WP 2007-04
March 2007

Working Paper

Department of Applied Economics and Management
Cornell University, Ithaca, New York 14853-7801 USA

The Impact of Generic Fluid Milk and Cheese Advertising on Regulated Dairy Product Markets: A System Dynamics Analysis

Charles F. Nicholson, Cornell University
Harry M. Kaiser, Cornell University

The Impact of Generic Fluid Milk and Cheese Advertising on Regulated Dairy Product Markets: A System Dynamics Analysis

Charles F. Nicholson and Harry M. Kaiser

Department of Applied Economics and Management
Cornell University, Ithaca, NY 14853

Paper submitted for the Workshop on System Dynamics Modeling and Marketing Strategy, Cornell University, Ithaca, New York, May 31 – June 1, 2007

Introduction

Dairy farmers pay a mandatory assessment of 15 cents per hundred pounds of milk marketed in the continental United States to fund a national demand expansion program. This assessment generally ranges between 0.75 and 1% of the price farmers receive for their milk, and most of the money is devoted to generic advertising of fluid milk (e.g., Got Milk?) and cheese (e.g., Behold the Power of Cheese) products. The aims of this program are to increase consumer demand for fluid milk and dairy products, enhance dairy farm revenue, and reduce the amount of surplus milk purchased by the government under the Dairy Price Support Program. Legislative authority for these assessments is contained in the *Dairy Production Stabilization Act* of 1983. To increase fluid milk and dairy product consumption, the National Dairy Promotion and Research Board was established to invest in generic dairy advertising and promotion, nutrition research, education, and new product development. More recently, fluid milk processors began their own generic fluid milk advertising program (the Milk Mustache print media campaign), which is funded by a mandatory $0.20 per hundredweight processor "checkoff" on fluid milk sales. These two programs represent the two largest generic promotion programs in the United States, raising $370 million per year.

Generic advertising differs from traditional branded advertising in several important ways. First, while branded advertising is an individual firm's activity, generic advertising is a collective effort by all firms within an industry. Second, branded advertising attempts to differentiate a firm's product from its competitors; generic advertising is not geared at product differentiation and is most successful for products that are homogeneous in characteristics such as basic commodities. Third, the goal of generic advertising is to increase overall demand for a commodity, while branded advertising is primarily market share driven. If generic advertising is effective in increasing demand and price, the long run effectiveness of the program will depend critically on the nature of the supply response to the price increase. Consequently, in evaluating the impact of generic dairy advertising, modelers must explicitly link supply response to demand and price increases due advertising.

There has been a lot of research on the economic impacts of generic dairy advertising since it is the largest generic advertising program (see Ferraro et al. (1996) for a thorough annotated bibliography). This research falls into two broad categories. The first category of research has been positive in nature, and has evaluated what are the economic impacts of generic advertising on dairy markets. The majority of this research indicates that generic advertising has increased overall market demand and prices at all market levels, and the benefits of generic advertising substantially outweighs the cost. For instance, Kaiser (2006) found a benefit-cost ratio of 4.32 for fluid milk and cheese advertising by dairy farmers. The second line of research has been more normative in nature, investigating optimal allocation issues. Studies include optimal spatial allocation of advertising by markets (Liu and Forker, 1990), allocation of advertising over time (Vande Kamp and Kaiser, 2000), allocation of advertising across products (Kaiser and Forker , 1993), allocation of advertising by media type (Pritchett, Liu, and Kaiser, 1998) and allocation of expenditures by marketing and research activity (Chung and Kaiser, 1999). All these studies have either used econometric methods, optimization, or a combination of both. There have been no studies done that have used System Dynamics (SD).

There are two characteristics of U.S. dairy markets which present difficulties to researchers interested in modeling the impacts of generic dairy advertising. First, the U.S. dairy industry is one of the most heavily regulated markets in terms of economic regulations. Milk pricing at the farm and processor levels is significantly impacted by federal and state milk marketing orders, the Dairy Price Support Program, and import tariffs. Properly incorporating the impacts of these regulations on prices is essential for sound evaluation of generic advertising. Second, milk is a raw commodity that has many components that have differing end uses. This makes modeling all the possible uses for these components and the associated elaborate pricing structure of the market a complicated process. Unfortunately, the majority of previous studies have dealt with these issues through simplifying assumptions and aggregation of products, and have therefore omitted potentially important linkages that could effect the accuracy of the models. These two characteristics of the dairy market make the use of SD very appealing.

Accordingly, the purpose of this paper is to examine the impacts of generic advertising expenditures for fluid milk and cheese in a multiple-product dynamic simulation model, and examine selected expenditure strategies to increase revenues received by dairy farmers. A broader objective is to contribute to our understanding of how generic advertising influences product markets.

Model Description

A conceptual feedback model (Figure 1) illustrates a number of the differences between the impacts of generic and branded advertising. First, one important overall objective of generic

