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POTENTIAL ECONOMIC IMPACTS OF BOVINE SOMATOTROPIN ON THE U.S. DAIRY INDUSTRY-- A WEST COAST PERSPECTIVE

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Potential Economic Impacts of Bovine Somatotropin on the U.S. Dairy Industry--A West Coast Perspective[1]

L.J. Butler and H.O. Carter

Attitudes toward the growth hormone, Bovine Somatotropin (BST) are not much different on the West Coast from those in the rest of the nation. News of the impending commercial availability of BST (now considered to be 1990 or later) has created a mixture of curiosity, indifference, apprehension, circumspection and indignation. All four of the companies involved in the research and development of BST are carrying out, or are preparing to carry out, trials on commercial dairy herds in the west. In the meantime, most people, whether advocate or opponent, have adopted a wait-and-see attitude.

Although attitudes toward BST may be similar across the nation, there are some distinct differences in dairy management and in milk pricing systems in California that potentially differentiate the state's dairy producers from those in the rest of the United States. Three factors appear to influence the potential and outcome of BST in California. First, California's herds are larger then average; per cow production is higher, and the herd management style differs, partly due to the state's milk climate. The average herd size in California is around 400 cows compared to a U.S. average of 60. Average production per cow in California was about 17,000 pounds in 1986, compared to a national average of around 13,000 pounds. Cow numbers have been increasing in California in the last 10 to 15 years compared to an overall decline nationally.

Drylot dairies predominate in California, and producers purchase most of their feed requirements rather than growing their own. This allows for a much more intensive system of farming. For example, it is possible to milk up to 1000 cows on as few as 25-30 acres, although most dairies are larger than this. Purchasing total feed requirements means that milk production is much more sensitive to changes in feed costs. The state's mild year round climate with relatively low humidity puts less stress on milking stock and tends to stabilize annual milking cycles. It also means that less capital equipment is required for housing stock. As a consequence, costs of producing milk in California are consistently more than $1.00 per hundredweight (cwt.) lower than in other regions (Betts, 1987).

Second, California has its own unique state milk marketing order that sets minimum prices for all classes of milk. Since the price setting mechanism is independent of Minnesota-Wisconsin prices, the incentives created under the California system may differ from those created by the federal milk marketing orders. In general, prices received for raw milk are lower and more stable as a result of the stabilization and pooling mechanisms in effect in California.

Third, consumer attitudes and reactions to BST have already influenced the political agenda in California. At least three creameries have issued policy statements about accepting milk from cows treated with BST. Typically, attitudes and reaction of special interest groups seem to be more potent in California than in most other states, and so may have more influence on the adoption and diffusion of technologies like BST.

These differences between California and other states may lead to differing

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outcomes for BST when it becomes commercially available. Here we develop these differences and attempt to pinpoint those that may affect the economic impacts of BST.

Potential Impacts of BST at the National Level

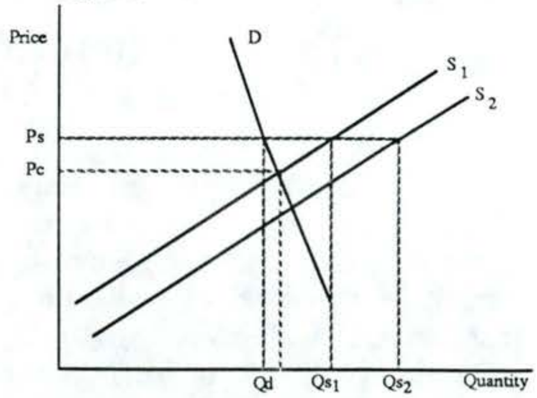
While there have been numerous working papers and study reports on the potential impacts of BST on the U.S. dairy industry, it is generally recognized that sufficient information is not yet available for economic analysis yielding reliable estimates.

Although the logic of the impact of BST at the national level is relatively clear, it is complicated by a number of institutional factors. First, free movement of prices to equilibrate supply and demand is hampered by the federal dairy price support mechanism. Second, a complex network of federal and state milk marketing orders exists which regulates the prices that farmers receive for milk. Third, other programs such as dairy import restrictions, antitrust exemptions associated with agricultural cooperatives, school lunch and other food aid programs, marketing requirements, and health and product growth standards all affect the structure of the dairy industry and contribute to the complexity of price movements.

While federal milk marketing orders play an important role in the structure of the dairy industry, the most important factors influencing prices and income is the dairy price support program. The effects of increased milk production due to the price support program can be seen in Figure 1.

Price supports maintain the price of milk at P_s, above the equilibrium price level P_c. Producers therefore supply Q_{s1}, while at price Ps, consumers demand Qd, leaving an excess in production Q_{s1} - Q_d. This excess is purchased by the Commodity Credit Corporation (CCC), stored, and eventually disposed of in a variety of ways (e.g. cheese give aways, military supplies, PL 480 exports). A new technology such as BST

Figure 1.



would force the supply curve out to the right (S_2) and increase the amount purchased by the CCC by Q_{s2} - Q_{s1}. While some price adjustment may occur at the local or farm level, there is little incentive for processors and manufacturers to decrease prices paid to producers if the price support is not also adjusted down. Thus, producers do not get a price signal unless, or until, Congress mandates a new lower price support level.

