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Household Response to Changes in Retail Prices for Dairy Products - Some New Evidence

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Household Response to Changes in Retail Prices for Dairy Products - Some New Evidence

The estimation of retail price elasticities for major dairy products has been identified as a major research priority for the dairy industry in the 1970's.[1] The substantial increase in both the number of dairy products being marketed as well as the major changes which have been occuring in consumption patterns may imply that older dairy product demand models may be improperly specified for present day conditions. In addition, the recent and rather substantial increases in dairy product prices suggests that we are significantly outside the range of the data on which previous estimates were based.

In order to help meet the need for such research, the United Dairy Industry Association purchased Market Research Corporation of America (MRCA) National Consumer Panel (NCP) household purchase data for dairy products for a 22 month period beginning in April 1972.[2] In total there were more than 1.6 million individual purchase observations from approximately 7500 households from across the United States. These data were subsequently made available for this research.

The overall objective of the research was to identify and analyze the structure of the household demand for selected major dairy products and in so doing provide, for policy purposes, numerical estimates of the demand response parameters. The study focus was on isolating the response in household purchasing to changes in retail prices and incomes. The purpose of this paper is to present research results which

isolate the estimated price response parameters and in do doing discuss the implications of these results for dairy industry policy and research in the late 1970's.

Research Methods and Data

Even though the theory of choice for an individual consumer under static conditions is contained in a well defined body of economic literature and provides important insights in understanding the concept of demand it often leaves much to be desired when formulating measurement attempts. In linking this body of theory to empirical demand analysis, the researcher must make several crucial assumptions regarding the relevant consuming unit, the time period, the product, the functional form of the relationship, the appropriate price and quantity and the choice of statistical tool, among others. While such decisions are in practice often either outside the direct control of the researcher or are made during the analysis, the nature of the data available for this study and the expense involved in its manipulation required that these decisions be made by the researchers and prior to the analysis stage. The obvious question which had to be answered was, how might these data best be employed to meet the stated research objectives? It is admitted that posing such a question deviates somewhat from the accepted principles of the scientific method but stating the question explicity serves as a rather subtle reminder that social science researchers must continually be aware of the possible lack of correspondence between the objectives of the research and the available data.

Two statistical models were developed for this research effort. A cross-section model, using individual households as the units of observation was employed to obtain an estimate of the longer run response to changes in price. Such an estimate is considered to be a long run response because "in a cross-section model the disequilibrium among households tends to be synchronized in response to common market forces so that many disequilibrium effects wash out (or appear in the regression intercept)" [Kuh, p. 208]. However, since cross-section data also contain some short-run disturbances, it is expected that these coefficients will tend only to approximate the fully adjusted long run responses.

Typically, cross-section models do not explain large percentages of the variation in household consumption. Spacial differences among households give rise to climatic, cultural or other factors associated with variations in consumption rates. Such variables are not easily identified and may not be measurable. Thus, response estimates based on the idea of viewing different households units in different circumstances may tend to overstate or understate their true response because part of the observed difference in consumption may be due to important excluded variables.

The general form of the cross-section model was as follows:

$$Q = f\ (P, DV, HDV, ED, OCC, R, HES, HC, RGN, INC)$$

where

Q = the quantity purchased by a panel household during the time period under study,

P = the reported price paid,

DV = the percent volume on deal,[3]

HDV = the percent volume purchased on home delivery,

ED = educational level of the household head,

OCC = occupation of the household head,

R = race of the household,

HES = employment status of the housewife,

CS = size of the city of residence,

HC = the age/sex composition of the household,

RGN = the geographic region, and

INC = annual household income.

Educational level of the household head, occupation of the household head, race, employment status of the housewife, city size and the geographic region were all entered in the regression as sets of intercept shifters. The age/sex composition of the household was specified by including as variables the actual number of members in each of nine age/sex classifications. A second order polynominal was specified for the income variable.

A second model, a modified time series model, was also specified. For this model the purchase observations generated by the static consumer panel were aggregated by geographic region and then averaged for each two week time period of data availability. It was expected that the results of this model would provide an estimate of the short run purchase response to changes in the average market price. The general form of the model was as follows:

$$Q = f(P_o; P_1, \ldots P_n; PX; DV; HDV; R; S)$$

where:

$$Q = \sum_{r=1}^{H} q_r/N$$

and

H = the total number of panel households

N = the total population of the H households

P_o = the weighted average price paid for the product

$P_1,\ldots P_n$ = the weighted average price paid for n substitute and/or complement products[4]

PX = the Consumer Price Index (CPI) for all food

DV = the proportion of the total quantity purchased by panel households subject to a special promotion or "deal."