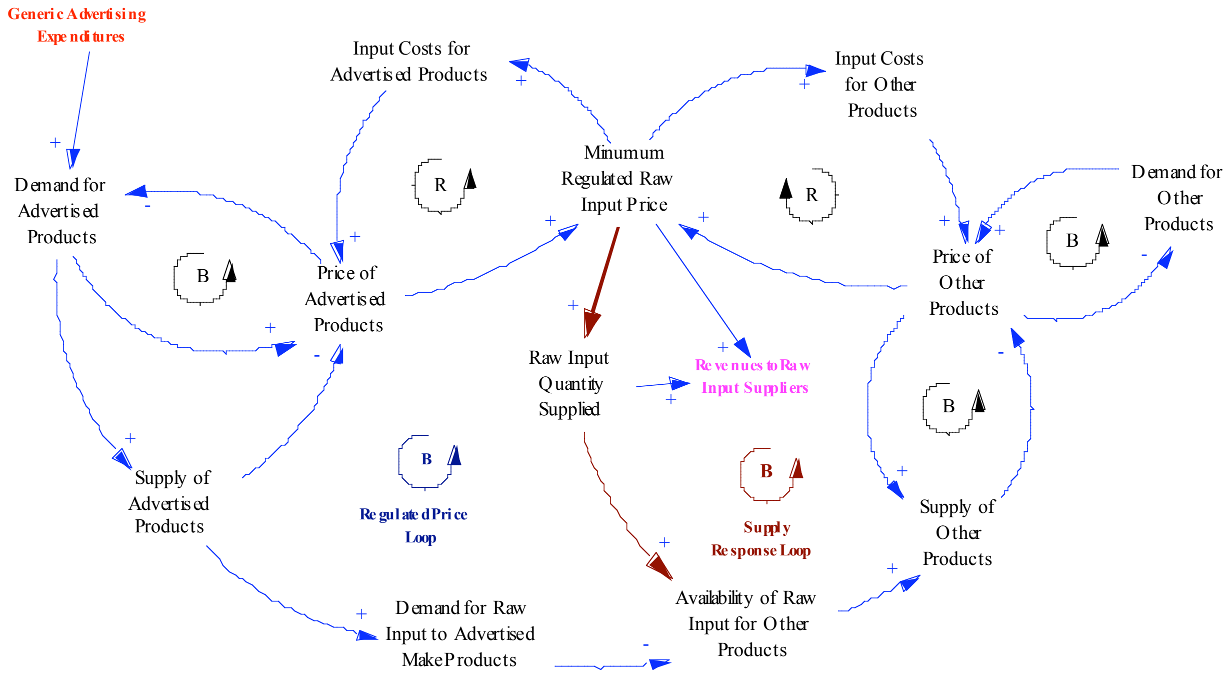

Figure 1. Conceptual Feedback Model of Generic Advertising Effects

advertising is to increase revenues for input suppliers (dairy farmers in this case). Generic advertising expenditures increase sales of the advertised products, which increases the demand for the raw input (milk) needed as an input to manufacture those products and increases their price. Increased raw input use for the manufacture of advertised products (fluid milk, cheese) decreases the availability of the raw input to manufacture non-advertised products (butter, dried milk). This reduces the available supply of non-advertised products, increasing their price. Minimum raw input price regulation exists in the US dairy industry; the minimum price is calculated as a function of product prices and product for which the raw input is used. An increase in the price of non-advertised products increases the minimum regulated price, which increases input costs for manufacturers of both advertised and non-advertised products. The price increase for advertised products also contributes to increases in the minimum regulated price. This increases the revenues earned by raw input suppliers (the objective), but also increases input costs. The input cost increase increases the prices of all products, which will have a dampening effect on demand.

In addition to the typical (balancing[1]) feedback effects between price, supply and demand that operate in most markets there are two other feedback loops that influence that outcomes of generic advertising that merit mention. The first is the regulated price loop, which implies that the effects of generic advertising will be offset to a certain extent through increases in input costs for all dairy product manufacturers through increases in the minimum regulated price. The second balancing loop indicates that increases in the price for the raw input supplier will increase the quantity supplied of the raw product. This increases the availability of the raw input for use in the manufacture of non-advertised products, decreasing their price compared to what they would have been. An important issue in the evaluation of generic advertising expenditures is the extent to which minimum price regulation and raw input supply response feedback loops erode the effectiveness of advertising expenditures over time.

To evaluate the effectiveness of generic advertising in the dairy industry context, we developed a more detailed empirical model. This model builds upon the conceptual commodity model described in Sterman (2000) and the dairy industry price determination model developed by Nicholson and Fiddaman (2003). To capture the effects of minimum price regulation, the model includes a total of 17 final and intermediate[2] dairy products. Perishable products such as fluid milk, yogurt and ice cream are treated as flow variables for which production is equal to

---

[1] The term "balancing loop" (indicated in Figure 1 with a B) implies that an initial change in one of the variables in the loop will ultimately result in pressure for that variable to move in the direction opposite the change, all other things being equal. .In contrast, a "reinforcing loop" (indicated in Figure 1 with an R) indicates than an initial change will be reinforced through the feedback process. More formally, loop polarity is defined as $SGN(\partial X_1^{Output} / \partial X_1^{Iuput})$ where SGN is the sign function and X^{Output} is the value of a variable X after one feedback cycle in response to an initial change in the value of X^{Input} (Sterman, 2000).

[2] In dairy modeling, "intermediate" products are those dairy products that are used in the manufacture of other products. A common example is the use of dried milk in cheese manufacturing. Final products are those used by non-dairy manufacturers (e.g, other food processors) or final consumers.

sales. Commercial inventories of storable commodities such as butter, cheese, dried milk and dried whey (used in the minimum pricing formulae) are represented as stock variables, where production increases inventories and sales reduces them. Increases in commercial inventories of these products result in decreases in the prices of these products. In the dairy industry, raw milk can be separated into a variety of components (butterfat, proteins, lactose and minerals) using various physical processes (e.g., filtration). Because of this, it is important to adequately represent the physical balance of these components across different product uses. This is represented in our model through the use of skim milk and cream components. (Essentially, cream represents fat and skim milk represents protein, lactose and minerals.)

In addition to the minimum regulated pricing that operates in the dairy industry, other key policy interventions include price supports for selected manufactured products (butter, cheese and dried milk) and restrictions on dairy product trade. Price supports operate through the willingness of the Commodity Credit Corporation (CCC; established by the federal government) to purchase dairy products at prices designed to maintain a minimum level of milk prices paid to dairy farmers[3], or through direct payments made to farmers when milk prices fall below a target level. Dairy trade policies restrict the quantities of many imported (storable) products, which maintains US milk and dairy product prices above those in international markets. Although under current market conditions they have limited impact on the effectiveness of generic advertising and are not shown in Figure 1, these policies are also represented in the empirical model.

Supply response is represented through changes in both productivity per unit capital (milk production per cow per year in this case) and changes in the capital stock (the number of

[3] When these purchases of butter, cheese or nonfat dried milk occur, then contribute to government inventory holding of these products. Government inventories are sometimes sold back to commercial firms or are used in domestic and international food donation programs.

cows). Productivity changes in response to changes in the price of the raw input (milk) in the short run (complete response to a step change in the milk price relative to a reference price occurs within about 3 months), whereas the number of cows responds to an exponential smooth of relative net margins over three years. The number of cows is determined by a biological reproduction rate (assumed to be constant) and the rate of removal of animals from the aggregated national herd, which depends on the average animal lifetime. The degree to which dairy farmers modify average animal lifetimes in response to relative margins is not well known, so the impacts of this parameter on simulated outcomes is evaluated with sensitivity analysis. Our structure assumes that dairy farmers will continue to expand herd sizes if long-run margins are above a constant reference value (albeit with both information and biological delays involved) and ignores changes in production costs over the model time horizon. These assumptions differ from many standard models of milk supply response (e.g., Chavas and Klemme, 1986) and make overshooting (and oscillatory) behavior in model-predicted milk prices more likely.

The impact of generic advertising on the demand for fluid milk and cheese is modeled using a modified multiplicative reference formulation (Sterman, 2000) as follows:

$$Sales_{jt} = SM\left[Sales_{jt}^{REF} \cdot \left(\frac{P_{jt}}{P_j^{REF}}\right)^{\eta_j} \cdot MAX\left\{MP_j, \left(\frac{GAE_{jt}}{GAE_j^{REF}}\right)^{\gamma_j}\right\}, AT\right]$$

$$Sales_{jt}^{REF} = Sales_j^{2004} \cdot \left(1 + \theta_j\right)^t$$

This formulation implies that sales of advertised dairy product j at time t are a function of a sales in the 2004 reference (base) year, product price P_j relative to reference price, and the maximum of the effect of generic advertising expenditures relative to their 2004 reference value or a minimum assumed proportion, MP_j, of the reference dairy product sales in the absence of generic advertising expenditures[4]. The parameters η_j are γ_j elasticities of sales with respect to price and generic advertising expenditures. Reference sales values are assumed to grow over time at proportional monthly growth rates θ_j. To reflect delays in the adjustment of sales to changes in price and generic advertising expenditures, exponential smoothing with a time constant of one month is used.

