EMPIRICAL ANALYSES OF THE DEMAND FOR FOOD: A REVIEW

by

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April 1977 No. 77-8

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This paper reviews the literature on the empirical analyses of the demand for food in the United States. Research results based on time-series data are considered first, but the emphasis of the paper is on results based on cross-section data, including longitudinal data generated by household panels.

The general objective of demand analysis is the estimation of the structure of demand. These estimates may be of interest in their own right, and they may be used to test various hypotheses suggested by theory. However, prediction and analysis of policy proposals, as a basis for decision-making, are usually considered more important objectives by applied economists.

The number of studies of price, demand, and consumption functions is huge, and any review must necessarily be selective. I emphasize model specification in the context of the objectives of demand analyses, and I also characterize the nature of selected empirical results and outline problems of empirical demand analyses. As the foregoing implies, the literature on demand theory is not reviewed, though theory and applications are obviously related. The citations are chosen to be illustrative, not exhaustive, but references that contain substantial bibliographies are identified.

Prepared for the Workshop on Research on the Economics of Household Consumption Behavior, Atlanta, Georgia, March 30-31, 1977.

Time-Series Studies

The time-series observations necessary for estimating demand relations for various foods have been available, and since they are obtained from secondary sources, they are inexpensive. Time-series data help describe the dynamic character of the economy, and consequently are well-suited to simulating policy proposals.

Such observations usually aggregate over microunits, such as households, and sometimes the data available from secondary sources are not directly applicable to the research problem of particular interest to decision-makers. In addition, the advantage of describing the economy with the passage of time can be a disadvantage in the sense that structural change and the dynamics of the economy may be difficult to specify correctly. Nonetheless, I would guess that thousands of price and demand studies for foods have been completed since the pioneering efforts of Moore.[1/]

Early models

Demand studies in the 1950s stressed estimating demand structures from annual observations. One controversy was whether demand functions for foods were best viewed as part of a simultaneous or a recursive system. Fox pointed out that production - hence the quantity available for consumption - in a particular year is often predetermined by events in the previous year. Hence, a price dependent demand relation can be viewed as part of a recursive system with the single equation estimated by least squares. In such equations, quantity consumed (or produced), quantity variables for close substitutes, and disposable income were the main explanatory variables. Population was taken into account by placing variables on a per capita basis, and in structural analyses of retail-level relations, prices and incomes were typically deflated by the Consumer Price Index.

Theory and logic provide few guides for the correct functional forms, and based on simplicity and goodness-of-fit measures, demand functions were typically specified as linear in the original observations or linear in the logarithms of the variables. Often first differences of the observations were used (e.g., Fox).

Some agricultural economists stressed the importance of the simultaneous equations problem in the 1950s. Demand and supply (or some important proportion of supply) may be simultaneously determined. Suits and Koizumi specified a model in which <u>harvested</u> production of onions was simultaneously determined with prices. Girshick and Haavelmo's five equation model for food was one of the first simultaneous equations systems estimated. Another approach to modeling - exemplified by Meinken's study of wheat - treats supply (production and beginning inventories) as predetermined, but specifies alternate uses and prices as simultaneously determined.

Waugh stressed the least squares estimation of single equations. Foote's classic bulletin summarizes much of the price and demand analysis experience of the 1950s. Tomek and Robinson review the price analysis literature through the early 1970s, including references on the issue of recursive versus simultaneous equations. (Other recent reviews include those by King, by Judge, and by Barton.) I shall argue below that economists now have a more balanced view about the importance of simultaneity relative to other model specification issues.

New models and empirical results

Most empirical analyses of annual data indicate the retail demand for individual foods to be price inelastic and the farm-level demand to be even more inelastic. Elasticity estimates for agricultural products are summarized by Buchholz, Judge, and West and by the Western Extension Marketing Committee Task Force on Price and Demand Analysis. Manderscheid provides a useful discussion of the interpretation of estimated elasticities.

The domestic demand for food in the aggregate is also highly price inelastic. A recent paper by Houthakker (1976) suggests an elasticity of -0.14 in the short run and -0.26 in the long run. However, the aggregate export demand for U.S. farm products is price elastic. Hence, while the aggregate demand for farm products is inelastic, Tweeten argues that the degree of inelasticity has been exaggerated by overemphasizing domestic demand.

With the dominance of annual data in early analyses, some economists thought of a year as the short run. Thus, Elmer Working analyzed the long-run demand for meats by using 5 and 10 year averages, and he found demand to be price elastic. Subsequently, Ladd and Tedford pointed out that the Working model was a misspecified version of a linear form distributed lag model; they did not find the demand for meat to be more price or income elastic in the long run using a general version of the linear form model.

Nerlove's popularization of geometric form distributed lag models and his rationalization of differences between the short and long run are important contributions to the literature. These models have received widespread use, particularly in agricultural supply analysis, but a clearer understanding of the limitations of models with lagged dependent variables has resulted in a more cautious use and interpretation of these models (reviewed in Tomek and Robinson).

On the demand side, institutional and technological impediments to quantity adjustments to price changes seem relatively unimportant for foods. Many food products are purchased frequently. In this context, lengthy long-run adjustment periods for individual foods are not very plausible. Of course, exceptions may exist for products not purchased frequently. Tomek and Cochrane applied linear and geometric form models to quarterly data for beef and pork, and they found adjustment periods of one to three quarters. In such instances, long-run elasticities based on quarterly data using distributed lag models are not much different than elasticities obtained from annual data and conventional models.

