August 1988 No. 292

A PROSPECTIVE ASSESSMENT OF THE IMPACTS OF BOVINE SOMATOTROPIN:

A CASE STUDY OF WISCONSIN

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A Prospective Assessment of the Impacts of Bovine Somatotropin: A Case Study of Wisconsin

Prospective assessments of new technologies are difficult and need to be judged by different standards than after the fact assessments (Fishel 1987). In most cases, potential benefits and costs of future technologies are uncertain. Moreover, the speed and extent of adoption are always unknown. However, social scientists are increasingly called to make social and economic assessments of technologies prior to their commercial introduction. Although such assessments may require wide confidence intervals, they still can provide insights that are useful to policymakers, potential adopters and interested parties. A well-developed model can examine the sensitivity of results to various assumptions and can be updated to narrow confidence intervals as more information becomes available.

Of the many biotechnology products potentially affecting agriculture, probably none has received greater attention than bovine Somatotropin (bST). Given a world awash in dairy products, bST has been greeted with far less enthusiasm than some other products of biotechnology. Some European countries are considering banning bST or requiring labelling of products made from bST produced milk. The Wisconsin legislature has scheduled hearings to consider policy alternatives concerning bST.

Prospective economic assessments of the impacts of bST can focus on individual farms or on aggregate prices and quantities or both. Farm impacts include rates of adoption of new technologies, adoption patterns across farms differing by size or productivity, and impacts on farm survival or exit. Aggregate impacts include overall changes in milk production and market prices, effects on related industries and regional relocation of dairy production. Clearly, farm level and aggregate impacts are interrelated. Aggregate demand for bST will affect the pricing decision of bST manufacturers. The market prices of milk, bST, and other inputs feed back into the farmer's decision whether to adopt bST.

The 1987 study by the U.S. Department of Agriculture's Economic Research Service (Fallert et al. 1987) is the most ambitious effort to model both the micro and macro impacts of bST. Westcott's simulation model of the dairy industry was linked to farm-level simulation models of representative dairy farms in different regions. While the results of this study are of considerable interest, they are heavily influenced by assumptions concerning: 1) the production response to bST; 2) the returns required by farmers to adopt bST; 3) the price that farmers will have to pay for bST; 4) the price of milk when bST is introduced; and 5) the speed and extent of adoption.

Several other studies have provided prospective assessments of the economic impact of bST (Kalter et al. 1984; Boehlje, Cole and English, 1987; Magrath and Tauer, 1985; Kalter and Milligan, 1987; Yonker, Knutson and Richardson, 1987; Butler and Carter, 1987; Marion, Wills and Butler, 1988). In each of these, the assumptions used concerning

the above five factors have a major bearing on the conclusions reached. In the research reported here, we explore the sensitivity of results to the assumptions for these five factors using Wisconsin dairy farms as a case study. We conclude that the economic feasibility of bST is very sensitive to the underlying assumptions and that the overall economic impact is likely to be much less than most other studies have predicted.

Farm Decision Model

Most of the previous analyses of the farm level profitability of bST have used simulation models of "representative" dairy farms. We employ a similar but more transparent farm enterprise model to determine the economic feasibility of bST in which incremental revenues and incremental costs are examined. Incremental revenue and costs were defined as:

Incremental Revenue from bST	=	% Production Response to bST * Original Production/Cow * Milk Price
Incremental Costs Plus Returns to Management	=	Cost of bST + Increased Feed Costs + Increased Hauling Costs + Increase in Other Variable Costs + Required Return to Management

Exact values are not available for the variables affecting incremental revenue and costs. Indeed, in some cases, a wide range of values is plausible. Since these variables drive the rest of our analysis and are the major reason our results differ from previous analyses, they warrant comment.

Impact of bST on Production Per Cow: A critical unresolved issue is whether bST will provide a proportional (e.g., 10 percent) or constant (e.g., 8 lbs.) increase in milk production, or a partly constant and partly proportional increase. Fallert et al. assumed an 8.4 pound increase per cow per day regardless of production per cow, whereas Kalter et al. assumed a proportional response. If a constant increase is assumed, bST tends to either be economically feasible for all cows (and herds) or for none. If a proportional response is assumed, bST may be economically feasible on high producing cows but not on low producing cows.

