An Economic Analysis of the U.S. Generic Dairy Advertising Program Using an Industry Model

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The market impacts of generic dairy advertising are assessed using an industry model which encompasses supply and demand conditions at the retail, wholesale, and farm levels, and government intervention under the dairy price support program. The estimated model is used to simulate price and quantity values for four advertising scenarios: (1) no advertising, (2) historical fluid advertising, (3) historical manufactured advertising, and (4) historical fluid and manufactured advertising. Compared to previous studies, the dairy-industry model provides additional insights into the way generic dairy advertising influences prices and quantities at the retail, wholesale, and farm levels.

The federal government has enacted various supply- and demand-management programs aimed at curbing milk surpluses that have occurred for much of the 1980s. Supply-management policies have been enacted in order to reduce or slow the rate of growth in milk production. Two examples include the 1984–85 Milk Diversion Program and the 1986–87 Dairy Termination Program. A demand-management program was authorized under the Dairy and Tobacco Adjustment Act of 1983. This act established the National Dairy Promotion and Research Program with an objective of increasing dairy-product consumption. Since then, generic dairy advertising has been funded by a mandatory $0.15 per cwt. assessment on milk marketings, generating over $200 million annually.

Given the magnitude of money involved in promoting dairy products, there is an obvious need for objective evaluation of the program's impact on various markets within the dairy sector. At the national level, both fluid and manufactured dairy products advertising activities have been partially evaluated. Ward and Dixon estimate a retail fluid milk demand equation covering twelve major milk market regions which represent 40% of the U.S. population. On the manufactured side, Blaylock and Blisard estimate retail natural and processed cheese demand equations for the U.S. at-home market. These and other studies have contributed to an understanding of the impact of U.S. generic dairy advertising. However, several important issues still need to be addressed.

First, the previous studies have estimated retail demand equations but have ignored retail supply. Hence, the retail price is treated as exogenous and is not affected by the increased demand due to advertising. Accordingly, such models may exaggerate the impact of advertising on retail demand. Second, the previous studies ignore markets other than those at the retail level. Since the link between the impact of advertising on the retail market and the subsequent impacts on the wholesale and farm markets have not been explicitly modeled, the effect of advertising on the wholesale and farm markets cannot be appropriately analyzed. Third, the implications of government price intervention have not been explicitly modeled. It will become clear that the advertising program has different effects depending on whether the market is competitive or government supported.[1] Finally, the

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[1] Due to recent large amounts of annual government purchases, it is tempting to describe the dairy sector exclusively as government supported. However, this observation is not appropriate when examining the market on a quarterly or monthly basis. Moreover, using government purchases for regime identification is flawed due to the existence of specialized manufacturing plants that package their product according to government standards and are not equipped to sell in commercial markets even when the competitive price exceeds the government price. Using the relationship between the government price and the market price as a criterion to identify regimes, our data indicate that the competitive regime held for 42% of the quarters during the period 1975–87.

previous studies have not taken into account the farm supply response to advertising. If the advertising program indeed increases the demand for milk and, hence, farm revenue, producers will likely increase supplies which might eventually wipe out any short-term gains.

Additional insight into the impact of the U.S. generic dairy advertising program can be gained if the evaluation is based on a dairy-industry model which encompasses supply and demand conditions in various markets and government intervention under the dairy price support program.[2] The purpose of this paper is to assess the impact of the U.S. generic dairy advertising program in a multiple-market setting. Based on a quarterly econometric model of the U.S. dairy industry, the price and quantity effects of fluid and manufactured dairy products advertising are simulated for the retail, wholesale, and farm levels.

Conceptual Framework

The econometric model of the dairy industry consists of a farm, retail, and wholesale level. At the farm level, raw milk is produced and sold to wholesalers, who in turn process and sell it to retailers. Both wholesale and retail levels are divided into a fluid and a manufactured component. The construction is similar to a previous model by Kaiser, Streeter, and Liu in that milk products are divided into fluid and manufactured dairy products. However, the previous model only considered the retail and the farm levels. The extension to include a wholesale level in this study facilitates the incorporation of government intervention in the wholesale manufactured market. A schematic view of the components of the dairy sector is in Figure 1.

In the retail fluid market, a general specification for supply, demand, and the equilibrium condition can be written as

(1a) $$Q_s^{rf} = f(P^{rf}, P^{wf} \mid Z_s^{rf}),$$

(1b) $$Q_d^{rf} = f(P^{rf} \mid Z_d^{rf}),$$

(1c) $$Q_s^{rf} = Q_d^{rf} \equiv Q^{rf},$$

where Q_s^{rf} and Q_d^{rf} are the retail fluid quantity supplied and demanded; P^{rf} and P^{wf} are the equilibrium retail fluid price and wholesale fluid price; Z_s^{rf} and Z_d^{rf} are vectors of exogenous supply and demand shifters pertaining to the retail fluid market; and Q^{rf} is the equilibrium retail fluid quantity.

The retail manufactured supply, demand, and equilibrium condition can be written following the form of the retail fluid market as follows:

(2a) $$Q_s^{rm} = f(P^{rm}, P^{wm} \mid Z_s^{rm}),$$

(2b) $$Q_d^{rm} = f(P^{rm} \mid Z_d^{rm}),$$

(2c) $$Q_s^{rm} = Q_d^{rm} \equiv Q^{rm},$$

where superscripts *rm*'s and *wm*'s represent the retail and wholesale manufactured markets, respectively.

The wholesale fluid supply, demand, and equilibrium condition are

(3a) $$Q_s^{wf} = f(P^{wf}, P^{II} + DIFF \mid Z_s^{wf}),$$

(3b) $$Q_d^{wf} = Q^{rf},$$

(3c) $$Q_s^{wf} = Q_d^{wf} \equiv Q^{wf},$$

where P^{II} is the Class II price and *DIFF* is the exogenous Class I differential. All other variables are similarly defined with superscript *wf*'s denoting wholesale fluid market variables. Equation (3b) specifies that the wholesale fluid demand should equal the equilibrium retail fluid quantity as all the quantity variables are expressed on a milk-equivalent basis.

