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**An Analysis of Household
Consumption of Dairy Products**

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TABLE OF CONTENTS

| | |
|---|----|
| Introduction | 4 |
| Scope of Study and Source of Data | 4 |
| Data, Assumptions, and Limitations | 5 |
| Methodology | 6 |
| Method of Analysis | 8 |
| Data Characteristics | 9 |
| Results of the Analysis | 13 |
| Influence of Product Price on Household Consumption | 13 |
| Influence of Income on Household Consumption | 15 |
| Household Response at Different Price and Income Levels | 16 |
| Influence of Household Characteristics | 16 |
| Occupational Status | 17 |
| Educational Level | 17 |
| Employment Status | 17 |
| Race | 17 |
| Influence of Age/Sex Composition of Households on Dairy Product Purchases | 19 |
| Life Cycle and Household Purchases | 22 |
| Summary | 23 |
| Appendix A | 24 |
| Appendix B | 25 |
| References | 27 |

LIST OF TABLES

| Table | Page |
|---|------|
| 1 Utilization of U.S. Milk Supply by Major Dairy Products and Percent Purchased Directly by Households | 5 |
| 2 Product Composition and Weight/Volume | 10 |
| 3 Average Price Paid and Quantity Purchased, Income, and Household Size of Those Consuming in a 16-Week Period | 11 |
| 4 Average Prices Paid by Households for Selected Dairy Products During These 16-Week Time Periods | 12 |
| 5 The Proportion of and Estimated Number of Households in the U.S. Dairy Market: 1972 | 12 |
| 6 Household Purchase Response to a One Percent Change in Average Price or Household Income | 14 |
| 7 Estimated Income Levels at Which Purchasing Response is Zero | 15 |
| 8 Household Purchase Response to a One Percent Change in Average Price and Income at the Mean Values and at Plus and Minus One Standard Deviation From the Mean | 16 |
| 9 Estimated Effect of Selected Household Characteristics on Annual Household Purchases of Major Dairy Products | 18 |
| 10 Average Age/Sex Composition of Households in the Survey | 19 |
| 11 Estimated Influence of the Number of Household Members in Selected Age/Sex Categories on Household Purchases of Selected Dairy Products | 20 |
| 12 Expected Life-Cycle Purchase Patterns of Hypothetical Households | 21 |

INTRODUCTION

Household consumption of dairy products is the major component in the total sales of the U.S. dairy industry. Therefore, understanding the factors which may significantly influence household consumption is important in the planning of farmers, processors and handlers, and manufacturers. Consumers' responses to changes in price and nonprice factors are basic to an economic analysis of almost all the policy decisions which relate to industry or government programs. Forecasting the future direction of household consumption, and how that direction might be modified through industry efforts or by national programs and policies, requires information on the relationships among prices, incomes, household characteristics and consumer demand.

This study focuses on households as consuming units, and explains and analyzes their purchasing behavior for dairy products. The study uses a different technique of analysis, different from the time series traditionally applied to the study of consumer behavior. This technique, known as the TOBIT method, is an effective alternative when analyzing purchasing behavior from cross section data obtained from a panel of consumers.

TOBIT was used to estimate demand because consumer panel data on consumer purchases presents an additional estimating problem from those encountered with standard time series observations. Consumption changes that result from changes in price or other demand determinates can, and often do, reflect two kinds of adjustments: (1) changes in number of actual consumers in the population of potential consumers, and (2) changes in the quantity purchased by those actually consuming the product. Where demand relations are estimated from time series observations on average consumption for the average consumer, both kinds of adjustment are included in the estimated relation. However, when cross sections of consumers from consumer panels, including both consumers and nonconsumers of a product, are used to estimate demand relations, the consumer exit-entry component of the market adjustment must be considered. If not considered results under-estimate the total adjustment. The TOBIT procedure is a way to overcome this difficulty and provide some additional and useful insights into product consumption.

SCOPE OF STUDY AND SOURCE OF DATA

The data utilized in this study was purchased from the Market Research Corporation of America (MRCA) and made available to the authors for research purposes by the United Dairy Industry Association. Dr. G. G. Quakenbush, Director of Economics and Marketing Research, UDIA, was instrumental in the development and dissemination of these data.

Data included about 7,800 U.S. households that reported weekly purchases of dairy and related products for the April 1972 to March 1973 period. Additional information for the April 1973 to January 1974 period was obtained for fluid milk items and butter.

Data on the prices paid and quantity purchased reported by each household was aggregated into three 16-week periods by researchers at

Purdue University.¹ The data used in this study was a random sample of 383 households drawn from the total 7,800 panel households. Consumption behavior for each of the 383 households was sampled in each period, resulting in a total of 1,149 observations.²

This study considers only household demand for major dairy products which represent from 40 to 74 percent of the various markets for dairy products. Estimates for 1973 show that household purchases accounted for about 44 percent of the butter sold, 57 percent of the American cheese, 40 percent of other than American cheese, and 58 percent of the ice cream (table 1). Households directly consumed about 74 percent of all fluid milk sold. Milk purchased away from homes, by institutions, and as an

Table 1. Utilization of U.S. milk supply by major dairy products and percent purchased directly by households

| Product | Milk equivalent used for ¹ | | Consumed by households ² |
|----------------------------|---------------------------------------|------------------|-------------------------------------|
| | billion pounds | percent of total | —percent— |
| Fluid products | 52.4 | 45 | 74 |
| Butter | 18.6 | 16 | 44 |
| American cheese | 16.8 | 14 | 57 |
| Other than American cheese | 6.8 | 6 | 40 |
| Ice cream | 11.1 | 10 | 58 |
| Other products | 10.5 | 9 | — |
| Total | 116.2 | 100 | — |

¹Milk equivalents on a fat solids basis, 1973.

²Hammond, J. and Thraen, C., "Components of the Market for Dairy Products." 1975., Unpublished working paper.

Source: USDA, SRS Milk, Production, Disposition, and Income, 1972-74, DA 1-2 (75), April 1975.

ingredient to be used in processing other products constitutes most of the remaining percentage. The consumption response reported in this study is for households only and not the entire market for dairy products. Therefore, the results cannot be used directly for policy analyses to evaluate total use response to changes in price or other economic stimuli.

