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PRICE ELASTICITY ESTIMATES FROM CROSS SECTION AND PANEL DATA: A SURVEY

Zuhair A. Hassan and S. R. Johnson*

INTRODUCTION

Most of the existing estimates of price elasticities obtained in a demand systems context are from aggregate time series data. Results of such applications and systematic treatments of the alternative demand systems which have been developed for generating them are in fact widely available (e.g., Brandow, Brown and Deaton, Green, et al, Hassan and Johnson (1976a), Houthakker and Taylor, Phlips, Powell (1974), Theil). Models for generating these results use specialized utility functions argued to be more appropriate for aggregated commodity groupings. As well, the available time series data are in general not sufficiently rich to support reliable estimation of systems parameters at more disaggregated levels. For these reasons, the present focus of the applied and theoretical work using aggregated time series data seems to be on the generalization of static demand systems models to dynamic settings involving inventories, habitual consumption behavior, savings, etc. (Howe (1975a), Lluch (1973, 1974), Phlips, Powell (1974)).

Cross section and consumer panel data and particularly the former, have been used more for the study of income effects on consumer demand (Allen and Bowley, Prais and Houthakker). Studies in this area have concentrated on the estimation of Engel curve parameters, their variation across time and countries, specification and problems of estimation (Brown and Deaton, Cramer, Ferber (1962), Hassan and Johnson (1976b)). Conceptual problems associated with many aspects of Engel curve estimation remain but there is a wealth of applied work employing cross section and panel data at different levels of commodity aggregation, points in time and for different populations (Brown and Deaton, Ferber (1973), Hassan and Johnson (1977a), Hymans and Shapiro, Muellauer.

The present survey begins with a review of the more traditional Engel curve analysis and then concentrates on approaches to the estimation of demand parameters which use similar data sources. The approaches reviewed are: the extended linear expenditure system (ELES) as applied to cross section data, direct estimation of price elasticities on the basis of available variation within cross section data and the analysis of longitudinal panel data with modern demand systems.

*Zuhair A. Hassan is Economist, Economics Branch, Agriculture Canada and S. R. Johnson is Professor of Economics and Agricultural Economics, University of Missouri, Columbia.

The discussion is organized as follows. A general restatement of the consumer optimization problem is presented with a view toward possibilities for experimental control in cross section and panel studies. In the next section, this framework is applied for Engel curve estimation. The expenditure systems, direct estimation and demand systems based on panel data are taken up in the three sections which follow. The treatments of these approaches include specializations in theory, the basics of application and some sample results. A final section, explores possibilities for integration and extension of these approaches to the study of price effects on consumer behavior in less aggregated contexts.

CONSUMPTION THEORY AND FAMILY BUDGETS

As consumer panel and family survey data are for micro units, the classical theory of consumer demand can provide the basic framework for the analysis. According to the classical theory, the consumer or consumption decision unit is assumed to maximize utility, subject to a total budget constraint. First order conditions for the consumer maximization problem equate ratios of marginal rates of substitution to prices. Under reasonable analytical restrictions, these first order conditions can be solved for quantities demand as functions of all prices and income, i.e.,

$$(2.1) \quad q_i = q_i(p_i, p_2, \ldots, p_n, y)$$

for i = 1,2, . . .,n commodities and where q_i is the quantity demanded of the i^{th} commodity, p_i is the price of the i^{th} commodity and y is nominal consumer income. With familiar regularity conditions, the demand equations are homogeneous to degree zero in prices and income, satisfy the adding-up criterion, and have a matrix of substitution terms is symmetric and negative semi-definite (Phlip, Powell (1974)). The value of these results for empirical applications of demand theory is associated with improvements in efficiency which can result from their imposition and related possibilities for hypothesis testing (Christensen, et al.). However, even with the aforementioned restrictions additional specialization is necessary for theoretically consistent applications of the classical consumer demand model[1].

Additional restrictions necessary for applications of the classical theory have been imposed by using three general methods. These are restrictions on the utility function, restrictions on the demand function parameters and restrictions implied by experimental control

1 With these restrictions $(1/2)(n^2-n) - 1$ parameters are required to estimate the system of demand equations, even with the simplifying assumption that the equations shown in (2.1) are linear.

in the data. For the former, it has been shown that by assuming specialized algebraic forms for the utility function, systems of demand relationships which are tractable for estimation can be derived (e.g., Stone, Houthakker). Approaches following from restrictions on the demand functions themselves can be viewed as in two subclasses: one in which the parameter restrictions are consistent with those implied by the classical model and the other involving ad hoc considerations. The former are reviewed by Powell (1974). The double log formulation is a common example of the second type of specification.

The third classification, and the one of primary concern in this instance, relates largely to studies based on consumer-panel and family-survey data. With prices and/or other factors at quasi-controlled or controlled levels, the problem of estimating parameters of demand systems is greatly simplified. For example, if conditioned on constant prices, the n equations (2.1) are functions of income only. It is on the basis of this observation that the Engel curve estimates to be discussed in the subsequent section have been made.

The aforementioned three approaches to the estimation of price parameters for demand systems make different assumptions regarding the theory and experimental control. The ELES implies strong but identifiable assumptions on the utility function (Howe (1977), Phlips). The payoff for these assumptions is that price parameters for demand system can be estimated from data which include no price variation. The direct empirical approach relies on the fact that prices, though controlled in family budget studies, may vary from region to region or consumer to consumer, giving limited possibility for estimating price elasticities. Of course, the theoretical implications of the simplified demand functions employed in this context are not attractive when viewed in the systems framework. Finally, panel data although recorded in more artificial circumstances can allow for price variation and the use of demand systems concepts. With such variations, demand systems can be estimated which follow from a more controlled environment for extraneous factors than is likely the case for time series data.