If storage is possible, then a demand function may include the demand for storage as well as for current use. Stock or speculative demand can be price elastic, and coefficients based on daily or weekly functions have been found to be highly price elastic (Pasour and Schrimper; Leuthold). In contrast, a controlled experiment for skim milk (where demand for stocks is essentially zero) found little response to a price change over a period of a few days. But complete adjustment occurred in about a month (Berry, Brinegar, and Johnson).

Conventional demand analyses usually include a limited number of substitutes. The omitted variables presumably have coefficients near zero. But logically the cross relationships are not zero and the aggregate of all cross effects may be important. A change in price for one commodity sets in motion events that influence the consumption and prices of many other goods and services, and for certain policy analyses, a complete system of demand coefficients may be highly desirable. However, a complete matrix of elasticities cannot be estimated from time-series data by conventional econometric procedures. For n commodities, there are n^2 direct-price and cross-price elasticities plus n income elasticities, and consequently the number of parameters far exceeds the number of observations unless the commodities are highly aggregated.

An important contribution in agricultural demand analysis has been the use of restrictions implied by classical demand theory, such as the homogeneity condition, in estimating complete matrices of elasticities for foods. Brandow provided a pioneering effort, and George and King provide a recent, detailed effort. Both studies provide matrices of elasticities for individual foods at the retail and farm levels. The relatively large number of elasticity coefficients meant that the demand constraints were not directly applied to a demand system estimated by econometric procedures. Rather both econometric and judgmental estimates were used in obtaining elasticities that met the constraints. Boutwell and Simmons formally imposed constraints on a seven commodity system where four of the commodities were dairy products, meats, cereals, and fruits and vegetables.

Bieri and deJanvry, George and King, and Barton provide comprehensive reviews of the literature on systems of consumer demand functions. Barton mentions a number of concerns: (a) practical considerations usually limit empirical applications to systems of less than 10 aggregate commodities, and this raises questions about aggregation over commodities and the usefulness of results; (b) the underlying theory is based on assumptions about individual consumers, and this raises questions about aggregation to market demands; (c) multicollinearity among prices is often a problem, and other econometric problems exist in estimating the demand system jointly; (d) the preferred functional form is uncertain; (e) prices are assumed exogenous, and the supply side is not considered; and (f) tests of the constraints have often rejected them. In sum, if having elasticity estimates that take account of demand interdependencies is important, then imposing the demand constraints should be useful. Otherwise, the complete demand system approach probably is not worthwhile. Unquestionably having estimates of complete matrices of elasticities for foods available, such as those obtained by George and King are useful.

Another attribute of recent research has been the shift from estimating parameters of demand structures with no specific application in mind to the estimation of models for prediction and simulation. A food processor, for example, may want a model that predicts the season low price of a commodity as a basis for purchase decisions (Cromarty and Myer). Policy-makers want to know the effects on consumer prices and other variables resulting from eliminating additives from livestock feed (Mann and Paulsen). Such applications usually require complete supply-demand models (e.g. Crom). Reutlinger, drawing on the work of Zusman, describes the analysis of time paths of endogenous variables in dynamic models. Meadows has summarized some of the commodity simulation work, and a recent book edited by Labys illustrates the range of commodity models available in the literature.

Problems in developing time-series models

Empirical econometrics involves a host of potential problems, and part of the art of the model builder is the identification of the most important ones. For example, the simultaneous equations problem was first ignored (partly because of ignorance and because of computing difficulties) and then perhaps overemphasized. While evidence is scarce, the simultaneous equations question now seems to have been relegated to a level of lesser importance; least squares estimation of models with some simultaneity has perhaps gained a certain respectability or at least is tolerated (e.g. Heien). The problem emphasized today - correctly so in my judgment - is correct model specification relative to the research objectives. Empirical econometricians are also coming to a better understanding of the implications of data snooping (Wallace) and to the use of biased estimators in the presence of multicollinearity (Brown and Beattie).

With respect to correct model specification, abrupt (and often seemingly unexplainable) shifts in demand and structural changes in demand are especially difficult to handle. Variables like population and income change rather smoothly and cannot explain abrupt shifts, and some of these shifts are not explained by abrupt changes in the supplies of close substitutes. A few plausible hypotheses exist in the literature. Of course, tastes and preferences may change, and price changes may induce changes in preferences. For instance, large supplies of beef and consequent low prices persisted for some time, and this may have shifted preferences toward beef. Hence, when supplies declined and prices rose, an abrupt shift in demand is observed because of the changed preferences (Goodwin, Andorn, and Martin). In contrast, high prices may induce consumers to economize; they learn more economical ways to use left-overs; they insulate their houses to save fuel; and such improvements are retained when prices subsequently decline (Hogarty and Mackay). Moreover, high prices may induce the development of substitutes; Waugh points out that the price support program for cotton may have provided part of the incentive for the development of man-made fibers.

An allied problem is the diversity of results related, in part, to the time period used in the analysis. Some economists argue that, in theory, the demand for food products should become more price inelastic with the passage of time (selected references in Tomek). Consumers have become more affluent and better educated on the average, and this leads to a more inelastic demand. On the other hand, economic development has resulted in the development of substitutes, and over time, products do not remain the same. Perhaps broiler chickens are a better substitute for beef and pork today than 30 years ago.

The discussion of changing elasticities is sometimes garbled by a failure to distinguish among three souces of change: (a) changing structure of demand, (b) shifts in supply along a demand function, causing the measured elasticity to be computed at different price-quantity levels, and (c) shifts in demand. In addition, empirical demand functions differ from study to study for a host of reasons (some summarized by Manderscheid) including the time period selected for analysis.

