EMERGING DATA ISSUES IN APPLIED FOOD DEMAND ANALYSIS

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EDITORS' NOTE

This Tennessee Experiment Station Bulletin is the edited collection of seven papers presented by members of the Changing Patterns of Food Consumption (S216 Regional Committee) at a 1993 Workshop held by the Regional Committee. They focus on a variety of emerging issues associated with data sets used in applied demand analysis. These pertain to topics that are not discussed in the extant literature but are quite germane to the extension of empirical models of food consumption.

USES OF SUPERMARKET SCAN DATA IN DEMAND ANALYSIS

Oral Capps, Jr.[1]

To quote Tomek, "existing secondary data seem especially inadequate for studying product demand in retail markets, and fundamental work needs to be done to obtain relevant data. The data associated with computerized checkout systems in grocery stores could become an important source of information for studying retail demand (1985, p. 913)." The introduction of scanning checkout systems into U.S. supermarkets in the mid-1970s opened tremendous possibilities for the generation of non-conventional data series and the use of such series in economic research.

There has been limited use of scanner data as a basis for demand analysis and consequently for understanding consumer behavior. Reasons for the lack of use of scanner data in this regard include the following. First, considerable resources are necessary to reduce the mass of data to useful summary figures for demand analysis purposes (the data overload problem). Second, questions have been raised dealing with the reliability of scanner data for application in economic research (the data integrity problem). Third, it is necessary to augment scanner data files to monitor advertising, promotional activities, and competitors' actions. Fourth, despite the sheer volume of price and quantity information, scanner data typically lack information pertaining to socio-demographic profiles of consumers. Finally, scanner data are not within the realm of the public sector; they are developed and maintained by private sources (e.g. Information Resources, Inc).

Despite these problems and pitfalls, demand analyses can be expanded through the use of scanner data. To illustrate, McLaughlin and Lesser (1986) used scanner data to assess impacts of promotional activity, to determine optimal space allocation, and to develop sales management models for potatoes. Shugan (1987) estimated brand positioning maps using supermarket scanning data. Capps (1989) estimated retail demand relationships for beef, fish,

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poultry, and pork using scanner data from over forty retail food stores in Houston. Capps and Nayga (1990) used scanner data to determine the effect of length of time on measured demand elasticities.

Indeed, scanner data hold great promise for developing insights into both applied and theoretical research. In this light, the purpose of this paper is to address two issues in demand analysis using scanner data, specifically: (1) to attempt to find some internal structure within a set of disaggregate products in order to understand how consumers make decisions concerning purchases (the issue of weak separability); and (2) to attempt to ascertain whether consumers respond in the same way to price increases as opposed to price decreases (the issue of nonreversibility or asymmetry). These issues have received scant attention in the literature. Each is discussed in turn.

WEAK SEPARABILITY

Weak separability is a key concept in empirical work because it is a necessary and sufficient condition for two-stage budgeting (Deaton and Muellbauer, 1980). But, separability restrictions have usually been rejected in empirical work due, perhaps, to the use of broad commodities and due to the nature of market-level data. In fact, Pudney states that, "the empirical fruit of the theory has been disappointing, but possibly only because it has generally been applied at the wrong level of aggregation (1981, p. 561)."

Moreover, because of the degree of aggregation, a considerable amount of information is potentially lost concerning the demands for disaggregated commodities. Some information on the appropriate grouping patterns of the commodities, for instance, could be extracted from using a lower level of aggregation. Using tests of separability, Eales and Unnevehr (1988) and Pudney (1981) suggest the importance of developing models for disaggregated commodities to obtain a more complete understanding of demand.

A test of the weak separability assumption on various groups of disaggregated meat products using scanner data from a retail food firm (43 supermarkets) in Houston is the present focus. The study, therefore, attempts to find some internal structure within the set of disaggregate meat products in order to understand how consumers make decisions concerning purchase patterns of meat expenditures. For instance, there is a need to know whether or not consumers select among various cuts or qualities of a particular type of meat or among meat types of like quality. Eales and Unnevehr (1988) show that consumers choose among meat products rather than among meat aggregates of a particular animal origin. There is no logical difficulty in imposing separability of closely related goods; separability does not imply that between-group responses are necessarily small, only that they conform to a specific pattern.

The notion of separability, conceived independently by Leontief (1947) and Sono (1961), is a relative concept whose frame of reference is some partition of the commodity set into mutually exclusive and exhaustive subsets. In general, separability of commodities within a utility function implies that the ratio of marginal utilities of a pair of commodities i and k is unaffected by the level of consumption of a third commodity j. Consequently, separability conditions require the marginal rates of substitution for certain pairs of commodities to be functionally independent of the quantities of certain other commodities. Such conditions reduce the number of parameters that enter into the family of demand functions and in short, make estimation of the parameter space more feasible.