The wholesale manufactured supply, demand, and equilibrium condition when the market is competitive are

(4a) $$Q_s^{wm} = f(P^{wm}, P^{II} \mid Z_s^{wm}),$$

(4b) $$Q_d^{wm} = Q^{rm},$$

(4c) $$Q_s^{wm} = Q_d^{wm} + QSP + \Delta INV \equiv Q^{wm},$$

where *QSP* is the quantity of milk sold to the government by specialized manufacturing plants, ΔINV is change in commercial inventories of manufactured products, and all other variables are similarly defined with superscript *wm*'s denoting variables pertaining to the wholesale manufactured market. The variables *QSP* and ΔINV are treated as exogenous in this study because they comprise a very small and rather constant portion of manufactured quantity.

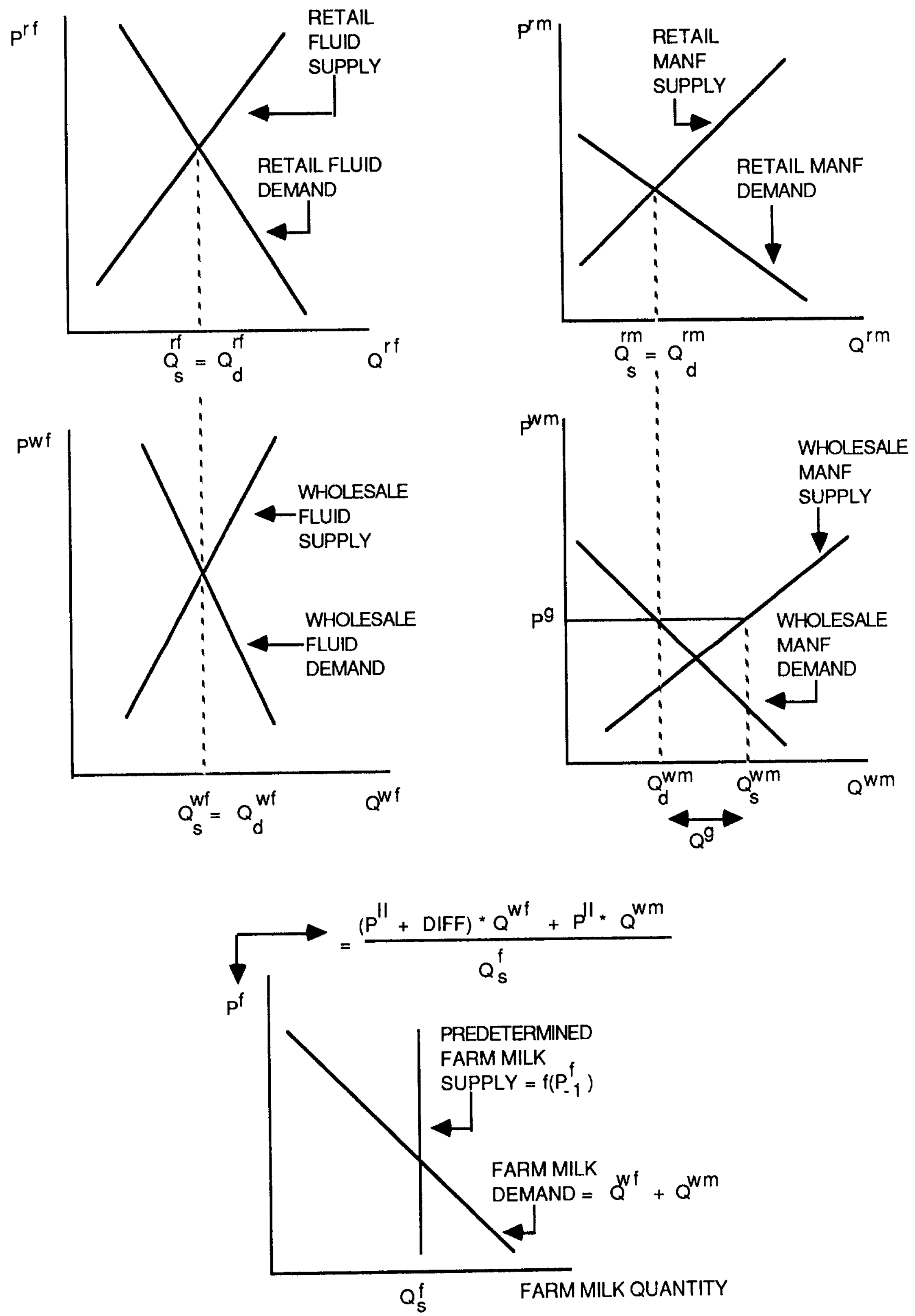
The wholesale manufactured price appearing in (2a) and (4a) is constrained by the price-support program. That is, since the government sets a purchase price for manufactured dairy products and is willing to buy surplus quantities of the products at that price, the following constraint holds:

(5) $$P^{wm} \geq P^{g},$$

where P^g is the aggregate government purchase

[2] Numerous studies have investigated the impact of individual state dairy advertising programs on the consumer and/or farm markets (e.g., Kinnucan and Forker; Liu and Forker; Thompson and Eiler). However, since the manufactured market is national rather than local in scope, reliable sales data for state-level manufactured dairy products do not exist. Hence, an industry-model approach to advertising at the state level is not possible.

Figure 1. Conceptual Model of the U.S. Dairy Market*



* Ignores changes in commercial inventories, specialized plant quantity, and farm use, for simplicity.

price for the manufactured products at the wholesale level.

When the government-support regime holds, P^{wm} simply equals P^g which is exogenous. However, the quantity of government purchases emerges as an additional endogenous variable. Accordingly, the equilibrium condition of (4c) for the wholesale manufactured market becomes

$$(4c') \quad Q_s^{wm} = Q_d^{wm} + QSP + \Delta INV + Q^g \equiv Q^{wm},$$

where Q^g is government purchases measured on a milk-equivalent basis.