The Food Security Act of 1985 introduced, for the first time, trigger mechanisms that allow the price support level to adjust according to expected purchases by the CCC. Since these mechanisms are due to go into effect on January 1, 1988, the effectiveness of the policy has not yet been observed.

Butler (1986) attempted to simulate the impacts of BST at the national level, accounting for the 1985 Food Security Act policies. Assuming four response rate levels and using results from Kalter et al. (1985) some rather dramatic changes were observed. Even at the lowest response rate of 6 percent, net government removals climbed from a projected level of 5 billion to 18 billion pounds and prices dropped to an average of $10.00 per hundredweight. But, the study was heavily criticized by dairy scientists who claimed that adoption rates would be much lower than those assumed in the Cornell study. This reaction has sent us back to the drawing board to examine the adoption and diffusion issue.

The Adoption and Diffusion Issue

The greatest challenge in evaluating the potential impacts of BST appears to be estimating, with any degree of accuracy, the potential adoption rates of the new technology. *Ex post* studies of the diffusion of innovations over time have shown that cumulative adoption follows an "S" shaped or Sigmoid distribution. Mathematically, these adoption patterns have been described, with relatively high levels of accuracy by logistic functions that have the convenient properties of tracking growth to some asymptote.

Griliches (1957) provided the first major application of the logistic curve to the study of technological change in his analysis of hybrid corn. In seeking to explain the differences in adoption of hybrid corn between regions, he used the origin, slope and upper limit of the asymptote along the logistic curve.

This and other studies using logistic functions to explain, *ex post*, the adoption and diffusion process, bring up the tempting possiblity of using them for *ex ante* evaluation of a technology. One such attempt was reported in the Kalter et al. study, and later by Lesser et al. (1986). An estimate of the discrete approximation to a differential equation whose solution has the form of the logistic function was applied to data aggregated from a survey of New York dairy producers. The survey asked dairy farmers the conditions under which they would adopt BST and over what period of time. The results appeared to be reasonable, and the method was relatively simple to apply. However, the study used survey data collected *after* respondents had been exposed to a hypothetical fact sheet detailing the results of experiments using BST. Thus, the survey data simply reflected the hypothetical scenario that was originally set up as information for the farmer. One could therefore conclude that the estimated adoption rates were also hypothetical

If we do not know anything about the potential profitability of an innovation and the availability of information pertaining to the innovation, then we can not account for the factors that influence the shape and speed of adoption. Until we are able to quantify the parameters required to drive these models, use of logistic functions for *ex ante* evaluation of technology will probably not be very useful. The *ex post* studies, however, can be used to determine what it is we do know about the adoption and diffusion process. Griliches (1957) had two main findings about differences among regions in acceptance or adoption of hybrid corn. First, differences of adoption among regions can be explained by the profitability of the new technology for producers in the various regions. Profitability, in turn, was found to be a function of the amount of adaptive research carried out by state agricultural experiment stations. Second, the differences in adoption among regions can be explained by the differences in size and densities of the market for the new technology. That is, adoption is a function of the potential profits of the company selling the innovation, which in turn will be determined by the number of potential buyers.

Others have had essentially similar results. For example, Mansfield (1961), using a model similar to Griliches' examined twelve innovations in four industries; he concluded that adoption of technology was influenced to a large extent by the profit potential of the innovation to the users and the size of the investment made by developers. Kislev and Schori-Bachrach (1973) found that the rate of adoption of technology was influenced by the skill level of the adopters and the availability of information about the innovation. In summary, then, it seems we know quite a bit about the adoption and diffusion process but do not have any good ways of using that knowledge for *ex ante* purposes. This would appear to be a fruitful area for future research.

Potential Demand for BST

While we may not be able to predict the rate of adoption and diffusion of BST, we might get some insights into the potential impacts of BST using demand analysis. For example, we could estimate a production function, and, assuming that farmers are profit maximizers, derive the neoclassical conditions for profit maximization by setting the first partial derivatives of the profit function to zero, yielding the familiar result that the value of the marginal product is equal to the price of each input.

Another approach toward examining the potential demand for BST has emerged out of studies at the University of Wisconsin. Subtracting the expenditures associated with the use of BST from the increased revenue generated by using BST, yields an expression for the net revenues gained on a per cow basis. For example:

Net Revenue = Increased Revenue - Feed Costs - Cost of BST.

