

Econometric Evidence of Cross-Market Effects of Generic Dairy Advertising

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ABSTRACT

We estimate a dairy demand system to evaluate generic dairy advertising in the US, 1990–2005. Previous empirical studies of generic dairy advertising focus only on the market of the advertised good, ignoring potential spill-over and feedback effects. We specify an LA/AIDS model of dairy demand, which allows consistent estimation of cross-price and cross-advertising effects across dairy product markets, and is flexible and satisfies the axioms of consumer theory. We use the non-linear 3SLS estimator to address endogenous prices and serial correlation, and conduct bootstrapping to generate empirical distributions of elasticity estimates. Results suggest that cross-market effects are economically and statistically important. Thus, econometric dairy demand models that ignore cross-advertising and cross-price effects are mis-specified. Previous work that ignores substitution between fluid milk and cheese overstates producers' returns to generic advertising for either product. © 2010 Wiley Periodicals, Inc.

INTRODUCTION

US dairy farmers and fluid milk processors spend approximately 350 million dollars annually on generic promotion programs. These programs, funded by a compulsory producer check-off, are designed to increase returns to producing milk and other dairy products, with an emphasis on demand enhancement. Similar check-offs exist for other commodities and in other countries, but the dairy check-off in the US is by far the largest. Accordingly, a large literature is dedicated to modeling and measuring the effects of generic dairy advertising.

Schmit and Kaiser (2004) is a recent example, and is illustrative of the methodological approach typically adopted in this literature (among others, Blisard, Chandran, Blayney, & Allshouse, 1999; Kaiser, 1997, 1999; Kaiser & Chung, 2002; Liu & Forker, 1990). They estimated separate, ad hoc demand models for fluid milk and cheese, in which demand is specified as a function of own price, income, non-alcoholic beverage price, advertising expenditure, and demographics. They found statistically significant own-advertising elasticities of 0.040 and 0.013 for milk and cheese, respectively. Estimates such as these have been used subsequently in simulation analyses to evaluate the effects of advertising on prices, quantities, and welfare (see Ferrero, Boom, Kaiser, & Forker, 1996 for a detailed review of these studies). Almost all of these studies have found that generic advertising yields large net benefits for dairy farmers and milk processors. For example, Nicholson and Kaiser (2008) developed a system dynamics model of the US dairy industry that included 17 intermediate and final dairy products to measure the impacts of

generic milk and cheese advertising. Their model incorporated complexities of US dairy markets by including supply response, economic regulations, and pricing of milk components. They found that permanent increases in generic dairy advertising expenditures increase net revenues for dairy farmers with a cumulative net benefit to cost ratio of 2.8. However, despite the incorporation of supply linkages the model overlooks the horizontal demand linkages across dairy products.

Recent conceptual work on potential spill-over effects of advertising suggests that the extant literature on generic dairy advertising may be incomplete. Balagtas and Kim (2007) demonstrated that horizontal demand and supply linkages across dairy product markets influence the effect of advertising on prices, quantities, and welfare. In particular, they show that substitution across dairy products in demand and the common use of milk in various dairy products tend to reduce the effectiveness of product-specific promotion efforts. This finding is closely related to the work by Alston, Freebairn, and James (2001), who modeled and measured spill-over effects of advertising in the markets for beef, pork, and chicken, and Crespi and James (2007), who demonstrated a bargaining solution to internalize spill-overs from generic advertising.

To the extent that there are cross-market effects in dairy, the single-equation, ad hoc demand models adopted by the extant literature on generic dairy advertising are mis-specified and may provide misleading inference on the economic consequences of advertising. In their simulations, Balagtas and Kim (2007) assumed that milk and cheese are substitutes in demand and found that studies that ignored cross-market effects would tend to overstate producer returns to advertising. Kinnucan and Zheng (2005) also find that producer returns are over-stated when cross-effects are ignored.

Of course, whether dairy products are related in demand is an empirical question. A few previous demand studies have estimated cross-price effects across dairy product markets, but evidence on the sign and magnitude of cross-price effects is mixed (e.g., Heien & Wessells, 1988; Huang, 1993; Chouniard, Davis, LaFrance, & Perloff, 2005). None of these studies addressed generic advertising or included advertising expenditure in the demand function. Most of the empirical literature on dairy advertising ignores cross-market effects. An exception is Wohlgenant and Clary (1994), who estimate derived demand for farm milk, allowing advertising expenditures for fluid milk, cheese, and butter to enter the demand specification separately. While this reduced-form approach permits measurement of the net effect of advertising on the derived demand for milk, it does not provide direct estimates of the cross-market effects in demand.

In this article we simultaneously estimate the impacts of generic advertising of fluid milk, cheese, butter, and frozen dairy products on the demand for each product. We adopt a demand system approach that allows consistent, joint estimation of horizontal demand relationships across dairy product markets. To our knowledge this is the first research to measure the own- and cross-market impacts of generic advertising on demand for dairy products. This is also one of the few articles in this literature to attempt to correct for endogenous prices. Also, we construct confidence intervals of the estimates of cross-price and cross-advertising elasticities by bootstrapping. The resulting estimates fill a void in the empirical literature on generic commodity promotion, providing practitioners with economic information that was heretofore unknown yet is essential for a full understanding of the economic effects of generic commodity promotion in dairy markets (Balagtas & Kim, 2007).