ENGEL CURVES

The three approaches to the estimation of price parameters from cross section and panel data can be in a sense viewed as having evolved from studies of Engel curves. For this reason, it will be useful to review the status of the Engel curve estimation problem. Difficulties which remain with the estimation of Engel curves have implications for methods of obtaining price parameters from cross section and panel data. This follows since the income response is an important component for each of the approaches to the estimation of price effects.

Important problems which have been encountered in estimation of Engel curves relate to the income variable, family size and functional form. In the former case, actual or nominal income as recorded in the survey may not represent an accurate measure of income as perceived by the household. This has lead to attempts to find a suitable surrogate or to construct an income variable that reflects expectations for changes in the income stream and the life-cycle. Possibly, because researchers found expenditures more easy to measure, total expenditure was initially recommended as a substitute argument in Engel curve analysis. The fallacy in this approach was shown by Summers who argued that since expenditure on a particular commodity, the left-hand-side variable, is a component of total expenditure, the latter is itself random. The result is that ordinary least squares parameter estimates that have undesirable small and even large sample properties. Alternatively, difficulties with the use of nominal income as a right-hand-side variable were indicated by Friedman. Friedman showed that ordinary least squares estimators based on nominal income as a measure of unobservable "true" or permanent income are biased and inconsistent.

Two methods for handling this measure problem which have been widely used follow from the classical errors in variables (Johnston) and instrumental variables (Sargan) approaches. To formalize these two approaches, consider the equations:

$$(3.1) \quad e_i = a_{oi} + a_{1i}y^* + a_{2i}f + v_i$$

$$(3.2) \quad e = a_o + a_1y^* + a_2f + u$$

$$(3.3) \quad e = \Sigma_{i=1}^{n} e_i$$

where e_i is expenditure p_iq_i on commodity i, f is family size, y* is the permanent or "appropriate" income measure, e is total expenditure, the a's are parameters of the linear expressions and the structural disturbances are v_i and u. Thus, equation (3.1) is the customary, linear stochastic form of Engel curve conditioned for family size and equation (3.2) is the similarly conditioned household consumption function.

The equation of interest for the Engel curve analysis

$$(3.4) \quad e_i = b_{oi} + b_{1i}e + b_{2i}f + w_i.$$

For the structure given in equations (3.1), (3.2) and (3.3), the parameters in expression (3.4) can be expressed as $b_{oi} = a_{oi} - a_{1i} a_o/a_1$, $b_{1i} = a_{1i}/a_1$ and $b_{2i} = a_{2i} - a_{1i} a_2/a_1$. The Liviatan instrumental variables approach to the estimation of b_{1i} is to use y as an instrument for y* in equation (3.2). Consistent estimates of the parameters in equation (3.4) can then be obtained by using a two-stage procedure where e in equation (3.2) is estimated with the instrument y for y* and then itself used as an instrument for e in equation (3.4).

For the Friedman approach based on the classical errors in variables model, the estimation problems again are those associated with e and y*. Substituting e for y* in equation (3.1) and y for y* in equation (3.2) yields expressions which are of the classical errors in variables form,

(3.5) $e_i = d_{oi} = d_{1i}e + d_{21}f + v_i$ and,

(3.6) $e = d_o + d_1y + d_2f + u.$

Applying ordinary least squares to estimate the parameters for equations (3.5) and (3.6), it can be shown that a_{1i} from equation (3.1) is consistently estimated by the product of the estimates for d_{1i} and d_1, $d_{1i} \cdot d_1$ (Johnston). More modern rationalizations for the problem with the income measure exist (Zellner), but still estimates with only attractive large sample properties can be obtained.

The family size problem has also received considerable treatment in the literature. To appreciate the nature of this problem, observe that for the equations in this section, we have used f without adjusting for age on the commodity in question. Obviously, family members of different ages have different impacts on expenditure behavior (Cramer, Prais and Houthakker). Moreover, misspecification of this variable can effect the properties of the estimated income coefficient. Modern approaches to this problem are promising but involve substantial increases in the numbers of parameters to be estimated for a system of Engel curves, artificial age categorizations and frequently, restrictive assumptions about the similarity of family size effects across commodity groups (Cramer, Singh and Nagar).

Finally, the question of functional form is important for Engel curve estimation. Those most frequently employed are the double log, semi-log and linear functions. Each imposes important _a priori_ restrictions on the resulting income elasticity estimates. For example, in the double log formulation, the income elasticity is constant--not varying with income levels. Although there are reasonable rationalizations for the differing functional forms (Prais and Houthakker, Cramer, Brown and Deaton) a systematic empirical test which allows for discrimination among customary functional forms has not been applied (Benus, _et al_.).

Thus, although familiar in applied economics, the estimation of parameters for Engel curve remains a problem on which additional results would be welcomed. The fact that the estimates of price parameters which are obtained from cross section and panel data are conditioned as well on an income variable makes these problems with specification and estimation of even more consequence. The subsequent treatment of the alternative approaches to the estimation of price parameters will not dwell on these considerations but they are factors which can substantially effect the results and interpretations of applied studies of consumer behavior.

THE EXTENDED LINEAR EXPENDITURE SYSTEM AND CROSS SECTION DATA

Derivations of the ELES model are generally available and quite accessible (Phlips, Powell (1973)). For this reason, the current discussion emphasizes the application to cross section data and some sample empirical results.

