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Potential Impacts of bST on the Minnesota Milk Supply

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POTENTIAL IMPACTS OF bST ON THE MINNESOTA MILK SUPPLY

John Helming and Jerome Hammond*

Introduction

Products of the new-biotechnology have the potential of significantly increasing milk production per cow. The technology has lowered the production costs for vaccines or naturally occurring substances useful in regulating animal physiology and health and may have far reaching economic implications for agriculture. In animal reproduction, breakthroughs such as embryo sex selection, storage and transfer along with twinning are a practical reality. Commercial ventures are being established to apply these methods to animal production (Kalter, et al. 1985). As these technologies have advanced, so has the concern about their safety for consumers, animals, and economic adjustments that may be required from their adoption. Perhaps no bio-technology has generated more interest, concern and controversy than Bovine Somatotropin (bST). [b]ST is a naturally occurring protein in cows. However, it can be supplemented with a bio-technology derived somatotropin to increase milk production. It has been shown in scientific experiments to increase daily milk production by more than 30 percent. The Federal Food and Drug Administration appears to be proceeding with extreme caution before granting approval for commercial use of the product. Nevertheless, the FDA has been criticized for its testing and approval procedures for bST. Legislation has been introduced in some states to ban the use of the product.

In 1990, the legislature in Minnesota and Wisconsin passed legislation that placed moratoria on the use of bST within the states for a one year period. The 1991, Minnesota extended the authorization for a ban, but it becomes effective only if Wisconsin enacts similar legislation. The Wisconsin legislature, in 1991, considered legislation to require specific labelling of milk produced with supplemental bST, but it was not enacted. Nevertheless, efforts continue to restrict or limit the commercial use of bST. An important question for the dairy industry in Minnesota regarding such a ban on its use, is, if bST is an economically viable technology that is adopted in all other states, how will it affect the relative position of Minnesota in the U.S. dairy industry?

In this study, we develop and apply a method to assess how bST may impact on Minnesota's share of the U.S. dairy industry with respect to total cow numbers, milk production per cow and the total milk supply. To make this assessment, we examine the industry under three scenarios:

1. bST is not available anywhere in the U.S. during the years being simulated;

2. The application of bST is prohibited in Minnesota and Wisconsin during the years being simulated, but it is available in the rest of the U.S.

3. bST is available in all states including Minnesota and Wisconsin for the years being simulated.

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Before developing the method and analyzing bST impacts under alternative scenarios, we'll briefly examine some of the general characteristics of the milk producing industry in Minnesota and factors that are likely to affect the adoption of bST, when and if it is approved.

Background

U.S. milk production increased from 124.2 billion pounds in 1965 to 144.3 billion pounds in 1989, a 16.2 percent increase. However, Minnesota's share of U.S. milk production declined from its peak of 8.6 percent in 1965 to 6.7 percent in 1990. Its share declined in two ways. Table 1 shows that Minnesota's share of the total U.S. dairy herd declined from 8.2 percent in 1965 to 6.9 percent in 1990. Table 1 also shows that in 1965, milk production per cow in Minnesota averaged 4.9 percent higher than in the U.S. total. In 1990 it was 3.8 percent lower. These trends will likely continue for the foreseeable future. Restricting the use of any productivity enhancing technology that may be used elsewhere in the U.S. will accelerate the decline in Minnesota productivity relative to the U.S. average and its share of the U.S. dairy industry. Specific estimates of these changes will be presented in subsequent sections of this report.

Table 1. Minnesota's Share of Total U.S. Milk Production and of Total U.S. Milk Cows and Minnesota Milk Production per Cow as a Percent of the U.S, 1965-1990.

	Share of Total Milk Production	Share of Total Number of Milk Cows	Production per Cow as Percent of Average U.S. Milk Production per Cow
	- - - - - - - - - - - - - -	%	- - - - - - - - - - - - - - -
1965	8.6	8.2	104.9
1970	8.2	7.9	104.1
1975	7.8	7.9	97.7
1980	7.4	8.0	93.0
1985	7.6	8.3	91.3
1986	7.4	8.2	89.7
1987	7.3	8.0	91.8
1988	7.2	7.6	91.8
1989	7.0	7.2	96.7
1990	6.7	6.9	96.2

Source: "Milk Production, Disposition and Income", NASS, USDA, selected years.

Administration of bST to lactating cows results in a progressive increase in milk production over a 4 to 6 day period after treatment. Production responses have been noted at all stages of lactation, but the magnitude of the response is not as great before peak milk production as thereafter. Table 2 shows production data collected from several experimental studies at several locations. The cows were injected for 266 days with 12.5, 25 or 50 milligram of bST. Injections began 4 to 5 weeks after calving. The data in Table 2 show average increases in milk production per cow per year from 6 to 29 percent when cows are injected with bST.

Which type of dairy farmer is most likely to adopt bST and what impact will it have on productivity if it becomes commercially available? The average increase in milk production per cow per year in a herd using bST will depend on numerous factors. For any given herd, impacts will depend on the amount of two-year old cows and three years and older cows in the herd. Research indicates that two-year old cows do not respond as well to bST as do older cows. Some argue that more data will be required to verify this observation (Annexstad and Otterby, 1988).

Most experiments with bST have been conducted in well managed herds. It is probable that positive responses in poorly managed herds will be smaller and short-lived. Although average production per milk cow in Minnesota is low relative to the national average, there is a large part of the producers who do use proven management techniques. Feed nutrient testing and formulation, use of herd records, good herd culling practices, animal health programs, and many other management practices were reported as being used in the 1988 Minnesota dairy survey (Hammond, 1989). In some respects, the Minnesota dairy industry appears ahead of other states in the northern dairy area. The northern states dairy survey for 1988 reported that the percentage of farms that have a culling rate of 30 percent or more is highest in Minnesota. Minnesota also has the lowest percentage of all dairy farms reporting a culling rate of 15 percent or less (Borton, 1989).

Table 2: Responses of 3.5% Fat Corrected Milk (lbs/day).

