Measuring the Effects of Generic Dairy Advertising in a Multi-Market Equilibrium

Joseph V. Balagtas and Sounghun Kim

We develop a multi-market equilibrium displacement model that allows demand linkages across downstream product markets, and supply linkages through the common use of a raw commodity as the key input. Applying the model to the dairy sector, we find that the effectiveness of producer-funded advertising depends on the demand relationships across dairy product markets (cross-price and cross-advertising elasticities) as well as the reallocation of milk toward the advertised market. We show that the previous literature, which ignores the horizontal linkages highlighted here, tends to overstate the effectiveness of generic commodity promotion for dairy, and thus results in too much advertising.

Key words: dairy, equilibrium displacement model, generic advertising, spillover effects.

Numerous studies have examined the effectiveness of producer-funded generic promotion for milk and for cheese (among others, Blisard et al. 1999; Kaiser 1997, 1999; Kaiser and Chung 2002; Liu and Forker 1990; Schmit and Kaiser 2002, 2004). The typical analysis estimates econometric models of fluid milk or cheese demand as a function of own prices, prices of related goods, demographic characteristics, and generic advertising expenditure. While empirical findings vary across studies and across products, promotion is typically found to generate positive and significant increases in demand, as well as large returns to producers' investment.

However, the typical approach, which models the market for the advertised product in isolation, is incapable of capturing the effects of commodity promotion on horizontally related markets (Alston, Carman, and Chalfant 1994; Piggott, Piggott, and Wright 1995; Kinnucan 1996; Kinnucan and Miao 2000; Alston, Freebairn, and James 2001). This omission is particularly crucial for analysis of dairy product promotion for two reasons. First, individual dairy products are linked on the supply side through their common use of milk as key inputs. Thus, an increase in demand for any given product will result in a higher price for milk in all products and a reallocation of milk across product markets. Second, dairy product markets are arguably related on the demand side, so that prices and advertising for one product affect demand for other products.

This paper develops an analytical, multi-market model of the dairy industry that captures these horizontal linkages across dairy product markets. We apply the model to trace the economic effects of generic commodity promotion on markets for dairy products and the market for milk. Comparative statics show that the effect of advertising on the prices and quantities of milk depends on the horizontal demand and supply linkages across markets. Further, we derive an expression for the optimal advertising expenditures for alternative dairy products, and then evaluate the importance of the horizontal linkages through the numerical simulation. A key result is that ignoring the horizontal relationships that link dairy product markets leads to errors in measurement of the effectiveness of advertising. This is due to two effects: a supply-side effect wherein increased derived demand for milk in the advertised product results in a higher price of milk in all dairy products and a reallocation of milk away from the non-advertised products; and a demand-side effect wherein increased demand for the advertised product comes, in part, at the expense of reduced demand for dairy products that substitute for the advertised product.

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A key contribution of this paper is the extension of work by Alston, Freebairn, and James (2001) to link the markets for advertised products through supply, as well as demand.[1] This concept is applicable to other industries where a single commodity is allocated to multiple downstream markets. Examples may include the allocation of a farm commodity in alternative processed markets, processed versus fresh markets, or foreign versus domestic markets. As well, this paper demonstrates that the empirical literature on generic dairy advertising, most of which ignores horizontal markets, is missing important economic effects and potentially misstating the returns to advertising.

A Multi-Market Model of the U.S. Dairy Industry with Per Unit Check-Off Funding

A 1-input x 2-product Model of the Dairy Industry with Advertising

We develop an equilibrium displacement model (EDM) of the U.S. dairy industry for the purpose of demonstrating analytically the role of linkages between related markets for determining the effects of generic promotion (see Alston, Norton, and Pardey 1995 for a recent treatment of EDMs). To keep the exposition simple, we specify a model in which milk is used in the manufacture of two distinct dairy products (e.g., fluid milk and manufactured products), and an integrated post-farm gate marketing sector combines processing and retailing functions.

The model is written in general form as follows:

(1) *Milk supply*
$$M = M(W_f)$$

(2) *Production of fluid products*
$$X_1 = g_1(M_1)$$

(3) *Production of manufactured products*
$$X_2 = g_2(M_2)$$

(4) *Fluid product demand*
$$X_1 = X_1(P_1, P_2, t_1 M, t_2 M)$$

(5) *Manufactured product demand*
$$X_2 = X_2(P_1, P_2, t_1 M, t_2 M)$$

(6) *Pricing of milk for fluid products*
$$W_1 = g_{M1} P_1$$

(7) *Pricing of milk for manufactured products*
$$W_2 = g_{M2} P_2$$

(8) *Price discrimination*
$$W_1 = W_2 + D$$

(9) *Blend price of milk*
$$W = (M_1 W_1 + M_2 W_2)/M$$

(10) *The farm price*
$$W_f = W - t_1 - t_2$$

(11) *Milk adding up condition*
$$M = M_1 + M_2.$$

Equation (1) expresses the supply of milk, M, as a function of the farm price of milk, W_f. Equations (2) and (3) are the production functions that transform milk into dairy products, X_i. Equations (4) and (5) are the dairy product demands. Demand for each dairy product is a function of prices for both products, P_1 and P_2, as well as advertising expenditure for those products, $t_1 M$ and $t_2 M$, where t_i is a tax or check-off levied on all milk production for advertising for product i. Equations (6) and (7) express the competitive equilibrium condition for milk, that the processor price of milk for fluid products or manufactured products is the equal to the value marginal product of milk, where g_{Mi} is the marginal product of milk in product i. Equation (8) captures price discrimination by Federal Milk Marketing Orders (FMMOs) and similar state programs, which raises the price of milk paid by fluid products processors by a fixed mark-up, D, relative to that paid for manufacturing milk. Equation (9) defines the blend price of milk paid to all producers under FMMO regulation as a weighted average of processor prices of milk for fluid products and manufactured products. Equation (10) defines the net farm price, as the blend price less the per unit check-off collected for dairy product advertising, t_i. Equation (11) is the market clearing condition that supply equals demand for milk.