ELES and Cross Section Estimation[2]

Lluch (1973, 1974) has shown that the intertemporal maximization of Klein-Rubin utility function leads to the following set of commodity expenditure equations

$$(4.1) \quad e_i = p_i q_i = p_i \gamma_i + \beta \mu_i (y^* - \sum_j p_j \gamma_j)$$

for i = 1,2, . . .,n where as before, e_i is expenditure on the i^{th} commodity, y^* again represents permanent income and the other variables are as previously defined. The parameters are β the marginal propensity to consume, μ_i the marginal budget share of the i^{th} commodity, and γ_i the minimum required quantity of the i^{th} commodity. For the i = 1,2, . . .,n, the parameters of equation (4.1) must satisfy the restrictions: $0 < \mu_i < 1$, $\sum_i \mu_i = 1$ and $p_i q_i - p_i \gamma_i > 0$.

Howe (1975a,b) has shown that a system parelleling that described in (4.1) can be obtained from a temporal maximization of Klein-Rubin utility function by introducing savings as a commodity with a zero subsistence level. This version of ELES can be written as

$$(4.2) \quad p_i q_i = p_i \gamma_i + \beta \mu_i (y - \sum_j p_j \gamma_j)$$

for i = 1,2,. . .,n and where y denotes current or observed income. Demographic effects can be incorporated into the ELES by first writing the expenditure equations as shown in the form

2 This section relies on the derivations contained in Howe (1975a, 1977) and Powell (1974).

$$(4.3)\quad e_{ih} = p_i q_{ih} = p_i \gamma_{ih} + \beta\mu_i (y_h - \sum_i \gamma_{ih} p_i)$$

where the new subscript h denotes the household or family unit. It is then assumed, albeit more arbitrarily than for the model developed to this point, that the minimum required quantities, γ_i's, depend linearly on a number of household characteristics; e.g.,

$$(4.4)\quad \gamma_{ih} = \sum_k \theta_{ik} X_{kh}$$

with the X_{kh}'s denoting the household characteristics assumed to condition γ_{ih} and the θ_{ik}'s the parameters determining the necessary consumption levels. Substituting equation (4.4) into equation (4.3) gives

$$(4.5)\quad e_{ih} = p_i \sum_k \theta_{ik} X_{kh} - \beta\mu_i \sum_i \sum_k \theta_{ik} X_{kh} p_i + \beta\mu_i y_h$$

or more simply,

$$(4.5a)\quad e_{ih} = \sum_k \alpha_{ik} X_{kh} - \beta\mu_i \sum_i \sum_k \alpha_{ik} X_{kh} + \beta\mu_i y_h$$

where $\alpha_{ik} = p_i \theta_{ik}$ is the value of the k^{th} characteristic's contribution to the subsistence expenditure for the i^{th} good or service. In reduced or more simplified form equation (4.5a) can be written as

$$(4.6)\quad e_{ih} = \sum_k \delta_{ik} X_{kh} + \mu_i^* y_h$$

with the newly defined parameters given by $\delta_{ik} = \alpha_{ik} - \beta\mu_i \sum_i \alpha_{ik}$ and $\mu_i^* = \beta\mu_i$. Equation (4.6) is easily recognized as being of the same form as those frequently used in estimating Engel curves from family budget data[3].

From equation (4.6) the derived estimate of the marginal propensity to consume, β, is obtained by

$$(4.7)\quad \Sigma\mu_i^* = \Sigma\beta\mu_i = \beta\Sigma\mu_i = \beta$$

Estimates for marginal budget shares are then obtained by dividing μ_i^* by β; i.e.,

$$(4.7a)\quad \mu_i^*/\beta = \beta\mu_i/\beta = \mu_i.$$

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3 Note the similarity between equation (4.6) and equation (3.1) which excepting for y* can be rewritten in the following form

$$e_{ih} = \Sigma\theta_{ik} X_{kh} + \theta_i y_h$$

here the X's represent the constant term and family size.

Finally, estimates for $\alpha_{ik} = p_i\theta_{ik}$ are computed using the expression $\delta_{ik} = \alpha_{ik} - \beta\mu_i\Sigma\alpha_{ik}$ are given by

$$(4.7b)\quad \alpha_{ik} = \delta_{ik} + \mu_i^*\Sigma\delta_{ik}/(1 - \beta)$$

Thus, parameters from equations used in estimating Engel curves conditioned for family size and perhaps other socioeconomic characteristics have implications for price effects on consumption within the ELES structure.

Example Application

Data used in the estimation of Engel curve parameters were from the 1972 Urban Family Expenditure Survey reported in Statistics Canada (1975). This household survey was conducted in February and March of 1973 and refers to the calendar year 1972. The major purpose of the survey was to provide information on families and unattached individuals living in private dwellings in eight Canadian urban centers: St. John's, Halifax, Montreal, Ottawa, Toronto, Winnipeg, Edmonton and Vancouver. Usable schedules were tabulated for 3,562 families and unattached individuals (Statistics Canada (1975, p. x)). Commodity groups analyzed were: food, shelter, household operation, household furnishings and equipment, clothing, personal care, medical and health care, smoking, alcoholic beverages, travel and transportation, recreation, reading, education and a miscellaneous group; a total of fourteen. Socio-economic partitionings afforded by the sample included: city, family cycle, class of tenure and education. For the present analysis these are suppressed.

The estimated structional parameters for the ELES and associated price elasticities were derived from Engel curves reported by Hassan and Johnson (1976b). The Engel curve parameters were estimated using ordinary least squares and nominal income. Structural parameter estimates are reported in Table 1. Associated elasticities computed at sample mean values are shown in Table 2[4]. Inspection of the results presented in Table 1 indicates that the marginal budget shares for each of the commodity groups are positive. These estimated marginal budgets shares sum to 1 and have relative magnitudes which appear reasonable on an intuitive basis. The estimated $\Sigma\alpha_{ik}X_{kh}$'s represent minimal expenditure levels for the various commodities, and as expected are all positive. For this application, the two conditioning variables for the γ_i's were, of course, family size and a constant.