The remainder of the paper is organized as follows. In the next section we describe the conceptual model. In the subsequent sections we introduce the data, present the

empirical model and discuss the econometric results. The final section concludes and provides direction for future research.

EMPIRICAL MODEL

We develop a model of dairy demand that permits substitution or complementarity across dairy products. Further, we assume that the demand for a dairy product is influenced by own- and cross-advertising expenditures, as well as the own price, prices of close substitutes and complements, and income.

We model a dairy demand system for fluid milk, cheese, butter, and frozen dairy products. Although demand systems have been widely used in applied demand analysis, the extant literature on dairy advertising has used a single-equation approach. Of course, single-equation demand models suffer from ad hoc selection of variables that affect demand and may not be consistent with the theory of consumer behavior. In contrast, demand systems can exactly satisfy the axioms of consumer choice and allow direct tests of the restrictions of homogeneity and symmetry. Moreover, a demand system specification allows us to estimate cross-commodity effects consistently. These effects are such that advertising of a dairy product can have direct effects on the demand for other dairy products. In addition, returns to producers from advertising for one product are influenced by price feedback effects from markets for related products. For example fluid milk advertising can indirectly affect the demand for other dairy products through induced changes in fluid milk prices.

A systems approach requires an assumption of two-step budgeting based on weak-separability of the subset of goods of interest from all other goods. This assumption can easily be challenged for any subset of goods. Therefore, we follow LaFrance and Hanemann (1989) in adopting a flexible structural model that is closely tied with theory. We assume weak-integrability of the system of dairy product demand and form a complete demand system by including demand for all other food.

We specify a Linear Approximate Almost Ideal Demand System (LA/AIDS) model originally developed by Deaton and Muellbauer (1980b). We choose the LA/AIDS model over the more flexible AIDS or Generalized AIDS models for several reasons. The LA/AIDS has the desirable integrability property as in its more flexible counterparts (LaFrance, 2004), but is appealing for its simplicity especially in the case of added non-linearities due to autocorrelation correction. Further, the LA/AIDS model is an excellent approximation to AIDS when prices are highly collinear (Deaton & Muellbauer, 1980b; Piggott, Chalfant, Alston, & Griffith, 1996).¹

The LA/AIDS model can be expressed as

$$w_i = \alpha_i + \sum_j^n \gamma_{ij} \ln p_j + \beta_i \ln \frac{M}{P} \quad (1)$$

¹Some researchers have pointed out several undesirable properties of LA/AIDS most notably biased parameter estimates of the Stone Price Index (e.g., Green & Alston, 1990). However, Hahn (1994) concludes that the LA/AIDS is a reasonable approximation for a demand system. Moschini (1995) argues that the linear model is a good approximation of the non-linear model if a proper price index is used (i.e., "corrected" Stone's Price Index). Finally, Satyanarayana, Wilson, and Dencey (1999) argue that even though the LA/AIDS results in biased parameter estimates for the Stone Price Index, the bias is less severe for demand systems using aggregate data compared with micro-level data.

where w_i is the budget share of good i , p_j is price of good j , M is income, and P is the corrected Stone's Price Index given by $\ln P = \sum_k w_k \ln(p_k/\bar{p}_k)$, where \bar{p}_k normalized prices by their respective averages (Moschini, 1995); α_i , γ_{ij} , and β_i are parameters to be estimated. We assume that demand shifters such as advertising act to shift the demand for the commodities. This assumption requires an additive augmentation of the demand system and can be incorporated as

$$\alpha_i = \alpha_i^* + \sum_j \mu_{ij} \ln A_j$$

where $\ln A_j$ is the log of advertisement expenditures of the j th commodity. Finally, the estimated model can be defined as:

$$w_i = \alpha_i^* + \sum_j \gamma_{ij} \ln p_j + \sum_j \mu_{ij} \ln A_j + \beta_i \ln \frac{M}{P}. \quad (2)$$

The restrictions of economic theory involve only the unknown parameters so can be easily imposed. The restrictions are

$$\sum_i \alpha_i^* = 1, \quad \sum_i \gamma_{ij} = 0, \quad \sum_i \mu_{ij} = 0, \quad \sum_i \beta_i = 0 \quad (\text{adding up}) \quad (3)$$

$$\sum_j \gamma_{ij} = 0 \quad (\text{homogeneity}) \quad (4)$$

$$\gamma_{ij} = \gamma_{ji} \quad (\text{symmetry}). \quad (5)$$

MODELING THE DYNAMIC NATURE OF ADVERTISEMENT ON DEMAND

It is widely recognized in the previous literature that advertising has carryover or lagged effects so that current consumption is affected by advertising in previous periods. In an often cited article, Clarke (1976) suggests a carry-over effect of three-to-six months for food items. Nevertheless, establishing the dynamic structure of advertising effects that best fits the sample data is an empirical problem. Generally, researchers prefer more flexible structures and determine an appropriate weighting scheme and lag length empirically from data. Some studies simply included lagged advertising expenditures in the demand estimation where Akaike Information Criterion (AIC) or Schwarz Criterion (SC) is used to determine the optimal lag length (Piggott et al. 1996). Schmit and Kaiser (2004) and Brester and Schroeder (1995) used a second-order exponential distributed lag structure (EDL) that allows hump-shaped or geometric lag length structure. Although relatively flexible, EDL requires a pre-specification of maximum lag length to calculate the lag weights. On the other hand, some other studies have used the polynomial inverse lag (PIL) approach to allow for an infinite distributed lag structure (Kinnucan & Miao, 1999; Piggott, Zhen, Beach, & Wohlgenant, 2007). Originally proposed by Mitchell and Speaker (1986) PIL neither requires *a priori* endpoint restrictions nor adds any nonlinearities while allowing both humped and monotonically declining lag weight distributions. We use PIL because of its desirable properties and based on specification tests in preliminary work with single equation models.²

