Simulating BST Introduction in California for Dairy Policy Analysis

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An econometric model is estimated to simulate the impact of introducing bovine somatotropin (BST) on the California dairy industry. Forecasts of 1991–94 milk production and prices without BST are compared to those with BST under the 1990 Farm Bill. The effects are evaluated under a range in assumptions, given the uncertainty about BST's commercial benefits and costs. Results indicate the aggregate returns to BST introduction for California are positive, but small, assuming no adverse consumer reaction.

Key words: bovine somatotropin, California, dairy policy, econometric model.

Milk production in California has more than doubled in the last 20 years. Much of the increase in production was due to rising productivity per cow, a result of rapid adoption of improved management and production technologies. Bovine growth hormone or somatotropin (BST), a technology expected to be approved for commercial use in the early 1990s, has the potential to stimulate further production increases in the California dairy industry.

BST merits assessment for its potential impact on the California dairy industry for several reasons. Due to apparent concern about negative consumer reaction to a product which is a hormone and consumer concerns that recombinant BST may have a potentially adverse impact on smaller dairy farms, some retail chains in California have refused to accept milk from farms involved in BST research trials until BST is approved by the Food and Drug Administration. In addition, California is a large seller of surplus products to the Commodity Credit Corporation (CCC).[1] Further increases in production in California due to BST, or any other output-enhancing technology, are likely to add to the costs of the support price program, adding pressure to reduce the price support level. BST is also viewed as a technology which will exacerbate structural change. Survey work indicates larger farms in California are more receptive towards BST (Zepeda).

The purpose of the study reported here is to determine how BST will affect California's production of milk, producer and consumer prices, and government purchases under different assumptions about farmer behavior and government dairy policies. The Pacific region is extremely heterogeneous and California is a large player in both the region and the U.S. dairy industry. It produces the second largest amount of milk, and its producers are viewed as technological leaders who may be the most likely to be the first to adopt BST. In addition, California has its own milk marketing order, separate from the federal milk marketing order system. State policy makers could benefit from the economic analysis of the policy alternatives considered. The analytical results should also be useful to producers, industry groups, consumers, and others interested in the economic impact of BST.

Background

California's dairy industry is highly productive, large in scale, and composed of relatively few producers. Dairies in California tend to be

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[1] Until 1988 California sold 70–80% of its nonfat dry milk and 30–45% of its butter to the CCC [California Agricultural Statistics Service (CASS)].

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dry-lot farms where most feed and forage is purchased. Average production per cow in 1989 was 17,530 pounds. Production per cow grew an average of 4.3% in California over the past 20 years, two percentage points per year above the U.S. average [California Department of Food and Agriculture (CDFA) 1978–90a]. There were 2,401 dairies in California in 1989 with an average herd size of 460 milking cows (CASS). The average herd size in the U.S. in 1989 was 49 cows [U.S. Department of Agriculture (USDA) 1990].

California is not part of the Federal Milk Marketing Order System. Minimum prices for Grade A milk, over 97% of production, are determined by the California Department of Food and Agriculture (CDFA 1978–90a). Grade A milk component prices for butterfat (fat) and solids not fat (SNF) are classified by usage, but differ from federal classification.[2] Minimum Class 4 prices are set using the higher of national products market or support prices and adjusted for moisture content and the make allowance, where appropriate. Class 2 and 3 prices are set as differentials above the reference Class 4 price. The Class 1 price is the weighted average of the Class 4 price, the California Cost of Milk Production Index, and a California manufacturing wage index (CDFA 1984).

Revenues are pooled for all classes of milk and distributed to producers under a three-tiered priority system (CDFA 1974). The three categories are quota, base, and overbase. Quota is the right to receive the quota price set for milk by the CDFA. Quota prices have been about $1 to $1.50 per cwt. above base and overbase prices.[3] Quota and base can be bought and sold by producing dairy farmers, subject to approval by the CDFA. Base is the right to receive base price for milk and was originally linked to historic milk production. Since the amount of milk that is eligible for quota or base prices is predetermined, any excess production is sold at an overbase price. Hence, increases in milk supply generally result in lower average farm prices.

