Analyses of Consumers' Dietary Behavior: An Application of the AIDS Model to Supermarket Scanner Data

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ABSTRACT

Nationwide food consumption surveys often find no difference in the diets of lower and higher income Americans, while studies of particular food commodities find major differences. These contrasting results represent a consumption paradox. We attempt to gain an understanding of this paradox by using supermarket scanner data to examine food purchases and, by extension, consumption patterns for consumers in two, geographically distinct, income areas. These areas are part of the larger Columbus, OH, metropolitan area (CMA) and six stores are selected for purchase and consumption analyses—three from the lowest income areas of the CMA and three from the highest income areas. Seven product categories are analyzed in this study and these categories are subdivided into meaningful nutritional classes. An Almost Ideal Demand System is employed and the empirical results reveal major differences in consumption behavior for the two groups. [EconLit citations: D120 and D190.] © 2003 Wiley Periodicals, Inc.

1. INTRODUCTION

Research on selected food commodities has revealed widely different consumption patterns for consumers with different levels of income. For example, several studies on milk have reported widespread and heavy use of whole milk among lower income consumers, but limited use of whole milk and heavy uses of skim and low-fat milk among higher income consumers (Jones & Akbay, 2000; Reger, 1998; Zho, Chern, & Jacobson, 1996).

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Similarly, higher income consumers have been shown to express a stronger preference for fresh fruits and vegetables, more nutritious types of breakfast cereals, and low-calorie beer and soft drinks (Akbay, 2000; Eastwood, 1997; Jones, 1997; Jones, Mustiful, & Chern, 1994; The Packer, 1997–2001). These results, when extrapolated, suggest a more nutritious diet for higher income consumers. Yet, food nutritionists have used comprehensive data sets to assess consumers' diets and these data analyses show little to no nutritional difference in the diets of higher and lower income consumers (Murphy & Bayer, 1998; Murphy, Rose, Hudes, & Viteri, 1992). The confluence of these results is a paradox in which the sum (total diet) seems unrelated to its collective parts (selected commodities). How can this be? And how can this paradox be resolved?

This study uses supermarket scanner data to examine food shopping behavior and consumption patterns for consumers in the metropolitan area of Columbus, OH. Data from six supermarkets are used in these analyses. Three stores are selected from the lowest income areas of Columbus and three are selected from the highest income areas. These selections form the basis for the overall premise of this research. Stores in the lowest income areas attract a larger proportion of lower income shoppers and are therefore expected to reveal purchase and consumption behavior that is characteristic of lower income consumers. Likewise, stores in the highest income areas attract a larger proportion of higher income shoppers and are therefore expected to reveal purchase and consumption behavior that is characteristic of higher income consumers.

Supermarket scanner data provide an alternative for simultaneously assessing consumers' behavior with respect to individual commodities and total diets. Retail stores are typically organized into 60 or more food and nonfood categories, such as baked breads, canned fruits, canned vegetables, frozen potatoes, and paper products. Analyses for a selected group of food categories will provide an assessment of consumer behavior for these specific categories; analyses for all food categories will provide an assessment of consumer behavior for a total diet. This research examines the consumption behavior of consumers within two distinct geographic areas: one with a large proportion of lower income consumers (described as below $50,000 majority in household income), and one with a large proportion of higher income consumers (described as above $50,000 majority in household income). Seven product categories are included in these analyses: breakfast cereals, cooking oils and shortening, fluid milk, ice cream, mayonnaise, salty snacks, and salad dressings.[1] Selection of these categories was motivated partly by the ease in which nutritional contents could be used to distinguish product classes, but also by a desire to capture categories that represent frequent purchases for consumers at all income levels.

To help guide this discussion of consumer behavior, the remaining parts of this article are organized into five sections. Section II provides a discussion of: (a) product categories and classes; (b) supermarket scanner data; and (c) some of the socioeconomic characteristics of supermarket shoppers within the two geographic areas. Section III presents the Almost Ideal Demand System (AIDS) and its concomitant set of demand equations that is estimated to derive the empirical results. Section IV provides a discussion of some descriptive statistics that illuminate differences in the behavior of consumers for the two geographic and income areas. Section V provides a discussion of empirically estimated

[1]Salad dressings consist of two types: pourable and semisolids. Semisolids are more comparable to mayonnaise, and these products have therefore been combined with mayonnaise. For discussion purposes, these combined products are identified as mayonnaise.

own-price elasticities and this discussion highlights important relationships among elasticities and per unit prices paid by shoppers in the two groups. Section VI ends the article with a summary and conclusions.

2. PRODUCT CLASSES, SCANNER DATA, AND SOCIOECONOMIC CHARACTERISTICS

Given the nutritional focus of this article, it is imperative that each product category be segmented into nutritional classes that are meaningful for research. As consumers express their product preferences through purchases, many supermarket managers have begun to identify product classes within product categories and then build promotional strategies around these classes. For example, supermarkets classify pourable salad dressings into fat-free, light, and regular classes and a promotional strategy for a given week may focus on all products within one of these classes. For this research, supermarket managers (from a leading grocery chain that provided the scanner data) have provided a listing of product brands that fall into each class. These lists and classes were used as a starting point to identify product classes. Additional information was gained from the examination of many product labels and several nutritional studies, especially when a large number of new or lesser-known products were encountered in a given category. From nutritional studies, the health attributes of calories, cholesterol, fat (monounsaturated, polyunsaturated, and saturated), fiber, sodium, and sugar were identified as being most relevant for classifying products in the aforementioned categories. A total of 32 product classes were identified from the seven categories and these are shown in Table 1.

Table 1 shows that some product categories suggest their own classes. Milk, for example, suggests product classes based on its fat content: 0% (skim), 1/2%, 1%, 2%, 3.25% (whole), and an "all other" or "unclassified" class that consists mainly of flavored and lactose products. Both fat and cholesterol are used to segment brands of ice cream into six product classes. Similarly, fat, cholesterol and calories are used to segment salad dressings into six product classes—three for pourable salad dressings, and three for mayonnaise. A premise of this study is that these 32 classes will reveal widely different purchasing patterns for the two groups of consumers. Results consistent with resolving the aforementioned paradox would reveal higher levels of purchases of some healthy product classes by the below $50,000 majority.