Research by dairy scientists presents a mixed picture. Given the same level of management, most of the research points toward a constant response from cows of differing genetic capability. However, much of the difference in production per cow of commercial dairy farms is attributable to differences in management. And there seems to be a strong consensus that poor management will severely restrain the production response to bST. Thus, to the extent that production per cow serves as a proxy for the level of management, the response to bST may by greater in high producing herds than in low producing herds.

The level of response under field conditions is also uncertain. Although some of the early research showed daily responses from bST of 25 to 40 percent (Kalter et al. 1984), recent research suggests a more realistic figure is 20 to 25 percent for well fed and managed cows. This translates to a 12.5 to 15.5 percent increase in annual production. And, if the

response under field conditions is 25 percent less than under experimental conditions (the estimate by Fallert et al.), the expected response under field conditions would be 9.4 to 11.6 percent.

There is also some evidence that first calf heifers may respond less than older cows (current research by University of Wisconsin dairy scientists), and uncertainties exist about the response rate to bST in the second, third or later years of administering bST. Given the considerable uncertainties about the responses to bST, sensitivity analysis is appropriate. In the research reported here, we examine three levels of proportional responses, 9, 12 and 15 percent, and a response that is partly constant and partly proportional.

Cost of bST to Farmers: Because of the lack of information on how bST will be priced, most studies have either omitted this as part of farmer costs, assumed a certain price, or determined bST price as a residual. Lesser, Magrath and Kalter used a bST price of 17¢/cow/day in the fictional ad sent to surveyed farmers. Fallert et al. assumed that farmers will require a return to management that is twice the cost of the drug in order to use bST. Assuming an 8.4 lb. per cow per day response to bST and 1986 price levels, they found that representative dairy farmers in the U.S. could pay 24¢/cow/day and still achieve the required 2 for 1 return. An underlying assumption of several studies is that bST will be sufficiently profitable that the price of bST will not be a

constraint to its adoption. This may stem, in part, from estimates that the cost of producing bST will be 8.5 to 18.6 cents per daily dose (Kalter et al. 1984) and assumptions that bST will be priced near its cost of production. However, the companies developing bST have substantial R&D costs on which they hope to realize a return. And the structure of the bST manufacturing industry will be sufficiently concentrated that oligopolistic coordination and/or price leadership is likely to allow bST to be priced substantially above production costs.

In our analysis, we estimate the potential for bST under different assumptions and calculate the price at which manufacturers will jointly maximize profits. Based upon this analysis, we believe bST will be priced at 30 to 35 cents per daily dose. In our sensitivity analysis, we allow bST prices to range from 25 to 40 cents per dose.

Returns to Management Required by Farmers to Adopt bST: Most studies have made no explicit assumption about this variable. An exception is Fallert et al., who accepted pharmaceutical company estimates that "farmers will not likely adopt bST unless they can obtain a $2 net return for each $1 in bST purchase cost" (p. 8). Using this premise, if bST costs 25 cents per daily dose, an increase in net profit of 50 cents/cow/day would be required; if bST costs 40 cents, net profit would have to increase by 80 cents. We have reservations about the logic of this premise. Since bST will be a variable cost of production, not a capital investment,

we see no reason why farmers' expected returns from adopting bST should vary with the price of bST.

A survey in mid-1987 of Wisconsin dairy farmers asked, "How much additional net profit on a per cow basis would you require before you would use BGH?" Only 96 of the 270 respondents answered the question. Of those responding, 36% said they would require 50 cents or less profit/cow/day of bST use, 35% would need $.51 to $1.00/cow/day of bST use, and 29% would require over $1.00/cow/day of bST use. Given the level of information on bST available to farmers at the time of this survey, this is at best a very rough estimate of the returns required for adoption.

