NEW METHODOLOGIES FOR COMMODITY PROMOTION ECONOMICS

PROCEEDINGS FROM THE NEC-63 CONFERENCE

Red Lion Inn ❖ Sacramento, California ❖ October 5-6, 1995

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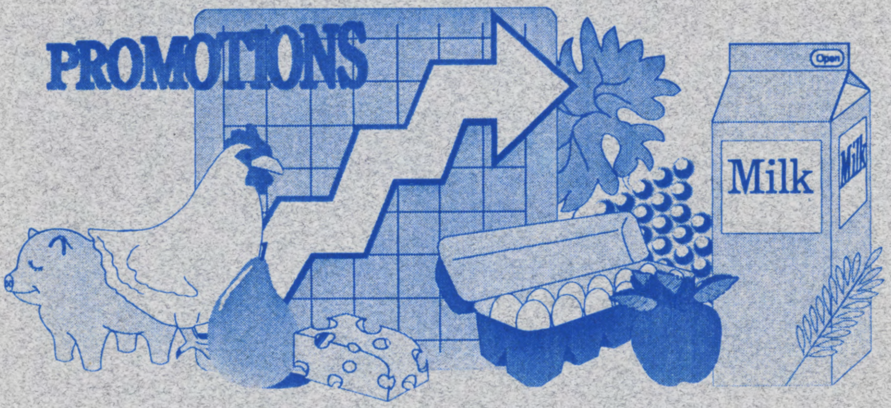

Imperfect Competition Models and Commodity Promotion Evaluation: The Case of U.S. Generic Dairy Advertising

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Almost all previous models used to evaluate the economic impacts of commodity promotion programs have assumed perfect competition in the market. However, this may not be a realistic assumption for many commodities. Specifically, market power likely exists both on the buying and the selling side of the market. For example, farmers, through their cooperatives, may exert a degree of selling power over processors buying agricultural commodities. Alternatively, processors may have some buying power relative to farmers or cooperatives, and/or may have some selling power over buyers of the processed products.

The existence of market power may give biased results if traditionally perfect competition models are used to evaluate economic impacts of promotion programs. This is an important issue because nearly all previous studies have assumed perfect competition. Two exceptions to this include a study of generic milk promotion in Japan (Suzuki et al.) and a study of generic beef advertising in Canada and the United States (Cranfield and Goddard).

The purpose of the research reported in this paper is to determine whether the assumption of perfect competition in the U.S. dairy industry biases the findings of economic impacts of generic dairy advertising in the United States. Two models of the U.S. dairy industry are used to simulate the impacts of generic dairy advertising:

(1) an imperfect competition model, and (2) a perfect competition model. The imperfect competition model endogenizes the degree of market competition using an approach similar to Appelbaum. The perfect competition model treats the price premiums obtained by cooperatives through bargaining power as exogenous. A comparison of results between the two models provides insight on whether the perfect competition assumption is appropriate for studies of generic dairy advertising in the United States.

Conceptual Model

Although raw milk is essentially a homogeneous input in the production of fluid milk and manufactured dairy products, in the United States the price received for fluid milk usage is higher than the price received for manufactured product usage. Under a system of federal and state milk marketing orders, the minimum Class I differential (the difference between the price received for milk used for fluid products and that for manufacturing) is fixed by the authority of the federal and/or state government. In many markets, the effective price for fluid milk use is higher than the minimum Class I price because of bargaining by cooperatives for over-order fluid payments (Fallert, p. 154). Such differences indicate that the prices are not competitively determined. Consequently, the effective fluid milk price differential is the minimum Class I differential plus any over-order payment.

The ability of producers to negotiate over-order payments for fluid milk depends on the producer organization's share of the total supply in addition to general demand and supply conditions in the market. If milk handlers can buy milk from non-cooperative producers, it may be difficult for a cooperative group to obtain premiums above the minimum Class I price (Robinson, p. 115). Therefore, the effective fluid milk price differential reflects the degree of imperfection in the U.S. milk market created by federal policies, dairy cooperatives, and milk handlers.

