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POTENTIAL IMPACTS FOR THE U.S.

by

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BOVINE SOMATOTROPIN AND MILK PRODUCTION: POTENTIAL IMPACTS FOR THE U.S.

Harry M. Kaiser[1]

Bovine somatotropin (bST) is a protein hormone produced in the pituitary gland of a dairy cow that regulates and stimulates milk production. Through advances in genetical engineering, synthetic bST can now be produced that is virtually identical to natural bST. When injected into cows, synthetic bST has increased milk yields from 10 to 25% in experimental herds (Animal Health Institute). Bovine somatotropin is currently under review by the Federal Drug Administration and may be approved as early as late 1990 (Fallert). At the same time, various farm, environmental, and consumer groups are lobbying against bST, attacking it on such grounds as its safeness for animals and humans, concern over its implications for increased farm attrition, and its impact on government costs of dairy subsidies.

The purpose of this paper is to investigate the potential impacts of bST on national milk production, farm price and income, and dairy surpluses removed by the government via the dairy price support program. A national milk policy simulation model is used to simulate these impacts for 1990-95 assuming dairy provisions similar to the 1985 Food Security Act are in effect. Composite estimates of key parameters such as adoption rates, yield response and increase in variable costs due to bST are developed by averaging parameters used in several previous studies. The results of the bST scenario are compared with a scenario

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which assumes a national ban on bST. In addition, sensitivity analysis is performed on the adoption rate and the national increase in yields to determine upper and lower bounds on the model results.

METHODOLOGY

The simulation model used in this paper was developed by Kaiser and is called the National Economic Milk Policy Impact Simulator (NEMPIS). It is assumed that the national dairy market consists of an aggregate farm sector and an aggregate retail sector, which is the same structure used by Kaiser, Streeter, and Liu. Within this framework, dairy farmers produce and sell raw milk to retailers of dairy products. The retail market is sub-divided into two groups based on the type of products being processed and sold. Class 1 (fluid products) retailers process and sell fluid products directly to consumers, and Class 2 (manufactured products) retailers process and sell manufactured dairy products directly to consumers. Additionally, the two major federal programs which provide economic regulations for the dairy industry, the federal dairy price support and federal milk marketing order programs, are assumed to be in affect.[2]

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2 Under the dairy price support program, the government supports the price of manufactured grade milk by agreeing to buy unlimited quantities of storable dairy products at specified purchase (support) prices. By increasing the farm demand for milk, the government thereby indirectly supports the price of raw milk. The basic thrust of federal milk marketing orders is to institute a classified system of pricing for Grade A (fluid eligible) milk, where handlers of milk used for fluid purposes pay a higher price (Class 1 price) than handlers of manufactured grade milk, who pay Class 2 or Class 3 prices. Farmers receive an average of the class prices, weighted by the fluid and non-fluid utilization rates in the marketing area.

NEMPIS uses national annual time series data (1960 through 1989) on retail and farm market variables to estimate supply and demand functions for the U.S. dairy market. To simplify the estimation of the model, it is assumed that farmers expect the milk price in period t+1 to be the price in period t. This assumption, which is often used in dairy models [e.g., Chavas and Klemme; LaFrance and de Gorter], allows the farm supply to be estimated independently from the retail market because the lagged milk price is exogenous. The following describes the results of the econometric model and the procedures used in the simulation component of NEMPIS.

The Econometric Model

Table 1 presents the econometric results for the estimated equations and Table 2 defines all variables used in NEMPIS. The coefficients for all variables have the expected signs and the estimated equations appear to fit the data reasonably well based on the adjusted coefficient of variation.

The two estimated equations in the farm market are cow numbers and production per cow. The cow number equation (CN) is estimated using ordinary least squares (OLS) as a function of cow numbers in the previous period, real average milk price lagged one year (P^{m}_{-1}), real dairy feed costs (FC), and a policy dummy variable corresponding to the years that the Dairy Termination Program (DTP) was in affect.[3] The use of cow numbers in the previous year reflects capacity constraints on the national dairy herd, dairy feed costs correspond to the major variable

[3] The term "real" used throughout this paper means that the nominal measure was deflated by the Consumer Price Index for all items (1967 = 100).

Table 1. The Econometric Equations for the Farm and Retail Markets.*

Cow Numbers Equation

$$\ln CN = 0.9896 \ln CN_{-1} + 0.0617 \ln P^{m}_{-1} - 0.0760 \ln FC - 0.0391\, DTP + 1/(1 + 0.7073\, L)\, u$$
(76.7) (1.3) (-2.4) (-3.7) (4.7)

$R^2 = 0.99$; $DW = 1.97$

Production Per Cow Equation

$$\ln PPC = 2.4482 + 0.7254 \ln PPC_{-1} + 0.0592 \ln P^{m}_{-1} - 0.0582 \ln FC + 0.0054\, T + u$$
(2.5) (6.8) (1.9) (-2.3) (2.1)

$R^2 = 0.99$; $DW = 2.30$

Retail Fluid Price Instrument

$$P^{f} = 8.4176\, SP + 12.2101\, W + 1/(1 + 0.9524\, L)\, u$$
(4.0) (4.3) (17.7)

$R^2 = 0.99$; $DW = 2.23$

Fluid Demand Equation

$$\ln Q^{fd}/POP = -1.0246 - 0.4756 \ln P^{f}_{ins} + 0.0653 \ln P^{b} + 0.4562 \ln Y - 0.9811 \ln A_2 - 0.0315\, T + u$$
(-3.0) (-3.4) (1.7) (3.6) (-2.4) (-12.0)

$R^2 = 0.99$; $DW = 1.48$

Class I Milk Price Equation

$$P^{I} = 2.6555 + 0.7891\, SP + 0.0875\, T$$
(2.6) (18.3) (4.7)

$R^2 = 0.99$; $DW = 1.14$

Fluid Supply Equation

$$\ln Q^{fs} = 0.7200 + 0.7240 \ln Q^{fs}_{-1} + 0.1034 \ln P^{f}_{ins} - 0.1364 \ln P^{I}_{ins} - 0.0454 \ln P^{c} + u$$
(1.9) (7.0) (2.5) (-4.0) (-2.2)

$R^2 = 0.89$; $DW = 1.40$

Retail Manufactured Price Instrument

$$P^{m} = 4.9210\, SP + 25.5289\, W + 1/(1 + 0.7816\, L)\, u$$
(3.5) (13.8) (6.6)

$R^2 = 0.99$; $DW = 1.81$

Table 1. Continued.

