THE USE OF DISCRETE VARIABLES TO ESTIMATE PRICE AND INCOME ELASTICITIES FOR PRODUCTS WITH SEASONAL CONSUMPTION PATTERNS

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The consumption of a number of agricultural products varies from one season of the year to another. For some products, seasonal variations in consumption correspond to variations in production. For others, such as fluid milk, consumption and production patterns tend to vary inversely, Downen [2] reported significant seasonal variations in daily average sales of fluid milk with the highest sales occurring in the fall and winter months and the lowest in the spring and summer months. Other studies [1, 5] have also reported seasonal variations in per capita sales of fluid milk. Conversely, production of fluid milk naturally tends to peak in the spring and summer months and reach its lowest point in the fall and winter.

Reflection of the effects of seasonal consumption patterns are important considerations in studies designed to estimate price and income elasticities. A method for accounting for seasonal variations in consumption of fluid milk products is presented herein.

APPROACHES TO THE ANALYSIS OF DEMAND FOR FLUID MILK PRODUCTS

Theoretically, seasonal variations and the quantity of a product consumed may be a reflection of (1) a movement along a given demand function to a new equilibrium price and quantity as a result of a shift in the supply function, Figure 1A, (2) a shift in the demand function given no change in the supply function, Figure 1B, or (3) a shift in both supply and demand functions. Seasonal variations in the slope of the demand function and/or elasticities may also occur.

Three general types of models may be used to estimate the parameters of the demand relations: (1) a simultaneous equations model, (2) a recursive model, or (3) a single equation model. Briefly, the

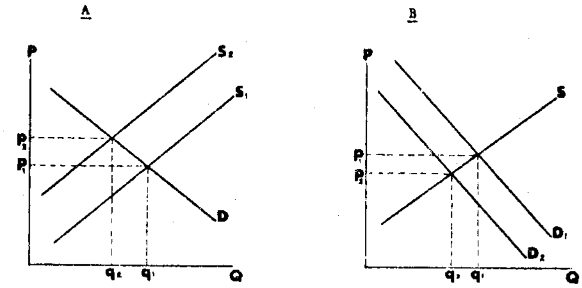

FIGURE 1. ILLUSTRATION OF SEASONAL CHANGES IN CONSUMPTION

simultaneous equations model presumes that the variables are jointly determined and provides for one equation for each jointly determined variable. The recursive model presumes that some endogenous variable is dependent upon several predetermined variables in an equation. This endogenous variable then becomes a predetermined variable in the next equation. Structurally, the recursive model is similar to the simultaneous equations model but computationally it works like the single equation model.

For the study upon which this paper is based [9,10], a single equation least squares regression model was selected. Use of such a model presupposes that the independent variables are predetermined. Such appeared to be the case. First of all, there was never a shortage of Grade A milk available for use in the various fluid milk products considered in the study. In effect, the supply of milk was perfectly elastic over the relevant range of quantities required. Secondly, during the time period studied (1962-1968) the Mississippi Milk Commission established prices at the wholesale and retail level. Further, as these prices changed, proportionate changes resulted in all levels with respect to all products. Thus,

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the consumers were classified as price takers and quantity adjusters, i.e., they had available to them any amounts they desired at the given price levels. Excess supplies were available, in effect, for any given price established during the period. Thus, changes were considered to be demand effects rather than supply effects.

Shifts in the demand curve, during the period, were caused by a number of factors. Changes in tastes and preferences over time, varying levels of emphasis on advertising and promotion, and changes in the prices of substitutes were probably some of the factors. Other factors, believed to be operative, were changes in consumer incomes and seasonality effects. Little, if any, quantitative information was available for reflecting changes in tastes and preferences over time and the emphasis on advertising and promotion. Neither did the data permit the evaluation of substitution between various fluid milk products or between different container sizes for individual products. As indicated earlier, prices for all products and container sizes tended to vary together during the period studied. Consequently, demand shifters included in the study were restricted to consumer incomes and seasonality effects.

THE DATA

The data, upon which the analysis was based, covered monthly observation of quantities of fluid milk sold in Mississippi (from monthly reports of processors and distributors of fluid milk on file in the offices of the Mississippi Milk Commission). Processors and distributors reported selling 25 different products in seven different container sizes. For purposes of the analysis, the products were grouped into 11 product classes. Since not all container sizes were used for each product class, a total of 28 product class-container size combinations was obtained. For each of these combinations, monthly sales data were converted to daily sales and further reduced to estimates of daily sales per 1,000 persons.

Monthly prices for each product class-container size combination were obtained from the files of the Mississippi Milk Commission. Estimates of consumer income, and population for Mississippi for 1962-1968, were obtained from published sources [11, 12]. Price and per capita personal income estimates were deflated by the Bureau of Labor Statistics Consumer Price Index (1957-59 = 100).