HDV = the proportion of the total quantity purchased by panel households from a home delivery distributor, and

R = geographic region

S = season of the year

Geographic region and season of the year were entered into the regression as sets of discrete variables (zero or one). Prices, other than own price, were included if on the basis of a priori information they were thought to be close substitutes or complements of the product under study.

This model is similar to a model estimated by Purcell and Raunikar in 1971 for meat poultry and fish. While the model, at least conceptually, permits "tracing the reaction of a specific group of consuming

units of known characteristics to changes in economic variables approximately as they occur in the market place" [Purcell and Raunikar, p. 217]. It still suffers from several shortcomings. Price variability between consuming units within the selected geographic markets is averaged out. Further, there is no obvious way, at least in the short time series available, to make allowances for changes in socio-economic characteristics of individual households.

The single equation model was chosen for use in this study. Parameter estimates were obtained by an equation by equation application of ordinary least squares (OLS) regression. All variables were included in the models linear in the actual variates except that a second order polynominal term was included for the income variable in the cross-section model.

Since the products are closely related the implicit OLS assumption that there exists no other regression model with a disturbance that would be correlated with the equation error was thought to be seriously violated.[5] If this is the case, the application of Zellner's "Seemingly Unrelated Regression" (SUR) technique will result in parameter estimators which are at least asympotitically more efficient than those obtained by an equation by equation application of OLS [Zellner].

The method of SUR was applied to the time series model equations. Equations were grouped for estimation on the basis of hypothesized interdependent demands. Disturbance intercorrelation between equations was relatively "weak" (i.e. < .30) and it was concluded that important gains in efficiency were not realized by estimating these product demands in a system of "seemingly unrelated" equations. There were only

minor differences in either the estimated coefficients or their standard errors regardless of the method of estimation. All results subsequently reported are for the OLS estimation only.

Results

A summary of the selected study results is contained in Tables 1 and 2. In Table 1 the level of the demand for each of the 12 major dairy products is indicated by the average annual per capita consumption and average price paid. Per capita quantities are the simple averages of the two week per capita quantities purchased adjusted for a 12 month period. Prices paid are simple averages of the weighted average prices obtained for each two weeks of the study period. While the results in Table 1 are not strictly comparable to the total civilian disappearance statistics published annually by the United States Department of Agriculture they do indicate the relative importance of "at home" consumption levels for each of the products. For example, the 40 half gallons of fluid milk per person per year reported by panel households indicates that about 60 percent of the estimated 292 pounds per person total annual disappearance is accounted for by "at home" consumption. Away from home consumption accounts for about 55 percent of the total butter disappearance which is estimated to be 4.18 pounds per person per year.

The results also indicated certain shifts in consumption patterns. During the 21 month period of the study, consumers continued to shift from regular whole milk to the lowfat milks. This shift in consumption alone had the effect of stabilizing somewhat the total consumption of

Table 1. Annual Per Capita Consumption and Average Prices Paid by United States Households for Twelve Major Dairy Products, 1972-73.

Product	Unit	Per Capita Quantity Consumed	Average Price Paid in Cents
Total Fluid Milk	Half gallon	40.08 (4.22) 1/	59.14 (5.70)
Regular Whole Milk	Half gallon	26.48 (4.75)	60.03 (5.63)
Two Percent Milk	Half gallon	9.43 (5.15)	57.35 (5.31)
Buttermilk	Half gallon	.97 (.53)	62.22 (6.20)
Nonfat Dry Milk Powder	Pound	1.71 (.32)	62.62 (3.81)
Butter	Pound	2.09 (.99)	83.57 (3.21)
Ice Cream	Half gallon	4.70 (.89)	77.91 (6.42)
Ice Milk	Half gallon	.97 (.52)	60.67 (11.01)
Cottage Cheese	Pound	4.62 (1.39)	40.24 (2.16)
Process Cheese	Pound	1.12 (.28)	96.15 (3.69)
Total Natural Cheese	Pound	3.08 (.95)	113.01 (5.82)
Half and Half Cream	Pint	1.03 (.62)	35.71 (2.97)

1/ Standard deviations in parenthesis

fluid milk and retarding somewhat the increase in the weighted average price of the total fluid milk product. Study results indicated that regular whole milk consumption was reduced from 68.4 percent of total consumption to 64.8 percent during the period May 1972 to January 1974. Lowfat milks increased as a percent of the total from 29.5 to 33.4 percent, a 13 percent increase in only 21 months.