Some of these points are illustrated by the three equations for beef presented in Table 1. One point is the instability of the coefficients depending on the time period used. However, some tendencies

Table 1. Demand for beef, selected time periods[a]

INTERCEPT	D_1	D_2	D_3	QB	QPR	Y	$\bar{R}^2$	d	$1/\eta$[c]
1948-58									
103.28	-4.92	-5.33	1.27	-6.10	-1.25	.062	.90	1.36	-1.68
(8.19)[b]	(2.78)	(2.37)	(.56)	(12.39)	(2.00)	(5.24)			
1959-68									
112.67	-1.67	- .24	2.99	-3.27	.32	.019	.77	1.34	- .90
(13.65)	(1.63)	(.20)	(2.21)	(6.84)	(.83)	(3.90)			
1969-75									
83.32	.063	-1.62	2.57	-3.01	- .86	.035	.80	1.40	- .83
(3.40)	(.04)	(.90)	(1.52)	(5.18)	(2.04)	(8.15)			

[a]Variables: price of choice beef deflated by CPI is dependent; D_1, D_2 and D_3 are seasonal dummy variables; QB is quantity of beef consumed per capita; QPR is quantity of pork per capita; Y is real disposable income, \$ per capita; data are quarterly observations for the indicated years.

[b]Coefficients in parentheses are t-ratios.

[c]$1/\eta$ is an estimated price flexibility coefficient. Each coefficient is computed for the quantity-price ratio .2759. That is, the same level of quantity is used for each equation, but to obtain the same price, the levels of demand must be different for the 3 equations (because the slope coefficients differ).

exist: (a) the t-ratios for the seasonal dummies are smaller in the recent period;[2/] (b) the absolute values of the quantity and the income coefficients declined from 1948-58 to 1969-75; (c) R^2 also declined, implying that price is less well determined by the given set of regressors. If one uses the same ratio of quantity to price in computing flexibilities, one finds demand is less flexible (more price elastic) in the recent period - contrary to conventional wisdom.

Beef is probably the most studied food product, and there should be more agreement about the elasticity of demand for beef than for most commodities. George and King report a retail-level price elasticity of -0.64 in their comprehensive study. The conventional analysis reported here suggests an elasticity of about -1.1 in the 1960s and 1970s. Differences of this magnitude cannot be ignored by potential users. The results reported in Table 1 should be treated with skepticism. The Durbin-Watson statistics are suggestive of some autocorrelation, and the model probably omits relevant variables. However, these results do illustrate the potential diversity of empirical coefficients, and I am convinced that some sort of structural change occurred in the 1958-59 period.

This diversity of results, while frustrating, can be useful if it leads to improved analyses and to critical and discriminating applications of results. Perhaps researchers should spend more time trying to integrate their work with past research. A related problem is the lack of continuing research efforts by one research group that builds on past research. While some diversity is essential, agricultural demand analysis in land grant universities has probably underemphasized coordinated research efforts.[3/] The agricultural sectors now being placed in commercial econometric models (e.g. Chen) and the price analysis done by private firms are generally exceptions.

Cross-Section Studies

Research based on cross-section data should complement time-series studies. Cross-section observations are obtained as samples from specific populations, usually household units. In a sample for one time period, the preferences of consumers can be treated as fixed, but there usually is great diversity in the socio-economic characteristics among households. This diversity is both an advantange and a disadvantage. In contrast to time-series studies, cross-section analyses provide inferences about the structure of demand at a micro-level and usually for a more precisely defined population. Thus, such studies can help to answer specific questions about the effects of, say, the food stamp program or the consequences of changes in income on consumption for specific target groups.

Of course, cross-section data, like time series, are not perfect. Errors in variables exist - not just collection errors but also differences between measured variables and the conceptual variables needed in the analysis. The variety and complexity of factors influencing individual household behavior make correct model specification exceedingly difficult. (In contrast, the effects of such factors tend to "average out" in aggregate time-series observations.) The next several subsections consider contributions made to model specification, characterize empirical results, and discuss problems of analysis.

Model specification

In analyzing cross-section data, economists have emphasized consumption-income relations; i.e. consumption functions (Engel curves). Books by Prais and Houthakker and by Burk are illustrative of work in this area and contain a number of references. A paper by Stigler and a bulletin by Williams and Zimmerman survey the early history of empirical studies of consumer behavior.

Measures of consumption. Consumption is typically measured in terms of expenditures (e.g. Houthakker, 1957) but sometimes in terms of physical quantities. Expenditure data are used because they are more readily available; also expenditures may be more accurately measured than physical quantities. If the product's price did not vary with different purchases during the sample period, then it wouldn't make any difference whether consumption were measured by expenditure or by quantity. However, the usual assumption is that the quality of the product and price vary directly. Higher income households presumably purchase both larger quantities and better quality (higher priced) products than lower income households, and hence expenditures are more responsive than are quantities to income changes (Goreux). Where both expenditure and quantity data are available, both relationships can be obtained, and quality, quantity, and expenditure elasticities can be computed. Adrian and Daniel, using 1965-66 household survey data for the U.S., converted the quantities of food consumed to quantities of nutrients and analyzed nutrient-income relationships.