Dairy Market Models

Hallberg and Fallert; Wharton; Salathe et al.; and Wescott developed models to examine the effect of policy on the U.S. dairy industry. Since production per cow is endogenous in these models, analyzing exogenous changes in productivity, such as BST adoption, is not possible. Two other models, Krog's U.S. dairy industry simulation model and Milligan's model of the California dairy industry, permit analysis of exogenous productivity changes. Elements drawn from these two models for analysis of BST introduction are: modeling supply and demand at the producer, processor, and retail levels; establishing production per cow as a control variable; and separating of costs and prices in the farm supply equation. It is also convenient for policy analysis to permit the support price to be a control variable.

BST Studies

Simulations of the impact of BST on the U.S. dairy sector by Kaiser and Tauer indicated that a cow removal program and support price adjustments are the most attractive policies in terms of government costs and producer profits. Sellschopp and Kalter found that if support price and Class 1 differentials remain unchanged when BST is introduced, milk production shifts to the western states and results in "enormous government expenditures." A USDA study by Fallert et al. on the national economic impact of BST found government purchases increase and milk prices fall if BST is introduced. Blayney and Fallert's update of the study reached many of the same conclusions and emphasized that the impact of BST depends on U.S. dairy policy.

Existing research on BST is not directly transferable to California for two major reasons: California has its own marketing order with its own pricing rules and the Pacific region is not homogeneous. A market model of California's industry is needed to assess the impact of BST on milk production and prices at the farm, on retail prices, and on government purchases of dairy products from California.

The Structural Model

The California producer, processor, and consumer sectors are modeled as a system for an-

[2] Class 1 includes all drinking milk and yogurt; Class 2 includes cream, cottage cheese, and similar products; Class 3 contains frozen products; Class 4a is butter and powdered milk; and Class 4b is hard cheese (CDFA 1986).

[3] Base and overbase prices exceeded quota prices in late 1989 and early 1990 but have since fallen below quota prices.

Table 1. Model of the California Dairy Industry

(1) Farm Supply of Milk: $\bar{R}^2 = .98$

$Q_t =$	C	+ FP_{t-18}	+ $COST_t$	+ $TECH_T$	+ JF_t	+ MA_t	+ $MJJA_t$	+ SO_t	+ DTP_t	+ $DRT_t{*}FP_t$
Coefficients	−27.43	.99	−.534	3.847	−1.05	.585	2.177	1.27	−.467	.411
t-statistic	−16.7	12.5	−4.8	36.9	−4.4	2.6	9.8	5.1	−1.7	14.6
Elasticity		.285	−.126	1.473	−.004	.002	.017	.005	−.002	.01

(2) Price Determination Behavioral Equation: $\bar{R}^2 = .94$

$FP_t =$	C	+ SP_t	+ $COST_t$	+ $MANWAG_t$	+ Q_t
Coefficients	4.07	.72	.135	.876	−.114
t-statistic	11.8	22.8	3.4	8.2	−10.4
Elasticity		.683	.108	.263	−.39

(3) Retail Supply of Milk Products: $\bar{R}^2 = .96$

$RQP_t^S =$	C	+ RPP_t	+ SP_t	+ $DWAGE_t$	+ Q_t
Coefficients	−6.2	5.06	−1.336	−1.04	1.04
t-statistic	−5.1	1.6	−3.9	−8.8	19.4
Elasticity		.48	−.835	− .65	2.34

(4) Retail Demand for Milk Products: $\bar{R}^2 = .94$

$RQP_t^D =$	C	+ RPP_t	+ Y_T	+ $MJJA_t$	+ JF_t	+ SO_t	+ DRT_t
Coefficients	8.1	−8.506	1.707	2.95	−1.93	1.12	2.34
t-statistic	7.0	−9.6	29.0	12.1	−6.7	3.9	5.4
Elasticity		−.809	1.312	.053	−.017	.01	.012

