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NEW DEVELOPMENTS IN FOOD CONSUMPTION ANALYSIS

An Appraisal of the Strengths and Weaknesses of the
Econometric Approach*

by

Gordon A. King
University of California, Davis, California

The econometric approach presupposes the use of economic theory, mathematics and statistics for use in understanding and predicting consumer demand for food. In empirical analyses of time series, survey, or panel data, problems arise as to the appropriate economic model, the mathematical form of the relationship among variables, the statistical model itself, and in related measurement problems such as multicollinearity and autocorrelated error terms. This paper will focus on recent developments in the formulation of the economic models, omitting important areas of interest relating to specification analysis and alternative statistical estimating techniques.

GUIDELINES FROM ECONOMIC THEORY

In empirical analyses, we are immediately confronted with aggregation problems and with changes over time in the structure of the demand for food and related marketing services. Although our present body of economic theory does not provide us with precise theorems for handling these admittedly difficult problems, it does provide important guidelines especially if additional assumptions are added to the basic theorems. As Houthakker recently pointed out: "From the view of empirical research

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such special theorems are often of greater importance than the general axioms."^{1/}

The theory of consumer choice may be stated in terms of consumer income and prices and quantities of all goods.^{2/} Such a system of equations, however, is not subject to quantification. It is possible to aggregate commodities into groups if, for example, the relative prices of a subset remain constant. Recent work has developed conditions under which it is possible to analyze these subaggregates, involving the concept of "separably additive" utility functions.^{3/} Frisch has used this idea of want-structure independence and the idea of the representative individual in providing a framework for estimating a complete set of demand elasticities for market data.^{4/} Brandow has utilized the idea of want-independence between nonfood and individual food items in setting values for the nonfood price elasticity coefficients in his recent study of demand for farm products and is an excellent example of how such special theorems may be highly useful in econometric analyses.^{5/}

In studying the dynamic aspects of consumer demand, we find theoretical guidelines less helpful. We share problems with economists studying supply response in that technological change has taken place both in production

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^{1/} Houthakker, H. S., "The Present State of Consumption Theory," Econometrica, 29(4):704-740, October 1961.

^{2/} See Samuelson, Paul A., Foundations of Economic Analysis, Cambridge: Harvard University Press, 1948, pp. 97-100.

^{3/} Gorman, W. M., "Separable Utility and Aggregation," Econometrica, 27(3):469-481, July 1959.

^{4/} Frisch, Ragnar, "A Complete Scheme for Computing All Direct and Cross Demand Elasticities in a Model with Many Sectors," Econometrica, 27(2):177-96, April 1959.

^{5/} Brandow, G. E., Interrelations Among Demands for Farm Products and Implications for Control of Market Supply, Pennsylvania Agr. Exp. Sta. Bul. 680, (Interregional Publication for the State Agricultural Experiment Stations), August 1961.

and in marketing. Isolation of the demand for food from the demand for services as such deserves further consideration. Also expectations models such as those used by Nerlove and the "rational expectations" hypothesis of Muth need to be considered further in formulation of economic models.^{6/} In this area especially, empirical testing of hypotheses should not await the development of a completely satisfactory theory, if such exists.

CURRENT RESEARCH

This review of current research of necessity must be limited to a selected group of studies, which, in this paper, all relate to total food at the retail level. Examples are given from cross-section data, time series with and without constrained coefficients, and panel data. Emphasis is given to the estimates of income elasticities which are of particular relevance in projections of future demand for food.

Cross-Section Surveys

Studies using these data have attempted to measure the effect of such variables as income, family size and composition, urbanization, region, price and quality on food expenditures. Also, quantity of food purchases has been introduced as the dependent variable, and considerable experimentation has been done as to the effect of alternative measures of expenditures and quantity.

A general model for the analysis of food expenditures may be expressed as follows:

$$E = f(Y, C, P, Q, N, U, R, O)$$

^{6/} Muth, John F., "Rational Expectations and the Theory of Price Movements," Econometrica, 29(3):315-335, July 1961.

where E is a measure of food expenditures standardized as to number of meals, Y is a measure of income, C is family size and composition, P is price of food, Q is quality, N is price of nonfoods, U is urbanization, R is region, and O is all other nonspecified variables. Ignoring for the moment any price, and quality considerations, we have the five variables of income, family size and composition, urbanization and regional effects on food expenditures.