Totally differentiating equations (1) through (11) and converting to elasticity form yields a system of equations linear in percentage

[1] Kaiser and Schmit (2003) consider the incidence of generic promotion on fluid milk and cheese processors, noting that all dairy processors compete for milk. However, they do not address the implications for dairy-farmer welfare, or for farmer-funded advertising.

changes. Using the symbol E to denote percentage change, the model is as follows:

$$(12)\quad EM = \varepsilon_f EW_f$$

$$(13)\quad EX_1 = EM_1$$

$$(14)\quad EX_2 = EM_2$$

$$(15)\quad EX_1 = \eta_{11}EP_1 + \eta_{12}EP_2 + \alpha_{11}(Et_1 + EM) + \alpha_{12}(Et_2 + EM)$$

$$(16)\quad EX_2 = \eta_{21}EP_1 + \eta_{22}EP_2 + \alpha_{21}(Et_1 + EM) + \alpha_{22}(Et_2 + EM)$$

$$(17)\quad EW_1 = EP_1$$

$$(18)\quad EW_2 = EP_2$$

$$(19)\quad EW_1 = \gamma EW_2$$

$$(20)\quad EW = v_1(EM_1 + EW_1) + v_2(EM_2 + EW_2) - EM$$

$$(21)\quad EW_f = \omega_f EW - \omega_{t1}Et_1 - \omega_{t2}Et_2$$

$$(22)\quad EM = s_1 EM_1 + s_2 EM_2$$

where ε_f is the elasticity of supply of milk with respect to the farm price; η_{ij} is the elasticity of demand for product i with respect to the price of product j; α_{ij} is the elasticity of demand for product i with respect to advertising expenditure for product j; γ $(\equiv W_2/W_1)$ is the ratio of milk prices for fluid products and manufactured products; v_i $(\equiv (W_iM_i)/(WM))$ is the share of milk revenue from product i; $\omega_f(\equiv W/W_f)$ is the ratio of the blend price to the net farm price; ω_{ti} $(\equiv t_i/W_f)$ is the ratio of the per unit check-off for product i to the farm price; s_i is the share of milk allocated to product i, where the shares sum to one. Equations (13) and (14) follow from an assumption of constant returns to scale technology in dairy product manufacturing.

The model can be expressed equivalently in matrix form as

$$(23)\quad \boldsymbol{RY} = \boldsymbol{Z}$$

where $\boldsymbol{R}$ is a matrix of model parameters, $\boldsymbol{Y}$ a column vector of endogenous, proportional changes in prices and quantities relative to an initial equilibrium, and $\boldsymbol{Z}$ a column vector of zeros, the proportional changes in the per unit check-offs, advertising elasticities of demand, and the ratio of the per unit check-offs to farm price as follows:

$$(24)\quad \boldsymbol{R} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & -\varepsilon_f & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\alpha_{11}-\alpha_{12} & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & -\eta_{11} & -\eta_{12} \\ -\alpha_{21}-\alpha_{22} & 0 & 0 & ?? & 1 & 0 & 0 & 0 & 0 & -\eta_{21} & -\eta_{22} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -\gamma & 0 & 0 \\ 1 & -v_1 & -v_2 & 0 & 0 & 0 & 1 & -v_1 & -v_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & -\omega_f & 0 & 0 & 0 & 0 \\ 1 & -s_1 & -s_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$(25)\quad \boldsymbol{Y} = \begin{bmatrix} EM \\ EM_1 \\ EM_2 \\ EX_1 \\ EX_2 \\ EW_f \\ EW \\ EW_1 \\ EW_2 \\ EP_1 \\ EP_2 \end{bmatrix}, \quad \text{and}$$

$$(26)\quad \boldsymbol{Z} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ \alpha_{11}Et_1 + \alpha_{12}Et_2 \\ \alpha_{21}Et_1 + \alpha_{22}Et_2 \\ 0 \\ 0 \\ 0 \\ 0 \\ -\omega_{t1}Et_1 - \omega_{t2}Et_2 \\ 0 \end{bmatrix}.$$

The model defines proportional changes in equilibrium dairy prices and quantities in response to exogenous changes in the advertising check-offs:

$$(27)\quad \boldsymbol{Y} = \boldsymbol{R}^{-1}\boldsymbol{Z}.$$

The change in producer surplus created by advertising can be measured in terms of the changes in prices and quantities from solutions of the model, as follows

$$(28)\quad \Delta PS = W_{f0}M_0\,[EW_f][1 + 0.5EM]$$

where subscript *0* indicates initial price and quantity, and EW_f and EM are the appropriate elements of the vector on the right-hand side of equation (27).[2]

Comparative Statics

Dividing equation (27) by Et_1 yields the elasticities of dairy-sector prices and quantities with respect to the per unit check-off for advertising product 1 as follows:

$$(29)\quad \frac{EM}{Et_1} = \frac{\begin{aligned}&\varepsilon_f[(1 + v_1(\gamma - 1))\omega_f(s_1\alpha_{11} + s_2\alpha_{21}) + \omega_{t1}(s_1(\gamma\eta_{11} + \eta_{12}) \\ &+ s_2(\gamma\eta_{21} + \eta_{22})) + (v_1 - s_1)\omega_f(\alpha_{21}(\gamma\eta_{11} + \eta_{12}) - \alpha_{11}(\gamma\eta_{21} + \eta_{22}))]\end{aligned}}{\Delta}$$

$$(30)\quad \frac{EM_1}{Et_1} = \frac{\begin{aligned}&(1 + v_1(\gamma - 1))\varepsilon_f\omega_f(\alpha_{11} - s_2(\alpha_{11}\alpha_{22} - \alpha_{12}\alpha_{21})) \\ &+ s_2[(\alpha_{21} - \varepsilon_f\omega_{t1}\alpha_{22})(\gamma\eta_{11} + \eta_{12}) - \alpha_{11}(\gamma\eta_{21} + \eta_{22})] \\ &+ \varepsilon_f\omega_{t1}[(1 - s_2\alpha_{21})(\gamma\eta_{11} + \eta_{12}) + (\alpha_{11} + \alpha_{12})s_2(\gamma\eta_{21} + \eta_{22})] \\ &+ (s_1 - v_1)\varepsilon_f\omega_f[\alpha_{11}(\gamma\eta_{21} + \eta_{22}) - \alpha_{21}(\gamma\eta_{11} + \eta_{12})]\end{aligned}}{\Delta}$$

$$(31)\quad \frac{EM_2}{Et_1} = \frac{\begin{aligned}&(1 + v_1(\gamma - 1))\varepsilon_f\omega_f(\alpha_{21} + s_1(\alpha_{11}\alpha_{22} - \alpha_{12}\alpha_{21})) \\ &- s_1[\alpha_{21}(\gamma\eta_{11} + \eta_{12}) - \alpha_{11}(\gamma\eta_{21} + \eta_{22})] \\ &+ \varepsilon_f\omega_{t1}[(1 - s_1(\alpha_{11} + \alpha_{12}))(\gamma\eta_{21} + \eta_{22}) + s_1(\alpha_{21} + \alpha_{22})(\gamma\eta_{11} + \eta_{12})] \\ &+ (s_1 - v_1)\varepsilon_f\omega_f[\alpha_{11}(\gamma\eta_{21} + \eta_{22}) - \alpha_{21}(\gamma\eta_{11} + \eta_{12})]\end{aligned}}{\Delta}$$