Location	Base Prod.	Daily Dosage of bST (mg/day) 12.5	25	50
	lbs/day	Milk production increases lbs/day (percent)		
Kentucky	59.4	7.5 (13%)	5.1 (9%)	8.8 (15%)
Minnesota	64.0	6.2 (10%)	15.0 (23%)	14.1 (22%)
Ohio	63.6	3.7 (6%)	5.3 (8%)	13.0 (20%)
Pennsylvania	53.2	15.0 (28%)	13.0 (24%)	15.2 (29%)
Ontario	58.7	8.4 (14%)	10.6 (18%)	9.0 (15%)
Mean	59.8	8.2 (14%)	9.8 (16%)	12.0 (20%)

Source: Otterby and Annexstad, 1988

Its often been asserted that bST is directly size neutral because it doesn't require a capital investment. However, as Milligan indicates, size will indirectly be a determinant of successful adoption of bST. The attainment of the high levels of productivity associated with successful adoption may require capital investments that are not size neutral. Examples include more sophisticated feeding systems and computerized information systems. These are likely to have significant economies of size associated with them.

It may also be argued that the most profitable and economically efficient dairy farms will be first to adopt bST. On the other hand, farms in poor financial health may by being early and/or highly successful adopters, substantially add to income to improve the financial health. Data from the Minnesota Dairy Farm Survey indicates that financial situation of a dairy farm might be related to intentions to adopt or not adopt bST. Of the farmers with debt of 70 percent or more of assets or 100 percent or more of assets, respectively 13 and 11 percent reported that they will adopt bST if it becomes available. Of the farmers with a debt-to-asset ratio of 70 percent or less, 9 percent reported that they will adopt bST if it becomes available (Hammond, 1989). This is consistent with data on the Minnesota pork industry. In a recent survey among a group of pork producers in Minnesota, a significant negative relationship between the level of net returns per hundredweight (a measure of profitability) and adoption of pST was calculated. The authors concluded that producers might be more interested in adopting productivity enhancing technologies when forced to by economic circumstances, rather than when they are more comfortable financially (Lazarus, 1990).

Supply Adjustments in Minnesota Under Alternative Scenarios Regarding Adoption of bST

The Analytical Framework for Analysis

Sellschopp and Kalter state that the true comparative advantage position of an industry in a particular region can only be captured through the modelling of resource constraints and competing production activities. This requires a modelling system which includes all such linkages. Only rarely, however, is it practical to include all linkages in one analysis system. A trade-off between comprehensiveness and practicality has to be made. (Sellschopp and Kalter, 1989; and Penson and Chen, 1988). Examples of bST studies that rely on an econometric dairy industry model at national level are those by Kaiser and Tauer, 1989, and Kaiser, 1990. The models yield useful conclusions for a national setting, but their implications for a particular state or region are unclear.

Our approach for examining national and individual state adjustments, that may result from bST, is the `top-down' approach. With this approach, a state model is designed as a satellite system to a national model. The national model generates national variables that are specified as exogenous variables for the producing sector at the state level. An implicit assumption of this approach is that the state model is correctly isolating the developments that have been aggregated for all states in the national model. From the standpoint of a particular state, a satellite model may be appropriate for policy analysis if changes within any single state's dairy industry does not dramatically affect national performance (Azzam, et al. 1987).

In this study, we assume no impact of the total milk supply in Minnesota on national prices. This means that the total milk supply in Minnesota is judged to be small relative to the total milk supply in the U.S. This is, of course, a simplification of the real relationship between model variables, but it allows us to apply a regional econometric model and a national econometric model in a recursive system. We don't have a simultaneous-equation problem in this situation. The limited time available for this study and the knowledge that in many applications the results of such recursive systems do not differ very much from those obtained by more sophisticated methods under the assumptions stated above, justifies our decision.

The National Model

The national model used in this study is the National Economic Milk Policy Impact Simulator (NEMPIS). The structure of NEMPIS is a system of equations and equilibrium conditions developed by Kaiser, Streeter and Liu. The model is estimated for the time period 1960 through 1989.

The model specifies the national dairy market to consist of an aggregate farm sector and an aggregate consumption sector. Within this framework, dairy farmers produce and sell raw milk to users of dairy products. The consuming market is sub-divided into two segments based on the type of products being processed and sold. Class 1 users process and sell fluid products directly to consumers and Class II users process and sell manufactured dairy products to consumers. Equilibrium between the farm and the retail sectors is specified by the following condition:

$$MILK_t = Q^f_t + Q^m_t + CCC_t, \tag{1}$$

where: MILK is the total commercial milk marketings by dairy farmers, Q^f and Q^m are the equilibrium fluid (Class I) and manufactured (Class II) quantities in the commercial market and CCC is government purchases under the dairy price support program. Given the prices paid for raw milk by each of the retail sectors (Class I and Class II), the national all milk price, USMP, is determined through the following condition:

$$USMP_t = P^{II}_t ((Q^m_t + CCC_t)/MILK_t) + P^I_t (Q^f_t/MILK_t). \tag{2}$$

NEMPIS is capable of simulating annual equilibrium prices and quantities for the national dairy market through 2008.

There are two milk production technologies available in NEMPIS. One specifies that bST is not available during all years being simulated. Any increases in production per cow are assumed to be due to non-bST technological advances, increases in the milk price, and/or decreases in variable cost of production. The second option specifies that bST will be available for all, or part of the selected simulation period. The option of bST is incorporated by multiplying the production per cow equation by one plus the product of the imputed increase in milk yields of treated cows due to bST times the cumulative adoption rate. Thus, the impact of bST on the milk production per cow of the national level is incorporated directly in the milk production per cow equation.

NEMPIS offers several categories of price support policy. One choice is automatic support price adjustments, without a Dairy Termination Program as provided in the 1985 Food Security Act. Another permits automatic support price adjustments with a Dairy Termination Program. Another permits the user to set any arbitrary level of price support. For our analysis, we specified the support price at the current level of $10.10 per hundredweight for each year, 1991 through 1996.

The State Model for Minnesota

The econometric model of the dairy sector in Minnesota for this study includes only the supply side of the market at the farm level. The model consists of three equations. Behavioral equations are estimated for the number of milk cows (MNCN) and milk production per cow (MNPPC). It explains the supply of raw milk. The total supply of raw milk is defined as the number of cows (MNCN) times production per cow (MNPPC). While the supply of raw milk could be estimated directly, estimating separate equations for MNCN and MNPPC provides additional information that otherwise could not be obtained (Kaiser et al. 1987). The two behavioral equations are estimated using ordinary least squares (OLS). The regional model uses regional and national annual time series data from 1962 through 1990. The data used in this study is presented in Appendix A.

