates estimates are about equal.
[b]The Pigou relationship is calculated as the absolute value of the own-price elasticity divided by the expenditure elasticity.

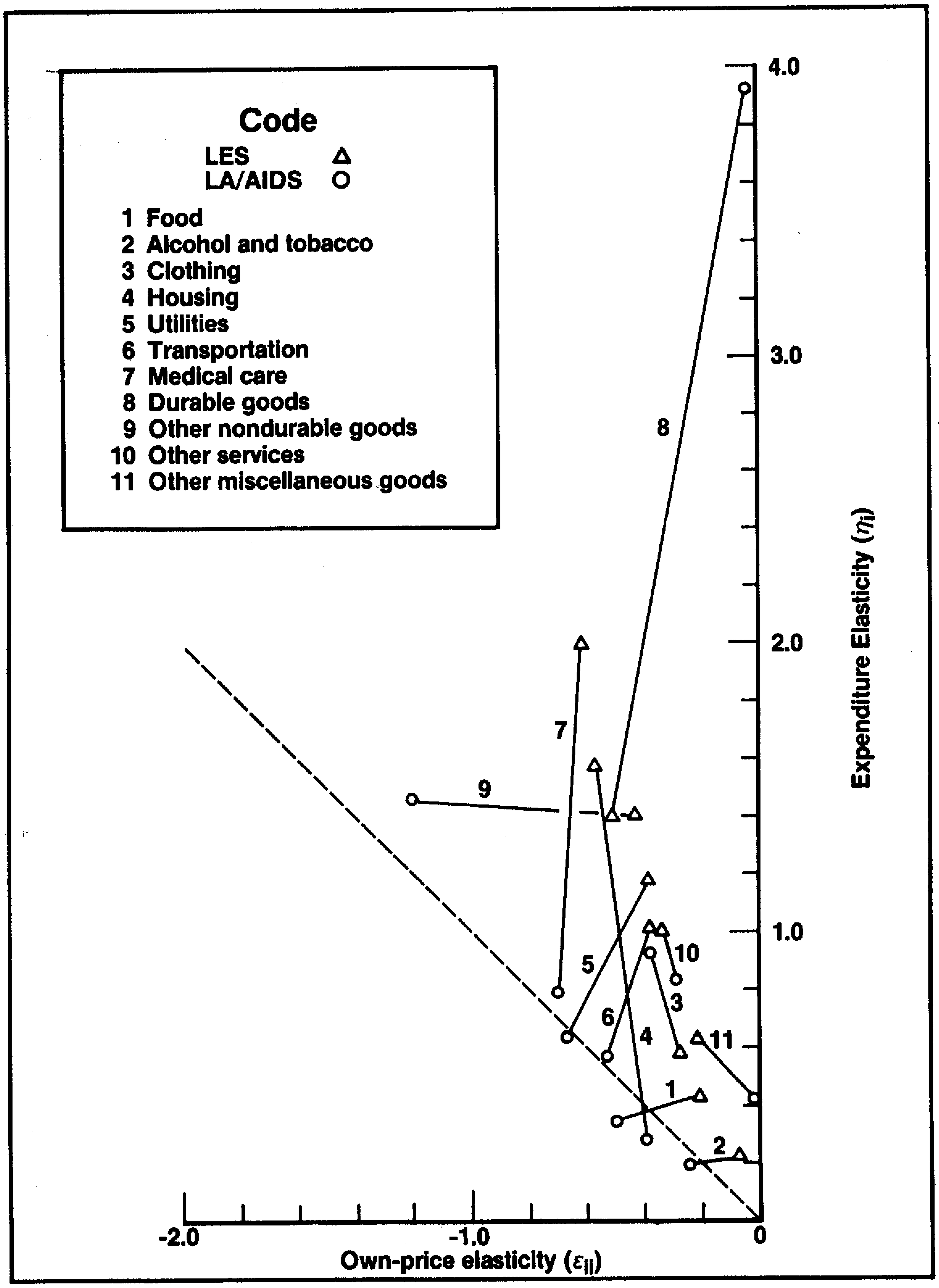

Figure 4.1. Changes in Own-Price and Expenditure Elasticities: LES versus LA/AIDS/H

Source: Table 4.8

Table 4.9 The Dynamic Linear Expenditure System (Homogeneous and Symmetric): Estimates for Eleven Aggregate Commodity Groups

Commodity group i		Estimated or derived coefficients[a]		
		Marginal budget share β_i	Habit parameter α_i^{**}	Physiological effect γ_i^*
Food	(1)	0.120[b]	0.686	137.42
		(5.81)	(0.99)	(4.48)
Alcohol plus tobacco	(2)	0.024	0.577	54.42
		(6.61)	(8.86)	(5.90)
Clothing	(3)	0.081	0.726	49.86
		(6.94)	(11.3)	(3.49)
Housing	(4)	0.018	1.019	1.47
		(2.51)	(108.5)	(0.84)[c]
Utilities	(5)	0.034	0.812	8.64
		(5.71)	(19.8)	(3.50)
Transportation	(6)	0.060	0.892	6.60
		(8.07)	(31.2)	(1.39)[c]
Medical care	(7)	0.027	0.996	-1.55
		(2.23)	(42.7)	(0.57)[c]
Durable goods	(8)	0.454	0.314	83.52
		(14.7)	(3.33)	(3.97)
Other nondurable goods	(9)	0.077	0.747	13.21
		(7.55)	(15.7)	(2.96)
Other Services	(10)	0.072	0.927	2.63
		(4.7)	(21.6)	(0.25)[c]
Other miscellaneous goods	(11)	0.031	0.762	27.75
		(3.53)	(13.0)	(4.10)

a/ Coefficients are based on United States data for the years 1948-1978. Data are given in Appendix 5.

b/ Values in parentheses are asymptotic t-statistics.

c/ Not statistically significant at the 5 percent level of significance.

Table 4.10

A Comparison of the Elasticities for the Dynamic Linear Expenditure System and the Dynamic Linear Approximate Demand System with Homogeneity Imposed: Estimates for Eleven Aggregate Commodity Groups

Commodity group i		DLES			D/LA/AIDS/H			Direction of Change From DLES to LA/AIDS/H	
		Elasticities		Pigou Relationship[b]	Elasticities		Pigou Relationship[b]	Elasticities[a]	
		Expenditure	Own-price	ϕ	Expenditure	Own-Price	ϕ	Expenditure	Own-price
Food	(1)	0.59	-0.20	0.34	0.37	-0.43	1.16	-	+
Alcohol plus tobacco	(2)	0.47	-0.10	0.21	0.24	-0.25	1.04	-	+
Clothing	(3)	0.81	-0.20	0.25	0.75	-0.59	0.79	-	+
Housing	(4)	0.14	-0.11	0.79	0.01	-0.25	25.00	-	+
Utilities	(5)	0.94	-0.20	0.21	0.62	-0.69	1.11	-	+
Transportation	(6)	0.79	-0.21	0.27	0.44	-0.38	0.86	-	+
Medical care	(7)	0.41	-0.19	0.46	0.31	-0.37	1.19	-	+
Durable goods	(8)	3.63	-0.72	0.20	4.42	-0.12	0.03	+	-
Other nondurable goods	(9)	1.48	-0.29	0.20	1.13	-0.92	0.81	-	+
Other Services	(10)	0.68	-0.20	0.29	0.71	-0.24	0.34	+	+
Other miscellaneous goods	(11)	0.57	-0.13	0.23	0.39	0.03	0.08	-	-

[a]Based on the absolute value of the own-price elasticity.

[b]The Pigou relationship is calculated as the absolute value of the own-price elasticity divided by the expenditure elasticity.

Table 4.11

A Comparison of the Predictive Accuracy of Four Models (11 Commodity Groups) for the Sample Period (1948-1978) and for Subsequent Years (1979-1981)

Commodity group i		Years	Mean Budget Share	Percentage Root Mean Square Error: LA/AIDS[a] (A)	LES (B)	D/LA/AIDS[a] (C)	D/LES (D)	Ranking of Models			
				percent							
Food	(1)	1948-1978	20.27	1.01	1.92	0.93	1.36	C	A	D	B
		1979-1981	17.67	3.64	0.97	3.38	2.46	B	D	C	A
Alcohol plus tobacco	(2)	1948-1978	5.13	0.78	2.32	0.79	1.36	A	C	D	B
		1979-1981	3.83	8.53	8.37	8.11	5.43	D	C	B	A
Clothing	(3)	1948-1978	10.02	1.03	2.98	0.97	1.48	C	A	D	B
		1979-1981	7.52	17.28	5.07	11.24	2.80	D	B	C	A
Housing	(4)	1948-1978	13.24	0.88	5.41	0.56	0.67	C	D	A	B
		1979-1981	14.63	12.41	2.03	11.00	2.84	B	D	C	A
Utilities	(5)	1948-1978	3.64	1.18	3.63	1.17	2.12	C	A	D	B
		1979-1981	4.48	0.79	1.88	0.80	2.25	A	C	B	D
Transportation	(6)	1948-1978	7.54	0.74	2.86	0.63	1.11	C	A	D	B
		1979-1981	9.78	7.12	10.49	4.39	2.96	D	C	A	B
Medical care	(7)	1948-1978	6.56	1.79	4.31	1.29	1.73	C	D	A	B
		1979-1981	9.73	6.43	7.55	2.76	0.75	D	C	A	B
Durable goods	(8)	1948-1978	12.51	2.30	5.52	2.08	2.89	C	A	D	B
		1979-1981	11.16	9.33	15.70	4.28	1.51	D	C	A	B
Other nondurable goods	(9)	1948-1978	5.19	1.73	3.94	1.35	2.39	C	A	D	B
		1979-1981	4.61	9.37	22.90	9.66	7.56	D	A	C	B
Other services	(10)	1948-1978	10.52	1.15	2.64	1.10	1.47	C	A	D	B
		1979-1981	11.48	10.07	5.63	5.97	1.00	D	B	C	A
Other miscellaneous goods	(11)	1948-1978	5.38	1.26	4.01	1.25	1.96	C	A	D	B
		1979-1981	5.14	4.71	5.73	5.46	1.37	D	A	C	B
Total[b]		1948-1978	100	1.25	3.54	1.09	1.60	C	A	D	B
		1979-1981	100	8.31	6.76	5.99	2.43	D	C	B	A

[a]Homogeneity imposed to provide comparison with LES and D/LES models.
[b]Based on percentage root mean square errors weighted by the respective mean budget shares.

Sample Period (1948-1978)

The dynamic linear approximate AIDS gives the lowest root mean square percentage error (RMS) error for ten of the 11 groups, while the static linear approximate AIDS gives the lowest RMS percentage error for one group. An estimate of the overall accuracy of the four models was obtained by weighting the RMS percentage errors by their respective budget shares for the 1948-78 period. On this basis, the dynamic linear approximate AIDS (model C) would be selected, followed by the static linear approximate AIDS (model A), the dynamic LES (model D), and the LES (model B). All models have less than 3 percent RMS error for the sample period. However, the two linear approximate AIDS models outperform the two LES models for the sample period.

Predictive Performance (1979-1981)

The predictive accuracy of the models outside the sample period is lower than in the sample period with the weighted average percentage RMS errors ranging from 2.43 percent to 8.31 percent. The dynamic versions of the models outperform their static counterparts, with the dynamic LES model clearly the best overall model. For individual commodity groups, the dynamic LES gave the lowest RMS percentage error for eight of 11 groups; the static LES for two of 11 groups (including food); and the static linear approximate AIDS for one group.

Based on these findings, one cannot claim clear superiority of one model for both within-sample period and for predictive accuracy. It would appear that further work is needed to find reasons for prediction error and on model modifications that might capture these effects more accurately.

Conclusions on the 11 Commodity Group Analysis

1. The analysis of the predictive accuracy of the four models suggests that the dynamic or habit formation models are generally preferred over their static counterparts. However, the same model would not be selected for within-sample error and three-year prediction error. The

dynamic linear approximate AIDS is superior on a "within-sample" error criterion whereas the dynamic LES is superior for the particular years outside the sample.

2. The effects of imposing homogeneity were analyzed in both the static and dynamic linear approximate AIDS. For commodity groups where homogeneity is rejected, the imposition of homogeneity tends to lower the d statistic, indicating induced autocorrelation (the result noted by Deaton and Muellbauer). However, for cases where homogeneity is not rejectd, imposition of homogeneity raises the d statistic indicating an improved model specification (in contrast with Deaton and Muellbauer's findings for U.K. data).
3. Elasticity (price and expenditure) estimates change considerably from the LES-type models to the AIDS-type model. In general, the AIDS-type models give higher price elasticities and lower expenditure elasticities than the LES model counterparts. There is need for further study as to the expected change in elasticities with changes in expenditures and prices in demand systems.
4. The dynamic (or habit) models appear, on balance, to provide the more appropriate specification of demand relationships.

5. ANALYSIS OF CONSUMER FOOD EXPENDITURES

The Almost Ideal Demand System (AIDS) - Food

In this section results are presented for various static models. The basic model is the Deaton-Muellbauer AIDS which, when restricted, has properties of symmetry, homogeneity, and adding-up. Correction is made for autocorrelation. A comparison is given with the additive preference LES model. Further evidence on homogeneity is explored with the linear approximate AIDS model, and a rough comparison is made between symmetric and nonsymmetric formulations. This study's results are then compared with those of Manser (1979).

The Static AIDS Model

The model expresses the budget share for a particular group as a function of prices and real food expenditures (see section 2 for details). The coefficients have the following interpretation:

α_i = *intercept:* averge budget share when all logarithmic prices and real expenditures are equal to one.

β_i = *expenditure coefficient:* change in the i^{th} budget share with respect to a percentage change in real food expenditure with prices held constant.

γ_{ij} = *price coefficients:* change in the i^{th} budget share with respect to a percentage change in the j^{th} price with food expenditures held constant.