On a per cow basis the expression is:

NR=[((PM*PB)/100)*RR] - [((CHFC/.1)*RR)*FC]-(CHP * 215)

where

NR = Net Revenue
PM = Price of Milk in $/cwt
PB = Production base of cow in lbs
RR = % response rate from BST
CHFC= expected % change in feed costs per 10% increase in milk production
FC = total feed costs in $/cow/year
CHP = cost of BST plus additional profit

It is unlikely that dairy producers will use BST if the net returns from it are negative, nor if it only permits them to break even. Therefore, breakeven levels are estimated by comparing the production level at which net returns are positive, with the distribution of cows at each production level. This yields the minimum production level at which BST would be profitable. However, there may be extra labor costs and other possible risks to using BST that are currently unknown. Therefore dairy producers will probably demand a return on their investment before adopting BST. For example, a recent survey of 270 Wisconsin dairy farmers revealed that approximately 44 percent of respondents would require more than $200 additional profit per cow per year before they would adopt BST. Another 34 percent said they would require between $100 and $200 additional profit per cow per year. Only 22 percent said they would adopt BST for less than $100 per cow per year additional profit. Other surveys have indicated that farmers would require a $2:1 or $3:1 return on investment before adopting. These profit ranges translate into additional profits or returns to investment of $.25 to $1.00 per cow per day and are effectively extra costs of adopting BST. In the following analysis, these additional returns to investment should be taken into account in assessing the potential demand for BST.

Comparative Demand for BST: California and Wisconsin

Griliches and others pointed out that differences in adoption of a new technology among regions may be explained by its profitability for both buyers and sellers. Therefore, a comparative demand analysis of BST between two regions should be helpful in illustrating the potential adoption and diffusion differences between regions, and in demonstrating the sensitivity of certain parameters to change. The choice of Wisconsin and California is useful because of the striking differences between the two production regions. While Wisconsin is the largest producer of milk in the nation, the characteristics of its dairy industry differ markedly from those of California. Wisconsin has approximately 35,000 dairy herds averaging about 50 cows per herd; dairy farmers there usually grow most of their own feed; but due to the severe climate, substantial capital expenditures are required for animal housing and other facilities. In contrast, California has approximately 2500 dairy herds averaging about 400 cows per herd; feed is almost always purchased; and its mild climate reduces milk production costs substantially below those of other regions in the nation. Figure 2 compares the percentage distribution of cows in California and Wisconsin, with California having a larger percentage of cows at higher production levels. Figure 3 compares the distribution of cows by production level in the two states. From these comparisons, it is not at all clear what the nature of the potential demand for BST in either of these regions would be.

Using the expression for net revenues derived previously, within a BASIC program, breakeven production levels were found for each level of the cost of BST required to justify its use. The following assumptions were made:

(1) The expected percentage change in feed costs per 10 percent increase in milk production (CHFC) was set at 5%.

(2) Total feed costs (FC) for California was set at 1.5 times that for Wisconsin.

(3) Response rates to BST (RR) are assumed to be percentage increases over base, for an entire lactation.

Findings about the potential demand for BST, impacts of the supply of milk and effects on milk prices, are discussed below and exceptions and qualifications to the analysis are given.

Potential Demand

Figures 4 and 5 show the percentage of total cows that could potentially use BST at various combinations of cost of BST plus profit for Wisconsin and California respectively. For example, if the price of BST is around $0.50 per day and the profit required to justify its use is $0.50 per cow per day (total CHP = $1.00) then maximum demand for BST at an average response rate of 15 percent is approximately 24 percent of California's cows and only 6 percent of Wisconsin's. However, on an absolute number basis, the result is somewhat less dramatic. As shown in Figures 6 and 7, the proportions represent

Figure 2. Estimated Percentage Distribution of Cows in California and Wisconsin, 1986