Manufactured Demand Equation

$$\ln Q^{md}/POP = -1.7644 - 0.9467 \ln P^{m}_{ins} + 0.0911 \ln P^{fo} + 0.4980 \ln Y - 2.8103 \ln A_1 - 0.0461\, T + u$$
$$(-2.9) \quad (-5.7) \quad (1.3) \quad (2.0) \quad (-6.5) \quad (-4.6)$$

$R^2 = 0.83$; $DW = 2.08$

Class II Milk Price Equation

$$P^{II} = 0.3555 + 0.7891\, SP + 0.0875\, T$$
$$(2.6) \quad (18.3) \quad (4.7)$$

$R^2 = 0.99$; $DW = 1.14$

Manufacturing Supply Equation

$$\ln Q^{ms} = 0.6759 + 0.6118 \ln Q^{ms}_{-1} + 0.6163 \ln P^{m}_{ins} - 0.2832 \ln P^{II}_{ins} + 0.0051\, T + 1/(1 - 0.4975\, L)\, u$$
$$(2.0) \quad (4.7) \quad (2.5) \quad (-2.6) \quad (3.8) \quad (-2.5)$$

$R^2 = 0.94$; $DW = 1.82$

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* R^2 is the adjusted coefficient of variation, DW is the Durbin-Watson statistic, u is white noise, L is the lag operator, ln is the natural logarithm, and t-values are given in parentheses.

Table 2. Definitions of Variables Used in NEMPIS.*

Variable Name	Unit of Measurement	Description
CN	1,000 head	Number of cows in the U.S.
P^m	$/cwt.	3.67% butterfat average farm milk price deflated by the Consumer Price Index for all items (CPI; 1967 = 100)
FC	$/cwt.	Dairy ration costs deflated by the CPI
DTP	1 or 0	Intercept dummy (equals 1 for 1986-87)
PPC	lbs.	National average production per cow
T	integer	Trend variable; 1960=1, 1961=2,...
P^f	1967=100	Retail fluid milk price index
SP	$/cwt.	3.67% butterfat support price
W	$/hour	Average hourly wage rate in manufacturing sector
Q^{fd}	bil. lbs.	Fluid demand
POP	mil.	Civilian population
$P^f{}_{ins}$	1967=100	Retail fluid price instrument deflated by the CPI
P^b	1967=100	Retail nonalcholic beverage price index deflated by the CPI
Y	$1,000	Disposable per capita income deflated by the CPI
A_1	%	Percent of population under 19 years of age
A_2	%	Percent of population between 25 and 64
P^I	$/cwt.	3.67% butterfat Class 1 price
Q^{fs}	bil. lbs.	Fluid supply ($Q^{fd} = Q^{fs}$)
$P^I{}_{ins}$	$/cwt.	Class I price instrument deflated by the CPI
P^e	1967=100	Fuels and energy price index deflated by the CPI
P^m	1967=100	Retail manufactured price index
Q^{md}	bil. lbs.	Manufactured demand
$P^m{}_{ins}$	1967=100	Retail manufactured price instrument deflated by the CPI
P^{fo}	1967=100	Retail fats and oils price index deflated by the CPI
P^{II}	$/cwt.	3.67% butterfat Class 2 price
Q^{ms}	bil. lbs.	Manufactured supply ($Q^{md} = Q^{fs}$)
$P^{II}{}_{ins}$	$/cwt.	Class II price instrument deflated by the CPI
MILK	bil. lbs.	Total milk marketings
CCC	bil. lbs.	Milk surplus purchased by the government
TOTDEM	bil. lbs.	Total commercial demand for milk products

* Unless otherwise noted, all quantities are expressed in milk equivalent butterfat basis.

cost face by dairy farmers, and the policy dummy variable captures the significant reduction in cows in 1986 and 1987 due to the DTP. To correct for autocorrelation, a first-order autoregressive error structure is imposed.

The production per cow (PPC) equation is estimated using OLS as a function of production per cow in the previous year, the real average milk price lagged one year, real feed costs, and a trend variable (T). Lagged production per cow is used to reflect dynamic adjustments in milk yields over time, real feed costs represent the most important variable cost influencing milk yields, and the trend variable is used as a proxy for genetic improvements in cows over time.

The retail fluid market consists of a retail fluid demand and supply equation, which are estimated simultaneously using two-stage least squares (2SLS) to correct for bias due to price and quantity being determined simultaneously. An instrumental variable is constructed for the retail fluid price (P^f) by regressing it on two exogenous variables: the support price (SP) and the average hourly wage in the manufactured sector (W). To deal with autocorrelation, a first-order autoregressive error structure is imposed. The resulting predicted value for the retail fluid price (P^f_{ins}) is used as an instrument in the retail fluid supply and demand equations instead of the actual retail fluid price.

Retail per capita fluid demand (Q^{fd}/POP) is estimated as a function of the real retail fluid price instrument, real price of nonalcoholic beverages (P^b), real disposable income per capita (Y), percent of population between 25 and 64 years old (A_2), and a time trend. The real price of nonalcoholic beverages is used as a proxy for fluid substitutes, the percent of people between 25 and 64 captures the decline in fluid milk consumption in this age group, and the time trend is used as a proxy for changing consumer tastes away from high-fat products.

An important retail fluid supply determinant is the Class 1 price (P^I) paid by retail suppliers. Because P^I is endogenous, an instrumental variable is constructed by regressing it on the support price and a time trend. The resulting predicted value (P^I_{ins}) is used in the retail fluid supply function in place of the actual Class 1 price. Other retail fluid supply determinants include supply in the previous year, the real retail fluid price instrument, and the real energy price index (P^e). Lagged retail supply is included to capture short term production constraints on fluid supply, and the real energy price index is a proxy for energy costs, which is another important determinant of supply.

The retail manufactured market consists of a retail manufactured demand and supply equation, which are also estimated using 2SLS. An instrumental variable is constructed for the retail manufactured price (P^m) by regressing it on the support price and the average hourly wage in the manufactured sector. To deal with autocorrelation, a first-order autoregressive error structure is imposed. As was the case with the retail fluid price instrument, the predicted values for the retail manufactured price (P^m_{ins}) are used as an instrument instead of the actual manufactured price in the retail manufactured supply and demand equations.