DATA, ASSUMPTIONS, AND LIMITATIONS

Cross-sectional data provides information on demand variables and demand relations that are not easily obtained or interpreted in a time series format. Relevant demographic variables may be included as determinates

¹Emerson Babb and Bill Boehm. The three periods of approximately 16 weeks over which the panel data were obtained are: May 1972 to August 1972, September 1972 to December 1972, and January 1973 to April 1973.

²Prices and quantities for the 383 households were recorded during three time periods in order to expand the total sample size and retain the representatives of the population as a whole. In estimating the relationship, a dummy variable was included to net out any variation due to changing periods. Estimated quantities are therefore interpreted as applicable to the average 16-week period during a year.

of consumption along with prices and incomes. The nature of cross-sectional data is such that estimated differences in consumption revealed by such data are considered to reflect complete adjustments by consumers to prevailing price and income levels; thus, they may be interpreted as long-run adjustments.

Estimation of demand response to price for many food items is difficult or impossible, because of the lack of sufficient price variations on which to calculate the relation. However, for dairy products, particularly fluid milk items, there is considerable price variation from one marketing region to another. So although climate and/or cultural differences of consumers who are spatially separated may account for some of the differences in consumption, consumer's purchases of a product, net of these influences, may be largely explained by price differences.

Two major points should be raised concerning interpretation and reliability of own price elasticities derived from cross-sectional data. The first is the assumed stability of price and income conditions prevailing at the time the cross-sectional data is compiled. What is required in the way of relevant assumptions is that each household had sufficient time to adjust consumption to the observed price level within that market when the data was collected. Should this assumption not hold, the estimated longrun response of consumers to different prices or incomes would be confused with possible shortrun reaction of particular subgroups of consumers.

The second point concerns lack of information on substitute prices. The cross-sectional data used in this study did not provide the price of dairy product substitutes. However, if one of two possible assumptions holds, the data should still permit valid estimates of own price elasticities. First, and not too likely, if spatially separated consumers were faced with identical substitute prices, own price elasticity of demand could be estimated. The second, and more likely, assumption occurs if substitute prices vary randomly among regions. However, to the extent that the price of substitutes are not random but correlated with the dairy product price, exclusion of the price of substitutes will lead to bias in the estimated coefficients on the own price variable.

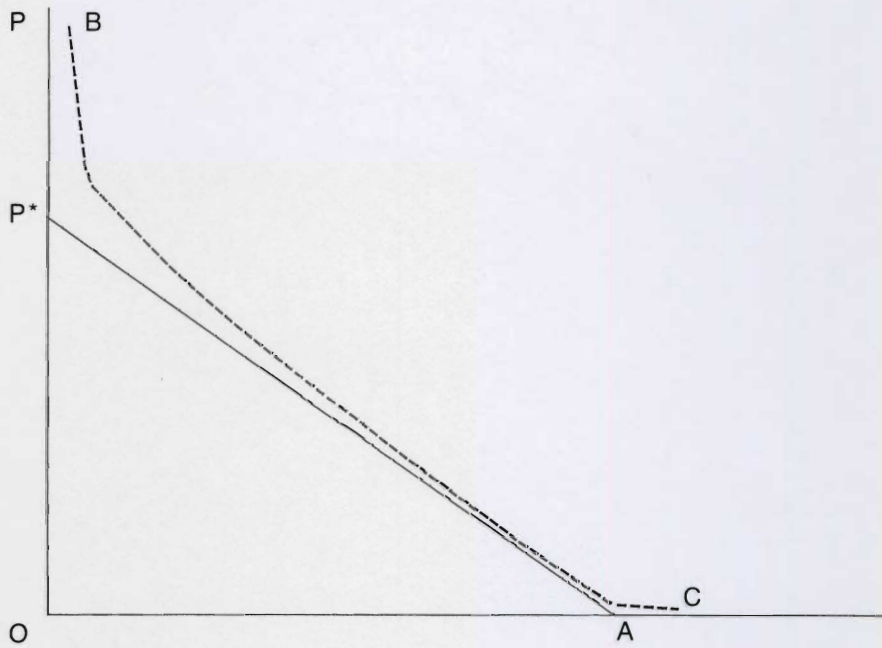
METHODOLOGY

Estimated demand functions indicate the expected consumption of dairy products at various prices holding other factors constant. Most of the estimated functions describe nothing about the probability that the particular consumer defined by the values of the independent variables may not purchase the product at all, or what relation that probability bears to the expected amount of consumption. But, changes in income, prices, or other variables bring about changes in the number of consuming units as well as changes in the consumption habits of those actually consuming.

An illustration may aid in clarifying this relationship. Consider the price-quantity observations on household purchases of various quantities of some good and the price of that good. Assume that quantities taken are

a function only of the prevailing price.³ For many commodities, there will be a concentration of zero purchases reported at high prices. At some threshold level of prices, P^* , consumption of the particular good becomes feasible. Thus at $P < P^*$, the household would report positive purchases and at $P \geq P^*$, zero purchases. This is demonstrated in figure 1.

Figure 1



At prices above P^* , there would occur a series of observations for which purchases equalled zero. If all households were homogeneous with respect to price, then the P^* price threshold would be the same for all households and no product would be purchased at a price above P^* . The relationship could be adequately expressed by estimating P^*A . However, the threshold P^* price may be quite different for individual households. The demand curve relationship to be estimated in this case would be similar to the dotted line BC in figure 1.

Analysis of cross-sectional data often eliminates the zero consumption level from the sample. This avoids two problems: (1) the problem of no

³In actuality, the threshold is assumed to be a linear combination of many relevant variables, i.e., price, income, and household characteristics.

reported prices for zero consumption and (2) bias in estimating the slope of the demand functions. However, by deleting observations where quantity purchased is zero, the researcher implicitly assumes that the resultant data represents 100 percent participation. The price and income elasticities estimated via such a sample reflect only the change in average quantity for an average consuming household and not the entire market.