²In preliminary work with single equation models we compared different lag lengths based on AIC. The highest lag length (eight quarters) were optimal for all demand equations which further supports the choice of infinite distributed lag structure.

To illustrate PIL consider the following regression equation:

$$w_{it} = b + \sum_{s=0}^{\infty} \omega_s \ln A_{j,t-s} + e_{it} \tag{6}$$

where b is the collection of other independent variables and their associated coefficients, e_{it} is the error term of the i th equation and ω_s are distributed lags assumed to be of the form

$$w_s = \sum_{m=2}^n \frac{a_{jm}}{(s+1)^m}, \quad s = 0, \dots, \infty, \tag{7}$$

where s is the lag length, m is the degree of polynomial, and a_{jm} are parameters to be estimated. By substituting (7) into (6) and rearranging we obtain the equation to be estimated

$$w_{it} = b + \sum_{m=2}^n a_{jm} Z_{jmt} + R_{jt} + e_{it}, \tag{8}$$

where

$$Z_{jmt} = \sum_{s=0}^{t-1} \frac{\ln A_{j,t-s}}{(s+1)^m}, \quad m = 2, \dots, n, \tag{9}$$

and

$$R_{jt} = \sum_{m=2}^n \sum_{s=t}^{\infty} \frac{a_{jm} \ln A_{j,t-s}}{(s+1)^m}. \tag{10}$$

Given data, Z_{jmt} can be calculated for all j ; however, R_{jt} cannot be calculated since it includes infinite lags. Mitchell and Speaker (1986) showed that R_{jt} is negligible for $t > 8$ so estimation should be performed by deleting the first eight data points. A remaining issue is the determination of the optimal degrees of polynomial, n , which can be chosen based on AIC, SC, or statistical tests for nested models.

We construct an LA/AIDS model to be estimated by seemingly unrelated regressions (SUR). After incorporating the PIL structure, the general model with n degrees of polynomial is formulated as:³

$$w_{it} = \alpha_i^* + \sum_j \gamma_{ij} \ln p_{jt} + \sum_{m=2}^n a_{jm} Z_{jmt} + \beta_i \ln \frac{M}{P} + e_{it}. \tag{11}$$

The restrictions implied by economic theory, (3)–(5), can be imposed with parameter a_{im} replacing μ_{it} in (3). To allow for autocorrelation the error term is specified as $e_t = \mathbf{R}e_{t-1} + v_t$ for $t = 2, \dots, T$, where v_t 's are independent $N(0, \Sigma)$ and \mathbf{R} is a five by five matrix of unknown parameters (Berndt & Savin, 1975). Given our aggregate data, prices are suspected to be endogenous. We use dairy supply shifters as instruments: prices of energy, replacement heifers, hay, alfalfa, and feed rations, as well as wages paid by farmers. In auxiliary regressions of dairy product prices on instruments, the instruments are jointly significant at conventional levels and R^2 is more than 0.90 in each equation.

³We assume a common polynomial lag for all dairy products in the system. This assumption is empirically necessary to have the same right-hand side variables in all share equations.

Lastly, advertising elasticities are computed from (9) using the formula

$$\partial \ln q_i / \partial \ln A_j = \sum_{s=0}^{t-1} \omega_{js} / w_j \quad (12)$$

where $\partial \ln q_i / \partial \ln A_j$ is the demand elasticity of product i with respect to advertising expenditure on product j .⁴

DATA

We estimate the model using quarterly US dairy market data, spanning 1990 through 2005 (64 observations).⁵ Data on advertising expenditures were acquired from three separate entities that conduct generic advertising programs for fluid milk and dairy products. These are: (1) Dairy Management, Inc., which is the national promotion association for dairy farmers, (2) Qualified Programs, which are the state and regional dairy associations that run the regional advertising programs, and (3) MilkPEP, which is the national fluid milk processor program. While the three are administratively distinct, they are well coordinated and have similar objectives for enhancing dairy demand. Following other researchers we aggregate advertising expenditures from all three entities to capture generic advertising impacts (e.g., Schmit & Kaiser, 2004).⁶ A media cost index provided by DMI is used to deflate the advertising expenditures.

Our quantity data are aggregate dairy commercial disappearance. These together with data related to US milk supply are acquired from USDA's Dairy Situation and Outlook reports. Total food expenditure is obtained from reports by ERS, USDA. Consumer price indices of fluid milk, cheese, butter, and frozen dairy products are obtained from the Bureau of Labor Statistics (US Department of Labor) and converted into real prices in order to obtain product expenditure. These data have been used in the previous literature to assess generic dairy advertising (e.g., Schmit & Kaiser, 2004). Lastly, there are no data on price of all other food (i.e., food other than fluid milk, cheese, butter, and frozen dairy). Therefore, we use the CPI for all food as a proxy for price of all other food assuming that prices of the goods of interest have no measurable effect on the CPI for all food.⁷ Summary statistics are presented in Table 1.