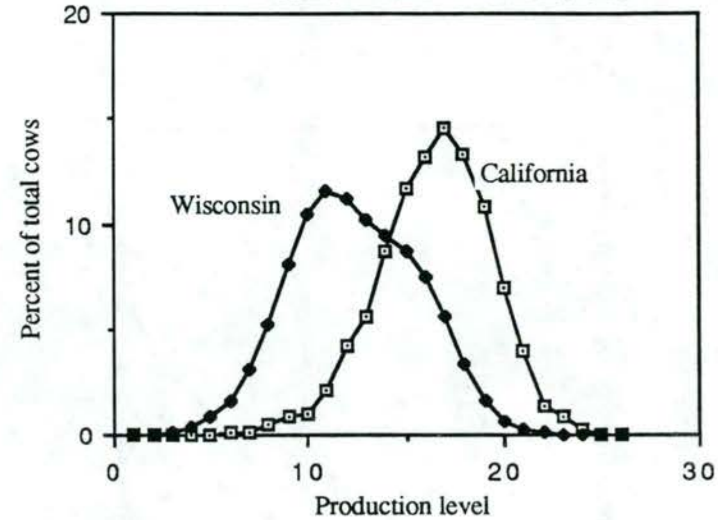


Figure 3. Estimated Total Distribution of Cows in California and Wisconsin, 1986

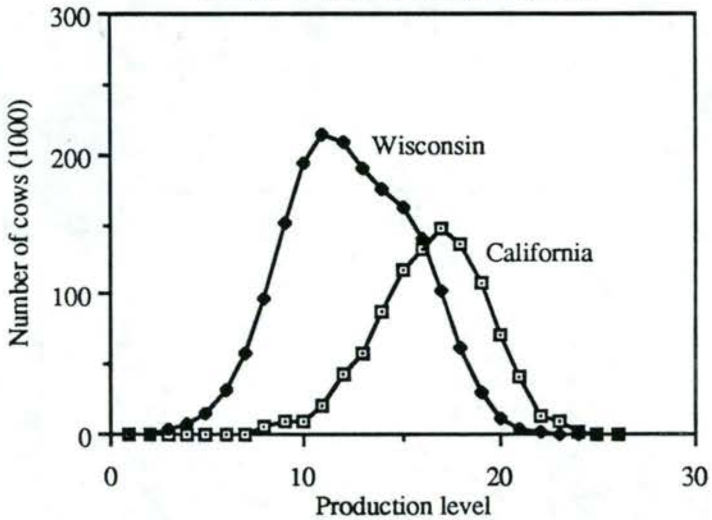


Figure 4. Potential Demand for BST: Wisconsin
Percent of Total Cows

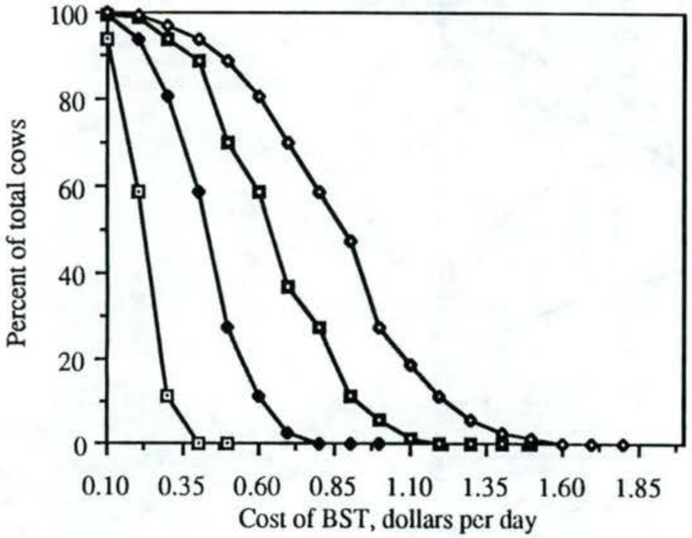


Figure 6. Potential Demand for BST: Wisconsin
Number of Cows

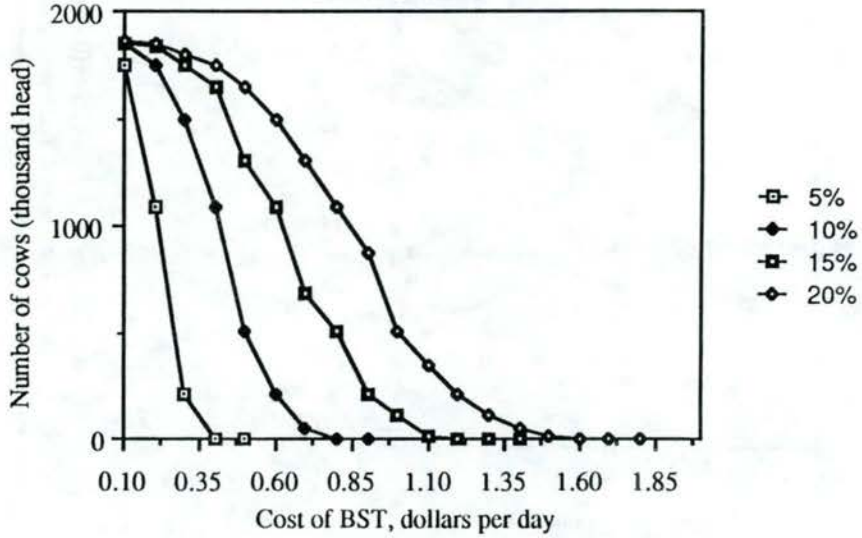


Figure 5. Potential Demand for BST: California
Percent of Total Cows

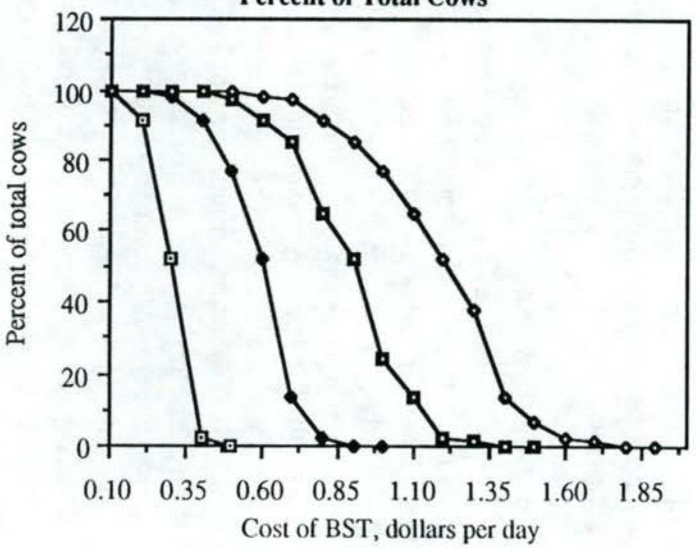
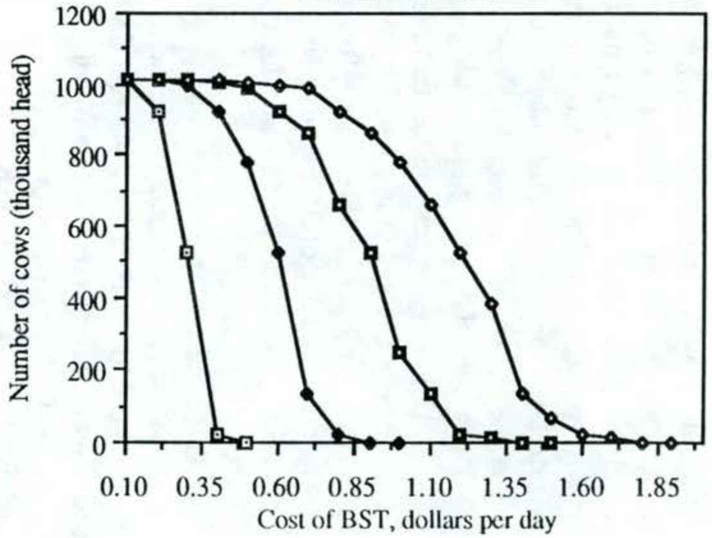


Figure 7. Potential Demand for BST: California
Numbers of cows



about 246,000 cows in California and 110,000 in Wisconsin. The picture that emerges is that at lower levels of cost for BST plus profit, the demand for BST is much higher in Wisconsin because of the higher cow numbers there. However, as the price of BST increases, demand for BST in California decreases at a much slower rate than for Wisconsin. This slower rate of decrease is mainly due to California's larger proportion of cows at higher production levels (recall Figure 3). The sensitivity of potential demand to increasing cost of BST indicates that within the expected range of costs of BST, potential demand for BST is higher in California than in Wisconsin. However, if the price of BST is kept at relatively low levels, say around $0.25 to $0.35 per day then potential demand for BST is equally proportional to total cow numbers in both regions.

Impacts on the Supply of Milk

Increased production of milk for various levels of cost of BST plus profit is approximated at the mid-point of each production level. The percentage increase in milk production at various response rates is presented in Figures 8 and 9. As would be expected, the percentage increase in milk production as the cost of BST plus profit increases, decreases at a slower rate in California than in Wisconsin. With CHP = $1.00 and response rate of 15 percent, increased milk production would be approximately 4.5 percent in California compared to about 1.5 percent in Wisconsin. Again, because of the larger volume of production in Wisconsin, these estimates translate into absolute quantities of about 756 million pounds for California compared to 316 million pounds in Wisconsin (Figures 10 and 11).