<u>The production per cow equation</u>: To develop the model of production per cow, we first consider a profit maximizing competitive firm with a static restricted profit per cow function as follows:

$$P(P_y,W_x,Z,X) = P_y y(X,Z) - W_x'X, \qquad (3)$$

where P_y is price of output y( ),
W_x is a vector of prices of variable inputs X,
y( ) is the production per cow function,
$\partial y(X,Z)/\partial X$, and $\partial y(X,Z)/\partial Z > 0$, and
Z is a vector of quasi-fixed inputs.

The profit maximizing choice of the variable inputs is found by differentiating (3) with respect to X:

$$\partial P(P_y,W_x,Z,X)/\partial X = P_y\,(\partial y(X,Z)/\partial X) - W_x = 0 \qquad (4)$$

This is the classical first order condition for production efficient behavior of a competitive firm. It states that at the optimum, value marginal product ($P_y\,(\partial y(X,Z)/\partial X)$) is equal to input price W_x. Equation 4 is also the factor demand curve. It measures the relationship between the price of a factor and the profit maximizing choice of that factor (Varian, 1987). This relationship for profit maximization means that total milk production per cow should be increased if the prices of variable inputs decrease relative to the price of milk. Milk production per cow should be reduced if the prices of variable inputs increase relative to the price of milk.

Now, consider the introduction of a new technology such as bST. It changes the production function. The marginal increases in production in response to increases in variable inputs will be increased. Thus, the profit maximizing output per cow will be increased. This will, however, require increases in input use in addition to the use of bST. As noted by Giesen et al., to arrive at the new equilibrium point, (1) the cow needs more feed input and feed that is also of better quality, (2) veterinary costs may increase, and (3) costs of milking and milk handling may increase. etc. They also note that the expected number of productive lactations may decrease.

In addition to changes in variable inputs, short term production response will still be influenced by the fixed factors of production, particularly, the basic production unit, the cow. To incorporate this element into the production relation, lagged production per cow ($MNPPC_{-1}$) is added to reflect this constraint on milk production. A trend term (T, 1960 = 1) is used to reflect shifts in the production function over time. It can be seen as a proxy for genetic improvements, for average improvements in the quality of management practices, for quality of resources or for economies that may be associated with size of the farm unit.

Using natural logarithm of the data, the following milk production per cow function was estimated:[1]

$$\ln MNPPC_t = \underset{(.1575)}{3.0001} + \underset{(.0249)}{0.6628 \ln MNPPC_{-1}} + 0.0397 \ln (PM/CR)_{-1} \qquad (5)$$

$$+ \underset{(.0026)}{0.0051\,T}$$

where $MNPPC_t$ = milk production per cow in Minnesota (lbs/cow) in year t;
T = trend variable, 1962=1, 1963=2, etc.;
CR = the price of corn per bushel in Minnesota ($/bu);
PM = the average farm milk price in the U.S. ($/cwt).

$R^2 = 0.97$

The national farm milk price is used instead of the average farm milk price in Minnesota in order to tie the Minnesota model to the national model. This is quite reasonable because most of Minnesota's milk supply in processed form is marketed elsewhere in the U.S. This makes the farm milk price in Minnesota independent of the demand for milk in Minnesota.[2] CR is a proxy for the feed costs which are often the most important variable cost of production for dairy farmers. It may also reflect opportunity costs of using the land and some of the equipment in other farm enterprises. It is assumed that farmers expect the milk price to feed cost ratio in period t-1 to be the ratio in period t.

The milk production per cow is modeled as a linear function of time (T) to avoid the problem of increasing productivity gains over time. Milk production per cow in Minnesota has a significant upward trend, but the trend does not appear to be accelerating.

Alternative production per cow equations were estimated, but this specification required fewer assumptions and projections of exogenous variables for projection purposes. Statistical significance of the coefficients is high. Consequently, only this formulation was retained for the simulations.

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[1] The numbers in parentheses are standard errors of the estimates.

[2] The following linear relationship over the period 1950 - 1988, between the farm milk price in Minnesota (MNMP) and the farm milk price in the U.S. (USMP) was estimated:

$$MNPM = \underset{(-10.6)}{-0.88} + \underset{(102.5)}{1.01\,USPM}$$

$R^2 = 0.997$

The shift in milk production per cow in Minnesota that would be caused by bST is incorporated into the simulations as in the national (NEMPIS) model. The estimated production per cow equation is multiplied by one plus the product of the increase in milk production per cow due to bST (I) times the cumulative adoption rate (C):

$$MNPPC = (1 + IC)\exp[3.3001 + 0.6628 \ln MNPPC_{-1} + 0.0397\,(PM/CR)_{-1} + 0.0051T] \quad (6)$$

<u>The cow number equation</u>: The determinants of dynamic adjustments in the quasi-fixed inputs, such as number of milk cows, have been identified in various theories of investment. Many of these theories can be linked to the flexible accelerator model of Chenery. The model deals with the time pattern of investments. The firm is taken to have a desired level of capital determined by long run considerations. Capital is adjusted toward its desired level by a certain proportion of the discrepancy between desired and actual capital in each period:

$$K_t - K_{t-1} = (1-\lambda)[K^*_t - K_{t-1}], \quad (7)$$

where, K is actual capital and K^* is desired capital and where λ, such that $0 < \lambda < 1$, can be seen as the rate of decline and where $(1-\lambda)$ can be seen as the speed of adjustment. Equation (7) can also be written as:

$$K_t = (1-\lambda)K^*_t + \lambda K_{t-1}, \quad (8)$$

to obtain a model of the capital stock. In the dairy industry, an important onto component or indicator of capital stock is the number of milk cows, CN. Thus, (8) may be rewritten as:

$$CN_t = (1-\lambda)CN^*_t + \lambda CN_{t-1}, \quad (9)$$

The specification of desired capital has developed along four major lines. These approaches have been discussed by Jorgenson and Siebert (1968) and more recently by Weersink and Tauer (1989). These theories of investment are: neoclassical, accelerator, expected profits and liquidity. In this study, we use the expected profits theory of investment as proposed by Tinbergen and modified by Grunfeld (Jorgenson and Siebert, 1968 and Weersink and Tauer, 1989). Tinbergen proposed a theory in which investment depends on the level of profits. Higher profitability increases future expectations, which stimulates current investment and may also ease constraints on the supply of funds to finance expansion. Jorgenson et al. (1968) suggest that profit expectations be measured by the market value of the firm (V), which should equal discounted future cash flow net of investment expenditures. Stock markets provide continuous quotes for this value for publicly traded corporations. Because equity shares for farms are not traded publicly or are not readily reported elsewhere, one may argue that an appropriate proxy for future profitability of dairy farms may be the current price of dairy cattle. In any event, we believe that a large part of the increase in profits is capitalized into dairy cattle, which are marketable assets for dairy farmers. Thus, the desired capital stock can be seen as a proportional function of the current market price of dairy cattle:

$$CN^*_t = a_0 + a_1 PDC_t, \quad (10)$$

where PDC is the market price of milk cows.