Retail per capita manufactured demand (Q^{md}/POP) is estimated as a function of the real retail manufactured price instrument, real retail price for fats and oils (P^{fo}), real disposable income per capita, percent of population under 19 years old (A_1), and a time trend. The real retail price of fats and oils is used as a proxy for manufactured substitutes, the percent of people under 19 years old reflects the lower consumption of manufactured dairy products in this age bracket, and the time trend is used as a proxy for changing consumer tastes away from high-fat products.

An important retail manufactured supply determinant is the Class 2 price (P^{II}) paid by retail suppliers. As was the case with the retail fluid supply estimation, an instrumental variable is necessary here because P^{II} is endogenous. The instrument is constructed by regressing P^{II} on the support price and a time trend. The resulting predicted value (${P^{II}}_{ins}$) is used in the retail manufactured supply function in place of the actual Class 2 price. Other retail manufactured supply determinants include supply in the previous year, the real retail manufactured price instrument, and a time trend. Lagged retail supply is included to capture short term production constraints on manufactured supply, and the time trend is included to capture supply shifters such as changes in technology. To correct for autocorrelation, a first-order autoregressive error structure is imposed.

Simulation Procedures

The farm market is defined in NEMPIS by the estimated cow number and production per cow equations, one identity (milk marketings, the product of cow numbers time production per cow times 98.5%), and an equilibrium condition requiring milk marketings to equal commercial fluid and manufactured demand plus government purchases of dairy products via the dairy price support program. Based on the cow number equation in Table 1, the number of cows in any year t is equal to the following equation:

$$CN_t = CN_{t-1}^{.989} \; P^m{}_{t-1}^{.06} \; FC_t^{-.08}$$

The option of using bST is incorporated in NEMPIS by multiplying the estimated production per cow equation in Table 1 by one plus the product of the increase in milk yields of treated cows due to bST (I) times the cumulative adoption rate (C) times a binary variable (A) which equals 1 if bST is available and 0 otherwise. Production per cow in any year t is equal to the following equation:

$$PPC_t = (1+ICZ)\; \exp(2.45)\; PPC_{t-1}^{.73} \; P^m{}_{t-1}^{.06} \; FC_t^{-.06} \; T_t^{.005}$$

The use of bST will increase variable costs as feed and labor costs will increase and there is the added cost of purchasing bST. This is incorporated into both the production per cow and cow number equations by increasing feed costs by the assumed percentage increase in variable costs due to bST.

Milk marketings is the product of cow numbers and production per cow. However, since about 1.5% of milk production is not marketed commercially due to on-farm use, commercial milk marketings (MILK) are defined as the following in NEMPIS:

$$MILK_t = .985 \; CN_t \; PPC_t$$

Finally, the equilibrium condition between the farm and retail sectors is specified by the following condition:

$$MILK_t = Q^f{}_t + Q^m{}_t + CCC_t,$$

where: Q^f and Q^m are the equilibrium fluid and manufactured quantities in the commercial market and CCC is purchases by the Commodity Credit Corporation (CCC) under the dairy price support program.

The Class 1 price is equal to the Class 2 price plus a fixed fluid differential which varies among all federal milk marketing orders. Since this is a national model, which assumes one federal marketing order, the Class 1 price is equal to the Class 2 price plus the national average fluid differential ($2.30 per hundredweight). While processors must pay these class prices, the milk price received by all farmers is equal to the average of P^I and P^{II}, weighted by the percent of fluid and manufactured market utilization. That is,

$$P^m{}_t = P^{II}{}_t \; ((Q^m{}_t + CCC_t)/MILK_t) + P^I{}_t \; (Q^f{}_t/MILK_t)$$

In the fluid retail market, the equilibrium fluid price (P^f) equation is generated by setting the estimated fluid supply equation (Q^{fs}; see Table 1) equal to the estimated fluid demand equation (Q^{fd}) and solving for the retail fluid price. This price is computed for each year and is substituted into either the supply or demand function to obtain the equilibrium quantity of fluid products (Q^f). An analogous procedure is done in the manufactured product market.

The rest of the equations in NEMPIS are accounting equations which define other variables. Total commercial demand (TOTDEM) is equal to the sum of fluid and manufactured product demand, i.e.:

$$TOTDEM_t = Q^f{}_t + Q^m{}_t$$

Finally, the quantity of government purchases is equal to the difference between milk marketings and commercial demand,

$$CCC_t = MILK_t - TOTDEM_t$$

The bST Parameters

All scenarios are simulated for 1990 through 1995, which corresponds to the duration of the next Farm Bill. Each exogenous variables in the model is forecasted by regressing it on a time trend and its past two year values. The 1989 values are used to initialize the lagged dependent variables appearing in the retail supply, cow number, and production per cow equations.

It is assumed that support price adjustments each years are based on the 1985 Food Security Act provisions. That is, the support price is decreased by $0.50 per hundredweight in year t if CCC purchases are projected to be above five billion pounds of milk equivalent (butterfat basis). If CCC purchases are forecasted to be under 2.5 billion pounds, then the support price is increased by $0.50 per hundredweight.

The impact of bST on milk production will depend upon: (1) the average increase in milk yield in treated cows, (2) the rate of adoption, and (3) the average increase in variable costs due to bST.

Table 3 presents the assumed levels for each of these parameters in several previous studies on bST. In cases where more than one parameter was assumed, the average is used to represent that study. In terms of percentage increase in milk yields due to bST, the average of these studies is 14.3%, which is used in this paper. In the bST scenario, it is assumed that bST is available beginning in 1991. The average adoption rates from these studies are used. That is, it is assumed that 8.7% of all cows are treated with bST in 1991, 18.5% in 1992, 35.1% in 1993, 53.8% in 1994, and 61% in 1995. Finally, it is assumed that the increase in variable costs associated with cows treated with bST (14.3% increase in yields) is 7.5%. This figure is derived by using the average increase in feed costs and the average cost of bST from the studies in Table 3. The percentage increase is based on a variable cost of $10.92 per hundredweight without bST (which is total cash expenses for 1988, Shapouri, et al.).

RESULTS

The results of the two scenarios are presented in Figures 1 through 7. Milk production, on average, is 6% higher with bST than under the bST ban scenario. Moreover, the difference in production widens consistently over time as more cows become treated with bST (Figure 1). By 1995, milk production reaches 164 billion pounds when bST is available, which is 20 billion pounds more than with a bST ban.

The reason for the gap in milk production between scenarios is due mainly to the difference in milk yields between scenarios. Milk yield per cow averages 16,853 pounds for 1990-95 when bST is available, and

Table 3. Assumed bST Parameters in Previous Studies.