The scanner data for this research are collected from a national supermarket chain in the Columbus, OH, metropolitan area (CMA). Data are available for a large number of economically diverse and geographically dispersed stores. These data represent weekly observations, and they consist of product sales, prices, units sold, customer counts, and total store sales. Product sales cover many package sizes and many product varieties. Considerable computation is required to transform these disaggregated units into recognizable data observations. The supermarket chain maintains data for 65 weeks before discarding it; hence, approximately five quarters of data are available to conduct this research. Despite the ready availability of scanner data, it is recognized that consumers do not purchase all of their food at supermarkets. Away-from-home food consumption represents approximately 40% of food expenditures (Blisard, 2000). Yet, given the fact that away-from-home foods are known to contain more nutrients that adversely impact consumers' health, such as fat and saturated fat, it is likely that at-home food consumption provides the most relevant measure of diet comparisons (Lin, Frazao, & Guthrie, 1999).

TABLE 1. Segmentation of Product Categories into Product Classes

Product Category and Class	Identifying Product Characteristic
Milk	
Skim	
One-half percent	
One percent	Fat
Two percent	
Whole	
All other	
Ice cream	
Regular	
Premium	Fat and
Super premium	cholesterol
Regular healthy	
Premium healthy	
Super premium healthy	
Salad dressing	
Fat free	Fat
Low fat	cholesterol and
Regular	calories
Mayonnaise	
Fat free	Fat
Low fat	cholesterol and
Regular	calories
Breakfast cereals	
Healthy	
Moderately healthy	Fat
Hot cereals	fiber and
Snack cereals	sugar
Salty snacks	
Healthy	Fat and
Moderately healthy	sodium
Regular	
Cooking oils	
Canola	
Olive	
Corn	
Vegetable	Monounsaturated fat and
Shortening	saturated fat
Stick-free spray	
All other	

The selected stores are identified from socioeconomic information provided by the chain for all residents within a 3-mile radius of each store. As shown in Table 2, stores 1, 2, and 3 are located in areas that have large proportions of lower income shoppers (69% of households have incomes below $50,000), while stores 4, 5, and 6 are located in areas that have large proportions of higher income shoppers (58% of households have incomes

TABLE 2. Household Demographic Data for Six Stores (by Percentage)

	Below $50,000 Majority				Above $50,000 Majority			
Demographic Information	Store 1	Store 2	Store 3	Average	Store 4	Store 5	Store 6	Average
Household income								
Under $10,000	13.8	12.9	9.3	12.0	3.8	5.0	3.8	4.2
$10,000–49,999	57.6	58.3	54.1	56.7	32.8	41.8	37.7	37.4
$50,000–74,999	18.5	18.2	22.4	19.7	27.4	20.9	24.6	24.3
$75,000–99,999	6.5	6.3	8.4	7.1	17.5	12.1	15.3	15.0
$100,000 +	3.8	4.3	5.9	4.7	18.8	20.2	18.2	19.1
Race								
White	59.2	83.6	85.7	76.2	95.4	92.4	93.1	93.6
Black	38.6	14.4	12.1	21.7	2.3	3.2	5.0	3.5
Others	2.1	2.0	1.8	2.0	2.6	4.6	1.9	3.0
Education								
Grade school	7.3	10.0	11.1	9.5	4.1	2.0	2.5	2.9
Some high school	21.3	25.4	25.8	24.2	11.6	5.0	8.6	8.4
High School graduate	33.5	36.7	37.6	35.9	28.2	16.2	27.0	23.8
Some college	24.3	19.2	17.8	20.4	26.2	26.6	28.2	27.0
College graduate	13.8	8.8	7.5	10.0	29.9	50.6	33.5	38.0

Source: Spectra, 2001.

above $50,000). Also reflected in Table 2 is the large disparity in the under $10,000 incomes for the two groups. Twelve percent of the households surrounding stores 1, 2, and 3 have incomes below $10,000, as compared to just 4% of the households surrounding stores 4, 5, and 6. With respect to education, college graduates represent an average of 38% of the prospective shoppers for stores 4, 5, and 6, but just 10% of the prospective shoppers for stores 1, 2, and 3. Relative to race, stores with large proportions of lower income shoppers are shown to have more heterogeneous populations than stores with large proportions of higher income shoppers. These and other socioeconomic factors are likely to influence consumer purchase decisions and help focus the contrast between the diets of consumers with higher and lower incomes.

3. THEORETICAL AND EMPIRICAL MODEL

Deaton and Muellbauer (1980a, 1980b) have shown that that the Almost Ideal Demand System (AIDS) generates a system of demand equations that is consistent with neoclassical consumer theory. The AIDS model has its roots in duality theory and multistage budgeting, and it is most useful for providing insight into the process consumers use to allocate expenditures first among food groups and then among products within food groups. Researchers have used the model extensively and have made many modifications to improve its empirical usefulness (Blanciforti & Green, 1983; Chafant, 1987; Moschini & Meilke, 1989; Seale, Sparks, & Baxton, 1992). As used in this study, the AIDS model provides a complete set of demand parameters for seven categories of food products: breakfast cereals, cooking oils and shortening, fluid milk, ice cream, salty snacks, mayonnaise, and pourable salad dressings.

Each category of products is segmented into product classes, but at the first budgeting stage, consumers are assumed to allocate their budgets among seven categories. At the second budgeting stage, consumers allocate expenditures among product classes within a category, and this process is consistent with the assumption of weak separability. To provide a complete demand system, an "all other category" equation is added to each demand system and this equation consists of all categories except the category under consideration.[2] For example, in deriving empirical estimates for classes of breakfast cereals, an "all other category" consists of cooking oils and shortening, fluid milk, ice cream, salty snacks, mayonnaise and pourable salad dressing.