The model is formulated using System Dynamics conventions: it is a system of nonlinear differential equations solved by numerical integration. Model structure, response parameter values and initial stock values were developed based on previous dairy industry models (Bishop and Nicholson, 2004; Nicholson and Fiddaman, 2003), data from the Agricultural Marketing Service of the US Department of Agriculture (which administers the minimum pricing regulations), and an extensive network of industry contacts (Cornell Program on Dairy Markets and Policy, 2006). Values of the elasticity of fluid milk and cheese demand with respect to advertising expenditures are from Kaiser and Dong (2006), and are equal to 0.037 and 0.035, respectively. Values of the elasticity of fluid milk and cheese demand with respect to price are based on Schmit and Kaiser (2004) and Bishop and Nicholson (2004) and are equal to -0.2 and -0.5, respectively. The model simulates all variables at monthly time intervals over the six-year period 2004 to 2009[5]. The model has been evaluated using the process described in Sterman (2000) and has previously been used to evaluate the impact of growth in dairy product demand on dairy farmer revenues (Nicholson and Stephenson, 2006). For the purposes of the analyses herein, underlying growth in demand for dairy products (i.e., outward shifts in the demand curves) in response to increases in household income and population are assumed to be exogenous, and are from Nicholson and Stephenson (2006) and Schmit and Kaiser (2006).

[4] This formulation is necessary to avoid zero sales in the absence of generic advertising.
[5] Note that the time unit of observation is months, but the time unit of calculation (numerical integration) much smaller (0.0625 months) to minimize integration error.

Although the financial resources used for generic advertising in the dairy industry are derived from assessments on dairy farmers and fluid milk processors (and thus depend on milk production and sales of fluid milk) the allocation of funds to generic advertising is not proportional to funds available, so generic advertising expenditures are assumed to be exogenous[6].

Model Scenarios

We focus on two types of analyses of the dynamic market impacts of generic advertising (Table 1). The first is an analysis of permanent (i.e., "step") changes in generic advertising in the presence of growth in demand for dairy products, and the second is an analysis of which proportional allocation of 2004 advertising expenditures between fluid milk and cheese maximizes cumulative discounted dairy farmer revenues. For each of these scenarios, the impact of two assumed values of the long-term supply response (sensitivity of average animal lifetime—which influences cow numbers) to smoothed relative net margins for dairy farmers) is evaluated. For the baseline scenarios, the value of the sensitivity of average animal lifetime in response to relative net margins is equal to 1.0; for scenarios termed "less sensitive," the value of this parameter is 0.5. The average animal lifetime uses a multiplicative-reference formulation in which the average lifetime is equal to a reference lifetime modified by the ratio of current smoothed net margins divided by a reference net margin to the power of the sensitivity parameter described above. Thus, this is equivalent to the economics concept of a constant elasticity formulation.

[6] Funds from dairy farmers are used for a variety of promotional purposes, including product research and development and other forms of promotion in addition to advertising. Funds from fluid milk processors are used to promote fluid milk only; dairy farmer funds have been used for a variety of dairy products and dairy ingredients (Alan Reed, Dairy Management, Inc., personal communication).

Table 1. Generic Advertising Scenarios Analyzed

Scenario	Implementation
Baseline	Assumed exogenous growth rates for dairy products and 2004 level of generic advertising expenditure; Allocations between fluid milk and cheese as in 2004
Increase Generic Advertising	Increase generic advertising on both fluid milk and cheese by 100% from 2004 levels as a permanent (step) change beginning in January 2006
Eliminate Generic Advertising	Eliminate generic advertising on both fluid milk and cheese as a permanent (step) change beginning in January 2006
Optimal Product Allocation of Generic Advertising	Determine the optimal allocations of 2004 generic advertising expenditures between fluid milk and cheese as a permanent step change beginning in January 2006

Following standard system dynamics convention, the model is initialized in dynamic equilibrium (inflows and outflows for all stocks are equal, so that values of endogenous variables do not change over time) using the average values of product prices, production and dairy product inventories for 2004. Changes in generic advertising are assumed to be implemented fully (i.e., as step changes) in January 2006 and maintained until December 2009.

Key outcome variables to be assessed are changes in product sales, changes in selected dairy product prices, changes in dairy farmer revenues (monthly and cumulative), milk production (supply response) and the cumulative benefit-cost ratio (CBCR; the ratio of changes in dairy farmer revenues to changes in overall generic advertising expenditures). The changes in cumulative dairy farmer revenues and the CBCR are calculated from January 2006, when changes in generic advertising expenditures are assumed to occur. Because of the nonlinear feedback dynamics present in the system, each of these variables is likely to vary over time. The benefit-cost ratio of generic advertising, previously evaluated only in a static sense, is of particular interest.

Results

Impacts of Step Increases or Decreases in Generic Advertising Expenditures

A permanent increase in generic fluid milk and cheese advertising expenditures initially increases fluid milk sales during the first two months relative to the 2004 dynamic equilibrium baseline which also includes the assumed exogenous growth rates (Figure 2). As consumers respond over time to the associated price increases brought about by increased demand for the raw milk to make fluid milk and cheese, there is a relatively small decrease in fluid milk sales from their peak value during the next 12 months. This effect of increasing prices on sales is small because fluid milk demand is highly inelastic (0.2 is the elasticity value used in the simulations). About 16 months after the change in generic advertising expenditures fluid demand begins to grow again due to decreases in milk price (Figure 3) arising from increased milk production (Figure 4). The value of the sensitivity of the responsiveness of average animal lifetime to changes in long-run relative margins has a limited impact on fluid milk sales.

Permanent elimination of generic advertising expenditures reduces fluid milk sales by a larger amount than the permanent increase raises them (Figure 2). There is an initial rapid decrease in fluid milk sales, followed by a brief recovery, then continued decline. The effect is larger than the effect of increased advertising expenditures, indicating an asymmetry in the effect of advertising expenditures. The pattern is the inverse of that observed for expenditure increases, and again results from the interaction of dairy product demand, farm milk prices and milk production. The decrease in demand for fluid milk and cheese reduces the demand for raw milk from farms, which reduces milk prices and farm margins (Figure 3). As milk production

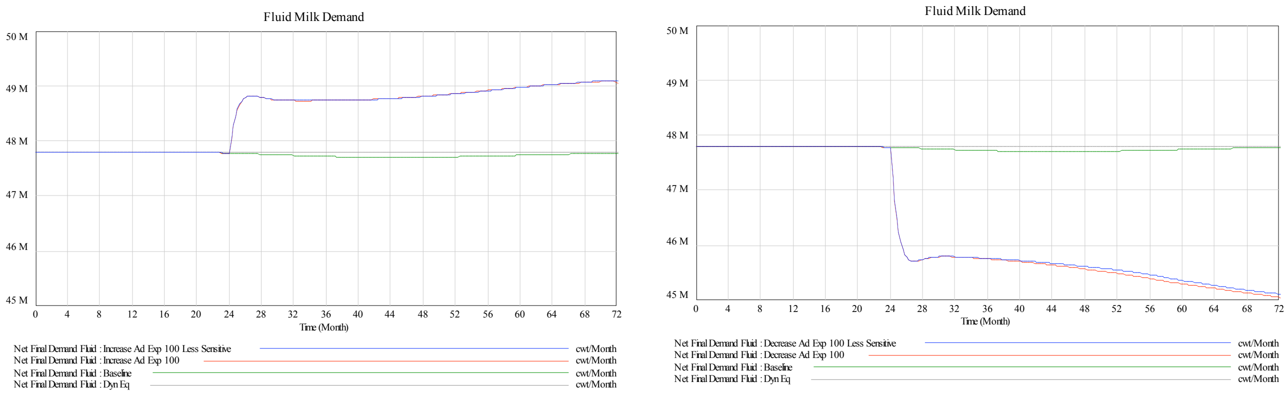

Figure 2. Fluid Milk Sales in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

