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The Impact of Nutritional Information On the Demands for Dairy Products

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Abstract

A demand system is invoked to study how nutritional information impacts dairy consumption. Whole and lowfat milk are disaggregated to facilitate the study of consumption within this category. Results indicate that nutritional awareness has decreased consumption of whole milk and frozen products and increased consumption of lowfat milk and cheese.

Many recent studies have established linkages between nutrition and health information and the consumption of food items by American consumers (see review by Capps and Schmitz). To date, however, little work has been done with disaggregate fluid milk components. Gould, Cox, and Perali consider whole and lowfat milk with other beverages, but do not consider nutritional factors. Disaggregation of the fluid milk category is important since aggregation of these items masks the considerable change in consumption which is occurring within the fluid milk category.

The purpose of this paper is to determine what impact nutritional information may have on the consumption of disaggregate dairy products. Although considerable change has been seen in the consumption of individual fluid products, this change may be related to any of a number of factors. Nutrition is a likely candidate to cause such a change since little difference exists between the fluid milk products, other than nutritional quality.

Some substitution involving fluid milk and other dairy products is also possible. Dairy products represent one of the four basic food groups. Thus dairy products represent a natural subset of all food commodities. Nutritionists recommend eating a variety of foods from within a given food group to meet dietary needs (American Medical Association; National Academy of Sciences). Since such substitution is encouraged, other dairy items, namely cheese and frozen dairy products, are included as part of the demand system.

Model Development

The inclusion of nutritional information within a demand system begins with the augmentation of utility theory to include such information. The augmentation commonly used specifies the utility function as

$$U_t = U(q_t;\ \theta(r_t))\ , \tag{1}$$

(Capps and Schmitz). This utility function allows for measures of information (r), in this case nutritional information, to impact utility via some function (θ). Schmitz augmented a dynamic Almost Ideal Demand System (AIDS) to include a polynomial distributed lag (PDL) model to study the demand for various food groups. This model, the PDL/AIDS model, is used here to study the impact of nutritional information on dairy products.

The PDL/AIDS model can be expressed in its reduced-form as

$$w_{it} = \left(\alpha_i + \zeta_i w_{i,t-1} + \sum_{d=0}^{D} \delta_{id} R_{dt} + \psi_i C_t\right) + \sum_{j=1}^{N} \gamma_{ij} \ln P_j + \beta_i \ln\left(\frac{X}{P^*}\right)_t + \varepsilon_{it}\ , \tag{2}$$

where w_i is the budget share for good i, P_j is the price for good j, X is the total expenditure on all N goods, and P^* is the sum of the logged prices multiplied by the corresponding lagged budget shares. The R and C terms provide two specifications for nutritional information. The first one provides the PDL formulation while the second provides for the inclusion of an additional measure of nutritional information with no provisions for a lag structure. The formulation of the PDL requires that the Rs be calculated as

$$R_{0t} = r_t + r_{t-1} + r_{t-2} + \cdots + r_{t-L}\text{, and} \\ R_{dt} = r_{t-1} + 2^d r_{t-2} + 3^d r_{t-3} + \cdots + L^d r_{t-L} : \forall\, d = [1 \cdots D]\,, \tag{3}$$

where r is the nutritional information to be included, L is the length of lag, and D is the desired degree of polynomial. The restrictions for homogeneity, Slutsky symmetry and adding-up are imposed as normal. Structural coefficients for the PDL terms are a function of the γs:

$$\omega_{i,j} = \delta_{i0} + \delta_{i1} j^1 + \cdots + \delta_{iD} j^D : \quad \forall\, j = [1 \cdots L]\,. \tag{4}$$

Head and tail restrictions are imposed on the model. These restrictions constrain the structural coefficients $\omega_{i,-1}$ and $\omega_{i,L+1}$ in (4) to equal zero.

The lagged budget share is included to capture effects of habit persistence. This term may overstate the effects of habits since it can potentially capture numerous other factors including nutritional factors (Schmitz; Heien and Durham). In this application, however, the capturing of these other effects is advantageous since it will reduce the level of other effects captured by the nutritional measures.

Nutritional information is included in the model in two different forms. The first measure (developed by Brown and Schrader) is an index of medical journal articles which establish or refute a linkage between the consumption of cholesterol in the diet and coronary heart disease. The second measure (proposed by Schmitz) considers the release of ten major articles which discuss guidelines for healthy diets. A review of these articles was conducted by Cronin and Shaw. The first measure (B-S Index) is based solely on cholesterol information while the second index (C-S Index) considers more global nutritional information. Previous research by Schmitz has indicated that these two indices work well within the same model.