It is well known that the AIDS model has its roots in a class of preferences known as Price Independent Generalized Logarithmic (PIGLOG), and these preferences can be represented by an expenditure or cost function. Further, it has been shown that price derivatives of cost functions yield quantities demanded (Diewert, 1974). Utilizing these principles, the economic form of the AIDS budget share demand function for these product categories can be written as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log\left(\frac{x}{P}\right), \tag{1}$$

where w_i is average expenditure share for good i; $\alpha_i, \beta_i, \gamma_{ij}$ are parameters of the system;

$$x = \sum_{i=1}^{n} p_i q_i$$

is total food expenditure; p_j represents the price of the jth good; p_i and q_i represent the price and quantity, respectively, of the ith good; and P is a price index defined as

$$\log P = \alpha_0 + \sum_{k=1}^{n} \alpha_k \log p_i + \frac{1}{2} \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \log p_k \log p_j. \tag{2}$$

As expressed here, the price index is nonlinear in its parameters, and this creates difficulties for empirical estimation. As such, a linear approximation of the AIDS model (LA/AIDS) is often used and this model substitutes the Stone index for $\log P$ in equation (2). Further, Moschini (1995) has suggested alternative price indices that, unlike the Stone index, are invariant with the units of measurement. Included among these alternatives are the log-linear analog to a Laspeyres index, and this index is used in this study. It is defined as

$$\ln P_t^L = \sum_{i=1}^{n} w_i^0 \ln(p_{it}), \tag{3}$$

[2]As as alternative to this approach, one reviewer suggested the estimation of each product category as a separate demand system. We chose to add a composite equation to each product category as a way of developing an econometrically complete demand system. Specifically, LaFrance (1991) suggested this method as a way of avoiding econometric problems that could arise from endogenous group expenditures.

where w_i^0 is the expenditure share of good i in the base period and p_{it} is the price of good i in the period t. This index has been shown to perform well in Monte Carlo experiments (Buse & Chan, 2000)[3], and it solves the problem of endogeneity (Chern, 1999). Some theoretical restrictions that are derived from utility theory and directly imposed upon the parameters in equation (1) are:

$$\Sigma_i \alpha_i = 1, \Sigma_i \gamma_{ij} = \Sigma_i \beta_i = 0, \text{ and } \gamma_{ij} = \gamma_{ji}. \tag{4}$$

These restrictions are known as the adding-up condition, homogeneity, and Slutsky symmetry. Critical to the full development of the AIDS model with scanner data are the derivation of prices and the incorporation of demographic variables. Prices are derived by expressing each product sale as a ratio of all product sales within a given product class. That is, weighted prices are derived for each product class i during each time period. Mathematically,

$$P_i = \sum_j W_{ij} P_{ij}, \text{ where } W_{ij} = P_{ij} Q_{ij} \Big/ \sum_j P_{ij} Q_{ij} \tag{5}$$

and j denotes the products in a particular class. Given the many brands and package sizes that are represented by scanner data, it is important to emphasize that all brands and package sizes within a given product class are converted to a common unit of measurement, for example, gallons or ounces. Prices are then calculated, but weighted by the number of units sold. As an illustration, skim milk consists of both store and other brands of milk of various sizes (e.g., pint, quart, half gallon, and gallon). A weighted price (P_i) is calculated for this class of milk and the relevant weights represent ratios of product sales for a given size and brand to total skim milk sales.

Still missing from equation (1) is the inclusion of demographic variables. Given the influence of demographic and noneconomic factors on consumer behavior, it is natural to extend the AIDS model to incorporate these factors. This objective is accomplished by employing a demographic translating method, as proposed by Pollak and Wales (1978, 1980). To include the effects of demographic and noneconomic variables, price coefficients of the expenditure function are assumed to depend on demographic variables. The intercept term, α_i, in equation (1), is assumed to be a linear function of the following demographic attributes: product promotion, calendar holidays, time trend, pay periods, customer counts, lagged expenditure share, store differences, seasonality, and product/promotion interactions. These variables are deemed to be relevant for supermarket scanner data and they can be incorporated into the LA/AIDS model by specifying:

$$\alpha_i = \alpha_i^* + \sum_{j=1}^{N} \delta_{ij} D_j, \tag{6}$$

[3]Buse and Chan (2000) conclude that all indices that are substituted for the true index in the AIDS model produce biased and inconsistent estimators. However, for a linear AIDS model with positive collinearity among price data, Buse and Chan found the Laspeyres index to outperform other indices in terms of bias alone. Adding variance to the picture in the face of collinear price data, the Laspeyres index proved to be almost equally ranged with the top-performing Tornquist index. Hence, given our specification fo a LAIDS model with time series data and positive price colinearity, our use of the Laspeyres index seems to be a prudent selection.

where D_j are demographic attributes, α_i^* is the intercept net of demographic effects, and δ_{ij} are the parameters associated with D_j. Equation (6) can be rewritten as:

$$\alpha_i = \alpha_i^* + \delta_{i1} PR_t + \delta_{i2} H_t + \delta_{i3} T_t + \delta_{i4} PAY_t + \delta_{i5} Count_t + \sum_{h=1}^{m} \delta_{ih} W_{h(t-1)} + \sum_{s=1}^{2} \delta_{is} SD_{st} + \sum_{k=1}^{11} \delta_{ik} S_{kt} + \sum_{m=1}^{n} \delta_{im} I_{mt}, \quad (7)$$

where PR_t is product promotion, representing the number of products in a given product class that receives discount pricing during week t; H_t is a zero-one dummy variable that captures the effect of calendar holidays; T_t is a trend variable intended to capture growth of product sales; PAY_t is nearness to pay periods (1 for weeks including the first and 15th of each month; 0 otherwise); $Count_t$ is the total number of shopping customers per week, and it is intended to capture the effects of store traffic on food purchases; $W_{j(t-1)}$ is the lagged expenditure share of good j; SD_{st} is a dummy variable intended to capture differences between stores; S_{kt} is the monthly seasonal dummy variable to capture monthly seasonal effects; and I_{mt} is a variable that captures interaction between product price and product promotion. Note that the original nonlinear AIDS model is difficult to estimate because of a large number of demographic variables. Furthermore, Alston, Cholfant, & Piggott (2001) point out that use of linear translation in the LA/AIDS model does not violate the invariance property with respect to the unit of measurement. The violation occurs in the AIDS, not the LA/AIDS.