Measures of income. The explanatory variable "income" has been measured in a variety of ways. A common measure is total expenditures made by the household on all goods and services. This is justified, in part, by the availability and relative accuracy of the observations. If household expenditures are based on permanent income (Friedman), then total expenditures may be a better measure of permanent income than other available alternatives. However, since total expenditures are influenced by the timing of purchases, including large expenditure items, and if such expenditures are influenced by transitory income then total expenditures may not be the preferred measure of permanent income. Also, by definition, expenditure on the individual product and total expenditures are simultaneously determined (Summers), and least squares estimates would be statistically inconsistent.

If some measure other than expenditures is to be used, numerous alternatives exist. Income of the head of the household or total family income are two. The income of the household head is probably more accurately reported, but the errors in measuring total household income are probably smaller than the differences between total income and household head income (Currie).

Purchasing power is presumably better measured by net household income than by gross income. However, the question of how to measure total household income - whether or not it is net of taxes - is not an easy one. Income should include imputations from growing own food or in-kind payments, transfer payments, and income subsidies, and the problem of measuring income can be compounded by the possibility of negative incomes for self-employed persons and the effects of inter-household differences in fringe benefits.

Considering the various types of income, another question is whether an aggregate measure should be used or whether certain types of income should be treated as separate regressors. For instance, consumers may view different kinds of income as having different levels of permanence. Consequently, propensities to consume can differ by type of income (Holbrook and Stafford). If the propensity to consume out of total income is a weighted average of the propensities to consume out of the different types of income and if the research interest is only in the aggregate figure, then total income can be used as the single regressor. In other instances, an important research question may center on the marginal propensities to consume (mpc) out of different types of income. West and Price treat bonus food stamps and free school lunches as separate regressors in an analysis of food consumption by poverty households. They found, for example, that the mpc food out of bonus food stamp income was 0.3, six times larger than for total income.

Other questions related to specifying the income variable are the possibility of an adjustment process and the distinction between the short and long run and the possible irreversible response of consumption to income changes (Benus, Kmenta, and Shapiro). Some empirical evidence on these questions is presented below.

Functional form. The form of the functional relationship between consumption and income has received considerable attention (Goreux; Leser; Prais and Houthakker; Thomas). In selecting among alternative functional forms, authors discuss the following: (a) the logic of the relationship, e.g. the possibility of an initial income below which the commodity is not purchased, a declining mpc as income grows, and a possible satiety level in consumption; (b) the validity and usefulness of the equation over the plausible range of expenditures, i.e. predictions and elasticities should be reasonable at the end-points of the data; and (c) simplicity and convenience of estimation.

Leser emphasizes that Engel curves should meet the "adding-up criterion." This is the constraint, when expenditure data are used, that the sum of expenditure for all "n" individual goods and services equal total expenditures (the explanatory variable). However, imposing the constraint can create problems. The same functional form must be used for every good and service, and the particular form used may not be logical for every product. Prais and Houthakker argue that it is more important to have the flexibility of fitting different forms to different products. Presumably the criterion would be important in studies looking at the total effects of income change, but less important in studies emphasizing a few commodities.

Goreux used logarithmic, semilog, and log-inverse functions for food products. These three forms are special cases of the general transformation-of-variables form (see Zarembka, p. 83).[4/] This implies that the functional form might be estimated from the data rather than selected on the basis of judgment alone. Benus, Kmenta, and Shapiro (p. 132) mention this approach in their recent analysis of food expenditures, but their actual procedure was judgmental.

Estimated income (or expenditure) elasticities for a particular product can vary by 50% or more at the means because of differences in the functional form (e.g. in Prais and Houthakker). Even if elasticities are similar at the mean levels of the data for alternate equations, the elasticities can change drastically at the data extremes.

Thus, if the fitted equation is to be used to make projections at the data extremes (or beyond the range of the original sample), the form of the function becomes especially important.

Household size and composition. If the consumption-income relation is viewed as the basic relationship, then household size and age-sex composition are probably the next most important explanatory variables. Herrmann's analysis suggests that household size was particularly important in explaining food consumption. Household size has several effects. *Ceteris paribus*, physical requirements for food increase with household size. For a given household income level, per capita income declines by definition as household size increases. In this sense, household size has a negative income effect, but some economies of size in consumption probably exist as household size increases. Clearly, physical requirements and economies of size are influenced by the age-sex composition of the members of the household.

Modeling the effects of household size and composition has proven difficult. The simplist approach is to place consumption and income on a per capita basis or include size as a separate variable. But such specifications do not account for the composition of the household or economies of size. Considerable research effort has been devoted to developing "equivalent adult scales." This should allow for differences in composition among households. David Price discusses the development of such scales and reviews the literature through the mid-1960s, and Currie (pp. 27-31) briefly analyzes the development and use of equivalent scales. Both Price and Currie seem rather pessimistic about the development of fully satisfactory scales. A different scale is required for each commodity, and estimating scales has involved a circular analysis. Unbiased estimates of the scales requires unbiased estimates of income parameters, but the scales are required to estimate the income parameters. Nonetheless, equivalent adult scales are computed and used as deflators in a number of studies (e.g. West and Price). Hymans and Shapiro use equivalent scales derived directly from USDA minimum food requirement standards.

If household size is included as a separate regressor, then economies of size may be specified through an interaction term. Another approach to the household size-composition specification is the use of categories and analysis of covariance models. In this case, interactions may be specified among the size, age, and income variables. The correct definition of categories and the potentially large number of categories could prove to be problems. Herrmann's analysis of U.S. data contained 7 family size groups, 4 age of homemaker groups, 4 groups dealing with the presence and age of children, and 3 marital status groups. This gives 336 categories without considering interactions. Unless there are a very large number of observations, a number of cells may have few or no observations.