The imposition of the assumption of separability attacks the Bieri-de Janvry "degrees-of-freedom problem," thereby making the estimation of complete systems of demand equations, via econometric analysis, tractable. However, this assumption hinges upon the identification of separable groups. In actual practice, it is next to impossible to look upon marginal utilities to determine the nature of separability. If the imposition of separability restrictions are inconsistent with the true preference ordering of the representative consumer, empirical estimates of structural demand parameters are invalid. Thus, it is worthy to consider tests for separability of preferences.

Separability also allows the empirical analysis of groups of goods in isolation from other goods and, therefore, permits the use of the two-stage or multiple budgeting concept. The focus on the second stage of the two-stage budgeting procedure, for instance, justifies the analysis of conditional demand systems. This type of analysis implies that the demand of a subset of goods depends only on their prices and on the expenditure on this subset of goods. To be consistent with utility maximization, however, the direct utility function has to be weakly separable in the partition of interest.

ROTTERDAM MODEL

The analysis centers on the use of the absolute price version of the Rotterdam model (Theil, 1980) which may be written as:

$$w_i \, \mathrm{dlog}\,(q_i) = \theta_i \, \mathrm{dlog}\,(Q) + \sum_{j=1}^{n} \pi_{ij} \, \mathrm{dlog}\,(p_j) \tag{1}$$

where $\mathrm{dlog}\,(Q) = \sum_i w_i \, \mathrm{dlog}\,(q_i)$ is the Divisia volume index.

In this model, w_i corresponds to the expenditure share of the ith commodity in time period t; q_i denotes the quantity of the ith commodity in time period t; and p_j corresponds to prices in time period t. Log differentials are approximated by log differences in empirical applications. Consequently, the Rotterdam model cannot be considered as an exact representation of preferences unless restrictive conditions are imposed. Nevertheless, the Rotterdam model is a flexible approximation to an unknown demand system (Barnett, 1979; Mountain, 1988). This model necessitates the use of classical restrictions so that the estimates of demand parameters conform to theory. The restrictions for the Rotterdam model are as follows:

$$\sum_j \Theta_j = 1 \text{ (AddingUp); } \sum_j \pi_{ij} = 0 \text{ (Homogeneity);} \qquad (2)$$
$$\text{and } \pi_{ij} = \pi_{ji} \text{ (Symmetry).}$$

Operationally, when estimating demand systems, one equation must be omitted to avoid singularity of the variance-covariance matrix of disturbance terms. Through the classical constraints, the demand parameters associated with the omitted equation are subsequently recovered. The Rotterdam model is estimated using Zellner's seemingly unrelated regression procedure (1962, 1963) with homogeneity and symmetry restrictions imposed.

DATA

The source of data for the analyses in this study is from a retail food firm in Houston. Scanner data from all the stores in the firm are aggregated to form weekly time series observations over the period September 1986 to November 1988. The number of supermarkets in operation by this firm over this time interval was 43. Importantly, the retail food firm in this study caters to relatively high-income customers.

This study is based on point-of-sale purchases. The number of individual fresh meat products is 366. These individual products are then aggregated to form 21 disaggregate meat products (Figure 1). The numbers in parentheses correspond to the number of products in the respective category. A listing of the individual cuts corresponding to these products is available from the author upon request. Pounds corresponding to the individual cut as well as the price corresponding the individual cut are reported by week for the time period in question.

The quantities of the various fresh meat products correspond to the sum of the respective quantities of the relevant products. The prices of the products in question are weighted averages of all individual prices within the particular commodity group. The weights correspond to the relative shares of the quantities of the products to the total quantity within the relevant commodity group.

The weighted average prices change with the quantities of the component goods consumed. In addition, quality effects may result from commodity aggregation (Houthakker, 1952; Cox and Wohlgenant, 1986). Although the use of these implicit prices potentially limits the analysis, quality effects attributable to commodity aggregation could be assumed negligible given that the meat products in question are relatively homogenous.

Mean expenditure shares, mean quantities, and mean prices of the disaggregated meat products are exhibited in Table 1. Ground beef and other chicken are the most important items in terms of purchases per 1000 customers. On average, purchases per 1000 customers are 169 pounds for ground beef and roughly 72 pounds for chicken breasts, 57 pounds for chicken parts, and 102 pounds for other chicken. The least important commodity group is veal with purchases of only about two pounds per 1000 customers on the average. Purchases per 1000 customers for roast pork, other pork, turkey parts, other turkey, and lamb are less than ten pounds on average. Ground beef, ham, beef loin, and chicken breasts comprise about 50 percent of the total dollar sales on meat products. None of the remaining individual 17 commodities comprises more than 7 percent of the dollar sales.

In terms of prices, veal is the most expensive item ($6.92 per pound on average) while turkey parts ($.98 per pound) and chicken parts ($1.01 per pound) are the least expensive commodities. Beef loin, rib, turkey breast, and veal are more than $4 per pound. Total expenditures per 1000 customers is roughly $1648 on average.