Incorporating equation (7) into equation (1) and following standard procedures of applying Hotelling-Shephard Lemma and logarithmetic differentiation to the extended AIDS cost function, the demand function in budget share form becomes:

$$W_{it} = \alpha_i^* + \delta_{i1} \mathrm{PR_t} + \delta_{i2} \mathrm{H_t} + \delta_{i3} \mathrm{T_t} + \delta_{i4} \mathrm{PAY_t} + \delta_{i5} \mathrm{Count_t} + \sum_{\mathrm{j=1}}^{\mathrm{n}} \delta_{\mathrm{ij}} \mathrm{W_{j(t-1)}} + \sum_{s=1}^{2} \delta_{is} SD_{st} + \sum_{k}^{11} \delta_{ik} S_{kt} + \sum_{m}^{n} \delta_{im} I_{mt} + \sum_{j=1}^{n} \gamma_{ij} \log p_{jt} + \beta_i Log\left(\frac{X}{P^*}\right) + e_{it}, \quad (8)$$

where P^* is the Laspeyres price index; X is total expenditure; α_i^* represents the budget share when all logarithmic prices, expenditure, and noneconomic factors are zero; γ_i, δ_i, and β_i are model parameters to be estimated, and e_{it} is an error term.

It should be noted that equation (8) does not include measures of income, cross-category prices, and competitor prices. Data for these variables could not be obtained, and these omissions should have minimum impact on the results if the assumption holds that utility for each category is weakly separable from other categories. This assumption applies for categories within a particular store as well as for categories across stores. Applying these assumption in the model specification means that uncompensated or Cournot own-price elasticities can be calculated as a function of three factors: budget share, coefficient of expenditure and coefficient of own-price (Chalfant, 1987). More specifically, the formula is given as:

$$1 + \frac{\gamma_{ij}}{w_i} + \beta_i, \tag{9}$$

where γ_{ii} is the coefficient of own-price, β_i is the coefficient of expenditure, and w_i is the budget share.

Because this study uses retail-level demand equations for a group of frequently purchased related food products, it is reasonable to expect errors across equations to be highly correlated. This type of correlation is known as contemporaneous correlation (Zellner, 1962). For food products, this correlation can be due to many factors. Some of the more common ones are the general level of economic activity, competitors' actions, prices of other products within a retail firm, and omitted factors (Capps, 1989). When contemporaneous correlation exists, it has been shown that it is more efficient to estimate all equations jointly, rather than estimate each one separately with least squares (Judge et al., 1988; Zellner, 1962, 1963). For this study, a system of demand equations for each commodity category is estimated independently for each income group.

Zellner (1962) has shown that seemingly unrelated regression (SUR) is one of the most efficient methods for estimating demand models. Because the budget shares sum to one in the AIDS model, the contemporaneous covariance matrix of disturbance terms is singular. This singularity of the system leads to estimation by an iterative SUR estimation technique. This method requires the exclusion of one equation, which is chosen to be the category for "all other goods" because it has the highest market share. The iterative SUR estimators are equivalent to maximum likelihood estimators as long as the error terms have a multivariate normal distribution (Judge et al., 1988). Excluding one equation from the system automatically satisfies the adding-up restriction, but homogeneity and symmetry restrictions are imposed in the estimation procedures.

4. INSIGHTS FROM DESCRIPTIVE STATISTICS

The descriptive statistics of Table 3 provide quantity shares and unit prices for the two groups of shoppers and these data reveal insight into their purchase and consumption behavior. Most revealing among the seven categories is the widely different consumption patterns for milk. Low-fat milk (skim, 1/2 and 1%) constitutes just 18% of milk consumption for shoppers in the below \$50,000 majority area, but 48% of milk consumption for shoppers in the above \$50,000 majority area. By contrast, whole milk represents 42% of milk consumption for the former group, but just 13% of milk consumption for the latter group. Unit prices show that shoppers within the below \$50,000 majority areas pay consistently lower prices and these price differences, as measured by z-tests of mean differences, are statistically significant for all but 1/2% milk. Given uniform prices across stores, this suggests a type of utility maximization in which consumers with lower incomes select either more lower priced store brands or larger product sizes with lower per-unit costs.

Although Table 3 shows the above \$50,000 majority shoppers to have a strong preference for low-fat milk, this preference function is somewhat mixed for a milk-related product, ice cream. These same consumers purchase healthy brands of ice cream (33% of purchases) more frequently than below \$50,000 shoppers (20% of purchases). Shoppers in the above \$50,000 majority areas are far more likely to purchase premium and super premium brands of nonhealthy ice cream. These brands make up 38% of the purchases

TABLE 3. Descriptive Statistics (Sample Means) of Selected Variables

Product Classes	Quantity Shares ABOVE $50,000 Majority	Quantity Shares BELOW $50,000 Majority	Z-Values* Mean Tests	Prices Paid per Ounce ABOVE $50,000 Majority	Prices Paid per Ounce BELOW $50,000 Majority	Z-Values* Mean Tests
Milk						
Skim milk	27.79	7.69	58.90	3.73	3.61	1.97
0.5% milk	2.96	0.56	25.47	3.54	3.51	0.55
1% milk	17.13	9.88	26.60	3.61	3.41	4.07
2% milk	35.47	36.53	−3.21	3.68	3.51	3.27
Whole milk	13.35	42.13	−64.10	3.72	3.55	2.98
Other milk	3.29	3.21	0.51	5.88	5.54	4.50
Ice cream						
Regular	28.68	58.89	−110.86	3.31	3.01	4.93
Premium	35.03	20.96	42.61	5.72	5.61	2.03
Super prem.	2.95	0.31	7.73	21.59	18.49	60.57
Regular healthy	16.49	15.78	1.58	3.92	3.71	4.04
Prem. healthy	15.93	3.99	126.73	6.01	5.59	7.45
S. Prm. healthy	0.90	0.07	5.27	17.61	15.61	13.91
Salad dressing						
Fat free	27.21	16.20	40.40	13.48	13.61	−2.14
Low fat	17.76	6.78	33.25	11.10	11.82	−13.31
Regular	55.03	77.02	−64.44	14.50	13.48	19.61
Mayonnaise						
Fat free	6.81	2.63	15.33	11.51	11.16	5.75
Low fat	26.91	10.26	50.42	9.69	8.70	18.29
Regular	66.27	87.11	−61.07	9.52	8.84	13.28
Breakfast Cereals						
Healthy	44.41	34.77	35.37	18.22	17.28	15.46
Less healthy	32.56	41.76	−27.86	19.08	17.52	28.83
Hot cereals	8.70	11.04	−6.85	15.28	13.08	44.79
Snack cereals	14.33	12.42	4.25	16.10	13.22	55.38
Salty snacks						
Healthy	14.90	8.52	23.41	16.00	15.92	1.48
Less healthy	15.03	18.25	−9.75	13.91	15.07	−21.44
Regular	70.07	73.23	−9.26	17.63	17.00	12.11
Cooking oils						
Canola oil	20.30	14.64	20.77	5.48	5.30	2.96
Olive oil	10.68	1.72	27.13	30.64	29.18	26.98
Corn oil	3.99	4.42	−1.26	5.56	5.32	4.89
Vegetable	24.01	36.60	−28.04	5.54	5.35	3.65
Shortening	12.38	21.83	−100.30	7.14	6.29	14.91
Stick-free spray	3.62	1.50	13.46	31.70	30.84	11.40
All other	25.02	19.29	21.03	9.59	6.94	43.58