⁴Taking the partial derivative of Equation (11) with respect to $\ln A_j$ yields

$$\partial w_i / \partial \ln A_j = \partial (p_i q_i / x) / \partial \ln A_j = (p_i q_i / x) \partial \ln q_i / \partial \ln A_j = \sum_{s=0}^{t-1} \sum_{m=2}^n \frac{a_{jm}}{(s+1)^m} = \sum_{s=0}^{t-1} \omega_{js}.$$

It follows from the last equality that

$$\partial \ln q_i / \partial \ln A_j = \sum_{s=0}^{t-1} \omega_{js} / w_i.$$

⁵The final model is estimated on 55 observations: 8 observations are lost due to incorporating PIL and 1 observation is lost due to the autocorrelation correction.

⁶Some previous studies have also included branded advertising expenditures in their analysis. However, Schmit and Kaiser (2004) found insignificant effects of branded advertising expenditures of fluid milk and cheese on demand for these products. Branded advertising expenditures may be more likely to be important for butter and frozen dairy products. Noting that our elasticity estimates without branded advertising are plausible and within the range of estimates found in the previous literature, we leave the investigation of these effects for future research.

⁷This assumption is reasonable because in the sample data the share of dairy expenditure of total food expenditure is small, approximately 8%.

TABLE 1. Description of Data

Variable	Description ^a	Units	Mean ^b
<i>Quantities</i>			
Fluid milk	Quarterly commercial disappearance of fluid milk	mil. lbs	13,804 (346)
Cheese	Quarterly commercial disappearance of cheese	mil. lbs	1,965 (275)
Butter	Quarterly commercial disappearance of butter	mil. lbs	293 (54)
Frozen	Quarterly commercial disappearance of frozen dairy product	mil. lbs	3,428 (526)
<i>Prices</i>			
Fluid milk	Consumer retail price for fresh milk and cream constructed from CPI for fresh milk and cream (1982-1984 = 100)	\$/lb	0.33 (0.04)
Cheese	Consumer retail price cheese constructed from CPI for cheese (1982-1984 = 100)	\$/lb	3.61 (0.41)
Butter	Consumer retail price butter constructed from CPI for butter (1982-1984 = 100)	\$/lb	2.38 (0.68)
Frozen	Consumer retail price for frozen dairy products constructed from CPI for frozen dairy products (1982-1984 = 100)	\$/lb	0.73 (0.09)
All other food	CPI for all food products (1982-1984 = 100)	index	159 (18)
Food expenditure ^c	Total food expenditures per quarter	mil. \$	187 (37)
<i>Advertising expenditures</i>			
Fluid milk	Generic fluid milk advertising expenditures deflated by the Media Cost Index (\$2001)	\$1000	30,499 (13,929)
Cheese	Generic cheese advertising expenditures deflated by the Media Cost Index (\$2001)	\$1000	13,826 (5,204)
Butter	Generic butter advertising expenditures deflated by the Media Cost Index (\$2001)	\$1000	86 (139)

TABLE 1. Continued

Variable	Description ^a	Units	Mean ^b
Frozen	Generic frozen dairy products advertising expenditures deflated by the Media Cost Index (\$2001)	\$1000	67 (134)
<i>Milk supply shifters</i>			
Energy price	Real energy price index (1982–1984 = 100)	index	102 (15)
Cow price	Average price of slaughter cows	\$/cow	1,286 (222)
Farm wage	Farm Wage Index (1982–1984 = 100)	Index	129 (22)
Ration price	Average Price of dairy rations	\$/cwt	7.8 (0.63)
Hay price	Hay price	\$/ton	87 (9.5)
Alfalfa price	Alfalfa price	\$/ton	92 (10)

^aAll prices are deflated by the consumer price index (1982–1984 = 100).

^bStandard deviations are reported in parentheses.

^cQuarterly food expenditure is obtained by linear interpolation of the annual data.

Notably, deflated generic advertising expenditures over the period of 16 years average almost \$45 million per quarter, the vast majority of which is allocated to advertising for fluid milk and cheese. Almost 99% of the advertising for butter and frozen products occurred prior to 1995; generic advertising expenditure for butter and frozen products has been negligible since 1995.

EMPIRICAL MODEL SELECTION AND RESULTS

We estimate the system in Equation (11) using price, quantity, advertising, and other data that are described in the previous section. We also include quarterly dummy variables to allow for seasonality in demand. We considered the potential effects of demographic variables that are used in previous studies of demand analysis of dairy products. However, based on the results of our specification analysis we did not include demographic variables in the final model.⁸

The final system is estimated under two different specifications of the autocorrelation matrix, \mathbf{R} . In the first specification all elements are set to zero (i.e., no autocorrelation), $\mathbf{R} = \mathbf{R0}$. In the second specification only off-diagonal elements are set to zero, and the autocorrelation coefficients are restricted to be equal across equations, $\mathbf{R} = \mathbf{R1}$. A non-linear, iterated three-stage least-squares, n3SLS, estimation procedure is employed to estimate $\mathbf{R1}$ (Berndt & Savin, 1975; Greene, 2003, pp. 347).⁹ To avoid singularity caused by the adding-up restriction, the equation for all other food is omitted and demands for milk, cheese, butter, and frozen dairy product are estimated directly. The econometric results are invariant to the choice of deleted equation and the estimates of deleted equation are recovered from the restrictions of economic theory. Homogeneity, symmetry, and adding-up conditions are imposed.