The imperfect competition model used in this study was originally developed to study the impacts of deregulation on the national dairy market (Suzuki et al.). The model assumes that dairy cooperatives allocate their raw milk supply to fluid and manufacturing markets in a manner which maximizes total milk sales revenue, achieved by equating marginal revenue between fluid and manufacturing milk. Equality across markets of "perceived" marginal revenues is expressed by the following condition:

$$(1)\qquad P_f (1 - \theta_f/\varepsilon) = P_m (1 - \theta_m/\eta), \text{ or}$$
$$P_f + \theta_f Q_f/(\partial Q_f/\partial P_f) = P_m + \theta_m Q_m/(\partial Q_m/\partial P_m),$$

where: P_f is the fluid milk price, θ_f is the degree of competition parameter for the fluid market, ε is the price elasticity of fluid demand in absolute value, P_m is the manufacturing milk price, θ_m is the degree of market competition parameter for the manufacturing milk market, η is the price elasticity of manufacturing milk demand in absolute value, Q_f is aggregate quantity of fluid milk demand, and Q_m is aggregate quantity of manufacturing milk demand.

The parameter θ can be thought of as an aggregate indicator of the degree of competition in the milk market, since it not only reflects the market power of cooperatives, but also the countervailing market power of processors.[1] A zero value for θ indicates perfect competition in the market, in which case the optimal condition in (1) is satisfied by equating the fluid and manufacturing price. At the opposite extreme, a value of one for θ indicates monopoly or perfect collusion in the market.

It is unlikely that the degree of market competition parameter is the same for the fluid and manufacturing milk markets. Rather, dairy cooperatives face more competition in the manufacturing milk market than in the fluid milk market. This is partly due to higher transportation costs for fluid milk products than manufacturing milk products. As a result, the manufacturing milk market is more national in scope and more competitive, while the fluid milk market is more local and is usually dominated by just a few processors.

Separate parameters can be estimated for degree of competition for the fluid and manufacturing milk markets by estimating the fluid (or manufacturing demand) equation and equation (1). The manufacturing (or fluid) demand equation can then be substituted into equation (1). The advantage of this approach is that it allows for direct estimation of θ as a coefficient of equation (1) (Bresnahan), and θ_f and θ_m can be separately identified. Unfortunately, since the coefficients for the manufacturing (or fluid) demand equation could not be identified, this approach was not used here.

Instead, two different estimates were made to determine the degree of market competition parameter for the fluid and manufacturing milk markets. In Case 1, it is assumed that θ_m is zero (perfect competition in manufacturing milk market) and θ_f is solved assuming that θ_f is constant in each time period and that cooperatives realize the condition expressed by (1). In Case 2, it is assumed that $\theta_m = \theta_f$. In reality, the degree of competition parameter for the manufacturing milk market probably lies somewhere between these two cases.

The imperfect competition model of the U.S. dairy industry used in this research is represented by the following six equations having six endogenous variables:

$$(2) \quad Q = f(BP),$$

$$(3) \quad Q_f = g(P_f, A_f),$$

$$(4) \quad Q_m = h(P_m, A_m),$$

$$(5) \quad P_f + \theta_f Q_f/(\partial Q_f/\partial P_f) = P_m + \theta_m Q_m/(\partial Q_m/\partial P_m),$$

$$(6) \quad Q \equiv Q_f + Q_m + FUSE,$$

$$(7) \quad BP = (P_f Q_f + P_m Q_m)/(Q - FUSE),$$

where Q is aggregate milk production, BP is blend price, A_f is fluid milk advertising expenditures, A_m is manufacturing milk advertising expenditures, FUSE is farm use of milk produced (assumed to be exogenous), and all other variables are as previously defined. Other exogenous variables, such as feed price, income, and trend, are not noted in the above abbreviated equations, but are included in the empirical model. Equation (2) is the farm milk supply function, while equations (3) and (4) are the fluid and manufacturing milk demand functions, respectively. Equation (5) is the first-order condition for optimal milk allocation between fluid and manufacturing markets to maximize milk sales. Equation (6) is an equilibrium condition requiring farm milk supply to equal fluid and manufacturing processors' milk demand plus farm use of milk. Equation (7) is the formula for the blend price, which is a weighted average price received by farmers based on the Class prices and utilization of the

Table 1. Estimated Equations for U.S. Milk Supply, Fluid Demand, and Manufacturing Demand.