*All z-values with magnitudes of 1.96 or greater (absolute value) are statistically significant at the .05 level.

for the above $50,000 majority, but just 21% of the purchases for below $50,000 majority. These products contain much more butterfat than the regular brands, thereby offsetting some of the nutritional advantages of low-fat milk. It should be noted that consumption shares of regular healthy ice cream do not differ statistically for the two groups, but prices paid per ounce are statistically different. Shoppers in the below $50,000 majority areas lagged behind those in the above $50,000 majority areas with respect to purchases of brands from premium healthy and super premium healthy classes, but these differences are possibly due to an income constraint imposed by higher prices.

Salad dressing and mayonnaise, two products that are part of the same category but are separated for discussion purposes, differ widely in consumption patterns between the defined areas. From the three classes of salad dressing, low-fat and fat-free dressings represent 45% of purchases for above $50,000 majority, but just 23% of that for below $50,000 majority. Fat-free and low-fat salad dressing are two of three classes of products for which shoppers in the below $50,000 majority did not pay a per-unit price lower than those paid by above $50,000 majority. This phenomenon is perhaps best explained by the fact that a limited number of store brands and product sizes exist in the low-fat category.

For mayonnaise, low-fat and fat-free classes represent 34% of purchases for above $50,000 majority, but just 13% of that for below $50,000 majority. These patterns are clearly preference related, as uniform pricing existed among all classes of salad dressing and the three classes of mayonnaise. Consumers in the below $50,000 majority areas, compared to those in the above $50,000 majority areas, paid lower per unit prices for all classes of mayonnaise. This cost minimization is perhaps due to the fact that store brands and a large variety of package sizes are available across all classes of mayonnaise.

Table 3 shows that healthy cereals represent 44% of purchases for the above $50,000 majority, but just 35% of those for below $50,000 majority. These purchase patterns are likely influenced by product prices. Many of the more nutritional cereals, such as those made from oats, rice, and wheat, are included in this healthy class, and these are also some of the higher priced products. As such, it is likely that an income constraint in the form of higher prices place limits on the choices made by shoppers in the below $50,000 areas. It should be noted that hot cereals such as grits and oatmeal are considered quite nutritional and, as shown in Table 3, shoppers in the below $50,000 majority areas purchase these products in larger quantities. Across all cereal classes, the below $50,000 majority are shown to pay lower per unit prices, and this outcome obviously reflects an attempt to derive a maximum amount of utility through the selection of a large number of store brands.

Although many nutritionists might consider the term healthy salty snacks an oxymoron, this study used the salt and fat content of products to identify three classes of salty snacks. Products with no fat and/or no salt are classified as healthy and those with low fat and/or low salt are classified as moderately healthy. All other products are considered regular. Using these classifications, the above $50,000 majority shoppers are shown to have a stronger preference for healthy snacks; the below $50,000 majority shoppers have a stronger preference for less healthy snacks. Both groups have a stronger preference for regular snack products that include both salt and fat. Although salty snacks are often labeled impulse items, the below $50,000 majority shoppers paid lower per-unit prices for two of the three classes of products, although just one of these differences is statistically significant.

Canola and olive oils are classified by nutritionists as the healthiest classes of oils and these two products are shown to represent 31% of the purchases for the above $50,000 majority shoppers, but just 16% of oil purchases for the below $50,000 majority shoppers. These purchase patterns are intriguing because, although vegetable and canola oils are similarly priced, the below $50,000 majority shoppers expressed a much stronger preference for vegetable oil. This could suggest an information constraint regarding the nutritional value of canola oil, or it could mean that the below $50,000 majority shoppers consider vegetable oil to be of similar or higher nutritional value. Additionally, it could mean that one group of consumers simply have a preference for vegetable oil, regardless of its health attributes.

5. ESTIMATION AND DISCUSSION

Over 1,600 parameter estimates are derived from the empirical models of this study and these estimates are obviously too numerous to discuss individually.[4] This discussion will therefore focus on uncompensated own-price elasticities and expenditure elasticities, but a brief discussion is first provided of some statistical and econometric issues. Three of the product classes, 1/2% milk, super premium healthy ice cream, and fat-free mayonnaise, had reasonably small budget shares and could not be empirically estimated. Each class was therefore combined with an adjacent class. Additionally, the "all other" class of milk was dropped because the price variable generated problems of multicollinearity. A total of 28 product classes remained and this led to an estimation of 56 equations (28 for each consumer group). R^2s are shown in Table 4 for each equation from which the elasticities are derived. Four of these 56 equations have adjusted R^2s below 0.50, but overall the R^2s have values that are statistically acceptable. The Durbin h statistic for each equation showed no problem with first-order autocorrelation. Relative to habit effects, most of the parameter estimates for the lagged dependent variables are positive, but statistically insignificant.[5]

As shown in Table 4, the below $50,000 majority are more sensitive to price changes for milk, save for skim milk. It should be noted that a simple pair-wise comparison of own-price elasticities for the two groups of consumers showed all the elasticities to be statistically different at the 0.05 level or better. The empirical estimates of higher levels of price sensitivity for the below $50,000 majority across three of the four classes of milk are consistent with economic theory, and these values are further confirmation of the statistical insights revealed by the descriptive statistics of Table 3. Per-unit prices paid suggest that the below $50,000 majority has a higher level of price sensitivity, even for skim milk. The empirical estimate of a lower value, relative to that calculated for the above $50,000 majority, most likely reflects wide disparities in budget shares. That is, with skim milk being a relatively small proportion of total milk purchases for the below $50,000 majority, it is possible for an empirical measure to be less precise.