The statistical results, presented in Table 5.1 (Part A), indicate the nature of the model. The intercept terms (α_i) approximate the 1948-78 average budget shares and add to 1. The expenditure coefficients (β_i) are positive for relative luxuries and are negative for relative necessities. Since the coefficients must sum to zero, the values must be offsetting. Thus, it is meaningful to talk about goods that in relative terms are luxuries (i.e., meats, and fruits and vegetables) and necessities (i.e., cereals, and miscellaneous foods). The meaning of the β_i coefficients is that if food expenditures increase by 10 percent, the food budget share for meats, for example, will increase by 3.3 percent. Three of the four coefficients are highly significant and the fourth coefficient, for fruits and vegetables has a t-value of 1.3.

The direct-price coefficients (γ_{ii}) are positive as expected for three of four groups (the negative coefficient is not significant for miscellaneous foods). The cross-price coefficients are symmetric, giving only six independent values. Only one of six is statistically significant, however, perhaps reflecting the aggregate groups used here. In total, three of the ten price coefficients are statistically significant (at the 5 percent level).

Table 5.1

The Almost Ideal Demand System: Estimates for Four Food Groups

Part A: No Autocorrelation (ρ set equal to zero)

Food group i		Estimated Coefficients[a]							Elasticities[b]							
									Expenditure		Uncompensated price of group i with respect to group j				Budget share 1974–1978 average value
		α_i	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	$\sum_j \gamma_{ij}$	Total[c]	Food	Meats	Fruits and Vegetables	Cereal and bakery products	Miscellaneous Foods	
Meats	(1)	0.327 (111.8)[d]	0.328 (8.7)	0.1103 (4.6)	−0.1400 (−9.3)	−0.0125 (−1.2)	0.0421 (1.1)	−0.0001	.90	2.06[e]	−0.99	−0.67	−0.18	−0.22	0.309
Fruits and Vegetables	(2)	0.209 (88.2)	0.052 (1.3)	−0.1400 (−9.3)	0.1596 (4.4)	−0.0039 (−0.2)	−0.0158 (−0.3)	−0.0001	.55	1.26	−0.78	−0.26	−0.05	−0.17	0.202
Cereal and bakery products	(3)	0.129 (82.3)	−0.078 (−4.1)	−0.0125 (−1.2)	−0.0039 (−0.2)	0.0169 (1.0)	−0.0005 (−0.0)	0.0	.18	0.42[e]	0.10	0.09	−0.00	0.19	0.134
Miscellaneous foods	(4)	0.336 (72.9)	−0.302 (−4.5)	0.0421 (1.1)	−0.0158 (−0.3)	−0.0005 (−0.2)	−0.0258 (−0.3)[f]	0.0	.07	0.15[e]	0.40	0.13	0.11	−0.79	0.355
Sum of Coefficients		1.0	0.0	−0.0001	−0.0001	0.0	0.0	−0.0002							

Part B: With Autocorrelation[g] (ρ unrestricted)

Food group i		Estimated Coefficients[a]							Elasticities[b]							
									Expenditure		Uncompensated price of group i with respect to group j				Budget share 1974–1978 average value
		α_i	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	$\sum_j \gamma_{ij}$	Total[c]	Food	Meats	Fruits and Vegetables	Cereal and bakery products	Miscellaneous Foods	
Meats	(1)	0.329 (13.4)[d]	0.034 (0.3)	0.1099 (3.1)	−0.0422 (−1.8)	−0.0364 (−2.2)	−0.0313 (−0.6)	0.0	0.48	1.11	−0.68	−0.16	−0.13	−0.14	—
Fruits and Vegetables	(2)	0.219 (15.1)	0.014 (0.1)	−0.0422 (−1.8)	0.0723 (2.0)	−0.0215 (−0.8)	−0.0086 (−0.1)	0.0	0.47	1.07	−0.23	−0.66	−0.12	−0.07	—
Cereal and bakery products	(3)	0.124 (7.0)	−0.085 (−1.2)	−0.0364 (−2.2)	−0.0215 (−0.8)	0.0673 (1.6)	−0.0094 (−0.01)	0.0	0.16	0.37	−0.06	−0.02	−0.42	0.14	—
Miscellaneous foods	(4)	0.328 (11.9)	0.037 (0.3)	−0.0313 (−0.6)	−0.0086 (−0.1)	−0.0094 (−0.1)	0.0493 (0.1)[f]	0.0	0.48	1.10	−0.12	−0.05	−0.04	−0.09	—
Sum of Coefficients		1.0	0.0	0.0	0.0	0.0	0.0	0.0							

[a]Coefficients are based on United States data for the years 1948 to 1978. Data are given in Appendix 5.
[b]Elasticity formulas can be found in Section 2. Calculated at mean (1948–1978) values.
[c]Based on first stage expenditure elasticity for food of 0.435.
[d]Values in parentheses are symptotic t-statistics.
[e]Calculations are based on β_i coefficient with $t > 2$.
[f]This is an approximate t-value, since there are no covariance terms.
[g]The autocorrelation coefficient equals ρ, 0.9069 with a t-value of 10.8.

Expenditure elasticities for meats and other groups with respect to *food expenditures,* shown in Table 5.1, reflect the expected higher values for meats and for fruits and vegetables than for other categories. Most studies report elasticities with respect to *total expenditures* (or income) rather than with respect to a group expenditure (e.g., food). To convert such expenditure elasticities (and price elasticities) from one base to the other requires placing stringent conditions on the two-stage budgeting procedures. Bieri and de Janvry (1972) and Deaton and Muellbauer (1980b pp. 129-133) discuss the problems involved in such quantitative efforts, and this study makes no claim to be consistent with a two-stage budgeting process.[27] However, an approximate relation suggested by Bieri and de Janvry (1972, p. 26) and by Manser (1976, p. 887) is:

$$\eta_{iY} = \eta_{iYF} \cdot \eta_{FY}$$

where

η_{iY} = food expenditure elasticity for commodity group i with respect to total expenditures (income),

η_{iYF} = commodity group i expenditure elasticity with respect to food expenditures, and

η_{FY} = food expenditure elasticity with respect to total expenditure (income).

The choice of an appropriate η_{FY} value is somewhat arbitrary at this point since the focus of the study is on the analysis of alternative functional specifications rather than models of consistent two-stage budgeting. However, to illustrate how these results compare with other studies a value of $\eta_{FY} = 0.435$ from Table 4.7 is used. Using the above formula, we obtain $\eta_{iY} = (2.06)(0.435) = 0.90$ for meat, as shown in Table 5.1.

Homogeneity requires that the sum of the uncompensated price and food expenditure elasticities equals zero. This holds for each food group. Note that the uncompensated price elasticities have not been corrected, as were the food expenditure elasticities, since the formulas reported in Bieri and de Janvry are complex in relation to the accuracy of our estimated cross elasticities. The reader should not expect the price elasticities to necessarily be consistent with those derived in studies using total expenditures. All own-price elasticities indicate inelastic demands for these groups.

The use of FIML techniques for such a demand subsystem provides desirable statistical properties. However, the tradeoff is in the level of aggregation needed to assure convergence of the system. For many policy issues, more disaggregated approaches should be used. Other tradeoffs will be noted in subsequent analyses.

Test for Autocorrelation

Presence of autocorrelation may reflect misspecification of the model. Here, results for a first-order autoregressive model are given; in a subsequent section a habit formation model will be presented. The model adjusted for autocorrelation (given in Table 5.1 Part B) is compared with the uncorrected model (given in Table 5.1 Part A). The null hypothesis that the autocorrelation parameter equals zero is rejected, so the autoregressive model should provide improved results.[28] Note that in contrast to the linear approximate AIDS fitted by OLS, a single value of ρ is used for all commodity groups.[29]

There are considerable differences among some of the coefficients and "t" values for the two specifications. The *intercept terms* (α_i) have similar magnitudes, as expected, since these reflect

[27]That is, the two-stage procedure does not necessarily correspond to a single maximization process, but *given* the expenditures on broad categories, the utility maximization for food, can be treated as a plausible demand subsystem.

[28]The likelihood ratio test statistic (-2 log λ) equals 46.5 which is far greater than the critical chi-square value ($\chi^2_{.05,1} = 3.84$).

[29]This restriction ($\rho_i = \rho$ for all i) must hold in order to be consistent with singular demand or expenditure systems; see, e.g., Berndt and Savin (1975).

average budget shares; however, "t" values drop sharply in the autoregressive model. The *expenditure coefficients* (β_i) are considerably different and levels of significance are poor in the autoregressive model. The expenditure elasticities are much lower for meats and much higher for miscellaneous foods.

The *price coefficients* (γ_{ij}) also are highly variable with only the meat own-price coefficient estimates showing similar magnitudes. The cross-price coefficients are not satisfactory in most cases. Similarly, the *price elasticities* are not very satisfactory from a statistical point of view.

Additive versus Nonadditive Preferences

A comparison between the LES (additive preferences) and the AIDS (indirectly nonadditive) models can be summarized briefly:

1. AIDS direct-price elasticites (absolute values) exceeded those of LES in three of four cases, as was expected based on the 11-commodity analysis.

2. The AIDS model appears to be preferable to LES in that the approximate proportionality between direct price and expenditure coefficients is not imposed by model specification.

3. The autoregressive specification was required for both LES and AIDS. The LES models are reported in Blanciforti (1982) and are not repeated here, since only marginal insights were gained from these models.

Homogeneity

To test the implications of the imposition of homogeneity, the linear approximate AIDS was fitted by OLS. The results are summarized in Table 5.2; the major conclusions are:

1. Homogeneity is rejected for two groups (meat and miscellaneous foods) and is not rejected for the other two groups of food expenditures.

2. For meats and miscellaneous foods, the imposition of homogeneity appears to generate serial correlation in the residuals. This supports the Deaton-Muellbauer results as noted in the discussion of the 11-commodity group. The R^2 values also are lowered when homogeneity is imposed, as expected.

3. The imposition of homogeneity affects the food expenditure elasticities to a greater extent than the direct-price elasticities (which change very little).

4. The linear approximate AIDS (nonsymmetric and nonhomogeneous) provides elasticity estimates roughly comparable to AIDS corrected for autocorrelation. The OLS procedure allows more flexibility in adjusting individual equations for homogenity, for example, and for ease in estimation (OLS versus FIML) but at the cost of statistical elegance.

Symmetry

The final comparison of the static models is that of symmetry of the cross-price coefficients (not elasticities). The comparison is not rigorous since we will compare non-nested formulations and because cross-price coefficients are notoriously difficult to estimate accurately. The models compared are:

AIDS: symmetric and homogeneous (FIML)

LA/AIDS: nonsymmetric and homogeneous (OLS)

In both models homogeneity is imposed which provides an equitable comparison since imposition of that property should result in roughly equal autocorrelation for each model.

Table 5.2

The Effects of Relaxing the Homogeneity Condition in the State Linear Approximate Almost Ideal Demand System (Nonsymmetric): Estimates for Four Food Groups

Part A: Estimated Coefficients[a]

Food group i	α_i*		β_i		γ_{i1}		γ_{i2}		γ_{i3}		γ_{i4}		$\sum_j \gamma_{ij}$		Summary Statistics: SSE (10^{-2})		R^2		DW	
	H[b]	NH[c]	H	NH	H	NH	H	NH	H	NH	H	NH	H	NH	H	NH	H	NH	H	NH
Meats (1)	-1.763 (-6.1)[d]	-0.564 (-1.5)	0.328 (7.2)	0.148 (2.4)	0.106 (4.7)	0.120 (6.6)	-0.118 (-2.3)	-0.042 (-1.0)	-0.048 (-1.1)	-0.056 (-1.6)	0.060 (0.6)	0.010 (0.4)	0.0	0.032 (4.2)	0.873	0.684	0.688	0.816	0.869	0.976
Fruits and Vegetables (2)	-0.191 (-0.9)	0.230 (0.7)	0.062 (1.8)	-0.004 (-0.1)	-0.131 (-7.6)	-0.127 (-7.4)	0.126 (3.3)	0.153 (3.7)	0.030 (0.9)	0.028 (0.9)	-0.025 (-0.4)	-0.043 (-1.7)	0.0	0.011 (1.6)	0.661	0.643	0.851	0.864	1.531	1.574
Cereals and bakery products (3)	0.553 (4.3)	0.538 (2.5)	-0.067 (-3.3)	-0.064 (-1.9)	-0.005 (-0.5)	-0.005 (-0.5)	-0.025 (-1.1)	-0.026 (-1.0)	0.031 (1.6)	0.032 (1.6)	-0.001 (-0.1)	-0.001 (-0.1)	0.0	0.000 (0.1)	0.390	0.398	0.438	0.438	1.401	1.397
Miscellaneous foods (4)	2.424 (6.8)	0.787 (1.9)	-0.328 (-5.8)	-0.070 (-1.1)	0.030 (1.0)	0.011 (0.7)	0.020 (0.3)	-0.084 (-1.7)	-0.013 (-0.2)	-0.003 (-0.1)	-0.037 (-0.3)	0.032 (1.0)	0.0	-0.043 (-5.0)	1.082	0.782	0.717	0.858	1.160	1.647

Part B: Elasticities[e]

Food group i	Food Expenditure elasticity		Uncompensated price elasticity of group i with respect to group j: Meat		Fruits and Vegetables		Cereal and bakery products		Miscellaneous Foods	
	H	NH	H	NH	H	NH	H	NH	H	NH
Meats (1)	2.06[g]	1.45[g]	-0.66	-0.61	-0.38	-0.14	-0.16	-0.18	0.19	-0.03
Fruits and Vegetables (2)	1.31	0.98	-0.65	-0.63	-0.37	-0.24	0.15	0.14	-0.13	-0.21
Cereals and bakery products (3)	0.51[g]	0.52	-0.04	-0.04	-0.18	-0.19	-0.77	-0.77	-0.01	-0.01
Miscellaneous foods (4)	0.08[g]	0.81	0.08	0.03	0.06	-0.24	-0.04	-0.01	-1.10	-0.91

Part C: Homogeneity Test Results

Food group i	F-value[f] critical value: F(1.25) = 4.24
Meats (1)	17.40*
Fruits and Vegetables (2)	2.43
Cereals and bakery products (3)	0.01
Miscellaneous foods (4)	24.78*

[a]Coefficients are based on United States data for the years 1948 to 1978. Data are given in Appendix 5.
[b]H indicates results from the homogeneous model.
[c]NH indicates results from the nonhomogeneous model.
[d]Coefficients in parentheses are t-values.
[e]Elasticities are calculated using the LA/AIDS. See Section 2. Calculated at mean (1948-1978) values.
[f]* indicates rejection of the homogeneity hypothesis.
[g]Calculations are based on β_i coefficient with t > 2.