Again as the cost of BST plus profit decreases, the impact in terms of increased milk production is higher in Wisconsin than in California. Thus, within the expected range of cost of BST plus profit, it would appear that BST may have a greater impact on milk production in California than in Wisconsin. However, if the cost of BST is kept relatively low, the impacts appear to be the same in both regions.

Effects of Changing Prices of Milk

A similar picture emerges when the response rate is held constant at 15 percent and the price of milk is varied from $10 to $13 per cwt. As would be expected, as the price received for milk increases, potential demand for BST increases. The impact on a percentage of total cows basis is much greater in California than in Wisconsin (see Figures 12 and 13). However, because of the larger numbers of cows in Wisconsin, the effect on a total cow number basis is less dramatic.

The same pattern emerges as the cost of BST varies. At higher cost levels, California displays a much stronger potential demand for BST than Wisconsin. But at lower costs of BST , the potential demand in both regions is approximately equal. Similarly, as the price of milk decreases from $13 to $10 per cwt, California emerges with a stronger demand pattern at expected levels of BST costs plus profit than Wisconsin. This is particularly so at lower milk price levels. However, this pattern only holds if the cost of BST plus profit is above $0.50 - $0.60 per day. At lower levels the potential demand for BST is approximately equal, or greater, in Wisconsin.

Exceptions and Qualifications to the Analysis

First, the 15 percent response rate is still uncertain. It was assumed that the 15 percent response rate is a lactation response rate. It represents nearly 23 percent daily response rate during administration of BST which would appear to be a high figure at the moment. A more appropriate annual or lactation response rate might be 10 percent, which implies about 15 percent daily response rate during BST use.