To place returns per cow per day in perspective, it is useful to translate these into annual dollar returns for a 50 cow herd. If bST is administered for 215 days, a return of 50 cents per day would mean a return/cow/year of $107.50. In a 50 cow herd, annual returns to management would be $5375.00. Annual returns corresponding to 20, 30, 40 and 50 cents per cow per day of bST are:

Return/Cow/Day of bST	Annual Return in 50 Cow Herd
$.20	$2150.00
.30	3225.00
.40	4300.00
.50	5375.00

If administering bST is relatively easy, as appears likely, and if the management requirements are not too difficult -- a point on which we have little knowledge -- an additional two to four thousand dollars strikes us as a plausible incentive to adopt

bST given the pressure on profitability many dairy farmers are likely to be under by 1990 to improve profitability. In our analysis, we allow farm returns to range from 20 to 40 cents/cow/day.

The following section demonstrates that bST manufacturers will have strong incentives to make bST as easy to use and manage as possible. Since at least some of the management changes needed to effectively use bST will involve front-end "investments" in human capital or management systems, operators of small herds may require a higher return/cow/day to adopt bST than operators of large herds.

Milk Prices: Many of the previous studies have examined the profitability of bST using the milk and feed prices and production per cow that existed at the time of the research. Fallert et al. developed their profitability estimates using 1986 milk prices and output per cow. Kalter et al. used 1980 milk and feed prices for representative farms in New York State in arriving at the conclusion that bST will be profitable for most farms.

Milk prices have dropped substantially in recent years and may drop even further by the time bST is introduced in 1990. Whereas Kalter et al. used an all-milk price of $12.96/cwt. and Fallert et al. used a price of $12.52 in estimating bST profitability, Wisconsin's all milk price in 1988 will be approximately $11.25. By 1990, Wisconsin dairy economists expect the Wisconsin all-milk price will be $10.25 to $10.75 per cwt.

In our analysis, we use projected milk prices for 1990. For most of our analysis, we use a milk price of $10.75 or allow prices to range from $10.25 to $11.25 per cwt. While the 1988 drought may confound our projections, we believe it makes more sense to estimate the economic conditions at the time bST will be introduced rather than use past prices and output per cow.

Increase in Feed Costs: The increase in milk production from bST requires additional feed. Indeed, cows that are on inadequate rations may show relatively small responses to bST.

Wisconsin Farm Enterprise Budgets (Luening et al. 1987) estimate that for cows producing between 12,000 and 20,000 lbs. per year, every 10% increase in production is associated with an increase in feed costs of 6.2 to 7.2 percent. The increase in feed costs associated with a 10% increase in milk production from bST appears to be in the same range. Fallert et al. increased feed costs about 6.7% for each 10 percent increase in production from bST for their U.S. calculations and about 7.1% for representative farms in the Lake States. In our analysis, we assume a 6 percent increase in feed costs for every 10 percent

increase in production due to bST.[1] If this estimate is low, our results will tend to overstate the feasibility of adopting bST.

Increase in Hauling and Other Variable Costs: Increased milk production from bST will likely increase the variable costs of milk hauling, farm labor, power, breeding and veterinary services. The marginal costs of hauling in Wisconsin is currently about 20 cents/cwt. Absent any research on additional labor, veterinary, breeding and power expenses associated with bST, data from Wisconsin Farm Enterprise Budgets are used (Luening et al. 1987). These indicate that as production per cow increases, these expenses increase 67 cents/cwt. Thus, hauling and other variable costs are assumed to increase by 87 cents/cwt. for milk increases resulting from bST.

To illustrate the farm decision model, assume the following values for the key cost and return variables:

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[1] Since the increase in feed costs are calculated as a percentage of feed costs without bST, the latter must also be estimated. Based upon Luening et al. 1987, the annual feed costs per cow assumed without bST are:

Production Per Cow/Year	Annual Feed Cost
12,000 lbs.	$548.30
14,000	605.05
16,000	664.30
18,000	723.55
20,000	778.10

Feed costs for other production levels are obtained by linear interpolation or extrapolation. These estimates are sensitive to feed prices (Kalter et al. 1984). In this analysis, we make no attempt to vary feed prices.