Prices. It is reasonable to treat prices as exogenous in cross-section observations. But the critical question is whether prices vary systematically across observations and whether prices are correlated with variables included in the consumption function. In omitting prices from the model, the implicit assumption is that this does not create a specification bias. Even in a perfectly competitive market, prices vary systematically by region and quality. Sales tax differences and transportation costs may result in regional price differences. Moreover, Mincer points out that market prices may not measure the "true" price of a product to an individual consumer. Consumption activities can involve specific costs to consumers over and above the money price paid to the seller. Prochaska and Schrimper use an analogous idea in suggesting that the opportunity cost of consumers' time is an important variable in the consumption function of away-from-home food consumption.

Mincer (p. 79) also suggests that in markets where prices vary because of imperfect information, prices and consumer incomes may be correlated. Using the ideas of marginal revenue (savings) and of marginal cost of an additional unit of search for lower prices, he concludes that a direct relationship should exist between income and the prices of "necessities." Hence, treating most foods as necessities suggests that omitting prices paid by individual households in a cross section may bias the income coefficient downward. Of course, the omitted variable effect could be very small, and it may be exceedingly difficult to obtain a measure of the omitted variable.

Other variables. Numerous other socio-economic variables influence food consumption. Variables sometimes considered are a measure of assets, education of household head or homemaker, occupation, urbanization, region, and race. Past research does not provide clear guides to the most important of these variables. Analysis of British National Food Survey data (Thomas) found social class - i.e. occupation - and region to be statistically significant regressors. Herrmann's work with 1955 U.S. data suggests that urbanization and region are important variables (beyond family size and income). He also identified three major interactions: between household size and income, between household size and urbanization, and among size, urbanization, and income. Lee and Philip's analysis of 1960-61 data also suggests that urbanization and regionality are important variables.

West and Price fitted regressions for a relatively homogenous sample - households containing 8 to 12 year old children in the state of Washington. These regressions differed by race, and an assets variable, defined as the total market value of owned property plus liquid assets, had large t ratios in several of these equations.

Zero-level consumption. Another specification issue is how to handle sample observations with zero-level consumption (Thomas). The answer depends on why the household did not purchase the product. If the survey period is sufficiently long that non-purchase implies non-consumption and if such households are part of the common group that do not buy the product because their incomes are too low, then the observations should be included in the analysis. In this case, the functional form should be such that zero levels of consumption are permitted with positive incomes, or the researcher may wish to consider a probit or similar type model.

However, the zero purchase may be explained by a qualitative variable other than income. A particular religious or racial group, for instance, might not consume pork. In this case, the data could be grouped on the basis of the qualitative factor and the non-purchase group excluded. Alternatively, the groups could be pooled provided that the different behavior of purchasers and non-purchasers is appropriately modeled.

If the survey period is short, non-purchase may reflect that a proportion of the sample households are consuming out of inventories and that only a certain proportion of households need purchase the product in a particular week. Currie et al (p. 127) demonstrate that the omission of non-purchasing households in this circumstance leads to biased estimates of the population propensity to consume. On balance, the arguments favor retaining the zero-level consumption observations with the model (hopefully) explaining the full range of observed behavior.

Aggregation over households. Still another question is whether to aggregate over household observations and conduct the analysis on group averages or to use the individual observations. While aggregation greatly inflates R^2 coefficients, it need not cause problems in estimating the income parameter of the equation (Prais and Houthakker, pp. 59-62; Johnston, pp. 228-238), and the grouping may simplify data handling and computations. However, with modern high speed computers, the tendency has been to work with the individual observations. These observations require a more complex model, but presumably the results are richer and more detailed.

In using individual observations, the researcher needs to be alert to several problems. As mentioned above, complex models may result in few or no observations in particular cells, even though the total number of observations is large. Using Herrmann's classes, one may wonder how many households (out of 3,641) are in the group with the homemaker over age 60 with the youngest child 0 to 5 years old. In this circumstance, an unusual observation could create especially perverse results, and clearly analysts want to guard against such difficulties. Another potential difficulty is computational accuracy. Large numbers of observations on tapes require considerable manipulation, and summing, cumulative multiplication, and matrix inversion may result in considerable truncation of numbers and other computational problems. These problems are well-known (Boehm et al), and accurate computer programs are available. However, it is not clear whether researchers have been sensitive enough to the computational accuracy issue. Perhaps human error in using programs is even more important than inaccuracies in the programs themselves. If policy decisions are to be based on empirical results, I would argue for independent attempts at reproduction of results prior to their use.

Demand constraints. A relatively recent development in the literature is the application of the constraints of demand theory, such as the homogeneity condition, to cross-section household data. Howe provides a recent survey paper on this topic. In particular, he discusses linear expenditure systems in which selected parameters are functions of certain household characteristics (a model with interactions). The advantages and disadvantages of cross-section applications are analogous to those for time-series applications (outlined above). Howe mentions a number of limitations of the model, including the linearity of the Engel functions, and he suggests that care be exercised in extrapolating results beyond the sample observations. Nevertheless, Howe believes that "the results have often been reasonable enough to encourage further application to cross-section data" (p. 147).

Time dimension

Cross-section samples of particular household populations are taken periodically. Traditionally each sample is analyzed separately with comparisons made among years. The British National Food Survey is probably the most comprehensive data set in the world, and income elasticities are published annually in Household Food Consumption and Expenditures (as cited in Thomas, p. xii). In principle, such data could be pooled, assuming certain parameters are unchanged over the time interval. A considerable econometric literature has developed on pooling time-series and cross-section observations (e.g. Maddala), but this literature is not reviewed here.