The comparative analysis is given in Table 5.3. Note that the intercept terms differ: α_i for the AIDS and α_i^* for the LA/AIDS. However, these parameters are linked through the relationship:

$$\alpha_i^* \cong \alpha_i - \beta_i \log \xi \text{ (see section 2).}$$

The value of ξ can be calculated through the relationship given previously (equation 10) as:

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \tfrac{1}{2}\sum_k\sum_j \gamma_{kj}^* \log p_k \log p_j.$$

At the average values, log P was approximately equal to log P* when α_0 was valued at per capita expenditures in the reference year (1972), so the term ξ equals $586.90. The difference in intercept terms, therefore, has little effect on the calculated price elasticities from the two models.

The main conclusions on the imposition of symmetry, based on these models, are:

1. The food expenditure coefficients (β_i) and elasticities are not particularly affected by symmetry.
2. The direct price coefficients (γ_{ii}) and the associated elasticities are very similar except for the fruits and vegetables elasticity.
3. The symmetry condition should have the greatest effect on the cross-price coefficients (γ_{ij}) and

both direct and cross-price coefficients. Thus, with approximately equal direct price coefficients, one might expect approximately equal cross-price effects. Given the low level of significance of many cross-price effects, no rigorous statements are warranted. However, the imposition of symmetry does not appear to be an unreasonable restriction. On the other hand, the LA/AIDS

Table 5.3

The Effect of Imposing Symmetric in the Static Models—A Comparison of Results from the Almost Ideal Demand System (Symmetric and Homogeneous) with the Linear Approximate Almost Ideal Demand System (nonsymmetric and Homogeneous): Estimates for Four Food Groups

Part A: Estimated Coefficients; Summary Statistics[a]

Food group i	α_i	α_i^*	β_i		γ_{i1}		γ_{i2}		γ_{i3}		γ_{i4}		$\sum_j \gamma_{ij}$		SSE (10^{-2})	R^2	DW
	Sym[b]	NS[c]	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS	NS	NS	NS
Meats (1)	0.327[d]	-1.763	0.328	0.328	0.110	0.106	-0.140	-0.118	-0.012	-0.048	0.042	0.060	0.0	0.0	0.873	0.688	0.976
	(111.8)	(-6.1)	(8.7)	(7.2)	(4.6)	(4.7)	(-9.3)	(-2.3)	(-1.2)	(-1.1)	(1.1)	(0.6)					
Fruits and Vegetables (2)	0.209	-0.191	0.052	0.062	-0.140	-0.131	0.160	0.126	-0.004	0.030	-0.016	-0.025	0.0	0.0	0.661	0.851	1.574
	(88.2)	(-0.9)	(1.3)	(1.8)	(-9.3)	(-7.6)	(4.4)	(3.3)	(-0.2)	(0.9)	(-0.3)	(-0.4)					
Cereals and bakery products (3)	0.129	0.553	-0.078	-0.067	-0.012	-0.005	-0.004	-0.025	0.017	0.031	-0.000	-0.001	0.0	0.0	0.390	0.438	1.397
	(82.3)	(4.3)	(-4.1)	(-3.3)	(-1.2)	(-0.5)	(-0.2)	(-1.1)	(1.0)	(1.6)	(-0.0)	(-0.1)					
Miscellaneous foods (4)	0.336	2.424	-0.302	-0.328	0.042	0.030	-0.016	0.020	-0.000	-0.013	-0.026	-0.037	-0.0	0.0	10.82	0.717	1.647
	(72.9)	(6.8)	(-4.5)	(-5.8)	(1.1)	(1.0)	(-0.3)	(0.3)	(-0.0)	(-0.2)	(-0.5)	(-0.3)					
Sum of Coefficients	1.000	1.023	0.0	-0.005	0.0	0.0	0.0	0.003	0.001	0.0	0.0	-0.003					

Part B: Elasticities[a]

Food group i	Food Expenditure elasticity		Uncompensated price elasticity of group i with respect to group j: Meat		Fruits and Vegetables		Cereal and bakery products		Miscellaneous Foods	
	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS
Meats (1)	2.06[f]	2.06[f]	-0.99	-1.01	-0.67	-0.59	-0.18	-0.29	-0.22	-0.16
Fruits and Vegetables (2)	1.26	1.31	-0.78	-0.75	-0.26	-0.44	-0.05	0.11	-0.17	-0.23
Cereals and bakery products (3)	0.42[f]	0.51[f]	0.10	0.12	0.09	-0.08	-0.80	-0.70	0.19	0.15
Miscellaneous foods (4)	0.15[f]	0.08[f]	0.40	0.39	0.13	0.24	0.11	0.08	-0.79	-0.79

[a]Summary statistics are only available for the LA/AIDS model and are not available for the AIDS model.
[b]Sym indicates results are from the symmetric AIDS model (i.e., $\gamma_{ij} = \gamma_{ji}$) previously reported in Table 5.1.
[c]NS indicates results are from the nonsymmetric LA/AIDS/H model previously reported in Table 5.2. The α_i values adjusted according to $a_i = a_i^* + \beta_i \log a_0$ are 0.328, 0.204, 0.126, and 0.333 for food groups one to four, respectively.
[d]Values in parentheses are t-statistics.
[e]Elasticities are calculated at mean (1948-1978) using the AIDS formulas for the Sym results and the adjusted AIDS formulas for the NS results. Per capita expenditures in the reference year 1972, α_0, are valued at \$586.90.
[f]Calculations are based on β_i coefficient with $t > 2$.

Table 5.4

Comparison of the Static Model Results of Food Expenditure and Own-Price Elasticity Estimates for Food Commodities to those from the Manser Study (1976)

Part A: Food Expenditure Elasticities

	This Study						Manser Study			
	Nonadditive Models				Additive Models		Nonadditive Models			Additive Models
	AIDS		LA/AIDS		LES					Klein-Rubin
Food group i	p = 0	p ≠ 0	NH	H	p = 0	p ≠ 0	ITL	ITLLE	ITL	(LES)
Meats (1)	2.06	1.11	1.45	2.06	1.73	1.33	1.73	1.56	1.34	1.40
Fruits and Vegetables (2)	1.26	1.07	0.98	1.31	-0.42	0.99	0.85	0.73	-0.36	1.19
Cereals and bakery products (3)	0.42	0.37	0.52	0.45	0.88	0.40	0.23	0.16	1.15	-0.17
Miscellaneous foods (4)	0.15	1.10	0.81	0.08	1.21	0.95	0.79	1.40	1.49	1.26

Part B: Own-Price Elasticities

	This Study						Manser Study			
	Nonadditive Models				Additive Models		Nonadditive Models			Additive Models
	AIDS		LA/AIDS		LES					Klein-Rubin
Food group i	p = 0	p ≠ 0	NH	H	p = 0	p ≠ 0	ITL	ITLLE	ITL	(LES)
Meats (1)	-0.99	-0.68	-0.76	-0.01	-1.05	-0.78	-0.79	-0.49	-0.81	-0.57
Fruits and Vegetables (2)	-0.26	-0.66	-0.24	-0.44	-0.34	-0.69	-0.38	-0.33	0.55	-0.42
Cereals and bakery products (3)	-0.80	-0.42	-0.70	-0.70	-0.63	-0.70	-1.18	-0.99	-0.61	0.06
Miscellaneous foods (4)	-0.79	-0.89	-0.84	-0.79	-0.88	-0.72	-0.87	-0.50	-0.92	-0.59

Some Conclusions on the Static Model Results

The four-food commodity analyses provide some useful insights as to the effects of model specification on empirical findings. Major points are:

1. Aggregation of food commodities into only four groups does not allow enough flexibility for most policy questions. However, it does allow the use of FIML methods and the imposition of symmetry which is not possible with the linear approximate models fitted by OLS.

2. Autocorrelation of residuals is evident in the AIDS and LES—one indication of a misspecified model. A first-order autoregressive specification corrects for this problem, but "t" values drop sharply on most expenditure and price coefficients (see Table 5.1). The results for the dynamic (habit) models given in the next section also were weakened by lack of significance for expenditure and price coefficients. This gives rise to additional concern about the level of aggregation in these analyses.

3. The AIDS formulation appears to be preferable to the LES models in that proportionality of expenditure and price elasticities is not imposed in the former as it is (implicitly) in the later.

4. Imposing homogeneity of static individual consumer behavior on aggregate market data appears too restrictive an assumption.

5. The analysis of symmetry in this study is not rigorous, but results indicate only minor differences in expenditure and direct-price elasticities.

6. The linear approximate AIDS fitted by OLS appears to offer a viable alternative to FIML methods, particularly when more commodity detail is advantageous.

The Dynamic Almost Ideal Demand System - Food

Here the dynamic AIDS model is compared with various alternative model specifications. Thus, comparisons include the effects of habits, the effects of correction for autocorrelation, additive preferences versus indirectly nonadditive models, homogeneous versus nonhomogeneous models, and symmetric versus nonsymmetric models. This section will be followed by an overall comparison of the strengths and weaknesses of the results presented here, including comments on several alternative approaches to the analysis of food demand analysis.

The Dynamic AIDS Model

The static AIDS model expresses budget shares (w_i) as a function of prices (p) and real income (x/P); or

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log (x/P) \tag{29}$$

where α_i is the average budget share when all logarithmic prices and real expenditures are equal to one.

In the habit formation version, we have the average budget share (α_i) influenced by past consumption (q_{it-1}) or

$$\alpha_i = \alpha_i^* + \alpha_i^{**} q_{it-1}. \tag{30}$$

The equation to be estimated is obtained by substituting equation (30) into (29), as discussed for the 11-commodity group. Again, the coefficients have the following meaning:

α_i^* = *intercept:* a random element without economic content, but used in calculation of elasticity values for particular years.

α_i^{**} = *habit effect:* change in the i^{th} budget share associated with a unit change in past year's consumption.

β_i = *expenditure term:* change in the i^{th} budget share with respect to a percentage change in real food expenditures with prices and past year's comsumption held constant.

γ_{ij} = *price terms:* change in the i^{th} budget share with respect to a percentage change in the j^{th} price, with real food expenditures and last year's consumption held constant.

This model, characterized by symmetry, homogeneity, and the adding-up condition, was estimated by FIML methods. The D/AIDS results (see Table 5.5 Part A) will be discussed briefly and then compared with other formulations.

1. The *intercept* terms (α_i^*) add to 1 and are all statistically significant (5 percent level).

2. The *habit effect* coefficients (α_i^{**}) reflect persistence in expenditure shares (i.e., positive values) for meats, fruits and vegetables, and for cereal and bakery products. The coefficient is negative for miscellaneous foods reflecting either an "inventory effect" of perhaps a negative time trend. Note that these coefficients do not have to sum to zero since q_{it-1} differs for each equation. Three of four are statistically significant.

3. The *expenditure coefficients* (β_i) are disappointing compared to the results for the static AIDS model (not corrected for autocorrelation), for only one of four is statistically significant. It appears that in the dynamic specification, the current expenditure effect is picked up by the habit coefficient associated with last year's consumption. We noted a similar decrease in the significance of the expenditure coefficient with the first-order autoregressive model (see Table 5.1).

4. The *direct-price* coefficients and elasticities are roughly the same for the static and habit formation models. These coefficients are much more acceptable statistically for meats and for fruits and vegetables than for the other two groups.

A Statistical Test for Habits and Autocorrelation[30]

In this test, the dynamic AIDS model is taken as the "correct" specification. The argument is that the static AIDS has a specification bias that can be "corrected" by (a) a first order autoregressive static AIDS or (b) a habit formation dynamic AIDS or (c) an autocorrelated habit formulation.

The maintained hypothesis, then, is that of an autocorrelated habit formation model. The following tests are carried out:

H_0: all $\alpha_i^{**} = 0$ and $\rho = 0$

versus

H_1: not H_0.

The likelihood ratio test statistic ($-2 \log \lambda$) can be shown to be asymptotically distributed as a chi-squared variable with degrees of freedom equal to the number of restrictions. The computed value of $-2 \log \lambda$ is 64.46 which greatly exceeds the critical value $\chi^2_{.05,4} = 9.49$. Thus, habits and/or autocorrelation are present in the static AIDS.

The next question is to ask whether these results were due to only one factor (i.e., habits or autocorrelation). Actually, the models are somewhat similar in that lagged values occur in both the habit model and the first order autoregressive model ($\rho = .91$). The order of testing is arbitrary. Here, the hypothesis is that

H_0: $\rho = 0$

versus

H_1: $\rho \neq 0$.

As noted previously, the static model test for autocorrelation (t = 10.8) indicated the presence of serial correlation. Thus, we accept H_1 that $\rho \neq 0$.

The test for the habit effects is:

H_0: all $\alpha_i^{**} = 0$

versus

H_1: Not H_0.