$$(32)\quad \frac{EW_f}{Et_1} = \frac{\begin{aligned}&(1 + v_1(\gamma - 1))\omega_f(s_1\alpha_{11} + s_2\alpha_{21}) + \omega_{t1}(s_1(\gamma\eta_{11} + \eta_{12}) + s_2(\gamma\eta_{21} + \eta_{22})) \\ &+ (v_1 - s_1)\omega_f[\alpha_{21}(\gamma\eta_{11} + \eta_{12}) - \alpha_{11}(\gamma\eta_{21} + \eta_{22})]\end{aligned}}{\Delta}$$

$$(33)\quad \frac{EW}{Et_1} = \frac{\begin{aligned}&(1 + v_1(\gamma - 1))[s_1\alpha_{11} + s_2\alpha_{21} + \varepsilon_f\omega_{t1}(1 - s_1(\alpha_{11} + \alpha_{12}) - s_2(\alpha_{21} + \alpha_{22}))] \\ &+ (v_1 - s_1)[(\gamma\eta_{11} + \eta_{12})(\alpha_{21} + \varepsilon_f\omega_{t1}(1 - \alpha_{21} - \alpha_{22})) \\ &- (\gamma\eta_{21} + \eta_{22})(\alpha_{11} + \varepsilon_f\omega_{t1}(1 - \alpha_{11} - \alpha_{12}))]\end{aligned}}{\Delta}$$

[2] Our measure of the change in producer surplus assumes that supply and demand are linear in the region of interest.

$$(34)\quad \frac{EW_1}{Et_1} = \frac{\begin{array}{l}\gamma[s_1\alpha_{11} + s_2\alpha_{21} + \varepsilon_f\omega_{t1}(1 - s_1(\alpha_{11} + \alpha_{12}) - s_2(\alpha_{21} + \alpha_{22}))\\ \quad + (s_1 - v_1)\varepsilon_f\omega_f(\alpha_{11} - \alpha_{21} - \alpha_{11}\alpha_{22} + \alpha_{12}\alpha_{21})]\end{array}}{\Delta}$$

$$(35)\quad \frac{EW_2}{Et_1} = \frac{\begin{array}{l}s_1\alpha_{11} + s_2\alpha_{21} + \varepsilon_f\omega_{t1}(1 - s_1(\alpha_{11} + \alpha_{12}) - s_2(\alpha_{21} + \alpha_{22}))\\ \quad + (s_1 - v_1)\varepsilon_f\omega_f(\alpha_{11} - \alpha_{21} - \alpha_{11}\alpha_{22} + \alpha_{12}\alpha_{21})\end{array}}{\Delta}$$

where $\Delta = \{1 + v_1(\gamma - 1)\}\varepsilon_f\omega_f\{1 - s_1(\alpha_{11} + \alpha_{12}) - s_2(\alpha_{21} + \alpha_{22})\} - s_1(\gamma\eta_{11} + \eta_{12}) - s_2 \times (\gamma\eta_{21} + \eta_{22}) + (v_1 - s_1)\varepsilon_f\omega_f[(\gamma\eta_{11} + \eta_{12}) \times (1 - \alpha_{21} - \alpha_{22}) - (\gamma\eta_{21} + \eta_{22})(1 - \alpha_{11} - \alpha_{12})]$. Note that we suppress the elasticities of retail prices and quantities, since $EX_i/Et_1 = EM_i/Et_1$ and $\frac{EP_i}{Et_1} = \frac{EW_i}{Et_1}$ under our maintained assumption of constant returns technology. Equations (29)–(35) define the marginal effects of a change in producer-funded advertising for product 1.

Optimal Advertising Expenditure for Dairy Products

The comparative statics in equations (29)–(35) can be used to develop a rule for allocating dairy advertising expenditure funded by per unit check-off. Following Alston, Freebairn, and James 2001 we define the optimal per unit check-off for advertising for each dairy product as that which maximizes producer surplus:

$$(36)\quad \begin{aligned} PS &= TR - TVC \\ &= W_f M - TVC(M) \\ &= (W - t_1 - t_2)M - TVC(M) \end{aligned}$$

where PS is the net producer surplus for dairy farmers, TR is the total milk revenue, and TVC is the total variable cost of producing milk. The first-order condition for the optimal per unit check-off for fluid milk advertising is

$$(37)\quad \frac{\partial W}{\partial t_1} = 1.$$ [3]

Noting that W is the processor price of milk, equation (37) indicates that producers should continue to increase the check-off as long as the vertical shift in derived aggregate demand is large enough to raise the equilibrium processor price by the change in the check-off, leaving the net farm price no lower than without the check-off. (Note from equation (10) that $\partial W/\partial t_1 = 1$ implies that $\partial W_f/\partial t_1 = 0$.) This first-order condition can be restated in proportional change form:

$$(38)\quad \frac{EW}{Et_1} = \frac{t_1^*}{W}$$

or

$$(39)\quad t_1^* = \frac{EW}{Et_1}W.$$

It follows that optimal advertising expenditure is

$$(40)\quad A_1^* = \frac{EW}{Et_1}WM.$$

Equations (39) and (40) show that the optimal per unit check-off, and thus optimal advertising expenditure, is proportional to the elasticity of the blend price with respect to the check-off. Substituting equation (33) into (39) and (40) yields the optimal per unit check-off and advertising expenditure:

[3]The first-order condition for the optimal per unit check-off is

$$\begin{aligned}\frac{\partial PS}{\partial t_1} &= \frac{\partial W}{\partial t_1}M + W\frac{\partial M}{\partial t_1} - M - t_1\frac{\partial M}{\partial t_1} - t_2\frac{\partial M}{\partial t_1} - \frac{\partial TVC}{\partial M}\frac{\partial M}{\partial t_1} \\ &= \left(\frac{\partial W}{\partial t_1} - 1\right)M + (W - t_1 - t_2)\frac{\partial M}{\partial t_1} - MC\frac{\partial M}{\partial t_1} = 0.\end{aligned}$$

Under the maintained hypothesis of perfectly competitive markets, $W_f(= W - t_1 - t_2) = MC$, so that $\frac{\partial PS}{\partial t_1} = (\frac{\partial W}{\partial t_1} - 1)M = 0$. Then, assuming a strictly positive quantity of milk at the optimum, we have $\frac{\partial W}{\partial t_1} = 1$.