Incremental Revenue	
Milk Price in $/cwt.	$10.75
Annual Production Per Cow Without bST	15,780 lbs.
% Annual Response to bST	12%

Thus: 157.8 cwt. * .12 = 18.936 cwt. Incremental Milk Production
18.936 cwt. * $10.75 = $203.56 Incremental Revenue

Incremental Costs	
bST Price/Cow/Day	.35
Increased Returns to Farm Mgt./Cow/Day	.30
Milk Hauling Costs/Cwt.	.20
Labor, Power, Breeding & Vet. Costs/Cwt.	.67
Feed Cost Increase per 10% Response from bST	6%

Thus:	
bST Price: $.35 * 215 days use/cow	75.25
Returns to Mgt.: $.30 * 215 days	64.50
Milk Hauling: $.20 * 18.936 cwt.	3.79
Other Variable Costs: $.67 * 18.936 cwt.	12.69
Increased Feed Costs: .072 * $657.78	47.36
Total Incremental Costs	$203.59

Thus, given these assumed values, incremental revenues just equal incremental costs plus the return to management. bST would be economically feasible on cows producing 15,780 pounds of milk per year or more. The "breakeven" production per cow changes significantly for different responses to bST, different milk prices and different bST prices plus farm return (Table 1). The economic feasibility of bST is highly sensitive to the value of these key variables.

Distribution of Wisconsin Herds by Average Production Per Cow

If the response to bST is at least partially proportional to the production per cow, then the distribution of cows by level of output becomes important in estimating the potential use of bST. Data on the distribution of Wisconsin herds by level of production are from a

Table 1. Production Per Cow At Which bST Use is Feasible Under Different Economic Conditions

A. 15% Response to bST Milk Price/cwt.:	bST Price Plus Farm Return			
	.55	.60	.65	.75
$ 9.75	12,723	13,726	14,729	16,735
10.25	11,891	12,828	13,766	15,641
10.75	11,161	12,041	12,921	14,680
11.25	10,516	11,345	12,174	13,831
B. 12% Response to bST Milk Price/cwt.:				
$ 9.75	15,481	16,735	17,989	20,496
10.25	14,469	15,641	16,812	19,156
10.75	13,581	14,680	15,780	17,980
11.25	12,795	13,831	14,868	16,940
C. 9% Response to bST Milk Price/cwt.:				
$ 9.75	20,078	21,750	23,421	26,764
10.25	18,765	20,327	21,890	25,014
10.75	17,613	19,080	20,546	23,479
11.25	16,595	17,976	19,358	22,121
D. 900# + 6% Response to bST Milk Price/cwt.:				
$ 9.75	15,870	18,175	20,522	25,303
10.25	14,045	16,167	18,337	22,772
10.75	12,463	14,421	16,431	20,558
11.25	11,084	12,892	14,758	18,609

survey of 1078 herds (54,620 cows) conducted by the Wisconsin Agricultural Statistics Service (WASS) in January 1987.

These data for the month of January are projected for the year 1987 and for all dairy herds in Wisconsin in Table 2.[2] WASS collected data on the total milk produced by herd and the number of cows in each herd. We use these data to calculate average production per cow for each herd. Thus, the figures in Table 2 give all cows in a herd the same production level.

While the distribution of cows by level of production in 1987 is of interest, we are more interested in the distribution of cows in 1990 when bST will be introduced. The 1990 distribution was estimated by increasing the production of each herd in the WASS sample by 7.7 percent -- a compounded annual increase in production per cow of 2.5%. The resulting distribution of cows in 1990 as well as the estimated percent of state milk by cows with various levels of annual production are shown in Table 2. We use the estimated distribution for 1990 in the following sections to calculate the number of cows on which bST will be economically feasible under various conditions, and the increase in state milk production that may occur as a result of bST.

Potential Demand for bST

The impact of bST on state and national milk production depends upon the extent to which it is adopted and how fast, and the production

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[2] Annual sample 1987 milk production was calculated by dividing January 1987 values by .0813, the average proportion of annual milk production accounted for by January milk production for 1977-86. The percentages in each sample size category were applied to the total January 1987 Wisconsin diary cow inventory to derive state values.