The average consumption for the total market population is a combination of both the average household consumption and participation rate. Analysis of cross-sectional data should take both into account. It also follows that elasticities derived from cross-sectional data where both consuming and nonconsuming units are included are a combination of two quantity responses to price, income, or other factors: (1) the response of quantity consumed per household actually consuming and (2) elasticity of market participation stated in terms of proportion of households.

Algebraically, elasticity of price is:

$$E_{\bar{q}p}^* = E_{qp} + E_{prp}$$

Where $E_{\bar{q}p}^*$ is the total elasticity, with respect to price
 E_{qp} is the quantity elasticity of participants, with respect to price
 E_{prp} is the elasticity of the proportion of households in the market with respect to price.

The derivation of this relationship is presented in appendix A.

METHOD OF ANALYSIS

James Tobin pioneered a mathematical model of demand behavior based on the threshold concept and a statistical method (TOBIT) to estimate the different elements of such a model. By application of the TOBIT method to cross-sectional data, it is possible to derive the expected probability that a household will purchase some particular dairy product and the expected amount of consumption. The method is a hybrid of PROBIT analysis and multivariate regression analysis and is sufficiently complex so that an in-depth derivation will not be presented in this paper. Only a general overview will be presented.⁴

To generalize the method, the PROBIT model as applied to economic survey data yields estimates of the probability of observing a positive response (i.e., positive consumption, expenditure, etc.), given prices, incomes, and other relevant information. This probability is then interpreted as the expected number of participants out of a market of N potential consumers.⁵ Tobin's extension of the PROBIT method yields estimates of the expected value of the positive response. An important aspect of this extension is that it takes into account the sample information supplied by the nonconsuming unit as well as the actual consumer.

⁴The actual conceptual and statistical derivation of the TOBIT model and method is necessarily complex and is not presented in this study. The interested reader is referred to Goldberger and Tobin, listed on page 28.

⁵This assumes that the sample is representative of the total market population. Should this not be the case, then the extension to the market participation concept is valid only for that population which the sample represents.

By utilizing the Tobin method as a tool of analysis, this study was able to estimate the extent of the entry/exit phenomenon in relationship to the total quantity change brought about by differences in prices, income, and family characteristics of households in the dairy product market.

DATA CHARACTERISTICS

Household purchases of dairy products were categorized into 13 product groups as shown in table 2. Quantities were expressed in the most frequently purchased weight or volume units. For example, the most frequently purchased volume for all fluid milk types was the half gallon. Purchases of quart, gallon, or other size containers were converted into half gallon units.

Prices represented the equivalent price per half gallon when other than half gallon containers were purchased. Because the price per half gallon of milk purchased in quart containers would likely be higher than if purchased in half gallon containers, some additional variation in price between households is introduced. If households purchasing relatively small quantities tend to purchase in smaller, more expensive containers, and households purchasing relatively large quantities tend to purchase in larger, less expensive containers, then the bias would result in underestimating the response of household consumption to price changes. To the extent that households purchased the same mix of weight or volume units, no bias would be expected.

Average prices paid and quantities of dairy products purchased by 383 sample households during the May 1972 to April 1973 period are shown in table 3.⁶ The standard deviation of both price and quantity is shown for each dairy product. This provides a measure of the variation in both price and quantity among households. Thus, about 67 percent of the total 1,149 observations paid between 49 and 65 cents per half gallon of fluid milk and consumed between 2 and 94 half gallons (table 3). The average income and the size of households consuming some of each of the dairy product groups along with one standard deviation are also shown in table 3. Sixty-seven percent of the households consuming fluid milk had incomes between \$3,790 and \$16,570 and household sizes between 1.4 and 4.4 people. These results indicate substantial variation in all variables that are generally found to affect consumption. This variation makes it possible to estimate the factors that explain differences in household consumption of dairy products.

The average price of the products generally increased from the earliest to the most recent period. However, the change was relatively small. The increase in cheese was more marked than for other products (table 4). Because the increase in average prices over the three time periods was relatively small, any bias due to short-run adjustments using multiple price and quantity purchase data for each household should not seriously bias the analysis.

The proportion of households actually purchasing individual dairy products is given in table 5. Fluid milk has the largest proportion of the

⁶Unfortunately, no prices are reported for nonpurchasing households. To use these observations in the analysis, for each nonconsuming unit, we assigned a price which was the

Table 2. Product composition and weight/volume

| Product Group | Product Composition | Standardized Weight/Volume |
|------------------------|---|----------------------------|
| Total fluid milk | All fluid milk types | Half gallon (64 oz.) |
| Nonfat dry milk powder | | Pound (16 oz.) |
| Butter | | Pound (16 oz.) |
| Ice cream | Includes ice cream novelties | Half gallon (64 oz.) |
| Ice milk | Includes ice milk novelties | Half gallon (64 oz.) |
| Frozen bulk | All bulk purchases of ice cream, ice milk, mellorine, and sherbet | Half gallon (64 oz.) |
| Cottage cheese | Excludes ricotta | Pound (16 oz.) |
| Process cheese | "Process cheese" on label | Pound (16 oz.) |
| American cheddar | | Pound (16 oz.) |
| Total natural cheese | American Cheddar, Swiss, Brick, Muenster, and Italian | Pound (16 oz.) |
| Canned milk | Evaporated, condensed, and evaporated skim | Half pint (8 oz.) |
| Total fresh cream | Half & half, whipping, and table | Pint (16 oz.) |
| Dairy dips | Sour cream & cheese dips | Half pint (8 oz.) |