DATA

The estimation of the demand system above requires data on prices and quantities for these dairy items. Annual consumption data for the years 1960 through 1988 are available through the USDA for a wide variety of dairy items. However, prices are not available at such a disaggregate level. Therefore, it is necessary to aggregate some of these commodities in order to have appropriate price data. Consumption data are divided into four categories: whole milk, lowfat and skim milk, cheese products, and frozen dairy items. Prices for whole milk are readily available from the USDA, while prices for cheese and frozen dairy items are available from the USDC.

The lowfat milk series is more difficult to obtain since data are not available for either lowfat or skim milk throughout this time period. Gould, Cox and Perali encountered this same difficulty. They used an auxiliary regression of the skim milk price on the lowfat milk price. These two series overlap during the early 1980s. An attempt to duplicate their results obtained similar, albeit, less than desirable results. This duplication resulted in a regression equation

$$P_{lowfat} = 0.861 + \underset{(0.043)}{0.210}\, P_{skim} : \quad R^2 = 0.276, \quad Std.\ Error\ of\ Est. = 0.009 \qquad (5)$$

These results are then used to estimate a lowfat milk price for the period before 1978, using skim milk price published by the USDA. The lowfat milk price for the period after 1978 is published by the USDC. Representative prices are needed to convert these price indices to actual prices. Such prices are taken from the USDA, ERS. Descriptive statistics are presented in Table 1.

Descriptive statistics for the nutritional awareness variables are also presented in Table 1. The B-S index represents the index of cholesterol information developed by Brown and Schrader. The second index is based on a review by Cronin and Shaw. This index accounts for the release of ten important articles pertaining to nutrition and health. These ten articles were released over the period from 1977 through 1988. The B-S index contains sufficient complexity to be modeled using the PDL. However, the C-S index is not appropriate for use in a PDL. Thus it is directly included in the demand system without any lag structure.

Results

Results for this demand system are presented in Table 2. R-square values are very high, between 0.94 and 0.99, with no indication of serial correlation problems. Two of the four own-price coefficients and three of the six cross-price coefficients are statistically significant. Most of the significant

Table 1. Descriptive Statistics for Selected Dairy Items and Nutritional Information Variables.

Variable	Units	Mean	Standard Deviation	Minimum	Maximum	Coefficient of Variation
P_{whole}	Cents/lb.	17.41	6.35	10.29	26.91	36.74
P_{lowfat}	Cents/lb.	17.09	6.37	9.57	26.57	37.27
P_{cheese}	Cents/lb.	162.93	78.09	68.92	274.22	47.93
P_{frozen}	Cents/lb.	33.67	14.07	19.80	57.90	41.79
Q_{whole}	Lbs/capita	187.59	51.43	106.10	263.90	27.42
Q_{lowfat}	Lbs/capita	55.50	29.80	13.20	101.60	53.69
Q_{cheese}	Lbs/capita	14.83	5.10	8.30	24.01	34.39
Q_{frozen}	Lbs/capita	26.31	0.80	24.30	27.70	3.04
Expend.	$/quarter	77.57	35.49	39.04	135.47	45.75
B-S Index	Net articles	34.97	26.12	0	107	74.71
C-S Index	Counter	2.35	3.35	0	10	42.94

Table 2. Estimated Model Coefficients, Statistics and Elasticities.