The resulting value for $-2 \log \lambda$ is 37.5 which greatly exceeds the critical value $\chi^2_{.05,3} = 7.81$. Thus, the habit effect cannot be rejected. Overall, we cannot distinguish one factor alone as responsible for these results, but conclude that the static AIDS model as such is not a correct specification for this food analysis.

Autocorrelation in Dynamic AIDS

Even in the dynamic AIDS there is evidence of autocorrelated terms with $\rho = 0.98$ and a highly significant t value (40.6). The results, presented in Table 5.5 Part B, when compared with the model where $\rho = 0$, gives a likelihood ratio test value of 26.9 which exceeds the critical value of $\chi^2_{.05,1} = 3.84$.

A comparison of the two models in Table 5.5 reveals considerable instability in coefficients:

1. The autoregressive model of D/AIDS includes past levels of consumption plus essentially a first difference specification ($\rho = 0.98$). It is not surprising that the habit coefficient (α_i^{**}) tends to be statistically insignificant here, whereas it is significant in 3 of 4 cases when $\rho = 0$.

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[30]This section follows directly from Blanciforti and Green (1983b, p. 514-515).

Table 5.5

The Dynamic Almost Ideal Demand System

Part A: No Autocorrelation (ρ set equal to zero)

Food group i		Estimated Coefficients[a]								Elasticities[b]: Expenditure		Uncompensated price of group i with respect to group j				Budget share 1974–1978 average value
		a_i^*	$a_i^{**}(10^{-3})$	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	$\sum_j \gamma_{ij}$[g]	Total[c]	Food	Meats	Fruits and Vegetables	Cereal and bakery products	Miscellaneous Foods	
Meats	(1)	0.181 (3.7)[d]	0.767 (2.9)	0.046 (0.5)	0.1316 (3.8)	−0.0928 (−5.1)	−0.0237 (−1.3)	−0.0150 (−0.3)	0.0001	0.90	1.15	−0.62	−0.33	−0.10	−0.10	0.309
Fruits and Vegetables	(2)	0.085 (2.0)	1.011 (3.0)	−0.079 (−1.0)	−0.0928 (−5.1)	0.1322 (2.9)	0.0043 (0.1)	−0.0437 (−0.6)	0.0	0.48	0.61	−0.34	−0.27	0.07	−0.08	0.202
Cereal and bakery products	(3)	0.102 (2.9)	0.349 (0.7)	−0.092 (−3.6)	−0.0237 (−1.3)	0.0043 (0.1)	0.0420 (1.1)	−0.0226 (−0.3)	0.0	0.25	0.32e	0.04	0.17	−0.60	0.08	0.134
Miscellaneous foods	(4)	0.633 (7.5)	−1.420 (−3.9)	0.125 (1.0)	−0.0150 (−0.3)	−0.0437 (−0.6)	−0.0226 (−0.3)	0.0813 (0.8)[f]	0.0	1.07	1.35	−0.15	−0.19	−0.11	−0.90	0.355
Sum of Coefficients		1.0	—	0.0	0.0001	0.0	0.0	0.0	0.0							

Part B: With Autocorrelation[g] (ρ unrestricted)

Food group i		Estimated Coefficients[a]								Elasticities[b]: Expenditure		Uncompensated price of group i with respect to group j				Budget share 1974–1978 average value
		α_i	$a_i^{**}(10^{-3})$	β_{i1}	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	$\sum_j \gamma_{ij}$[g]	Total[c]	Food	Meats	Fruits and Vegetables	Cereal and bakery products	Miscellaneous Foods	
Meats	(1)	0.530 (1.3)[d]	−0.126 (−0.7)	−0.068 (−1.0)	0.0968 (2.5)	−0.0574 (−1.4)	−0.0548 (−2.1)	0.0153 (0.8)	−0.0001	0.61	0.78	−0.57	−0.10	−0.14	−0.04	—
Fruits and Vegetables	(2)	0.399 (1.4)	−0.230 (−0.5)	−0.068 (−1.0)	−0.0574 (−1.4)	0.5555 (1.7)	−0.0349 (−1.2)	0.0367 (0.9)	−0.0001	0.52	0.67	−0.11	−0.60	−0.11	0.04	—
Cereal and bakery products	(3)	0.186 (1.2)	−0.207 (−0.4)	−0.086 (−1.3)	−0.0548 (−2.1)	−0.0349 (−1.2)	0.0449 (0.5)	0.0448 (0.5)	0.0	0.28	0.36	−0.08	−0.02	−0.55	0.06	—
Miscellaneous foods	(4)	−0.116 (−1.4)	−1.588 (−1.1)	0.221 (2.4)	0.0153 (0.8)	0.0367 (0.9)	0.0448 (0.5)	−0.0968 (0.1)[f]	0.0	1.29	1.62[e]	−0.27	−0.13	0.02	−1.01	—
Sum of Coefficients		1.0	—	0.0	−0.0001	−0.0001	0.0	0.0	−0.0002							

[a]Coefficients are based on United States data for the years 1948–1978. Data are given in Appendix 5.
[b]Elasticity formulas can be found in Section 2. Calculated at mean (1948–1978) values.
[c]Based on first stage elasticity for food of 0.78.
[d]Values in parentheses are asymptotic t-statistics.
[e]Calculations are based on β_i coefficient with $t > 2$.
[f]This is an approximate t-value, since there are no covariance terms.
[g]The autocorrelation coefficient, ρ, equals 0.9845 with a t-value of 40.6

2. Although expenditure and price coefficients are not wholly satisfactory in either model, the elasticity coefficients for expenditures and direct-price effects are roughly comparable (except for the meat expenditure elasticity and the fruits and vegetables direct-price elasticity).

3. Since these results are not satisfactory, additional analysis of the data is reported using the linear approximate dynamic AIDS fitted by OLS (i.e., nonsymmetric). First a brief comment is given on the dynamic LES model.

A Note on the Dynamic LES Model

The dynamic LES was estimated by FIML methods (see Table 5.6). The theoretical basis of the model is given in section 2 and the interpretation of coefficients parallels that given for the 11-commodity group. Briefly, the interpretation of the coefficients is as follws:

β_i = *marginal budget share,*

γ_i^{**} = *habit parameter,* and

γ_i^{*} = *required minimum subsistence level* (with $\gamma_i^{**} = 0$).

The results, given in Table 5.6 Part A, indicate the importance of the habit parameter (γ_i^{**}) in relation to β_i and γ_i^{*} in three of four equations. However, the calculated expenditure elasticities are based on significant values for only two of four groups and price elasticities for only one of four groups.

Autocorrelation is present in the model ($\rho = 0.905$ with t = 17.3). The interesting outcome of the autoregressive model is that the habit parameter is reduced in significance in all cases, but the required subsistence level coefficient (γ_i^{*}) and the marginal budget share coefficients (β_i) maintain about the

Table 5.6

The Dynamic Linear Expenditure System (Homogeneous and Symmetric): Estimates for Four Food Groups

Food group i	Estimated Coefficients[a]	Derived Coefficients	Elasticities[b]

same levels of significance (see Table 5.6, part B). All expenditure elasticity coefficients except for "cereals and bakery products" are based on statistically significant β_i coefficients. The insignificant habit parameter estimates for all groups cast doubts on the reliability of the price elasticity values. However, there are no major changes in the mean price elasticity values.

Evidence on Homogeneity using D/LA/AIDS

The linear approximate dynamic AIDS is fitted by OLS and is not symmetric. Here we compare a model in which homogeneity is imposed (i.e., $\sum_j \gamma_{ij} = 0$) with an unrestricted model. There are several useful insights gained from these results (Table 5.7):

1. Autocorrelation is not a problem in two of four equations. Thus the linear approximate AIDS allows more flexibility in adjustment than is possible in the FIML systems approach which essentially forces all equations to have the same autoregressive coefficient (ρ).

2. The imposition of homogeneity actually improves the autocorrelation problem for meats. This supports the argument made for the static LA/AIDS analysis of food. As noted, homogeneity is rejected for meats and for miscellaneous foods.

3. The linear approximate AIDS, which does not impose symmetry and allows for choice between equations for homogeneity, provides the most statistically reliable coefficients of models considered. Analysis of symmetry, discussed next, concludes that the results in Table 5.8 are the most reliable for these food groups.

Symmetry

This comparison is of the symmetric D/AIDS with the D/LA/AIDS with homogeneity imposed (Table 5.8). The findings parallel that for the static model discussed previously (except for the added habit coefficient).

1. The *habit* effect (α_i**) is statistically significant for three of four groups, but more so for the nonsymmetric model.

2. The *expenditure* coefficients (β_i) also favor the nonsymmetric model, but problems still exist for meats.

3. The *direct-price* coefficients (γ_{ii}) favor the nonsymmetric model (three of four cases) as do the *cross-price* coefficients (nine of twelve cases).

4. The elasticity estimates tend to favor the nonsymmetric estimates on the basis of these results. However, note that the previous analysis rejected homogeneity for meats and miscellaneous foods.

Conclusions on the Food Demand Analysis

The main conclusions of this study of four groups of food commodities are:

1. There is strong support for a habit, or dynamic, demand model over its static counterpart.

2. The linear approximate dynamic AIDS appears to capture more detail on price and expenditure effects than the more sophisticiated but restrictive AIDS fitted by FIML methods.

3. Of the D/LA/AIDS models, we suggest estimation of both homogeneous and non-homogeneous models. Where homogeneity is rejected for a particular food group, the nonhomogeneous elasticity results should be used; otherwise, accept the homogeneous results. Autocorrelation does not appear to be a serious problem with this selection procedure, but it might be worthwhile to correct individual equations for autocorrelation.

Table 5.7

The Effects of Imposing Homogeneity on the Dynamic Linear Approximate Almost Ideal Demand System (Nonsymmetric): Estimates for Four Food Groups

Part A: Estimated Coefficients[a]

Food group i	a_i^*		$a_i^{**}(10^{-3})$		β_i		γ_{i1}		γ_{i2}	
	H[b]	NH[c]	H	NH	H	NH	H	NH	H	NH
Meats (1)	−0.216 (−0.5)[d]	−0.108 (−0.3)	0.732 (4.0)	0.423 (1.9)	0.063 (0.8)	0.055 (0.8)	0.131 (6.8)	0.129 (7.2)	−0.094 (−2.3)	−0.056 (−1.3)
Fruits and Vegetables (2)	0.704 (2.5)	0.774 (2.4)	1.218 (4.1)	1.165 (3.6)	−0.101 (−2.1)	−0.111 (−2.1)	−0.074 (−3.8)	−0.076 (−3.8)	0.081 (2.5)	0.090 (2.4)
Cereals and bakery products (3)	0.610 (4.6)	0.550 (2.6)	0.598 (1.4)	0.630 (1.5)	−0.083 (−3.6)	−0.074 (−2.2)	−0.022 (−1.4)	−0.024 (−1.5)	−0.027 (−1.2)	−0.031 (−1.2)
Miscellaneous foods (4)	2.500 (9.5)	1.367 (3.4)	0.889 (4.8)	0.572 (3.1)	−0.367 (−8.6)	−0.179 (−2.7)	−0.036 (−1.4)	−0.025 (−1.2)	0.074 (1.6)	−0.015 (−0.3)

Food group i	γ_{i3}		γ_{i4}		$\sum_j \gamma_{ij}$		Summary Statistics[a]: SSE (10^{-2})		R^2		BW	
	H	NH	H	NH	H	NH	H	NH	H	NH	H	NH
Meats (1)	−0.026 (−0.1)	−0.040 (−1.2)	−0.011 (−13.1)	−0.013 (−0.5)	0.000	−0.020 (−2.1)	0.696	0.652	0.809	0.839	1.568	1.347
Fruits and Vegetables (2)	0.043 (1.6)	0.042 (1.6)	−0.050 (−2.07)	−0.054 (−2.5)	0.000	0.002 (0.5)	0.520	0.528	0.911	0.912	2.367	2.353
Cereals and bakery products (3)	0.061 (2.2)	0.063 (2.2)	−0.012 (−18.7)	−0.010 (−0.6)	0.000	−0.002 (−0.4)	0.383	0.389	0.481	0.485	1.773	1.789
Miscellaneous foods (4)	−0.071 (−1.7)	−0.043 (−1.2)	0.032 (11.3)	0.054 (1.9)	−0.001	−0.029 (−3.3)	0.800	0.674	0.852	0.899	2.270	2.328

Part B: Elasticities[e]

Food group i	Food Expenditure elasticity		Uncompensated price elasticity of group i with respect to group j: Meat		Fruits and Vegetables		Cereal and bakery products		Miscellaneous Foods	
	H	NH	H	NH	H	NH	H	NH	H	NH
Meats (1)	1.20	1.18	−0.58	−0.58	−0.30	−0.18	−0.08	−0.13	−0.04	−0.04
Fruits and Vegetables (2)	0.50[g]	0.45[g]	−0.37	−0.37	−0.60	−0.55	0.21	0.21	−0.25	−0.27
Cereals and bakery products (3)	0.39[g]	0.45[g]	−0.16	−0.18	−0.20	−0.23	−0.55	−0.53	−0.09	−0.07
Miscellaneous foods (4)	−0.03[g]	0.50[g]	−0.10	−0.07	0.21	−0.04	−0.20	−0.12	−0.91	−0.85

[a] Coefficients are based on United States data for the years 1948–1978. Data are given in Appendix 4.
[b] H indicates results from the homogeneous model.
[c] NH indicates results from the nonhomogeneous model.
[d] Values in parentheses are t-values.
[e] Elasticities are calculated at the mean (1948–1978) values using the D/LA/AIDS formulas.
[f] * indicates rejection of the homogeneity hypothesis.
[g] Calculations are based on β_i coefficient with $t > 2$.