Table 2 contains a summary of the estimated purchase responses due to changes in the retail prices for the products. In general the results obtained in estimating the parameters for the time series model are quite consistent with the short run estimates obtained in previous studies [Bullion, George and King, Rojko]. Consumers in the short run appear more responsive to changes in the average market price for the manufactured products than for changes in the fluid milk prices. For example, the calculated short run price elasticity for regular whole milk was -.38. Butter, natural cheese and ice cream estimates were all in the range -.69 to -.85. However, the short run responses to changes in retail prices for specific products within products groups are generally more elastic than are the estimates for composite products. Such results imply that statements about the overall price elasticity of demand for the "manufactured" dairy products or for "fluid milk" must be made with great care. Further, they lend additional support to Fred Waugh's insightful comment that "there is probably no such thing as the elasticity of demand" for any of the products studied [p. 8].

The indicated short run relationships do not, however, appear to be supported by evidence from the cross-sectional model. The longer

Table 2. A Summary of the Long Run and Short Run Household Purchase Response to Changes in Retail Prices for Twelve Major Dairy Products, 1972-73.

Product	CROSS-SECTION MODEL		TIME SERIES MODEL	
	Estimated Regression Coefficients	Calculated 1/ Price Elasticity	Estimated Regression Coefficients	Calculated 1/ Price Elasticity
Total Fluid Milk	-5.86 * (.38)	-1.63	-3.68 (2.93)	- .15
Regular Whole Milk	-4.18 * (.34)	-1.70	-6.43 * (2.89)	- .38
Two Percent Milk	-1.91 * (.30)	-1.33	-3.46 * (1.85)	- .55
Buttermilk	- .23 * (.05)	-1.52	-1.06 * (.26)	-1.77
Nonfat Dry Milk Powder	- .44 * (.04)	-2.24	- .48 (.66)	- .45
Butter	-1.82 * (.44)	- .76	- .71 (.64)	- .73
Ice Cream	- .07 * (.01)	- .42	-1.61 * (.91)	- .69
Ice Milk	- .06 * (.02)	- .57	- .65 * (.30)	-1.05
Cottage Cheese	- .51* (.04)	-1.28	-1.88 (2.04)	- .42
Process Cheese	- .08 * (.01)	-1.71	- .88 * (.23)	-1.81
Total Natural Cheese	- .07 * (.01)	- .85	- .88 * (.47)	- .85
Half and Half Cream	- .40 * (.10)	-1.24	-1.00 * (.49)	- .91

run estimates from the cross-section model indicate that consumers may be more responsive to retail price changes for the fluid milk products than the shorter run estimates would lead us to believe. On the average, households purchasing fluid milk at prices 10 percent higher than the mean purchased at rates 16 percent lower than households purchasing at the mean price. The price response for each fluid milk type was negative, statistically significant and produced an elasticity estimate with an absolute value greater than one.

In contrast, the longer run estimates for the manufactured products as a group, excluding nonfat dry milk powder, were not substantially different from the shorter run estimates. Butter, ice cream, the hard cheese products and cream all had short run estimates which were quite similar to the estimates obtained from the cross-section model. The consumption of those products within each product group which have close substitutes and are not generally considered as essential in the diet appears to be, as expected, relatively more responsive to price changes than the other products in the group. However, the data appear to indicate that given the time to find relatively less expensive substitutes and/or adjust their diets, consumers will respond by purchasing less of those products which in the short run are quite insensitive to retail price changes.

The relative magnitude of the longer run price response estimates also provides some insights into household consumption patterns for the products studied. In general, households consuming the higher priced per unit product type (e.g., fluid milk rather than powder, ice cream rather than ice milk, natural cheese rather than process cheese, butter

rather than margarine) are less responsive to price changes than are households consuming the lower priced per unit product type. Apparently consumers who purchase the lower priced per unit product type do so at least partially because of a binding income constraint. Changing relative prices in such a way as to reduce the monetary advantage of the lower priced per unit product type has the result of increasing the consumption of the higher priced product. In other words, increasing the price of the already higher priced product type relative to the lower priced product type results in less consumer purchase response than increasing the price of the lower priced product type relative to the higher priced option.

Data such as those available for this study remind us in a very obvious way that changes in the aggregate market quantity from one time period to another are the result of (a) adjustments in purchasing rate by those who purchased in the previous time period as well as (b) the entry and/or exit of other consuming units. In estimating the cross-section model only consuming households were included as observations. This had the effect of not only excluding the (temporary ?) non purchaser but also including the infrequent purchaser . Thus, the cross-sectional parameter estimates provide little explicit information about purchasing versus non purchasing households. Comparisons of the effects of different demographic characteristics across products are not therefore, strictly valid. The time series model averages out the rather discrete purchase or non purchase decisions made by consuming units and the adjustment process is taken as continuous over time. Perhaps we

need to consider more seriously the concept of a "threshold price" in examing the purchase decision. A model of cross sections over time would appear to permit such a study. This appears to be an area where additional research is needed.