4 A Fortran program provided by Howard Howe, Economist, Federal Reserve Bank of Governors, was used in calculating the structural parameters and the elasticities.

Table 1. Estimated Structural Parameters for the Extended Linear Expenditure System Applied to the Family Survey Data, 1972.

Commodity Group	Marginal Budget Share μ_i	Minimum Required Expenditure $\sum_k \alpha_{ik} X_{kh}$
Food	0.1350	1601.59
Shelter	0.1664	1463.90
Household Operation	0.0585	308.27
Furnishings & Equipment	0.0886	346.87
Clothing	0.1151	615.64
Personal Care	0.0233	167.78
Medical & Health Care	0.0337	214.33
Smoking	0.0091	167.98
Alcoholic Beverages	0.0401	167.59
Travel & Transportation	0.2063	1011.23
Recreation	0.0671	293.53
Reading	0.0083	47.85
Education	0.0207	68.06
Miscellaneous	0.0279	157.33

Table 2. Direct Price and Income Elasticities for the Extended Linear Expenditure System Applied to the Family Survey Data, 1972[a].

Commodity Group	Direct Price Elasticity	Income Elasticity
Food	-0.1861	0.4137
Shelter	-0.2334	0.5364
Household Operation	-0.2516	0.8144
Furnishings & Equipment	-0.3185	1.0160
Clothing	-0.2759	0.8061
Personal Care	-0.1861	0.6342
Medical & Health Care	-0.2097	0.7009
Smoking	-0.0812	0.2759
Alcoholic Beverages	-0.2851	0.9703
Travel & Transportation	-0.3323	0.8618
Recreation	-0.2883	0.9377
Reading	-0.2121	0.7503
Education	-0.3247	1.1419
Miscellaneous	-0.2261	0.7704

a Elasticities evaluated at sample means.

The income elasticity estimates for the ELES model are reported in column two of Table 2. The price elasticity estimates shown in Table 2 are negative as expected but in general somewhat lower than would be indicated by available estimates from time series data. For purposes of a more careful evaluation of the price and income elasticities results of time series studies with similar commodity groupings are provided in Table 3. The studies selected for the examination were: (1) For Canada an LES model applied to time series data for the period 1949-1968 (McIntosh), an LES model for the period 1947-1972 (Green, et al.), and an LES model applied for the postwar period 1940-1963 (Powell (1965)), and an LES model applied for the period 1947-1968 (Wales), and (2) for the U.S. long run estimates from a dynamic LES model applied by Weiserbs for the period 1927-1970 and reported in Phlips. More extensive information regarding LES model estimates across countries is available in Goldberger and Gameltsos.

The main concern, of course, with the price elasticity estimates and in this case the comparison supports only modestly favorable conclusions. For example, the cross section estimate for food is -.19 contrasted with a range from the time series studies summarized of from -.26 to -.53. In the case of furnishings and equipment, a similar comparison shows an estimate of -.32 from the cross section and from the time series studies estimates ranging from -.47 and -.90. Results of related examinations show the cross section estimates generally lower but importantly, in relative magnitude comparatively close to those obtained from the time series studies where price variations are observed.

AN EMPIRICAL APPROACH AND AVAILABLE PRICE VARIATION IN CROSS SECTIONS

The focus of this section is on the possibility of developing price elasticity estimates from family budget data by applying standard multiple regression techniques to simplified demand equations. Specifically, implicit prices[5] derived from expenditure and quantity data compiled in a household survey are investigated for information they contain regarding price effects on consumption patterns.

Data and Model

The data source for the study to be reviewed is the 1974 Urban Family Food Expenditure in Canada reported in Statistics Canada (1977). The survey was designed to produce income and expenditure information on families and unattached individuals living in private households in 14 major cities: St. John's, Halifax, Saint John, Montreal, Quebec

5 The implicit price, p_i, was derived by dividing expenditure on the i^{th} commodity by quantity on the i^{th} commodity which was purchased.

Table 3. Estimates of Price and Income Elasticities Using LES Models and Time Series Data for Canada and the United States.

Study	Time Period Country	Commodity Groups	Elasticities Price[a]	Elasticities Income
McIntosh (1974)	1949-1968 Canada	Food	- .26	.45
		Clothing	- .22	.51
		Housing	- .67	1.30
		Transportation, Communication	- .59	1.41
		Recreation, Education, Entertainment	- .58	1.19
		Health	- .35	- .69
		Miscellaneous	- .70	1.39
Hassan Green Johnson (1977)	1947-1972 Canada	Food	- .30	.40
		Tobacco and Alcohol	- .53	.80
		Clothing	- .43	.63
		Rent, Fuel, Household Expenses	- .86	1.30
		Furniture, Furnishings	- .47	.68
		Drugs, Sundries	- .81	1.29
		Transportation, Communication	- .83	1.25
		Recreation, Education, Entertainment	-1.30	2.18
		Personal Goods, Services	.71	1.07
Powell (1965)	1949-1963 Canada	Food	- .46	.58
		Tobacco, Alcohol	- .54	.79
		Clothing	- .52	.74
		Shelter	- .38	.51
		Household Expenses	-1.28	2.13
		Transportation	-1.37	2.32
		Personal, Medical	.05	- .07
		Miscellaneous	- .67	.97
Wales (1971)	1947-1968 Canada	Food	- .27	.31
		Clothing	- .24	.33
		Shelter	- .81	1.14
		Miscellaneous	-1.02	1.67
Weiserbs[b] Phlips (1974)	1929-1970 U.S.	Food	- .53	.58
		Clothing	- .97	1.04
		Autos and Parts	-1.35	1.65
		Furniture, Furnishings	- .90	.92
		Other Durables	-1.50	1.88
		Gasoline and Oil	-1.17	1.76
		Other Non-Durables	- .92	1.21
		Housing	-1.43	3.49
		Household Expenses	-1.38	2.23
		Transportation	- .87	1.03
		Other Services	.85	- .99

a Where information was specified uncompensated price elasticities were reported.
b Long run estimates, from the dynamic LES model.