Figure 8. Percentage Increase in Milk Production: Wisconsin

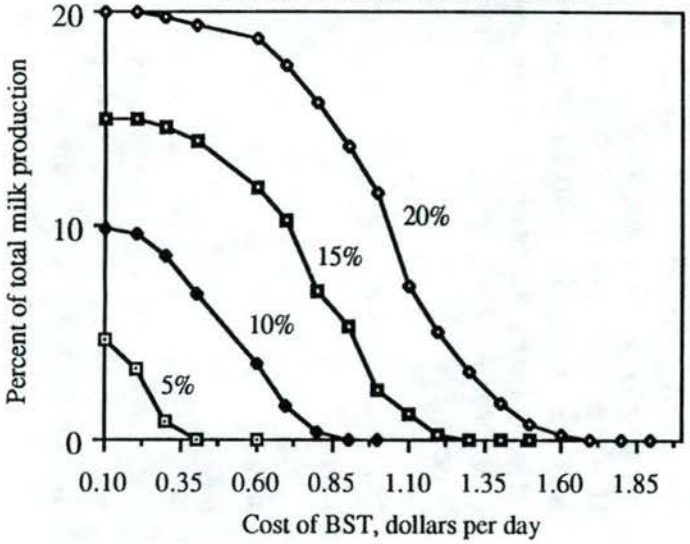


Figure 10. Volume Increase in Milk Production: Wisconsin

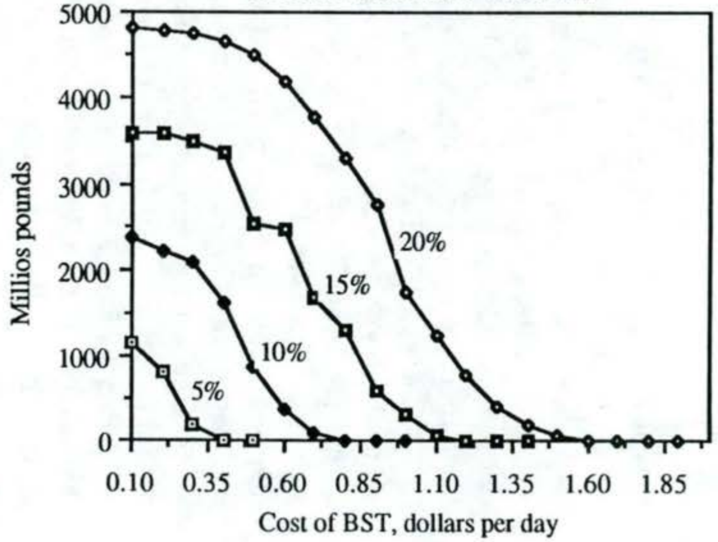


Figure 9. Percentage Increase in Milk Production: California

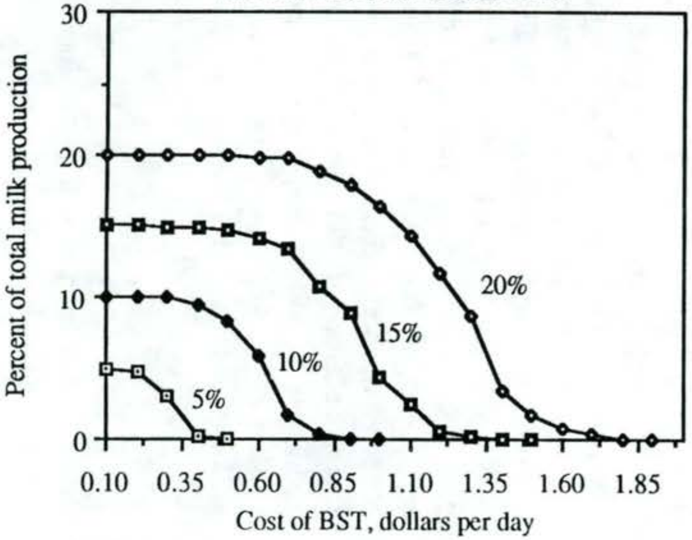


Figure 11. Volume Increase in Milk Production: California

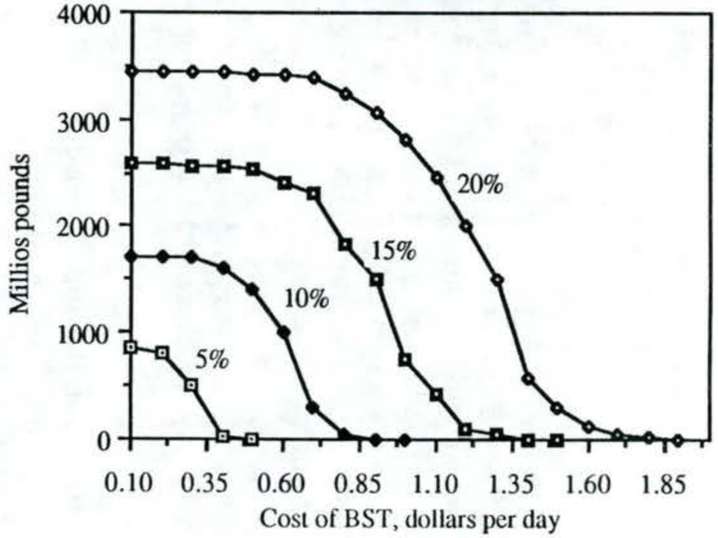


Figure 12. Demand for BST at Various Milk Prices
Percent of Total Cows: Wisconsin