Table 3. Average price paid and quantity purchased, income, and household size of those consuming in a 16-week period

| Product | Unit | Average per consuming household | | | | | | | |
|----------------------|-------------|---------------------------------|------------------------|-----------------|------------------------|-----------|------------------------|--------------------------|------------------------|
| | | Price | | Quantity | | Income | | Household size | |
| | | Average per unit | One standard deviation | Number of units | One standard deviation | Average | One standard deviation | Average number of people | One standard deviation |
| | | (cents) | (cents) | | | (dollars) | (dollars) | | (people) |
| Fluid milk | Half gallon | 57 | 8 | 48 | 46 | 10,180 | 6,390 | 2.9 | 1.5 |
| Nonfat dry milk | Pound | 71 | 13 | 6 | 7 | 10,470 | 6,050 | 3.1 | 1.4 |
| Butter | Pound | 81 | 13 | 5 | 5 | 11,300 | 7,240 | 3.0 | 1.5 |
| Ice cream | Half gallon | 85 | 34 | 6 | 6 | 10,520 | 6,600 | 3.0 | 1.5 |
| Ice milk | Half gallon | 63 | 24 | 4 | 4 | 8,910 | 5,480 | 2.9 | 1.5 |
| Bulk frozen | Half gallon | 82 | 33 | 7 | 7 | 10,230 | 6,490 | 3.0 | 1.5 |
| Cottage cheese | Pound | 42 | 9 | 7 | 8 | 10,670 | 6,720 | 2.9 | 1.5 |
| Process cheese | Pound | 101 | 17 | 3 | 3 | 10,870 | 6,340 | 3.3 | 1.7 |
| American cheese | Pound | 114 | 19 | 3 | 4 | 10,370 | 6,280 | 2.8 | 1.4 |
| Total natural cheese | | 119 | 26 | 4 | 4 | 10,450 | 6,361 | 2.9 | 1.4 |
| Canned milk | Half pint | 14 | 4 | 17 | 26 | 9,140 | 5,280 | 2.9 | 1.5 |
| Fresh cream | Pint | 53 | 21 | 6 | 11 | 10,970 | 6,180 | 2.8 | 1.4 |
| Dairy dips | Half pint | 42 | 14 | 2 | 2 | 12,140 | 6,620 | 3.4 | 1.4 |

Table 4. Average prices paid by households for selected dairy products during three 16-week time periods

| Product | Average price in period | | |
|--------------------------------|-------------------------|-----|-----|
| | 1 | 2 | 3 |
| | ----- cents/unit ----- | | |
| Fluid milk (half gallon) | 57 | 59 | 57 |
| Nonfat dry milk (lb) | 68 | 75 | 73 |
| Butter (lb) | 81 | 82 | 82 |
| Ice cream (half gallon) | 85 | 84 | 86 |
| Ice milk (half gallon) | 64 | 65 | 66 |
| Bulk frozen (half gallon) | 80 | 80 | 83 |
| Cottage cheese (lb) | 42 | 42 | 43 |
| Processed cheese (lb) | 99 | 101 | 103 |
| American cheese (cheddar) (lb) | 110 | 112 | 116 |
| Total natural cheese (lb) | 114 | 117 | 121 |
| Canned milk (half pint) | 13 | 13 | 13 |
| Fresh cream (pint) | 41 | 43 | 43 |
| Dairy dips (half pint) | 53 | 54 | 56 |

Table 5. The proportion of and estimated number of households in the U.S. dairy market: 1972

| | Percent | Estimated number of households —millions— |
|---------------------------|---------|---|
| Fluid milk | 95.7 | 63.4 |
| Nonfat dry milk | 18.9 | 12.5 |
| Butter | 42.7 | 28.2 |
| Ice cream | 75.0 | 49.6 |
| Ice milk | 21.6 | 14.3 |
| Bulk frozen | 82.3 | 54.5 |
| Cottage cheese | 61.9 | 41.0 |
| Process cheese | 40.3 | 26.5 |
| American cheese (cheddar) | 56.1 | 37.1 |
| Total natural cheese | 67.1 | 44.4 |
| Canned milk | 35.6 | 23.5 |
| Fresh cream | 24.2 | 16.0 |
| Dairy dips | 18.6 | 12.3 |

total household consumption market with 95.7 percent in 1972. Nonfat dry milk and dairy dips share the smallest market participation with 18.9 and 18.6 percent, respectively.

RESULTS OF THE ANALYSIS

The application of the TOBIT method to the cross-sectional data was made with two variations of the model. First, only income, price, family size, and season were included as independent variables. In addition to price and income, the second model included family age/sex characteristics, occupational status of husband, employment status of wife, race, and education. The price and income elasticities calculated from each model showed few differences between specifications. Results are presented here for the second model only.

The equations were statistically significant at the one percent probability level for all 13 products.⁷ The parameters on the income variable were significant at the 10 percent probability level for all products. The parameters on price were negatively related for all products and were significant at the 10 percent probability level for all products except for canned milk. The elasticities and the expected quantity adjustment for the statistically significant demographic variables which were derived from the TOBIT model are described below.

Influence of Product Price on Household Consumption

The division of total market response to price changes into response due to households entering or exiting the market, and response due to changing consumption levels of those in the market yielded some surprising results. For both price and income changes, entry or exit from the market accounted for more than half of the market response for all products except fluid milk (table 6). For fluid milk, the entry or exit of households accounted for about one-fourth of the total adjustment to a price change. For nonfat dry milk, American cheddar, and dairy dips, entry or exit of households into the market accounted for about 80 percent of the total market adjustment to both price and income changes (table 6).

The interpretation of the components of the elasticities in table 5 is straightforward. For nonfat dry milk, a 1 percent change in the average retail price will alter the total quantity consumed by 1.92 percent; 1.5 percent of that total adjustment was due to entry or exit of households into the market, and 0.42 percent due to adjustments in consumption of households remaining in the market.

One important implication of this finding is that longrun elasticities derived from cross-sectional data that measure only the quantity response to price changes for consuming households actually purchasing a product will significantly underestimate the *total market response* to price changes.

⁷The significance of the equations was checked by use of the -2 log likelihood ratio.