City, Ottawa, Toronto, Thunder Bay, Winnipeg, Regina, Saskatoon, Calgary, Edmonton and Vancouver and was conducted to provide highly disaggregated expenditure data on food. From these survey data information on 98 food commodities were isolated for study. As well, the survey was taken over a time period sufficiently long and for cities sufficiently diverse that a reasonable amount of variation in implicit prices was available for study. A total of 5,245 families and unattached individuals cooperated in providing at least one usable weekly diary (Hassan and Johnson (1977b)).

Variations in price levels over the period of observation and across the cities thus present a basis for statistically isolating their effects on consumption patterns. Preliminary tests showed that price variation relative to income was present but that variations in relative prices of foods were more limited. Accordingly, only own price, income and family size were included as explanatory variables in the demand relationships estimated. A linear statistical model was used in the analysis of the sample data (Hassan and Johnson (1977a)); i.e.,

$$(5.1) \quad q_{ij} = a_{0i} + a_{1i}p_{ij} + a_{2i}y_j + a_{3i}f_j + \xi_{ij}$$

where the previously used notational conventions apply.

Sample Results

The results presented in Table 4 show clearly that the price variations that occurred within the sample period were sufficient to reliably estimate the coefficients necessary for computing the price elasticities. Only six of the ninety-eight estimated price coefficients used in deriving the elasticity estimates were not statistically significant at the five percent level. Except for two food items, both of which are fresh fruits, all the estimated price elasticities have the negative signs which the theory suggests and as well have relative magnitudes which appear intuitively reasonable. The extensive nature of the empirical results presented in Table 4 prohibits a detailed discussion of the various estimated elasticities and their implications. Instead the results from alternative time series studies are summarized in Table 5 for comparisons that those with special interests may wish to make.

In summary, the demand model and statistical methods although far from elaborate, produced price elasticity estimates which were plausible and surprisingly reliable. Estimated direct price elasticities were consistent with theory and where available, empirical estimates from time series data. The viability of these example results is particularly encouraging. They underscore the possibility of using sets of cross section data to estimate price elasticities in cases

Table 4. Direct Price Elasticities, Reporting Families, 1974.

Commodity	Price Elasticity	Commodity	Price Elasticity
Dairy Products		Pork	
Fresh Milk	-0.4697	Bacon	-0.6413
Lowfat Milk	-0.2687	Ham, smoked, cooked & uncooked	-1.6940
Skim Milk	-0.0344*	Cottage Roll, smoked picnic	-1.0351
Condensed Milk	-0.3746	Loin, fresh	-1.3445
Powdered Milk	-0.4243	Ham, fresh	-1.2984
Ice Cream	-0.7561	Shoulder, fresh	-1.2906
Butter	-0.9013	Sausage	-0.6675
Cheddar Cheese	-1.1932		
Processed Cheese	-0.7874	Veal	-0.9307
Cottage Cheese	-0.5701	Lamb & Mutton	-0.3603
		Canned Meats	-0.5239
Eggs		Chicken	-1.1682
Grade A Eggs	-0.6140	Turkey	-0.4466
Bakery & Cereal Products		Fish	
Bread	-0.1634	Cod, fresh, frozen, smoked	-1.6542
Breakfast Cereal, prepared	-0.6537	Halibut, fresh, frozen	-0.6389
Breakfast Cereal, unprepared	-0.4298	Salmon, fresh, frozen, smoked	-1.5708
Flour	-0.7460	Canned Salmon	-0.7654
Rice	-1.1745	Canned Tuna	-0.9545
Beef		Fats and Oils	
Loin Cuts	-1.4286	Margarine	-0.5784
Round Cuts	-1.6788	Vegetable Shortening	-1.5838
Rib Cuts	-1.1547	Lard	-0.3944*
Shoulder Cuts	-1.1835	Corn Oil	-0.7633
Brisket Flanks	-0.4405	Salad Dressing	-1.0557
Stewing Beef	-1.6459	Peanut Butter	-1.3003
Hamburger	-1.0549		

*Indicates regression coefficients are not significant at five percent by two-tailed t-test.

Table 4 (continued)

Commodity	Price Elasticity
Beverages	
Coffee, regular, instant	-1.1728
Tea, all kinds	-0.3169
Soft Drinks	-0.7626
Miscellaneous Groceries	
Sugar	-0.1611
Molasses, Honey, Syrup	-0.4167
Canned and Dried Fruits	
Canned Peaches	-1.0135
Canned Pears	-0.8088
Canned Pineapple	-1.0639
Canned Cherries	-0.3019*
Canned Plums	-0.6819*
Canned Apple Juice	-0.6200
Canned Orange Juice	-0.3799
Raisins	-0.9356
Canned and Dried Vegetables	
Canned Peas	-0.8070
Canned Corn	-0.7603
Canned Baked Beans	-0.8810
Canned Tomatoes	-0.6832
Canned Tomato Juice	-0.7375
Fresh Fruits	
Oranges	-0.7133
Bananas	-0.4021
Apples	-0.9006
Grapefruits	-0.7079
Strawberries	-1.5947
Raspberries	0.3167*
Grapes	0.1820*
Peaches	-1.3292
Melons	-0.4189
Cherries	-1.2423
Plums	-0.8115
Pears	-0.8280
Fresh Vegetables	
Potatoes	-0.8448
Tomatoes	-1.5190
Lettuce	-0.3731
Carrots	-0.5207
Celery	-0.2940
Onions	-0.9264
Cabbage	-0.5834
Cauliflower	-0.4834
Turnips	-0.6374
Beans, green and yellow	-0.8389
Corn	-1.0179
Cucumbers	-0.7820
Mushrooms	-1.0083
Frozen Foods	
Strawberries	-0.3698*
Raspberries	-0.9753*
Orange Juice	-0.5296
Peas	-0.6392
Green Beans	-0.7296
Potatoes	-0.3711
Corn	-0.4256
Prepared Dishes	
Instant Mashed Potatoes	-1.2552
Snack Foods	-0.7483