Tests of Weak Separability

Very few studies, with the exception of the works by Pudney (1981) and by Eales and Unnevehr (1988), involve testing separability within groups of meat products. This paper examines tests for weak separability on "disaggregated" meat products using scanner data from supermarkets. The necessary and sufficient condition for weak separability is that the offdiagonal term in the Slutsky substitution matrix be proportional to the income derivatives of the two separable goods. Following Goldman and Uzawa (1964), if good i in group r is separable to good j in group s then,

$$S_{ij} = \Theta_{rs} \left(\frac{\partial q_i}{\partial y}\right)\left(\frac{\partial q_j}{\partial y}\right) \qquad \text{for all} \quad i \; \varepsilon \; r \text{ and } j \; \varepsilon \; s, \qquad (3)$$

where S_{ij} is the appropriate element in the Slutsky substitution matrix, q's are quantities, and Θ_{rs} is an intergroup coefficient which is a measure of the degree of substitutability between groups of goods. Using (3) for commodities i and k in group r and j in group s, then:

$$\frac{S_{ij}}{\frac{\partial q_i}{\partial y}} = \frac{S_{kj}}{\frac{\partial q_k}{\partial y}} \qquad \text{for all} \quad i, k \; \varepsilon \; r \text{ and } j \; \varepsilon \; s, \qquad (4)$$

Utilizing (4), the restrictions for weak separability may be expressed as:

$$\frac{\varepsilon^*_{ij}}{\varepsilon^*_{kj}} = \frac{N_i}{N_k} \qquad \text{for all} \quad i, k \; \varepsilon \; r \text{ and } j \; \varepsilon \; s, \qquad (5)$$

where $\varepsilon_{ij}*$ is compensated cross-price elasticity between commodities in group r and in group s; N_i represents the expenditure elasticity of commodity i. Under the assumption of weak separability of the direct utility function, the ratio of compensated cross-price elasticities of two commodities within the same group (r), with respect to a third commodity in another group (s), is equal to the ratio of their expenditure elasticities.

From (5), for the Rotterdam model, this result implies a nonlinear restriction on the parameters π_{ij}, where $i,k\varepsilon r$ and $j\varepsilon s$. This restriction is given by

$$\frac{\pi_{ij}}{\pi_{kj}} = \frac{\Theta_i}{\Theta_k} . \tag{6}$$

Operationally, then, given such nonlinearity, this test for separability hinges on a χ^2 statistic with degrees of freedom equal to the number of restrictions. The number of restrictions depends on the partition of commodities into separable groups. The procedure commonly rests on either a Wald test or a likelihood ratio test. The key feature of (6) is that the separability restrictions hold not only locally but also globally. This result sets the Rotterdam model apart from other functional forms such as the translog and AIDS.

Several a priori groupings of the disaggregated meat products are specified, based primarily on intuition, to test for weak separability in this paper (Table 2). The first utility tree is partitioned based on animal origin. There are, therefore, six separable groups (beef, pork, chicken, turkey, lamb, and veal). The second utility tree is partitioned based on the quality of the meat products. The separable groups are "high-quality" meat products, "low-quality" meat products, lamb, and veal. The "high-quality" products are beef loin, beef rib, beef round, pork chops, ham, pork roast, pork loin, chicken breasts and parts, and turkey breasts and parts. The "low-quality" meats are brisket, chuck, ground beef, other beef, spare ribs, other pork, other chicken, and other turkey. This utility tree allows consumers to choose among disaggregated products of the same quality type across animal origin. To quote Pudney, "the difficulty one experiences in attempting to specify an a priori grouping pattern suitable for a disaggregate model is often not that plausible choices are hard to find, but rather that there are too many plausible choices (1981, p. 576)." For instance, one could define a partition similar to the first utility tree but combine chicken and turkey into a single group and/or combine lamb and veal into a single group.

The number of nonredundant weak separability restrictions for any utility tree can be determined with the following formula:

$$\left(\frac{1}{2}\right)\ [N^2+N-S^2+S-\Sigma_s\ n_s(n_s+1)] \qquad \textbf{(7)}$$

where N is the number of products in the utility tree; S is the number of separable groups in the utility tree; and n_s is the number of products in group s. In utility tree 1, the number of weak separability restrictions is 153. In this case, N is 21; S is 6; n_1 is 7 (beef products); n_2 is 6 (pork products); n_3 is 3 (chicken products); n_4 is 3 (turkey products); n_5 is 1 (lamb); and n_6 is 1 (veal). In utility tree 2, the number of weak separability restrictions is 121. N is 21; S is 4; n_1 is 11 ("high-quality" products); n_2 is 8 ("low-quality" products); n_3 is 1 (lamb); and n_4 is 1 (veal).

To test restrictions in demand systems, it is common to use either the Wald test or the likelihood ratio test. The likelihood ratio test requires the estimation of both the unrestricted and the restricted models, whereas the Wald test only requires the estimation of the unrestricted model. The estimation of the restricted model, although not a problem with linear restrictions, can be difficult and cumbersome when dealing with nonlinear restrictions, especially when combined with linear restrictions (e.g. homogeneity and symmetry) in a demand systems context.