Finally, the farm supply is treated as predetermined due to the assumption that dairy farmers' price expectations are based on lagged prices only (e.g., Chavas and Klemme; Kaiser, Streeter, and Liu; LaFrance and de Gorter). As such, the farm supply equation is

$$(6a) \quad Q_s^f = f(P_{-1}^f \mid Z_s^f),$$

where Q_s^f is the farm milk supply, P_{-1}^f is the last period's farm milk price, and Z_s^f is a vector of exogenous farm supply shifters. Since milk used for fluid and manufactured purposes commands different prices, the farm milk price received by dairy farmers is the average of the Class I and Class II prices weighted by their respective quantities:

$$(6b) \quad P^f = \frac{(P^{II} + DIFF) * Q^{wf} + P^{II} * Q^{wm}}{(Q_s^f - FUSE)},$$

where $FUSE$ is on-farm use of milk, which is assumed to be exogenous. The model is closed by the following farm-level equilibrium condition:

$$(6c) \quad Q_s^f = Q^{wf} + Q^{wm} + FUSE.$$

To summarize, since the farm milk supply is predetermined, the above dairy model is recursive in nature consisting of a retail-wholesale subsystem (equations 1–5) and a farm market (equation 6). Given the predetermined farm milk supply, the retail-wholesale subsystem encompasses two possible regimes. In the case of a competitive regime, the endogenous variables are: retail and wholesale fluid quantities ($Q_d^{rf} = Q_s^{rf} = Q_d^{wf} = Q_s^{wf}$), retail manufactured quantities and wholesale manufactured demand ($Q_d^{rm} = Q_s^{rm} = Q_d^{wm}$), wholesale manufactured supply quantity (Q_s^{wm}), retail fluid price (P^{rf}), wholesale fluid price (P^{wf}), retail manufactured price (P^{rm}), wholesale manufactured price (P^{wm}), and Class II price (P^{II}). For a government-support regime, government quantity (Q^g) replaces P^{wm} as an endogenous variable.

Estimation Results

Since the underlying market structures are different depending on whether the market is competitive or government supported, an application of the conventional two-stage least squares procedure to the retail-wholesale subsystem in equations (1)–(5) will result in selectivity bias (Maddala 1983, pp. 326–35). Instead, the subsystem is estimated by a switching simultaneous system procedure. The six structural equations that need to be estimated simultaneously are: retail fluid demand, retail manufactured demand, retail fluid supply, wholesale fluid supply, retail manufactured supply, and wholesale manufactured supply. Quarterly data from 1975 through 1987 are used to estimate the equations. The farm supply equation in (6a) is estimated by ordinary least squares since the supply is assumed to be predetermined. Due to the availability of data, a longer time series from 1970 through 1987 is used in this estimation. A detailed description of the switching simultaneous system procedure and data used in the estimation can be found in Liu, Kaiser, Forker, and Mount.[3]

Retail-Wholesale Subsystem

The retail fluid and manufactured demand equations are estimated on a per capita basis, while the retail and wholesale supply equations are estimated on a total quantity basis because population is not a supply determinant. Both demand equations are expressed as functions of own-price, per capita income, price of substitutes, advertising, time trend, harmonic seasonal variables, and other shifters. The supply equations are expressed as functions of own-price, input prices, lagged supply, harmonic seasonal variables, and other shifters. The estimation results are shown in Table 1 (t-values in parentheses), and variables definitions are presented in Table 2. A more specific explanation of the equations follows.

[3] The generic advertising data are from various issues of *Leading National Advertisers*. Due to the survey techniques used, the expenditures reported in the publication are generally regarded as low compared to the true expenditures. However, alternative data sources for the U.S. market with the required extended time period are not available. Since the error in variable problem may result in downward-bias advertising coefficients in the estimation (rather than upward bias as one might have intuitively thought, see Maddala 1977, pp. 292–94), the result should be interpreted with care. An instrumental variable approach of regressing advertising on its own lags was initially tried to purge the correlation between the error term and the advertising variable. However, the resulting low R^2 in the instrumental equation indicates the poor performance of the procedure, which was subsequently abandoned.

Table 1. Estimated Dairy Industry Model

Retail Fluid Demand

$$\ln Q_d^{rf} = -2.236 - 0.282 \ln (P^{rf}/INC) + 0.154 \ln (PBEV/INC)$$
(−14.88) (−2.34) (2.31)

$$+ 0.0025 \ln DGFA + 0.004 \ln DGFA_{-1} + 0.0045 \ln DGFA_{-2}$$
(2.01) (2.01) (2.01)

$$+ 0.004 \ln DGFA_{-3} + 0.0025 \ln DGFA_{-4} - 0.179 \ln TIME$$
(2.01) (2.01) (−6.79)

$$- 0.028\, SIN1 + 0.083\, COS1 + 0.517\, (u_d^{rf})_{-1} + \ln POP$$
(−3.60) (10.70) (3.24)

Adj. R^2 = 0.88 Durbin-Watson = 1.84

Retail Manufactured Demand

$$\ln Q_d^{rm} = -2.467 - 0.928 \ln (P^{rm}/INC) + 0.645 \ln (PMEA/INC)$$
(−10.42) (−2.68) (2.29)

$$+ 0.0009 \ln DGMA + 0.0014 \ln DGMA_{-1} + 0.0016 \ln DGMA_{-2}$$
(1.64) (1.64) (1.64)

$$+ 0.0014 \ln DGMA_{-3} + 0.0009 \ln DGMA_{-4} - 1.436 \ln DPAFH$$
(1.64) (1.64) (−2.09)

$$+ 0.071 \ln TIME - 0.050\, SIN1 - 0.085\, COS1 + \ln POP$$
(2.64) (−4.92) (−8.29)

Adj. R^2 = 0.85 Durbin-Watson = 2.07

Retail Fluid Supply

$$\ln Q_s^{rf} = 2.809 + 0.940 \ln (P^{rf}/P^{wf}) - 0.111 \ln (PFE/P^{wf})$$
(6.00) (1.82) (−3.68)

$$- 0.015\, UNEMP + 0.237 \ln (Q_s^{rf})_{-1} - 0.227 \ln (Q_s^{rf})_{-4} - 0.001\, TIME$$
(−3.95) (1.76) (−1.98) (−1.90)

$$- 0.052\, SIN1 + 0.094\, COS1$$
(−3.90) (8.14)

Adj. R^2 = 0.90 Durbin-h = 1.60

Wholesale Fluid Supply

$$\ln Q_s^{wf} = 2.184 + 0.381 \ln [P^{wf}/(P^{II} + DIFF)] - 0.093 \ln [PFE/(P^{II} + DIFF)]$$
(4.03) (2.66) (−2.85)

$$- 0.016\, UNEMP + 0.240 \ln (Q_s^{wf})_{-1} - 0.223 \ln (Q_s^{wf})_{-4} - 0.003\, TIME$$
(−3.98) (1.79) (−1.96) (−3.74)

$$- 0.050\, SIN1 + 0.094\, COS1$$
(−3.74) (8.18)