Study	bST Increase in Milk Yield (%)	------- Adoption Rate ------					Cost of bST ($/Cow)	Increase in Feed Costs (%)
		1991 (%)	1992 (%)	1993 (%)	1994 (%)	1995 (%)		
Marrion and Wills	9, 12, 15						52.5, 84	3.8
Fallert, et al.	13.5	10	20	36	44	48	50.4	3.8
Kaiser and Tauer	8, 13.5	5	17	44	76	93	50	3.8
Schmidt	10, 15, 20	20	30	30	30	30	42, 105	
Yonkers, et al.	10, 15, 20							
Tauer and Kaiser	13.5	3	10	26	45	55	50	3.8
Magrath and Tauer	10, 15, 20	5.4	15.3	39.7	74	79	42	
Average	14.3	8.7	18.5	35.1	53.8	61	55.7	3.8
Standard Deviation	2.7	6.1	6.6	6.5	18.1	22.4	11.2	0

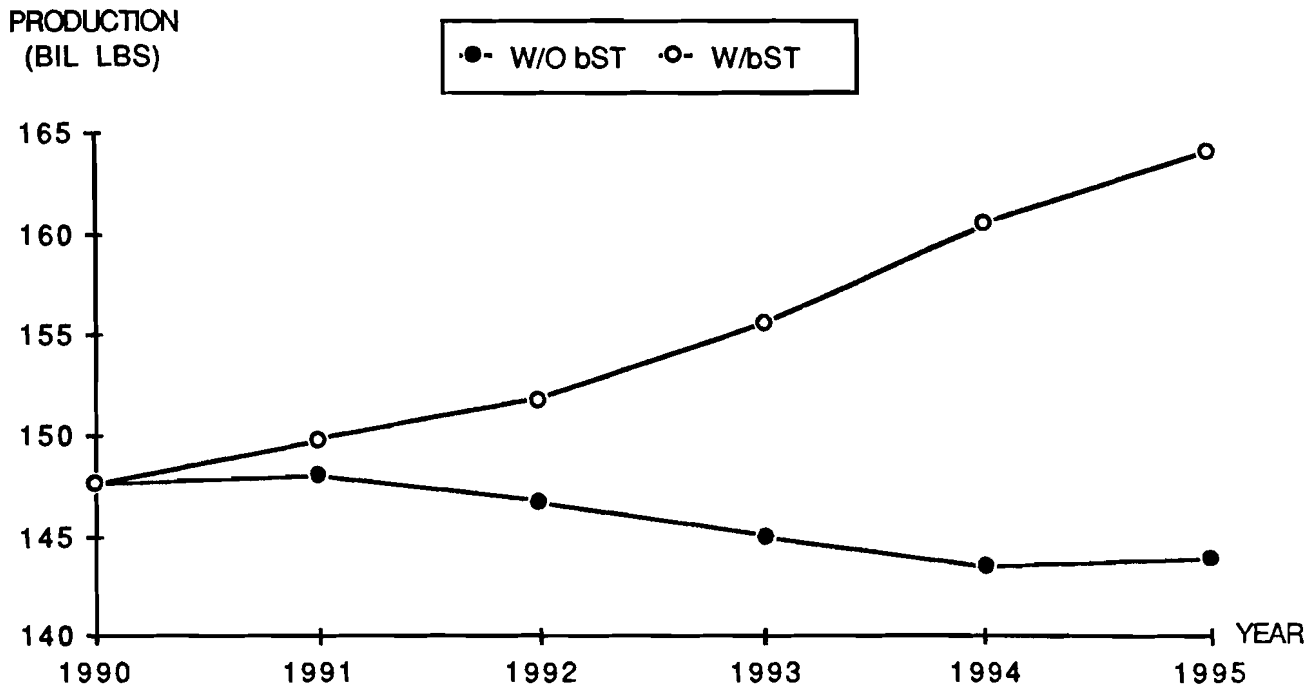

Figure 1. Milk Production With and Without bST, 1990-1995.

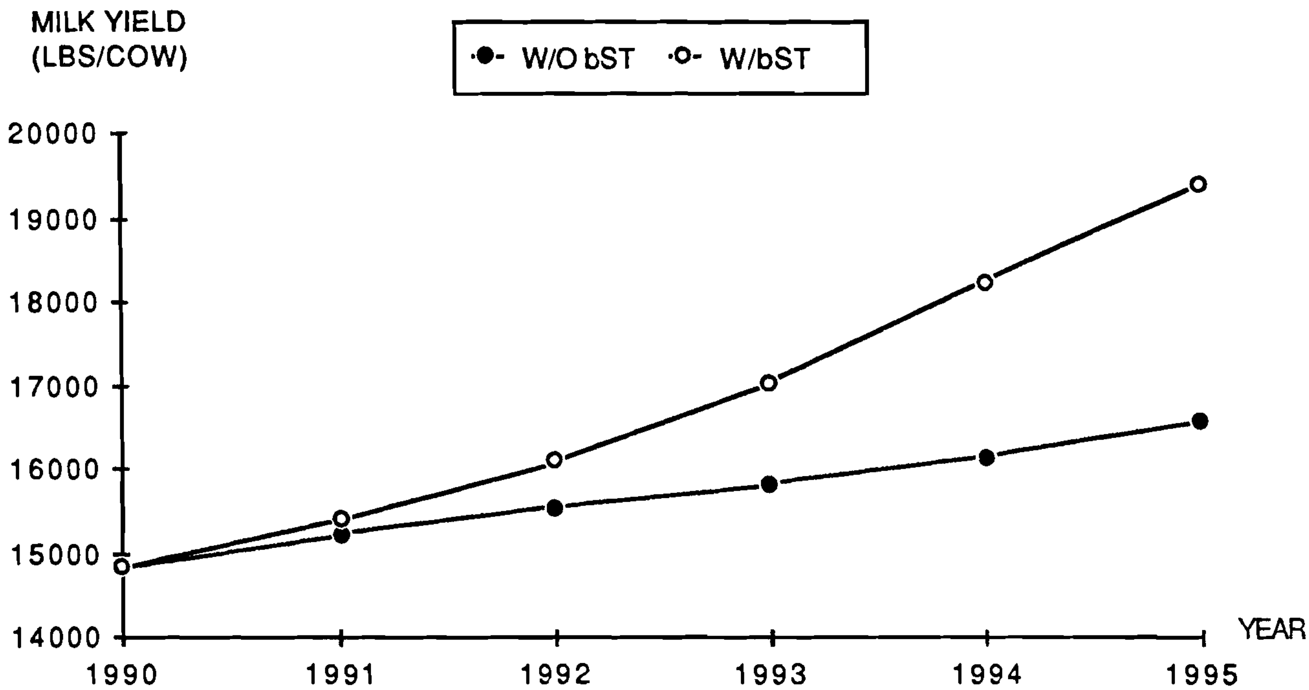

Figure 2. Milk Yield Per Cow With and Without bST, 1990-1995.