Moschini and Green (1991) acknowledged the difficulty of conducting formal statistical tests using nonlinear separability restrictions. For example, the Wald test has a drawback because of its non-invariance to the specification of nonlinear restrictions (Gregory and Veall, 1985). The Wald test is based on a linearization of the nonlinear restrictions, and the linearizations may differ depending on how the nonlinear restrictions are represented algebraically. Also, the Wald test is not invariant with respect to the choice of the nonredundant separability restrictions (Moschini and Green, 1991). To accommodate the likelihood ratio test, empirical estimates with the incorporation of the nonlinear restrictions are needed. To accomplish this task, about 120 to 150 nonlinear separability restrictions as well as the linear homogeneity and symmetry restrictions (210 in number) for each utility tree considered are imposed. This procedure is not only very cumbersome but also quite tedious.

In addition, tests of restrictions in large demand systems, for instance, are biased towards rejection which suggests the need for a size correction of the test (Laitinen, 1978; Meisner, 1979). Given this situation, a few studies (Moschini and Green, 1991; Anderson and Blundell, 1983) suggest that the critical value of the test needs to be increased to protect against over-rejection.

The likelihood ratio test statistic is given by

$$\psi = 2\ [LL_{UR} - LL_{R}] \tag{8}$$

which follows (at least asymptotically) a χ^2-distribution with degrees of freedom equal to the number of restrictions. Since the present models are heavily parameterized, it seems worthwhile to make a degrees-of-freedom adjustment to compensate for the known tendency of this statistic to overreject in large models (Laitinen, 1978; Byron, 1970). The adjusted statistic takes the form

$$\psi* = \psi + T \log\left(\frac{nT - p_1}{nT - p_0}\right), \quad \text{where} \quad n \tag{9}$$

is the number of equations (21); p_0 is the number of parameters under separability and classical conditions (restricted model); and p_1 is the number of parameters under classical conditions only (unrestricted model). In addition to making the adjustment to the test statistic, a similar adjustment to the corresponding critical values is made. The adjusted critical value is given by

$$K* = nT \log \left[1 + \left(\frac{p_1 - p_0}{nT - p_1} \right) F_{p_1 - p_0,\, nT - p_1} \right]. \qquad (10)$$

For details on these adjustments, see Pudney (1981).

EMPIRICAL RESULTS

The econometric estimates and associated standard errors of the structural parameters in the Rotterdam model with homogeneity and symmetry restrictions imposed are available from the author upon request. The estimates of the compensated price elasticities, as well as the expenditure elasticities, subject to only the classical restrictions, are exhibited in Table 3. All own-price compensated elasticities are negative and, except for other turkey (-0.719), are in the elastic range. The own-price elasticities vary from -0.719 (other turkey) to -8.695 (brisket). Also, 78 percent of the compensated elasticities are positive, with nearly 50 percent statistically significant. Consequently, in line with a priori expectations, a majority of the commodities are substitutes in the Hicks-Allen sense. Only 22 percent of the compensated elasticities are negative, with roughly 5 percent statistically significant. All the expenditure elasticities are positive, ranging from 0.581 (pork chops) to 4.514 (brisket).

The results of the separability tests are exhibited in Table 4. The econometric estimates and associated standard errors of the structural parameters in the Rotterdam model with symmetry and separability restrictions imposed are also available from the author[2]. To protect against over-rejection, weak separability tests are conducted at the 1 percent level of significance. According to the likelihood ratio tests, both utility trees exhibited in Table 2 are rejected. Consequently, no separable partition exists among disaggregate meat products, at least of those considered. This evidence is in contrast to the work by Eales and Unnevehr (1988), but consistent with the work by Pudney (1981). Because the meat products in this

[2]Due to computational problems, homogeneity restrictions along with the symmetry and separability restrictions were not imposed.

system are not separable, the implication from this analysis is the following: consumers who shop at this firm in Houston neither select among various cuts or qualities of a particular meat type nor select among meat types of like quality.

NONREVERSIBILITY

Nonreversibilities refer to asymmetrical changes from a previous position in time (Wolffram, 1971). Ward (1982) found that retail markets for fresh vegetables were more responsive to falling wholesale prices than to rising wholesale prices. Kinnucan and Forker (1987) found that the price transmission process in the dairy sector was also characterized by asymmetry. In this paper, an attempt to ascertain whether asymmetry exists in price changes for selected meat products is made. If consumers are more responsive to falling rather than to rising prices, then supermarkets may wish to initiate more promotions which result in lower prices (e.g. coupons, discounts, etc.). If asymmetry fails to exist, then other types of promotions which do not involve pricing may be used.

SPECIFICATION OF NONREVERSIBLE FUNCTIONS

This analysis employs the method developed by Houck (1977) in dealing with specifying and estimating nonreversible functions in economic research. The specification of nonreversible functions may be given as:

$$\Delta Y_i = a_0 + a_1 \Delta X_i^R + a_2 \Delta X_i^D + a_3 \Delta A_i, \qquad (11)$$

for i=1, 2, ... , t, and where $\Delta Y_i = Y_i - Y_{i-1}$; $\Delta X_i^R = X_i - X_{i-1}$ if $X_i > X_{i-1}$ and 0 otherwise; $\Delta X_i^D = X_i - X_{i-1}$ if $X_i < X_{i-1}$ and 0 otherwise; and $\Delta A_i = A_i - A_{i-1}$. Let Y_0, X_0, and A_0 denote the initial values of Y, X, and A respectively. Obviously, Y, X, and A are time-series variables.