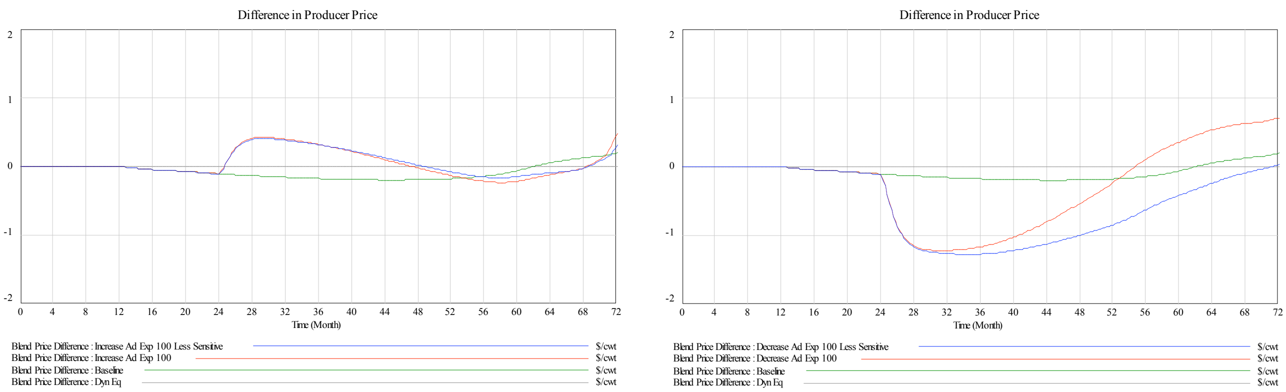

Figure 3. Difference in Producer Milk Price in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

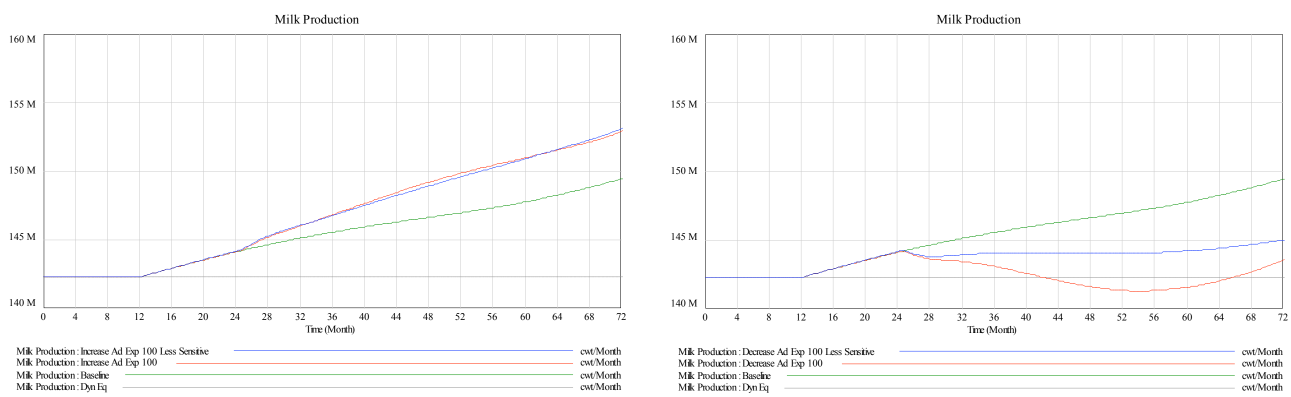

Figure 4. Milk Production in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

capacity responds over time, milk production decreases relative to what it would have been, and milk prices increase compared to what they would have been (Figure 3). An important conclusion to be drawn from these results is that milk prices will not always be higher for the scenario with increased generic advertising, nor lower for the scenario with elimination of generic advertising (Figure 3). As milk production responds over time to initial price increases or decreases through the supply response feedback loop, about 30 months after the increase or decrease farmer milk prices become higher (for the decrease) or lower (for the increase) than they would have been in the absence of any change in generic advertising expenditures.

The patterns of changes in cheese sales in response to generic advertising changes are qualitatively similar to those for fluid milk (Figure 5). However, cheese sales increase more rapidly and continuously in the case of increased generic advertising expenditures because the assumed underlying rate of growth in cheese demand is about 1% per year, whereas it is 0% for fluid milk. Cheese sales also decrease more rapidly and continuously in response to a decrease in advertising expenditures. These patterns are responses to the changes in cheese prices that occur in response to changes in generic advertising expenditures (Figure 6). In response to the increase in sales due to increased advertising, cheese prices initially increase by about 7 cents per pound during the first six months. After that, as consumers decrease cheese purchases in response to increased cheese prices and dairy farmers increase milk production, commercial inventories of cheese accumulate and the price decreases. By about two years after the increase in advertising expenditures, the cheese price becomes lower than it would have been in the absence of an increase in advertising.

Conversely, the elimination of all generic advertising initially results in a reduction in cheese prices of more than 10 cents per pound over the first six months, but by two years after