Adj. R^2 = 0.90 Durbin-h = 1.13

Retail Manufactured Supply

$$\ln Q_s^{rm} = -1.507 + 0.683 \ln (P^{rm}/P^{wm}) - 0.334 \ln (MWAGE/P^{wm})$$
(−1.69) (2.37) (−1.51)

$$- 0.042\, COS1 + 0.163 \ln (Q_s^{rm})_{-1} + 0.581 \ln (Q_s^{rm})_{-4}$$
(−2.78) (2.21) (6.55)

Adj. R^2 = 0.93 Durbin-h = 1.36

Table 1. Continued

Wholesale Manufactured Supply

$$\ln Q_s^{wm} = \underset{(2.70)}{0.528} + \underset{(1.50)}{0.870} \ln (P^{wm}/P^{II}) - \underset{(-2.86)}{0.544} \ln (MWAGE/P^{II})$$

$$- \underset{(-4.37)}{0.122}\, POLICY + \underset{(3.40)}{0.301} \ln (Q_s^{wm})_{-1} + \underset{(4.15)}{0.351} \ln (Q_s^{wm})_{-4}$$

$$+ \underset{(4.29)}{0.00017}\, TIME^2 + \underset{(4.08)}{0.077}\, SIN1 - \underset{(-6.42)}{0.125}\, COS1 + \underset{(4.05)}{0.751} (u_s^{wm})_{-1}$$

Adj. $R^2 = 0.96$ Durbin-h = 0.25

Farm Supply

$$\ln Q_s^f = \underset{(5.16)}{1.727} + \underset{(4.81)}{0.492} \ln (Q_s^f)_{-1} + \underset{(2.44)}{0.065} \ln (P^f/PFEED)_{-1}$$

$$- \underset{(-2.88)}{0.201} \ln DFWAGE_{-1} - \underset{(-3.33)}{0.028}\, POLICY + \underset{(5.26)}{0.002}\, FTIME$$

$$+ \underset{(2.28)}{0.018}\, SIN1 - \underset{(-20.74)}{0.068}\, COS1 + \underset{(5.84)}{0.014}\, COS2$$

Adj. $R^2 = 0.96$ Durbin-h = 0.72

Per capita retail fluid demand (Q_d^{rf}/POP) is estimated as a function of the ratio of the fluid milk price index (P^{rf}) to per capita income (*INC*); the ratio of the retail nonalcoholic beverage price index (*PBEV*) to per capita income; deflated generic fluid advertising expenditures (*DGFA*); a time trend (*TIME*); and two harmonic seasonal variables (*COS*1 and *SIN*1).[4] The specification of the two price-to-income ratios is consistent with the zero homogeneity assumption for prices and income (Phlips, pp. 37–38). The beverage price index is a proxy for the price of fluid-product substitutes. The current and lagged advertising variables account for the impact of advertising on demand. The impact of current and lagged fluid advertising expenditures on demand is specified as a second-order polynomial distributed lag with both end point restrictions imposed and are tested and not rejected (Maddala 1977, p. 358). This specification is consistent with Ward and Dixon and is also used for the manufactured advertising expenditures in the retail manufactured demand equation that follows. The sum of the advertising coefficients is 0.018, which can be interpreted as the long-term fluid advertising elasticity. The time trend (first quarter of 1975 equals 1) captures the effect of changes in consumer preferences over time, specifically the increasing concern about the link between heart disease and fluid milk consumption. The two harmonic seasonal variables capture seasonality in demand. Based on the estimated autocorrelation and partial autocorrelation functions of the residuals, a first-order moving-average error structure is imposed.

Per capita retail manufactured demand (Q_d^{rm}/POP) is estimated as a function of the ratio of the retail manufactured price index (P^{rm}) to per capita income; the ratio of the retail meat price index (*PMEA*) to per capita income; deflated generic manufactured advertising expenditures (*DGMA*); the deflated retail price index for food away from home (*DPAFH*); a time trend; and the two harmonic seasonal variables. The meat price index is a proxy for the price of manufactured product substitutes. The sum of current and lagged advertising coefficients is 0.006, indicating the long-term manufactured advertising elasticity is only about one-third of that of fluid advertising. The away-from-home price index is included because a large portion of cheese is consumed away from home. The trend variable measures the increase in consumer preferences for cheese and yogurt; unlike fluid product, consumers do not perceive manufactured products such as cheese as high-fat products even though they contain as much fat as whole milk (Cook et al., p. 9). Brand advertising is also included in the preliminary estimation, but is omitted from the final equation because its resulting coefficient is insignificant. Blaylock and Blisard

[4] All deflated price variables are defined as the nominal measure divided by the consumer price index for all items (1967 = 100). The variables *COSi* and *SINi* represent the *i*th wave of the cosine and sine, respectively (Doran and Quilkey). The variable *POP* is the civilian population of the United States.