$$
(41) \quad t_1^* = W\left(\frac{\begin{array}{l}(1+v_1(\gamma-1))[s_1\alpha_{11}+s_2\alpha_{21}+\varepsilon_f\omega_{t1}(1-s_1(\alpha_{11}+\alpha_{12})-s_2(\alpha_{21}+\alpha_{22}))]\\ \quad +(v_1-s_1)[(\gamma\eta_{11}+\eta_{12})(\alpha_{21}+\varepsilon_f\omega_{t1}(1-\alpha_{21}-\alpha_{22}))\\ \quad -(\gamma\eta_{21}+\eta_{22})(\alpha_{11}+\varepsilon_f\omega_{t1}(1-\alpha_{11}-\alpha_{12}))]\end{array}}{\Delta}\right)
$$

and

$$
(42) \quad A_1^* = WM\left(\frac{\begin{array}{l}(1+v_1(\gamma-1))[s_1\alpha_{11}+s_2\alpha_{21}+\varepsilon_f\omega_{t1}(1-s_1(\alpha_{11}+\alpha_{12})-s_2(\alpha_{21}+\alpha_{22}))]\\ +(v_1-s_1)[(\gamma\eta_{11}+\eta_{12})(\alpha_{21}+\varepsilon_f\omega_{t1}(1-\alpha_{21}-\alpha_{22}))\\ -(\gamma\eta_{21}+\eta_{22})(\alpha_{11}+\varepsilon_f\omega_{t1}(1-\alpha_{11}-\alpha_{12}))]\end{array}}{\Delta}\right).
$$

The presence of cross-price and cross-advertising elasticities, as well as the own-price elasticity for manufactured milk (η_{22}), in equations (41) and (42) make it clear that optimal advertising depends on the direct effect of advertising on demand in each market, as well as the links between the two markets. However, most of the empirical literature on the economics of generic advertising for dairy ignores the market for non-advertised dairy products. An exception is Wohlgenant and Clary (1994), who allow for linkages across dairy product markets by estimating the effects of advertising on the (inverse) derived demand for farm milk. In another exception, Kaiser and Schmit (2003) model the supply link (i.e., fluid milk and cheese processors competing for the same input), but assume cross-price and cross-advertising elasticities are zero. In this case, the optimal check-off and advertising expenditure can be viewed as a special case of equations (41) and (42).[4] The rest of the literature considers yet a more restricted model in which prices and quantities in markets for non-advertised dairy products are assumed exogenous, thereby eliminating all spillover and feedback effects within the dairy sector.

[4] Kaiser and Schmit consider the effects of advertising for fluid milk on cheese processors, and of advertising for cheese on fluid milk processors. However, they do not make the important link back to dairy farmers, or discuss the implications for the effectiveness of advertising funded by farmers. That is, they do not find or calculate the appropriate, restricted versions of equations (41) and (42).

Numerical Simulation of the Effects of Generic Dairy Advertising

We now turn to numerical simulation to quantify the effects of generic dairy advertising in the U.S. dairy sector and to demonstrate the role of horizontal markets. We model the markets for three products (fluid milk, cheese, and other dairy products) produced from milk and potentially related in demand. To simulate the model, we draw parameter values from the literature where available, and use data on the 2005 U.S. dairy market. We consider a range of possible values for the cross-advertising elasticities of demand (α_{ij}, $i \neq j$), as no published estimates exist.

Parameter Values and Data Used for Simulations

Base values of demand elasticities used in our simulations are reported in table 1. Published estimates of demand and supply elasticities vary as a result of different levels of aggregation across time, products, and geography, as well as different econometric specifications. Estimates of the own-price elasticity of U.S. retail demand for fluid milk range from −0.882 to −0.0431 (Heien and Wessels 1988; Huang 1993; Kaiser 1999; Schmit and Kaiser 2002; Chouinard et al. 2005). Estimates of the own-price elasticity of U.S. retail demand for cheese range from −0.773 to −0.146

Table 1. Demand Elasticities Used in Base Scenario

	Elasticity with Respect to					
	Price of (η_{ij}):[a]			Advertising Expenditure for (α_{ij}):[b]		
Demand for:	Fluid Milk	Cheese	Other Dairy Products	Fluid Milk	Cheese	Other Dairy Products
Fluid milk	−0.20	0.02	0.00	0.036	−0.055	0.0
Cheese	0.02	−0.50	0.00	−0.018	0.027	0.0
Other dairy products	0.00	0.00	−0.60	0.0	0.0	0.020

[a]Price elasticities reflect published estimates. Cross-price elasticities between other dairy products and fluid milk or cheese are assumed to be zero.
[b]Own-advertising elasticities reflect published estimates. Cross-advertising elasticities between fluid milk and cheese are imputed from Bassmann's adding up condition, assuming fluid milk and cheese are separable. Cross-advertising elasticities between other dairy products and fluid milk or cheese are assumed to be zero.

(Heien and Wessels 1988; Huang 1993; Kaiser 1999; Schmit and Kaiser 2002; Chouinard et al. 2005). Estimates of the own-price elasticity of U.S. demand for butter range from −0.410 to −0.2428 (Huang 1993; Chouinard et al. 2005). Estimates of own-price elasticities of demand exist for frozen products (Huang 1993, −0.0784; Chouinard et al. 2005, −0.803) and yogurt (Chouinard et al. 2005, −0.773). Based on the published estimates, we choose own-price elasticities that fall in the range of the published estimates: −0.2 for fluid milk, −0.5 for cheese, and −0.6 for other dairy products.

Evidence on the sign and magnitude of cross-price elasticities is mixed (Heien and Wessels 1988; Huang 1993; Chouinard et al. 2005). We proceed under the assumption that dairy products are likely to be substitutes at the level of aggregation relevant for national generic commodity advertising. This assertion is supported by many of the published estimates, and also by the recent 3-A-Day™ dairy advertising campaign that encourages consumers to consume three servings of milk, cheese or yogurt a day (DMI 2006). As base values in our simulation analysis, we assume the cross-price elasticities between fluid milk and cheese are 0.02, and the cross-price elasticities between other dairy products and cheese and other products and fluid milk are zero.

Estimates of the U.S. own-advertising elasticity of demand for fluid milk range from 0.014 (Liu et al. 1990) to 0.057 (Kaiser 1999). Estimates of the own-advertising elasticity of demand for cheese range from 0.015 (Kaiser 1999) to 0.039 (Kaiser and Schmit 2003). We choose 0.036 as the own-advertising elasticity of demand for fluid milk, 0.027 as the own-advertising elasticity of demand for cheese, and 0.02 as the own-advertising elasticity of demand for other dairy products.

None of the research listed above estimates cross-advertising elasticities. Basmann 1956 showed that for a weakly separable group of n products, the advertising elasticities must satisfy $\sum_{i=1}^{n} B_i \alpha_{ij} = 0$, $j = 1, \ldots, n$, where B_i is the retail (consumer) expenditure share for the i^{th} product. Intuitively, Basmann's adding up condition states that if advertising is effective at increasing demand for the advertised product, it must also decrease demand for some other products. Thus advertising has potentially important direct effects on demand for non-advertised products (e.g., Alston, Freebairn, and James 2001; Kinnucan and Myrland 2002; Kinnucan and Miao 2000). In the case of dairy advertising, under our maintained hypothesis that dairy products are substitutes, advertising for one product decreases demand for other dairy products. In our base scenario, we impute the cross-advertising elasticities under the assumption that cheese and fluid milk comprise a separable group of dairy products. This scenario sets an upper bound on the magnitude of the cross-advertising elasticities for fluid milk and cheese. We also simulate the model under the assumption that the cross-advertising elasticities between cheese and fluid milk are zero. In all scenarios, the cross-advertising elasticities between other dairy products and fluid milk and cheese are assumed to be zero.