Table 6. Household purchase response to a one percent change in average price or household income

| | Price response | | | Income response | | |
|--------------------|----------------|-------------------------------|-------------------|-----------------|-------------------------------|-------------------|
| | Total response | Market participation response | Quantity response | Total response | Market participation response | Quantity response |
| Fluid milk | -.89 | -.23 | -.65 | +.12 | +.03 | +.09 |
| Nonfat dry milk | -1.92 | -1.50 | -.42 | +.45 | +.36 | +.09 |
| Butter | -.70 | -.47 | -.22 | +.34 | +.23 | +.11 |
| Ice cream | -.23 | -.12 | -.11 | +.12 | +.06 | +.06 |
| Ice milk | -.92 | -.71 | -.21 | -.52 | -.40 | -.12 |
| Bulk frozen market | -.28 | -.13 | -.15 | +.08 | +.04 | +.04 |
| Cottage cheese | -.75 | -.45 | -.30 | +.26 | +.16 | +.10 |
| Process cheese | -.62 | -.43 | -.19 | +.04 | +.03 | +.01 |
| American cheddar | -.62 | -.49 | -.13 | +.44 | +.35 | +.09 |
| Natural cheese | -.23 | -.12 | -.11 | +.25 | +.13 | +.12 |
| Canned milk | -.25 | -.18 | -.07 | -.27 | -.19 | -.08 |
| Fresh cream | -1.22 | -.94 | -.28 | +.57 | +.44 | +.13 |
| Dairy dips | -.73 | -.61 | -.12 | +.80 | +.67 | +.13 |

Influence of Income on Household Consumption

Eleven of the products exhibit positive consumption responses at average income levels (table 6). However, for all products, consumption response is relatively small for changes in income. Fluid milk is very unresponsive; a 1 percent increase in income would increase fluid milk consumption by only 0.12 percent.

Two products, ice milk and canned milk, exhibit negative responses to income changes at average income levels (table 6). Ice milk consumption declines 0.52 percent and canned milk consumption declines 0.27 percent for each one percent increase in income. This kind of response for ice milk may occur because buyers shift to ice cream, a more expensive product, as income increases. Low income households may use more canned milk in home-prepared foods and shift away from this product as income rises.

The coefficient on the income-squared variable was included in calculating the quantity adjustment to income changes for each product only when the total quadratic term was significant. When the squared variable was included, the income levels at which consumption of the individual products no longer responded positively to income increases could be estimated. Family income levels at which dairy product consumption reaches a maximum were calculated for 10 of the products (table 7). They were calculated while holding all other factors that affect household consumption of dairy products at their average values. Fluid milk consumption for the average family shows no more increases after income reaches \$16,200. Processed cheese consumption reaches a maximum at a family income of \$12,600, American cheddar at \$17,000, and other natural cheese at \$19,200. Dairy dips do not reach a maximum until family income reaches an estimated \$41,500.

Canned milk purchases, which have a negative response to income at the average income of \$10,121, respond positively up to an income of \$5,600. The income level at which households no longer increase purchases exceeds average household income for all products listed except canned milk and ice milk.

Table 7. Estimated income levels at which purchasing response is zero

| Product | Income level |
|------------------|--------------|
| | —dollars— |
| Fluid milk | 16,200 |
| Nonfat dry milk | 18,500 |
| Bulk frozen | 18,300 |
| Cottage cheese | 43,900 |
| Processed cheese | 12,600 |
| American cheddar | 17,600 |
| Natural cheese | 19,200 |
| Canned milk | 5,600 |
| Fresh cream | 19,000 |
| Dairy dips | 41,500 |

Household Response at Different Price and Income Levels

Results showed that the expected response in household purchases depended on the absolute level of both product prices and family incomes (table 8). Households in areas of the country with high-priced dairy products respond more to a given price change than household in areas with similar low-priced products, assuming equal average income levels in all instances. For products with substantial regional price differences, such as fluid milk products, this indicates that household adjustment is about 70 percent higher where prices are a standard deviation above mean prices than for regions with prices in standard deviations below the mean.

The adjustments to income changes exhibit some varying patterns at different income levels. For seven of the products listed here: butter, ice cream, bulk frozen dessert, cottage cheese, and dairy dips, the income elasticities increase over the income range considered. The elasticities, with respect to income for other products declines at the higher income levels.

Table 8. Household purchase response to a one percent change in average price and income at the mean values and at plus and minus one standard deviation from the mean

| Product | Price response at selected price levels | | | Income response at selected income levels | | |
|------------------|---|-------------|-------|---|----------|----------|
| | -1 | \bar{P}^1 | +1 | \$3,600 | \$10,121 | \$16,500 |
| Fluid milk | -.70 | -.89 | -1.18 | .09 | .12 | .009 |
| Nonfat dry milk | -1.45 | -1.92 | -2.35 | .28 | .45 | .21 |
| Butter | -.57 | -.70 | -.81 | .11 | .34 | .50 |
| Ice cream | -.13 | -.22 | -.32 | .03 | .12 | .18 |
| Ice milk | -.52 | -.92 | -1.27 | -.13 | -.52 | -.90 |
| Bulk frozen | -.15 | -.28 | -.38 | .02 | .09 | .13 |
| Cottage cheese | -.55 | -.75 | -.92 | .10 | .26 | .32 |
| Process cheese | -.50 | -.62 | -.72 | .05 | .04 | -.10 |
| American cheddar | -.50 | -.62 | -.71 | .28 | .44 | .15 |
| Natural cheese | -.17 | -.23 | -.27 | .15 | .25 | .13 |
| Canned milk | -.17 | -.25 | -.32 | .04 | -.27 | -1.00 |
| Fresh cream | -.65 | -1.22 | -1.75 | .35 | .57 | .29 |
| Dairy dips | -.47 | -.73 | -.96 | .33 | .80 | .96 |

¹See table 3 for averages prices and standard deviations.

Influence of Household Characteristics

In addition to product price and family income, educational level and occupation of the household head, race, employment status of housewife, and age and sex composition of the household all may affect purchases of dairy products by a given household. The importance of all these factors except the age and sex were evaluated using dummy variables for selected categories of each factor. For example, households were grouped into three categories according to the level of education attained by the family head:

grades 0-8, grades 9-12, and grades 13 and above (college). The influence of age and sex composition was evaluated by including the actual number of household members in selected age and sex categories. The estimated influence of each factor is reported in the following sections.

Occupational Status:

Compared to the occupational category that included household heads who were either unemployed, retired, in school or otherwise not in the labor force, households with heads categorized as "blue collar workers" purchased significantly fewer of 5 of the 13 products studied: ice cream, bulk frozen, cottage cheese, canned milk, and fresh cream (table 9).