Table 2. Definition of Variables Used in the Estimated Dairy Industry Model

Q_s^{rf}, Q_d^{rf}	Retail fluid demand and supply, respectively, billion pounds of milk equivalent.
Q_d^{rm}, Q_s^{rm}	Retail manufactured demand and supply, respectively, billion pounds of milk equivalent.
Q_s^{wf}, Q_s^{wm}	Wholesale fluid and manufactured supply, respectively, billion pounds of milk equivalent.
Q_s^f	Farm raw-milk supply, billion pounds.
P^{rf}, P^{rm}	Retail fluid and manufactured price, respectively (1967 = 100).
P^{wf}, P^{wm}	Wholesale fluid price (1967 = 100) and wholesale manufactured price ($/cwt.), respectively.
P^{II}, P^f, *DIFF*	Class II, farm price, and Class I differential, respectively, $/cwt.
PBEV, *PMEA*	Consumer price index for nonalcoholic beverages and for meat, respectively (1967 = 100).
DGFA, *DGMA*	Generic fluid and manufactured advertising expenditures (in $1,000), respectively, deflated by the consumer price index for all items.
TIME, *FTIME*	Trend variable for retail-wholesale and farm equations, respectively, *TIME* = 1 for 1975.1 and *FTIME* = 1 for 1970.1.
*SIN*1, *COS*1, *COS*2	*SINi* and *COSi* are the *i*th wave of the sine and cosine, respectively.
POP, *UNEMP*, *INC*	Civilian population (in millions), unemployment rate (%), and per capita disposable income ($1,000), respectively.
DPAFH, *PFE*	Consumer price index for away-from-home food deflated by the consumer price index for all items, and the consumer price index for fuel and energy, respectively (1967 = 100).
MWAGE	Average hourly wage in manufacturing, $/hour.
POLICY	Policy dummy variable equal to 1 for first quarter 1984 through second quarter 1985 and second quarter 1986 through third quarter 1987.
PFEED, *DFWAGE*	Price of 16% protein dairy feed ($/ton) and farm wage index deflated by consumer price index for all items (1967 = 100).
u^{rf}, u^{wm}	Error terms—retail fluid demand and wholesale manufactured supply, respectively.

also found brand advertising to be insignificant, which may be explained by the fact that brand advertising is geared toward increasing the market shares of individual firms rather than the total sales of the industry.

Retail fluid supply (Q_s^{rf}) is estimated as a function of the ratio of the retail fluid price index to the wholesale fluid price index (P^{wf}); the ratio of the fuels and energy price index (*PFE*) to the wholesale fluid price index; lagged supply; unemployment rate (*UNEMP*); a time trend; and the harmonic seasonal variables. The specification of the retail to wholesale price ratio and energy price to wholesale price ratio is consistent with the zero homogeneity assumption for prices. Wholesale fluid and energy prices represent two of the most important costs in fluid retailing. The two lagged dependent variables are included to capture short- and longer-term production-capacity constraints. The unemployment rate is used as a proxy for the state of the economy, while the time trend is included to capture other determinants of supply such as labor costs in the retail fluid sector, which are unavailable. It should be noted that the unemployment rate and trend variables are not measured in logarithms because using logarithms results in a wrong sign for the coefficient of the retail fluid price variable.

Wholesale fluid supply (Q_s^{wf}) is estimated as a function of the ratio of the wholesale fluid price index to the Class I price for raw milk (i.e., P^{II} + *DIFF*); the ratio of the fuel and energy price index to the Class I price; lagged supply; unemployment rate; a time trend; and the harmonic seasonal variables. The Class I price is included because it represents the most important cost in fluid wholesaling.

Retail manufactured supply (Q_s^{rm}) is estimated as a function of the ratio of the retail manufactured price to the wholesale manufactured price (P^{wm}); the ratio of average hourly wages in the manufactured sector (*MWAGE*) to the wholesale manufactured price; lagged supply; and a harmonic seasonal variable. The wholesale manufactured price accounts for the largest portion of variable costs, and the manufactured wage rate measures labor costs in manufactured retailing. The energy price and unemployment rate were included in the initial estimation of this equation, but are subsequently omitted because their coefficients are the wrong sign. Also, the trend variable and *SIN*1 are omitted because their coefficients are insignificant. The exclusion of *TIME* and *SIN*1 does not change the results of the estimation significantly.

Wholesale manufactured supply (Q_s^{wm}) is estimated as a function of the ratio of wholesale manufactured price to the Class II price (P^{II}); the ratio of manufactured wage to the Class II price; lagged supply; a policy dummy variable (*POLICY*); a time trend; and the harmonic seasonal variables. The Class II price is included because it represents the most important variable cost in manufactured wholesaling. The policy dummy variable (equal to 1 for the first quarter of 1984 through the second quarter of 1985 and the second quarter of 1986 through the third quarter of 1987) accounts for the significant reductions in raw milk supply due to the implementation of the Milk Diversion Program and the Dairy Termination Program, which had significant impacts on the wholesale manufactured market. A first-order moving-average error structure is imposed to correct for serial correlation in the residuals. All the coefficients remain stable after imposing the moving-average term.

The farm milk supply (Q_s^f) is specified as a function of lagged milk supply; the lagged ratio of farm milk price (P^f) to 16% protein dairy feed cost (*PFEED*); lagged deflated farm wage (*DFWAGE*); the policy dummy variable (*POLICY*); a time trend (*FTIME*); and harmonic seasonal variables. Lagged supply is included to account for capacity constraints, while the feed price and farm wage represent two major input costs of dairy farming. The policy dummy variable captures the farm supply impact of the Milk Diversion and Dairy Termination Programs. The trend variable (first quarter of 1970 equals 1) captures genetic improvements of the dairy cows over time.

Model Validation

To determine the validity of the estimated dairy model in conducting advertising evaluation analyses, the model is dynamically simulated to assess its ability to replicate the historical values for the endogenous variables using the following procedures. First, given the values for the exogenous variables, lagged dependent variables, and the predetermined farm milk supply in the initial simulation period, equations (1)–(5) and (6c) are solved simultaneously by the Newton method to obtain the first-period simulated solutions for the endogenous variables in the retail-wholesale subsystem. Second, with these solutions the endogenous farm milk price is determined through (6b). Third, the first-period solution for the farm milk price is fed into (6a) to compute the second period's farm milk supply. The above constitutes a one-step-ahead simulation of the endogenous and predetermined variables of the model. Then, one proceeds to the second period of the simulation; with the previous-period solutions for the endogenous variables becoming the lagged dependent variables and the farm milk supply becoming the predetermined variable for the second-period simulation, the above simulation procedure is repeated. This procedure is iterated until the last period of the simulation is reached. Since the purpose of the paper is to assess the impact of the dairy advertising program at the national level and the national program started its expenditures in September 1984, the simulation is conducted from the third quarter of 1984 through the last quarter of 1987.

The root-mean-square percent simulation errors (RMSP) pertaining to each variable under historical simulation are presented in the second column of Table 3. The model does a reasonably good job in forecasting fluid and manufactured quantity variables with the RMSPs ranging from 2.80% to 5.14%. The model also performs well in forecasting such price variables as retail fluid price, retail manufactured price, wholesale fluid price, and wholesale manufactured price. Among these price variables, the lowest RMSP pertains to the retail manufactured price (1.23%), and the highest RMSP pertains to the wholesale fluid price (7.20%). As to the farm milk supply, the RMSP is 3.28%.