There are three main approaches that have been used in handling family size and composition, namely (a) to use per capita data, (b) to treat family size only as an explicit variable, and (c) to construct some measure such as equivalent adult scales to represent family size and composition. Urbanization (or regional) effects may be obtained by estimating separate equations for such groups as urban, farm and rural nonfarm or by introducing dummy variables into one estimating equation.

The first mentioned approach is to set aside adjustments for family size and composition and to analyze relationships between per capita expenditures and income. This model has been used extensively by Burk in analyzing differences in income elasticities among regions and urbanizations by running separate equations for a given subset.^{7/} This model may be expressed as

$$E_{u_i/S'} = f(Y_{u_i/S'} + e_i)$$

where u_i refers to a particular urbanization, S' is the number of family members, and Y is disposable money income. The mathematical form of the relationship generally is specified as a double logarithmic function

7/ Burk, Marguerite C., "Some Analyses of Income-Food Relationships," Journal of the American Statistical Association, 53(284):905-927, December 1958.

which provides directly the income elasticity coefficient. The statistical measurement model is the single equation shock model.^{8/}

The study of the 1955 survey data by Burk, referred to previously, indicates an income elasticity of .25 for the United States using "total market value of food at home and away from home" and an elasticity of .37 using "food expenditures at home and away." The use of quantity of food variables rather than value variables results in generally lower elasticity coefficients (see Table 1). Urbanization effects also were quantified, with farm group much lower than the urban group both for quantity and value measures.

Another method of introducing family size is as a separate variable. Clark, et al., used six methods for adjusting for family size, one of which was the introduction of this separate variable.^{9/} These data related to urban families only. Consideration was given to regional differences (North vs. South) but for these 1948 data, adjustments for the urban differences in expenditures were not important. The income elasticity of food expenditures for families of two or more persons was .40 with family size as an explicit variable and .30 using per capita data.

A third approach has been to construct some measure, such as equivalent adult scales, to represent family size and composition. A good illustration of this approach is that developed by Prais and Houthakker

^{8/} For a discussion of problem associated with errors in the income variable when using budget data and the possible use of instrumental variables, see Liviatan, Nissan, "Errors in Variables and Engel Curve Analysis," Econometrica, 29(3):336-362, July 1961.

^{9/} Clark, Faith, Jane T. Murray, Gertrude S. Weiss, and Evelyn Grossman, Food Consumption of Urban Families in the United States, U. S. Department of Agriculture Information Bulletin 132, p. 39, October 1954.

TABLE 1

Selected Studies of the Demand for All Food^{a/}

Study	Period	Dependent variable	Elasticity with respect to:					R ²
			Income		family size	Price		
			Current	Lag		Food	Nonfood	
A. Tobin cross-section time series restricted nonrestricted	1941 1913-41	family exp. BAE index physical quantity	.56 .45 .27	 .11 .00	.25	 -.53 -.28	 .06	.93 .87
B. Tobin-Stone nonrestricted	1913-41	USDC ser.	.69	.12		-.51	-.29	
C. Burk cross-section time series value cross-section time series quantity cross-section time series	1942 1929-41 1955 1948-57 1955 1948-57	mkt. value all food same cons. all food, retail	.30 .68 .25 .38 .12 .20	 		 -.20	 	.95 .84 .92 .77 .96 .86
D. Sparks cross-sections combined analysis Model A' Model B' b/	1955-58 1955-58	family exp. exp. deflated by price index	.31 .25 .10	 	.57 .64 .52	 -.70 -.60	 .12 .14	.63 .62 .84
E. Stone (UK) cross-section time series restricted ^{c/}	1937-49 1921-38	family exp. first diff. of exp. de- flated	.59 .53	 		 -.35	 .23, .12	.97 .38
F. Nerlove-Addison time series (UK) static dynamic long-run short-run	1921-38	exp. deflated	.31 .14 .04	 		-.84 -.83 -.24		.92 .99

a/ Sources of data are given in text. Studies for which family size coefficient is not given are based on per capita or (Stone) per equivalent adult.

b/ Logarithmic function using Detroit BLS price index. Model A' specifies no separate family variable, whereas Model B' specifies a constant for each of 113 family units.

c/ The income coefficient is based on budget data (.9 x .59) and the equation for time series data fitted subject to this restraint.

in the analysis of British consumption data.^{10/} Their concern was to develop equivalent-adult-scale coefficients relating to specific and groups of commodities and to determine the economies of scale in consumption units.