As a result of (10), the capital stock model (9) can be written as:

$$CN_t = (1\text{-}\lambda)a_0 + (1\text{-}\lambda)a_1 PDC_t + \lambda CN_{t-1}. \qquad (11)$$

CN_t in equation (11) measures the value of dairy cow capital invested in the U.S. dairy sector at the beginning of the production period. Ignoring the price-component, we assume that the number of milk cows in the U.S. dairy sector in year t is a proxy for capital.

Milk cows are seen as a quasi-fixed input (Chavas and Klemme, 1986; Howard and Shumway, 1987; and Weersink and Tauer, 1989). The funds to raise or purchase a quasi-fixed input as milk cows must be paid out immediately, whereas the income or benefits accrue over time. Because the benefits are based on future events, investments in milk cows should be evaluated under alternative futures with respect to prices, productivity, and cost to determine the expected profitability.

In this study, we relate the number of milk cows in Minnesota to the general profitability of dairy farms in the U.S. Because profit figures are not readily available, an appropriate proxy must be selected for this variable. We assume that the expected milk production per cow is an important element in determining expected profitability of investments in milk cows. As stated above, the expected milk production per cow depends on such factors as quality of management practices, quality of available resources and business size. Therefore, we specify the desired number of milk cows in Minnesota ($MMCN^*_t$) as a linear function of expected milk production per cow in Minnesota:

$$MMCN^*_t = a_0 + a_1\, EPPC^*_t, \qquad (12)$$

where $EPPC^*$ is the expected milk production per cow in Minnesota.

Given a two year lag $EPPC^*$ can be written as:

$$EPPC^*_t = 0.67^*(MNPPC)_{-1} + 0.33^*(MNPPC)_{-2}, \qquad (13)$$

where, MNPPC is production per cow in Minnesota.

Lags of one, two, and three years were used in the analysis. The two period lag provided the best statistical fit for the following equations. Substitution of equation (13) in equation (12) and equation (12) in equation (9) yields the following cow number equation for Minnesota:

$$MMCN_t = (1\text{-}\lambda)a_0 + (1\text{-}\lambda)a_1\, EPPC^* + \lambda MMCN_{t-1} \qquad (14)$$

Estimation of this equation yields:

$$\underset{}{MNCN_t} = 205.7192 + \underset{(.0719)}{0.8758\, MNCN_{-1}} - \underset{(.0080)}{.01002\, EPPC^*_t} \qquad (15)$$

where MNCN = total cow numbers in Minnesota (1000);

$R^2 = 0.97$

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

$$MNMP = (0.985 * MNCN * MNPPC)/1000 \qquad (16)$$

where MNMP = milk marketed in Minnesota (bil. lbs.).

Alternative Price Support and bST Scenarios

Three scenarios are examined with respect to the potential impacts of approval of bST by the U.S. Food and Drug Administration (FDA) and its adoption by U.S. milk producers. All three scenarios apply to the U.S. and Minnesota dairy sectors for the period 1991 through 1996. Scenario 1 is the base situation where bST is neither approved nor adopted anywhere in the U.S. It provides a basis for comparison for the other two scenarios. Scenario 2 reflects a situation where bST is approved by the FDA and adopted in all states but Minnesota and Wisconsin because of legislative bans on its sale and use. Scenario 3 is a situation where bST is approved by the FDA and adopted throughout the U.S. including the states of Minnesota and Wisconsin.

In order to simulate Scenarios 1 through 3 we first run the national model, NEMPIS to estimate the U.S. farm milk price. This variable is the linkage between the national model and the regional model. However, before the national and Minnesota model can be used to forecast future impacts on the dairy industry, we must make assumptions and forecasts for variables for the simulation period that are not predicted by the model. Specifically, we must include the federal support prices that are expected to prevail, the price of corn that is included as a determinant of milk production in Minnesota, the average per cow response to the use of bST by adopters of this technology and the annual adoption rate for herds in the U.S. and in Minnesota.

The support prices that were included in each of the scenarios are based on the price support rules that are currently established by the Food, Agriculture, Conservation and Trade Act (FACT) of 1990. The FACT mandates that annual support price adjustments be based on the level of dairy surpluses acquired by the federal government. It requires the Secretary of Agriculture to forecast government purchases of dairy products prior to each calendar year. If projected purchases are between 3.5 and 5 billion pounds of milk equivalent, the support price will be unchanged, currently, at $10.10 per hundredweight. The support price is to be increased by not less than $.25 per hundredweight if government purchases are predicted to be less than 3.5 billion pounds. If government purchases are projected to exceed 5 billion pounds of milk equivalent, the price support is to be reduced by $.25 to $.50 per hundredweight, but in no event, can the support price be reduced below $10.10 per hundredweight.

The FACT also provides for assessments on producers who do not expand production over the previous year, but because the national model (NEMPIS) does not provide for this feature, they are not incorporated into our analysis. We expect these to range from $.05 to $.20 per hundredweight for producers who expand production. Because it is a relatively small part of the total milk price, we do not expect that its omission from the analysis will have a large influence on the results.

We used Kaiser's NEMPIS to estimate CCC removals with price support set at the minimum of $10.10 per hundredweight. If the estimated removals trigger adjustments in support for any year, the NEMPIS model was recalculated with the appropriate support prices. These results for the 1991-96 period with associated support prices based on the FACT provisions are presented in Table 3 for each of the scenarios.