(5) Retail Supply of Fluid Milk: $\bar{R}^2 = .62$

$RQF_t^S =$	C	+ RPF_t	+ FP_t	+ $MJJA_t$	+ SO_t
Coefficients	19.3	4.35	−.479	−.657	.428
t-statistic	44.0	9.5	−12.0	−8.1	4.5
Elasticity		.233	−.335	−.013	.004

(6) Retail Demand for Fluid Milk: $\bar{R}^2 = .69$

$RQF_t^D =$	C	+ RPF_t	+ Y_T	+ MA_t	+ $MJJA_t$	+ SO_t
Coefficients	17.4	−3.162	.2034	.104	−.346	.578
t-statistic	53.3	−6.8	13.7	2.5	−4.8	6.7
Elasticity		−.169	.166	.001	−.007	.006

(7) $CCC_t = Q_t - RQP_t^S - RQF_t^S$
(8) $RQP_t^S = RQP_t^D$
(9) $RQF_t^S = RQF_t^D$

Note: t = monthly observation; T = yearly observation. For definitions of variables, see table 2.

Table 2. Variable Definitions for the Econometric Model

C	= Constant.
CCC_T	= Sales of California products to the USDA's Commodity Credit Corporation, average daily sales in milk equivalents (million pounds per day). Source: CDFA, Bureau of Milk Stabilization (1988) and USDA, Agricultural Stabilization and Conservation Service (1988–90).
$COST_t$	= Variable cost to produce hundredweight of 3.5% market milk, South Valley, bimonthly (dollars per cwt.). Source: CDFA, Bureau of Milk Stabilization, January 1978–December 1990b.
DRT_t	= Dummy variable for 1988 drought.
DTP_t	= Dummy variable to indicate months the Dairy Termination Program was in effect (April 1986 through September 1987).
$DWAGE_t$	= Average hourly wage of dairy plant workers (dollars per hour). Source: Employment Development Department.
FP_t	= Average price paid farmers in California per hundredweight of 3.5% milk (dollars per cwt.). Source: CDFA (1978–90a).
FP_{t-18}	= FP_t lagged 18 months.
JF_t	= Seasonal dummy variable for January and February.
MA_t	= Seasonal dummy variable for March and April.
$MANWAG_t$	= Weekly earnings of manufacturing workers in California (hundred dollars per week). Source: Employment Development Department.
$MJJA_t$	= Seasonal dummy variable for May, June, July, and August.
Q_t	= Average daily production of milk in California (million pounds per day). Source: CDFA (1978–90a).
RPF_t	= Average retail price of milk in Sacramento and San Francisco (dollars per half gallon). Source: CDFA, Market News Branch.
RPP_t	= Average retail price for butter in Sacramento and San Francisco (dollars per pound). Source: CDFA, Market News Branch.
RQF_t	= Average daily quantity of Class 1 milk in California by month (million pounds per day). Source: CDFA (1978–90a).
RQP_t	= Retail quantity of Class 2, 3, and 4 products, average daily quantity (million pounds per day). Source: $RQP_t = Q_t - RQF_t - CCC_t$.
SO_t	= Seasonal dummy variable for September and October.
SP_t	= Federal support price for 3.5% butterfat manufacturing milk (dollars per hundredweight). Source: National Milk Producers Federation.
$TECH_T$	= Technology, average production per milk cow (thousand pounds per year). Source: CDFA (1978–90a).
Y_T	= Personal income per capita in California (thousand dollars per year). Source: California Department of Finance.

alyzing the effects of BST adoption. The farm milk supply and farm price of milk are specified to reflect formula pricing. Production is not separated into fat and SNF components. Government purchases are determined as a residual. Since there is no significant difference in the regional adoption response to BST within California (Zepeda), it is not necessary to model production regionally as Milligan did. His profit-per-cow variable is replaced with separate variables for costs and prices to analyze the effect of BST.