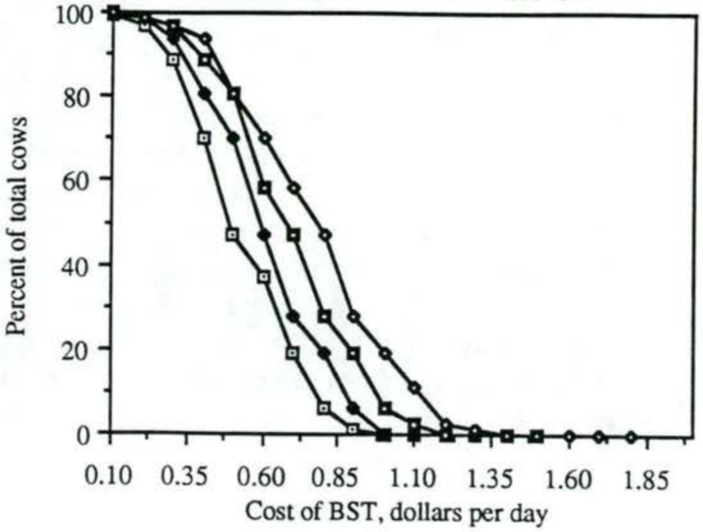
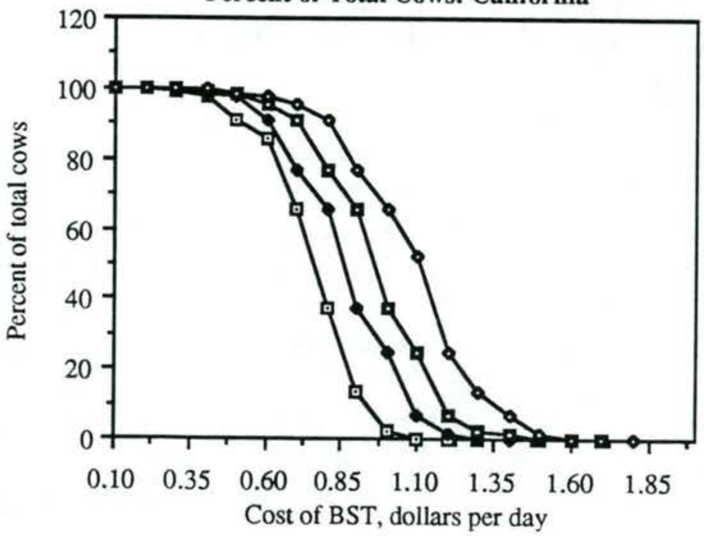
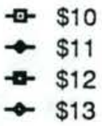


Figure 13. Demand for BST at Various Milk Prices
Percent of Total Cows: California





Second, the estimates of feed costs assume average levels for each state. But California milk production is much more sensitive to changes in feed cost because California producers purchase most of their feed. This sensitivity to feed costs in California could be a large equalizer between the two regions if purchased feed costs increased.

Third, since there are no comprehensive data sets indicating the number of cows at each production level, the derived distributions used are approximate, although DHI data from both regions indicate that California does have a higher proportion of cows at higher production levels than Wisconsin. Remember too, that the distributions are for 1986 only. They may change in the future.

Fourth, milk prices tend to be lower in California than in Wisconsin. For example, it may be more appropriate to examine the impacts of changing milk prices between California and Wisconsin assuming that California prices may be up to a $1.00 per cwt lower than Wisconsin prices. Again, this would tend to equalize the regions and make the differences between them less dramatic than indicated in the above analysis.

Finally, "potential demand" represents the maximum possible at each production level and at each cost level. There may be differences between regions in attitudes or adoption, or in efficiency levels at each production level. Producers in both states have expressed concerns about daily injections of BST. Consumers have reacted in both states to the potential health risks of BST in milk. These types of differences may influence the extent to which the potential demand for BST varies in both regions.

Nevertheless, given these qualifications and imprecisions, the levels of comparison presented in this analysis should be reasonable indicators of the differences between the two states.

Effect of BST on Prices in California

One compelling difference between California and the rest of the United States is the unique state milk marketing order that dictates minimum prices in California. There are four classes of milk in California, compared to three in federal milk marketing orders. In addition, component pricing is used in California. In general, prices for the various classes of milk are lower in California but much more stable. A 1986 comparison is shown in Table 1.