We use likelihood ratio (LR) tests to choose optimal polynomial lag length under two different specifications of \mathbf{R} .¹⁰ Table 2 presents LR test results for the optimal polynomial lag. Under both $\mathbf{R0}$ and $\mathbf{R1}$ we reject the null hypotheses of $n = 0$ and $n = 2$ against the alternative hypotheses of $n = 2$ and $n = 3$, respectively. However, the null of $n = 3$ cannot be rejected against the alternative of $n = 4$. Therefore, we choose a third degree polynomial for advertising variables. That is, only Z_{i2t} and Z_{i3t} enter in (9) for each product i .

Next we conduct LR tests to determine whether there is serial correlation. We test the null hypothesis of $H_0 : \mathbf{R} = \mathbf{R0}$ against its alternative $H_a : \mathbf{R} = \mathbf{R1}$ under specifications $n = 0, 2, 3$, and 4. We reject the null in cases of $n = 0, 3$, and 4 at conventional levels of significance level indicating that there is serial correlation. For $n = 2$ we failed to reject the null. Based on these results we ultimately estimate the model with $n = 3$ and $\mathbf{R} = \mathbf{R1}$ (i.e., autocorrelation).

⁸Previous studies have found various combinations of demographic variables, such as age, race, food expenditure away from home and consumer health concerns, to affect dairy demand. We attempted to estimate our models with demographics, but found the effects to be largely insignificant. Moreover, inclusion of demographics caused serious multicollinearity problems due to the fact that demographic variables, such as race and age, do not exhibit much variation within the study period (16 years). Most importantly, our estimates of elasticities were robust to the inclusion of demographics.

⁹Under the assumption that the v_t s are normally distributed this procedure is equivalent to maximum likelihood.

¹⁰ $LR = 2(\text{Log } L^U - \text{Log } L^R) \approx \chi^2(k)$ where $\text{Log } L^U$ and $\text{Log } L^R$ are maximized log-likelihood values of unrestricted and restricted models, respectively, and k is the number of restrictions.

TABLE 2. Likelihood Ratio Tests for the Determination of the Optimal Polynomial Length

Model	H_0 : NoAdv	H_0 : $n = 2$	H_0 : $n = 3$
	H_a : $n = 2$	H_a : $n = 3$	H_a : $n = 4$
R0	81.2^a	106.6	11.8
R1	54.8	108.6	25
df	16	16	16
$\chi^2_{0.05,df}$	28.85	28.85	28.85

Bold face indicates statistical significance at a 5% significance level.

ESTIMATION RESULTS, BOOTSTRAP ELASTICITIES AND DISCUSSION

The n3SLS estimates for milk, cheese, butter, and frozen dairy product demand are presented in Table 3. These estimates represent the effects of explanatory variables on the budget share of the respective product and hence they do not have convenient economic interpretations. Therefore, we focus our discussion here on elasticities of demand with respect to prices, expenditure, and advertising expenditure. Nevertheless, a quick inspection of the estimates reveals that there are statistically significant horizontal linkages across dairy products.¹¹ We used an LR test to test the joint significance of generic dairy advertising variables in the system. We reject the null hypothesis of $H_0 : a_{im} = 0$ against its alternative of $H_a : a_{im} \neq 0$ for all m and i where $m = 2, 3$, and $i =$ milk, cheese, butter, and frozen products, at the 1% significance level, indicating that advertising variables are jointly significant.

Point estimates of price and advertising elasticities have been subsequently used in simulation context to determine benefit cost ratios of generic advertising programs. However, it is important to know the precision of these elasticity estimates and analyze the sensitivity of simulation results given such precision (Piggott, 2003). Therefore, we used a parametric bootstrap approach to create empirical distributions of each elasticity parameter by randomly sampling from the residuals of the n3SLS estimation (see Dorfman, Kling & Sexton, 1990). We draw from the residuals of Equation (11) one thousand times with replacement to construct the empirical distributions of the parameters of interest.¹² Table 4 presents 90% confidence intervals for each elasticity together with the mean value (i.e., the point estimate) and standard deviation of the constructed sample. Bold text indicates confidence intervals that do not include a value of zero. Also Figures 1 and 2 show the empirical cumulative distribution functions, CDF, for select elasticities of demand for milk, cheese, butter, and frozen products. The solid vertical lines in each graph indicate the lower and upper bounds of a 90% confidence interval (i.e., those reported in Table 4), and the vertical hash mark indicates a value of zero.

The point estimates of all of the own-price and expenditure elasticities have the expected signs and fall within the range found in the previous literature (among others, Chouniard et al., 2005; Heien & Wessels, 1988; Huang 1993; Kaiser 1999).¹³

¹¹Besides many of the cross-effects, also note that except the case of frozen dairy products, each of the own-price and the own-advertisement effects is statistically significant.