Estimates of the elasticity of the U.S. milk supply range between 0.22 and 2.53, depending on the relevant time horizon and econometric specification (Chavas and Klemme 1986, short-run elasticity of 0.22, long-run elasticity of 1.17; Cox and Chavas 2001, 0.37; Helmberger and Chen 1994, 0.583; Chen, Courtney, and Schmitz 1976, 2.53). We use 1.0 as the value of the elasticity of supply for milk over a one-year time horizon.

Table 2. 2005 U.S. Dairy Market Statistics Used in Simulations

	Units	
Prices		
Farm price of milk (W_f)	\$/cwt	14.92
Blend price (W)	\$/cwt	15.07
Processor price of milk in fluid milk (W_1)	\$/cwt	17.13
Processor price of milk in cheese (W_2)	\$/cwt	13.97
Processor price of milk in other products (W_3)	\$/cwt	14.35
Retail price of fluid milk (P_1)	\$/gallon	3.19
Retail price of cheese (P_2)	\$/lb.	4.13
Retail price of other dairy products (P_3)	\$/lb.	1.13
Per unit check-off		
Check-off for fluid milk advertising (t_1)	¢/cwt	3.85
Check-off for cheese advertising (t_2)	¢/cwt	5.85
Check-off for other dairy products advertising (t_3)	¢/cwt	0.50
Quantities		
Farm supply of milk (M)	mil. lbs. per year	176,989
Farm milk sold for fluid milk (M_1)	mil. lbs. per year	54,724
Farm milk sold for cheese (M_2)	mil. lbs. per year	66,504
Farm milk sold for other dairy products (M_3)	mil. lbs. per year	55,761
Retail supply of fluid milk (X_1)	mil. lbs. per year	54,543
Retail supply of cheese (X_2)	mil. lbs. per year	10,349
Retail supply of other diary products (X_3)	mil. lbs. per year	18,635

Note: All prices and quantities are from data in U.S. Department of Agriculture (USDA-NASS Agricultural Statistics 2005 and Federal Milk Marketing Order Statistics) and U.S. Department of Labor. W_1 and W_2 are weighted averages of FMMO Class 1 and Class III prices, respectively. W is the weighted average FMMO uniform price, and W_f is calculated as the blend price less the check-off of \$0.15. W_3 is imputed from FMMO data. P_i is from the U.S. Department of Labor, Bureau of Labor Statistics. Quantities are from data in USDA-NASS Agricultural Statistics 2005 in U.S. Department of Agriculture, and t_i is based on the 2003 Dairy Management Inc. (DMI) annual report.

Shares and price ratios used in the model are calculated from data from the U.S. Departments of Agricultural and Labor, reflecting prices and quantities in U.S. dairy markets in 2005 (table 2). The processor prices for milk in fluid milk (W_1) and cheese (W_2) are weighted averages of FMMO Class 1 and Class III prices, respectively. The blend price (W) is the weighted average FMMO uniform price, and the net producer price (W_f) is calculated as the blend price less the check-off of \$0.15. The processor price of milk in other dairy products (W_3) is imputed from FMMO data. We calculate product-specific check-offs based on the 2003 Dairy Management Inc. annual report (DMI 2003). The DMI annual report shows that a total of 68% DMI revenue was used for "marketing," which we take to mean generic advertising: 23% of the DMI budget was used for fluid milk marketing, 35% for cheese marketing, 3% for dairy ingredient marketing, and 7% for school marketing. We allocate the 7% for school marketing to the other three categories based on each category's share of the DMI marketing budget, and multiply the result by the full check-off (\$.15/cwt) to calculate the product-specific check-off rates.

Simulation Scenarios

In order to quantify the importance of cross-market linkages in measuring the effects of dairy advertising, we simulate 40% increases in the check-offs for fluid milk and for cheese. In each case, we measure the market effects under four parameter scenarios:

1. Base scenario with horizontal supply and demand linkages: the cross-advertising elasticities between fluid milk and cheese are imputed using Basmann's adding-up condition, assuming fluid milk and cheese are a separable group, and all other model parameters reflect likely values (tables 1 and 2).
2. A restricted model assuming no horizontal demand linkages (i.e., all cross-price and cross-advertising elasticities of demand are zero), but allowing for horizontal supply linkages (i.e., dairy product markets are

Table 3. Market Effects of a 40% Increase in the Per Unit Check-off for Fluid Milk Advertising

	1. Horizontal Demand and Supply Linkages[a]		2. No Horizontal Demand Linkages[b]		3. No Horizontal Demand or Supply Linkages[c]		4. No Cross-Advertising Effects[d]	
	% Change	Level Change	% Change	Level Change	% Change	Level Change	% Change	Level Change
Prices (cents per cwt)								
Net farm price of milk (W_f)	0.116	1.7	0.301	4.5	0.375	5.6	0.305	4.5
Blend price (W)	0.218	3.3	0.401	6.0	0.474	7.1	0.405	6.1
Processor price of milk in fluid milk (W_1)	0.117	2.0	0.294	5.0	1.199	20.5	0.296	5.1
Processor price of milk in cheese (W_2)	0.144	2.0	0.360	5.0	0.0	0.0	0.362	5.1
Processor price of milk in other products (W_3)	0.140	2.0	0.350	5.0	0.0	0.0	0.353	5.1
Quantities (million lbs. per year)								
Farm supply of milk (M)	0.116	205.7	0.301	533.3	0.375	664.2	0.305	539.0
Farm milk sold for fluid milk (M_1)	1.417	775.6	1.392	761.8	1.214	664.2	1.400	765.6
Farm milk sold for cheese (M_2)	−0.789	−524.4	−0.172	−114.2	0.0	0.0	−0.167	−111.3
Farm milk sold for other dairy products (M_3)	−0.082	−45.5	−0.204	−113.8	0.0	0.0	−0.206	−114.8
Producer surplus (mil. dollars per year)		31		80		99		81

Note: To conserve space, we do not report results for retail prices and quantities. Under our assumption of constant returns technology, percentage changes in the retail price and quantity of each dairy product are equal to the percentage changes in the farm price and quantity of milk used in that product.
[a]Assumes demand elasticities equal to the values reported in table 1.
[b]Cross-price and cross-advertising elasticities are assumed equal to zero ($\eta_{ij} = 0$ and $\alpha_{ij} = 0, i \neq j$).
[c]All prices and quantities in markets for cheese and other dairy products are assumed exogenous.
[d]The cross-advertising elasticities between cheese and fluid milk are both set equal to zero ($\alpha_{ij} = 0, i \neq j$).

integrated through their common use of raw milk).
3. A restricted model assuming no horizontal demand or supply linkages.
4. A restricted model assuming no cross-advertising effects (i.e., all cross-advertising elasticities of demand are zero), but allowing for cross-price effects in demand and horizontal supply linkages.