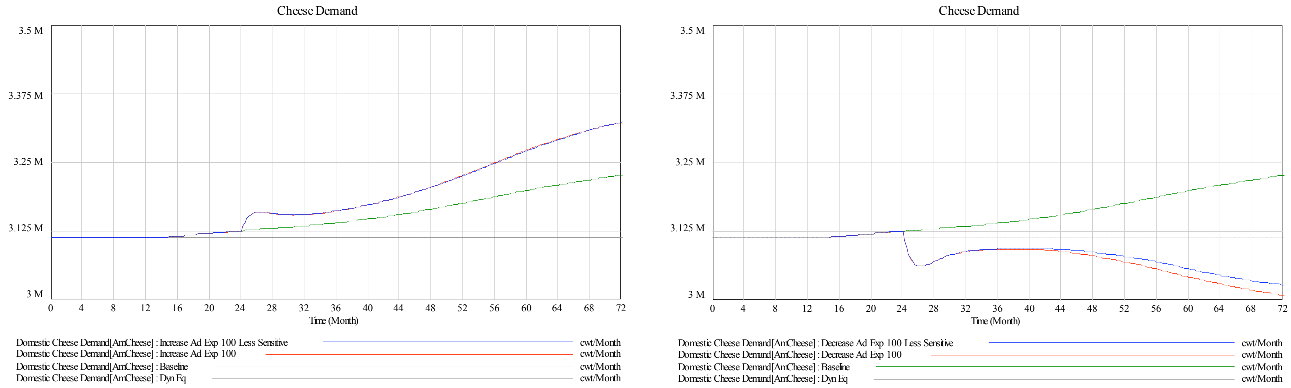

Figure 5. Cheese Sales in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

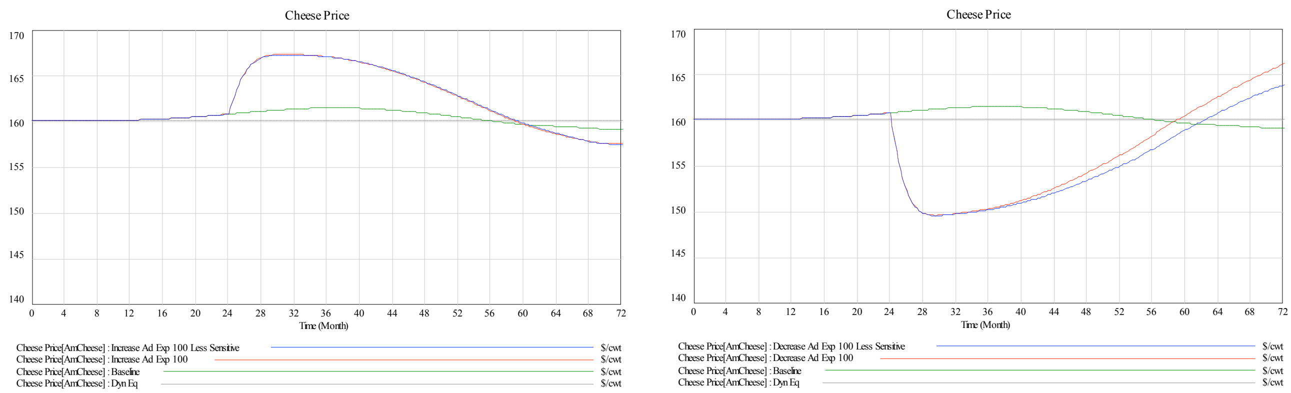

Figure 6. Cheese Prices in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

the change in advertising, cheese prices are higher than they would have been in the absence of the advertising change (Figure 6). Again, there is an asymmetric response to equivalent dollar-value changes in generic advertising expenditures. One additional difference is that the value of the sensitivity of producer adjustments in average animal lifetime results in more marked differences in cheese prices. When dairy farmers adjust more quickly, cheese prices rise more quickly over time, resulting in a 3 cent difference per pound by the end of model simulation.

As noted above, changes in generic advertising expenditures influence the price of cheese and the milk price received by farmers. This effect is mediated by the regulated price feedback loop, which increases the minimum regulated price as cheese prices increase, or decrease the

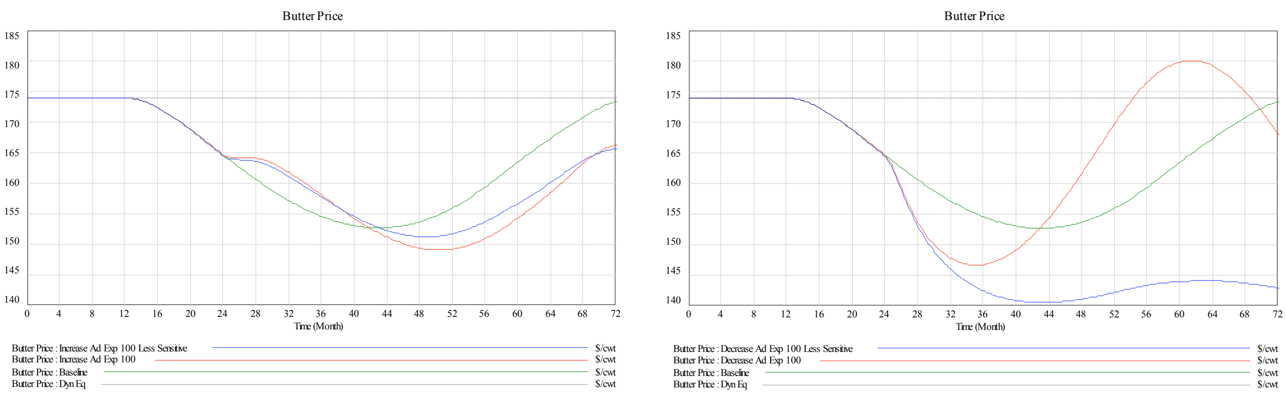

Figure 7. Butter Prices in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

minimum price as cheese prices decrease (all else equal). However, because there are multiple products made from the components in milk, prices of dairy products other than fluid milk and cheese will be influenced by changes in generic advertising expenditures. A good example is butter (Figure 7). Growth in demand for products assumed in the baseline is simulated to reduce the butter price over time. This occurs because the demand for dairy products made from milk components other than fat is increasing more quickly than those made with higher fat contents.

The impact of an increase in generic advertising expenditures is initially to increase the butter price from what it would have been, but after about 18 months butter prices are lower because milk production (and therefore butterfat) has increased and the demand for butterfat has not increased as quickly. Because butter is another product used in the minimum price regulation formulae, this decrease in the butter price offsets to a certain extent the impacts of generic advertising. When generic advertising expenditures are eliminated, an initial decrease in the butter price occurs. When producers are less responsive (modify average animal lifetime less in response to margin changes), butter prices remain low because milk production does not decrease as rapidly. When producers modify average animal lifetimes relatively quickly, there is a large and rapid increase in the butter price beginning one year after the elimination of generic advertising, and what appears to be the beginning of relatively large-amplitude fluctuations in butter price. Nicholson and Fiddaman (2004) and other dairy industry analysts have recognized for some time that butter prices tend to be more volatile in recent years than other dairy product prices, and our analysis suggests that changes in generic advertising expenditures—when dairy farmers are relative more responsive—may enhance the amplitude of butter price fluctuations.

One principal objective of generic advertising for fluid milk and cheese is to increase revenues received by US dairy farmers. Our analyses suggest that even when various balancing feedback loops are taken into account, expenditures on generic advertising return far more revenue to dairy farmers than the expenditures. An permanent doubling of generic advertising expenditures would increase cumulative dairy farmer revenues by about \$3 billion, but would cost only about \$485 million over the four years from 2006 to 2009 (Figure 8). Elimination of generic advertising expenditures would reduce dairy farmer revenues between \$5.3 and \$7.5 billion over those four years, when the sensitivity of milk production to changes in long run margin is higher and lower, respectively.