For the United States, an analysis of the 1955 survey data for individual households by Herrmann indicates that differences do exist in income elasticities by household type and that in general, income elasticities increase with household size.^{11/} The relevance of these findings depends on the extent to which family size and composition change over time. Herrmann gives some indication of the impact of such changes in projections of food consumption.

Consideration of price and quality variations are undoubtedly important but difficult to measure. Prais and Houthakker also are concerned with the quality aspect, and suggest a model in which quality (measured by average expenditure per physical unit) is a function of the equivalent-adult-scale and the economy of size coefficients. Ladd discusses the problem of estimating regional demand functions from cross-section data for individual commodities.^{12/}

^{10/} Prais, S. J. and H. S. Houthakker, The Analysis of Family Budgets, University of Cambridge, Department of Applied Economics Monographs, No. 4, Cambridge: Cambridge University Press, 1955.

^{11/} Herrmann, Robert O., An Investigation of Differences in Income Elasticities of Demand for Food in Households of Differing Size and Composition, unpublished M.S. dissertation, Michigan State University, East Lansing, 1961.

^{12/} Ladd, George W., "The Estimation of Regional Demand Functions," paper presented to the Interregional Research Methods Workshop, Raleigh, North Carolina, January 10-11, 1963.

Time Series Analysis

Although an economic model may specify various factors that affect food consumption over time, data limitations restrict the number of variables that may be included in time series analyses. Changes in the food market in the post-war period are difficult to isolate due to rising prices and income, especially when consideration is directed to changes in the demand for marketing services.^{13/} A study by Burk provides data as to the difference in income elasticity coefficients, both for cross-section and for time series analyses, when alternative measures of food expenditures (or quantities) are used.^{14/} Use of a quantity variable gives a lower income elasticity than an expenditure variable (see Table 1).

Important contributions have been made to the study of short- and long-run demand for food and individual commodities by Working, Ladd and Tedford, and Nerlove as summarized in a useful article by Rojko.^{15/} The Working approach employs moving averages of quantity and income to explain variation in current price. On the other hand, Nerlove approaches the problem as one in which the short- and long-run elasticities are related by a "coefficient of adjustment." The method involves an estimating equation in which consumption is expressed as a function of income, lagged consumption, and an error term. The lagged consumption term in this model is supposed to reflect the influence of past prices and incomes on current consumption, but may in fact include the influence of other factors. Nerlove and Addison have applied this method of

^{13/} See Daly, Rex F., "Demand for Farm Products at Retail and the Farm Level, Some Empirical Measurements and Related Problems," Journal of the American Statistical Association, 53(283):656-668, September 1958.

^{14/} Burk, op. cit.

^{15/} Rojko, Anthony S., "Time Series Analysis in Measurement of Demand," Agricultural Economics Research, 13(2):37-54, April 1961.

distributed lags to Stone's data relating to the United Kingdom, obtaining short- and long-run estimates of price and income.^{16/} Results of this analysis, shown in Table 1, indicate a lower long-run elasticity (.14) than would be obtained from the more common static analysis (.31) which does not specify the "length of run."

Constrained Time Series Analysis

Due to various limitations in the use of time series data such as multicollinearity, researchers have attempted to bring in additional information from budget studies or theoretical restraints on the coefficients. Wold refers to "conditional regression analysis" for the use of income elasticities obtained from budget data as a constraint on the value of time series data.^{17/} Similarly, Stone utilizes estimates of income elasticities from budget studies in conjunction with time series data, referring to this procedure as the "use of extraneous estimators."^{18/} Although this procedure appears highly useful, there are difficulties in obtaining comparable sets of data, other than the use of panel data. This may be illustrated in Tobin's study of the demand for food.^{19/}

Tobin's budget data were for 1941 using adjusted averages for 37 groups of urban families (family demand function). The estimating equation, linear in logarithms, expressed food expenditure as a function of disposable income and family size.