In California, Class 4 prices (manufacturing milk price for cheese, butter and powder) are determined by the higher of either market prices or support prices for butter and powder. If market prices (butter on the Chicago Mercantile Exchange and powder in California) drop below support price levels, then Class 4 prices are determined solely by support prices. Class 4 prices are used to determine Class 1, 2 and 3 prices. Class 2 and 3 prices are simply Class 4 prices with a differential added. Class 1 prices are determined by a formula using:

(1) the cost of milk production index for California, lagged 5 months and weighted 43 percent;
(2) the Class 4 price, lagged 3 months and weighted 42 percent;
(3) the average weekly spendable earnings of manufacturing workers in California, lagged 4 months and weighted 15 percent.

Hence, California milk prices tend to slightly lag national trends and price fluctuations are substantially dampened as shown by the standard deviations of prices in Table 1.

Since Class 4 prices are stablized by price supports, and average weekly earnings do not fluctuate much, the major factor affecting Class 1 prices in California due to the use of BST, is the cost of production index. Yet, it is not clear that the impact would be substantial. Costs of production will obviously decrease for those using BST, but it will not change for those not using it. The cost of production index is determined by a survey of 200 California milk producers every two months. A rapid adoption of BST would obviously decrease the cost of production, but increased demand for feed could also send feed prices up, partially offsetting the effect of decreased costs. In many ways, California dairy producers may find themselves experiencing the classic "treadmill effects" expounded by Cochrane (1958). As production increases, prices adjust, albeit slowly, and the only gainers are the early adopters in the short run. In the long run, processors and consumers gain, if prices are passed on, but producers may be relatively worse off.

Other Factors

Apart from the milk production and management characteristics and the marketing differences in California dairying, some other factors may influence the adoption and diffusion of BST in California. First, the attitudes and reactions to BST of some special interest groups may have a substantial impact on the adoption process. California's reputation for trend setting and innovative legislation is not a figment of the imagination. Special interest groups are active and politically well supported. The recent ice minus trials are a case in point. A private firm and the University of California, attempting to use the modified ice minus bacterium in open air trials, were held up for two years awaiting decisions at the federal level, only to be stymied for another two years at the state and local levels. Even when the trials were approved earlier this year, they were vandalized by active opponents to the bacterium's use.

In the case of BST, consumer groups have already influenced the political agenda in California by insisting that food outlets that marketed milk from cows treated with BST would be boycotted. Large food chains in turn warned creameries that milk containing BST was not acceptable. Thus, at least three creameries have publicly issued statements saying that they will not accept milk from cows that have been treated with BST. The only people using BST were the pharmaceutical companies carrying out trials —their experiments were adversely affected for a time. This type of reaction, common in California, may be an important factor in slowing BST's adoption and diffusion.

A second factor that may influence the adoption of BST in California is the effect of competing technologies. For example, it has been pointed out that three times-a-day milking, and use of DHI or isoacids may be just as profitable or more so than BST in California. California producers are not averse to adopting technologies, but they tend to adopt those technologies that best suit their management styles. Three times-a-day milking, for example, requires considerable change and skill in management practices. If BST also requires considerable changes in management practices, then the same producers who have not adopted three-times-a-day milking may not adopt BST.

Finally, the adoption of BST may be influenced by the intensive drylot management styles in California. For example, BST could be used to increase production without increasing herd size. Thus, it may give the highly intensive dairy producer a chance to expand production without a commitment to extra land or facilities.

All in all, there still seem to be many unknown factors that would influence the adoption and diffusion of BST in California. Current work being carried out at the University of California, Davis, will hopefully throw more light on these issues. In the meantime, the impacts of BST on the dairy industry seem destined to be more speculative than factual.

Table 1. Comparison of Prices Paid to Producers in California and the United States, 1986.

	All Whole Milk a/ ($/cwt)			Manufacturing Milk b/ ($/cwt)		
	California	U.S	Difference	California	U.S.	Difference
January	11.97	12.50	.53	10.66	11.12	.46
February	11.90	12.40	.50	10.66	11.04	.38
March	11.81	12.20	.39	10.65	11.02	.37
April	11.65	12.00	.35	10.66	10.98	.32
May	11.63	12.00	.37	10.66	10.98	.32
June	11.35	11.90	.35	10.66	11.00	.34
July	11.31	12.00	.69	10.65	11.06	.41
August	11.59	12.20	.61	11.03	11.33	.30
September	11.90	12.70	.80	11.03	11.55	.52
October	12.16	13.10	.94	11.04	11.69	.65
November	12.16	13.40	1.28	11.05	11.91	.86
December	12.09	13.27	1.18	10.86	11.86	1.02
Average	11.77	12.47	.81	10.80	11.30	.50
Std.Dev.	.282	.508		.176	.348	

a/ All whole milk prices for California are the California statewide average blend price, and for the U.S. are the all whole milk average price.

b/ Manufacturing milk prices for California are the California Class 4a price and for the U.S. are the Minnesota-Wisconsin price series

Sources: *Bureau of Milk Pooling Average Blend Price Report*, 1986; *Dairy Outlook and Situation Report*, December, 1986; *California Dairy Information Bulletin*, various issues; *Milk Marketing News*, various issues.

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