Variable	Whole	Lowfat	Cheese	Frozen
Constant	0.881*	-0.114	-0.472*	-0.001
	(0.321)	(0.160)	(0.249)	(0.078)
Whole	0.078	0.024	-0.104*	0.002
	(0.083)	(0.050)	(0.028)	(0.028)
Lowfat	0.024	0.002	0.011	-0.037*
	(0.050)	(0.035)	(0.017)	(0.017)
Cheese	-0.104*	0.011	0.117*	-0.024*
	(0.028)	(0.017)	(0.027)	(0.010)
Frozen	0.002	-0.037*	-0.024*	0.059*
	(0.028)	(0.017)	(0.010)	(0.013)
Expenditure	-0.071*	0.017	0.044	0.010
	(0.040)	(0.024)	(0.038)	(0.012)
Lag(w)	0.744*	0.828*	0.663*	0.525*
	(0.071)	(0.095)	(0.090)	(0.097)
$B\text{-}S_0$ (*100)[a]	-0.195*	0.095*	0.093*	0.015
	(0.059)	(0.040)	(0.056)	(0.022)
$B\text{-}S_1$ (*100)	-0.294*	0.142*	0.141*	0.022
	(0.089)	(0.060)	(0.085)	(0.032)
$B\text{-}S_2$ (*100)	-0.294*	0.142*	0.141*	0.022
	(0.089)	(0.060)	(0.085)	(0.032)
$B\text{-}S_3$ (*100)	-0.195*	0.095*	0.093*	0.015
	(0.059)	(0.040)	(0.056)	(0.022)
C-S (*100)	0.011	0.010	0.217*	-0.154*
	(0.138)	(0.099)	(0.132)	(0.064)
R^2	0.999	0.997	0.998	0.941
Durbin-h	1.541	-0.782	0.085	-1.235
ϵ^H_{whole}	-0.375*	0.174	0.080	0.121
ϵ^H_{lowfat}	0.647	-0.866*	0.404*	-0.184
ϵ^H_{cheese}	0.116	0.158*	-0.313*	0.039
ϵ^H_{frozen}	0.468	-0.191	0.102	-0.378*
$\epsilon^M_{own\text{-}price}$	-0.755*	-1.005*	-0.667*	-0.505*
ϵ^{Income}	0.559*	0.758*	0.757*	0.718*

* Indicates significantly difference from zero (One in case of income elasticities) at $\alpha = 0.10$.

( ) Standard error of coefficient.

[a] Coefficients and standard errors are multiplied by 100 to maintain format.

price coefficients are associated with the cheese and frozen items. This result is not unexpected since the price series for whole and lowfat milk are highly collinear. Expenditure also offers only one significant coefficient, the coefficient for whole milk. All of the lagged budget shares are statistically significant and lie between 0.5 and 0.83. Hicksian elasticities as well as Marshallian own-price and income elasticities are also included in Table 2 (see Appendix for elasticity formulas). All of the own-price elasticities are negative. The elasticities for the fluid milks are considerably more elastic than estimates obtained by Huang and George and King. A more elastic result is expected since the disaggregate case allows a fluid milk alternative which is not available in these two comparison studies. Own-price elasticities for cheese and frozen products are comparable to those estimated by Huang and George and King. Lowfat milk and cheese products are found to be substitutes while all other goods are found to be independent.

The nutritional coefficients are also statistically significant in most cases. The B-S index shows a decrease in the consumption of whole milk with an increase in consumption of lowfat milk and cheese products. The C-S index also indicates an increase in cheese consumption and a decrease in the consumption of frozen products.

Elasticity calculations can also be made for these nutritional awareness terms. The PDL model, since it is dynamic, yields both short-run and long-run estimates. The short-run estimates show the immediate reaction to the release of nutritional information while the long-run estimates show the impact after full adjustment has been made. Since the C-S index is included without a lag structure, no distinction can be made between short-run and long-run. Elasticity estimates for the C-S index are calculated for comparison purposes. However, the nature of this index does not lend itself to elasticity measurement as readily as does the B-S index.

Elasticity estimates for these nutritional terms are given in Table 3. Lowfat milk shows the most elastic response to nutritional information with whole milk showing the second most elastic response. This result is expected in light of the consumption trends and nutritional characteristics of these two items. Cheese products also show considerable response to such information while frozen products show relatively little response to nutritional information. Elasticities of nutritional response for frozen products are based on insignificant coefficients for the B-S index and are a meager -0.03. for the C-S index. Within the frozen dairy category are products which may be substituted for one another in response to nutritional information (i.e. yogurt instead of ice cream). Such subtitutions would have no effect on this model. More disaggregate cheese and frozen dairy categories might show many more changes in dairy consumption like the change between whole and lowfat milk. However, more disaggregate price information is needed to model these categories.

Conclusions

Nutritional awareness has significant impact on the consumption of dairy items. Results indicate a strong movement away from whole milk and toward lowfat and skim milk consumption. The average level of the B-S index for the last three years of data is 87, a 150% increase over the mean level. Such an increase calls for a greater change in consumption than is indicated by the data. This situation may result from the large deviation from the elasticity point, violations of the *ceteris paribus* conditions, failure of the system to fully adjust to these levels, or estimation error. However, these results

Table 3. Nutritional Awareness Elasticities for the Selected Dairy Items.