The California dairy industry model consists of six equations and three identities (table 1). The endogenous variables in the system are: the average daily production of milk in California (Q); the average farm price for milk in California (FP); the average daily retail supply (RQP^S) and demand (RQP^D) for Class 2, 3, and 4 dairy products; the average retail price for butter (RPP); the average daily retail supply (RQF^S) and demand (RQF^D) for Class 1 milk; the retail price for fluid milk (RPF); and the average daily purchase of California dairy products by the CCC (CCC). The control variables are the production per cow ($TECH$), which can be set to reflect the impact of BST on production, and the federal support price for milk (SP). Variables are listed in table 2; further details are available from the authors.

The farm supply of milk is specified as a function of lagged farm milk price[4] (FP_{t-18}), production costs ($COST$), technology level

[4] Farm price is lagged 18 months, to represent the length of the production decision. Since impregnated cows are brought to term to produce milk and bovine pregnancy lasts 10 months, the minimum lag in the production decision is 10 months. Culling decisions of new stock are made before breeding, 16 months after birth. Therefore, prices 10 to 26 months prior would influence the number of replacement heifers in the current period. Plots of farm prices and production indicate 18 months is the optimal lag. The fit of the model verifies this.

(*TECH*), seasonal dummy variables (*JF, MA, MJJA, SO*), a Dairy Termination Program (*DTP*) variable, and the interaction of the 1988 drought with the farm milk price ($DRT * FP_t$). The second equation is a behavioral price equation based on the CDFA formula pricing of milk.[5] The formula includes U.S. support price (*SP*), production costs (*COST*), and manufacturing wages (*MANWAG*). The farm milk supply (*Q*) is included to reflect that average farm price falls as quantity increases.

Equations (3) and (4) describe the retail supply of and demand for milk products. The retail quantity of milk products comprises all products which are not sold to the CCC, including out-of-state sales. Separate data do not exist for in-state and out-of-state retail product sales. Retail products supply is explained by retail products prices (*RPP*), the support price (*SP*), dairy production wages (*DWAGE*), and farm milk supply (*Q*). Retail product demand is explained by retail milk products prices (*RPP*), per capita income (*Y*), and dummy variables to reflect seasonal changes in the demand or storage[6] of dairy products (*JF, MJJA, SO, DRT*).

Equations (5) and (6) describe the retail supply of and demand for fluid milk. The retail supply of fluid milk is specified as a function of California retail fluid prices (*RPF*), the cost of milk to retailers, i.e. the farm price (*FP*), and dummy variables to reflect the school-year effects on contracts for sales of fluid milk (*MJJA, SO*). The retail fluid milk demand includes both institutional and government demands for fluid milk.[7] It is explained by the retail fluid milk price (*RPF*), consumer income (*Y*), and dummy variables to reflect shifts in demand during the school year (*MA, MJJA, SO*).

Equation (7) is an identity defining the sale of milk products to the USDA through the CCC as total California milk production minus milk consumed for retail products and fluid milk in the state. Since the support price is determined politically, and the CCC also buys outside of California, a demand equation for CCC purchases was not estimated. Identities (8) and (9) equate the supply and demand for milk products and fluid milk in California.

Results

Monthly data for January 1978 through December 1988 were used to estimate the model. The system of six equations was estimated using Three-Stage Least Squares which provides consistent and asymptotically efficient parameter estimates. The adjusted R^2, variable coefficients, t-statistics, and elasticities calculated at the means of the data are reported in table 1. All signs are consistent with economic theory.

The estimate of the supply elasticity for milk at the farm level from equation (1) is .285, at the lower end of the .25 to .92 range estimated by Milligan. For comparison, the long-run regional supply elasticity for the Pacific region estimated by Weersink and Howard was .42. The Dairy Termination Program did not significantly reduce production in California. However, the drought, through farm prices in 1988, had a significant positive effect on production. The initial drop in production due to the drought stimulated farm prices which caused an expansion in supply.