The model does not do well, however, in forecasting Class II and farm milk prices with their RMSPs at 18.5% and 17.1%, respectively. A comparison between the simulated values and the historical values indicates that the reason for the unsatisfactory performance is due to the model's overprediction of the seasonal pattern of the above two price variables. The RMSP associated with the government quantity is also very large (49.7%), but this is due to the relatively small magnitude of the variable (i.e., a modest deviation from the historical value would result in a rather high RMSP).

In the ex post policy evaluation context of the current study, the performance of the model can be further improved as the historical shocks in each equation can be observed and subsequently adjusted. Upon incorporating the observed residuals into each equation in the simulation, the RMSPs are reduced substantially, as reported in the third column of Table 3. The RMSP associated with the government quantity is reduced to 13.0%, while those for Class II and farm milk prices to less than 2.5%. Furthermore, the RMSPs for other price and

Table 3. Root-Mean-Square Percent Simulation Errors

Variables	Without Shock Adjustments	With Shock Adjustments
Retail-wholesale subsystem		
Q^{rf}, Q^{wf}	2.80	0.20
Q^{rm}, Q_d^{wm}	4.84	0.25
Q_s^{wm}	5.14	0.32
Q^g	49.7	13.0
P^{rf}	4.97	0.72
P^{rm}	1.23	0.38
P^{wf}	7.20	1.08
P^{wm}	3.16	1.27
P^{II}	18.5	2.49
Farm market		
P^f	17.1	2.29
Q_s^f	3.28	0.16

quantity variables become quite small, ranging from 0.16% for the farm milk quantity to 1.27% for the wholesale manufactured price.

Advertising Analysis

The equilibrium price and quantity values in the dairy sector are simulated from the third quarter of 1984 through the last quarter of 1987 under four advertising scenarios. The base scenario assumes no fluid and manufactured advertising during the period. Due to the logarithmic specification, advertising expenditures are set at 1, rather than zero, in the simulation, which amounts to assuming a minimal goodwill spending of $1,000 per quarter in 1967 dollars. The second scenario takes the historical fluid advertising spending level as given but assumes no manufactured advertising. The third scenario takes the historical manufactured advertising spending level as given but assumes no fluid advertising. The fourth scenario takes the historical spending levels of both fluid and manufactured advertising as given.

A comparison of the simulated endogenous variables between the no-advertising scenario and the fluid-only scenario provides the impact of fluid advertising. Similarly, a comparison between the no-advertising scenario and the manufactured-only scenario yields the impact of manufactured advertising. Finally, a comparison between the no-advertising scenario and the fluid-plus-manufactured scenario gives the impact of combined advertising. Since the impacts of advertising vary depending on whether the market is competitive or government supported, it is useful to note that the first three scenarios result only in government-support solutions for the entire simulation period, while the fourth scenario of allowing for both types of advertising yields two competitive solutions. The levels and percentage changes of the above three pairwise comparisons are in Table 4.

Fluid-Only Advertising Impacts

The variables positively affected by fluid-only advertising are retail and wholesale fluid equilibrium quantity ($Q^{rf} = Q^{wf}$), retail fluid price (P^{rf}), wholesale fluid price (P^{wf}), Class II price (P^{II}), farm milk price (P^f), and farm milk supply (Q^f_s). The variables negatively affected by fluid advertising are wholesale manufactured supply (Q^{wm}_s) and government quantity (Q^g). Finally, the variables not affected by fluid advertising are retail manufactured equilibrium quantity and wholesale manufactured demand ($Q^{rm} = Q^{wm}_d$), retail manufactured price (P^{rm}), and wholesale manufactured price (P^{wm}).

Since fluid advertising shifts the retail fluid demand curve to the right, the retail fluid quantity, and, hence, the wholesale fluid quantity, must increase. As the wholesale fluid quantity increases, the wholesale fluid price must rise, which requires the retail fluid supply curve to shift to the left.[5] The increase in the wholesale fluid price also means the Class II price must increase.[6] Since the Class II price increases, the wholesale fluid supply curve must shift to the left as well. The final result in the fluid market is higher prices and quantities both at the retail and wholesale levels.

Regarding the manufactured market, since the Class II price is increased, the wholesale manufactured supply curve must shift to the left. However, due to the result that both the fluid-only and the base scenario of no advertising yield only government-support solutions, the leftward shift in the above supply curve does not result in an increase in the wholesale manufactured price. As such, the retail manufactured supply curve does not shift. Hence, fluid advertising reduces the wholesale manufactured supply and government quantity, while leaving unchanged the retail manufactured equilibrium quantity, wholesale manufactured demand, retail manufactured price, and wholesale manufactured price. Finally, with the increase in class prices and the fluid utilization rate, the farm milk price increases, leading to an increase in the subsequent farm milk supply.

As shown in the third column of Table 4, the variable most affected by fluid advertising (in percentage terms) is government quantity. Compared to the no-advertising scenario, fluid advertising reduces government purchases by 16.2%. This amounts to a saving in government costs of $390,900 per quarter in 1987 dollars (where costs are estimated as the purchase price times government quantity). Put differently, each dollar invested in fluid-only advertising reduces government costs by $2.72. Fluid advertising also affects retail and wholesale fluid prices significantly with increases

[5] Notice that in the price-quantity planes contained in Figure 1, the positions of the retail fluid supply curve and the retail manufactured supply curve are conditional on their endogenous input prices—wholesale fluid and wholesale manufactured prices, respectively. Similarly, the positions of the wholesale fluid supply curve and the wholesale manufactured supply curve are conditional on the endogenous Class II price. As the values for the above endogenous price variables change, the supply curves will shift.

[6] The wholesale fluid supply equation in (3a), the wholesale manufactured supply equation in (3b), and the farm-level equilibrium condition in (6c) can be used to solve for the Class II price as a monotonically increasing function of the wholesale fluid price and wholesale manufactured price, given the predetermined farm milk supply.