¹²We preserve the cross-correlation structure of the system by sampling contemporaneous residuals at each draw.

¹³We report uncompensated price elasticities. Because the expenditure shares are so small, the uncompensated price elasticities are approximately equal to the compensated price elasticities. Green and Alston (1991) provide the formulas of price and expenditure elasticities in the LA/AIDS.

TABLE 3. Non-linear 3SLS Estimates of Dairy Demand System

Variable	Milk	Cheese	Butter	Frozen products
Constant	0.1600*** (0.0192)	0.2947*** (0.0330)	0.0131 (0.0079)	0.0572** (0.0252)
D1	-0.0001 (0.0005)	-0.0033*** (0.0010)	-0.0014*** (0.0004)	0.0015* (0.0008)
D2	-0.0013*** (0.0003)	-0.0022*** (0.0007)	-0.0001 (0.0003)	0.0042*** (0.0006)
D3	-0.0011*** (0.0003)	-0.0020*** (0.0005)	-0.0002 (0.0002)	0.0036*** (0.0004)
Milkprice	0.0071* (0.0038)	0.0153*** (0.0046)	0.0014** (0.0007)	0.0008 (0.0028)
Cheese pr.	0.0153*** (0.0046)	0.0295*** (0.0090)	-0.0014 (0.0013)	-0.0028 (0.0050)
Butter pr.	0.0014** (0.0007)	-0.0014 (0.0013)	0.0045*** (0.0004)	-0.0004 (0.0009)
Frozen pr.	0.0008 (0.0028)	-0.0028 (0.0050)	-0.0004 (0.0009)	0.0080 (0.0053)
Otherfood pr.	-0.0246*** (0.0031)	-0.0406*** (0.0070)	-0.0041*** (0.0014)	-0.0056 (0.0052)
Z _{M2}	0.0030** (0.0015)	-0.0040 (0.0031)	0.0013 (0.0011)	0.0058** (0.0024)
Z _{M3}	-0.0020 (0.0017)	-0.0012 (0.0037)	-0.0017 (0.0013)	-0.0065** (0.0028)
Z _{C2}	-0.0055*** (0.0015)	0.0098*** (0.0032)	-0.0015 (0.0011)	-0.0031 (0.0025)
Z _{C3}	0.0061*** (0.0016)	-0.0117*** (0.0034)	0.0025** (0.0012)	0.0044* (0.0026)
Z _{B2}	0.0016** (0.0007)	-0.0044*** (0.0016)	0.0021*** (0.0006)	-0.0014 (0.0012)
Z _{B3}	-0.0017** (0.0008)	0.0046*** (0.0018)	-0.0022*** (0.0007)	0.0017 (0.0013)
Z _{F2}	0.0012 (0.0007)	-0.0018 (0.0016)	-0.0007 (0.0006)	-0.0001 (0.0012)
Z _{F3}	-0.0011 (0.0008)	0.0018 (0.0018)	0.0006 (0.0006)	0.0002 (0.0013)
Tot. food exp.	-0.0216*** (0.0043)	-0.0384*** (0.0090)	0.0063*** (0.0031)	-0.0135* (0.0072)
ρ	-0.1661** (0.0773)			

Notes: 1: D1, D2, and D3 are the seasonal dummies for quarters 1, 2 and 3, respectively. 2: Z_{ij} is the stock variable for advertising of product *i* calculated per Equation (9), with *j* = *m*. 3: Asterisks denote statistical significance at the 1% level (***), 5% level (**), and 10% level (*).

The point estimates of the own-price elasticities suggest inelastic demand. Interestingly, demand for fluid milk appears to be more elastic than demand for other dairy products. The confidence intervals for the own-price elasticities of milk and cheese do not include the value of zero.

TABLE 4. 90% Confidence Intervals of Dairy Demand Elasticities

	Mean	St. Dev	5%	95%
<i>Demand for milk w.r.t</i>				
Milk price	-0.769	0.130	-0.990	-0.550
Cheese price	0.470	0.168	0.200	0.750
Butter price	0.308	0.060	0.210	0.410
Frozen price	0.073	0.105	-0.095	0.25
Other price	-0.682	0.136	-0.910	-0.470
Expenditure	0.407	0.117	0.210	0.600
Milk advertising	0.093	0.022	0.058	0.130
Cheese advertising	-0.059	0.029	-0.110	-0.010
Butter advertising	0.021	0.010	0.004	0.037
Frozen advertising	0.023	0.011	0.004	0.042
<i>Demand for cheese w.r.t</i>				
Milk price	0.349	0.108	0.170	0.530
Cheese price	-0.426	0.205	-0.770	-0.081
Butter price	0.528	0.147	0.280	0.780
Frozen price	0.057	0.109	-0.12	0.23
Other price	-0.667	0.167	-0.940	-0.380
Expenditure	0.364	0.143	0.140	0.600
Milk advertising	-0.112	0.028	-0.160	-0.069
Cheese advertising	0.046	0.032	-0.005	0.1
Butter advertising	-0.036	0.013	-0.057	-0.014
Frozen advertising	-0.019	0.014	-0.045	0.004
<i>Demand for butter w.r.t</i>				
Milk price	0.456	0.178	0.160	0.740
Cheese price	-0.137	0.36	-0.42	0.74
Butter price	-0.037	0.159	-0.71	0.45
Frozen price	-0.126	0.226	-0.51	0.25
Other price	-1.494	0.455	-2.200	-0.760
Expenditure	2.218	0.656	1.100	3.300
Milk advertising	0.009	0.106	-0.18	0.18
Cheese advertising	0.152	0.122	-0.048	0.35
Butter advertising	0.209	0.058	0.110	0.300
Frozen advertising	-0.132	0.062	-0.230	-0.027
<i>Demand for frozen w.r.t</i>				
Milk price	0.002	0.175	-0.29	0.29
Cheese price	-0.275	0.328	-0.81	0.25
Butter price	0.145	0.122	-0.051	0.35
Frozen price	-0.467	0.337	-1	0.075
Other price	-0.131	0.407	-0.81	0.051
Expenditure	0.366	0.344	-0.18	0.97
Milk advertising	0.099	0.065	0.008	0.2
Cheese advertising	0.021	0.085	-0.12	0.16
Butter advertising	-0.021	0.027	-0.064	0.024
Frozen advertising	0.025	0.033	-0.03	0.077