Although the state determines minimum class prices for milk, the pooled price farmers receive also depends upon the amount of milk produced. The estimated elasticity for farm price [equation (2)] is −.39%. Each 1% increase in the support price implies a .683% increase in the farm milk price. A 1% increase in the cost of production increases farm milk price by only .108%.

The retail supply of milk products in California [equation (3)] does not appear to be very price elastic. The estimated value is .48. However, the coefficient for price is not statistically significant. Reflecting the focus of California processors on government sales, the absolute value of the elasticity for support price is larger: .835. The estimated retail demand for milk products [equation (4)] is much more elastic, −.809, than the demand for fluid milk and than Milligan's estimates of −.04 to −.19. Milk products appear to be a slightly superior good; the income elasticity is 1.312. Milligan calculated an income elasticity of .5. This difference may reflect higher incomes and a greater

[5] Prices are not deflated because the CDFA formula is used to determine nominal prices.

[6] Note that data on retail products measure the goods bound for the retail market, not the actual quantities sold. Therefore, retail demand includes inventories held for retail markets.

[7] Data on institutional and government purchases and prices are unavailable, however, it is assumed that institutional and government prices follow retail price trends.

Table 3. Values of Endogenous Variables of California Dairy Model: Baseline Forecasts

Scenario 1	1990	1991	1992	1993	1994
Farm Milk Supply (million lbs.)	20,906	20,559	20,192	20,504	20,998
Farm Milk Price ($/cwt.)	12.05	10.89	10.95	10.87	10.75
Milk Products Supply/Demand (million lbs. milk equivalent)	12,143	12,088	12,023	12,416	12,926
Milk Products Price ($/lb.)	1.54	1.74	1.96	2.00	2.02
Fluid Milk Supply/Demand (million lbs.)	6,624	6,748	6,801	6,828	6,876
Fluid Milk Prices ($/half gallon)	1.10	1.05	1.08	1.10	1.11
Government Purchases (million lbs. milk equivalent)	2,139	1,724	1,367	1,261	1,195

emphasis on convenience in the late 1970s and 1980s.

The retail supply for fluid milk [equation (5)] appears inelastic. This reflects stable milk consumption between 1978 and 1988 and unchanged fluid milk contracts and fluid bottling capacity. Should a prolonged shift in fluid consumption occur, milk would be expected to move from lower-priced product use to the higher-priced fluid use. However, fluid consumption has fluctuated seasonally more than it has over the time analyzed. Consumer demand for fluid milk [equation (6)] is inelastic: −.169. Milligan calculated a price elasticity of −.05. The income elasticity of fluid milk indicates that it is a normal good and that income changes have the same magnitude effect as price. Milligan calculated an income elasticity for fluid milk of .09.

Estimates of the effect of technological change on retail quantities of milk products and fluid milk use were derived using coefficients of the model. Equations (10) and (11) are analytical derivations from the equations for farm milk supply (1), retail supply of milk products (3), and retail supply of fluid milk (5):

$$(10)\quad \frac{\partial RQP^S}{\partial TECH}\cdot\frac{TECH}{RQP} = \frac{TECH}{RQP}\cdot\frac{\partial RQP^S}{\partial Q}\cdot\frac{\partial Q}{\partial TECH},$$

and

$$(11)\quad \frac{\partial RQF^S}{\partial TECH}\cdot\frac{TECH}{RQF} = \frac{TECH}{RQF}\cdot\frac{\partial RQF^S}{\partial FP}\cdot\frac{\partial FP}{\partial Q}\cdot\frac{\partial Q}{\partial TECH}.$$

Substituting the estimated coefficients into equations (10) and (11) indicates that a 1% increase in productivity per cow in California results in a 3.45% increase in the retail supply of milk products and a .19% increase in the supply of fluid milk. For example, if BST increases milk production by 10% and is adopted by 50% of the milk producers, retail supplies of fluid milk would increase by .95% and retail supplies of dairy products would increase by 17%.