Table 2. Distribution of Wisconsin Cows by Level of Production Per Cow Per Year

Lbs. Milk Per Year	1987 # of Cows	1987 % of Cows	Estimates for 1990 # of Cows	Estimates for 1990 % of Cows	Est. Milk Produced (million lbs.	% of State Production	Cumulative Percentage % of Cows	Cumulative Percentage % of Milk Production
1000 - 1999	3,854	0.21	2,520	.14	3.78	.01	.14	.01
2000 - 2999	4,221	0.23	4,670	.25	11.67	.04	.39	.05
3000 - 3999	8,992	0.49	5,577	.30	19.52	.07	.69	.12
4000 - 4999	7,157	0.39	8,466	.46	38.09	.14	1.15	.26
5000 - 5999	22,204	1.21	18,612	1.01	102.36	.37	2.16	.63
6000 - 6999	20,735	1.13	11,926	.65	77.52	.28	2.81	.91
7000 - 7999	25,690	1.40	24,189	1.32	181.40	.65	4.13	1.56
8000 - 8999	69,180	3.77	31,110	1.70	264.42	.94	5.83	2.50
9000 - 9999	90,833	4.95	80,529	4.39	764.99	2.73	10.22	5.23
10000 - 10999	104,045	5.67	91,918	5.01	965.09	3.45	15.23	8.68
11000 - 11999	148,452	8.09	95,110	5.18	1093.71	3.90	20.41	12.58
12000 - 12999	153,223	8.35	136,466	7.44	1705.76	6.09	27.85	18.67
13000 - 13999	205,337	11.19	147,653	8.05	1993.25	7.12	35.90	25.79
14000 - 14999	177,078	9.65	188,003	10.25	2725.93	9.73	46.15	35.52
15000 - 15999	210,842	11.49	179,905	9.80	2788.44	9.96	55.95	45.48
16000 - 16999	156,159	8.51	186,288	10.15	3073.67	10.97	66.10	56.45
17000 - 17999	140,011	7.63	148,796	8.11	2603.85	9.30	74.21	65.75
18000 - 18999	106,981	5.83	129,545	7.06	2396.52	8.56	81.27	74.31
19000 - 19999	75,969	4.14	131,527	7.17	2564.72	9.16	88.44	83.47
20000 - 20999	51,380	2.80	81,705	4.45	1674.91	5.98	92.89	89.45
21000 - 21999	26,424	1.44	55,399	3.02	1191.06	4.25	95.91	93.70
22000 - 22999	9,359	0.51	36,048	1.96	811.07	2.90	97.87	96.60
23000 - 23999	9,359	0.51	18,343	1.00	431.06	1.54	98.87	98.14
24000 - 24999	6,231	0.34	7,626	.42	186.84	.67	99.29	98.81
> 25000	1,101	0.06	13,069	.71	340.47	1.22	100.00	100.03
Total	1,835,000	100	1,835,000	100	28,010.10	100		

response to bST. Several other studies have concluded that bST will be widely and quickly adopted at least in part because they have also assumed it will be profitable on most cows and for most farmers. Lesser, Magrath and Kalter (1986) surveyed 173 New York farmers in 1984 using a fictional advertisement for bST. Based upon the results, they estimated that 63 to 85 percent of New York farmers would adopt bST within three years of commercialization. Nowak and Barnes (1986) surveyed 270 Wisconsin dairy farmers in April 1987. The responses indicated 13 percent were likely to be early adopters of bST, 31 percent were unlikely to adopt, and the remaining 56 percent would fall in-between.

A major limitation of these surveys is that farmers are being asked to respond to a hypothetical set of facts -- which may or may not hold when bST is introduced. Those conducting the surveys often fail to recognize the "what if" thin ice on which their results are resting, even when their survey results provide a warning. For example, Lesser, Magrath and Kalter report: "...when asked if an increase in the price of bGH (from $0.17 shown in the fictional advertisement) to $0.25 per dose would affect their adoption decision, 47 percent responded that they would be less likely to try the product....Considering the profitability of compound use, this price sensitivity is quite surprising" (p. 166). In spite of this, the authors draw their conclusions based upon the response to the 17 cent advertisement. And, their conclusion that bST will be widely and quickly adopted has been "adopted" by other researchers.