*Indicates regression coefficients are not significant at five percent by two-tailed t-test.

Table 5. Direct Price Elasticities From Time-Series Data.

Source	Period	Direct Price Elasticity
	--Lamb--	
Tryfos & Tryphonopoulos (1973)	1954-1970	-1.801
Reimer & Kulshreshtha (1974)	1949-1971	-1.0426
Hassan & Johnson (1976a)	1957-1972	-1.866
	--Veal--	
Tryfos & Tryphonopoulos (1973)	1954-1970	-1.40
Reimer & Kulshreshtha (1974)	1949-1971	-1.330
Hassan & Johnson (1976a)	1954-1972	-2.593
	--Chicken--	
Yankowsky[a] (1970)	1949-1969	- .56
Reimer & Kulshreshtha[a] (1974)	1949-1971	- .4023
Hassan & Johnson (1976a)	1957-1972	- .5637
	--Turkey--	
Hassan & Johnson (1976a)	1957-1972	-1.090
	--Fluid Milk--	
Perkins, *et al.*[b] (1969)	1957-1966	- .276
Sahi & Harrington (1974)	1958-1972	- .32
Hassan & Johnson (1976a)	1958-1972	- .439
	--Butter--	
Perkins, *et al.* (1969)	1957-1966	-1.242
Sahi & Harrington (1970)	1958-1972	-1.05
Hassan & Johnson (1976a)	1950-1972	- .8583
	--Cheese--	
Perkins, *et al.* (1969)	1957-1966	- .913
Sahi & Harrington (1974)	1958-1972	- .55
Hassan & Johnson (1976a)	1958-1972	- .9077
	--Skim Milk Powder--	
Perkins, *et al.* (1969)	1957-1960	- .324
Sahi & Harrington (1974)	1958-1972	- .23
Hassan & Johnson (1976a)	1958-1972	- .1924
	--Margarine--	
Hassan & Johnson (1976a)	1950-1972	- .6276
	--Lard--	
Hassan & Johnson (1976a)	1950-1972	- .4628
	--Shortening--	
Hassan & Johnson (1976a)	1950-1972	- .9680
	--Sugar--	
Hassan & Johnson (1976a)	1950-1972	- .0805
	--Coffee--	
Hassan & Johnson (1976a)	1950-1972	- .3726

a Poultry
b Fluid milk and cream

where time series data to support the estimation of the necessary price coefficients at such a disaggregated level simply are not available. Even if available, the time series data are likely to be collinear in prices and income, making the statistical isolation of the required coefficients a difficult and unreliable process. As well the approach can produce estimates of demand parameters at highly disaggregated levels.

DEMAND SYSTEMS AND PANEL DATA

There are numerous issues regarding the design, collection and analysis of data from longitudinal panel studies that could be discussed in the present context. In fact, the design, collection of panel data and merging of data files has been the focus of a recent NBER conference (Ferber (1974)). The conference included papers merging or linking of data files (Alter), analysis of recall (McWhinney and Champion), compensation (Ferber and Seymore), etc. A more recent study summarizing some of these methodological issues in the analysis of longitudinal surveys has been published by Singer and Spilerman. These papers focus on improving the quality of panel data and establishing a stronger basis for their generalization to tests of the theory and policy contexts.

From the viewpoint of economic analysis, longitudinal panel data have been used to study several problems which have at least tangential relationships to consumer demand. Examples of these studies are those on mobility and discrimination (McCall), income dynamics (Morgan and Smith) and microsimulation of household behavior (Guthrie, *et al*.). The latter is, in fact, an approach to which the current discussion will return when reviewing potentially productive areas for additional research.

The most extensive application of demand systems concepts to longitudinal panel data appears to have been made by Benus, *et al*. Other less ambitious but relevant studies of panel data are those by Boehm and Havlicek and Hymans and Shapiro. The latter focuses on low income households and relates the income elasticity of demand for food to income by source. These results demonstrate the flexibility and specialization which is possible through the use of panel data. The present discussion will concentrate on the work of Benus, *et al*., since it involves an explicit demand system. As in the two previous sections, first the model and data will be reviewed and then example results will be presented.

Data and Model

Data for the Benus, et al. were from a panel study of income dynamics covering the period 1968-1972. The panel involved some 5,000 U.S. households and included income by source, expenditures and socio-economic and demographic characteristics of the consuming units (Morgan). The model applied is that for the LES--similar to the one show in equation (4.1). Two variations on this basic model were explored, a functional form analysis representing a rather cursory marriage of the work of Box and Cox, and Ramsey, and a habit persistence or partial adjustment hypothesis of conventional form (Phlips). The partial adjustment mechanism was specified using desired and actual food expenditures,

$$(6.1) \quad e_{ijt} - e_{ijt-1} = \phi\,(e^*_{ijt} - e_{ijt-1}) + \omega_{ijt}$$

with e^*_{ijt} the equilibrium or desired expenditure of the j^{th} family unit at time t and ω_{ijt} a stochastic term with the usual properties. With income by source--basic, transfer, food subsidy--and prices for food, housing, clothing, transportation, and health and recreation (obtained from the Consumer Price Index specialized by SMSA) along with five family size classifications and the adjustment coefficient, the model in the form used for estimation was quite complex. Thus, much more detail was included than would appear feasible for estimation from available aggregate time series.