The hypothesis central to the analysis is that one-unit <u>increases</u> in X from period to period have a different absolute impact on Y than do one-unit <u>decreases</u> in X. A nonreversibility occurs in ΔY if $a_1 \neq a_2$.

To link (11) to the initial position, Houck shows that

$$Y_t = Y_0 + \sum_{i=1}^{t} \Delta Y_i \ , \ i = 1, 2, \ldots , t, \tag{12}$$

where t is the number of observations beyond the initial value. Consequently the difference between the <u>current</u> and the <u>initial</u> value of Y is the sum of the period-to-period changes that have occurred. Using (11) and (12), the following holds:

$$\Sigma \ \Delta Y_i = a_0 t + a_1(\Sigma \Delta X_i^R) + a_2(\Sigma \Delta X_i^D) + a_3(\Sigma \Delta A_i)$$
$$\text{or} \tag{13}$$
$$Y_t - Y_0 = a_0 t + a_1 R_t^* + a_2 D_t^* + a_3(A_t - A_0),$$

where R^*_t is the sum of all period-to-period increases in X from its initial value up to period t, and D^*_t is the sum of all period-to-period decreases in X from its initial value up to period t. Houck notes that $R^*_t>0$ and $D^*_t<0$. Importantly, if a positive (negative) relation exists between Y and X, both a_1 and a_2 are positive (negative) in Houck’s formulation (equation (13)).

The segmentation and data transformations indigenous to (13) use up two degrees of freedom — one for the added variable and one for the loss in the initial observation. If $Ho{:}a_1=a_2$ is rejected, then a nonreversibility occurs with respect to prices. To test for nonreversibility, it is possible to use either a t-test, an F-test, or a Wald (χ^2) test.

DATA

In this analysis, reversibilities for beef and pork products using scanner data are examined. The set of beef products includes: (1) brisket, (2) loin, (3) rib, (4) round, (5) ground, (6) chuck, (7) roast, (8) steak, (9) veal, and (10) all other beef. The set of pork products includes (1) chops, (2) spare ribs, (3) roast, (4) loin, and (5) all other pork (excluding ham). These products correspond to those considered previously in the section on weak separability.

In compliance with (13), the dependent variables in this analysis are purchases per 1,000 customers; R_t^* corresponds to the sum of all period-to-period increases in own-price from the initial value up to period t; and similarly, D_t^* corresponds to the sum of all period-to-period decreases in own-price from the initial value up to period t. A_t corresponds to the amount of print space, measured in terms of square centimeters, given to the meat product in the advertisement flier in week t.

ECONOMETRIC ANALYSIS

To keep this analysis tractable, the specification ignores cross-price and cross-advertising effects. Consequently, there may exist specification bias because of the omission of these variables. A seemingly unrelated regression (SUR) procedure is to account for the fact that the disturbance terms of the fifteen equations may be contemporaneously correlated. Given that the exogenous variable are not the same in each relationship, gains in estimation efficiency can be expected with the SUR procedure relative to the use of ordinary least squares.

The estimated coefficients and associated t-statistics for this analysis are exhibited in Table 5. The level of significance chosen is the 0.05 level in lieu of the 0.01 level chosen for the analysis of weak separability. The reason for this change is that in the analysis of the nonreversibility, the model is not heavily parameterized. As expected, all coefficients associated with R_t^* and D_t^* are negative, and importantly, all are significantly different from zero. Also, all own-advertising effects are positive, in conjunction with theory, and all are statistically significant. Twelve of the 15 trend coefficients are statistically significant; of these, 3 are positive and 9 are negative. The goodness-of-fit statistics (R^2) range from .4548 (spare ribs) to .8782 (chuck). No serial correlation problems are evident.

Results of the tests of nonreversibility for the beef and pork products are given in Table 6. The own-price and advertising elasticities are exhibited in Table 6 as well. At the 0.05 level, the hypothesis of symmetry of price responses for only three products: pork chops, chuck, and beef roast is accepted. For the other 12 products, there exists sample evidence to indicate that price responses are asymmetric. For spare ribs, pork roast, brisket, and round, the elasticity for price rises exceeds the elasticity for price declines. For pork loin, other pork, beef loin, ribs, ground, steak, all other beef, and veal, the reverse holds; that is, the elasticities for price declines exceed the elasticities for price rises. In all but one instance, the own-price elasticities are in the elastic range. Thus, for beef or pork products, consumers are not only sensitive to own-price changes, but also in the majority of cases, they are more sensitive to price declines than to price increases. This result corroborates the findings by Ward (1982) and by Kinnucan and Forker (1987). This supermarket chain may wish to initiate more promotions which lead to lower prices, at least for pork loin, other pork, beef loin, rib, ground, steak, all other beef, and veal.