Dependent Variables	Milk Supply ln(Q)	Fluid Demand Q_f/N	Manufacturing Demand Q_m/N
Estimation Periods	1975.2 - 90.4	76.3 - 90.4	76.3 - 90.4
Independent Variables			
Intercept	3.899(24.75)[a]	-0.077(-2.49)	0.378(4.66)
ln(MF)	0.019(3.86)		
$\ln(MF)_{-1}$	0.032(3.86)		
$\ln(MF)_{-2}$	0.040(3.86)		
$\ln(MF)_{-3}$	0.043(3.86)		
$\ln(MF)_{-4}$	0.040(3.86)		
$\ln(MF)_{-5}$	0.032(3.86)		
$\ln(MF)_{-6}$	0.019(3.86)		
TREND	0.0039(8.17)		
MDP	-0.024(-1.67)		
DTP	-0.041(-2.94)		-0.0059(-1.71)
SIN1	-0.0053(-1.94)	0.0016(8.28)	-0.0013(-1.98)
COS1	-0.052(-19.57)	0.0023(10.15)	-0.0074(-9.08)
COS2	0.071(5.40)	0.00018(3.70)	0.00074(2.12)
$(U^Q)_{-1}$	0.734(7.57)		

P_f/CPI		-0.105(-3.16)	
INC/CPI		0.0011(2.70)	-0.0069(-3.55)
(GA_f)		1.0×10^{-7}(3.10)	
$(GA_f)_{-1}$		1.7×10^{-7}(3.10)	
$(GA_f)_{-2}$		2.0×10^{-7}(3.10)	
$(GA_f)_{-3}$		2.0×10^{-7}(3.10)	
$(GA_f)_{-4}$		1.7×10^{-7}(3.10)	
$(GA_f)_{-5}$		1.0×10^{-7}(3.10)	
BA_f		6.8×10^{-7}(2.60)	
AU19		0.387(4.85)	
$(U^{Qf/N})_{-1}$		0.788(4.94)	
P_m/CPI			-1.113(-3.96)
(BA_m)			3.6×10^{-7}(2.34)
$(BA_m)_{-1}$			5.4×10^{-7}(2.34)
$(BA_m)_{-2}$			5.4×10^{-7}(2.34)
$(BA_m)_{-3}$			3.6×10^{-7}(2.34)
D89.4			0.018(2.80)
D90.4			-0.022(-3.16)
$(U^{Qm/N})_{-1}$			0.670(3.78)
Adj. R^2	0.95	0.92	0.78
D.W.	1.79	2.02	1.74

[a]Figures in parentheses are t-values.

milk supply.

The results of both imperfect competition models were compared to a conventional perfect competition model. The perfect competition model assumed that the fluid (Class I) price differential was exogenous. The perfect competition model was the same as the imperfect competition models, except that equation (5) was replaced with:

$$(8) \qquad P_f = P_m + DIFF,$$

where DIFF is the exogenous fluid (Class I) price differential.

Estimated Model

Quarterly data from 1975 through 1990 were used to estimate the model. The farm milk supply, manufacturing demand, and fluid demand equations were estimated using two stage least squares since prices and quantities are endogenous.

The effective fluid milk price used in the estimation is defined as the manufacturing milk price (Minnesota-Wisconsin price) plus the minimum Class I differential plus any over-order payment. There were no data for national over-order payments for fluid milk. However, the effective fluid milk price (P_f) could be estimated by solving the blend price equation for P_f, that is:

$$(9) \qquad P_f = [BP\,(Q - FUSE) - P_m\,Q_m)]/Q_f,$$

where the term BP in equation (9) refers to the all milk price, which is a measure of the national blend price including over-order payments. The effective fluid milk price computed by equation (9) may be somewhat higher than the true effective fluid price because the all milk price includes over-order payments for Class II and III milk, as well as for Class I milk. However, over-order premiums for Class II and III milk are usually much smaller on a national basis than Class I premiums. Therefore the potential upward bias in P_f from equation (9) is likely to be small.

The estimated farm milk supply, manufacturing demand, and fluid demand equations are presented in Table 1, while all variable definitions and data sources are listed in Table 2. The milk supply equation (Q) was estimated as a function of the milk-feed price ratio (MF = blend price / feed price), a time trend (TREND), intercept dummy variables for the Milk Diversion Program (MDP) and the Dairy Termination Program (DTP), and harmonic seasonality variables (SIN1, COS1, and COS2). It was assumed that farmers formulate price expectations based on past price observations. Accordingly, a polynomial distributed lag was specified for the milk-feed price ratio.[2] The most significant results were achieved with a second degree polynomial distributed lag imposed with both endpoints constrained to lie close to zero and a six quarter lag length. Considering the biological reproduction cycle of the cow, this lag length is reasonable. The time trend variable was included as a proxy for improvements in technology over time, while the intercept dummy variables for the MDP and DTP were included because these two programs were designed to reduce milk supply. The three harmonic variables captured seasonality in milk supply throughout the year. The Cochrane-Orcutt procedure was employed to overcome significant first-order autocorrelation in the disturbance term. The computed long-run price elasticity of milk supply was 0.224, which is similar to Chavas and Klemme's estimated two-year price elasticity of 0.20, and Weersink's estimate of 0.29.