A particularly important result for this article is that many of the cross-price elasticities are statistically significant. This result suggests that previous studies, which ignored horizontal price relations, may be subject to omitted variable bias. Point estimates of

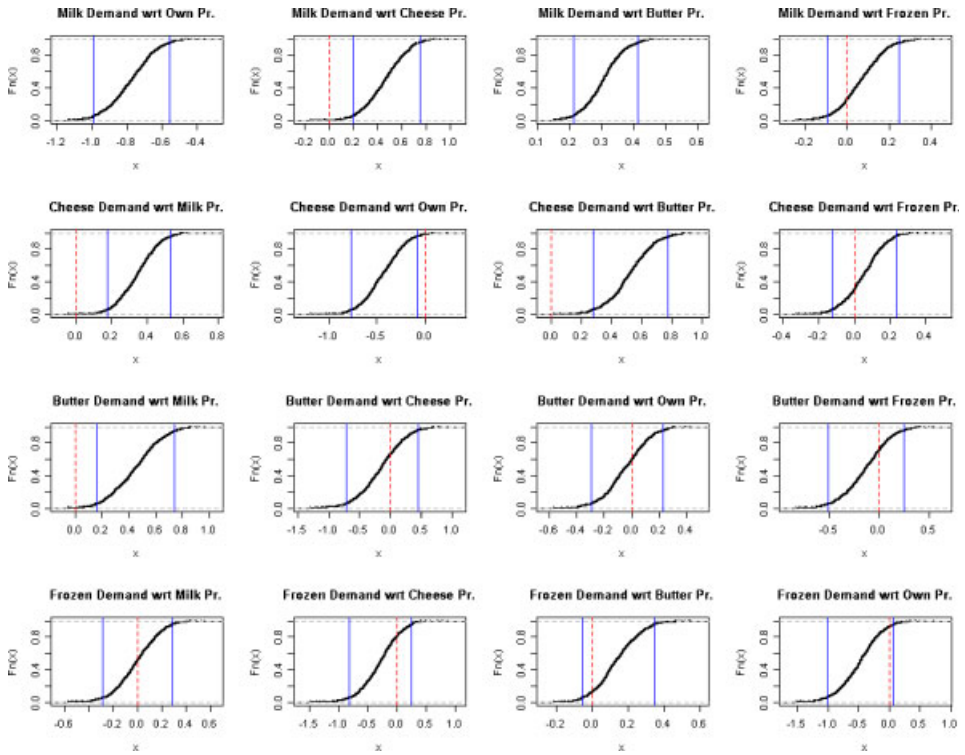


Figure 1 Empirical CDFs of price elasticities.

the cross-price elasticities for milk and cheese suggest that these products are substitutes. Also note that in the case of milk, cheese, and butter, some of the cross-price effects are approximately of the same or greater magnitude as the own-price effects. For example, a 1% increase in cheese price decreases cheese consumption by 0.43%; whereas a 1% decrease in the price of milk, ceteris paribus almost increases cheese demand by 0.35%, and a 1% decrease in the price of butter increases cheese demand by 0.53%. These findings have important implications for the generic dairy advertising. Balagtas and Kim (2007) found that substitution between dairy products reduces the effectiveness of product-specific generic dairy advertising.

We turn now to the estimates of own- and cross-advertising elasticities reported in Table 4 and Figure 2. Consider first the point estimates of the own-advertising elasticities for the four commodities presented in Table 4. Each of the point estimates of the own-advertising elasticities has expected signs. Similar to Schmit and Kaiser (2004), we find fluid milk has a larger own-advertising elasticity than cheese. Butter has a much higher own-advertising elasticity than fluid milk, but this may be due to the fact that there is very little butter advertising over the sample period. Ninety percent confidence intervals for the own-advertising elasticities for fluid milk and butter do not include a value of zero; in the case of cheese, the lower bound of the 90% confidence interval only includes zero.