THE REGRESSION MODELS

Eight regression models were selected for each of the 28 product-container size combinations (i = 1, 28). These models reflecting either linear, exponential, or quadratic curvilinear relations are as follows:

I. $\text{Log}Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i18}\text{Log}I + \varepsilon_i$

II. $\text{Log}Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i19}\text{Log}P_i + \varepsilon_i$

III. $\text{Log}Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i18}\text{Log}I + \beta_{i19}\text{Log}P_i + \varepsilon_i$

IV. $Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i12}I + \beta_{i13}P_i + \varepsilon_i$

V. $Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i12}I + \beta_{i13}P_i + \beta_{i16}P_i^2 + \varepsilon_i$

VI. $Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i12}I + \beta_{i13}P_i + \beta_{i16}P_i^2 + \beta_{i17}P_iI = \varepsilon_i$

VII. $Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i12}I + \beta_{i13}P_i + \beta_{i15}I^2 + \beta_{i16}P_i^2 + \varepsilon_i$

VIII. $Q_i = \beta_{i0} + \beta_{i1}X_1, + \ldots + \beta_{i11}X_{11} + \beta_{i12}I + \beta_{i13}P_i + \beta_{i15}I^2 + \beta_{i16}P_i^2 + \beta_{i17}P_iI + \varepsilon_i$

Where the B_{ij} s denote the respective parameters of the equations and

Q_i	= Estimated per capita sales of the i^{th} specified product per month
I	= Deflated personal income per capita
P_i	= Deflated price of the i^{th} product
$X_1, \ldots, X_{11}$	= Discrete variable used to adjust for seasonality
ε_i	= Random error

The 11 discrete variables in this study $X_1, X_2, \ldots, X_{11}$, were used to reflect seasonal differences in the level of demand. January was used as a base month and the discrete variables were used for the months of

February through December. For the month of February, X_1 was set equal to one for all observations in that month and equal to zero for observations in other months. For the month of March, X_2 was equal to one for all observations in that month and zero for observations in other months. Similar definitions were used for the other discrete variables. Such use of discrete variables implies that the parameters associated with the price and income variables are the same for each month. For further discussion, see [3].

RESULTS OF THE ANALYSIS

Estimates of both price and income elasticities were calculated for each of the 28 product-container size combinations. However, only the results for Models III and IV for total Whole Milk sales in half-gallon equivalent were selected for presentation in this paper, Table 1.

TABLE 1. ESTIMATES REGRESSION COEFFICIENT, MODELS III AND IV, TOTAL WHOLE MILK SALES IN HALF-GALLON EQUIVALENT, MISSISSIPPI, 1962-1968

Statistic	Model III	Model IV
b_0	2.06888	97.16478
b_1	0.01312	1.12164
b_2	−0.01173	−1.00543
b_3	−0.01446	−1.19990
b_4	−0.07021[b]	−5.85957[b]
b_5	−0.13577[a]	−10.97217[b]
b_6	−0.13151[b]	−10.59599[b]
b_7	−0.10708[b]	−8.74738[b]
b_8	0.02525[a]	2.23970
b_9	0.02169	1.92467
b_{10}	0.01946	1.73624
b_{11}	−0.03083[a]	−2.61895[a]
b_I	0.28851[b]	0.01652[b]
b_P	−0.40367[b]	−71.38767[b]
R^2	.89628	.89821
F	46.52886[b]	47.3867 [b]

[a]Significant at the 5 percent level.

[b]Significant at the 1 percent level.

The regression coefficient for the discrete variable (b_1–b_{11}) for the logarithmic model (III) and the linear model (IV) were consistent with respect to signs but of a different magnitude. However, the differences between the regression coefficient for the discrete variables for a given model tended to be proportional, i.e., the coefficient b_5 was almost twice b_4 in both models.[1] Calculated price elasticities for the two models were almost the same (–0.41 and –0.42, respectively). Calculated income elasticity for both models was 0.29.[2]

In the overall analysis, elasticity estimates for the total sales by individual products were elastic for five of the 11 products–two percent skim milk, flavored milk, sour cream, yogurt, and eggnog. Three of four estimates of price elasticity for two percent skim milk were elastic, ranging from –1.992 to –2.312. Price elasticity estimates for total sales of flavored milk in half-pint equivalents ranged from –1.993 to –2.643. Three of the four estimates obtained for sour cream in half-pints were elastic, ranging from –1.068 to –1.626. One price elasticity estimate with a logical sign of –4.210 was obtained for eggnog in quarts. For the other products, inelastic estimates of price elasticities were obtained. These estimates ranged from –0.1 to –0.8.

EVALUATION OF RESULTS

The Statistical Technique

The specifications and assumptions implicit in the use of a statistical technique can substantially affect the results obtained. Choice of the mathematical model for the regression analysis can be critical from two aspects. First, the independent variables selected for inclusion in the model directly affect the results. Second, the functional form chosen–whether linear or curvilinear, and if curvilinear, the nature of the curvilinear relationship specified–can determine, in part, the "goodness of fit" of the regression.