Table 2. Definitions of Variables and Data Sources

Q = milk production (billion pounds), from Dairy Situation and Outlook,

MF = all milk price per cwt. divided by the 16% protein feed price per ton, from, Dairy Situation and Outlook,

TREND = time trend variable equal to 1 for 1970, quarter 1,...,

MDP= intercept dummy variable for the Milk Diversion Program equal to 1 for 1984, quarter 1 through 1985, quarter 2, equal to 0 otherwise,

DTP = intercept dummy variable for the Dairy Termination Program equal to 1 for 1986, quarter 2 through 1987, quarter 3, equal to 0 otherwise,

SIN1, COS1, and COS2 = harmonic seasonality variables representing the first wave of the sine function (1,0,-1,0), the first wave of the cosine function (0,-1,0,1), and the second wave of the cosine function (-1,1,-1,1), respectively. (1,0,-1,0) etc. are values for each quarter, where the first quarter means $\pi/2$, second π, third $3\pi/2$, and fourth 2π,

$\mathbf{U_{-1}}$ = lagged residual,

$\mathbf{Q_f}$ = fluid milk marketed (billion pounds), from Dairy Situation and Outlook,

N = U.S. population (million persons), from Handbook of Basic Economic Statistics,

$\mathbf{P_f}$ = effective Class I price ($/cwt.) estimated using equation (12),

CPI = consumer price index for all items (1982-84 = 100), from Consumer Price Index,

INC = disposable personal income per capita ($1,000), from Employment and Earnings,

$\mathbf{GA_f}$ **and** $\mathbf{BA_f}$ = generic and branded fluid advertising expenditures ($1,000) deflated by the media price index, from Blaylock,

AU19 = ratio of persons under 19 years old to the total population, from Economic Report of the President,

$\mathbf{Q_m}$ = manufacturing milk marketed (billion pounds), computed as the milk production minus farm use minus fluid milk marketings,

$\mathbf{P_m}$ = M-W price ($/cwt), from Dairy Situation and Outlook,

$\mathbf{BA_m}$ = branded manufacturing advertising expenditures deflated by the media price index ($1,000), from Blaylock,

D89.4 = intercept dummy variable equal to 1 for 1989, quarter 4, equal to 0 otherwise,

D90.4 = intercept dummy variable equal to 1 for 1990, quarter 4, equal to 0 otherwise.

Table 3. Estimated Degree of Competition Parameters (Annual Average).

Year	Case 1[a] θ_f when $\theta_m = 0$	Case 2[b] $\theta_f = \theta_m$
1977	0.077(0.024)	0.089
1978	0.065(0.021)	0.075
1979	0.066(0.021)	0.076
1980	0.066(0.021)	0.076
1981	0.065(0.020)	0.076
1982	0.061(0.019)	0.072
1983	0.059(0.019)	0.071
1984	0.056(0.018)	0.066
1985	0.061(0.019)	0.073
1986	0.057(0.018)	0.067
1987	0.058(0.018)	0.069
1988	0.050(0.016)	0.059
1989	0.044(0.014)	0.052
1990	0.055(0.017)	0.065

[a]Figures in parentheses are standard errors defined by: $(P_f - P_m)\, N/(Q_f\, CPI)$ [standard error of the fluid demand function's estimated slope].

[b]Standard errors cannot be computed in this case because of the nonlinear relationship.