Panel data also involve observations obtained from a cross-section of households with the passage of time. The idea of a panel usually implies that a given set of households (perhaps with replacements as necessary) provide records on a regular schedule over a period of time. Panels often pertain to specific locations (populations). For example, one panel consisted of 300 Atlanta, Georgia households who provided weekly observations for the five year period, 1958 to 1962 (Purcell et al). The Survey Research Center at the University of Michigan collected data from 5000 U.S. households for the five years, 1968-72. Funded by the Office of Economic Opportunity, "the panel study represents a unique effort to reach the very limits of what is achievable by sample survey techniques in collection of needed evidence on family income dynamics" (Morgan, et al, p. x; see "introduction" for description of study).

In 1974 the University of Georgia established a panel in Griffin, Georgia (Raunikar), and in the 1950s Michigan State University maintained a panel in Lansing, Michigan (Quackenbush and Shaffer). Some of the unique characteristics of panel data and their limitations are described by Shaffer.

Perhaps the main advantage of panel data is the ability to study the dynamic behavior of individual households with the passage of time. Such data also make the study of price effects easier. Because the observations are for individual households, prices are exogenous. However, with "pure" cross-section data, one is not sure whether price differences are measuring location, quality, or other differences. Panel data permit market prices at given locations and levels of quality to vary. In addition, the combination of a time and cross-section dimension may minimize multicollinearity problems.

While panel data are an especially rich source of information, this richness is the source of the main problem in using the data: namely how to correctly model the behavior of individual households with the passage of time. With large panels, a subsample of the data can be used for model experimentation, and then the final model can be fitted to an independent subsample (e.g. Hymans and Shapiro). When the panel is limited to a particular location, another problem is the limited generality of the results. Also, keeping records of purchases and regular reporting over a long time period may influence the purchasing patterns of the family.

Articles and bulletins by Purcell and Raunikar (1967, 1971) and by Raunikar, Purcell and Ford illustrate a range of applications of panel data from a specific location. They examine income elasticities for food by level of income, estimate price elasticities, and analyze the demand for specific commodities. Their results seem quite plausible relative to studies involving cross-section data for wider regions. To my knowledge, these data were not utilized to study the dynamic behavior of consumers.

In a recent article, Benus, Kmenta, and Shapiro develop an elegant model to analyze dynamic behavior of food consumption using the national panel data obtained by the University of Michigan. The model considers types of income (wage, transfer, etc.), allows for a dynamic adjustment process to income changes, permits the consumer to react differently to income increases than to income decreases, considers flexible functional forms a la' Zarembka, uses the error components model for pooled time-series and cross-section observations, considers possible autocorrelation in the time dimension, and includes variables for household composition. In short, most of the known innovations in modeling were used, but the long-run price elasticity of demand was estimated to be -3.14, about 10 times larger (in absolute value) than the typical estimates of price elasticities for food (e.g. Tweeten). It is, to say the least, rather discouraging to find such a careful study with such an implausible result. The elasticity with respect to income was a more reasonable 0.2.

Selected empirical results from cross-section studies

The demand for food in the aggregate in the U.S. is income inelastic and apparently becoming more inelastic with the passage of time (Table 2). Many problems of model specification (hence interpretation) have been enumerated; less has been said about the changing nature of "food". Food today presumably contains more marketing services than 30 years ago. Economists agree that the marketing service component of food is more income elastic than the farm-origin input into food, but they have disagreed about the possible magnitude of the elasticity of demand for marketing services. Anschel has suggested an income elasticity of 0.5 (see also Waldorf).

Table 2. Income (or expenditure) elasticities for food, United States

Source[a]	Date of data	elast.	comments
Burk (1951)	1935-36	0.49	entire U.S.
Burk (1951)	1941	0.49	entire U.S.
George & King	1955	0.27	entire U.S.
George & King	1965	0.28	entire U.S.
Price	1955	0.28	urban
		0.16	single woman, age 20-64
		0.36	couple, 2 children
Rockwell	1955		nonfarm
		0.25	low income
		0.21	medium income
		0.15	high income
			farm
		0.08	low income
		0.19	medium income
		0.15	high income
Lee & Phillips	1960-61	0.52	urban
		0.50	rural nonfarm
		0.26	farm
Benus, et al	1968-72	0.20	entire U.S.

[a]See reference list under indicated name for a full citation.

Income elasticities for individual foods are typically less than 1.0; indeed most are less than 0.5. Rockwell provides a comprehensive set of income and expenditure elasticities for 1955 data; George and King (p. 70) estimate elasticities for 43 products. They found 13 negative expenditure elasticities. An important minority of foods, such as beans and flour, apparently have negative income elasticities under average aggregate conditions in the U.S.

Harmston and Hino compare income elasticities for 1955 and 1965 at given income levels, and the vast majority declined between the two time periods. For example, at the $15,000 level, the estimated elasticities for beef were 0.52 in 1955 and 0.44 in 1965 and for butter were 0.72 and 0.49, respectively. Fresh fruits and vegetables were the main commodities showing increases in income elasticities. Of 36 products analyzed by Harmston and Hino, 11 had negative elasticities at the $15,000 income level in 1965.

Purcell and Raunikar (1967) provide income elasticities for selected products at different income levels. Rockwell estimated elasticities at low, medium, and high incomes. These and other studies show elasticities declining as one increases income along the Engel function; this result usually is implicit in the functional form used.