The model chosen did not include all of the variables that economic theory indicates as being important in explaining the changes in the quantity of the product purchased. The omission of variates that were unobserved could have introduced some bias into the regression coefficients estimated [7]. However, it is almost impossible to include in an analysis all of the variables which influence demand. For this analysis, the large coefficients of multiple determination (R^2) obtained (the preponderance of them in the

[1]Estimates of regression coefficients and other selected statistics for all models are available in Appendix B of the overall report [9, 10].

[2]Elasticities were calculated at the means of the variables for the linear model.

range .85 to .95 and larger) indicate that the price, income, and seasonality variates included were accounting for most of the variability in quantities purchased.

From the eight different regression models, the statistical evidence (the R^2 and F values) was not clear-cut with respect to which model provided the "best" regression estimates. On the other hand, the larger R^2 and F values obtained pointed toward the quadratic models. In some instances, the sign of the price elasticity estimate was illogical for the model with the largest R^2 and F statistics. Even though the results obtained were rather erratic, one or more of the models provided "reasonably acceptable estimates," in my opinion, for most of the product-container size combinations considered.

The Data. Another factor which must be considered in the interpretation of results from regression analyses is the degree of correlation between the independent variables. If the independent variables are highly correlated, then the multiple regression techniques do not yield precise estimates of the net effects of the independent variables. Two of the independent variables used in this study, deflated price and income, were fairly highly correlated for some product-container classes. The highest correlation coefficient (0.773) between deflated price and income was calculated for regular skim milk in half-gallon containers.

The smallest correlation (–.003) was between the logarithm of income and the logarithm of price for quarts of homogenized milk. Correlation coefficients for price versus income exceeded 0.50 for 17 of the 28 product-container classes. Even though the correlations differed by product-container classes, no pattern to the relationship between correlation coefficients and the variability in elasticities was discernible.

Inherent in any regression analysis is the possibility that the data for the variates included will be such that spurious relationships will be obtained. The correlation between the income data and a trend variable formed by numbering the months consecutively beginning with January, 1962, was extremely high ($r = 0.997$). Hence the estimates of the income effect presented earlier may not have reflected a true income effect but may have been a reflection of the relationship between purchases of the product and some other variable which was changing monotonically over time.

The relatively narrow range over which the observations on prices of the products varied must also be considered in evaluating the results obtained. During the period considered in this study, prices for half-gallons of homogenized milk (the price used in the analysis for whole milk) ranged from 52 to 61 cents. The range was even narrower for some other product-container size classes. Prices for half-pints of homogenized milk varied only from 9 to 10.75 cents per unit. When the prices were deflated by the consumer price index for the regression analysis, the range became even narrower. Consequently, the price elasticity estimates must be interpreted as being applicable to the relatively narrow range of the data rather than to the broad spectrum of all possible prices.

Theoretical Considerations. The extent to which the results of the statistical analyses conform to economic theory must also be considered in their evaluation. Most of the estimates of price elasticity obtained were negative and, thus, generally consistent with economic theory. The consistency of the estimates of income elasticity obtained may be more questionable.

Theoretically, it is difficult to develop a convincing argument that some of the creams and certain other product-container classes are inferior goods. Consequently, since the income variable was highly correlated with time, the decreases in purchases indicated were likely a reflection of changes in tastes and preferences, substitution, and other demand shifters that were not considered, rather than income effects. A number of products considered to be substitutes for the cream products were developed and placed on the market during the period covered by this study. The increased emphasis placed on dieting during the period could have contributed to the trend away from the high-fat products and toward lower-fat dairy or non-dairy substitutes. Also, changes in consumer preferences for a particular container size, based upon factors other than price and income, could have affected the results obtained. Perhaps, there was a shift in preferences from quart containers toward the larger container sizes for whole milk, skim milk and buttermilk products.

The extent to which factors other than price and income affected the results obtained was not definitely determined in this study. However, the negative income elasticities estimated are believed to be more a reflection of effects of factors other than income rather than income effects.

Even though direct comparisons between the price elasticity estimates obtained in this study and earlier aggregate estimates cannot be made, some indirect comparisons based upon theoretical considerations can be made. Theoretically, the demand for individual products would be expected to be more elastic than the demand for the aggregate product because of the possibility of substitution between products.

The results obtained in this study were generally consistent with theoretical considerations when compared to the estimates from earlier studies. Most of the elasticities in these studies were inelastic. By comparison, elastic estimates were obtained from one or more models for 14 of the 28 product-container classes analyzed in this study.

SUMMARY

Overall, it would appear that many of the price elasticity estimates obtained in this study compare favorably with those obtained in earlier studies. While this favorable comparison, of itself, does not validate the estimates obtained, it does constitute additional evidence and support for them.

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