In our analysis, we first examine the extent to which bST is economically feasible for Wisconsin cows using various assumptions.

Using the incremental revenue-cost model and the distribution of Wisconsin herds by production level, we estimated the potential demand for bST. Table 3 presents two representative bST responses: (1) a 12% proportional response and (2) a partly fixed (900 lbs./year) and partly proportional (6%) response. Milk prices are assumed to be $10.75 at the time bST is introduced. Three different returns to management are considered, 20, 30 and 40 cents per cow per day. The price of bST is varied from 15 to 50 cents per daily dose.

In order to estimate "contribution to manufacturer development costs and profits," we assume that the cost of producing bST will be 10 cents per daily dose. This is at the lower end of the range 8.4 to 18.6 cents estimated by Kalter et al. (1984), which depended on plant size. Increasing the cost of producing bST does not alter the profit maximizing price for bST shown in Table 3.

The profit maximizing price for manufacturers ranges from 40 cents per daily dose if farm returns are 20 cents/cow/day and bST increases annual production 12 percent, to 20 or 25 cents per daily dose if farmers require a 40 cent return and the response to bST is partly fixed and partly proportional.

If manufacturers are successful in making it so easy to adopt bST that farmers will do so for 20 cents/cow/day, then manufacturers will be able to charge a higher price for bST and achieve a greater contribution to development costs and profits. The profit incentive for manufacturers is substantial (compare A, B and C sections in Table 3).

Table 3. Potential Demand for bST in 1990 and Manufacturer Contributions to Profits with Different bST Prices and Returns to Farmers

	bST Price/ Cow/Day	Returns to Management for Using bST	Number of Cows On Which bST is Feasible		Potential Contributions to Manufacturer Development Costs and Profits Per Day if Cost to Produce bST = $.10	
			12%	900# + 6%	12%	900# + 6%
A.	.50	.20	644,411	410,997	257,764	164,391
	.40	.20	1,048,321	1,097,186	314,496	329,156
	.35	.20	1,238,161	1,397,142	309,540	349,286
	.30	.20	1,394,738	1,593,965	278,948	318,793
	.25	.20	1,519,227	1,733,972	227,884	260,096
	.20	.20	1,621,531	1,778,902	162,153	177,890
B.	.50	.30	333,256	51,376	133,302	20,550
	.40	.30	644,411	410,997	193,323	123,299
	.35	.30	847,881	728,004	211,970	182,001
	.30	.30	1,048,321	1,097,186	209,664	219,437
	.25	.30	1,238,161	1,397,142	185,724	209,571
	.20	.30	1,394,738	1,593,965	139,474	159,397
C.	.50	.40	115,025	---	46,010	---
	.40	.40	333,256	51,376	99,977	15,413
	.35	.40	476,272	166,559	119,068	41,640
	.30	.40	644,411	410,997	128,882	82,199
	.25	.40	847,881	728,004	127,182	109,200
	.20	.40	1,048,321	1,097,186	104,832	109,719
	.15	.40	1,238,161	1,397,142	61,908	69,857