Table 3: CCC Purchases and Support Price Levels 1990 Through 1996 for Three Alternatives Regarding Use of bST.

	Scenario 1: (bST not permittted in any state)		Scenario 2: (bST permitted except in Minnesota and Wisconsin)		Scenario 3: (bST permitted in all states)	
Year	Support price ($/cwt)	CCC (bil. lbs.)	Support price ($/cwt)	CCC (bil. lbs.)	Support price ($/cwt)	CCC (bil. lbs.)
1990	10.10	10.84	10.10	10.84	10.10	10.84
1991	10.10	9.43	10.10	9.43	10.10	9.43
1992	10.10	6.88	10.10	7.58	10.10	7.81
1993	10.10	4.26	10.10	6.16	10.10	6.77
1994	10.60	1.81	10.10	4.50	10.10	5.61
1995	11.10	0.09	10.35	3.31	10.10	4.62
1996	11.60	0.04	10.85	2.64	10.35	3.78

The next step for each scenario is to estimate the production per cow, cow numbers, and milk marketings in Minnesota using the equations developed in preceding sections of this report. Scenarios 2 and 3 require incorporation of bST productivity gains and adoption rates into the models. This is done both in the national model and in the state model by the adjustment rules described previously. A critical question regarding these components is, what will be the average impact of bST on per cow milk production in herds that adopt the technology, and what rate will be adopted by producers. This is critical because the forecasted effects of bST on milk supply in Minnesota under Scenarios 2 and 3 are very sensitive to the assumed increase in milk production of treated cows and adoption of bST.

Scientists from the Department of Animal Science of the University of Minnesota (1989) believe that bST can increase lactation yield by 10 to 15 percent for most cows under conditions of good management. Recall that 15 percent is approximately the mean of the experimental results presented in Table 2. We believe that productivity gains from experimental studies would not be attained on average in practical application. Thus for our analysis, we use a 10 percent increase in milk production per cow per year for those herds adopting bST.

The adoption rate for bST is even more difficult to estimate because there is little substantive data on likely adoption. A study done by Kalter et al. in 1985 concluded that bST will be widely and quickly adopted. This was concluded, at least in part, because it was assumed that it would be profitable on most cows, and for most farmers. They estimated that bST would be used on 63 to 85 percent of New York cows within three years of commercialization (Kalter et al. 1985). These results were based upon a survey of 173 farmers in 1984. They are not, however, very consistent with the reported percentages in the Summary of the 1988 Northern U.S. Dairy Farm Survey. This survey shows that between 40 and 50 percent of all dairy farms in the survey do not plan to use it. Only 7 to 10 percent of the farms indicate that they would be early adopters (Borton et al. 1990).

Larson and Kuchler point out that while there is no consensus on either the per cow yield or the aggregate supply impact of bST, more recent studies have made smaller claims than earlier studies. They cite the cost of bST adoption, which include the hormone price,[3] increased feed requirements, and additional management time and skills. They conclude that: (1) there may not be sufficient economic incentives to adopt bST; and (2) if farmers adopt bST, the economic incentive will be such as not to produce at the biological maximum obtained in test studies.

Marion and Wills use an incremental revenue-cost model and the distribution of Wisconsin herds by production level to estimate the potential demand for bST under various key assumptions: (1) the impact of bST on production per cow, (2) cost of bST to farmers, (3) returns required by farmers to adopt bST and (4) the price of milk. They project an adoption of bST of 7 percent of cows during the first year of use in Wisconsin. Estimates for the second, third, and fourth years were 20, 33 and 40 percent, respectively (Marion and Wills, 1990).

For our analyses in Scenario 2, we assumed that bST becomes commercially available in the rest of the U.S. in 1992 and milk production in treated cows is 10 percent higher than non-treated cows. Its assumed that, on average, U.S. farmers apply bST to an additional 5 percent of the herd each year so that 25 percent of the U.S herd is treated with bST by 1996. However, greater rates of adoption will simply accentuate some of the differences in productivity and production between the U.S. and the Minnesota dairy industry.

Scenario 3 uses the same bST assumptions as the second scenario, but it is assumed that bST is also approved and commercially available in Minnesota. For these estimates, we assume that the increase in milk production in treated cows and adoption rates are equal in Minnesota and in the U.S.

In order to make Scenario 3 more comparable with Scenario 2 we adjusted the national adoption rate. This is necessary because, with bST commercially available in Minnesota and in Wisconsin, more cows would be treated with bST assuming that the cows outside of Minnesota and Wisconsin represent 5 percent of the national dairy herd which includes Minnesota and Wisconsin. In effect, more than 5 percent of the dairy cows outside of Minnesota and Wisconsin are being treated with bST under Scenario 2. To determine this new adoption rate for Scenario 3, the following equality was specified:

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[3] Kalter et al., showed that the average cost of producing bST is much lower than the expected increase in profits its use could generate. As stated by Larson and Kuchler (1990), and by Marion and Wills (1990), the cost of producing bST may have little bearing on the price charged to farmers.

$$USCN \bullet AD2 = (USCN - (MNCN + WICN)) \bullet AD3, \quad (17)$$

where USCN = total cow numbers in the U.S. in 1989,
MNCN = total cow numbers in Minnesota in 1989,
WICN = total cow numbers in Wisconsin in 1989,
AD2 = annual adoption rate in Scenario 2, and
AD3 = annual adoption rate in Scenario 3.

Using an annual adoption rate of 5 percent in Scenario 2 and equality (17), we calculate an annual U.S. adoption rate of 6.6 percent for Scenario 3.

Simulation Results

Continuation of the FACT support price adjustment rule results in declining CCC purchases under all three scenarios throughout the 1990-96 period. All three scenarios show increased support prices by 1995 or 96 because CCC purchases fall below the trigger level for upward adjustments. CCC purchases and support price levels under the three scenarios are presented in Table 3.

Projected milk prices and quantities through 1990 for each situation are describe below. For comparison, the actual 1990 prices and quantities are presented in the tables and used in the discussion.

Scenario 1. With the base situation for 1990 through 1992, Scenario 1, national milk production declines during the first part of the 1990's, see Table 4. This is caused largely by the low support price and market price for milk that would prevail. As production declines commercial demand expands which causes CCC purchases for price support decline and both the support price and market prices begin to increase markedly by 1996. Annual average production per cow in the U.S. increases from 14,642 pounds in 1990 to 17,010 pounds in 1996, a 16.2 percent increase.