Seven of the eight own-price elasticities for milk are inelastic and these values most likely reflect the importance of milk in consumers' diets. Among the expenditure elasticities for milk, it is of interest to note that the below $50,000 majority increases their consumption of low-fat milk (a combined class of 1/2 and 1%) by more than 1% for each 1% increase in total expenditures. Indeed, both income groups show the highest

[4]All of the regression results are available upon request.

[5]Heien and Durham (RES, 1991) estimated habit effects from both time series and cross-section data for a comparable set of households, and their results show much smaller effects for cross-section data. They concluded that habit effects are possibly overstated in time series studies by a factor of 3 or more. The authors noted that some of this difference in magnitude might be due to the fact that their studies employed quarterly data for the cross-section study, but annual data for the time series study. In both data sets, their estimated habit effects were positive and statistically significant. In our model, lagged shares are included primarily to satisfy the adding up condition. Weekly data are employed in our model and, more often than not, the habit effect is found to be statistically insignificant. Relative to the findings of Helen and Durham, our results seem to suggest a diminishing habit effect as time periods narrow.

TABLE 4. Own-Price, Expenditure Elasticities, and Related Statistics for 28 Product Classes

	Above $50,000 Majority				Below $50,000 Majority			
Product Category and Class	Own-Price Elasticity*	*t*-Ratio	Expenditure Elasticity**	*R*-Square	Own-Price Elasticity*	*t*-Ratio	Expenditure Elasticity**	*R*-Square
Milk								
Skim	−0.595	−4.075	0.651	0.89	−0.402	−1.905	0.504	0.89
Low-fat	−0.537	−3.949	0.837	0.47	−2.281	−10.759	1.025	0.85
Two percent	−0.596	−5.228	0.695	0.94	−0.742	−4.497	0.559	0.78
Whole	−0.593	−4.147	0.608	0.97	−0.670	−4.408	0.558	0.82
Ice cream								
Regular	−1.616	−9.130	0.790	0.77	−1.810	−11.987	0.697	0.63
Premium	−2.193	−16.244	1.065	0.88	−1.997	−11.958	0.820	0.85
Super premium	−0.579	−2.003	0.814	0.95	−2.327	−3.784	0.836	0.72
Regular healthy	−0.836	−3.943	0.423	0.78	−1.212	−5.637	0.487	0.61
Premium healthy	−1.489	−9.365	0.827	0.92	−2.255	−7.803	0.942	0.68
Salad dressing								
Fat free	−1.157	−6.026	0.902	0.90	−1.632	−7.286	1.212	0.73
Low fat	−1.847	−7.023	0.942	0.94	−1.947	−7.947	1.258	0.79
Regular	−1.313	−6.282	0.969	0.53	−1.454	−8.707	1.361	0.58
Mayonnaise								
Healthy	−1.613	−5.581	1.253	0.79	−0.529	−1.959	0.507	0.58
Regular	−0.660	−2.018	0.871	0.54	−0.266	−0.731	1.117	0.43
Breakfast cereals								
Healthy	−1.620	−12.656	0.907	0.89	−1.933	−19.330	0.740	0.66
Less healthy	−1.559	−11.136	0.809	0.83	−2.198	−20.542	0.967	0.79
Hot cereals	−2.361	−9.756	1.415	0.86	−1.836	−6.928	1.225	0.80
Snack cereals	−1.260	−6.563	1.059	0.68	−1.442	−6.136	1.293	0.76
Salty snacks								
Healthy	−0.550	−4.167	0.915	0.52	−1.101	−8.341	0.917	0.74
Less healthy	−1.867	−7.468	1.047	0.70	−1.804	−7.216	0.878	0.65
Regular	−0.425	−3.195	1.070	0.76	−1.288	−9.684	0.898	0.58
Cooking oils								
Canola	−1.362	−6.879	0.866	0.57	−2.307	−7.983	1.213	0.67
Olive	−0.883	−3.436	0.456	0.93	−0.801	−2.213	1.354	0.33
Corn	−0.358	−0.817	1.217	0.55	−1.836	−3.793	1.439	0.68
Vegetable	−1.997	−6.635	0.927	0.68	−2.781	−11.398	1.451	0.89
Shortening	−1.004	−4.365	0.827	0.63	−1.374	−6.802	1.523	0.88
Stick-free spray	−0.708	−3.806	0.515	0.37	−0.283	−1.685	0.858	0.67
All other	−0.930	−9.490	0.488	0.69	−1.193	−13.256	0.969	0.68

*A simple pair-wise comparisons of the own-price elasticities for the two groups of consumers show all the elasticities to be statistically different at the .05 level or better.

***t*-Ratios for expenditure elasticities are excluded because of a space constraint, but 19 of 56 elasticities are statistically significant at the .01 level and all are statistically significant at the .10 level.

expenditure elasticity for this class of milk. However, it should be noted that the next highest expenditure elasticity for both groups is for two percent, not skim. Additional preference rankings of expenditure elasticities for milk show the above $50,000 majority moving from 2% to skim, but the below $50,000 majority moving from 2% to whole. These estimates are consistent with the observation that consumers in the lower income areas are making a slower transition from whole to low fat (milk with a fat content of 1% or less).