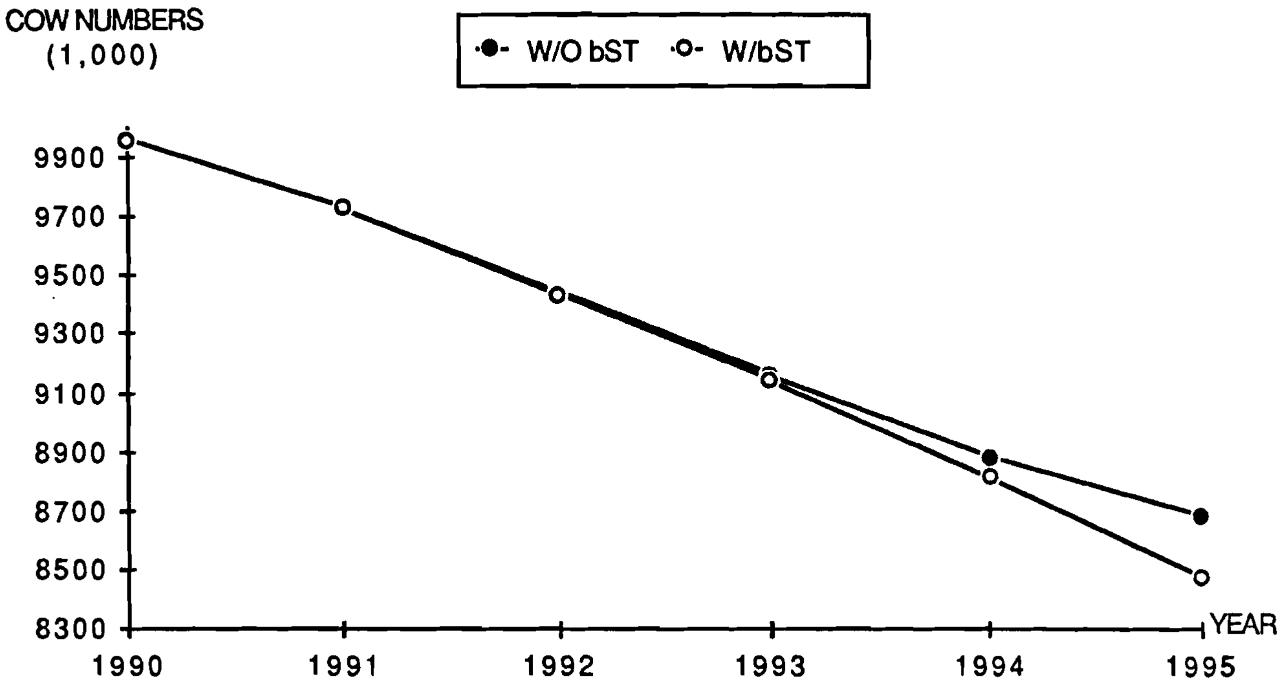

Figure 3. Number of Cows With and Without bST, 1990-1995.

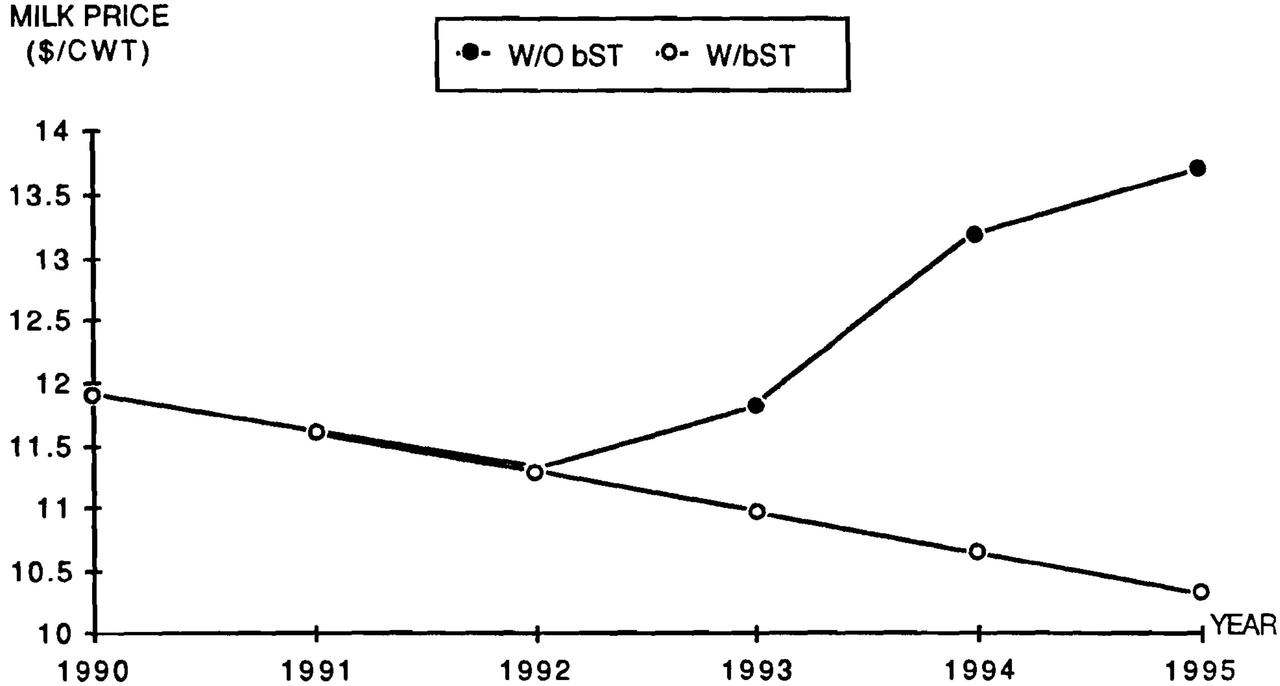

Figure 4. Average Milk Price With and Without bST, 1990-1995.