Table 4. Impact of Advertising Scenarios Compared to No Advertising (Quarterly Average)

	Fluid Advertising		Manufactured Advertising		Combined Advertising	
Variables	Change	% Change	Change	% Change	Change	% Change
Retail-wholesale subsystem						
Q^{rf}, Q^{wf}	0.3830	2.74	0	0	0.3719	2.67
Q^{rm}, Q_d^{wm}	0	0	0.1793	0.99	0.1557	0.85
Q_s^{wm}	−0.2950	−1.44	0	0	−0.2511	−1.21
Q^g	−0.2950	−16.2	−0.1793	−9.63	−0.4069	−18.7
P^{rf}	0.0631	10.2	0	0	0.0648	10.5
P^{rm}	0	0	0.0068	0.77	0.0082	0.92
P^{wf}	0.0467	8.32	0	0	0.0490	8.71
P^{wm}	0	0	0	0	0.0002	0.44
P^{II}	0.0007	2.24	0	0	0.0011	3.15
Farm market						
P^f	0.0008	2.27	0	0	0.0011	3.09
Q_s^f	0.0879	0.25	0	0	0.1209	0.34

of 10.2% and 8.32%, respectively. The percentage changes in fluid quantity, wholesale manufactured supply, Class II price, and farm milk price are at rates of 2.74%, −1.44%, 2.24%, and 2.27%, respectively. The impact of fluid advertising on farm supply is small, only 0.25%. With an increase in the farm milk price and a small supply response, the farm-level rate of return is estimated at $7.04 for every dollar spent on fluid advertising.

Manufactured-Only Advertising Impacts

The variables positively affected by manufactured-only advertising are retail manufactured equilibrium quantity and wholesale manufactured demand ($Q^{rm} = Q_d^{wm}$), and retail manufactured price (P^{rm}). The variable negatively affected by manufactured advertising is government quantity (Q^g). Other variables, including wholesale manufactured supply (Q_s^{wm}) and wholesale manufactured price (P^{wm}), are not affected by manufactured advertising.

Since manufactured advertising shifts the retail manufactured demand curve to the right, the equilibrium retail manufactured price and quantity must increase. Accordingly, the wholesale manufactured demand must also increase. However, due to the result that both the manufactured-only scenario and the base scenario of no advertising yield only government-support solutions, the increase in wholesale manufactured demand is not accompanied by an increase in the wholesale manufactured price. Since there is no change in the wholesale manufactured price, the retail manufactured supply curve does not shift. It also means no changes in the Class II price, and, hence, the wholesale manufactured supply curve does not shift as well. As such, the quantity of wholesale manufactured supply is the same and government quantity decreases.

Since the Class II price does not change, the fluid market is not affected. Also, since the class price and the fluid utilization rate are the same, the farm price is unaffected and, hence, so is the farm milk supply.

As shown in the fifth column of Table 4, the variable most affected by manufactured advertising is government quantity. Compared to the no-advertising scenario, manufactured advertising reduces government purchases by 9.63%, which amounts to a saving of $234,432 per quarter in 1987 dollars, or a 1.85 rate of return on manufactured advertising. The percentage changes in commercial manufactured quantity and retail manufactured price are at modest rates of 0.99% and 0.77%, respectively. Since manufactured advertising results in only a replacement of government purchases by increased private consumption, the corresponding farm-level rate of return is zero.

Combined Advertising Impacts

In the actual scenario of allowing for both fluid and manufactured advertising, the variables negatively affected are wholesale manufactured supply (Q_s^{wm}) and government quantity (Q^g). All other variables are positively affected as compared with no advertising. Furthermore, the above directions of the impact of the combined strategy are consistent with those when combining the individual impacts of the fluid-only and manufactured-only scenarios. However, the magnitude of the combined impact is not the sum of the individual impacts. Unlike previous scenarios, the combined advertising strategy results in some competitive solutions. Compared to the sum of the individual impacts of the fluid-only and manufactured-only strategies, the added competition yields larger price impacts and smaller quantity impacts for those variables in the retail-wholesale subsystem.

To simplify the illustration, consider first the situation of changing from the manufactured-only strategy to the combined strategy (hence only one retail demand curve is shifting). Compared to the manufactured-only scenario, the additional fluid advertising causes an outward shift in the retail fluid demand curve and an increase in the equilibrium fluid quantity (both at the retail and wholesale levels). With the increase in wholesale fluid quantity, the wholesale fluid price rises which causes a leftward shift in the retail fluid supply curve. The increase in wholesale fluid price also means that the Class II price must rise. As such, the wholesale fluid supply curve shifts to the left as well. Hence, the additional fluid advertising results in higher retail and wholesale fluid prices.

As to the manufactured market, the increase in Class II price means the wholesale manufactured supply curve must shift to the left. This results in a decrease in the wholesale manufactured supply quantity and an increase in the wholesale manufactured price, which becomes greater than the government price. As a result of the price increase, the retail manufactured supply curve shifts to the left as well. Hence, the additional fluid advertising decreases retail manufactured quantity (and, hence, wholesale manufactured demand) and increases retail manufactured price.

Now consider the case of changing from the fluid-only strategy to the combined strategy. Compared to the fluid-only scenario, the additional manufactured advertising causes an outward shift in the retail manufactured demand curve and results in a wholesale manufactured price greater than the government purchase price. Since the wholesale manufactured price is increased, the retail manufactured supply curve shifts to the left. The net result is an increase in the equilibrium retail manufactured price and quantity and, hence, the wholesale manufactured demand. In addition, with the increase in wholesale manufactured price, the Class II price must increase, which requires the wholesale manufactured supply curve to shift to the left. The resulting wholesale manufactured supply quantity (and, hence, demand quantity) is greater than the supply quantity under the fluid-only case. The leftward shift in the wholesale manufactured supply curve can never result in a reduction in the wholesale manufactured supply quantity as this requires an increase in the fluid equilibrium quantity, given the predetermined farm milk supply. An increase in the fluid quantity requires a decrease in the Class II price, which is not consistent with a rising wholesale manufactured price.

Regarding the fluid market, the increase in the Class II price implies a leftward shift in the wholesale fluid supply curve, which results in an increase in the wholesale fluid price. This price increase indicates that the retail fluid supply curve must also shift to the left. Accordingly, the additional manufactured advertising increases fluid prices and decreases fluid quantities both at the retail and wholesale levels.