The cumulative benefit-cost ratio (CBCR) at time *t* can be computed during the period 2006 to 2009 as:

$$CBCR_t = \frac{\sum_{t=2006}^{2009} Reveues_t^S - Revenue_t^B}{\sum_{t=2006}^{2009} GAE_t^S - GAE_t^B}$$

where $Revenues_t$ are the cumulative dairy farmer revenues at time t for scenarios S and B (the baseline) and GAE_t are generic advertising expenditures for the same scenario. The CBCR varies over time depending on developments in dairy product markets (Figure 9). However, for both increases and decreases in generic advertising expenditures the CBCR grows rapidly then decreases. For a doubling of generic advertising expenditures, the CBCR increases to about 8.5

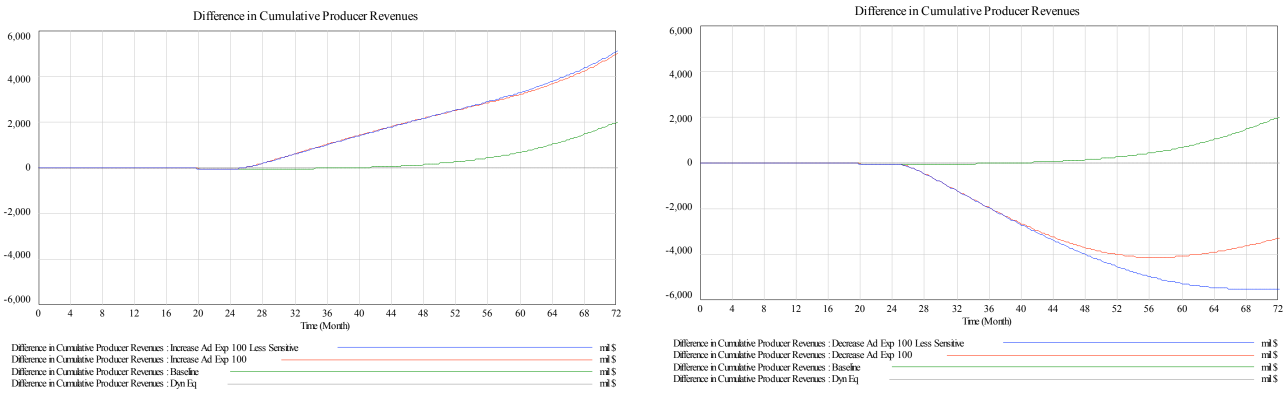

Figure 8. Difference in Cumulative Producer Revenues in Response to Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

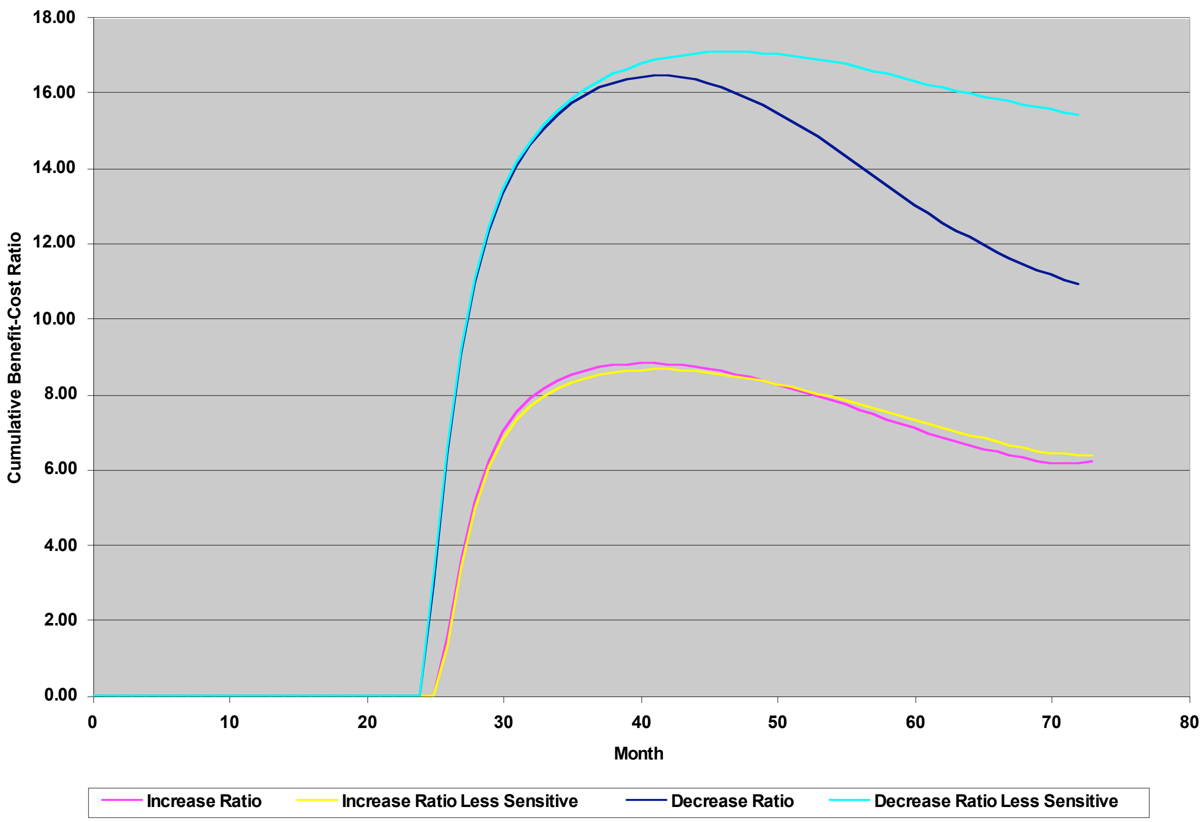

Figure 9. Dynamic Cumulative Benefit Cost Ratio for Increases and Decreases in Generic Advertising Expenditures, by Sensitivity of Capital Investment Response

and then decreases to a value just above 6. These estimates are higher than past benefit-cost ratios estimated for generic dairy advertising (e.g., 5.40 for the period 1975 to 1993 by Kaiser (1995). However, this is likely due to the fact that most previous estimates are net benefit-cost ratios, where our estimates are based on gross dairy farm revenue and therefore should be higher. The sensitivity of dairy farmers to average animal lifetime has little impact on the CBCR for generic advertising expenditure increases. If generic advertising were eliminated, the value of the CBCR is larger (after the initial increase, it is greater than 11.0) and the ratio is larger when dairy farmers are less sensitive (Figure 9). The differences in the values of these dynamically-calculated CBCR are also indicative of asymmetric responses to increases and decreases in generic advertising expenditures.

Overall, the scenarios indicate that on average over the period 2006 to 2009, increased generic advertising expenditures on fluid milk and cheese would increase fluid milk and cheese sales, increase milk production, increase cumulative dairy farmer revenues, and have a CBCR far larger than 1.0 (Table 2). Conversely, elimination of the generic advertising expenditures would decrease fluid milk and cheese sales, decrease milk production, and decrease cumulative dairy farmer revenues. Moreover, the CBCR of generic advertising expenditures appear to be larger at smaller expenditures levels, as indicated by the asymmetries in response in doubling and elimination. Thus, our analyses support the effectiveness of generic advertising to enhance dairy farmer well-being, even in the face of multiple feedback loops and product market effects.