Simulated Scenarios

The estimated model is used to predict the effect of BST introduction on the aggregate supply of milk and milk products and their prices in California. The model is simulated for 1990 through 1994, without BST adoption, to provide a benchmark for assessing the impact of BST. The values of the endogenous variables generated for the baseline model are given in table 3.

Exogenous variable forecasts are as follows. Seasonal and other dummy variables are set according to their occurrence. Lagged farm price equals actual prices until 1990 and is generated by the model thereafter. Support price is a control variable. Linear regressions for the productivity index, *TECH*, and per capita income, *Y*, yield *R*-squared values of .92 and .99, respectively. Productivity increases due to BST are added to *TECH* and are discussed within each scenario. Box-Jenkins times-series forecasts of the cost of production and wage indices (*COST*, *MANWAG*, and *DWAGE*) generate unrealistic forecasts. A simple regression of the cost of production index with one lag and seasonal dummy variables yields an R-squared of .9. Wages of dairy plant workers (*DWAGE*) are forecast using wages lagged one and 12 months, and manufacturing wages are forecast with lagged wages and seasonal dummy variables. The R-squared of the respective models are .98 and .99.

Assumptions

Ranges in BST's price and effectiveness are used to reflect the degree of uncertainty about BST. It is not known when BST will be available for commercial use, however, 1991 has been chosen as a likely year. How much BST will cost is also unknown; its potential manufacturers wish to keep this information from their competitors. A range of 25–50¢ per day per cow including a syringe or other delivery system is used. It is assumed BST is used for 215 days out of a 305-day lactation period. The increase in fat corrected milk production for a full lactation is assumed to be 10% or 15% above the average untreated cow, which produces 180 cwt. of milk per lactation in California. Increases in veterinary and reproductive costs associated with BST use are assumed to be proportional to production increases. That is, a 10% or 15% increase in production results in a 10% or 15% increase in veterinary and reproductive costs.

Nytes, Combs, and Shook reported that BST-treated cows consume 9.2% more dry matter, while their milk production increases by 15%. This implies a 5% increase in feed efficiency or a 5% decrease in the average variable cost of producing milk. Regional estimates of feed costs within California range from $6 to $6.50 per cwt. of milk over five years. However, the components are not calculated for the entire state. Therefore, USDA data were used for a statewide ration. The USDA (1988) estimates that a ration costs $6.30 per hundredweight of milk produced in the Pacific region of the U.S., thus a 5% increase in feed efficiency equals a 32¢ decrease in the average cost of milk production.

Feeding more of the same ration is not an option for most California milk producers; they are already feeding for high production and the gut capacity of cattle is limited. Therefore, 32¢ represents the maximum feed savings possible per hundredweight of milk. To increase the energy fed to a cow, it is likely that the quality and cost of the ration would increase. If this offsets the increased revenues from added milk production, the change in average cost of production is zero. Therefore, it is assumed that feed savings is between zero and 32¢ per hundredweight of milk.

It is assumed that there is no change in consumer demand if BST is used. However, consumers in other states say they would prefer milk from cows not treated with BST and are willing to pay a premium for the milk (Douthitt). An analysis of the effect on farm returns of product differentiation on the basis of BST use is beyond the scope of this study.

Under these assumptions, BST is extremely profitable; the range in rate of return is two to six times its cost. However, the calculations are based on averages, and do not reflect how returns differ for individual producers. Also, the effective use of a technology depends upon the management skills of a producer; two producers with similar herds could obtain different responses to the same technology. For this and other reasons, producers differ in their willingness to adopt new technologies. A survey of milk producers in California indicated approximately 45% would adopt BST if it becomes available (Zepeda). Because there may be some variability between what people say they will do and what they actually do, adoption of BST is assumed to be between 30–60% four years after its introduction. The time path of adoption follows proportions indicated by the California producers surveyed.