While changes in Minnesota's dairy seem to parallel those in the national industry, Minnesota's gains in production per cow are less than the national average and cow numbers decline more rapidly than the national average, see Table 4. Between 1990 and 1996, Minnesota's share of the national dairy herd is projected to decline from 7.1 percent to 7.0 percent. Production per cow increases 5.1 percent from 14,093 pounds per cow in 1990 to 14,808 pounds per cow in 1996 which is a lower rate of increase than the average national increase. Production per cow in Minnesota in 1990 was 96.3 percent of the national average, by 1996 its projected to decline to 87.1 percent under Scenario 1. Consequently, Minnesota's share of national milk production declines from 6.7 percent in 1990 to 6.1 percent by 1996.

Scenario 2. Scenario 2, where bST is approved and adopted by some producers in all states except Minnesota and Wisconsin, accelerates the tendencies already existing in Minnesota. Nationally, average productivity increases per cow are even greater than without bST, a 22 percent increase from 1990 to 1992 compared to 16.2 percent without the use of bST. National cow numbers decline from 10,127 to 8,514, but not enough to offset the increase in production per cow, see Table 5. The national change in cow numbers is not greatly different from the situation where bST is not adopted. In total, commercial supply continues to exceed commercial demand by sufficient amounts so that price support increases do not occur until 1995 and 1996. The All-U.S.

milk price, though increasing after 1991, is almost $1.50 below the level projected for 1996 if bST is not introduced. For those that adopt bST or achieve productivity gains by other means, the reduced prices relative to Scenario 1 would be offset, fully or partially, by reduced costs of production.

Minnesota's role in the national dairy industry declines substantially more under Scenario 2, where bST is banned in Minnesota and Wisconsin, but not elsewhere in the U.S compared to no use of bST anywhere in the U.S. Total Minnesota milk production would decline by 8 percent between 1990 and 1996. Its share of U.S. milk production would decline from 6.7 percent to 5.9 percent by 1996. The decline in cow numbers in Minnesota is the same as that with Scenario 1. Production per cow increases by 4.8 percent, not nearly as rapidly as the national average increase. By 1996, milk production per cow in Minnesota is projected to be only 82.9 percent of the national average per cow production, Table 5. In fact, the lower milk prices after 1993 that are caused by the introduction of bST elsewhere in the U.S. slow the increase in milk production per cow in Minnesota relative to Scenario 1. Its share of the national dairy herd is essentially unchanged, from 7.0 percent in 1990 to 7.1 percent in 1996.

Scenario 3. This scenario, where Minnesota producers can use bST if it is approved for use and adopted elsewhere in the U.S., permits Minnesota's dairy industry to retain a larger share of the national dairy market and to achieve greater productivity gains than without the technology, Table 6. Because, Minnesota and Wisconsin producers are permitted to use the technology, the impacts on the national total milk production and average productivity per milk cow are substantially greater than under Scenario 2. With the same rates of adoption in Minnesota and Wisconsin as throughout the remainder of the U.S., total U.S. milk production increases by 2.7 percent by 1996 while total Minnesota milk production declines by 8.2 percent. This is substantially less than the 12 percent decline that is forecast for the scenarios without bST. Consequently, Minnesota's share of national milk production falls to only 6.0 percent by 1996 as opposed to 5.9 percent if bST is used elsewhere in the U.S., but not in Minnesota and Wisconsin.

The number of milk cows in the U.S. in 1996 is 16.7 percent lower than in 1990 under Scenario 3. However, Minnesota's cow numbers decline by 20.2 percent causing only a small decline it Minnesota's share of total U.S. milk cows, 7.0 to 6.9. In this situation, gains in average milk production per cow are substantially greater than with the preceding scenarios, 11.6 percent over the period, 1990 through 1996, compared to only about a 5 percent gain for Scenarios 1 and 2.

To determine how sensitive the estimates are to the bST assumptions made in Scenario 3, Scenario 3 is recalculated assuming the 10 percent increase in milk production of treated cows but with 10.0 percent of all farms adopting bST each year. The results are presented in Table 7. The table shows that the cow numbers decline between 1990 and 1996 is only marginally different in both the U.S. and in Minnesota than with the lower bST adoption rates. Table 7 also shows that with an annual adoption rate of 10 percent, Minnesota's share in total milk cows remains the same throughout the period. Minnesota's share in total U.S. milk production declines from 6.7 percent to 6.2 percent, slightly less than with the smaller annual bST adoption rates. Average production per cow in Minnesota increased by 15.2

Table 4: Scenario 1; no bST in the U.S. nor in Minnesota*

Year	MNCN (1000)	MNPPC (lbs./cow)	MNMP (bil. lbs.)	PM ($/cwt)	USPPC (lbs./cow)	USCN (1000)	USMP (bil. lbs)	(MNCN/USCN) *100 (%)	(MNMP/ USMP) *100 (%)	(MMPPC/ USPPC) *100 (%)
1990	710.0	14,093	10.01	13.77	14,642	10,127	148.28	7.0	6.7	96.3
1991	687.4	14,180	9.75	12.00	15,238	9,727	148.00	7.1	6.6	93.1
1992	665.9	14,221	9.47	12.10	15,594	9,462	147.33	7.0	6.4	91.2
1993	646.6	14,313	9.25	12.19	15,934	9,217	146.66	7.0	6.3	89.8
1994	628.9	14,440	9.08	12.68	16,266	8,959	145.54	7.0	6.2	88.8
1995	612.2	14,609	8.94	13.16	16,627	8,713	145.00	7.0	6.2	87.9
1996	596.1	14,808	8.83	14.59	17,010	8,514	144.66	7.0	6.1	87.1