Implications

The results of this study suggest that households do adjust their purchasing rates to changes in the retail prices of dairy products. The evidence almost without exception indicates that consumers are not passive to price level changes either in the short or the longer run. The longer run adjustments to price level changes for the fluid milk products appear to be somewhat more elastic than is generally thought to be the case. The short run adjustments to price changes seem, however, quite consistent with previous studies.

The implications of these results for dairy industry policy regarding these findings are rather clear. If the impact of increased production and processing costs on dairy product sales is to be minimized, all segments of the industry must continue to make every effort to improve efficiency and keep retail prices as low as possible consistent with adequate returns to labor and capital. Additional effort by university and industry researchers may be needed to isolate those areas where inefficiencies still exist. Such areas as raw product flows and final product processing and distribution would appear to be logical candidates. Additional effort may be required to develop new products which can be made available to consumers at a relatively low cost per unit.

Consumer acceptance of such products as the low fat milks, ice milk and yogurt serve an example of what can be done in this area.

The relative long run responsiveness of consumers to changes in fluid milk prices versus the manufactured products may well suggest that the industry will rely increasingly on the increased consumption of manufactured products for increased total milk equivalent consumption. Ironically, up until now, these products have served the industry in the role of "residual claimant". This expected result may be enhanced somewhat by the recent stabilized increases in the rate of population growth. 6/

Finally, the results of this study would indicate that as the industry considers alternatives to the present process of pricing raw milk and other dairy products, serious consideration should be given to those pricing systems which would tend to keep retail prices as low as possible consistent with adequate returns to capital and management. We may need to adopt policies which will encourage the increased production of raw milk in those areas of the country with a comparative advantage to do this. Blakely has indicated that the current pricing system based on the competitively determined price of manufacturing grade milk in Minnesota-Wisconsin milk shed plus transportation costs from Eau Claire, Wisconsin "has resulted in lower prices in the high income regions and higher prices in the low income regions" [p. 15]. Furthermore, this pricing process has resulted in higher prices in those areas with the highest retail price elasticities [Bullion]. Results of this study lend support to these conclusions and reinforce the findings of Bullion. While time and space considerations do not permit the presentation and discussion of all

results, the study showed significant differences in regional consumption patterns and responses to price changes for milk and other dairy products. Such differences provide an opportunity for the industry and regulatory agencies to devise pricing strategies which will minimize the impact of increased production and processing costs on dairy product sales.

At least the current industry practice of placing disproportionate increases on fluid milk prices to cover increased costs should be examined. The longer run consequences of such a policy do not appear as "painless" as the short-run price elasticity estimates imply. A policy which spreads such costs over more dairy products may have more desirable long run consequences.

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Footnotes

*Assistant Professor of Agriculture Economics, Virginia Polytechnic Institute and State University(VPI&SU). VPI&SU Agricultural Economics Staff Paper No. 4. This paper is based in part on the author's unpublished 1974 Purdue University Ph.D Thesis, An Econometric Analysis of the Household Demand for Major Dairy Products. The important contributions of Emerson M. Babb in all steps of this research are acknowledged.

[1]See, for example, the papers by several dairy marketing specialists in, The UDIA Marketing and Economics Research Program and It's Data Needs, Ninth National Symposium on Dairy Market Development, Rosemont, Illinois, December 1972.

[2]The United Dairy Industry Association (UDIA) acquired these data as a client of the Market Research Corporation of America and made them available for this research. Dr. G. G. Quackenbush, Director of Economic and Marketing Research of UDIA was instrumental in initiating research using the panel data and made significant contributions in all phases of the research.

[3]When households reported the purchase of a particular dairy product, they also indicated whether or not there was any special promotion or "deal" ("cents off, free product, coupon sale, etc.") involved in the purchase. The percent of a household total purchase volume made subject to a special promotion was then specified as an independent variable in the cross-section regression model.

[4]Prices, other than own price, were included in the model if, on the basis of a priori reasoning or previous study they were felt to be close substitutes or complements. The potential problem in estimating coefficients with highly correlated exogenous variables is recognized.

[5]See Kamenta for more detail.

[6]The study revealed that family age/sex composition, especially the presence of young children was an important positive influence in household fluid milk consumption.