BST Available under a Support Price of $10.10

The cost of BST and feed savings had little direct impact on aggregate supply and prices.[8] Differences in aggregate results are less than 1% over the ranges in BST costs and feed savings. Therefore, these scenarios were eliminated from further consideration, and in subsequent analysis BST is assumed to cost 37.5¢ per day and to improve feed efficiency by 2.5%.

Scenario 1 (table 3) is a baseline model in which BST is not available. BST is available in the rest of the scenarios. The support price

[8] Although BST costs and feed savings do not appear to affect milk production and prices, obviously they would affect the demand for BST, thereby indirectly affecting aggregate milk supply and prices. Since the demand for BST is not known, this indirect effect can only be incorporated by evaluating the results under a range of adoption rates. The lower the cost of BST and the greater the feed savings, the more likely a high adoption rate.

Table 4. Average Differences from Baseline Forecasts in Endogenous Variables if BST is Available (Percentage)

	Farm Milk Supply	Farm Milk Price	Milk Products Supply	Milk Products Price	Fluid Milk Supply	Fluid Milk Price	Government Purchases
Scenario 2: Low Adoption and 10% Response							
1991	0.48	−0.31	0.53	−1.18	0.04	−0.21	1.83
1992	1.32	−0.88	1.45	−2.86	0.10	−0.57	6.25
1993	2.58	−1.79	2.78	−5.55	0.21	−1.14	13.42
1994	3.83	−2.84	4.07	−8.38	0.33	−1.75	21.49
Scenario 3: High Adoption and 10% Response							
1991	0.95	−0.62	1.06	−2.36	0.07	−0.41	3.66
1992	2.64	−1.75	2.90	−5.72	0.21	−1.14	12.49
1993	5.16	−3.58	5.56	−11.11	0.42	−2.27	26.83
1994	7.67	−5.68	8.13	−16.76	0.65	−3.51	42.98
Scenario 4: Low Adoption and 15% Response							
1991	0.72	−0.47	0.80	−1.77	0.06	−0.31	2.75
1992	1.99	−1.34	2.18	−4.31	0.16	−0.87	9.41
1993	3.89	−2.73	4.19	−8.38	0.32	−1.73	20.21
1994	5.78	−4.35	6.13	−12.65	0.50	−2.68	32.39
Scenario 5: High Adoption and 15% Response							
1991	1.43	−0.94	1.59	−3.55	0.11	−0.63	5.5
1992	3.98	−2.67	4.36	−8.62	0.32	−1.74	18.82
1993	7.78	−5.47	8.38	−16.75	0.64	−3.47	40.42
1994	11.57	−8.70	12.27	−25.29	1.00	−5.37	64.77

for milk in scenarios 2, 3, 4, and 5 is $10.10/cwt. Scenarios 2 and 3 assume a 10% production response to BST use, and scenarios 4 and 5 assume a 15% response. Scenarios 2 and 4 assume a low adoption rate and scenarios 3 and 5 a high adoption rate of BST. Table 4 shows the percentage difference between the scenarios and the baseline forecasts. By 1994, milk production is between 3.8% and 11.6% greater due to BST introduction, over the range of adoption rates and production responses assumed. Farm prices are 2.8–8.7% lower by 1994.

Retail milk products and fluid milk production climb by 4–12.3% and .3–1%, respectively, above the baseline, while their prices fall by 8.4–25.3% and 1.75–5.4%, respectively. Surplus sales of milk products to the government are 21–65% greater with BST than without it by 1994. For the scenarios examined, the greatest impact of BST is on the price of retail milk products and the sale of milk products to the U.S. government.

Aggregate Effects of BST within California

Table 5 contains data on farm revenues generated for 1991 to 1994 under the different scenarios. Under scenarios 2–5, aggregate farm income differs by between −.6% to 1.6% from the baseline forecasts. Table 5 also contains estimates of consumer and government expenditures on dairy products under the alternative scenarios. Recall that this analysis assumes no preference or aversion towards products made from the milk of BST-treated cows. In other words, consumer decisions are based only on price. Given this, total consumer expenditures on milk and milk products would fall under all scenarios, although consumption would increase. Government expenditures would climb by 2–5% under current legislation with BST introduction (scenarios 2–5).