Our results also indicate that product-specific dairy advertising indeed has spill-over effects into other dairy markets. Point estimates for six of the 12 cross-advertising elasticities are statistically significantly different from zero. For example,

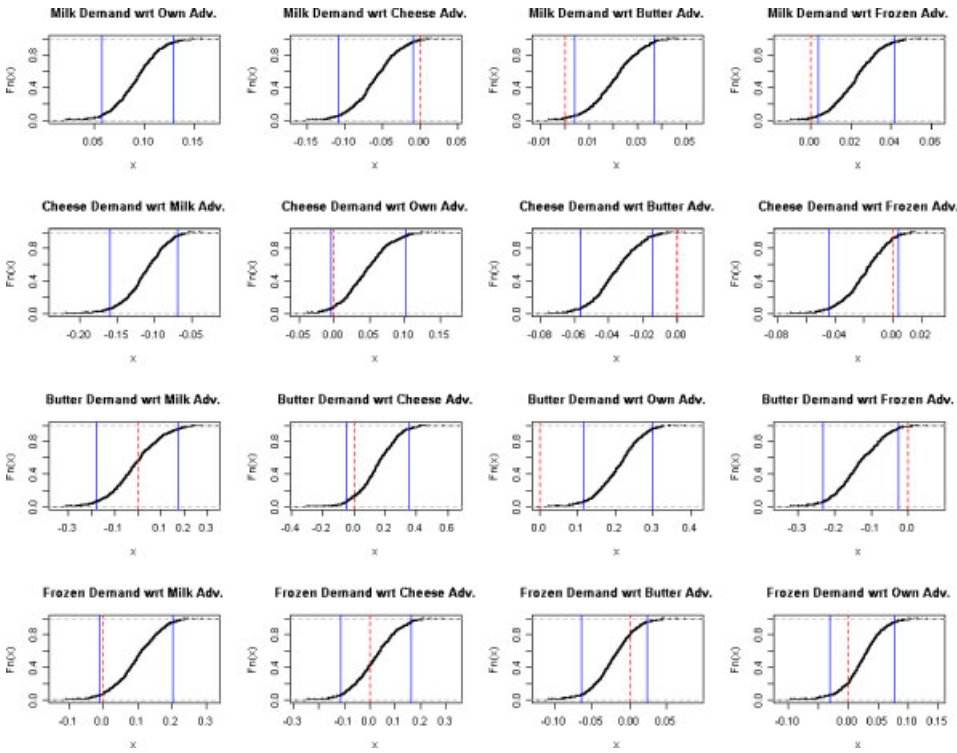


Figure 2 Empirical CDFs of advertising elasticities.

we find that elasticity of demand for fluid milk with respect to fluid milk advertising is positive (0.093), but that the elasticity of demand for cheese with respect to fluid milk advertising is negative (-0.112). While cheese advertising has a negative impact on fluid milk demand (-0.059), both butter and frozen product advertising has positive effects (0.021 and 0.023, respectively). Butter advertising has a negative impact (-0.036) on cheese demand similar to frozen product advertising (-0.132) on butter demand. In some cases, the point estimates of the own-advertising impacts are smaller than those of the cross-advertising effects. The (negative) cross-advertising elasticity of demand for cheese with respect to milk advertising is larger in magnitude than the positive own-advertising elasticity of demand for cheese. This result gives support to the results of Balagtas and Kim (2007) that show that horizontal market relationship tends to diminish the effectiveness of advertising. The negative cross-advertising elasticities between cheese and milk reduce producers' return to advertising.

CONCLUSION

This article estimates an LA/AIDS model of US dairy demand in order to assess the effects of product-specific generic dairy advertising on demand for the advertised product and other, non-advertised dairy products. This article is the first to estimate cross-advertising elasticities of demand for dairy products. Also, to our knowledge, our demand systems approach, our treatment of endogenous prices, and our bootstrap procedure to generate empirical distributions of demand elasticities-while

hardly new to empirical demand analysis-have not been applied to the analysis of generic dairy advertising.

We adopt a PIL structure to model the dynamic nature of advertising's effect on demand. Based on a series of diagnostic tests, we estimated a dairy demand model with a third degree polynomial in the advertising variable and a diagonal \mathbf{R} -matrix to correct for autocorrelation.

We find statistically and economically significant cross-market relationships in dairy demand. For instance, we find that milk and cheese are substitutes in demand (i.e., cross-price elasticities are positive). Also, negative cross-advertising elasticities between cheese and fluid milk are significant and considerably large in magnitude relative to the positive own-advertising elasticities. These results lend support to the finding by Balagtas and Kim (2007) that increased demand for advertised dairy products comes partly at the expense of decreased demand for other, non-advertised dairy products. Attempts to measure the effects of advertising on prices, quantities, and welfare—including the producer returns to advertising—should take these cross-market effects into account. Our evidence of cross-market effects also suggests that single-equation dairy demand models, which have been the workhorse of the empirical generic dairy advertising literature, are mis-specified.

Finally, our empirical CDFs of dairy demand elasticities show that they are, in some cases, estimated imprecisely. This result underscores Piggott (2003)'s warning against relying solely on point estimates of estimated advertising elasticities when evaluating advertising programs.

ACKNOWLEDGMENTS

This research was supported in part by the USDA Cooperative State Research, Education & Extension Service, Hatch project #202583. Senior authorship is shared. The authors thank Harry Kaiser for providing the data.

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