The advertising elasticities range from .0087 (pork chops) to .2188 (brisket). A strategy to increase advertisement exposure to boost demand for the set of beef and pork products considered may also be worthwhile. However, it is not possible to discern whether a strategy to reduce prices is preferable to a strategy to increase advertising exposure or vice versa. Such a determination rests on the costs of the respective strategies.

CONCLUDING COMMENTS

Scanner data hold great promise for developing insights into both applied and theoretical research. Though much empirical and theoretical work exists with respect to demand analyses in recent years, reliable estimates of demand parameters for disaggregate commodities are few in number. In this paper, scanner data on meat products are used to conduct demand analyses, specifically to conduct tests of weak separability and tests of nonreversibility. The hypothesis of weak separability is rejected, but the hypothesis of nonreversibility or asymmetry of price responses is generally not rejected.

Despite the potential to analyze retail demand models with scanner data, concern lies with generalizing the results to regional or national levels. Scanner data for supermarkets in a particular location, the present case, represent a "controlled" experimental situation. Community-specific results may not allow defensible, broad regional or nationwide inferences. Consequently, future work with scanner data should involve data collections from various markets, either on a regional or national level. Replication using scanner data has not yet been reported in the economic literature.

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Figure 1. Fresh Meat Products

Beef	Pork	Chicken	Turkey	Lamb(14)	Veal(18)
Brisket(3)	Chops(13)	Breast(20)	Breast(15)		
Chuck(9)	Ham(60)	Parts(29)	Parts(8)		
Ground(9)	Spare Ribs(7)	All Other Chicken(24)	All Other Turkey(26)		
Loin(23)	Roast(5)				
Rib(11)	Loin(11)				
Round(14)	All Other Pork(16)				
All Other Beef(31)					

Table 1. **Average Expenditure Shares (W), Average Purchases Per 1000 Customers (Q) and Average Prices (P) of the Meat Products**

Meat Product	W	Q (pounds)	P (cents/pound)
Beef			
Brisket	0.0229	25.842	175.19
Chuck	0.0348	25.708	263.63
Ground	0.1953	169.000	190.42
Loin	0.0988	38.582	440.04
Rib	0.0497	19.566	420.38
Round	0.0623	36.013	309.44
All Other Beef	0.0585	35.602	281.59
Pork			
Chops	0.0541	28.181	321.18
Ham	0.1056	52.997	351.12
Spare Ribs	0.0195	15.576	207.44
Roast	0.0048	4.258	196.13
Loin	0.0181	10.524	286.02
Others	0.0072	6.272	197.24
Chicken			
Breast	0.0994	71.844	231.66
Parts	0.0321	57.281	101.49
Others	0.0579	101.750	110.86
Turkey			
Breast	0.0379	15.875	404.47
Parts	0.0022	4.016	98.24
Others	0.0081	6.532	212.21
Lamb	0.0208	9.322	383.71
Veal	0.0092	2.240	692.50

Table 2. Possible Utility Trees for this Analysis

Commodity Products	Utility Tree[a]	
	1	2
Beef		
Brisket	A	B
Chuck	A	B
Ground	A	B
Loin	A	A
Rib	A	A
Round	A	A
All Other Beef	A	B
Pork		
Chops	B	A
Ham	B	A
Spare Ribs	B	B
Roast	B	A
Loin	B	A
Others	B	B
Chicken		
Breast	C	A
Parts	C	A
Others	C	B
Turkey		
Breast	D	A
Parts	D	A
Others	D	B
Lamb	E	C
Veal	F	D
No. of Commodity Groups	6	4
No. of Joint Tests	153	121

[a] In each tree, all commodities with the same letter are assumed to belong to the same group. Commodities with different letters are assumed to be weakly separable.

Table 3. Compensated Price Elasticities and Expenditure Elasticities for the Meat Products — Under Classical Restrictions