On a per capita basis, California consumer expenditures on milk and milk products would fall by $3.68–11.92 per year, much less than the prices consumers indicated they were willing to pay for milk from untreated cows (Douthitt). Since the savings do not offset the willingness to pay for untreated milk, there are political incentives to prevent BST approval and market incentives to differentiate milk from untreated cows if BST is approved. Federal per capita expenditures on purchases of milk from California are between $.56 and $.73

Table 5. Farm Income and Consumer and U.S. Government Expenditures for the California Dairy Industry, 1991-94

Scenario	Adoption Rate	Response Rate	Farm Revenue ($ million)	Consumer Expenditure ($ million)	Government Expenditure ($ million)
Baseline	0	0	8,939.0	21,314.8	560.3
#2	Low	10%	8,991.3	20,903.2	615.1
#3	High	10%	9,038.2	20,461.4	669.9
#4	Low	15%	9,013.3	20,681.5	642.9
#5	High	15%	9,075.3	19,979.5	725.5

per year under the various scenarios. Using California's population only, per capita federal purchases of California milk products in the baseline forecast average $5 per year and range from $5.94–6.48 if BST is introduced.

Conclusions and Implications

To determine the impact of BST on the California dairy industry, a simulation model of the industry was developed. Research on the impact of BST in other regions of the U.S. is not directly transferable given differences in scale and resource endowments and a different marketing order and pricing structure for milk in the state. The estimated coefficients are of the expected sign, and the fit and in-sample predictions are good. The model is used to make forecasts of prices and quantities for 1991–94. Forecasts during the period, assuming BST is not available, are used as a baseline for comparing the effects of BST introduction. A range of assumptions about BST are used to reflect the uncertainty about BST's effect on milk production and its price to farmers. The assumptions which appear to be major determinants of its effect are the adoption rate of BST and the production response. The price of BST and feed savings have little direct effect on aggregate milk supply and prices.

Under current legislation, California farm milk supply would increase 2–6% over the baseline forecasts if BST is adopted. CCC sales increase 10–29%. Farm milk prices, retail products prices, and fluid milk prices fall.

If they have no aversion to BST use, the aggregate benefits of BST introduction are large for consumers. They would save 2–6% on expenditures for milk and milk products. However, on a per capita basis this translates to a yearly savings of $3.68–11.92, less than what surveys indicate consumers are willing to pay for milk from untreated cows.

When the economic effects of BST for consumers, farmers, and the government are compared, net farm income is relatively unchanged, while consumers save on milk purchases and federal expenditures on milk price supports will likely increase. Potential negative consumer reaction poses a risk to BST introduction generating net benefits to consumers.

The question for policy makers is, are the aggregate benefits of introducing BST large enough to offset its distributional and structural impact and the risk of adverse consumer reaction? To answer this question, better information on consumer preferences within California towards BST is needed. Since the results of the analysis are sensitive to assumed adoption rates and production responses, continued research on farmer preferences and on-farm production response of BST-treated cows in California is also needed. Acquisition of information from farmers on BST adoption requires better information on the retail price of BST and on-farm changes in feed efficiency. While this information had no direct effect on the results generated in this study, the demand for BST by farmers would likely be affected by such information. Determining BST demand would permit endogenizing it in the model.

Perhaps the most fruitful area of future economic research on BST is the effect of product differentiation. If California consumers are willing to pay more for milk from untreated cows, as research in other states indicates (Douthitt), and a cost-effective technique can be developed to verify BST use, potential gains for producers may result from its introduction. Verifiable product differentiation could lead to net benefits sufficiently large to warrant the risk of potential adverse consumer reaction to BST adoption.

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