Sample Results

The analysis of the panel data produced adjustment coefficient in the neighborhood of one-half. For food, the short and long run price elasticities evaluated at mean values for the sample were -2.22 and -3.14, respectively. These results for food are higher than those indicated by aggregate time series studies (Table 3). The steady state elasticity of food expenditure with respect to basic income was approximately .2. This is at the low end of estimates obtained in Engel curve studies and in time series analysis of aggregates (Table 2, 3).

Thus, the results from this particular panel study are in many respects at variance with those presently available. There were numerous sources of data problems, especially with prices used in this study, and perhaps an overly ambitious model specification. The fact remains, however, that the comprehensive analyses of panel data can produce estimates of price and income parameters not found in the available applied literature. More testing and applied work will be necessary before conclusions regarding the appropriateness of this approach and associated results can be made. In the meantime, the more direct methods of utilizing panel data for studying consumer behavior should continue to supply useful results (Boehm and Havlicek).

CONCLUSIONS AND IMPLICATIONS

The theme which emerges from this treatment of results from data sources which can support disaggregated estimation of demand parameters is that all are potentially productive for tests of the theory and the generation of results for policy. Additionally, it would appear that there is much room for integration. This could first come with something as simple as the introduction of extraneous information from one type of study to another. The Mixed Estimation framework for accomplishing this on a statistical basis is already in place and since each approach proports to estimate the same price and income parameters the application is consistent with the model specifications.

More extensive integration of the approaches is, of course, possible. In this respect, some of the work on merging the files from family budget and perhaps panel studies could substantially increase available data bases. On a theoretical plane, work on developing more systematic hypothesis regarding the inclusion of socioeconomic variables and time related factors is needed. Microsimulation models (Guthrie, et al.) may have some useful implications in this regard as well as in providing results which can be applied in an aggregated context. Finally, the old problems of functional form, and family size and appropriate income measure, although widely analyzed empirically, are still without conclusive answers. In short, though there has been a comparable explosion of published empirical and theoretical work on demand analysis in recent years, it has served only to show how very little we knew and know now about basic demand parameters at levels of disaggregation required for example, by modern food policies.

REFERENCES

Allen, R. G. D. and A. L. Bowley. Family Expenditures, London: Staples Press, 1935.

Alter, Horst. "Creation of a Synthetic Data Set by Linking Records of the Canadian Survey of Consumer Finances with the Family Expenditure Survey 1970," Annals of Economic and Social Measurement, 3(1974):373-394.

Benus, J., J. Kmenta and H. Shapiro. "The Dynamics of Household Budget Allocation to Food Expenditure," The Review of Economics and Statistics, 57(1976):129-138.

Boehm, W. T. and J. Havlicek, Jr. "The Estimation of Price Elasticities from Panel Data," paper presented at the American Agricultural Economics Association Annual Meeting, Columbus, Ohio, August 1975.

Box, G. E. P. and D. R. Cox. "An Analysis of Transformations," Journal of the Royal Statistical Society, B, 26(1964):211-243.

Brandow, G. E. "Interrelationships Among Demands for Farm Products and Implications for Control of Market Supply," Pennsylvania Agricultural Experiment Station Bulletin 680, University Park, 1961.

Brown, J. A. C. and A. Deaton. "Surveys in Applied Economics: Models of Consumer Behavior," The Economic Journal, 82(1972):1145-1236.

Christensen, L. R., D. W. Jorgenson and L. J. Lau. "Trancendental Logarithmic Utility Functions," American Economic Review, 65(1975):367-383.

Cramer, J. S. Empirical Econometrics, Amsterdam: North Holland Co., 1971.

Ferber, R. "Consumer Economics: A Survey," Journal of Economic Literature, 9(1973):1303-1342.

________. "Consumer Expenditure and Price Data," Annals of Economic and Social Measurement, 3(1974):299-306.

________. "Research on Household Behavior," American Economic Review, 52(1962):19-63.

Ferber, R. and Sudman Seymore. "Effects of Compensation in Consumer Expenditure Studies," Annals of Economic and Social Measurement, 3(1974):319-332.

Friedman, M. A Theory of the Consumption Function, Princeton, National Bureau of Economic Research, 1957.

Goldberger, A. S. and T. Gameltsos. "A Cross Country Comparison of Consumer Expenditure Patterns," European Economic Review, 1(1970:357-400.

Green, Richard, Zuhair A. Hassan and S. R. Johnson. "Alternative Estimates of Static and Dynamic Demand Systems: A Comparison Based on Canadian Data," American Journal of Agricultural Economics, 60(1978), (forthcoming).

Guthrie, Harold W., Guy H. Orcutt, Steven Caldell, Gerald Peabody and George Sadowsky. "Microanalytic Simulation of Household Behavior," Annals of Economic and Social Measurement, 2(1972):141-170.

Hassan, Zuhair A. and S. R. Johnson. Consumer Demand for Major Foods in Canada, Economics Branch, Agriculture Canada, April 1976a.

___________. "Direct Price Elasticity Estimated from Family Budget Data," Canadian Journal of Agricultural Economics, 25(1977a), (forthcoming).