Table 5: Scenario 2; bST approved in the U.S., but not in Minnesota*

Year	MNCN (1000)	MNPPC (lbs./cow)	MNMP (bil. lbs.)	PM ($/cwt)	USPPC (lbs./cow)	USCN (1000)	USMP (bil. lbs)	(MNCN/USCN) *100 (%)	(MNMP/ USMP) *100 (%)	(MMPPC/ USPPC) *100 (%)
1990	710.0	14,093	10.01	13.77	14,642	10,127	148.28	7.0	6.7	96.3
1991	687.4	14,180	9.75	12.00	15,238	9,727	148.00	7.1	6.6	93.1
1992	665.9	14,221	9.47	12.09	15,671	9,461	148.04	7.0	6.4	90.7
1993	646.6	14,312	9.25	12.18	16,148	9,214	148.55	7.0	6.2	88.6
1994	628.9	14,439	9.08	12.27	16,664	8,952	148.93	7.0	6.1	86.6
1995	612.2	14,590	8.93	12.55	17,216	8,700	149.54	7.0	6.0	84.7
1996	596.2	14,767	8.80	13.03	17,818	8,451	150.32	7.1	5.9	82.9

*Definitions of abbreviations:

MMCN - Minnesota cow numbers.
MNPPC - Minnesota production per cow.
MNMP - Total Minnesota milk production.
PM - U.S. all milk price.
USPPC - U.S milk production per cow.
USCN - U.S. cow numbers.
USMP - Total U.S. milk production.

Table 6: Scenario 3; bST approved in the U.S. as well in Minnesota. An annual adoption rate of 6.6% is assumed in the U.S and in Minnesota.*

Year	MNCN (1000)	MNPPC (lbs./cow)	MNMP (bil. lbs.)	PM ($/cwt)	USPPC (lbs./cow)	USCN (1000)	USMP (bil. lbs)	(MNCN/USCN) *100 (%)	(MNMP/ USMP) *100 (%)	(MMPPC/ USPPC) *100 (%)
1990	710.0	14,093	10.01	13.77	14,642	10,127	148.28	7.0	6.7	96.3
1991	687.4	14,180	9.75	12.00	15,238	9,727	148.00	7.1	6.6	93.1
1992	665.9	14,315	9.53	12.09	15,696	9,461	148.27	7.0	6.4	91.2
1993	645.9	14,565	9.41	12.18	16,217	9,213	149.16	7.0	6.3	89.8
1994	626.3	14,896	9.33	12.26	16,794	8,949	150.03	7.0	6.2	88.7
1995	606.1	15,287	9.27	12.34	17,419	8,696	151.20	7.0	6.1	87.8
1996	584.6	15,723	9.19	12.62	18,089	8,436	152.31	6.9	6.0	86.9

Table 7. Scenario 3 modified; bST approved in the U.S. as well in Minnesota. An annual adoption rate of 10 % is assumed in the U.S and in Minnesota.*

Year	MNCN (1000)	MNPPC (lbs./cow)	MNMP (bil. lbs.)	PM ($/cwt)	USPPC (lbs./cow)	USCN (1000)	USMP (bil. lbs)	(MNCN/USCN) *100 (%)	(MNMP/ USMP) *100 (%)	(MMPPC/ USPPC) *100 (%)
1990	710.0	14,093	10.01	13.77	14,642	10,127	148.28	7.0	6.7	96.3
1991	687.4	14,180	9.75	12.00	15,238	9,727	148.00	7.1	6.6	93.1
1992	665.9	14,363	9.56	12.09	15,748	9,460	148.75	7.0	6.5	91.5
1993	645.6	14,695	9.49	12.17	16,363	9,211	150.45	7.0	6.4	90.6
1994	625.0	15,134	9.46	12.25	17,066	8,944	152.36	7.0	6.3	90.1
1995	602.9	15,653	9.44	12.33	17,849	8,686	154.72	6.9	6.2	89.9
1996	578.6	16,234	9.39	12.40	18,703	8,420	157.12	6.9	6.2	89.7

*Definitions of abbreviations:

MMCN - Minnesota cow numbers.
MNPPC - Minnesota production per cow.
MNMP - Total Minnesota milk production.
PM - U.S. all milk price.
USPPC - U.S milk production per cow.
USCN - U.S. cow numbers.
USMP - Total U.S. milk production.

percent during the period. Interestingly, this permits average per cow production in Minnesota to fall less relative to the national average than with any of the preceding scenarios, production per cow in Minnesota falls only to 89.7 percent of the national average rather than 86.9 with the lower rate of bST adoption.

The impacts on gross farm income from milk sales were calculated for each of the scenarios, based on the assumption that Minnesota milk marketings are 98.5 percent of total milk production for each year and that the average Minnesota milk price is approximately $1.00 per hundredweight less than the national average price. For all for situations that were examined, the 1990 income was calculated to be $1.259 billion dollars. Given the projected price support policies, prices and gross dairy farm income in Minnesota will decline regardless of whether or not bST is available for commercial use. With no adoption of bST in the U.S., gross income declines to $1.182 billion dollars in Minnesota by 1996. If bST is adopted in all other states but Minnesota and Wisconsin, gross income declines to $1.042 by 1996. If bST is permitted in Minnesota and Wisconsin as well, gross income declines only slightly less to $1.052 billion by 1996. Because 1990 prices were high relative to the recent trend in prices, one should, perhaps make the comparisons with projected prices for 1991 when milk price is more in line with long term trends. Gross 1991 Minnesota dairy sales are estimated to be $1.056 billion. The projected 1996 dairy sales change very little from 1991. The market price increases that are projected for the latter part of the period, offset much of the decline in total milk production and marketings.

Nationally, gross income from milk sales is also projected to increase from 1990 levels if bST is not adopted but to decline with adoption of bST. Using assumption that 98.5 percent of production is marketed, the projected U.S. gross income from milk sales increases from 1990 to 1996 if bST is not adopted anywhere in the U.S., from 20.11 to 20.79 billion dollars. If bST is adopted in all states but Minnesota and Wisconsin, gross U.S milk sales decline to 19.29 billion dollars by 1996 or 4.1 percent. If bST is adopted in all states , gross U.S. milk sales decline to 18.93 billion dollars or 5.9 percent. Some of these declines would be offset by reduced production costs because of increased productivity, but our model and data do not permit us to make estimates of these savings or changes in net income for milk producers.

Summary And Conclusions

Minnesota's legislature has enacted legislation in the last two years that would place a moratorium on the sale and use of bST within the state for one year following its approval for use by the U.S Food and Drug Administration. Some groups would like to place a permanent ban on its use. What impact would such a restriction have on the Minnesota dairy industry, especially if it is approved for use elsewhere in the U.S? The technical feasibility of the hormone to increase milk production has been extensively studied and well documented. There seems little doubt that it can increase herd productivity by 10 percent or more per lactation period. However, the economic feasibility of the product is less well known and very uncertain.