Allocation of Existing Expenditures to Maximize Cumulative Dairy Farmer Revenues

Although the overall effectiveness of generic advertising expenditures is addressed in our previous analyses, another relevant question is whether those expenditures are being allocated in a manner that maximizes their effectiveness, that is, that generates the largest cumulative dairy

Table 2. Summary of Simulation Scenario Results

Scenario	Cumulative Advertising Expenditures ($ mil)	Average Fluid Milk Sales (mil lbs/mo)	Average Cheese Sales (mil lbs/mo)	Average Milk Production (bil lbs/mo)	Cumulative Producer Revenues ($ bil)	Cumulative Benefit Cost Ratio[1]
Baseline (with demand growth)	495.3	4774.5	317.1	14.7	117.3	--
Change from Baseline						
Increase Generic Advertising						
Base supply response	+495.3	+110.2	+4.9	+0.2	+3.0	6.2
Less sensitive supply response	+495.3	+110.3	+4.8	+0.2	+3.1	6.4
Eliminate Generic Advertising						
Base supply response	-495.3	-216.9	-10.5	-0.4	-5.3	10.9
Less sensitive supply response	-495.3	-213.2	-9.7	-0.2	-7.5	15.4
Optimal Product Allocation of Generic Advertising						
Base supply response	0.0[2]	-68.0	+7.0	0.1	+2.0	--[3]
Less sensitive supply response	0.0[2]	-65.3	+7.2	0.1	+1.5	--[3]

[1] The cumulative benefit cost ratio is defined as the change in cumulative producer revenues (from the baseline) divided by the change in cumulative advertising expenditures (from the baseline) at the end of model simulation time. It is calculated for the reported scenarios, not as a change from the baseline scenario.

[2] There is no overall change in aggregate generic advertising expenditures. However, $2.3 million of the funds provided by dairy farmers is switched from fluid milk to cheese advertising expenditures.

[3] Not reported because there is no change in cumulative advertising expenditures, only a reallocation among the two advertised products.

farmer revenues. Because the component contents of fluid milk and cheese differ (the proportion of other solids to fat is higher in fluid milk), because their estimated demand elasticities differ and because they have different impacts on the minimum regulated price formulae, it is possible that re-allocation of generic advertising expenditures may modify dairy farmer revenues.To explore this hypothesis, and to determine what allocation between fluid milk and cheese would maximize cumulative dairy farmer revenues, the Powell optimization algorithm in Vensim® dynamic simulation software (Ventana Systems, 2002) was used to examine what step change in fluid milk advertising expenditures from funds provided by dairy farmers would maximize cumulative revenues for dairy farmers. Because fluid milk processors allocate checkoff funds only to generic advertising of fluid milk, generic advertising expenditures by fluid milk processors was assumed to be constant. A corresponding change in generic advertising expenditures for cheese by dairy farmers was made to keep overall expenditures on generic advertising expenditures constant. The optimization assumed a permanent, simultaneous step change in allocation of generic advertising expenditures starting in January 2006[7].

The optimization results suggest that dairy farmer revenues could be increased through a complete reallocation of fluid milk advertising expenditures to cheese expenditures for funds provided by dairy farmers (Table 2). A reduction of 100% in fluid milk advertising expenditures by dairy farmers in expenditures on fluid milk (from about $2.3 million per month) and an increase of 141% in cheese expenditures (from $1.7 million per month to $4.1 million per month) maximizes dairy farmer revenues. It is important to note that under this optimal solution, there still is significant generic fluid milk advertising, but it is being financed entirely by fluid milk processors. The optimal allocation of advertising expenditures to the two products was not at all sensitive to the responsiveness of average animal lifetime. The dynamic patterns of behavior observed as a result of the optimal reallocation of expenditures results in a reduction in fluid milk sales and increase in cheese sales, with behaviors similar to those observed for these products in response to a decrease and increase in advertising expenditures, respectively (Figure 10). Producer prices first increase, then decrease, then increase again in response the reallocation, more so in the final months of the simulation than as a part of the initial response. Our results indicate that increases in cumulative dairy farmer revenues can be achieved through

[7] Note that this is distinct from an optimization approach to determine the optimal allocation of advertising expenditures across products and over time. This may be the subject of future work with the current modeling framework.

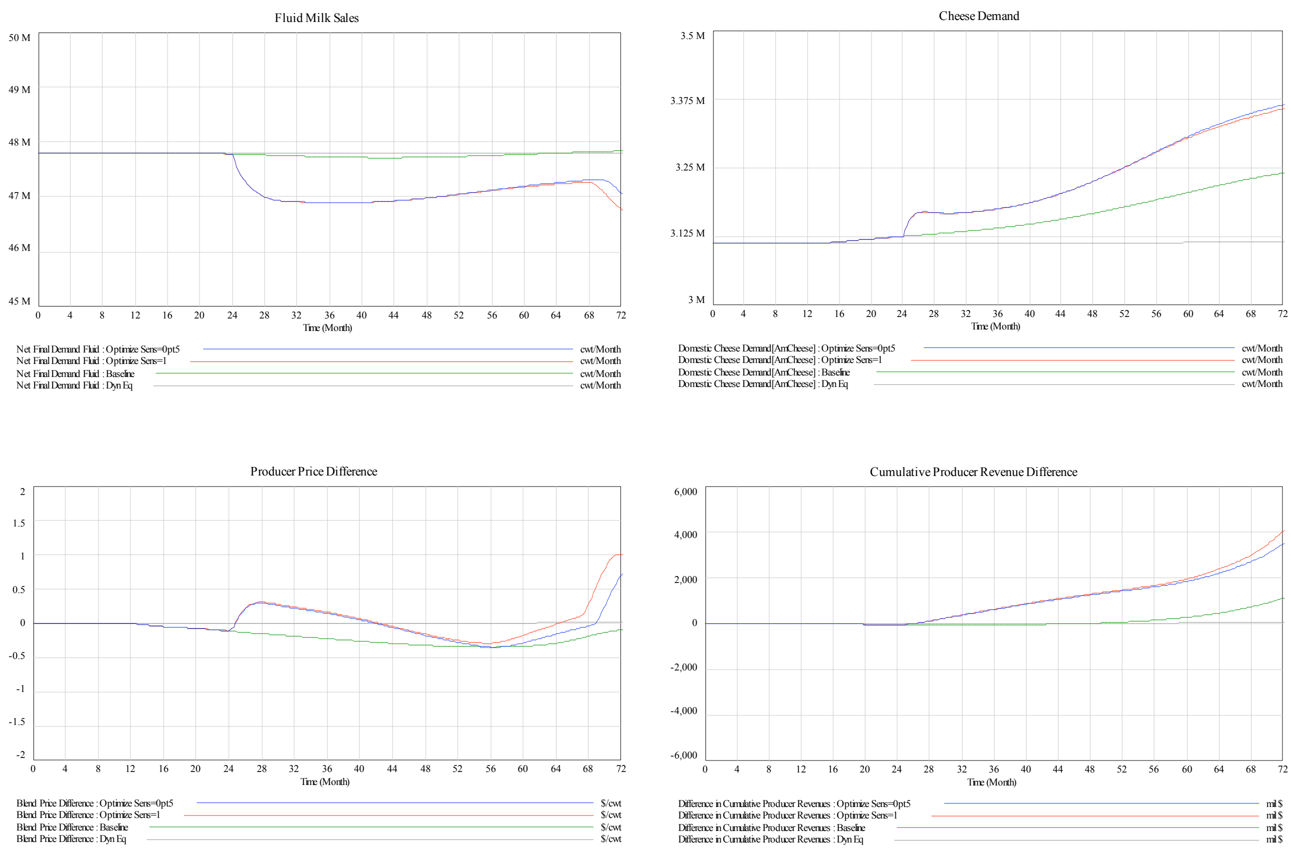

Figure 10. Selected Impacts of Changes to Allocation of Generic Advertising Expenditures by Dairy Farmers between Fluid Milk and Cheese to Maximize Discounted Producer Revenues