COMMODITY	BRISK	CHUCK	GROUND	BLOIN	RIB	ROUND	AOB	CHOPS	HAM	SRIBS	ROAST	PLOIN	OPORK	CBRST	CPARTS	OCHICK	TBRST	TPARTS	OTURK	LAMB	VEAL	EXPEND
BEEF																						
BRISK	-8.696*	0.492*	1.466*	0.622*	1.088*	1.310*	0.705*	0.612*	0.181	-0.293	0.072*	0.226*	0.071*	0.876*	0.232	0.858*	-0.191	0.015	0.073	0.164*	0.118*	4.514*
CHUCK	0.323*	-4.165*	0.307*	0.129	0.596*	0.721*	0.928*	-0.094	0.327*	0.407*	-0.024	0.048	0.051	0.305*	0.028	0.201*	0.027	-0.036*	-0.005	-0.043	-0.031	1.848*
GROUND	0.172*	0.055*	-1.220*	0.170*	-0.077*	0.126*	0.123*	0.067*	0.250*	-0.007	0.024*	0.033*	0.013*	0.040	0.050*	0.037	0.037	0.005*	0.044*	0.039*	0.018*	0.704*
BLOIN	0.144*	0.046	0.337*	-2.404*	-0.004	0.607*	0.228*	-0.000	0.136*	0.229*	0.013	0.028	0.005	0.200*	0.106*	0.095*	0.231*	0.013*	0.025	-0.053	0.022*	0.785*
RIB	0.501*	0.418*	-0.302*	-0.008	-1.567*	0.404*	-0.034	0.315*	0.295*	-0.279*	0.057	0.041	0.065	0.017	0.153*	0.116	-0.139	-0.003	0.048	-0.203*	0.104*	1.027*
ROUND	0.482*	0.403*	0.394*	0.963*	0.322*	-4.288*	0.211*	0.239*	0.326*	0.175*	0.038*	0.081*	0.060*	0.229*	0.085	0.205*	-0.046	-0.012*	0.039	0.062	0.032*	1.336*
AOB	0.276*	0.552*	0.409*	0.384*	-0.029	0.224*	-2.899*	0.211*	0.119	-0.041	0.065*	0.073	0.009	0.104	0.016	0.156*	0.218*	0.025*	-0.050	0.133*	0.045*	0.863*
PORK																						
CHOPS	0.259*	-0.061	0.243*	-0.001	0.290*	0.275*	0.229*	-1.719*	0.246*	-0.072	-0.001	-0.066	0.029	0.089	0.075*	0.096*	0.143*	-0.002	0.046	-0.009	-0.088*	0.582*
HAM	0.039	0.108*	0.463*	0.127*	0.139*	0.192*	0.066	0.126*	-1.838*	0.032	0.023*	0.009	0.019*	0.132*	0.082*	0.224*	0.052	0.004	-0.028*	0.012	0.016*	1.308*
SPARE RIBS	-0.344	0.727*	-0.068	1.160*	-0.711*	0.560*	-0.123	-0.200	0.174	-4.012*	0.066	0.550*	0.132	1.122*	0.270*	0.197	0.311	-0.000	-0.125	0.280	0.034	1.525*
ROAST	0.337*	-0.169	0.979*	0.259	0.584	0.487*	0.779*	-0.011	0.498*	0.264	-3.551*	-2.533*	0.027	0.573*	0.116	0.202*	0.485*	-0.096	-0.422*	-0.064	1.256*	1.186*
LOIN	0.286*	0.092	0.354*	0.151	0.114	0.278*	0.237	-0.197	0.054	0.593*	-0.681*	-2.339*	0.000	0.231*	0.194*	0.200*	0.059	0.145*	0.106	0.104	0.020	0.915*
OPORK	0.225*	0.245	0.342*	0.063	0.444	0.516*	0.072	0.214	0.278*	0.356	0.018	0.001	-3.499*	0.036	0.217*	0.103	-0.171	0.083	-0.128	-0.020	0.607*	0.820*
CHICKEN																						
CBRST	0.202*	0.107*	0.078	0.199*	0.008	0.144*	0.061	0.048	0.141*	0.220*	0.028*	0.042*	0.003	-1.876*	0.143*	0.135*	0.261*	0.003	0.011	0.039	0.002	0.640*
CPARTS	0.165	0.031	0.306*	0.326*	0.237*	0.166	0.029	0.127*	0.271*	0.164*	0.018	0.109*	0.049*	0.444*	-2.545*	0.203*	-0.042	0.011	-0.048	-0.029	0.009	0.778*
OCHICK	0.340*	0.121*	0.125	0.162*	0.099	0.220*	0.157*	0.090*	0.408*	0.067	0.017*	0.063*	0.013	0.233*	0.112*	-2.248*	-0.065	0.009*	0.012	0.052*	0.013*	0.963*
TURKEY																						
TBRST	-0.115	0.025	0.192	0.601*	-0.182	-0.076	0.336*	0.204*	0.145	0.160	0.062*	0.028	-0.033	0.685*	-0.035	-0.098	-2.467*	-0.029*	-0.014	0.558*	0.053*	0.881*
TPARTS	0.150	-0.552*	0.437*	0.588*	-0.057	-0.323*	0.652*	-0.042	0.181	-0.003	-0.208	1.167*	0.268	0.131	0.156	0.236*	-0.485*	-2.920*	0.122	0.118	0.384	0.630*
OTURK	0.208	-0.023	1.055*	0.301	0.296	0.302	-0.361	0.309	-0.369*	-0.302	-0.254*	0.237	-0.115	0.141	-0.189	0.088	-0.066	0.034	-0.720*	-0.697*	0.127	0.925*
LAMB	0.180*	-0.072	0.362*	-0.251	-0.485*	0.187	0.373*	-0.024	0.063	0.263	-0.015	0.090	-0.007	0.185	-0.044	0.145*	1.019*	0.013	-0.270*	-1.668*	-0.045	0.583*
VEAL	0.293*	-0.118	0.383*	0.233*	0.561*	0.217*	0.284*	-0.517*	0.177*	0.072	0.660*	0.039	0.475*	0.024	0.030	0.080*	0.219*	0.093	0.110	-0.101	-3.212*	0.597*