Of particular importance regarding feasibility is the consumer acceptability of milk produced in herds using bST. Although scientific evidence indicates that milk from bST herds is of the same quality as that from non-bST herds, that there are no adverse impacts for humans from using the milk or milk products, and that it is almost impossible to distinguish milk from non-bST milk in the laboratory; consumers may perceive that there is a difference and/or potential hazards from using the product. The reaction of consumers will likely be influenced by the labelling requirements. If milk products from bST produced milk are labelled as such, they may be perceived as inferior and require price discounts from the non-bST milk products.

To assess how the proposed ban on use of bST in Minnesota would impact the milk producing sector of this state, we have assumed that total milk and milk product demand would be unaffected. A national model of the dairy industry that permits incorporation of per cow productivity gains and adoption rates for bST was used to estimate the national effects of bST through 1996. A sub-model for the state of Minnesota was constructed that generates per cow production, dairy cow number, and total milk production for the same period. Three scenarios were examined, (1) no use of bST anywhere in the U.S. though 1996, (2) approval and adoption of bST beginning in 1992 in all states except Minnesota and Wisconsin, and (3) approval and adoption of bST in all states in 1992 including Minnesota and Wisconsin.

The analysis shows that, even without use of bST in any state, Minnesota's share of the U.S. dairy market declines as it has throughout the 1980's, from 6.7 percent of national milk production in 1990 to 6.1 percent in 1996. Much of it occurs because average production per milk cow in Minnesota increases less rapidly than in the remainder of the U.S. In 1990, Minnesota production per cow was 96 percent of the national average. With continuation of past trends, Minnesota per cow production will be 87 percent of the national average in 1996.

A ban on bST in Minnesota and Wisconsin, while its use is permitted elsewhere in the U.S., will reduce Minnesota's relative position in the U.S. industry. Per cow production will decline to 83 percent of the national average and Minnesota's share of national milk production will fall to 5.9 percent in 1996. This would occur with its share of the national dairy herd remaining constant.

Permitting Minnesota and Wisconsin milk producers to use bST when this technology is permitted and used elsewhere in the U.S. will allow Minnesota's dairy industry to retain a larger share of the national dairy market and to achieve increased performance in productivity per cow. Average Minnesota milk production per cow would be increased from 14,808 in 1990 to 15,723 pounds per cow in 1996, resulting in more than 11 percent compared to 5 percent without the technology. Total milk production in the state would decline by 8 percent rather than by 12 percent without bST. A striking feature of the projections for Minnesota is the slow rates of increase in production per cow relative to the national increases, 5.1 for Minnesota and 16.2 percent for the national average without the use of bST. If bST is permitted in all states, Minnesota's average production per cow increases from 1990 to 1996 are only 11 percent compared to 23.5 for the nation given our assumptions about the productivity gains per cow for adopters of bST.

In conclusion, our analysis indicates that if bST is not adopted anywhere in the U.S., Minnesota's dairy industry will continue to fall behind in terms of production per cow as well as experiencing a decline in total milk production in the state. If bST is approved and adopted in other states, production per cow falls even further behind the national average and its share of national milk production falls from 6.7 percent in 1990 to 5.9 percent in 1992. If bST is also approved and adopted in Minnesota and Wisconsin, substantial production per cow gains can be achieved. Nevertheless, average production per cow continues to fall relative to the national average and total milk production in the state declines, unless the Minnesota dairy producing sector can accelerate improvements in management and technology of milk production in areas other than the simple adoption of bST.

If bST is approved in the rest of the U.S and consumer demand for milk and milk products is not significantly altered because of the product, and it leads to substantial gains in productivity, there will be substantial pressure in Minnesota to remove any restrictions on its use. The reasoning is simply that the market price and support price for milk will fall in response to increased production. As the market price falls below the point where non-adopting firms no longer cover variable costs, these firms will either begin to exit the industry, be forced to adopt the new technology, or be forced to adopt other technologies to make themselves competitive, or to demand approval for use of the technology in the state. A very high increase in production outside Minnesota due to bST and no adoption of bST in Minnesota is not a very likely scenario.

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APPENDIX A: DATA USED TO ESTIMATE THE MODEL OF MILK PRODUCTION IN MINNESOTA.

Year	MNCN (1000)	MNPPC (lbs./cow)	CR ($/bu)	MP ($/cwt)	USPPC (lb./cow)
1960	1,265	8,120	0.91	4.21	7,029
1961	1,278	8,270	1.03	4.22	7,290
1962	1,278	8,200	1.05	4.09	7,496
1963	1,270	8,240	1.03	4.10	7,700
1964	1,269	8,790	1.09	4.15	8,099
1965	1,232	8,710	1.06	4.23	8,305
1966	1,145	8,820	1.16	4.81	8,522
1967	1,084	9,360	0.98	5.02	8,851
1968	1,036	9,670	1.02	5.24	9,135
1969	976	9,966	1.05	5.49	9,434
1970	949	10,154	1.18	5.71	9,747
1971	942	10,210	1.01	5.87	10,009
1972	932	10,279	1.50	6.07	10,259
1973	911	10,177	2.48	7.14	10,119
1974	890	10,542	2.92	8.33	10,293
1975	884	10,120	2.50	8.75	10,360
1976	878	10,523	2.03	9.66	10,894
1977	866	10,950	1.90	9.72	11,206
1978	837	10,859	2.08	10.60	11,243
1979	843	10,848	2.26	12.02	11,492
1980	862	11,062	2.85	13.05	11,891
1981	886	11,356	2.33	13.77	12,183
1982	903	11,452	2.63	13.61	12,306
1983	899	12,139	3.05	13.58	12,585
1984	887	11,647	2.47	13.46	12,503
1985	915	11,847	2.05	12.75	12,994
1986	891	11,912	1.46	12.50	13,260
1987	823	12,680	1.98	12.54	13,802
1988	783	13,299	2.40	12.21	14,291
1989	734	13,771	2.27	13.56	14,370
1990	710	14,093	2.15	13.77	14,642

Source: Minnesota Agricultural Statistics;
Milk Production, Disposition and Income, NASS, USDA;
Agricultural Prices, NASS, USDA.