Per capita fluid milk demand[3] (Q_f/N) was estimated as a function of the effective fluid milk price (P_f), per capita income (INC), the ratio of persons under 19 years old to the total population (AU19), current and lagged fluid advertising expenditures (branded BA_f and generic GA_f), and harmonic seasonality variables (SIN1, COS1, and COS2). All prices and income variables were deflated by the consumer price index, and the advertising expenditures were deflated by the media price index. To capture habit formation of advertising, a polynomial distributed lag was imposed. The most significant results (for generic fluid advertising) were obtained with a second degree polynomial distributed lag with both endpoints constrained to lie close to zero and a five quarter lag length. Current branded fluid advertising expenditures were found to be significant, but lagged expenditures were not significant. The elasticities of fluid demand with respect to price, income, and branded fluid advertising, calculated at their mean values, were -0.293, 0.483, and 0.0089, respectively, which are similar to previous studies (e.g., Liu et al.). The fluid demand function was estimated in linear form because other functional forms (double-log, semi-log, log-inverse, and inverse) resulted in negative marginal revenue estimates. A negative value for marginal revenue precludes discussion of the collusion case expressed by equation (1).[4]

Per capita manufacturing milk demand[5] (Q_m/N) was estimated as a function of the manufacturing milk price (P_m), per capita income, the ratio of persons under 19 years old to the total population, current and lagged manufacturing milk advertising expenditures (branded BA_m and generic GA_m), an intercept dummy variable for the DTP, and harmonic seasonality variables. Again, all prices and income were deflated by the consumer price index, and advertising expenditures were deflated by the media price index. Intercept dummy variables were also included for the fourth quarters of 1989 and 1990 because regression residuals for both periods were very large. The outlier for the fourth quarter of 1989 resulted more than likely from unusually strong demand for nonfat dry milk during that quarter, but there is no apparent explanation for the fourth quarter 1990 outlier. To account for habit formation of advertising, a polynomial distributed lag was imposed. The most significant results were obtained with a second degree polynomial distributed lag with both endpoints constrained to lie close to zero and a three quarter lag length. The effects of generic manufacturing advertising were negative and highly insignificant. The variable AU19 was also not significant. Consequently, these two variables were dropped from the

Table 4. Mean Absolute Percent Errors[a] (1980.1-90.4).

Endogenous Variables	Mean Absolute Percent Error Case 1	Case 2
	%	%
Fluid Milk Price (P_f)	3.10	3.16
Manufacturing Milk Price (P_m)	3.70	3.69
Blend Price (BP)	3.54	3.56
Fluid Milk Demand (Q_f)	1.60	1.59
Manufacturing Milk Demand (Q_m)	2.91	2.88
Milk Production (Q)	1.67	1.66

[a]The formula is: (1/n)Σ_(P-A)/A_×100, where P is the predicted value and A is the actual value.

Table 5. Estimated Average Increases in Producer Surplus Associated with 1 percent Increases in Advertising Expenditures (1980-90).

	Imperfect Competition Model Case 1 $\theta_m = 0$	Imperfect Competition Model Case 2 $\theta_f = \theta_m$	Exogenous Fluid Price Differential Model
Increases in Producer Surplus (1000$)	1,017	1,044	902
Percentage change in:			
Fluid Milk Price (%)	0.0222	0.0243	0.0135
Fluid Milk Quantity (%)	0.0484	0.0478	0.0508
Manufacturing Milk Price(%)	0.0154	0.0150	0.0171
Manufacturing Milk Quantity (%)	-0.0214	-0.0208	-0.0237

final model. Unexpectedly, the estimated coefficient on the income variable was negative and significant. Because individual dairy products have different demand patterns over time, disaggregated estimation would likely produce results more consistent with theory, however, that is beyond the scope of this paper. The estimated elasticities of manufacturing demand with respect to price and long-run branded advertising were -1.575 and 0.234, respectively, calculated at their mean values. The estimated price elasticity was relatively large compared to previous studies, e.g., -0.928 found by Liu et al.

The annual values for the degree of competition parameter derived from equation (1) and the estimated fluid and manufacturing demand equations are reported in Table 3. Again, in Case 1, it was assumed that θ_m is zero, while in Case 2 it was assumed that θ_f was equal to θ_m. It is interesting that the values of θ were only slightly larger in the second case. The results from both indicate that the U.S. milk market is neither perfectly competitive nor monopolistic. Also, the results suggest that the degree of market imperfection has been declining over time.

The fluid milk market may be becoming more competitive over time because of improvements in transportation technology and an increase in reserve areas other than Minnesota and Wisconsin. This has increased the geographic scope of fluid milk markets, which is a competitive influence on the market. The gradually decreasing degree of competition parameters could be the consequences of a power balance caused by these developments.