Comparing scenario 1, where the model includes all the cross-market effects, with scenarios 2, 3 and 4, where some of the cross-market linkages are suppressed, provides a measure of the direction and magnitude of estimated effects of different cross-market linkages on the estimated returns from generic advertising.

Simulated Effects of 40% Increases in Check-Offs for Dairy Advertising

Table 3 shows the effects of a 40% increase in the per unit check-off for fluid milk advertising under scenarios 1–4. Under all scenarios, fluid milk advertising increases the price and quantity of milk used in fluid products, as well as the price and quantity of fluid milk products.[5] When dairy product markets are linked through supply and demand (scenario 1), fluid milk advertising reduces both supply and demand for cheese, and reduces supply for other dairy products, causing reduced consumption of these products and reduced quantities of milk used in these products. We also find fluid milk advertising causes higher prices for milk in cheese and other dairy products. Because of the spillover and feedback effects of fluid milk advertising, the increase in milk production (M) is less than the increase in milk used

[5] Under our assumption of constant returns technology in dairy product manufacturing, the percentage changes in retail quantities and prices of dairy products are equal to the percentage changes in, respectively, the prices and quantities of milk used in those products. Thus we report results only farm prices and quantities to conserve space.

in fluid products (M_1). The 40% increase in advertising for fluid milk increases producer surplus by $31 million in scenario 1.

In contrast, in scenario 2 (all cross-price and cross-advertising elasticities of demand equal zero), demand for cheese and for other dairy products is not affected by fluid milk advertising. Advertising for fluid milk affects the markets for other dairy products only through the supply of milk; advertising raises the price paid for milk by all processors. Accordingly, the price increases are larger and reductions in the quantities smaller in the market for cheese in scenario 2 than in scenario 1. The cross-price and cross-advertising elasticities of demand have important effects on the ability of fluid milk advertising to raise the farm price of milk. When there are no demand linkages across dairy product markets, fluid milk advertising is 2.6 times as effective at raising the farm price of milk (a 0.301% increase compared to a 0.116% increase), and the net producer gain is 2.6 times as large ($80 million compared to $31 million).

In Scenario 3, both the supply and demand linkages across product markets are eliminated, so that prices and quantities in markets for cheese and other dairy products are exogenous. Thus, even though fluid milk advertising raises the price of milk in fluid uses, the price of milk in cheese and other products is assumed unaffected. Compared to scenario 1, fluid milk advertising is 3.2 times more effective at increasing the farm-price of milk (a 0.375% increase compared to a 0.116% increase) and producer surplus ($99 million versus $31 million), when there are no cross-market effects.

Under our maintained hypothesis that cheese and fluid milk are substitutes, fluid milk advertising is more effective when the cross-advertising elasticities are smaller. Thus, fluid milk advertising is more effective in scenario 4 than in scenario 1. However, comparison of scenarios 3 and 4 suggests that horizontal market linkages are important even when cross-advertising effects are zero. The change in producer surplus from fluid milk advertising in scenario 3, $99 million, is 22% higher than the change in producer surplus with in scenario 4, $81 million.

Table 4 tells an analogous story for generic cheese advertising, with two notable differences. In scenario 1, the increase in cheese advertising makes producers worse off. This result is driven by two factors. First, the relatively large cross-advertising elasticity of demand for fluid milk with respect to cheese advertising causes such a large decrease in demand for fluid milk so as to decrease the total consumption of milk. Second, because the initial price of milk in cheese is low relative to the price of milk in fluid products and other dairy products (table 2), cheese advertising effectively increases the share of milk sold to its lowest-value use, causing the net producer price to fall even though the price of milk in each product rises. Thus, milk marketing order regulation, which raises the price of milk in fluid products relative to that in manufactured dairy products, undermines the effectiveness of advertising for manufactured dairy products.

Also notable in the cheese advertising case is that the horizontal supply linkages increase the effectiveness of cheese advertising, which can be seen by comparing scenarios 2 and 3 in table 4. Note that the horizontal supply linkages across product markets have two related effects. First, the advertising-induced increase in the price of milk reduces consumption of the non-advertised products. Second, the demand response in the non-advertised markets increases the elasticity of (residual) supply of milk facing the advertised market. In the case of cheese advertising, the increased sale of milk in cheese outweighs the reduced consumption of fluid milk and other dairy products in response to the advertising-induced rise in the price of milk. This contrasts with the fluid milk advertising case, where the horizontal supply linkages reduce the effectiveness of fluid milk advertising; the reduced consumption of cheese and other dairy products outweigh the increased sales of fluid milk. The difference is caused in part by the relatively inelastic demand for fluid milk; the higher milk price caused by cheese advertising has a relatively small effect on fluid milk consumption. Further, relatively inelastic demand for fluid milk results in a relatively inelastic supply of milk facing the cheese market, so that the advertising-induced increase in cheese demand results in a relatively large increase in the price of milk in cheese. The larger market share of milk in cheese also contributes to the difference, as the positive effects of cheese advertising in the cheese market outweigh the negative effects of cheese advertising in the (relatively small) fluid milk market.

The change in producer surplus from cheese advertising assuming no cross-market effects, $54 million, is 11% lower than the change in producer surplus with no cross advertising

Table 4. Market Effects of a 40% Increase in the Per Unit Check-off for Cheese Advertising

	1. Horizontal Demand and Supply Linkages[a]		2. No Horizontal Demand Linkages[b]		3. No Horizontal Demand or Supply Linkages[c]		4. No Cross-Advertising Effects[d]	
	% Change	Level Change	% Change	Level Change	% Change	Level Change	% Change	Level Change
Prices (cents per cwt)								
Net farm price of milk (W_f)	−0.277	−4.1	0.228	3.4	0.206	3.1	0.232	3.5
Blend price (W)	−0.120	−1.8	0.381	5.7	0.359	5.4	0.384	5.8
Processor price of milk in fluid milk (W_1)	0.004	0.1	0.355	6.1	0.0	0.0	0.359	6.1
Processor price of milk in cheese (W_2)	0.005	0.1	0.435	6.1	1.075	15.0	0.439	6.1
Processor price of milk in other products (W_3)	0.005	0.1	0.424	6.1	0.0	0.0	0.428	6.1
Quantities (million lbs. per year)								
Farm supply of milk (M)	−0.277	−491.1	0.228	403.8	0.206	364.6	0.232	411.1
Farm milk sold for fluid milk (M_1)	−2.196	−1,201.4	−0.063	−34.4	0.0	0.0	−0.055	−29.9
Farm milk sold for cheese (M_2)	1.075	715.0	0.868	577.5	0.548	364.6	0.874	581.1
Farm milk sold for other dairy products (M_3)	−0.009	−4.7	−0.250	−139.3	0.0	0.0	−0.252	−140.6
Producer surplus (mil. dollars per year)		−73		60		54		61