Households with heads categorized as "white collar workers" purchased significantly less fresh cream than households with heads not in the labor force. No significant difference in purchases of all other products was observed at the 90 percent confidence level.

Educational Level

Households with heads that had attained 9th to 12th grade educations purchased significantly more ice milk, cottage cheese, American cheddar cheese, and natural cheese than households with heads with up to an 8th grade education. (table 9). However, they purchased less nonfat dry milk. Households with heads that had attained more than 12 years education (some college) purchased significantly less ice cream, canned milk, and significantly more fluid milk, cottage cheese, and natural cheese than their counterparts whose head attained 8 years or less of education.

Housewife Employment Status:

Whether or not the housewife is employed does not significantly influence the household purchases of most dairy products with the exception of fluid milk and ice milk (table 9). On the average, a household with an employed housewife will purchase 22.1 half gallons of fluid milk less per year than the average household with a nonemployed housewife. If the current trend among U.S. households is toward an increased number of households with employed wives, this finding could have significant implications for the demand for fluid milk products at retail in the years ahead.

Race:

The differentiation of households by race indicates significantly lower purchases by the black and oriental households than white households. The most striking difference is the higher use of fluid milk and cheese of all types by white households than black or oriental households. Canned milk was the only dairy product where black households purchased a significantly larger quantity than white households.

Table 9. Estimated effect of selected household characteristics on annual household purchases of major dairy products

| Product | Occupational status | | | Years of education attained by household head | | | Housewife employment status | | Race | | |
|------------------|---------------------|---------------------------|--------------|---|---------------------------|-------------------|-----------------------------|---------------------------|------------|---------------------------|---------------------|
| | Base group | Deviation from base group | | Base group | Deviation from base group | | Base group | Deviation from base group | Base group | Deviation from base group | |
| | not in labor force | blue collar | white collar | 0-8 (grammar) | 9-12 (high school) | over 12 (college) | not employed | employed | white | black | oriental and others |
| Fluid milk | 157.2 | +3.9 | +5.1 | 152.1 | +9.0 | +12.3* | 167.4 | -23.1# | 164.4 | -45.0# | -116.7# |
| Nonfat dry milk | 19.1 | -2.1 | -0.6 | 21.4 | -3.6+ | -2.7+ | 18.7 | +0.7 | 18.5 | -2.9 | -1.5 |
| Ice cream | 21.3 | -1.6# | — | 21.3 | — | -1.9# | — | — | 20.6 | — | -8.0+ |
| Ice milk | 11.8 | -0.8 | -0.8 | 10.5 | +1.3* | +1.3 | 10.5 | -1.5* | 11.0 | 0.0 | -2.1 |
| Bulk frozen | 25.8 | -2.4+ | -1.3 | 24.1 | +1.3 | -0.5 | 24.3 | -0.7 | 24.3 | 0.0 | -9.9# |
| Cottage Cheese | 25.8 | -3.0# | -1.5 | 21.6 | +3.3# | +3.3# | 24.4 | -0.5 | 24.9 | -9.6# | -11.4+ |
| Process cheese | 9.5 | -0.2 | 0.0 | 9.5 | +0.4 | +0.6 | 9.7 | +0.3 | 7.8 | -2.4# | -2.7+ |
| American cheddar | 9.0 | 0.0 | -0.4 | 6.3 | +1.5+ | 1.2 | 8.8 | 0.0 | 8.1 | -3.0# | -5.5 |
| Natural cheese | 13.5 | -0.2 | -0.8 | 13.8 | +2.1# | +2.4# | 15.0 | +0.4 | 15.9 | -5.1# | -9.0+ |
| Canned milk | 72.1 | -10.9* | +0.2 | 73.2 | -3.1 | -13.2# | 66.4 | +1.4 | 69.9 | +9.3 | -69.9 |
| Dairy dips | 6.5 | +0.6 | -0.3 | 6.3 | +0.4 | +0.4 | 6.8 | -0.3 | 5.7 | -2.2+ | — |

Note: Significance of estimates are indicated as follows: * = .1, + = .05, # = .01.

¹This category includes those household heads who were either unemployed, retired, in school, or not in the labor force at the time of reporting.

Influence of Age/Sex Composition of Households on Dairy Product Purchases

The average household sampled was comprised of about 2.9 persons (table 10). About half were over 40 years old and one fifth between 21 and 40 years old. Persons 20 years old and under made up the remaining three tenths.

Because no sex distinction was made for persons under 15 years old, the total male/female composition of the average household could not be identified. However, of the 1.4 persons over 40 years old in the average household, about 56 percent were females. The number of males and females between 15 and 40 in the average household was about the same.

Table 10. Average age/sex composition of households in the survey

| Age —years— | Sex | | Total —number of persons— |
|--------------------------|-------|---------|------------------------------|
| | Males | Females | |
| Over 40 | 0.63 | 0.81 | 1.44 |
| 21-40 | 0.28 | 0.28 | 0.56 |
| 15-20 | 0.12 | 0.10 | 0.22 |
| 7-14 ¹ | — | — | 0.41 |
| 3-6 ¹ | — | — | 0.20 |
| 2 and under ¹ | — | — | 0.09 |
| TOTAL | | | 2.92 |

¹No sex distinction was made for persons 14 years or under.

The number of persons, both male and female, over 40 years old significantly influenced household consumption of most of the dairy products studied: fluid milk, ice cream, ice milk, bulk frozen, cottage cheese, processed cheese, American cheese, and natural cheese (table 11). The number of males in this same age group influenced household butter purchases but the number of females did not. On the other hand, the number of females in this age group significantly influenced household purchases of canned milk while the number of males in that age group did not. Neither the number of males or females over 40 years of age significantly influenced household purchases of nonfat dry milk, fresh cream or dairy dips.

The number of males and females between 21 and 40 years of age positively influenced natural cheese purchases by households. The number of males in this age group positively influenced household purchases of processed cheese, bulk frozen, ice cream and fluid milk, while the number of females did not. The number of females in this age group positively influenced purchases of American cheese and nonfat dry milk and negatively influenced cottage cheese purchases.