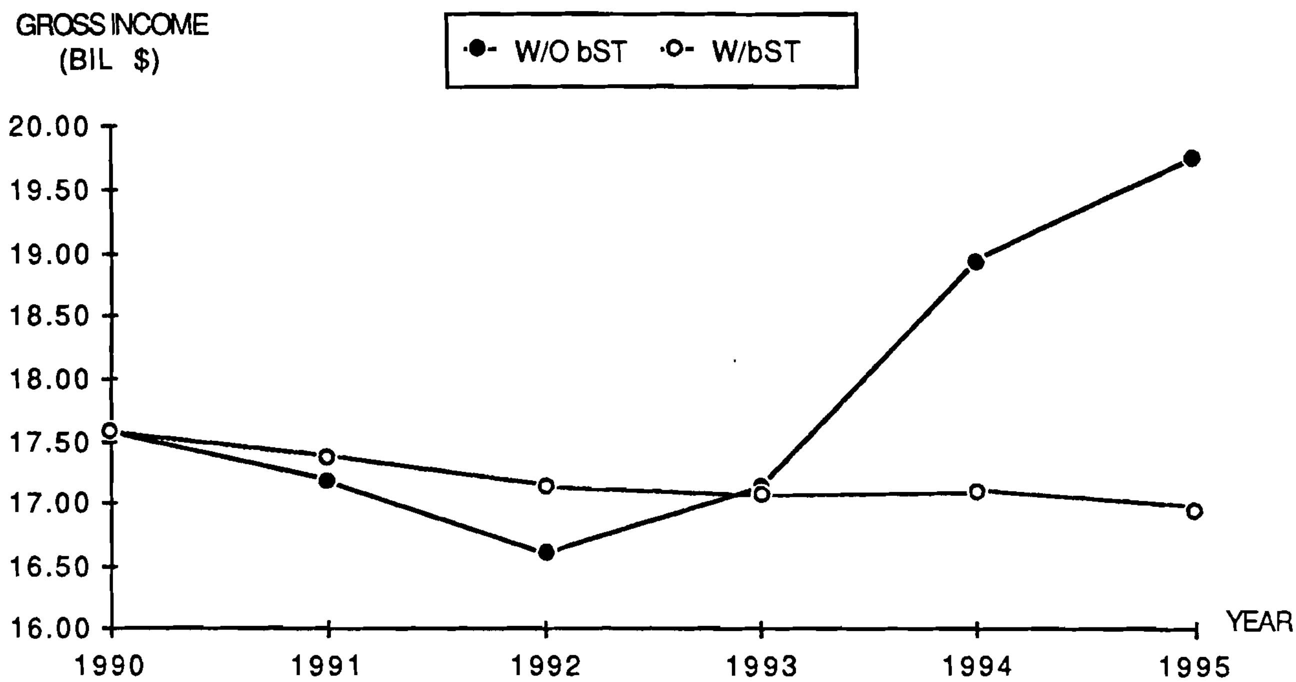

Figure 5. Gross Dairy Farm Income With and Without bST, 1990-1995.

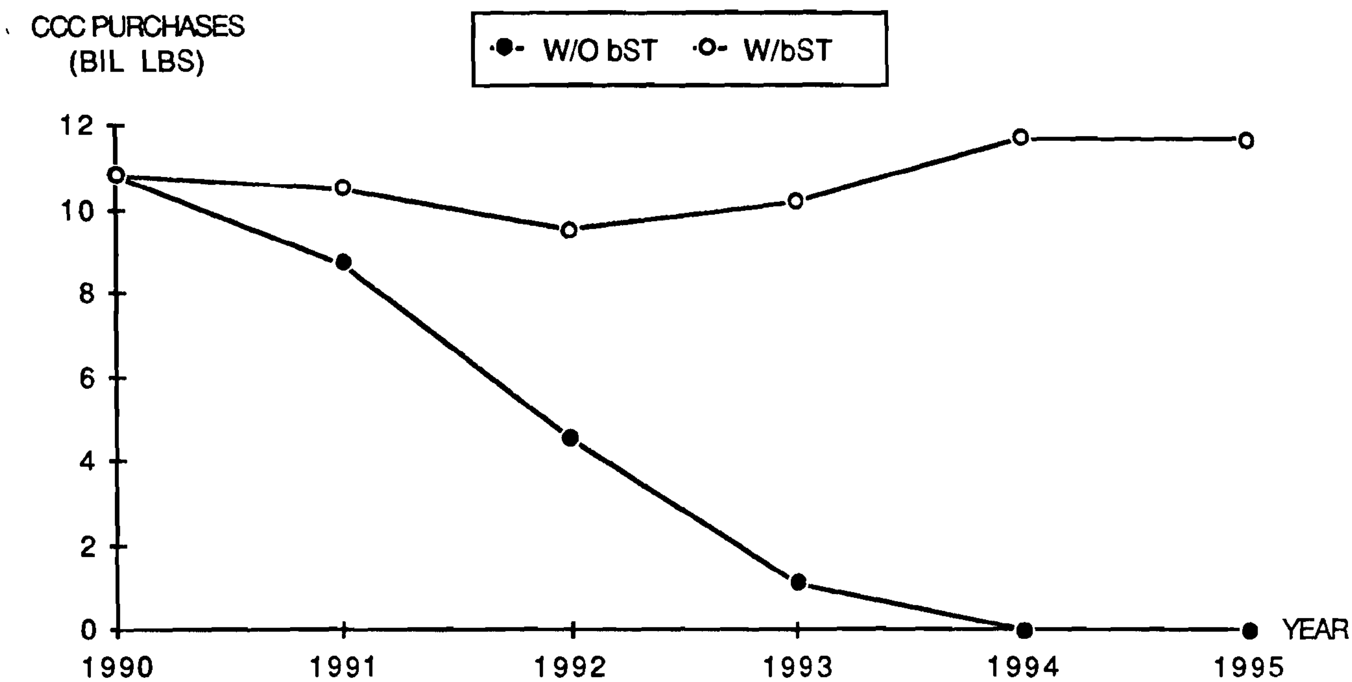

Figure 6. Net Removals by the CCC With and Without bST, 1990-1995.