Table 5.8

The Effect of Imposing Symmetry—A Comparison of the Results from the Dynamic Almost Ideal Demand System (Symmetric and Homogeneous) with the Dynamic Linear Approximate Almost Ideal Demand System (Nonsymmetric and Homogeneous): Estimates for Four Food Groups

Part A: Estimated Coefficients

Food group i	a_i^{**}	a_i^*	$a_i^{**}(10^{-3})$		β_i		γ_{i1}		γ_{i2}		γ_{i3}		γ_{i4}		$\Sigma_j \gamma_{ij}$		Summary Statistics[a] SSE (10^{-2})	R^2	BW
	Sym[b]	NS[c]	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS	NS	NS	NS
Meats (1)	0.181 (3.7)[d]	−0.216 (−0.5)	0.767 (2.6)	0.732 (4.0)	0.446 (0.5)	0.063 (0.8)	0.132 (3.8)	0.131 (6.8)	−0.093 (−2.3)	−0.094 (−1.3)	−0.024 (−1.3)	−0.026 (−0.1)	−0.015 (−0.3)	−0.011 (−13.1)	0.0	0.0	0.696	0.809	1.568
Fruits and Vegetables (2)	0.085 (2.0)	0.704 (2.5)	1.011 (3.0)	1.218 (4.1)	−0.079 (−1.0)	−0.101 (−2.1)	−0.093 (−5.1)	−0.074 (−3.8)	0.132 (2.9)	0.081 (2.5)	0.004 (0.1)	0.043 (1.6)	−0.044 (−0.6)	−0.050 (−20.7)	−0.001	0.0	0.520	0.911	2.367
Cereals and bakery products (3)	0.102 (2.9)	0.610 (4.6)	0.349 (0.7)	0.598 (1.4)	−0.092 (−3.6)	−0.083 (−3.6)	−0.024 (−1.3)	−0.022 (−1.4)	0.004 (0.1)	−0.027 (−1.2)	0.042 (1.1)	0.061 (2.2)	−0.023 (−0.3)	−0.012 (−18.7)	−0.001	0.0	0.383	0.481	1.773
Miscellaneous foods (4)	0.633 (7.5)	2.500 (9.5)	−1.420 (−3.9)	0.889 (4.8)	0.125 (1.0)	−0.367 (−8.6)	−0.015 (−0.3)	−0.036 (−1.4)	−0.044 (−0.6)	0.074 (1.6)	−0.023 (−0.3)	−0.071 (−1.7)	0.081 (0.8)	0.032 (11.3)	−0.001	−0.001	0.800	0.852	2.270

Part B: Elasticities[e]

Food group i	Food Expenditure elasticity		Uncompensated price elasticity of group i with respect to group j: Meat		Fruits and Vegetables		Cereal and bakery products		Miscellaneous Foods	
	Sym	NS	Sym	NS	Sym	NS	Sym	NS	Sym	NS
Meats (1)	1.15	1.20	−0.62	−0.64	−0.33	−0.34	−0.10	−0.11	−0.10	−0.10
Fruits and Vegetables (2)	0.61	0.50[f]	−0.34	−0.21	−0.27	−0.50	0.07	0.28	−0.08	−0.08
Cereals and bakery products (3)	0.32[f]	0.39[f]	0.04	0.03	0.17	−0.08	−0.60	−0.47	0.08	0.12
Miscellaneous foods (4)	1.35	−0.03[f]	−0.15	−0.22	−0.19	0.41	−0.11	−0.07	−0.90	−0.56

[a]Summary statistics are only available for the D/LA/AIDS model and are not available for the DAIDS model.
[b]Sym indicates results are from the symmetric DAIDS model (i.e., $\gamma_{ij} = \gamma_{ji}$).
[c]NS indicates results are from the nonsymmetric D/LA/AIDS/H model previously reported in Table 5.7. The α_i values are generated according $\alpha_i = \alpha_i^* + \beta \log a_0$ are 0.186, 0.060, 0.081, and 0.160 for food groups one to four, respectively. Similarly, the values of $\alpha_i^* + \beta \log a_0 + {}_i^{**}q_{i,\,t-1}$ are 0.314, 0.197, 0.127, 0.335, respectively and sum to 0.973.
[d]Values in parentheses are t-statistics.
[e]Elasticities are calculated at the mean (1948-1978) values using the DAIDS formulas for the Sym results and the adjusted for the NS results. Per capita expenditures in the reference year 1972, a_0, are valued at $586.90.
[f]Calculations are based on β_i coefficient with $t > 2$.

6. CONCLUSIONS

This study analyzed U.S. consumer behavior for the period 1948-78 using the almost ideal demand system. While there exist many tradeoffs among the various allocation models, the almost ideal demand system appears to be a viable specification to examine consumption patterns. Theoretically, it is a flexible form and allows aggregation across consumers. This is particularly important since many market demand specifications do not possess the properties that individual utility maximizing demand functions have. The cost associated with this desirable property is that the class of preferences that give rise to the AIDS is rather restrictive. Empirically, the AIDS yielded plausible price and income elasticity estimates. For example, the own-price and expenditure elasticity estimates for food were - 0.42 and 0.36, respectively (Table 4.3). Magnitudes of other commodity elasticities also appeared reasonable when compared to previous demand studies and *a priori* reasoning.

The flexible nature of the AIDS allows the researcher to test for the restrictions of homogeneity, symmetry, persistences in consumption patterns, etc. Based on likelihood ratio tests, the dynamic form of the AIDS better captured the behavior of U.S. consumers over the period of investigation. The empirical analysis also indicated that the researcher should include autocorrelation as part of the maintained hypotheses.

APPENDIX 2

Conditions for the Dynamic Cost Function To Be Linearly Homogeneous of Degree One In Current Prices

The dynamic AIDS cost function is given by

$$\log c = \alpha_0 + \sum_k(\alpha_k^* + \alpha_k^{**}\, q_{kt-1})\log p_k + \tfrac{1}{2}\sum_k\sum_j \gamma_{kj}^* \log p_k \log p_j + u\beta_0\, \pi p_k^{\beta_k}. \quad (1)$$

In order for the dynamic cost function to be linearly homogeneous in current prices the following condition must hold:

$$\log c(u, \theta p) = \log \theta + \log c(u, p). \quad (2)$$

Now $\log c(u, \theta p) = \alpha_0 + \sum_k(\alpha_k^* + \alpha_k^{**}q_{kt-1})\log(\theta p_k) + \tfrac{1}{2}\sum_k\sum_j \gamma_{kj}^* \log(\theta p_k)\log(\theta p_j) + u\beta_0\, \pi(\theta p_k)^{\beta_k}$ (3)

$$= \alpha_0 + \sum_k(\alpha_k^* + \alpha_k^{**}q_{kt-1})\log p_k + \tfrac{1}{2}\sum_k\sum_j \gamma_{kj}^* \log p_k \log p_j$$

$$+ u\beta_0\, \pi p_k^{\beta_k}(\theta^{\Sigma\beta_k}) + \log\theta\sum_k(\alpha_k^* + \alpha_k^{**}q_{kt-1}) + \tfrac{1}{2}\log^2\theta\sum_k\sum_j\gamma_{kj}^*$$

$$\tfrac{1}{2}\log^2\theta\sum_k\sum_j\gamma_{kj}^*\log p_k + \tfrac{1}{2}\log^2\theta\sum_k\sum_j\gamma_{kj}^*\log p_j. \quad (4)$$

Equation (4) equals

$$\log\theta + \log c(u, p) \quad (5)$$

provided that

$$\sum_k\beta_k = \sum_k\gamma_{kj}^* = 0 \text{ and } \sum_k(\alpha_k^* + \alpha_k^{**}q_{kt-1}) = 1.$$

APPENDIX 3

The Adding-Up Property of the Dynamic AIDS

The dynamic AIDS

$$w_i = \alpha_i^* + a_i^{**}q_{it-1} + \sum_j\gamma_{ij}\log p_j + \beta_i\{\log x - \alpha_0$$

$$-\sum_k(\alpha_k^* + \alpha_k^{**}q_{kt-1})\log p_k - \tfrac{1}{2}\sum_k\sum_j\gamma_{kj}^*\log p_k\log p_j\} \quad (1)$$

can be summed over i giving rise to

$$\sum_i w_i = 1 = \sum_i\alpha_i^* + \sum_i\alpha_i^{**}q_{it-1} + \sum_i\Big[\sum_j\gamma_{ij}\log p_j\Big] \quad (2)$$

$$+ \sum_i\beta_i\{\log x - \alpha_0 - \sum_k(\alpha_k^* + \alpha_k^{**}q_{kt-1})\log p_k - \tfrac{1}{2}\sum_k\sum_j\gamma_{kj}^*\log p_k\log p_j\}.$$

$\sum_i w_i = 1$ implies that $\sum_i\alpha_i^* = 1$ and $\sum_i\gamma_{ij} = \sum_i\beta_i = \sum_i\alpha_i^{**}q_{it-1} = 0$.

APPENDIX 4

The Money Flexibility Coefficient of AIDS

Claim: The almost ideal demand system implies a money flexibility value of minus one:

Proof: Consider the indirect utility function associated with the almost ideal demand system. See Deaton and Muellbauer (1980a, p. 313). Minimizing the indirect utility function subject to a budget constraint yields the direct utility function. Mathematically, we have

$$\min V = \frac{[\log x - \alpha_0 - \sum_k \alpha_k \log p_k - \tfrac{1}{2}\sum_k\sum_j \gamma^*_{kj} \log p_k \log p_j]}{\beta_0 \, \pi p_k^{\beta k}}$$

$$\text{s.t.} \quad \sum_i p_i q_i = x.$$

However, we are only interested in the first order conditions. The Lagrangian function is

$$L = V + \lambda(\sum_i p_i q_i - x)$$

and the first-order conditions are

$$\frac{\partial L}{\partial x} = \frac{\partial V}{\partial x} - \lambda = 0 \qquad (1)$$

$$\frac{\partial L}{\partial p_i} = \frac{\partial V}{\partial p_i} - \lambda q_i = 0, \text{ and} \qquad (2)$$

$$\frac{\partial L}{\partial \lambda} = \sum_i p_i q_i - x = 0 \qquad (3)$$

From (1), $\lambda = \dfrac{1}{x\,\beta_0\,\pi p_k^{\beta k}}$. Thus,

$$\frac{\partial \lambda}{\partial x} = -\frac{\beta_0\,\pi p_k^{\beta k}}{(x\beta_0\,\pi p_k^{\beta k})^2} = -\frac{1}{x^2\,\beta_0\,\pi p_k^{\beta k}}$$

and

$$\frac{\partial \lambda}{\partial x}\cdot\frac{x}{\lambda} = -\frac{1}{x^2\,\beta_0\,\pi p_k^{\beta k}} \cdot \frac{x}{\dfrac{1}{x\,\beta_0\,\pi p_k^{\beta k}}} = -1.$$

[redacted]

4. Housing
5. Utilities
6. Transportation
7. Medical care
8. Durable goods
9. Other nondurable goods
10. Other services
11. Other miscellaneous goods.

The commodities that make up the meats commodity group in Tables 6 to 8 are:

m_1 Beef and veal
m_2 Pork
m_3 Fish
m_4 Poultry.

Similar to the eleven aggregate commodity groups, the contents of the four food commodity groups are described in section 3. The four food commodity groups referred to in Tables 10 to 13 are:

1. Meats
2. Fruits and vegetables
3. Cereal and bakery products
4. Miscellaneous foods.

Table 5.A.1

Personal Consumption Expenditures: Eleven Aggregate Commodity Groups

	Aggregate Commodity Group i											
Year	1	2	3	4	5	6	7	8	9	10	11	Total
	Millions of dollars											
1947	40,142	12,364	22,531	14,065	5,288	10,714	6,821	17,251	7,904	15,138	9,524	161,742
1948	42,717	11,909	24,010	15,851	6,077	11,858	7,754	19,735	8,607	16,000	10,231	174,749
1949	41,730	11,804	23,121	17,684	5,972	12,442	7,995	22,079	8,781	16,426	10,101	178,135
1950	42,998	12,141	23,437	19,657	6,697	13,242	8,618	27,405	9,628	17,670	10,473	191,966
1951	48,323	12,770	25,071	22,049	7,236	14,377	9,297	26,349	10,571	18,798	12,225	207,066
1952	50,835	13,655	26,160	24,522	7,560	15,519	10,058	25,412	10,630	19,645	13,097	217,093
1953	51,918	14,005	26,507	27,310	7,937	16,689	11,020	28,874	11,032	20,973	13,400	229,665
1954	53,376	13,809	26,707	29,698	8,504	17,083	11,906	28,297	11,074	22,091	13,297	235,842
1955	55,213	14,163	27,930	31,719	9,274	18,329	12,614	34,705	11,906	24,322	13,486	253,666
1956	57,758	14,773	29,169	33,965	9,948	19,734	13,679	33,688	12,610	26,443	14,241	266,008
1957	61,281	15,352	29,458	36,410	10,558	21,163	15,024	34,871	13,381	28,047	14,864	280,409
1958	63,977	15,732	29,810	39,000	11,219	21,983	16,337	32,213	13,867	29,677	15,646	289,461
1959	66,301	16,937	31,494	41,782	11,665	23,749	17,822	37,357	14,914	32,101	16,647	310,769
1960	68,133	17,504	32,171	44,737	12,152	25,198	19,244	37,962	15,853	34,681	17,268	324,903
1961	70,034	18,008	32,849	47,600	12,561	25,740	20,561	36,363	16,772	36,726	17,779	334,993
1962	71,630	18,768	34,347	50,977	13,179	27,127	22,448	40,928	18,474	38,494	18,845	355,217
1963	73,535	19,564	35,338	53,960	13,867	28,101	24,188	45,304	19,752	41,107	19,862	374,578
1964	77,978	20,117	38,213	57,164	14,521	29,426	27,120	49,757	21,275	43,810	20,998	400,379
1965	83,510	21,191	40,228	60,968	15,288	31,627	28,897	55,768	23,012	47,070	22,595	430,154
1966	90,042	22,503	43,927	64,727	16,156	34,371	31,262	59,823	25,847	51,397	24,737	464,792
1967	92,301	23,575	45,957	68,883	17,007	36,792	33,881	61,514	27,158	56,155	27,135	490,358
1968	99,982	25,056	50,073	74,348	18,073	39,766	37,458	71,067	29,898	61,098	29,115	535,934
1969	106,795	26,260	53,835	80,671	19,349	43,539	43,291	75,887	32,394	66,328	31,364	579,713
1970	115,827	28,523	55,458	87,483	20,848	47,689	48,595	74,942	34,710	70,891	33,830	618,796
1971	119,328	29,909	59,500	96,187	22,582	52,284	53,463	86,436	37,077	76,042	35,364	668,172
1972	127,811	31,994	64,739	105,019	25,125	56,578	59,875	99,544	40,884	82,730	38,732	733,031
1973	143,567	34,436	71,732	115,012	28,299	62,072	66,855	110,434	45,959	90,161	41,358	809,885
1974	163,007	36,793	76,255	127,212	33,654	74,015	75,301	107,646	50,855	99,365	45,498	889,601
1975	180,493	39,617	81,884	139,614	39,498	79,589	87,407	117,123	53,762	110,099	49,985	979,071
1976	195,623	43,033	88,950	154,319	45,084	89,135	99,315	140,007	58,144	121,871	54,386	1,089,867
1977	212,877	45,389	96,590	173,766	51,375	99,827	114,566	159,505	63,249	133,274	59,551	1,209,969
1978	235,168	48,848	107,559	197,086	56,568	110,539	128,745	178,322	70,913	150,917	66,100	1,350,765
1979	266,509	58,584	116,247	217,591	63,943	139,760	139,882	182,727	70,247	174,396	77,281	1,507,167
1980	297,850	64,363	124,321	245,248	75,572	168,855	160,610	179,373	76,720	192,251	86,029	1,667,192
1981	322,366	69,343	136,307	272,060	86,518	183,215	189,581	195,635	84,476	208,977	94,706	1,843,154