The number of household members between 7 and 14 years old significantly influenced household purchases of more dairy products than any other age group below 21 years old. This age group positively

Table 11. Estimated influence of the number of household members in selected age/sex categories on household purchases of selected dairy products

| Dairy product | Age/sex categories of household members | | | | | | | | |
|------------------|---|---------|-------------|---------|-------------|---------|-------|-------|-----------|
| | Over 40 | | 21-40 years | | 15-20 years | | 7-14 | 3-6 | 2 or less |
| | males | females | males | females | males | females | years | years | years |
| Fluid milk | + | + | + | | + | + | + | + | + |
| Nonfat dry milk | | | | + | | | | + | |
| Ice cream | + | + | + | | + | + | + | + | |
| Ice milk | + | + | | | | | + | | |
| Bulk frozen | + | + | + | | + | + | + | + | |
| Cottage cheese | + | - | | - | - | | - | | - |
| Processed cheese | + | + | + | | | + | + | + | + |
| American natural | | | | | | | | | |
| cheese | + | + | | + | | | | | |
| Natural cheese | + | + | + | + | | | + | | |
| Canned milk | | + | | | - | | | | |
| Dairy dips | | | | | | | + | + | |

1" + " refers to positive and " - " to negative influences on household purchases. Only characteristics that were significant at the 90 percent confidence level or higher are shown in the table.

Table 12. Expected life cycle purchase patterns of hypothetical households

| Hypothetical family structure over household life cycle | Annual average purchase | | | |
|---|--------------------------|----------------------------|---------------------|---------------------|
| | Fluid milk (half gallon) | Frozen cream (half gallon) | Process cheese (lb) | Natural cheese (lb) |
| Couple 21-40 yrs, no children | 114.6 | 19.0 | 6.1 | 13.2 |
| 1 child, 1 or 2 yrs old | 143.7 | 19.0 | 8.4 | 14.1 |
| 1 child, 2, 1 child 3-6 yrs old | 181.5 | 21.8 | 9.9 | 14.5 |
| 2 children, 7-14 yrs | 218.7 | 26.6 | 7.9 | 16.3 |
| Couple over 40 yrs old | | | | |
| 2 children, 14-20 yrs | 223.5 | 25.5 | 7.4 | 12.8 |
| no children | 136.8 | 22.8 | 7.1 | 15.0 |
| Average household in sample | 161.1 | 24.5 | 7.7 | 15.1 |

influenced household consumption of fluid milk, ice cream, ice milk, bulk frozen, natural cheese and dairy dips and negatively influenced household purchases of nonfat dry milk and fresh cream (table 11). The number of household members between 3 and 6 years old influenced seven of the 13 dairy products studied. The number of household members less than 2 years old and males and females between 15 and 20 significantly influenced household purchases of 5 or fewer of the 13 products studied. Generally the number of household members in all age categories under 21 years old significantly influenced household purchases of fluid milk, ice cream, bulk frozen and processed cheese.

Life Cycle and Household Purchases

Expected consumption for hypothetical family structures representing the life cycle of a typical household were calculated from the results of the study. The following hypothetical family structures were selected: (1) a male and female couple between the ages of 21 and 40 years with (a) no children (b) with one child 2 years old or younger (c) with two children—one between 3 and 6 years old, and one 2 years old or younger (d) with two children between 7 and 14 years old; (2) a male and female couple over 40 years with (a) two children between 14 and 20 years old (b) no children.

The expected consumption of four dairy products for the above hypothetical households was calculated. Family income, educational level, occupational status of wife, and race of household were held at their average levels, and are presented in table 12. Results showed the impact of children on the household purchases of natural cheese is less marked than for the other three products.

Results also show that a male and female couple over 40 years old with no children consume about 20 percent more of all products than their counterparts in the 21 to 40 age group. This may be associated with improved taste for dairy products acquired while children are at home or a generally lower per capita consumption by younger people than by older people who acquired their tastes when per capita consumption was higher.

Among the hypothetical stages selected to represent a household life cycle, the maximum expected consumption of fluid milk is 223.5 half gallons annually for a household with a male and female over 40 and two children between 14 and 20 years old. The maximum purchases for ice cream and natural cheese, occurred earlier in the life cycle with a male and female couple between 21 and 40 years old with two children between 7 and 14 years old. The maximum household purchases of processed cheese occurred earlier yet, when the two children were between 3 and 6 years old.

SUMMARY

Total consumption adjustments of dairy products to price and income changes are the sum of two separate components: (1) the change in the number of consumers in the market and (2) the quantity adjustment of those consumers in the market. The change in the number of households purchasing as price and income changed was relatively important for manufactured dairy products. The quantity adjustments of those households in actually purchasing the product is relatively more important for fluid dairy products. The TOBIT method was used to estimate those consumption adjustments from recent consumer panel data. This study analyzed the following major characteristics of household demand for 13 dairy products with the following findings:

(1) At average income and price levels, the estimated elasticities were low for 11 of the 13 products. Price elasticities ranged from $-.22$ for ice cream to $-.92$ for ice milk. Only nonfat dry milk and fresh cream had elastic demands. Nonfat dry milk was very high with an elasticity of -2.35 . Income elasticities of 11 of the 13 products were positive but less than 1. At average household income levels, additional income brings about decline in the consumption of ice milk and canned milk.

(2) Market entry and exit accounted for approximately one-fourth of the fluid milk demand adjustments and two-thirds of the manufactured dairy product demand adjustments to own price changes. This apparent disparity between the two dairy product groups may well reflect that consumers consider fluid products a necessity. The relatively higher proportion of all households that purchase the product at all prices indicates an entrenched position of milk as an important component of household diets. Likewise, the lower proportion of all households purchasing manufactured products indicates that these products do not share as stable a position in household diets.

(3) Two dimensions of the relationship between income and dairy consumption were analyzed. The level at which household income failed to yield increases in household consumption of dairy products was also investigated. For most products the level was approximately one standard deviation above average household income. For fluid milk, family milk consumption attains a maximum of \$16,200 per year. As with price induced changes in demand, income changes have a larger proportional impact on market participation demand response than on average consumption of participating households for manufactured dairy products. For both fluid and manufactured dairy products, the proportion of all households that purchase the products increases as income increases.