^{16/} Nerlove, M. and W. Addison, "Statistical Estimation of Long-Run Elasticities of Supply and Demand," Journal of Farm Economics, Vol. 40, November 1958, pp. 861-880.

^{17/} Wold, H., Demand Analysis, New York, Wiley, 1953.

^{18/} Stone, Richard, The Measurement of Consumers' Expenditures and Behavior in the United Kingdom, 1920-1938, Cambridge, England, Cambridge University Press, 1954.

^{19/} Tobin, J., "A Statistical Demand Function for Food in the USA," Journal of the Royal Statistical Society, Series A, Vol. 113, II, 1950, pp. 113-141.

His time series analysis (1913-41), also given in Table 1, utilized the income elasticity of .56 from the survey data, and estimated the coefficients subject to the restraint that current and lagged income coefficients must add to this value. When this restraint is lifted, the current income elasticity coefficient is reduced to .27, as indicated in Table 1. In the discussion of Tobin's paper, Stone pointed out that the time series data on food related to physical quantity whereas the cross-section data were expenditure data. The substitution of an expenditure series resulted in an income coefficient of .69 as compared with Tobin's .27 estimate for the nonrestricted equation. A lower coefficient associated with quantity data is consistent with other studies. Although "extraneous estimators" may be highly useful in certain time series analyses, limitations in their use should be recognized.^{20/}

Probably the outstanding example of the development of a model for total food that incorporates various theoretical restraints and extraneous estimators is the study by Brandow which provides a matrix of direct, cross, and income elasticities for 24 foods or food groups.^{21/} The five conditions imposed relate specifically to the theory of individual consumer demand, but were found to be helpful approximations in this study. To illustrate, the homogeneity condition is imposed which states that the sum of the direct and cross-price elasticities and income elasticities for each food must add to zero. The most interesting condition is that based on Frisch's idea of want independence and the concept of money flexibility. This is used in specifying a uniform relation for each

^{20/} See the discussions by Kuh, Edwin and John R. Meyer, "How Extraneous are Extraneous Estimates?", The Review of Economics and Statistics, 39(4): 380-393, November 1957.

^{21/} Brandow, op. cit.

food between the price elasticity for nonfoods and for the income elasticity for that respective food; namely that the nonfood price elasticity is estimated at 33 percent of the income elasticity.

In the Brandow study considerable attention was directed to the use for projections of demand both at the retail and farm level. A major problem was that of determining the correct income elasticity and trend for individual and total food. However, he concludes: "It is virtually impossible to separate statistically the effects of income and trend in the post-war period because real income per capita rose almost linearly and because prices and uninfated income were highly correlated."^{22/} Alternative elasticities and trend values were established.

Consumer Panels

Consumer panels offer the opportunity to analyze the demand for food over time as well as at a given point in time. A nationwide panel as operated by the Market Research Corporation of America offers a potentially useful source of data. Crockett has utilized these data in analyzing the demand for food.^{23/} An analysis of these data for fluid whole milk is given by Rojko with emphasis on caution in their use.^{24/} The Michigan State Panel, which operated from 1951 to 1958 in Lansing, has provided the basis for several studies on food expenditures including Riley's thesis on the demand for meat.^{25/} Of particular interest to this

^{22/} Ibid., p. 23.

^{23/} Crockett, Jean, "Demand Relationships for Food," pp. 293-310, Proc. Conf. on Cons. and Saving, Vol. 1, edited by Irwin Friend and Robert Jones (Study of Consumer Expenditures, Incomes and Savings), University of Pennsylvania, 1960.

^{24/} Rojko, op. cit., p. 44.