Table 5.A.2

Personal Consumption Expenditures (Constant 1972 Dollars): Eleven Aggregate Commodity Groups

Year	Aggregate Commodity Group i 1	2	3	4	5	6	7	8	9	10	11	Total
	Millions of 1972 dollars											
1947	71,698	22,092	36,069	27,416	9,002	24,972	15,958	26,388	12,795	41,904	17,897	306,191
1948	71,535	21,504	36,336	28,997	9,392	25,141	17,364	28,985	13,074	42,081	18,343	312,752
1949	72,784	21,373	36,216	30,993	9,059	24,815	17,924	32,350	13,883	41,694	18,916	320,007
1950	73,682	22,133	36,987	33,275	9,994	25,220	19,101	38,999	15,115	44,129	19,424	338,059
1951	75,150	22,628	36,316	35,870	10,562	25,948	20,099	35,710	15,382	44,160	20,487	342,312
1952	77,916	22,775	38,213	38,307	10,869	26,696	20,747	34,413	15,782	43,299	21,883	350,900
1953	80,662	23,142	38,632	40,489	11,121	27,262	21,659	38,627	16,299	43,789	22,538	364,220
1954	82,402	22,425	38,813	42,521	11,834	27,007	22,647	39,085	16,431	44,957	22,804	370,926
1955	86,348	23,000	40,690	44,789	12,678	28,524	23,380	47,305	17,351	47,708	23,324	395,097
1956	89,490	23,682	41,597	47,116	13,357	30,139	24,843	44,623	18,040	49,210	24,180	406,277
1957	91,742	24,082	41,349	49,581	13,821	31,045	26,212	44,167	18,484	49,661	24,557	414,701
1958	91,976	24,456	41,656	52,152	14,498	31,355	27,571	40,689	18,663	50,748	25,208	418,972
1959	95,936	25,420	43,557	55,090	14,779	32,922	29,196	45,510	19,848	53,268	25,956	441,482
1960	97,363	25,579	43,812	58,111	15,140	34,097	30,601	46,041	20,765	55,071	26,411	452,991
1961	98,931	26,095	44,420	61,056	15,364	34,518	31,885	43,679	21,657	57,823	26,816	462,244
1962	100,132	26,857	46,221	64,603	16,109	36,022	34,119	48,378	23,673	58,861	27,895	482,870
1963	101,330	27,514	47,029	67,688	16,856	37,270	36,237	53,019	24,927	60,755	28,743	501,368
1964	105,625	27,869	50,298	70,997	17,785	38,981	39,842	57,652	26,411	63,397	29,836	528,693
1965	110,478	28,751	52,416	74,967	18,636	40,448	41,357	64,899	28,402	66,487	31,270	558,111
1966	113,187	29,694	55,817	78,507	19,504	42,734	42,861	69,479	31,601	69,661	33,023	586,068
1967	115,166	29,887	56,068	82,077	20,281	44,522	43,893	70,109	32,371	73,681	35,111	603,166
1968	120,121	30,224	58,035	86,522	21,235	47,008	46,161	78,094	34,298	75,557	36,162	633,417
1969	122,053	30,141	59,019	90,932	22,301	49,318	50,166	81,408	35,795	77,418	36,865	655,416
1970	125,180	30,789	58,461	94,728	23,105	51,120	53,653	78,389	36,897	78,631	37,960	668,913
1971	125,649	30,835	60,801	99,506	23,479	53,314	56,029	87,271	37,856	79,703	37,501	691,944
1972	127,815	31,994	64,741	105,018	25,126	56,577	59,875	99,544	40,883	82,726	38,731	733,030
1973	126,108	34,298	69,318	110,266	26,330	59,427	63,599	108,498	44,876	86,296	37,918	766,934
1974	123,199	34,436	68,893	116,110	24,977	59,782	65,704	99,072	44,347	87,749	36,433	760,701
1975	126,551	34,471	71,175	121,162	26,017	60,328	67,010	99,246	41,423	90,725	36,454	774,562
1976	134,339	35,738	74,799	127,024	27,098	62,539	70,980	112,192	42,378	95,844	37,638	820,569
1977	139,922	36,344	78,216	134,929	28,004	64,911	74,744	122,724	43,707	100,380	37,817	861,698
1978	140,408	36,848	84,428	143,170	28,694	68,537	77,283	129,853	46,550	106,190	38,817	900,778
1979	146,189	40,451	87,837	147,201	28,212	74,037	82,497	125,944	43,072	111,203	40,956	927,599
1980	149,509	41,188	88,546	152,441	27,801	71,471	85,096	116,140	43,023	114,917	40,356	930,488
1981	151,161	41,233	93,752	155,641	28,098	70,298	89,158	117,946	43,745	116,241	40,392	947,656

Table 5.A.3

Implicit Price Deflators: Eleven Aggregate Commodity Groups and Population

Year	Aggregate Commodity Group i 1	2	3	4	5	6	7	8	9	10	11	Population
	1972 = 100.0											(Millions)
1947	56.0	56.0	62.5	51.3	58.7	42.9	42.7	65.4	61.8	36.1	53.2	144.1
1948	59.7	55.4	66.1	54.7	64.7	47.2	44.7	68.1	65.8	38.0	55.8	146.7
1949	57.3	55.2	63.8	57.1	65.9	50.1	44.6	68.3	63.3	39.4	53.4	149.3
1950	58.4	54.9	63.4	59.1	67.0	52.5	45.1	70.3	63.7	40.0	53.9	151.9
1951	64.3	56.4	69.0	61.5	68.5	55.4	46.3	73.8	68.7	42.6	59.7	154.0
1952	65.2	60.0	68.5	64.0	69.6	58.1	48.5	73.8	67.4	45.4	59.9	156.4
1953	64.4	60.5	68.6	67.5	71.4	61.2	50.9	74.8	67.7	47.9	59.5	159.0
1954	64.8	61.6	68.8	69.8	71.9	63.3	52.6	72.4	67.4	49.1	58.3	161.9
1955	63.9	61.6	68.6	70.8	73.2	64.3	54.0	73.4	68.6	51.0	57.8	165.1
1956	64.5	62.4	70.1	72.1	74.5	65.5	55.1	75.5	69.9	53.7	58.9	168.1
1957	66.8	63.7	71.2	73.4	76.4	68.2	57.3	79.0	72.4	56.5	60.5	171.2
1958	69.6	64.3	71.6	74.8	77.4	70.1	59.3	79.2	74.3	58.5	62.1	174.1
1959	69.1	66.6	72.3	75.8	78.9	72.1	61.0	82.1	75.1	60.3	64.1	177.1
1960	70.0	68.4	73.4	77.0	80.3	73.9	62.9	82.5	76.3	63.0	65.4	180.0
1961	70.8	69.0	74.0	78.0	81.8	74.6	64.5	83.3	77.4	63.5	66.3	183.0
1962	71.5	69.9	74.3	78.9	81.8	75.3	65.8	84.6	78.0	65.4	67.6	185.8
1963	72.6	71.1	75.1	79.7	82.3	75.4	66.7	85.4	79.2	67.7	69.1	188.5
1964	73.8	72.2	76.0	80.5	81.6	75.5	68.1	86.3	80.6	69.1	70.4	191.1
1965	75.6	73.7	76.7	81.3	82.0	78.2	69.9	85.9	81.0	70.8	72.3	193.5
1966	79.6	75.8	78.7	82.4	82.8	80.4	72.9	86.1	81.8	73.8	74.9	195.6
1967	80.1	78.9	82.0	83.9	83.9	82.6	77.2	87.7	83.9	76.2	77.3	197.5
1968	83.2	82.9	86.3	85.9	85.1	84.6	81.1	91.0	87.2	80.9	80.5	199.4
1969	87.5	87.1	91.2	88.7	86.8	88.3	86.3	93.2	90.5	85.7	85.1	201.4
1970	92.5	92.6	94.9	92.4	90.2	93.3	90.6	95.6	94.1	90.2	89.1	203.8
1971	95.0	97.0	97.9	96.7	96.2	98.1	95.4	99.0	97.9	95.4	94.3	206.2
1972	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	208.2
1973	113.8	100.4	103.5	104.3	107.5	104.5	105.1	101.8	102.4	104.5	109.1	209.9
1974	132.3	106.8	110.7	109.6	134.7	123.8	114.6	108.7	114.7	113.2	124.9	211.4
1975	142.6	114.9	115.0	115.2	151.8	131.9	130.4	118.0	129.8	121.4	137.1	213.1
1976	145.6	120.4	118.9	121.5	166.4	142.5	139.9	124.8	137.2	127.2	144.5	214.7
1977	152.1	124.9	123.5	128.8	183.5	153.8	153.3	130.0	144.7	132.8	157.5	216.4
1978	167.5	132.6	127.4	137.7	197.1	161.3	166.6	137.3	152.3	142.1	170.3	218.1
1979	182.3	144.8	132.3	147.8	226.7	188.8	169.6	145.1	163.1	156.8	188.7	224.6
1980	199.2	156.3	140.4	160.9	271.8	236.3	188.7	154.4	178.3	167.3	213.2	227.2
1981	213.3	168.2	145.4	174.8	307.9	260.1	212.6	165.9	193.1	179.8	234.5	229.3

Table 5.A.4

Budget Shares of Personal Consumption Expenditures: Eleven Aggregate Commodity Groups

	Aggregate Commodity Group i										
Year	1	2	3	4	5	6	7	8	9	10	11
1947	0.248	0.076	0.139	0.087	0.033	0.066	0.042	0.107	0.049	0.094	0.059
1948	0.244	0.068	0.137	0.091	0.035	0.068	0.044	0.113	0.049	0.092	0.059
1949	0.234	0.066	0.130	0.099	0.034	0.070	0.045	0.124	0.049	0.092	0.057
1950	0.224	0.063	0.122	0.102	0.035	0.069	0.045	0.143	0.050	0.092	0.055
1951	0.233	0.062	0.121	0.106	0.035	0.069	0.045	0.127	0.051	0.091	0.059
1952	0.234	0.063	0.121	0.113	0.035	0.071	0.046	0.117	0.049	0.090	0.060
1953	0.226	0.061	0.115	0.119	0.035	0.073	0.048	0.126	0.048	0.091	0.058
1954	0.226	0.059	0.113	0.126	0.036	0.072	0.050	0.120	0.047	0.094	0.056
1955	0.218	0.056	0.110	0.125	0.037	0.072	0.050	0.137	0.047	0.096	0.053
1956	0.217	0.056	0.110	0.128	0.037	0.074	0.051	0.127	0.047	0.099	0.054
1957	0.219	0.055	0.105	0.130	0.038	0.075	0.054	0.124	0.048	0.100	0.053
1958	0.221	0.054	0.103	0.135	0.039	0.076	0.056	0.111	0.048	0.103	0.054
1959	0.213	0.055	0.101	0.134	0.038	0.076	0.057	0.120	0.048	0.103	0.054
1960	0.210	0.054	0.099	0.138	0.037	0.078	0.059	0.117	0.049	0.107	0.053
1961	0.209	0.054	0.098	0.142	0.037	0.077	0.061	0.109	0.050	0.110	0.053
1962	0.202	0.053	0.097	0.144	0.037	0.076	0.063	0.115	0.052	0.108	0.053
1963	0.196	0.052	0.094	0.144	0.037	0.075	0.065	0.121	0.053	0.110	0.053
1964	0.195	0.050	0.095	0.143	0.036	0.073	0.068	0.124	0.053	0.109	0.052
1965	0.194	0.049	0.094	0.142	0.036	0.074	0.067	0.130	0.053	0.109	0.053
1966	0.194	0.048	0.095	0.139	0.035	0.074	0.067	0.129	0.056	0.111	0.053
1967	0.188	0.048	0.094	0.140	0.035	0.075	0.069	0.125	0.055	0.115	0.055
1968	0.187	0.047	0.093	0.139	0.034	0.074	0.070	0.133	0.056	0.114	0.054
1969	0.184	0.045	0.093	0.139	0.033	0.075	0.075	0.131	0.056	0.114	0.054
1970	0.187	0.046	0.090	0.141	0.034	0.077	0.079	0.121	0.056	0.115	0.055
1971	0.179	0.045	0.089	0.144	0.034	0.078	0.080	0.129	0.055	0.114	0.053
1972	0.174	0.044	0.088	0.143	0.034	0.077	0.082	0.136	0.056	0.113	0.053
1973	0.177	0.043	0.089	0.142	0.035	0.077	0.083	0.136	0.057	0.111	0.051
1974	0.183	0.041	0.086	0.143	0.038	0.083	0.085	0.121	0.057	0.112	0.051
1975	0.184	0.040	0.084	0.143	0.040	0.081	0.089	0.120	0.055	0.112	0.051
1976	0.179	0.039	0.082	0.142	0.041	0.082	0.091	0.128	0.053	0.112	0.050
1977	0.176	0.038	0.080	0.144	0.042	0.083	0.095	0.132	0.052	0.110	0.049
1978	0.174	0.036	0.080	0.146	0.042	0.082	0.095	0.132	0.052	0.112	0.049
1979	0.177	0.039	0.077	0.144	0.042	0.093	0.093	0.121	0.047	0.116	0.051
1980	0.176	0.039	0.075	0.147	0.045	0.101	0.096	0.108	0.046	0.115	0.052
1981	0.175	0.038	0.074	0.148	0.047	0.099	0.103	0.106	0.046	0.113	0.051