	Whole	Lowfat	Cheese	Frozen
ϵ^{SR}_{B-S}	-0.159**	0.256**	0.102**	0.044
ϵ^{LR}_{B-S}	-0.795**	1.275**	0.511**	0.216
ϵ_{C-S}	0.001	0.002	0.016**	-0.030**

** Based on significant coefficients.

indicate that the change in the consumption pattern of fluid milk products is justifiable and explainable using nutritional information.

A disturbing result of this analysis is that whole and lowfat milk are found to be independent goods, despite the apparent substitution occurring between these two items. This result most likely occurs as a result of the high collinearity between the prices for the two goods. Collinearity leads to inflated variances and covariances for coefficients associated with these variables. These inflated values result in a lower t-value for the resulting elasticities. The independence of these goods may be further enhanced by the level of substitution which results from nutritional information, not price variation. Additional research is needed to disentangle these effects.

References

American Medical Association, Council on Scientific Affairs, "Concepts of Nutrition and Health", *Journal of the American Medical Association*, 242(1979):2335-8.

Brown, D.J. and L.F. Schrader, "Cholesterol Information and Shell Egg Consumption", *American Journal of Agricultural Economics*, 72(1990):548-555.

Capps, O.J., Jr. and J.D. Schmitz, "A Recognition of Health and Nutrition Factors in Food Demand Analysis", *Western Journal of Agricultural Economics*, 16(1991):21-35.

Cronin, F.J. and A.M. Shaw, "Summary of Dietary Recommendations for Healthy Americans", *Nutrition Today*, Nov/Dec 1988:26-33.

George, P.S. and G.A. King, *Consumer Demand for Food Commodities in the United States with Projections for 1980*, Giannini Foundation Monograph No. 26, March 1971.

Gould, B.W., T.L. Cox, and F. Perali, "The Demand for Fluid Milk Products in the U.S.: A Demand Systems Approach", *Western Journal of Agricultural Economics*, 15(1990):1-12.

Heien D. and C. Durham, "A Test of the Habit Formation Hypothesis using Household Data", *Review of Economics and Statistics*, 73(1991):189-99.

Huang, K.S. *U.S. Demand for Food: A Complete System of Price and Income Elasticities*, U.S. Dept. of Agriculture, Economic Research Service, Tech. Bulletin No. 1714, 1985.

National Academy of Sciences, National Research Council, Food and Nutrition Board, *Toward Healthful Diets*, Washington D.C., National Academy Press, 1980.

Schmitz, J.D., *The Impact of Nutritional Awareness on Food Demand: A Complete Systems Approach*, Ph D. dissertation, Texas A&M Univ., College Station, TX, 1991.

U.S. Dept. of Agriculture, *Food Consumption, Prices, and Expenditure*, USDA,ERS, Statistical Bulletin No. 804, Washington D.C., various issues.

U.S. Dept. of Agriculture, Economic Research Service, *Dairy Situation and Outlook*, USDA,ERS, Washington D.C., various issues.

U.S. Dept. of Commerce, *CPI: Detailed Report*, Washington D.C. Govt. Printing Office, various issues.

Appendix

Marshallian Elast.	Hicksian Elast.	Income Elast.
$\epsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta}{w_i}$ δ = 1 if i=j; 0 otherwise	$\epsilon^*_{ij} = \epsilon_{ij} + w_j\left(1+\frac{\beta_i}{w_i}\right)$	$\epsilon^{INC} = \tau\left(1 + \frac{\beta_i}{w_i}\right)$ I: Income τ is found by ln(X) = a + τ ln(I)
$VAR(\epsilon_{ij}) = \frac{VAR(\gamma_{ij})}{w_i^2} + \frac{w_j^2}{w_i^2} VAR(B_i) - \frac{2w_j}{w_i^2} COV(\gamma_{ij}, \beta_i)$	$VAR(\epsilon^*_{ij}) = \frac{VAR(\gamma_{ij})}{w_i^2}$	$VAR(\epsilon^{INC}) = \tau^2 \frac{VAR(\beta_i)}{W_i^2}$ τ is held constant.

B-S Index Elast. (SR)	B-S Index Elast. (LR)	C-S Index Elast.
$\epsilon^{SR}_{BS_i} = \omega_{i0} \frac{\overline{I}}{\overline{W}_i}$	$\epsilon^{LR}_{BS_i} = \sum_{j=1}^{L} \omega_{ij} \frac{\overline{I}}{\overline{W}_i}$	$\epsilon_{CS_i} = \psi_i \frac{\overline{C}}{\overline{W}_i}$