All own-price elasticities for the five classes of ice cream across the below $50,000 majority areas are elastic and statistically significant. Moreover, all but two of the own-price elasticities for the above \$50,000 majority areas are elastic and statistically significant. With most brands of ice cream having prices that are either perceived to be high or are actually high, the estimated elastic demands are consistent with prior expectations and economic theory. Comparing the two ice cream classes within the above \$50,000 majority areas that have inelastic own-price elasticities, it is revealing to note that the most inelastic value (−0.579) is for super premium ice cream. This estimated value is consistent with the data that show a super premium brand, Greaters, to be the number one seller (dollar sales) in all three of the higher income stores. Further, in one of the three stores, a different flavor of Greaters is the number one, two, and three sellers. These sales and own-price elasticity suggest that the above \$50,000 majority associate quality with the name Greaters, and therefore, cost is not a major issue.

Consumers in the below \$50,000 majority areas were hypothesized to show greater price sensitivity for all classes of ice cream and, with the exception of premium ice cream, these hypotheses are confirmed. This lower level of price sensitivity for the premium class of ice cream by the below \$50,000 majority is undoubtedly due to indulgence effects associated with brands within this class. That is, even though the below \$50,000 majority shoppers cannot afford the higher priced Greaters, they have obviously identified brands within the premium class that have quality attributes and natural ingredients that diminish the importance of price. Yet, because of an income constraint, product prices constrain their purchases to yield an elastic demand. Indeed prices paid per unit, shown in Table 3, show consumers in the lowest income areas having a higher level of price sensitivity, even for premium ice cream. For both groups of consumers, it should be noted that the highest expenditure elasticities are revealed for premium and superpremium classes. These elasticities are consistent with observations by the International Ice Cream Association that consumers are expressing a rising preference for high-fat ice cream (Hopkins, 2002).

Consumers can make their selections of salad dressings from a wide variety of brands, and these options were hypothesized to lead to own-price elasticities in the elastic range for both groups of consumers. Empirical estimates confirm the hypothesis and consumers in the below \$50,000 majority areas are shown to have greater price sensitivity for all product classes, even though per-unit prices paid show them paying higher prices for two of the three classes. This apparent anomaly is best explained by the fact that limited private label brands within those product classes placed a restriction on selections, but brand limitations had little impact on quantity selections in response to price changes. All of the elasticity estimates are statistically significant at the 0.01 level, suggesting considerable dispersion in both prices and quantities over the 61 weeks of these data. Expenditure elasticities are reasonably large for both groups of consumers, with all classes of salad dressing being identified as luxury goods for the below \$50,000 majority. Among the three classes of salad dressing, expenditure elasticities are largest for regular salad dressing for both consumer groups. As with ice cream, these estimates suggest that the richer taste associated with regular dressings plays a major role in consumers' selection process.

For empirical estimation, fat-free mayonnaise is combined with the low-fat class because of its low budget share. This combined class is shown as healthy in Table 4, and consumers in the two areas are shown to have widely different elasticities. Consumers in the above \$50,000 areas have an elastic own-price demand for healthy mayonnaise, while those in the below \$50,000 areas are shown to have an inelastic demand. Inelastic demands are revealed for regular mayonnaise for both groups of consumers, although the estimate is statistically insignificant for consumers in the below \$50,000 majority areas.

Some additional analysis at the brand level (not shown) coupled with those of Table 3 help to explain these empirical results. Consumers in the below $50,000 majority areas made their product selections primarily from private-label products, and these products showed a limited amount of price variability during the data period. Consumers in the above $50,000 majority areas made their product selections primarily from national brands, and these products showed considerably price variability during the data period. As prices changed, consumers in the above $50,000 majority areas altered their product purchases, and these fluctuations are captured as higher price elasticity.

Despite the somewhat unexpected empirical measures of price elasticities, Table 3 shows clearly that consumers in the below $50,000 majority areas paid lower per-unit prices for each class of mayonnaise. Expenditure elasticities show the above $50,000 majority increasing their consumption of healthy mayonnaise by more than 1% for each 1% increase in total expenditures, while the below $50,000 majority increases their consumption of regular mayonnaise by more than 1% for each 1% increase in total expenditures. These contrasts in expenditure elasticities coupled with the contrasts in quantity shares, as shown in Table 3, suggest a path of continued divergence for this product category.

Breakfast cereals are a product category that offers consumers many brand choices, and economic theory would therefore suggest highly elastic demands. Consistent with theory, the results in Table 4 show all consumers to have elastic demands, and all of these elasticities are statistically significant at the 0.01 level. Consumers in the above $50,000 majority areas are shown to have a more elastic demand for hot cereals, and this estimate is believed to reflect the sensitivity of the AIDS model to small budget shares. For the other three classes of breakfast cereals, the below $50,000 group is shown to be far more price sensitive. Further, even for hot cereals, the per unit prices paid, as shown it Table 3, support the premise that consumers with lower incomes display more price sensitivity.

It should be noted that both consumer groups express the lowest price sensitivity for snack cereals. This is a class of products that includes products consumers often buy on impulse and one would therefore expect a lower level of price sensitivity. Finally, it should be recognized that even though many of the more nutritious and higher priced products are included in the healthy class, both consumer groups paid higher per unit prices for the less healthy class of cereals. This class of cereals includes most of the sugarcoated brands that are higher priced, and per-unit prices paid suggest that both consumer groups expressed a strong preference for these products. For both groups of consumers, expenditure elasticities are highest for hot and snack cereals. Indeed these are luxury products for both groups, meaning an increase in consumption of more than 1% for each 1% increase in total expenditures. Relative to healthy and less healthy cereals, hot and snack cereals represent small quantity shares, but the expenditure elasticities suggest continued growth for these two classes.

Salty snacks are believed to have many of the same impulse characteristics as snack cereals. As such, it was difficult to hypothesize an expected range of elasticities for these products. The estimated own-price elasticities in Table 4 show consumers in the below $50,000 majority areas to be more price-sensitive for two (healthy and regular) of the three product classes. Further, these empirical estimates of own-price elasticities are supported by per unit prices paid, as shown in Table 3. These empirical estimates and quantity shares of Table 3 shed some interesting insights into the behavior of consumers. For salty snacks, consumers with higher incomes have made a two-step move: from regular to less healthy (low salt and/or low fat), and then to healthy (no salt and/or no fat). By contrast, consumers with lower incomes have made a step-and-a-half move: from regular to less healthy, and then partly to healthy snacks. Consumers in the above $50,000 majority areas appear to have developed a strong preference for healthy snacks, and they are less sensitive to price changes for this product category. Consumers in the below $50,000 majority areas have yet to develop a strong preference for healthy snacks, and they are still quite sensitive to price changes for this product class.