Beef	Pork	Chicken	Turkey	Lamb	Veal
BRISK -- Brisket	CHOPS -- Chops	CBRST -- Breast	TBRST -- Breast	LAMB	VEAL
CHUCK -- Chuck	HAM -- Ham	CPARTS -- Parts	TPARTS -- Parts		
GBEEF -- Ground beef	SRIBS -- Spare Ribs	OCHICK -- All Other Chicken	OTURK -- All Other Turkey		
BLOIN -- Lion	ROAST -- Roast				
RIB -- Rib	PLOIN -- Loin				
ROUND -- Round	OPORK -- All Other Pork				
AOB -- All Other Beef					

* Statistically significant at the .05 level. Estimates of the standard errors associated with the various elasticities are arrived at as follows:

$$\text{var}\ (\varepsilon_{ij}^{*}) = \frac{1}{w_i^2}\ \text{var}\ (\pi_{ij})\ .$$

Because this method assumes the budget shares are exogenous, the standard errors are only approximations (Chalfant, 1987).

Table 4. Results of Weak Separability Tests

Utility Tree	Number of Restrictions	ψ	Critical Value	ψ*	Critical Value (K*)
1	153	270.55	196.61	262.67	212.58
2	121	254.71	160.10	248.43	218.40

Table 5. SUR Estimates of the Nonreversible Functions

PRODUCT	R_t^* (Price Rise)	D_t^* (Price Fall)	t (Trend)	A (Advertisement Space)	R^2	DW
Pork Products						
pork chops	-.1091 [a] (13.09) [b]	-.1093 (14.25)	-.0687 (-1.93)	.0058 (4.04)	.6234	1.72
spare ribs	-.1253 (5.06)	-.1037 (4.07)	.1378 (2.80)	.0909 (9.48)	.4548	1.82
pork roast	-.0681 (13.42)	-.0602 (11.52)	.1320 (1.09)	.0110 (5.81)	.6008	1.66
pork loin	-.0296 (4.36)	-.0380 (5.73)	-.1101 (3.41)	.0298 (10.67)	.4788	1.69
other pork (excluding ham)	-.0479 (9.01)	-.0570 (10.15)	-.0749 (4.38)	.0063 (3.08)	.4745	1.44
Beef Products						
brisket	-.7418 (10.19)	-.6926 (9.49)	.8086 (2.97)	.1380 (7.11)	.7372	1.73
beef loin	-.1196 (12.08)	-.1318 (13.67)	-.4111 (2.88)	.0381 (6.99)	.7581	1.62
rib	-.0629 (6.42)	-.0765 (8.10)	-.1515 (3.27)	.0869 (10.67)	.6102	2.16
round	-.4046 (17.73)	-.3848 (18.03)	.4474 (2.18)	.0564 (8.69)	.8667	2.04
ground beef	-1.0252 (12.51)	-1.1234 (15.02)	-.8146 (2.50)	.0907 (7.54)	.7088	2.11
beef roast	-.3960 (15.44)	-.3916 (15.30)	.1439 (0.46)	.0976 (8.96)	.8401	2.10
steak	-.3521 (21.99)	-.3743 (23.79)	-.6898 (5.12)	.0342 (8.62)	.8102	1.74
chuck	-.3631 (16.56)	-.3581 (16.50)	.0792 (0.30)	.0454 (6.55)	.8782	1.92
all other beef	-.2957 (16.18)	-.3165 (16.87)	-.4703 (2.42)	.0301 (3.50)	.7656	1.55
veal	-.0073 (12.29)	-.0098 (14.07)	-.0172 (6.06)	.0249 (7.15)	.7733	1.73

[a] Estimated coefficient
[b] t-statistics are given in parentheses

Table 6. Results of the SUR Tests of Nonreversibility and Own-Price and Advertising Elasticities

Product	Test Statistic (Wald test) [a]	P-Value	Advertisement Elasticity [b]	Elasticity for Price Rise [b]	Elasticity for Price Decline [b]
Pork Products					
chops	0.00	.9595	.0087	-1.2438	-1.2460
spare ribs	5.78	.0161	.1227	-1.6683	-1.3813
roast	6.96	.0083	.0484	-3.1366	-2.7715
loin	4.04	.0444	.0580	-0.8035	-1.0337
other pork (excluding ham)	5.90	.0151	.0753	-1.5062	-1.7918
Beef Products					
brisket	4.31	.0380	.2188	-5.0287	-4.6954
loin	4.45	.0350	.0486	-1.3641	-1.5029
rib	13.49	.0002	.0501	-1.3505	-1.6437
round	3.31	.0689	.0817	-3.4765	-3.3062
ground	10.23	.0014	.0335	-1.1551	-1.2657
chuck	0.17	.6827	.0955	-3.7234	-3.6723
all other beef	4.50	.0339	.0399	-2.3384	-2.5030
roast	0.17	.6786	.1326	-2.3513	-2.3251
steak	14.86	.0001	.0519	-1.5168	-1.6126
veal	59.62	.0000	.0145	-2.2626	-3.0243

[a] χ^2 statistic with 1 degree of freedom
[b] At the same means