Table 5.A.5

Personal Consumption Expenditures for Food:
United States Department of Commerce (USDOC),
United States Department of Agriculture (USDA),
and New Estimates

Year	USDOC	USDA	New
	---------Millions of dollars---------		
1947	40,142	41,937	44,544
1948	42,717	44,805	47,548
1949	41,730	43,371	46,601
1950	42,998	43,992	47,192
1951	48,323	49,252	52,428
1952	50,835	50,932	54,692
1953	51,918	51,013	55,104
1954	53,376	51,140	54,776
1955	55,218	53,127	56,659
1956	57,758	55,548	58,903
1957	61,281	58,293	61,266
1958	63,977	60,994	64,381
1959	66,301	63,118	66,354
1960	68,133	66,881	69,153
1961	70,034	68,672	70,719
1962	71,630	71,317	73,436
1963	73,535	74,044	76,189
1964	77,978	77,504	78,613
1965	83,510	81,114	82,135
1966	90,042	86,923	87,827
1967	92,301	91,620	91,069
1968	99,982	96,789	96,223
1969	106,795	102,623	102,362
1970	115,827	110,590	109,820
1971	119,328	114,627	113,434
1972	127,811	122,192	121,200
1973	143,567	138,817	139,621
1974	163,007	154,617	160,264
1975	180,493	167,020	173,671
1976	195,623	183,301	183,224
1977	212,877	192,298	190,361
1978	235,168	215,961	213,513

Table 5.A.6

Price Indexes for Meat Items

Year	Meat Commodity Group i			
	m_1	m_2	m_3	m_4
	1972 = 100.0			
1947	50.5	66.8	45.3	128.4
1948	61.1	68.8	52.2	142.3
1949	57.0	63.7	52.5	134.1
1950	62.8	62.9	52.5	128.4
1951	73.4	66.7	58.8	134.6
1952	72.8	66.0	57.3	135.1
1953	57.3	73.4	55.1	131.7
1954	55.2	75.7	55.5	118.9
1955	54.6	65.2	54.3	123.8
1956	53.8	61.9	54.3	108.5
1957	57.8	71.3	55.0	105.8
1958	67.2	76.0	58.8	104.5
1959	69.2	67.6	59.8	95.3
1960	67.4	67.2	59.9	96.8
1961	66.3	70.3	61.2	87.4
1962	68.7	71.0	63.8	92.4
1963	67.9	69.2	63.6	90.9
1964	66.0	68.8	62.2	88.9
1965	69.1	78.4	64.0	91.7
1966	72.8	89.6	68.1	96.6
1967	73.2	82.2	70.5	90.6
1968	76.2	82.4	71.6	93.4
1969	83.8	89.7	75.5	98.7
1970	87.5	95.3	83.0	98.2
1971	91.4	86.3	91.8	98.7
1972	100.0	100.0	100.0	100.0
1973	119.9	133.0	114.7	140.2
1974	123.4	132.4	132.3	133.1
1975	124.5	161.9	143.3	147.1
1976	120.4	164.1	160.2	141.0
1977	119.8	155.3	177.3	141.9
1978	142.2	184.3	194.1	156.6

Table 5.A.7

Per Capita Consumption for Meat Items

Year	Meat Commodity Group i			
	m_1	m_2	m_3	m_4
	Pounds			
1947	64.8	64.7	10.3	21.7
1948	58.4	63.1	11.1	21.4
1949	58.6	63.0	10.9	22.9
1950	57.4	64.4	11.8	24.7
1951	50.3	66.8	11.2	26.1
1952	55.7	67.4	11.2	26.8
1953	69.9	59.1	11.4	26.7
1954	71.9	55.8	11.2	28.1
1955	72.4	62.1	10.5	26.3
1956	74.6	62.5	10.4	29.6
1957	72.8	56.8	10.2	31.4
1958	67.4	56.0	10.6	34.0
1959	66.8	62.8	10.9	35.2
1960	69.5	60.3	10.3	34.0
1961	70.5	57.6	10.7	37.3
1962	70.8	59.1	10.6	36.8
1963	74.0	61.1	10.7	37.6
1964	78.2	60.9	10.5	38.5
1965	77.9	54.7	10.8	40.7
1966	80.9	54.3	10.9	43.4
1967	82.0	59.8	10.6	44.9
1968	84.2	61.4	11.0	44.6
1969	84.7	60.6	11.2	46.6
1970	86.5	62.0	11.8	48.5
1971	85.8	68.2	11.5	48.7
1972	87.7	62.9	12.5	50.9
1973	82.6	57.6	12.9	49.2
1974	88.3	62.2	12.2	50.0
1975	92.5	51.2	12.3	49.2
1976	99.0	54.6	13.1	52.5
1977	96.4	56.7	12.9	54.1
1978	91.3	56.5	13.6	56.8

Table 5.A.8

Per Capita Personal Consumption Expenditures for Meat Items

Year	Meat Commodity Group i				Total
	m_1	m_2	m_3	m_4	
	---Millions of dollars---				
1947	39.8	36.6	5.4	12.6	94.4
1948	43.4	36.7	6.7	13.8	100.7
1949	40.6	34.0	6.6	13.9	95.2
1950	43.8	34.3	7.0	14.4	99.5
1951	44.9	37.7	7.6	15.9	106.1
1952	49.3	37.6	7.4	16.4	110.7
1953	48.7	36.7	7.3	16.0	108.7
1954	48.3	35.8	7.2	15.2	106.4
1955	48.1	34.3	6.6	14.8	103.7
1956	48.8	32.7	6.5	14.6	102.6
1957	51.1	34.3	6.5	15.1	106.9
1958	55.1	36.0	7.2	16.1	114.4
1959	56.2	35.9	7.5	15.2	114.9
1960	57.0	34.3	7.1	14.9	113.3
1961	56.9	34.3	7.6	14.8	113.5
1962	59.2	35.5	7.8	15.4	117.9
1963	61.1	35.8	7.9	15.5	120.3
1964	62.7	35.5	7.5	15.5	121.3
1965	65.5	36.3	8.0	16.9	126.6
1966	71.6	41.2	8.6	19.0	140.4
1967	73.0	41.6	8.6	18.5	141.7
1968	78.0	42.8	9.1	18.9	148.8
1969	86.3	46.0	9.8	20.9	163.0
1970	92.0	50.0	11.3	21.6	174.9
1971	95.4	49.8	12.2	21.8	179.2
1972	106.6	53.2	14.4	23.1	197.4
1973	120.4	64.8	17.1	31.3	233.6
1974	132.4	69.7	18.6	30.2	250.9
1975	140.0	70.1	20.3	32.9	263.3
1976	145.0	75.8	24.2	33.6	278.6
1977	140.4	74.5	26.4	34.9	276.1
1978	157.8	88.1	30.5	40.4	316.8

Table 5.A.9

Consumer Price Index for the Meat Group

Year	Published	New
	-----1972 = 100.0-----	
1947	59.6	60.8
1948	67.6	68.5
1949	64.0	64.5
1950	66.8	66.8
1951	74.7	74.5
1952	74.0	73.9
1953	70.0	67.8
1954	68.8	66.3
1955	64.7	63.0
1956	61.8	60.7
1957	67.0	65.8
1958	73.3	72.9
1959	70.5	70.5
1960	69.6	69.6
1961	69.8	69.3
1962	71.5	71.4
1963	70.4	70.3
1964	69.3	68.8
1965	73.8	73.7
1966	80.2	79.5
1967	78.1	77.5
1968	79.8	79.5
1969	86.6	86.5
1970	91.0	90.5
1971	91.3	90.8
1972	100.0	100.0
1973	125.3	125.3
1974	128.0	127.5
1975	139.1	136.9
1976	140.2	135.5
1977	139.4	134.9
1978	162.7	158.1

Table 5.A.10

Per Capita Personal Consumption Expenditures: Four Food Groups

Year	Food Commodity Group i: 1	2	3	4	Total
	---Millions of dollars---				
1947	92.5	53.3	41.5	123.2	310.5
1948	99.3	53.0	45.0	128.8	326.1
1949	94.4	54.4	45.1	121.0	315.0
1950	99.6	52.7	44.5	117.5	314.3
1951	106.4	60.2	48.1	132.8	347.5
1952	110.9	65.8	48.1	132.1	356.9
1953	112.2	64.6	47.8	132.2	356.8
1954	110.3	64.6	46.7	126.7	348.2
1955	106.5	68.5	46.9	130.0	351.9
1956	104.5	71.8	47.3	134.4	357.9
1957	108.9	73.7	50.8	132.4	365.8
1958	115.1	75.5	51.3	134.2	376.1
1959	114.9	77.9	53.1	134.3	380.2
1960	113.3	82.4	52.7	139.8	388.3
1961	114.3	82.9	52.9	141.2	391.3
1962	118.0	85.9	54.0	142.0	399.9
1963	120.4	86.6	55.1	146.5	408.7
1964	122.1	90.3	56.9	147.2	416.6
1965	126.9	92.8	58.7	150.6	428.9
1966	141.6	96.1	58.6	159.1	455.4
1967	142.9	99.0	63.7	162.0	467.5
1968	149.4	103.5	65.0	170.8	488.8
1969	163.1	107.5	65.3	178.3	514.2
1970	175.9	112.3	67.3	190.0	545.4
1971	180.2	118.9	75.0	182.4	556.5
1972	197.4	119.3	74.3	196.0	586.9
1973	233.6	137.5	82.7	217.1	670.8
1974	251.9	154.4	98.3	260.7	765.2
1975	267.5	168.6	114.2	275.4	825.7
1976	288.2	181.0	116.9	283.8	869.8
1977	285.3	193.9	120.7	295.9	895.8
1978	325.9	223.0	130.7	315.3	994.9

Table 5.A.11

Per Capita Personal Consumption Expenditures: Four Food Groups

Year	Food Commodity Group i: 1	2	3	4	Total
	---Constant 1972 dollars---				
1947	155.3	99.0	79.8	212.3	546.4
1948	146.9	95.6	78.4	207.5	528.4
1949	147.5	96.9	79.2	206.9	530.6
1950	149.1	97.9	76.8	197.1	520.9
1951	142.5	102.5	75.9	197.1	518.0
1952	149.8	101.9	74.2	196.6	522.5
1953	160.3	103.3	72.3	189.7	525.6
1954	160.3	104.9	68.9	179.4	513.5
1955	164.6	109.6	68.3	185.6	528.2
1956	169.0	109.4	67.8	188.8	535.1
1957	162.6	112.7	70.1	183.7	529.0
1958	157.0	107.9	69.5	190.1	524.5
1959	162.9	113.1	71.3	192.5	539.8
1960	162.8	116.7	69.5	196.1	545.1
1961	163.7	116.8	68.2	192.4	541.1
1962	165.0	120.2	68.1	195.8	549.2
1963	171.1	114.6	68.6	198.8	553.1
1964	176.2	115.1	70.6	193.7	555.6
1965	171.9	118.4	71.7	198.9	560.9
1966	176.6	120.0	68.8	200.6	565.9
1967	182.9	123.7	73.0	196.4	576.0
1968	187.3	119.9	74.3	200.5	582.0
1969	188.3	123.0	72.5	199.2	583.1
1970	193.3	123.8	70.9	197.2	585.2
1971	197.4	124.8	75.5	181.7	579.4
1972	197.4	119.3	74.3	196.0	586.9
1973	186.4	120.6	74.3	204.6	585.9
1974	196.8	116.4	67.9	202.7	583.8
1975	192.3	123.2	70.9	192.1	578.5
1976	205.5	129.0	74.2	178.8	587.5
1977	204.6	126.5	75.4	163.1	569.7
1978	200.3	130.9	75.0	169.7	575.9