Income elasticities based on cross-section studies are sometimes interpreted as long-run coefficients (Wold and Jureen). However, I am inclined to agree with Currie et al that a household's current consumption need not be in long-run equilibrium with respect to its current income (reported, say, in a particular week of the year). In Goreux's analysis, cross-section elasticities were sometimes larger than time-series elasticities, but this was not consistently true. Thus, it is not clear that cross-section results are more nearly a measure of long-run responses.[5/]

With respect to food in the aggregate, Goreux found the time-series income elasticity somewhat larger than cross-section elasticity. He attributed this to services being added to food with the passage of time - the changing definition of food - hence the greater responsiveness of food expenditures to income changes in a time series.

Prochaska and Schrimper analyzed away-from-home consumption (see their article for other references). They emphasize the importance of the opportunity cost of the time of the homemaker in models of away-from-home eating. They found expenditures on food away-from-home to be relatively responsive to income changes, particularly by urban consumers (elasticity = 0.8).

Important differences in consumption functions for food appear to exist between farm and urban households (Lee and Phillips; Rockwell; Prochaska and Schrimper). Farm households have smaller elasticities. The estimated differences perhaps identify basically different preferences for the two groups. However, the measured differences could be related to at least three other factors. (a) Assuming farm households have more unstable incomes than urban households, reported incomes by farmers may be a poorer measure of the concept of income to which they respond (say, a poor measure of permanent income) than for urban consumers. Hence, the estimated elasticity may have a larger bias for the farm group. (b) Measurement error also may be larger for farmers because of the larger consumption of home grown food. Consumption may be systematically understated for farmers, and hence true income would also be understated. (c) Finally, farmers may face different prices than urban consumers, a variable usually omitted in cross-section studies.

A related result is that elasticities and mpcs differ by type of income. For aggregate consumption functions (all goods and services), the mpc out of labor income is typically larger than out of other types of income (Holbrook and Stafford).[6/] In studies of food consumption, total income has usually been disaggregated into welfare, food subsidy, and wage (or similar) income components. Benus et al found the mpc to consume food to be .05 out of "basic" income, .08 out of transfer income, and .86 out of food subsidy programs. West and Price obtained an mpc of .3 out of bonus food stamp income for State of Washington data. The foregoing coefficients define the range of results for mpcs out of food subsidy income. Estimates by Reese et al vary from 0.6 to 0.72. Hymans and Shapiro's mpcs for food are larger for the lowest quintile of their sample (defined by per capita income) than for the remaining income groups. Selected results are displayed in Table 3. The differences between the two subsamples taken from the total sample, however, cast doubt on the linear model specification used by Hymans and Shapiro.

With the paucity of panel data, few estimates exist of the speed of adjustment of food consumption to income changes. Benus et al obtain a coefficient of adjustment of .57 for food. In their specification, the coefficient is a function of the level and direction of change of income. As one might expect, households with large and rising incomes tend to adjust food consumption more slowly than those with small and falling incomes. Finding a coefficient of adjustment of less than one is consistent with the observation, made above, that cross-section elasticities may not measure long-run phenomena.

Table 3. Marginal propensities to consume food, U.S. households

Income group	Food Subsidy Income		Aggregate Income	
	Urban	Nonurban	Urban	Nonurban
		first half sample[a]		
lowest quintile	.247	.541	.145	.147
other	.250	.446	.053	.061
		second half sample[a]		
lowest quintile	.644	.765	.174	.175
other	.510	.631	.037	.038

[a]First half sample used to search for hypotheses (data dredging) and the final model was estimated from the second sample.

Source: Hymans and Shapiro, p. 274.

The empirical estimates of the effects of household size and composition are consistent with a priori expectations. Per capita food consumption declines as household size increases (e.g., Goreux; Rockwell), and economies of size appear to exist (Herrmann; Benus et al). As expected, the economies are least for young children (age 0 to 4 years), and older children and adults "made the largest per capita claim on the food budget" (Benus et al, p. 135). David Price provides numerous results by age-sex composition of the household.

Results by region and/or urbanization category are reported in Rockwell, Prochaska and Schrimper, Hymans and Shapiro, Thomas, Adrian and Daniel, Lee and Phillips as well as other studies not cited in this paper. Variables for race are included by Prochaska and Schrimper and by Adrian and Daniel; West and Price fitted separate functions by race and found quite large differences in the results. For example, the mpc to consume food out of bonus food stamps income was estimated to be .15 for whites, .43 for blacks, and .61 for Mexican-Americans.

A relatively modest number of price elasticity estimates are available from panel data. As reported above, Benus et al obtained implausible estimates of price elasticities for aggregate food. Purcell and Raunikar (1971) report on price elasticities for individuals meats from the Atlanta panel. Elasticities were computed for week-to-week, quarter-to-quarter, year-to-year changes in prices. The coefficients tended to become more inelastic as the time period was lengthened. The elasticities seem reasonable in light of time-series results (e.g. an elasticity of -0.97 for beef and veal using quarterly changes).

Problems in developing cross-section models

Correct model specification is a difficult problem. The number of choices is huge. Omission of relevant variables and errors of measurement of included variables seem especially important. Indepth examination of previous studies is probably helpful in deciding on relevant variables to include. In principle, I have no objection to thoughtful data snooping; I do object to the mindless use of stepwise regression programs. These programs are not a substitute for thinking. When possible, the use of a subsample to experiment with model specification and then the use of a second subsample to test the "final" model seems like a good procedure. I also would like to see more attempts at duplicating prior results of other research workers and understanding how changes in model specification influence results. There well could be a Ph.D. thesis in seeing how alternate models influence empirical results for a given set of data. In other words, build on past research and try to understand why differences occur.