(4) The demographic characteristics including the age and sex structure of the consuming unit was found to be influential in determining consumption levels for most products. By generating an estimated consumption pattern for a hypothetical household over its life cycle, the impact of changing household consumption was examined. Estimated consumption for a young adult couple showed a 20 percent increase over the life cycle in the absence of children.

APPENDIX A

Components of Total Household Response†

With aggregate time series market data,

$$(1) \bar{q}^* = \frac{Q}{N} = \text{average per capita quantity consumed of a given product}$$

where Q = total disappearance
 N = total population

If $\bar{q}^* = f(p)$, then the price elasticity

$$(2) E_{\bar{q}^* p} = \frac{d\bar{q}^*}{dp} \cdot \frac{\bar{p}}{\bar{q}^*}$$

With cross sectional data only n of the N possible consumers are actually consuming the product. Here,

$$(3) \bar{q} = \frac{Q}{n} = \text{average quantity consumed by those households actually using the product}$$

$$\bar{q}^* = \bar{q} \text{ for } n = N \text{ but,}$$

$$\bar{q} < \bar{q}^* \text{ for } n < N$$

For $\bar{q} < \bar{q}^*$, let,

$$(4) pr = \frac{n}{N} = \text{proportion of total sample actually consuming}$$

$$(5) Q = \bar{q} \cdot n$$

Then,

$$(6) \bar{q}^* = \frac{qn}{N} = \bar{q} \cdot pr$$

†For a more complete treatment see Haidacher, R. "An Econometric Study of the Demand for Prune Juice." unpublished Ph.D. thesis, University of California, 1964.

If \bar{p}_r is also a function of price, then,

(7) $\bar{p}_r = g(p)$. The elasticity with respect to price contains two components, as follows:

$$(8) E_{\bar{q}\bar{p}}^* = \frac{d\bar{q}}{dp} \cdot \frac{\bar{p}}{\bar{q}} = \frac{d(\bar{q} \cdot \bar{p}_r)}{dp} \cdot \frac{\bar{p}}{(\bar{q} \cdot \bar{p}_r)}$$

then expanding (8),

$$(9) E_{\bar{q}\bar{p}}^* = \left[\frac{d\bar{q}}{dp} \cdot \frac{\bar{p}}{\bar{q}} \right] + \left[\frac{d\bar{p}_r}{dp} \cdot \frac{\bar{p}}{\bar{p}_r} \right]$$

which can readily be seen to be the sum of two elasticities:

$$(10) E_{\bar{q}\bar{p}}^* = E_{\bar{q}\bar{p}} + E_{\bar{p}_r p}$$

APPENDIX B

Data Summary

The data utilized in the study were supplied by the United Dairy Industry which contracted with the Market Research Corporation of America (MRCA) to do the actual survey work. The data bank was developed from a statistically representative sample of U.S. households for the period April 1972 through March 1973 with a supplemental update from April 1973 through September 1973. The data in this study is a representative random sample of 1,149 observations chosen from the larger MRCA panel data. The criteria for subsample selection was to maintain the representative factor distribution in order that the results may be extended to the national level with a minimum of distributional bias. The major characteristics of the data are as follows:

Price

In calculating the average price by half gallons for fluid milk products from the sample observations, a weighted average was utilized. The weights are the proportions of each fluid product purchased per 16-week period. In all other cases where the dependent variable was a single product, the price utilized was that which was reported. For respondents with zero purchases, an average price was calculated based on regionality and urbanization.

Region

The regional distribution of households for the subsample used in the study, along with the MRCA total sample distribution are given in the following table:

U.S. household distribution by region

| Region (%) | Study subsample (%) | MRCA Total sample (%) |
|---------------|---------------------|-----------------------|
| Northeast | 25.5 | 27.3 |
| South | 21.6 | 20.8 |
| North Central | 35.2 | 27.8 |
| Mountain/SW | 9.9 | 10.9 |
| Pacific | 7.8 | 13.2 |
| TOTAL U.S. | 100.0 | 100.0 |

City size

The city-size component was factored into four groups in this study. The city size and respective distributions are given in the following table:

U.S. household distribution by city size

| City Size | Percent of Household |
|----------------|----------------------|
| 10 M or less | 37.6 |
| 10 M-100 M | 14.8 |
| 100 M-500 M | 29.8 |
| 500 M and over | 17.8 |
| TOTAL U.S. | 100.0 |

Household size

The average household size calculated from the subsample used in the study is 2.88 persons.

Occupational distribution

The distribution of households in the subsample by occupation are given in the following table:

Distribution of households by occupational grouping: 1972 (% of total)

| Occupation of household head | Study subsample | Census estimate |
|------------------------------|-----------------|-----------------|
| Professional | 36.3 | 34.7 |
| Labor | 32.9 | 36.1 |
| Not in labor force | 30.8 | 29.2 |
| TOTAL | 100.0 | 100.0 |

Educational distribution

The educational level of the household was grouped into three categories according to the highest educational level of the household head: (1) Grammar (0-8); High School (9-12); (3) College (13 and over). The distribution for each group is given in the following table:

U.S. household distribution by educational level of the household head, 1972

| Educational level | Study subsample | Census estimate |
|-------------------|-----------------|-----------------|
| Grammar | 23.5 | 25.7 |
| High School | 44.4 | 48.5 |
| College | 32.1 | 25.8 |
| TOTAL | 100.0 | 100.0 |

Housewife employment status

The observations were coded into two groups—those households who had employed wives and those who did not. The distribution of the study subsample indicated 70.3 percent of the households had nonworking wives, while 29.7 percent had employed wives. The census estimate indicates a distribution of 65.2 percent and 34.8 percent respectively.

Race

The observations in the study were split into three racial categories—white, black, and oriental/other. The white race comprised 94.0 percent of the sample, black race 5.5 percent of the sample, and oriental and other 0.5 percent of the sample. The census estimate for similar groups is 89.2 percent white, and 10.8 percent nonwhite.

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