reallocation of existing expenditures that are one-half to two-thirds as large as those achieve through a doubling of expenditures but with the current product allocation, depending on dairy farmer responsiveness to average animal lifetime (Table 2).

Conclusions and Implications

Although there have been numerous econometric evaluations of generic dairy advertising, this is the first study that has applied System Dynamics to this type of research. The use of SD in generic dairy advertising evaluation is a contribution because it provides for a more complete model of the complexities of milk characteristics and economic regulations of the U.S. dairy industry. In particular, our SD model more realistically links milk supply response, dairy economic regulations, and pricing of all milk components than previous models, and thereby adds a more comprehensive analysis of generic advertising impacts on the industry.

Our analysis reaffirms the findings of other authors that generic dairy advertising is a highly profitable activity on the part of dairy farmers and milk processors. Indeed, the estimated cumulative benefit-cost ratios from this analysis are higher than previous estimates, but this is due to our estimates being gross measures while previous estimates have been net measures. Furthermore, unlike previous research, the results of this model provide detailed time paths of the response of important endogenous variables to changes in generic fluid milk and cheese advertising. One of the more interesting findings is the interaction between changes in demand caused by advertising, milk supply response, and prices. Specifically, we find that in the very short run, changes in advertising are positively associated with changes in prices. However, over time, milk production responses significantly erode the price impacts of advertising. This effect results in part from our assumptions about factors driving milk production response, suggesting that further research on micro-level production responses would be beneficial. The optimal product allocation of generic advertising was also investigated. The results indicate that fluid milk advertising should be reduced, and cheese advertising increased in order to maximize dairy farmer revenue.

One aim of this paper was to illustrate the usefulness of SD in advertising evaluation. There are many useful research extensions that could be made with this model, and we briefly discuss three of them here. One useful extension would be to use the current model to evaluate the optimality of other program activities such as other promotion programs, public relations, sponsorship, and new product research. Since more money is being invested by dairy farmers in alternative activities, an optimal portfolio analysis of this sort would be of tremendous interest to policy makers. Second, the optimal allocation of both advertising expenditures and other promotional activities over time could be analyzed, and could improve cumulative dairy farmer revenues through reduction of the effects of the supply response feedback loop (which results in increased milk supplies). Finally, milk prices and supply response differ on a regional basis. Thus, a more significant extension of our work would be to develop a multi-regional model that explicitly incorporates the regional pricing structure and supply response differences. Such an extension would also allow evaluating optimal advertising spending over geographic markets.

References

Bishop, P. M., and C. F. Nicholson. 2004. Dairy Market Impacts of US Milk Proteins and Policy Alternatives. Department of Applied Economics and Management, Cornell University. [Research Bulletin 2004-08]

Chavas, J.-P. and R. M. Klemme. 1986. Aggregate Milk Supply Response and Investment Behavior on US Dairy Farms. *American Journal of Agricultural Economics*, 68(1):55-66

Chung, Chanjin and Harry M. Kaiser. "Distributions of Gains from Research and Promotion in Multi-Stage Productions Systems: Comment." *American Journal of Agricultural Economics*. 81(1999):593-97.

Cornell Program on Dairy Markets and Policy. 2006. Dairy Contacts Listing. http://www.cpdmp.cornell.edu/CPDMP/Pages/Data/

Ferrero, Jennifer, Leen Boon, Harry M. Kaiser, and Olan D. Forker. "Annotated Bibliography of Generic Commodity Promotion Research (Revised)." *NICPRE Research Bulletin 96-3*, National Institute for Commodity Promotion Research and Evaluation, Department of Agricultural, Resource, and Managerial Economics, Cornell University, February 1996.

Kaiser, Harry M. 1995. An Analysis of Generic Dairy Promotion in the United States." Cornell University and National Institute for Commodity Promotion and Research Evaluation. [AEM Research Bulletin 95-01 and NICPRE 95-01].

Kaiser, H. M. and D. Dong. 2006. "Measuring the Impacts of Fluid Milk and Dairy Marketing. Department of Applied Economics and Management", Cornell University and National Institute for Commodity Promotion and Research Evaluation. [AEM Research Bulletin 2006-05 and NICPRE 2006-02].

Kaiser, Harry M. Chapter 3 of *USDA Report to Congress on the National Dairy Promotion and Research Program and the National Fluid Milk Processor Promotion Program*. USDA, Washington, D.C., 2006.

Kaiser, Harry M., and Olan D. Forker. "Analysis of Generic Dairy Advertising Scenarios on Retail, Wholesale, and Farm Milk Markets." *A.E. Res. 93-3*, Department of Agricultural Economics, Cornell University, June 1993.

Liu, D. and O. Forker. "Optimal Control of Generic Fluid Milk Advertising Expenditures." *American Journal of Agricultural Economics.* 72(1990):1047-1055.

Nicholson, C. F. and M. W. Stephenson. 2006. Market Impacts of High-Protein Whey Product Promotion. Report to Dairy Management, Inc., January.

Nicholson, C. F. and T. Fiddaman. 2004. How Volatile Have Milk Prices Been? *Hoard's Dairyman*, p. 91, February 10, 2004.

Nicholson, Charles F. and Thomas Fiddaman. 2003. Dairy Policy and the Origins of Dairy Price Volatility. Paper presented at the 21st International Conference of the System Dynamics Society, July 20-24, 2003, New York, NY.

Pritchett, James G., Donald J. Liu, and Harry M. Kaiser. "Optimal Choice of Generic Milk Advertising Expenditures by Media Type." *Journal of Agricultural and Resource Economics*. 23(1998):155-69.

Schmit, T. M. and H. M. Kaiser. 2006. Forecasting Fluid Milk and Cheese Demands for the Next Decade. *Journal of Dairy Science*, 89:4924-4936.

Sterman, John D. 2000. Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston: Irwin/McGraw-Hill.

Vande Kamp, Philip R. and Harry M. Kaiser. "Optimal Temporal Policies in Fluid Milk Advertising." *American Journal of Agricultural Economics*. 82(2000):274-86.

Ventana Systems, Inc. 2002. *Vensim's User's Guide, Version 5*.