In some instances, data on relevant variables may not be available, or the analyst may be uncertain about the correct definition of variables. As suggested above, measuring the opportunity cost of the time of the homemaker is important for some research. Or, omission of regional prices may explain part of the rural-urban differences in consumption. Or, the income variable may not be appropriately measured. Conscious recognition of such issues at least helps the researcher and others in interpreting empirical results.

Model specification is influenced by the problem to which the estimates will be applied, and there is a shifting emphasis from general studies to more problem-oriented analysis. In this context, it is important to understand how sensitive policy conclusions are to the alternate models and results. For instance, how important to policy analysis is the difference between an mpc of 0.5 and 0.75 out of food subsidy income for the target (say, poverty-level) consumers? Differences of this magnitude are extant in the literature.

Income coefficients estimated from cross-section studies have been used to make long-term demand projections. Harmston and Hino's evidence implies, however, that the income elasticity for a particular income level in one year is not a good guide to the elasticity for that income level a number of years later. Burk (1964) has argued that small income elasticities for food weaken the usefulness of income as a predictor of demand; a more telling argument is the relatively small t ratios for income as compared with other variables. Perhaps more can be done to identify samples of those who are the forerunners of changes in demand. Burk (1964) suggests that upper middle-income persons are keys to change.

Economists must be attuned to the latest changes in socio-economic factors. For instance, shifts have occurred toward one and two person households and toward more women in the labor force. The birth rate and age distribution of the population are changing. The proportion of total food expenditures spent on food eaten away from home has increased.[7/] Presumably much of the growth is in "fast food" outlets. In light of these trends, can useful predictions be made from current demand studies? For example, can a cross-section study be designed that estimates the effects on food consumption of a shift toward smaller households? While cross-section studies have provided snapshots of past consumption behavior, I have doubts about the relevance of many such studies for predicting future behavior.

Concluding Observations

In empirical demand analysis the basic question is: what is the objective of the analysis? What decision-makers are going to use the research? Thus, while I have used the division between time-series and cross-section studies as an organizing principle for this paper, these are ways of collecting data and not methods of organizing research. If, for example, the research problem is malnutrition in a target population, then the research should be designed to answer policy questions about this problem. A sample of households from the target population would be the preferred data set. But, even if an "optimal" data set is not available, the research objective is critical to model specification, evaluation, and use.

Empirical demand analyses in the 1970s clearly are more problem oriented than in the 1950s, and perhaps I am belaboring the obvious. But, the data used in demand studies are usually collected for other purposes, and sometimes more is asked of data than is actually there. Conversely, we may be inclined to ask questions the data can answer rather than ask of ourselves what are the important problems and what are the data needed to analyze these problems?

Research must build on past work. Others (e.g., King) have pointed to the fragmented nature of much of empirical work in agricultural economics and to the need for integrated research. I have mentioned the seeming lack of familiarity of some authors with existing literature.

Another facit of building on past work is learning from previous mistakes. A place exists for research that asks why past analyses have gone wrong and why results are so diverse? That is, careful evaluations of previous studies are needed. Helpful comparisons of alternate econometric results are not easy (Dhrymes et al), and it will require the continuing cooperation of individuals who have done these studies. Sometimes it is essentially impossible to reproduce the results obtained by others.

The nature of papers such as this is to view with alarm and to point to existing problems. Nonetheless, impressive research efforts exist in the literature, and I am confident that agricultural economists will complete demand analyses useful to policy-makers.

FOOTNOTES

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1/ If only the 30 years since the second world war are considered, one study per year per land grant university in the USA gives 1500 studies. This, of course, ignores the output of the USDA, other institutions, as well as the pre-war period.

2/ Of course, an F test is needed to test a null hypothesis about seasonality, but the smaller t values are suggestive that differences in demand by season are less significant in the recent time period.

3/ I am also concerned about the lack of familiarity with the literature of many professionals. Perhaps our graduate programs have not placed sufficient emphasis on the importance of existing literature. Literature retrieval systems, such as the one now supported by the American Agricultural Economics Association, also may help researchers do a better job.

4/ Let C = consumption and Y = income and define $C^{\lambda o} = \beta_o + \beta_1 Y^{\lambda 1}$ and $\lambda = 0$ is the logarithm of the variable, then $\lambda_o = \lambda_1 = 0$ is the logarithmic model, $\lambda_o = 1$ and $\lambda_1 = 0$ is the semilog model, and $\lambda_o = 0$ and $\lambda_1 = -1$ is the log-inverse model.

5/ In commenting on a draft of this paper, Lester Manderscheid stated that when income elasticities based on the Michigan State panel were used to predict consumption, the predictions overestimated the actual one-year change. This implies that cross-section elasticities overstate the short-run time-series effect, and this is consistent with treating cross-section elasticities as long-run coefficients. The evidence on how to interpret income elasticities obtained from cross-section observations is clearly mixed.

6/ Self-employed persons typically have lower mpcs than wage earners out of their respective aggregate incomes, a result consistent with farmers having lower mpcs.

7/ Away-from-home consumption of food was 19.9% of total personal consumption expenditures on food in 1960, 22.6% in 1970, and 23.7% in 1975 (computed from data in USDA's National Food Situation).

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