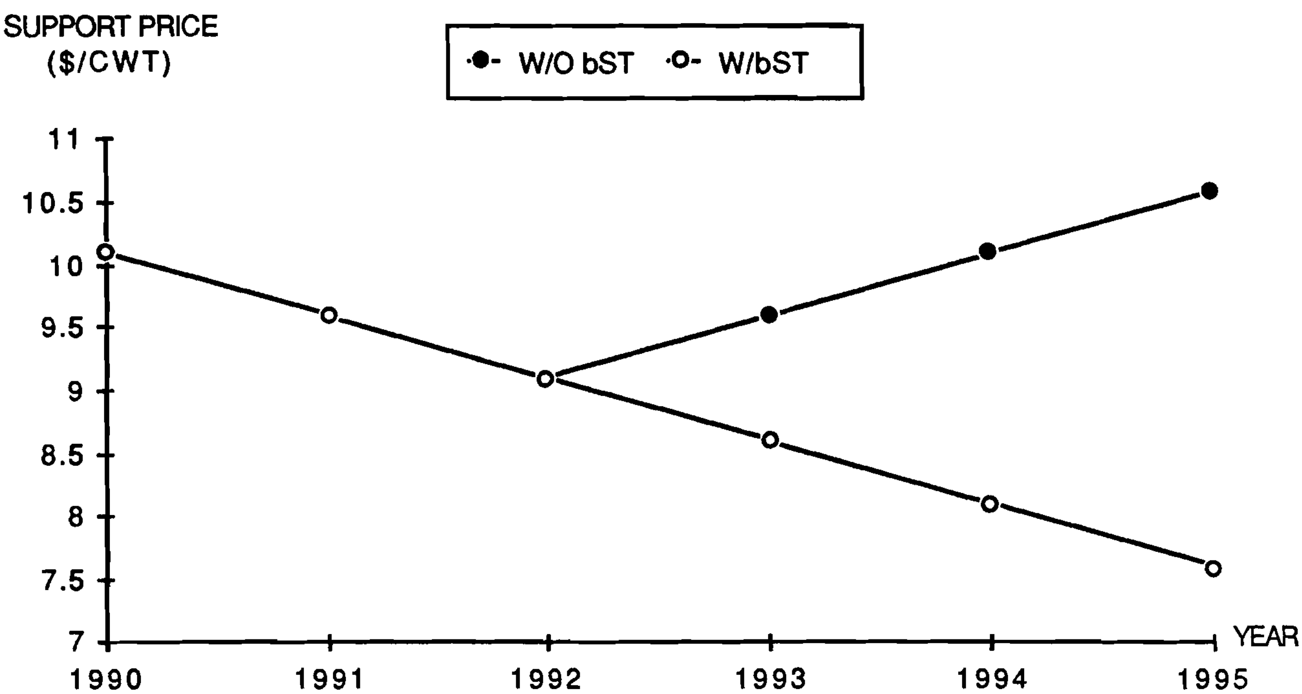

Figure 7. Milk Support Price With and Without bST, 1990-1995.

averages 15,711 pounds when bST is available. As is true with production, the difference in milk yields also widens consistently throughout time as more cows are treated with bST. By 1995, the difference in average milk yield between the bST and no bST scenarios reaches 2,820 pounds (Figure 2), or 17% of average milk yield assuming no bST.

While average milk yield is substantially different, cow numbers are similar between scenarios. For instance, the number of cows average 9.31 million from 1990-95 assuming a ban on bST. If bST is available, the number of cows is slightly lower, averaging 9.26 million over the simulation period. As is clear from Figure 3, cow numbers are virtually identical between scenarios from 1990 to 1992. This is due to the fact that the milk price is the same between scenarios over this time (Figure 4). However, beginning in 1993 and continuing through 1995, the milk price is substantially higher under the bST ban scenario. From 1993 to 1995, the milk price under the bST ban is $0.85, $2.55, and $3.39 per hundredweight higher, respectively, than in the bST scenario. With lower milk prices, the number of cows in the bST scenario begin to fall at a faster rate from 1993 to 1995 relative to the no bST scenario.

In terms of gross income, farmers are slightly better off under a bST ban than if bST is approved. Due to lower milk prices, gross income in the bST ban scenario is about 4% higher, on average, than under the bST scenario. It is interesting to note, however, that gross income is slightly higher in the bST scenario from 1990 to 1993, when milk prices are comparable (Figure 5). After 1993, the situation reverses and gross income in the bST scenario is lower than in the bST ban scenario. By

1995, the difference in gross income is $2.8 billion, or 16% of average gross income without bST.

Total demand increases consistently under the bST scenario at about 1% per year, which is the same as forecasted population growth. The growth in demand under the bST ban is lower than in the bST case because retail consumer prices are higher. Total commercial disappearance in the bST scenario is 144 billion pounds, which is 2.5 billion pounds higher than demand under a bST ban.

The market oriented policy is quite effective in reducing government purchases of dairy products when bST is not available. In this case, CCC purchases consistently fall from just under 11 billion pounds in 1990 to zero pounds in 1994 and 1995 (Figure 6). The decrease in CCC purchases is due to slight declines in production coupled with relatively faster growth in demand, both induced by two consecutive $0.50 per hundredweight reductions in the support price (Figure 7). By 1993, the previous reductions in the support price the market to become competitive in terms of supply being relatively scarce to demand. In fact, there are three consecutive increases in the support price from 1993-95.

On the other hand, the market oriented policy is not very effective in controlling excess milk supplies relative to demand when bST is available. In this case, CCC purchases increase slightly from 10.8 billion pounds in 1990 to 11.7 billion pounds in 1995 (Figure 6). Even though the support price is reduced by $0.50 per hundredweight every year under this scenario (Figure 7), the increase in milk yields due to bST are more than enough to offset the decrease in cow numbers.

This indicates that bST could be quite expensive in terms of government costs of surplus disposal.

These results depend upon the accuracy of the composite estimates of adoption rates and yield response to bST. To investigate the sensitivity of results with respect to the bST yield response parameter, the model is solved for two situations: (1) adding one standard deviation to average bST yield response, holding other parameters at their previous levels, and (2) subtracting one standard deviation from average bST yield response, holding all other parameters at their previous level. Similarly, to investigate the sensitivity of results with respect to adoption rate parameters, the model is solved for two situations: (1) adding one standard deviation to average adoption rates for 1991-95, holding other parameters at their previous levels, and (2) subtracting one standard deviation from average adoption rates for 1991-95, holding all other parameters at their previous level.