The aforementioned observation for salty snacks is similar to what has been observed for milk. All consumers of milk have increased their consumption of 2% milk as they reduced their consumption of whole, but consumers in the below $50,000 majority areas have made a slow transition from 2% to low-fat milk, such as 1% and skim. Statistically, expenditure elasticities for the two consumer groups are identical for healthy snacks, while the above $50,000 majority has higher expenditure elasticities for regular and less healthy. One consistency among the expenditure elasticities for both groups is the large magnitude of the elasticities. Such magnitudes suggest a sizeable increase in consumption for each 1% increase in total expenditures.

Consistent with the predictions of economic theory, consumers in the below $50,000 majority areas are shown to be more price sensitive toward the purchase of cooking oils. Although the magnitude of elasticities for two classes of oil (olive and stick-free spray) seem to violate this premise, it should be noted from Table 3 that these classes represent small budget shares for consumers in the below $50,000 majority areas (less than 2%). Further, the own-price elasticity for stick-free spray is statistically insignificant for the below $50,000 majority consumers and the elasticities for olive oil differ by just a small magnitude for the two groups. Additionally, per-unit prices paid for these two classes of products, as shown in Table 3, support the premise that consumers with lower incomes are more price sensitive toward cooking oil purchases than those with higher incomes. Interestingly, both consumer groups show the greatest price sensitivity for vegetable oil. This product class constitutes the largest proportion of oil purchases for the below $50,000 majority and the second largest proportion for the above $50,000 majority. Relative to expenditure elasticities, the above $50,000 majority are shown to increase their consumption of corn oil by more than 1% for each 1% increase in total expenditures, whereas the below $50,000 majority increases their consumption of all but two oils (stick-free spray and all others) by more than 1% for each 1% increase in total expenditures. These expenditure measures for cooking oils suggest widely different preferences for the two groups of consumers. Indeed, across all product categories, it can be concluded that own-price and expenditures show major differences for the two groups.

6. SUMMARY AND CONCLUSIONS

This research was motivated by a desire to explain why nationwide food consumption surveys can find little to no difference between the diets of consumers at opposite ends of the income spectrum, but selected studies of particular food commodities can find major differences. It was reasoned that this phenomenon could be explained by the fact that consumers show widely different preferences for particular food commodities (classes), but then make tradeoffs among commodities (classes) that lead to similar diets. Seven categories of food commodities (breakfast cereals, cooking oils, ice cream, mayonnaise, milk, salad dressings, and salty snacks) were investigated in this study to try to determine if tradeoffs among these commodities could shed some insight on dietary differences between income groups. Some interesting results were found.

Across the seven categories of food commodities, consumers in the highest income areas made larger purchases from the more nutritious classes. Yet, despite uniform pricing across stores, shoppers in the lower income areas paid consistently lower unit prices. One could speculate that prices are higher for more nutritious products, and therefore, larger purchases of these products would lead to higher per unit prices. For example, if cereal purchases by consumers in the highest income areas included a disproportionate share of high-priced bran cereals, one would conclude that price differences reflect differences in nutritional quality. Yet, this study reveals differences in prices paid even for products with identical nutrients. For example, consumers in the lowest income areas paid a lower per-unit price for all classes of milk, despite the fact that each class is nutritionally identical and uniformly priced across all stores. As an alternative to the aforementioned speculation, a more reasonable conclusion might be that all consumers are rational, but those at lower income levels are more price-conscious of each dollar of expenditure.

Differences in the behavior of consumers within the two income areas are revealed not just by per-unit prices paid, but also by empirical estimates of own-price elasticities and expenditure elasticities. Shoppers of the lowest income stores were hypothesized to be more price-sensitive and this hypothesis is confirmed by the results. For 20 of the 28 pairs of empirically estimated own-price elasticities, consumers of the lowest income stores are shown to be more price-sensitive. As shown in Table 4, most own-price elasticities are elastic and particularly noticeable is the relatively large elasticity for low-fat milk (1% and 1/2%) for the lowest income areas. As previously noted, consumers in the lowest income areas have made a full transition from whole milk to 2%, but they are still making the transition from 2 to 1%. The large elasticity suggests that these consumers still have a preference for whole and 2%, but will purchase low-fat milk when prices are quite favorable. One implication of this result is that consumption patterns for milk could undoubtedly be influenced by public policy. If health officials wished to reduce fat in consumers' diet, they could encourage retailers (perhaps with some incentives) to set a meaningful price differential on high-fat and low-fat milk, especially in stores serving consumers in lower income areas.

Although the seven categories of food products for this study have not fully unraveled the paradox of consumption behavior, these categories have provided some insight into the roles prices and income play in influencing behavior. Clearly, consumers at the lowest income levels are more price-sensitive, and they tend to search for the lowest priced products among all product classes. On occasions when no significant price differences exist among products, consumers at the lowest income level appear to make what nutritionists would regard as irrational choices. Such choices, however, are likely to reflect a number of demand and socioeconomic factors. For example, consumers in the lowest income areas expressed a strong preference for vegetable oil, when comparably priced and more nutritious canola oil was available. For such selections, it is likely that factors such as education, habits, information, and taste interact with, and perhaps dominate, prices and income in determining purchases. Further, the results of this study point to at least one tradeoff in consumption that helps to unravel the paradox. Although consumers in the highest income areas purchase large proportions of low-fat milk, they also purchase large quantities of the brand of ice cream that has the most butterfat—Greaters. This brand of ice cream was the number one seller in all three of the higher income stores. Indeed in one store, a different flavor of Greaters was the number one, two, and three sellers. These observations suggest one way in which tradeoffs are possibly made in consumers' market baskets that result in similarity in nutritional intakes for consumers across all levels of income. Analyses of the more than 54 other categories are needed to further unravel the paradox.

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