Table 5.A.12

Implicit Price Deflators: Four Food Groups and Population

Year	Food Commodity Group i 1	2	3	4	Population
	----------------1972 = 100.0			----------------	(Millions)
1947	59.6	53.8	52.1	58.0	142.6
1948	67.6	55.4	57.4	62.1	145.2
1949	64.0	56.1	57.0	58.5	147.6
1950	66.8	53.8	58.0	59.6	150.2
1951	74.7	58.7	63.3	67.4	151.0
1952	74.0	64.6	64.8	67.2	153.3
1953	70.0	62.5	66.1	69.7	156.0
1954	68.8	61.6	67.7	70.6	159.1
1955	64.7	62.5	68.7	70.0	162.3
1956	61.8	65.6	69.7	71.2	165.4
1957	67.0	65.4	72.4	72.1	168.4
1958	73.3	70.0	73.8	70.6	171.5
1959	70.5	68.9	74.5	69.8	174.5
1960	69.6	70.6	75.9	71.3	178.1
1961	69.8	71.0	77.5	73.4	181.1
1962	71.5	71.5	79.2	72.5	183.7
1963	70.4	75.6	80.3	73.7	186.5
1964	69.3	78.5	80.6	76.0	189.1
1965	73.8	78.4	81.8	75.7	191.6
1966	80.2	80.1	85.2	79.3	193.4
1967	78.1	80.0	87.2	82.5	195.3
1968	79.8	86.3	87.5	85.2	197.1
1969	86.6	87.4	90.1	89.5	199.1
1970	91.0	90.7	94.9	96.3	201.7
1971	91.3	95.3	99.3	100.4	204.2
1972	100.0	100.0	100.0	100.0	206.5
1973	125.3	114.0	111.3	106.1	208.1
1974	128.0	132.6	144.8	128.6	209.7
1975	139.1	136.8	161.1	143.4	211.4
1976	140.2	140.3	157.5	158.7	213.0
1977	139.4	153.3	160.0	181.4	214.7
1978	162.7	170.3	174.3	185.8	216.6

Table 5.A.13

Budget Shares of Personal Consumption Expenditures:
Four Food Groups

Year	Food Commodity Group i 1	2	3	4
1947	0.298	0.172	0.134	0.397
1948	0.305	0.162	0.138	0.395
1949	0.300	0.173	0.143	0.384
1950	0.317	0.168	0.142	0.374
1951	0.306	0.173	0.138	0.382
1952	0.311	0.184	0.135	0.370
1953	0.314	0.181	0.134	0.371
1954	0.317	0.186	0.134	0.364
1955	0.303	0.195	0.133	0.369
1956	0.292	0.200	0.132	0.376
1957	0.298	0.201	0.139	0.362
1958	0.306	0.201	0.136	0.357
1959	0.302	0.205	0.140	0.353
1960	0.292	0.212	0.136	0.360
1961	0.292	0.212	0.135	0.361
1962	0.295	0.215	0.135	0.355
1963	0.295	0.212	0.135	0.359
1964	0.293	0.217	0.137	0.353
1965	0.296	0.216	0.137	0.351
1966	0.311	0.211	0.129	0.349
1967	0.306	0.212	0.136	0.347
1968	0.306	0.212	0.133	0.350
1969	0.317	0.209	0.127	0.347
1970	0.322	0.206	0.123	0.348
1971	0.324	0.214	0.135	0.328
1972	0.336	0.203	0.127	0.334
1973	0.348	0.205	0.123	0.324
1974	0.329	0.202	0.128	0.341
1975	0.324	0.204	0.138	0.334
1976	0.331	0.208	0.134	0.326
1977	0.318	0.216	0.135	0.330
1978	0.328	0.224	0.131	0.317

Table 6.A.1
Dynamic Linear Approximate Almost Ideal Demand System Estimates

Commodity group i		Estimated Coefficients[a]														
		α_i^*	α_i^{**b}	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	γ_{i9}	γ_{i10}	γ_{i11}	$\sum_j \gamma_{ij}$
Food	(1)	1.145	0.095	-0.126	0.1285	0.0106	-0.0138	-0.0059	-0.0508	0.0399	0.0114	-0.0421	0.0991	-0.0797	-0.0726	0.025
		(4.4)[c]	(3.1)	(-4.0)	(2.8)	(0.2)	(-0.3)	(-0.1)	(-1.5)	(1.1)	(0.2)	(-0.8)	(1.5)	(-2.7)	(-1.2)	
Alcohol plus tobacco	(2)	0.391	-0.032	-0.042	-0.0067	0.0308	-0.0108	-0.0282	0.0057	-0.0132	0.0138	0.0145	-0.0436	-0.0055	0.0321	-0.011
		(8.7)	(-1.1)	(7.8)	(-0.9)	(3.4)	(-1.4)	(-3.9)	(1.0)	(-2.1)	(1.5)	(1.5)	(-4.0)	(-1.1)	(2.9)	
Clothing	(3)	0.205	0.0313	-0.015	0.0149	0.0281	0.0475	-0.0039	0.0301	-0.0662	0.0269	-0.0270	-0.0219	-0.0457	-0.0072	-0.024
		(1.6)	(0.9)	(-1.0)	(0.7)	(1.1)	(2.0)	(-0.2)	(1.9)	(-3.7)	(1.0)	(-1.1)	(-0.7)	(-3.1)	(-0.2)	
Housing	(4)	1.208	0.326	-0.150	-0.0789	-0.0681	-0.0489	0.0880	-0.0548	0.0401	-0.0264	-0.0362	0.0053	0.0686	0.0753	-0.036
		(13.8)	(8.2)	(-12.6)	(-5.6)	(-4.1)	(-3.0)	(7.1)	(-5.2)	(3.5)	(-1.6)	(-2.1)	(0.3)	(7.6)	(3.8)	
Utilities	(5)	0.129	-0.025	-0.011	0.0024	-0.0263	0.0036	0.0155	0.0143	-0.0058	0.0020	-0.0165	0.0327	0.0096	-0.0169	0.015
		(2.8)	(0.6)	(-2.0)	(0.3)	(-2.7)	(0.4)	(2.0)	(2.4)	(-0.9)	(0.2)	(-1.7)	(2.7)	(1.6)	(-1.5)	
Transportation	(6)	0.382	0.087	-0.040	-0.0177	-0.0100	0.0282	-0.0301	0.0159	0.0348	-0.0009	0.0107	-0.0387	0.0268	-0.0027	0.016
		(7.2)	(3.1)	(-6.2)	(-1.9)	(-0.9)	(2.7)	(-3.2)	(2.1)	(4.2)	(-0.0)	(0.9)	(-2.7)	(3.9)	(-0.2)	
Medical care	(7)	0.300	0.138	-0.031	-0.0301	0.0028	-0.0164	-0.0049	-0.0080	-0.0179	0.0229	-0.0090	0.0248	0.0348	0.0221	0.021
		(2.6)	(2.8)	(-2.1)	(-1.6)	(0.1)	(-0.8)	(-0.3)	(-0.6)	(-1.1)	(1.0)	(-0.4)	(0.9)	(2.6)	(0.8)	
Durable goods	(8)	-3.406	-0.118	0.440	0.0521	-0.0030	0.2069	0.1508	0.1641	-0.0563	-0.1922	0.1079	-0.0538	-0.1511	-0.2266	0.001
		(-9.2)	(-4.7)	(9.7)	(0.8)	(-0.8)	(3.1)	(2.8)	(3.6)	(-1.1)	(-2.7)	(1.4)	(-0.6)	(-3.8)	(-2.7)	
Other nondurable goods	(9)	-0.068	0.083	0.013	-0.0083	-0.0095	-0.0234	-0.0319	-0.0092	0.0001	-0.0118	0.0148	-0.0052	0.0217	0.0330	-0.030
		(-0.9)	(3.3)	(1.4)	(-0.6)	(-0.6)	(-1.8)	(-2.5)	(-1.0)	(0.0)	(-0.8)	(0.9)	(-0.3)	(2.5)	(1.9)	
Other services	(10)	0.360	0.085	-0.034	-0.0278	-0.0442	-0.0321	-0.0675	-0.0140	0.0072	0.0485	-0.0127	0.0040	0.0864	0.0114	-0.042
		(2.8)	(2.2)	(-2.1)	(-1.3)	(-1.7)	(-1.4)	(-3.1)	(-0.9)	(0.4)	(1.8)	(-0.5)	(0.1)	(6.0)	(0.4)	
Other medical goods	(11)	0.306	-0.022	-0.030	-0.0041	0.0058	-0.0178	-0.0128	-0.0605	0.0465	0.0178	0.0018	0.0005	-0.0319	0.0552	-0.005
		(3.3)	(-0.3)	(-2.6)	(-0.3)	(0.3)	(-0.9)	(-0.8)	(-4.5)	(3.1)	(0.9)	(0.1)	(0.0)	(-3.0)	(2.4)	

[a]Based on seemingly unrelated regression (SUR) model. Data are given in Appendix 5.
[b]Actual coefficient is that shown times 10^{-3}.
[c]Values in parentheses are t-statistics.

Table 6.A.2
The Dynamic Linear Approximate Almost Ideal Demand System (Homogeneous and Nonsymmetric):
Estimates for the Eleven Commodity Groups, United States, 1948-1978.

Commodity group i		Estimated Coefficients[a]														
		α_i^*	α_i^{**b}	β_i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	γ_{i7}	γ_{i8}	γ_{i9}	γ_{i10}	γ_{i11}	$\sum_j \gamma_{ij}$
Food	(1)	1.160	0.096	-0.128	0.1128	-0.0053	-0.0220	-0.0193	-0.0540	0.0556	0.0225	-0.0692	0.0980	-0.0757	-0.0434	1.0
		(4.5)[c]	(3.1)	(-4.1)	(2.7)	(-0.1)	(-0.5)	(-0.5)	(-1.6)	(1.7)	(0.4)	(-1.5)	(1.5)	(-2.6)		
Alcohol plus tobacco	(2)	0.371	0.000	-0.040	0.0000	0.0382	-0.0067	-0.0201	0.0079	-0.0207	0.0067	0.0263	-0.0419	-0.0066	0.0169	1.0
		(7.7)	(0.0)	(6.9)	(0.0)	(4.2)	(-0.8)	(-2.8)	(1.3)	(-3.4)	(0.7)	(3.1)	(-3.6)	(1.2)		
Clothing	(3)	0.220	0.060	-0.018	0.0275	0.0477	0.0489	0.0140	0.0311	-0.0820	0.0089	-0.0026	-0.0147	-0.0460	-0.0328	1.0
		(1.6)	(1.4)	(1.1)	(1.3)	(1.9)	(2.0)	(0.7)	(1.8)	(-5.0)	(0.3)	(-0.1)	(-0.4)	(-3.0)		
Housing	(4)	1.096	0.215	-0.129	-0.0669	-0.0513	-0.0645	0.0984	-0.0594	0.0318	-0.0238	-0.0226	0.0103	0.0760	0.0720	1.0
		(11.0)	(9.3)	(-10.3)	(-4.2)	(-2.7)	(-3.5)	(6.8)	(-4.6)	(2.4)	(-1.2)	(-1.2)	(0.4)	(6.6)		
Utilities	(5)	0.140	-0.015	-0.013	-0.0068	-0.0353	-0.0017	0.0081	0.0122	0.0033	0.0087	-0.0322	0.0326	0.0112	-0.0001	1.0
		(2.6)	(0.3)	(-1.9)	(-0.8)	(-3.2)	(-0.2)	(1.0)	(1.7)	(0.5)	(0.8)	(-3.2)	(2.3)	(1.6)		
Transportation	(6)	0.389	0.112	-0.042	-0.0280	-0.0203	0.0201	-0.0343	0.0115	0.0464	0.0039	-0.0052	-0.0342	0.0264	0.0137	1.0
		(6.3)	(3.8)	(5.5)	(-2.8)	(-1.7)	(1.7)	(-3.2)	(1.4)	(5.7)	(0.3)	(-0.5)	(-2.0)	(3.4)		
Medical care	(7)	0.340	0.168	-0.037	-0.0428	-0.0149	-0.0179	-0.0149	-0.0113	-0.0051	0.0360	-0.0265	0.0222	0.0348	0.0404	1.0
		(2.8)	(3.5)	(-2.4)	(-2.4)	(-0.7)	(-0.8)	(-0.9)	(-0.8)	(-0.4)	(1.6)	(-1.2)	(0.8)	(2.5)		
Durable goods	(8)	-3.437	-0.112	0.444	0.0540	-0.0075	0.2130	0.1518	0.1651	-0.0560	-0.1917	0.1083	-0.0567	-0.1522	-0.2281	1.0
		(-9.6)	(-4.8)	(10.0)	(1.0)	(-0.1)	(3.3)	(3.1)	(3.8)	(-1.3)	(-2.9)	(1.8)	(-0.7)	(-3.9)		
Other nondurable goods	(9)	-0.072	0.104	0.013	0.0079	0.0091	-0.0161	-0.0114	-0.0049	-0.0198	-0.0247	0.0477	-0.0011	0.0146	-0.0013	1.0
		(-0.8)	(3.8)	(1.2)	(0.5)	(0.5)	(-1.0)	(-0.8)	(-0.4)	(-1.6)	(-1.4)	(2.8)	(-0.0)	(1.3)		
Other services	(10)	0.313	0.062	-0.027	-0.0025	-0.0206	-0.0159	-0.0521	-0.0088	-0.0176	0.0352	0.0353	0.0029	0.0788	-0.0347	1.0
		(2.0)	(1.5)	(-1.4)	(-0.1)	(-0.7)	(-0.6)	(-2.1)	(-0.5)	(-0.9)	(1.1)	(1.3)	(0.1)	(4.5)		
Other medical goods	(11)	0.307	0.012	-0.031	-0.0042	0.0068	-0.0222	-0.0109	-0.0581	0.0438	0.0142	0.0012	0.0053	-0.0314	0.0555	
		(3.4)	(0.1)	(-2.8)	(-0.3)	(0.4)	(-1.1)	(-0.8)	(-4.3)	(3.2)	(0.7)	(0.1)	(0.2)	(-3.0)		

[a]Based on seemingly unrelated regression (SUR) model with the price of group 11 excluded for homogeneous model. Data are given in Appendix 5.
[b]Actual coefficient is that shown times 10^{-3}.
[c]Values in parentheses are t-statistics.

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