Note: To conserve space, we do not report results for retail prices and quantities. Under our assumption of constant returns technology, percentage changes in the retail price and quantity of each dairy product are equal to the percentage changes in the farm price and quantity of milk used in that product.
[a] Assumes demand elasticities equal to the values reported in table 1.
[b] Cross-price and cross-advertising elasticities are assumed equal to zero ($\eta_{ij} = 0$ and $\alpha_{ij} = 0, i \neq j$).
[c] All prices and quantities in markets for fluid milk and other dairy products are assumed exogenous.
[d] The cross-advertising elasticities between cheese and fluid milk are both set equal to zero ($\alpha_{ij} = 0, i \neq j$).

elasticities, $61 million (scenario 4). Again, analyses that ignore the cross-market effects misstate the returns to advertising, even when cross-advertising effects are negligible.

Optimal Advertising Expenditure of Dairy products

In table 5 we report the optimal check-offs and advertising expenditures for each product for each of the four scenarios, using equations (39) and (40). The results mirror those of the simulations reported in tables 3 and 4 and discussed above. Optimal advertising expenditure for fluid milk under the assumption that no horizontal relationships exist between dairy product markets ($316 million in scenario 3) is between 18% (compared to $268 million in scenarios 2 and 4) and 118% (compared to $145 million in scenario 1) greater than optimal expenditure under the more general models. In the case of cheese advertising, optimal expenditure assuming no horizontal linkages is larger or smaller than optimal expenditure under the more general models, depending on the magnitude of the cross-advertising elasticities and other model parameters. Optimal cheese advertising expenditure is zero in scenario 1.

Table 5. Optimal Advertising Expenditure Under Alternative Model Assumptions

		Horizontal Demand and Supply Linkages		No Horizontal Demand Linkages[b]	No Horizontal Demand or Supply Linkages[c]
		Large Cross-Advertising Elasticities[a]	No Cross-Advertising Elasticities[d]		
Fluid milk advertising					
EW/Et_1[e]		0.005	0.010	0.010	0.012
Optimal check-off	cents per cwt	8.2	15.1	15.1	17.9
Optimal expenditure	mil. dol.	145	268	268	316
Cheese advertising					
EW/Et_2[e]		−0.003	0.010	0.010	0.009
Optimal check-off	cents per cwt	0	14.5	14.3	13.5
Optimal expenditure	mil. dol.	0	256	254	239

[a] Assumes demand elasticities equal to the values reported in table 1.
[b] Cross-price and cross-advertising elasticities are assumed equal to zero ($\eta_{ij} = 0$ and $\alpha_{ij} = 0, i \neq j$).
[c] All prices and quantities in markets for fluid milk or cheese (depending on the advertising scenario) and other dairy products are assumed exogenous.
[d] The cross-advertising elasticities between cheese and fluid milk are both set equal to zero ($\alpha_{ij} = 0, i \neq j$).
[e] The optimal check-off and optimal advertising expenditure are proportional to EW/Et_i, the elasticity of the blend price of milk with respect to the check-off for the advertised product (equations (39) and (40)).

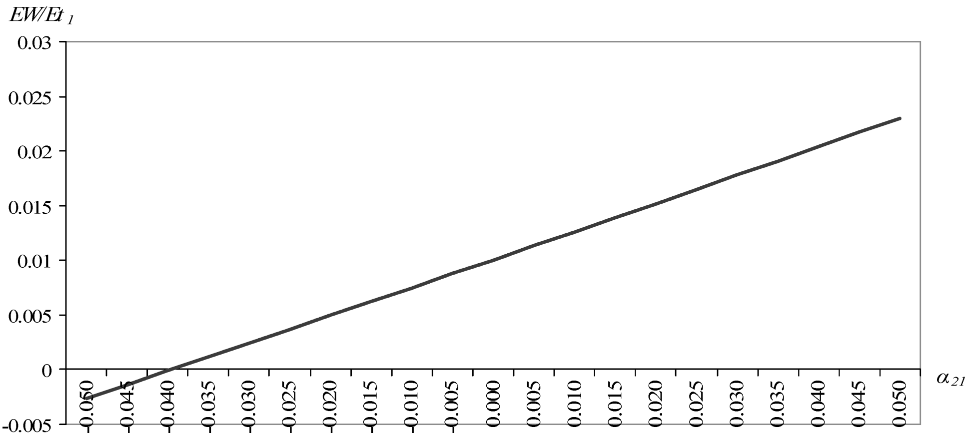


Figure 1a. Sensitivity of the effectiveness of fluid milk advertising (EW/Et_1) to the elasticity of demand for cheese with respect to advertising expenditure for fluid milk (α_{21})

Figures 1a–d illustrate the sensitivity of optimal advertising for fluid milk to key model parameters. In each figure, the vertical axis measures EW/Et_1, to which the optimal check-off and advertising expenditure for fluid milk are proportional.[6] Figure 1a shows that EW/Et_1 is increasing in the cross-advertising elasticity of demand for cheese with respect to fluid milk advertising (α_{21}), and may be negative for large, negative values of α_{21}.[7] Figures 1b and 1c show that EW/Et_1 is also increasing in the elasticity of demand for fluid milk with respect to the price of cheese (η_{12}) and in the elasticity of demand for cheese with respect to the price of fluid milk (η_{21}). Under our assumption that cheese and fluid milk are substitutes, the advertising-induced rise in the price of fluid milk increases the demand for cheese, and the rise in the price of cheese induced by fluid milk advertising feeds back to increase the demand for fluid milk. These feedback effects increase as η_{12} and η_{21} increase. Figure 1d shows that EW/Et_1 is increasing in the own-price elasticity of demand for cheese. As demand for cheese becomes less elastic, the (residual) supply of milk facing the advertised market becomes less elastic, and the

[6] All model parameters are held constant at the values used in scenario 1, as reported in tables 1 and 2.
[7] $EW/Et_1 < 0$ implies that the optimal check-off and advertising expenditure for fluid milk are zero.