Using the original parameters, average CCC purchases under bST are 10.76 billion pounds for 1990-95. When average bST yield response is increased and decreased by one standard deviation, a lower bound of 8.7 billion pounds and an upper bound of 12.8 billion pounds for CCC purchases is derived. On the other hand, when average adoption rates are increased and decreased by one standard deviation, a lower bound of 7.45 billion pounds and an upper bound of 14.28 billion pounds for CCC purchases is found. Therefore, the variation in the average estimate for adoption rates causes a larger confidence interval for CCC purchases than the variation in the average estimated bST yield response. This is not surprising because adoption tends to be a harder parameter to predict than yield response, where there already exists evidence from trial experiments. The same pattern holds true in terms of other variables.

The same result holds with respect to production. Average production with the original bST parameters is 154.9 billion pounds. The upper and lower estimates of production generated by adding and subtracting one standard deviation from mean yield response are 157 and 152.9 billion pounds, respectively. The range between the upper and lower bounds is higher in the case of the adoption rates. In this case, the upper and lower bounds on production are 158.5 and 151.5 billion pounds, respectively. Again, this is true because of the higher variation in adoption rate estimates than yield response estimates. Similar results apply to other variables in the model.

The average difference between the upper and lower bounds of some of these confidence intervals are quite large. For example, the average difference between the upper and lower bound estimates for CCC purchases in the case of the adoption rate parameter is 6.8 billion pounds, or 63.5% of average CCC purchases under bST. Therefore, some caution should be exercised in interpreting these results. On the other hand, the difference in upper and lower bounds for milk production is very small. The difference in production between the upper and lower bounds for average yield response is 4 billion pounds, or 2.6% of average milk production under bST.

SUMMARY

The purpose of this paper was to examine the potential impacts of bovine somatotropin on national milk production, farm price and income, and dairy surpluses removed by the government via the dairy price support program. A national milk policy simulation model was used to simulate these impacts for 1990-95 assuming a market oriented policy, where the support price is adjusted based on the provisions of the 1985 Food Security Act. Composite estimates of adoption rates, yield response and increase in variable costs due to bST from previous studies were used in several previous studies. The results of the bST scenario are compared with a scenario which assumes a national ban on bST.

The results indicate that while the market oriented policy stabilizes production and substantially reduces CCC removals when bST is not available, the same does not hold under the bST scenario. When bST is available, milk production consistently increases each year due to relatively large increases in average milk yields. The growth in milk production under bST is more than enough to trigger consecutive $0.50 per hundredweight decreases in the support price, which reaches a low of $7.60 in 1995. Because of this, gross farm income under bST is 4% lower, on average, than if bST is banned from the market. Moreover, the difference in milk prices and farm income between the bST and no bST scenarios gets progressively larger over time as adoption grows. Also, government costs are significantly higher under bST, as CCC purchases average 10.8 billion pounds as opposed to 4.2 billion pounds under the bST ban.

The variability in the average estimate of bST adoption rates was higher than the variation in the average estimate of bST yield response. Because of this, the confidence interval on results derived by adding and subtracting one standard deviation from mean adoption was slightly larger than the confidence interval generated for mean yield response.

Finally, the margin for error as measured by the difference between the upper and lower bounds was found to be quite large for CCC purchases, but low for milk production.

REFERENCES

Animal Health Institute. "Bovine Somatotropin (BST)." Alexandria, Virginia, 1988.

Chavas, J.P., and R.M. Klemme. "Aggregate Milk Supply Response and Investment Behavior on U.S. Dairy Farms." ***Amer. J. of Agr. Econ.,*** 68 (1986): 55-66.

Fallert, R., T. McGuckin, C. Betts, and G. Bruner. "bST and the Dairy Industry: A National, Regional, and Farm Level Analysis." U.S. Department of Agriculture, October 1987.

Kaiser, H.M. "A User's Guide to NEMPIS: National Economic Milk Policy Impact Simulator." ***A.E. Res 90-22,*** Department of Agricultural Economics, Cornell University, May 1990.

Kaiser, H.M., D.H. Streeter, and D.J. Liu. "Welfare Comparisons of U.S. Dairy Policies With and Without Mandatory Supply Control." ***Amer. J. of Agr. Econ.,*** 70 (1988): 848-58.

Kaiser, H.M., and L.W. Tauer. "Impact of Bovine Somatotropin on U.S. Dairy Markets Under Alternative Dairy Policy Options." ***Nor. Cen. J. of Agri. Econ.*** 11(1989): 59-73.

Lesser, W., W. Magrath, and R. Kalter. "Projecting Adoption Rates: Application of an Ex Ante Procedure to a Biotechnology Product." ***Nor. Cen. J. of Agri. Econ.*** 8(1986):159-174.

LaFrance, J.T., and H. de Gorter. "Regulation in a Dynamic Market: the U.S. Dairy Industry." ***Amer. J. of Agr. Econ.,*** 67 (1985): 821-32.

Magrath, W.B., and L.W. Tauer. "New York Milk Supply with Bovine Growth Hormone." ***Nor. Cen. J. of Agri. Econ.,*** 10(1988): 235-41.

Magrath, W.B., and L.W. Tauer. "The Economic Impact of bGH on the New York State Dairy Sector: Comparative Static Results." ***Nor. East. J. of Agri. and Res. Econ.,*** 15(1986): 6-13.

Marrion, B.W., and R.L. Wills. "A Prospective Assessment of the Impacts of Bovine Somatotropin: A Case Study of Wisconsin." ***Amer. J. of Agr. Econ.,*** 72 (1990): 326-36.

Schmidt, G.H. "Economics of Using Bovine Somatotropin in Dairy Cows and the Potential Impact on the U.S. Dairy Industry." ***J. of Dairy Sci.,*** 72(1989): 737-745

Shapouri, H., C. Betts Liebrand, W.B. Jessee, T. Crawford, J. Carlin. "Economic Indicators of the Farm Sector: Costs of Production -- Livestock and Dairy, 1988." U.S. Department of Agriculture, March 1990.

Tauer, L.W., and H.M. Kaiser. "Optimal Agricultural Policy With Biotechnology; Bovine Somatotropin and the Dairy Sector." ***A.E. Staff Paper 90-9***, Department of Agricultural Economics, Cornell University, May 1990.

Yonkers, R.D., R.D. Knutson, and J.W. Richardson. "Dairy Farm Income as Affected by bST: Regional Characteristics." Proceedings, ***National Invitational Workshop on Bovine Somatotropin***, pp. 146-66. St. Louis, MO, September 1987.

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