^{25/} Quachenbush, G. G. and J. D. Shaffer, Collecting Food Purchase Data by Consumer Panel -- A Methodological Report on the M.S.U. Consumer Panel, 1951-1958, Michigan Agr. Exp. Sta. Tech. Bul. 279, August 1960.

discussion is the Ph.D. thesis by Willard Sparks utilizing the Michigan panel data for four years (1955-58).^{26/}

This study provides an analysis of cross-section data for approximately 113 families and time series data for these same families over a four-year period. Eight different cross sections were quantified to appraise changes between seasons and between sample periods. The average income elasticity for these studies was .31, as shown in Table 1, using the following model:

$$\log E = \log I + \log F$$

where E is family expenditures for food, adjusted for the number of meals at home; I is income for the current four-week period plus one-third of the previous three four-week periods; and F is the number of adult male equivalent units in the family for one period. Alternative formulations were also tested.

The combined analysis utilized data for 113 families and 56 four-week time periods, giving 5,876 observations. One analysis, shown as Model A' in Table 1, fitted a logarithmic function of the following form:

$$Q^{it} = A + F^{it} + P^t + N^t + I^{it} + u^{it}$$

where Q^{it} is family food expenditures (deflated by a food price index) for the i^{th} family (1-113) and the t^{th} time period (four-week period 1-56), F is as defined above, P is the price of food, N is the price of nonfood, I is income in one period, and u is a random disturbance for the i^{th} family at period t. Model B' differs in that the term A is replaced by A^i with the result that a constant is obtained for each of the 113 families. The

^{26/} Sparks, Willard Robert, Estimates of the Demand for Food from Consumer Panel Data, unpublished Ph.D. dissertation, Michigan State University, East Lansing, 1961.

introduction of the family variable (Model B') reduces the income elasticity from .25 to .10 which gives further emphasis to consideration of variation due to this source in future analyses.^{27/}

APPRAISAL AND AREAS FOR FURTHER RESEARCH

An overall appraisal of the econometric approach would, I believe, indicate significant advances during the last ten years in methods of analysis. For time series analysis, the Brandow study is an excellent example of advances in possible approaches, but at the same time reflects the problems that plague the researcher. Changes have taken place in the post-war period that are difficult to isolate, thus making projections of the demand for food items and total food a most difficult task. Separation of the demand for marketing services from the demand for food itself perhaps must be undertaken on a much less aggregative basis if we are to understand such shifts. Houthakker suggests, in the article referred to previously, that useful insights might be gained by studying the technology of consumption. This would entail consumer panel data in an analysis of the demand for services as related to the desire for more leisure time associated with a higher level of real income. A linear programming framework is suggested as a possible approach.

Panel data have obvious advantages in obtaining comparable data for cross-section analysis and combined analyses that include variation over time. These must be weighed against such considerations as cost of operating and maintaining a representative consumer panel. The careful

^{27/} It might be noted that in Sparks' analyses of the combined data that although the expenditure data are deflated by a price index, the income and price data are in actual terms. This is in contrast to the Stone analysis in which all data are deflated. The latter seems to be the preferable approach.

analysis of such data by exploring alternative formulations, as demonstrated by Sparks, also is a large undertaking when consideration is given to individual food products. How important is it to obtain improved estimates of demand coefficients, and how much money and research effort should be devoted to this effort?

A strong argument is made by Orcutt for the development of micro-analytical models especially for use in forecasting the changes in the national economy.^{28/} A cost estimate was given of about 10 million dollars for a period of ten years to develop a working model. The argument is made that restricting models to the use of macro-components and macro-relations does not make full use of data that potentially is available and subject to analysis by means of high-speed computers. Further, there are the well-recognized difficulties with time series analyses such as autocorrelation, multicollinearity and errors of observation. The alternative is to obtain data on the micro-components such as the families that are aggregated in the macro-data and individual firms that are included in industry data. Emphasis is placed on decision units. Simulation techniques are suggested to generate estimates of the future path of the economy. Although this appears to be a very ambitious study, the approach has considerable appeal both for analysis of the demand for food and for supply analysis. It might be valuable to have a pilot study that would explore the potential of this approach specifically for problems that relate to the agricultural economy.

^{28/} Orcutt, Guy H., "Microanalytic Models of the United States Economy: Need and Development," The American Economic Review, 52(2): 229-240.