Model Validation and Simulations

The validity of the estimated model was determined by dynamically simulating values for the endogenous variables over a historical period (1980-90), given the values for the exogenous variables using the Gauss-Seidel technique. The mean absolute percent errors are presented in Table 4. Since the largest error was less than 4 percent, which was relatively small for a dynamic simulation, the model was deemed reasonable for this purpose.

To estimate the effectiveness of generic milk advertising, scenarios were simulated based on a 1 percent increase in generic fluid advertising expenditures in every period from the first quarter of 1980 until the fourth quarter of 1990. Because generic manufacturing advertising was determined as not statistically significant, only generic fluid advertising expenditures were considered in the simulation. The effectiveness of advertising was measured by the increase in producer surplus associated with the 1 percent increase in advertising expenditures. The change in producer surplus was approximated by the following trapezoid area;

$$(BP'-BP)\,(Q'+Q-2\,FUSE)/2, \quad (10)$$

where " ' " represents *ex post* value. *Ex ante* values were not observations but values solved by the fully dynamic simulation.

The results of both imperfect competition models, Case 1 and Case 2, as well as the perfect competition model, are shown in Table 5. The results represent the average increase in producer surplus, prices, and quantities from 1980 through 1990 associated with a 1 percent increase in generic advertising expenditures.

The results of the two imperfect competition models were very similar to one another. Thus, the results of Case 1 will be used to compare with the perfect competition model. The imperfect competition model (Case 1) found a $1 million increase in producer surplus due to a 1 percent increase in generic advertising expenditures, while the perfect competition model estimated a $902,000 increase in producer surplus. In other words, when some market imperfection was allowed in the model, the increase in producer surplus associated with increased advertising was almost 13 percent higher than when it was assumed that perfect competition prevailed.

With respect to impacts in the fluid milk market, the imperfect competition model (Case 1) estimated an increase in the fluid price and quantity of 0.0222 percent and 0.0484 percent due to a 1 percent increase in generic advertising expenditures. On the other hand, the perfect competition model estimated a smaller increase in the fluid milk price (0.0135 percent) and a larger increase in fluid milk quantity (0.0508 percent) than the imperfect competition model. The discrepancy in results between models in percentage terms was sizable; the estimated price impact was 64 percent larger and the quantity impact was 5 percent lower from the imperfect competition model relative to the perfect competition model.

Regarding impacts in the manufacturing milk market, the results between the two models were significant. The results of the imperfect competition model showed a 0.0154 percent increase in the manufacturing milk price and a 0.0214 percent decrease in manufacturing milk quantity due to a 1 percent increase in generic advertising expenditures. The results of the perfect competition model indicated that a 1 percent increase in generic advertising expenditures increased the manufacturing milk price by 0.0171 percent and decreased manufacturing milk quantity by 0.0237 percent. That is, the imperfect competition model predicted that a 1 percent increase in generic advertising expenditures would increase the manufacturing milk price by 10 percent less and would decrease the manufacturing milk quantity by 10 percent less than the predicted results of the perfect competition model.

Conclusion

The purpose of this paper was to determine whether the assumption of perfect competition in the U.S. dairy industry biased the findings of economic impacts of generic dairy advertising in the United States. Two models of the U.S. dairy industry were used to simulate the impacts of generic dairy advertising: (1) an imperfect competition model, and (2) a perfect competition model. The imperfect competition model endogenized the degree of market competition using an approach similar to Appelbaum. The perfect competition model treated the price premiums obtained by cooperatives through bargaining power as exogenous.

The estimated degree of competition parameters indicated that there is some market power in the U.S. milk market. The imperfect competition model demonstrated that greater market power resulted in larger returns from generic milk advertising than the perfect competition model. Therefore, the traditional perfect competition model may underestimate the magnitude of impacts of the U.S. generic milk advertising.

Endnotes

1. Since dairy cooperatives in the U.S. do not control member milk production, the marginal cost of production is not included in equation (1).

2. The number of cows was not included as an explanatory variable because long-run milk-feed price effects are considered by imposing a polynomial distributed lag.

3. The demand functions for fluid and manufacturing milk were derived demands by processors for milk. All quantities in the model were measured on a milk-fat equivalent basis to satisy the equilibrium conditions.

4. To be consistent with the fluid demand function, the manufacturing milk demand function was also estimated using a linear form.

5. Government purchases of dairy products and changes in commercial inventories were included with commercial demand in the manufacturing milk demand function because this is a derived demand for raw milk.

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