From the above discussion, the following conclusions hold when the market is competitive. Compared to the manufactured-only scenario, the additional fluid advertising in the combined advertising scenario has the effect of depressing the equilibrium manufactured quantity and enhancing the manufactured prices. Likewise, compared to the fluid-only scenario, the additional manufactured advertising in the combined advertising scenario has the effect of reducing the equilibrium fluid quantity and increasing the fluid prices. Since the combined advertising strategy adds some competitive solutions to the otherwise government-supported market environment, and since there are spillover effects from the fluid sector to the manufactured sector and vice versa when the market is competitive, the impact of allowing for both types of advertising is not simply the sum of the individual impacts of the fluid-only and manufactured-only strategies. The combined strategy yields larger price impacts and smaller quantity impacts for variables in the retail-wholesale subsystem. Schematic views of the impact of fluid and manufactured advertising on the retail-wholesale subsystem can be found in Liu et al.

As shown in the last column of Table 4, the variable most affected by combined advertising is government quantity. Compared to the no-advertising scenario, the combined advertising strategy reduces the government purchases by 18.7%, which amounts to a saving of $531,830 per quarter in 1987 dollars, or a rate of return of 1.97. The combined strategy also affects the retail fluid price and wholesale fluid price significantly at 10.5% and 8.71%, respectively. The percentage changes in fluid quantity, retail manufactured quantity and wholesale manufactured demand, wholesale manufactured supply, retail manufactured price, Class II price, and farm milk price are at rates of 2.67%, 0.85%, −1.21%, 0.92%, 3.15%, and 3.09%, respectively. The impacts on wholesale manufactured price and farm milk supply are small, with the percentage changes at 0.44% and 0.34%, respectively. The farm rate of return for the combination of fluid and manufactured advertising is estimated at $4.77 for every dollar invested.

Summary

The purpose of this paper was to examine generic dairy advertising impacts on milk price and volume at the retail, wholesale, and farm levels in the dairy sector. The analysis was based on a dairy-industry model encompassing supply and demand conditions in various markets within the dairy sector and government intervention of the dairy price support program. The estimated model was used to simulate price and quantity values for four advertising scenarios: (1) no advertising, (2) historical fluid advertising, (3) historical manufactured advertising, and (4) historical fluid and manufactured advertising.

Compared to no advertising, the fluid-only scenario increased retail fluid sales by 2.74%, while the manufactured-only scenario increased retail manufactured sales by 0.99%. Combined fluid and manufactured advertising resulted in the market becoming competitive during some periods. In this latter scenario, due to the price effect of the added competition, the sales increase was reduced slightly to 2.67% for fluid milk and to 0.85% for manufactured dairy products.

The fluid-only advertising scenario reduced government purchases by 16.2%, which amounts to an average saving in government costs of about $390,900 per quarter in 1987 dollars. Manufactured-only advertising reduced government purchases by 9.63% with a saving of $234,432 per quarter. The actual scenario of combining fluid and manufactured advertisings resulted in a reduction of government purchases by 18.7%, a saving of $531,830 per quarter.

The farm-level rate of return was estimated at $7.04 for every dollar spent on fluid-only advertising. The rate of return for manufactured-only advertising was zero because the strategy results in only a replacement of government purchases by the increased commercial consumption. With the scenario of both fluid and manufactured advertising, the overall farm-level rate of return was $4.77.

Compared to previous studies, the dairy-industry model provided additional insights into the way generic dairy advertising influences prices and quantities at the retail, wholesale, and farm levels. To further the usefulness of the model, it is essential to improve the existing data base for advertising expenditure variables. The current advertising data are at best proxies. It is also useful to refine the model to include regional disaggregation. A national industry model with regional characteristics would enable researchers and program managers to assess the differential impacts of the national and regional programs and determine the optimal expenditure pattern across regions.

References

Blaylock, J. R., and W. N. Blisard. *Effects of Advertising on the Demand for Cheese*. U.S. Department of Agriculture. Economic Research Service. Technical Bull. no. 1752. 1988.

Chavas, J-P., and R. M. Klemme. "Aggregate Milk Supply Response and Investment Behavior on U.S. Dairy Farms." *American Journal of Agricultural Economics* 68(1986): 55–66.

Cook, H. L., L. Blakley, R. Jacobson, R. Knutson, R. Milligan, and R. Strain. *The Dairy Subsector of American Agriculture: Organization and Vertical Coordination*. N.C. Project 117, Monograph 5. 1978.

Doran, H. E., and J. J. Quilkey. "Harmonic Analysis of Seasonal Data: Some Important Properties." *American Journal of Agricultural Economics* 54(1972):646–51.

Kaiser, H. M., D. H. Streeter, and D. J. Liu. "Welfare Comparisons of U.S. Dairy Policies With and Without Mandatory Supply Control." *American Journal of Agricultural Economics* 70(1988):848–58.

Kinnucan, H., and O. D. Forker. "Seasonality in the Consumer Response to Milk Advertising with Implications for Milk Promotion Policy." *American Journal of Agricultural Economics* 68(1986):562–71.

LaFrance, J. T., and H. de Gorter. "Regulation in a Dynamic Market: The U.S. Dairy Industry." *American Journal of Agricultural Economics* 67(1985):821–32.

Liu, D. J., and O. D. Forker. "Generic Fluid Milk Advertising, Demand Expansion, and Supply Response: The Case of New York City." *American Journal of Agricultural Economics* 70(1988):229–35.

Liu, D. J., H. M. Kaiser, O. D. Forker, and T. D. Mount. *The Economic Implications of the U.S. Generic Dairy Advertising Program: An Industry Model Approach*. A. E. Res. No. 89-22. Department of Agricultural Economics, Cornell University, 1989.

Maddala, G. S. *Econometrics*. New York: McGraw-Hill Book Company, 1977.

Maddala, G. S. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press, 1983.

Phlips, L. *Applied Consumption Analysis*. New York: North-Holland, 1983.

Thompson, S. R., and D. A. Eiler. "Determinants of Milk Advertising Effectiveness." *American Journal of Agricultural Economics* 59(1977):330–35.

Ward, R. W., and B. L. Dixon. "Effectiveness of Fluid Milk Advertising Since the Dairy and Tobacco Adjustment Act of 1983." *American Journal of Agricultural Economics* 71(1989):730–40.