___________. Family Expenditure Patterns in Canada, Economics Branch, Agriculture Canada, June 1976b.

___________. Urban Food Consumption Patterns in Canada, Economics Branch, Agriculture Canada, January 1977b.

Houthakker, H. S. "Additive Preferences," Econometrica, 27(1960):244-257.

Houthakker, H. S. and L. D. Taylor. Consumer Demand in the United States, 2nd ed., Cambridge, Mass: Harvard University Press, 1970.

Howe, Howard. "Cross-Section Application of Linear Expenditure Systems: Responses to Sociodemographic Effects," American Journal of Agricultural Economics, 59(1977):141-148.

___________. "Development of the Extended Linear Expenditure System From Simple Savings Assumptions," European Economic Review, 6(1975a): 305-310.

___________. Properties of Linear and Quadratic Expenditure Systems: Relevance for Cross-Section Analysis," mimeo., Board of Governors of the Federal Reserve System, October 1975b.

Hymans, S. H. and H. T. Shapiro. "The Allocation of Household Income to Food Consumption," Journal of Econometrics, 4(1976):167-188.

Johnston, J. Econometric Methods, 2nd ed., New York: McGraw-Hill, 1972.

Klein, L. R. and H. Rubin. "A Constant-Utility Index of the Cost of Living," Review of Economic Studies, 15(1947-48):84-87.

Kulshreshta, S. N. "The Demand for Major Fruits and Vegetables in Canada," Canadian Journal of Agricultural Economics, 18(1970):52-59.

Liviatan, N. "Errors in Variables and Engel Curve Analysis," Econometrica, 39(1971):336-362.

Lluch, C. "Expenditure, Savings and Habit Formation," International Economic Review, 15(1974):786-797.

________. "The Extended Linear Expenditure System," European Economic Review, 4(1973):21-32.

McCall, John J. Income, Mobility, Racial Discrimination, and Economic Growth, Lexington, Mass: D. C. Heath and Co., 1973.

McIntosh, C. E. "Canadian Food Expenditures in 1980," Canadian Journal of Agricultural Economics, 22(1974):45-51.

McWhinney, Isabel and Harold E. Champion. "The Canadian Experience With Recall and Diary Methods in Consumer Expenditure Surveys," Annals of Economic and Social Measurement, 3(1974):411-435.

Morgan, J. ed. Five Thousand American Families--Patterns of Economic Progress, I and II, Ann Arbor, Mich: Institute for Social Research, 1974.

Morgan, James N. and James D. Smith. A Panel Study of Income Dynamics, Ann Arbor, Mich: Institute for Social Research, 1969.

Muellauer, J. "Household Composition, Engel Curves and Welfare Comparisons Between Households," European Economic Review, 4(1974):103-122.

Perkins, B. B., J. H. Clark and R. G. Marshall. Canadian Dairy Policies, A Report to the Federal Task Force on Agriculture, Ottawa, January 1969.

Phlips, Louis. Applied Consumption Analysis, Amsterdam: North-Holland Publishing Co., 1974.

Powell, Alan A. Empirical Analytics of Demand Systems, Lexington, Mass: D. C. Heath and Co., 1974.

_____________. "Estimation of Lluch's Extended Linear Expenditure System From Cross Section Data," Australian Journal of Statistics, 15(1973).

______________. "Post-War Consumption in Canada: A First Look at Aggregates," Canadian Journal of Economics and Political Science, 31(1965):559-565.

Prais, S. J. and H. S. Houthakker. The Analysis of Family Budgets, Cambridge, Mass: The Cambridge University Press, 1955.

Ramsey, J. B. "Limiting Functional Forms for Market Demand Curves," Econometrica, 40(1972):327-341.

Remier, E. W. and S. N. Kulshreshtha. Forecasting Livestock Production and Feed Grains Demand: An Econometric Analysis of Canadian Livestock Feed Grains Sector, Technical Bulletin 74-04, Department of Agricultural Economics, University of Saskatchewan, Saskatoon, February, 1974.

Sahi, R. K. and D. Harrington. "A Note on Econometric Simulation Model for Canadian Dairy Industry," Canadian Journal of Agricultural Economics, Proceedings of the 1974 CAES Workshop, Ottawa, August 1974.

Sargan, J. D. "The Estimation of Economic Relationships Using Instrumental Variables," Econometrica, 36(1958):27-56.

Singer, Burton and Seymour Spilerman. "Some Methodological Issues in the Analysis of Longitudinal Surveys," Annals of Economic and Social Measurement, 5(1976):447-474.

Singh, B. and A. L. Nagar. "Determination of Consumer Unit Scales," Econometrica, 41(1973):347-356.

Statistics Canada. Urban Family Expenditure Survey, 1972, Catalogue 62-541, Ottawa, 1975.

________________. Urban Family Food Expenditure in Canada, 1974, Catalogue 62-542, Ottawa, 1977.

Stone, J. R. N. "Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand," The Economic Journal, 64(1954):511-527.

Summers, R. "A Note on Least Squares Bias in Household Expenditure Analysis," Econometrica, 37(1959):121-126.

Theil, H. Economics and Information Theory, Amsterdam: North-Holland Publishing Co., 1967.

Tryfos, P. and N. Tryphonopoulos. "Consumer Demand for Meat in Canada," American Journal of Agricultural Economics, 55(1973):647-652.

Wales, T. J. "A Generalized Linear Expenditure Model of the Demand for Non-Durable Goods in Canada," The Canadian Journal of Economics, 4(1971):471-484.

Yankowsky, Z. "The Intermediate and Long Term Market Outlook for Canadian Beef," Canadian Journal of Agricultural Economics, Proceedings of the 1970 CAES Workshop, (1970):53-70.

Zellner, A. "Estimation of Regression Relationships Containing Unobservable Variables," International Economic Review, 9(1970):441-454.