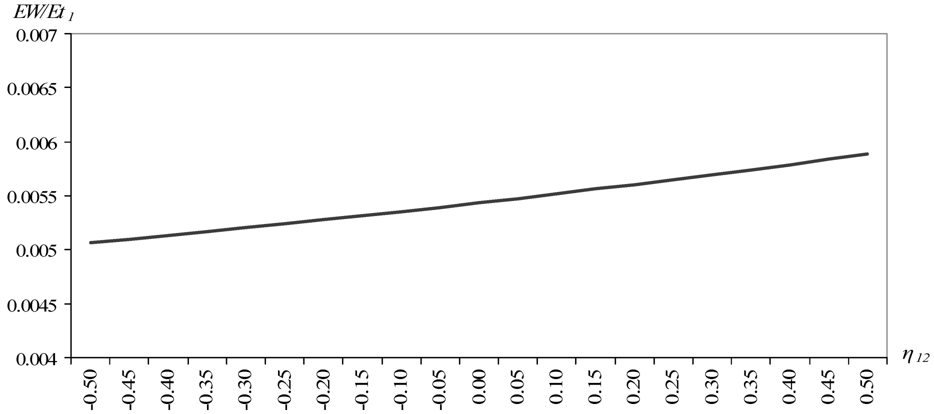


Figure 1b. Sensitivity of the effectiveness of fluid milk advertising (*EW/Et*$_1$) to the elasticity of demand for fluid milk with respect to the price of cheese (η_{12})

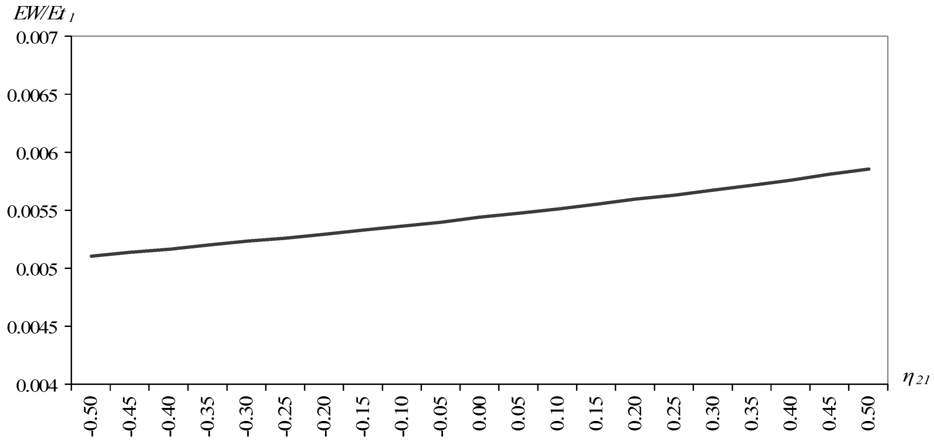
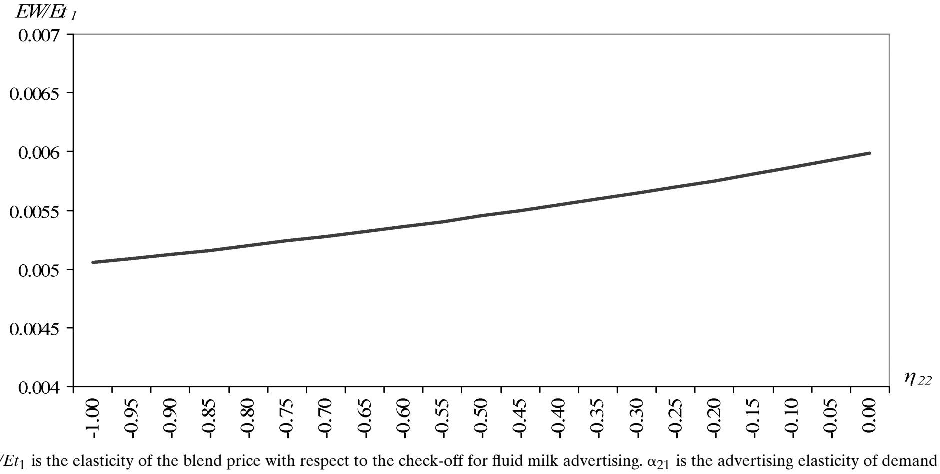


Figure 1c. Sensitivity of the effectiveness of fluid milk advertising (*EW/Et*$_1$) to the elasticity of demand for cheese with respect to the price of fluid milk (η_{21})



Note: EW/Et_1 is the elasticity of the blend price with respect to the check-off for fluid milk advertising. α_{21} is the advertising elasticity of demand for cheese with respect to per unit check-off for fluid milk advertising, η_{12} the price elasticity of demand for fluid milk with respect to cheese price, η_{21} the price elasticity of demand for cheese with respect to fluid milk price, and η_{22} the own-price elasticity of demand for cheese. In each figure, all model parameters (except that measured on the horizontal axis) are held constant at the values used in scenario 1.

Figure 1d. Sensitivity of the effectiveness of fluid milk advertising (*EW/Et*$_1$) to the own-price elasticity of demand for cheese (η_{22})

advertising-induced shift in demand for fluid milk has a larger effect on the price of milk.

Conclusion

This article provides theoretical and empirical evidence that producer-funded generic advertising for dairy products has important spillover and feedback effects that influence the return to advertising and optimal advertising expenditure. We draw on the concept, highlighted recently in this journal by Alston, Freebairn, and James (2001), that commodity advertising increases demand for the advertised product at the expense of producers of substitute commodities. We extend this idea to the case of the dairy sector, where dairy farmers produce a single commodity that is used in multiple products, some of which are related in demand. We show that in this setting, the spillover effects of product-specific advertising are internalized and should be considered to accurately measure the returns to advertising.

A multitude of empirical research has assessed the economic effects of dairy advertising in the United States. With few exceptions, this literature has considered only the partial equilibrium effects of advertising in the advertised market. Our multimarket equilibrium displacement model of the dairy sector makes explicit the implications for dairy advertising of horizontal linkages across dairy markets. Cross-price and cross-advertising elasticities of demand cause shifts in demand for non-advertised dairy products, and feedback effects in the advertised market. Moreover, dairy product markets are linked through the common use of milk, so that an advertising-induced increase in demand for milk in one product raises the price of milk in all products.

Numerical simulations of our model suggest that the extant literature does not accurately measure the returns to dairy advertising. In our simulations we find that analyses of fluid milk advertising that ignore cross-market effects overstate returns to dairy farmers by at least 22% and by as much as 219%. Further, we find that generic cheese advertising in the presence of cross-market effects may actually reduce producer welfare, a result driven in part by milk marketing order regulation that raises the price of milk in fluid products and reduces the price of milk in cheese and other manufactured dairy products. In this case, analyses that ignore cross-market effects misstate not only the magnitude, but the direction of the effects of generic advertising.

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