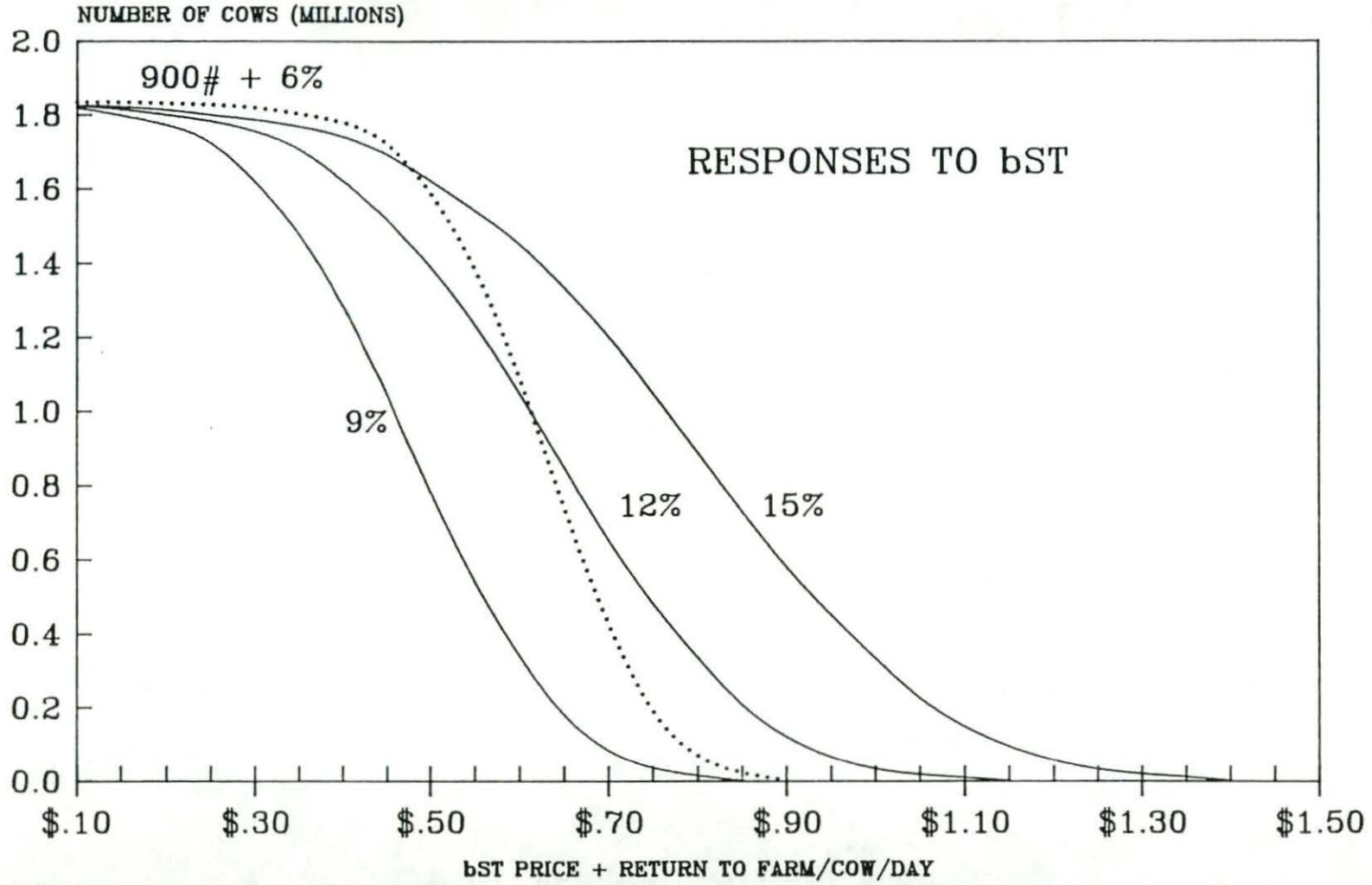
Assumptions: Milk price = 10.75

When bST price and farm returns are combined, manufacturer profits are maximized (or nearly maximized) in the range 55 to 70 cents. Relatively small changes in either bST price or farm returns substantially change the number of cows on which bST is feasible and the contribution to manufacturer profits. In much of the analysis that follows, we combine bST price and farm returns to reflect the trade-off shown in Table 3. Based upon the above analysis, we believe bST manufacturers will price bST at 30 to 35 cents per daily dose. In making this judgement, we assume that the structure of potential demand nationally is similar to that for Wisconsin. Manufacturers will want to price bST so as to maximize profits nationally, not just in Wisconsin. We also assume there is sufficient interdependence and "discipline" among bST manufacturers that they will be able to price at a joint profit maximizing price. Should one or more company choose a low price strategy in hopes of developing a dominant market share, bST could be priced much closer to production costs, at least for a while.

Sensitivity of Results

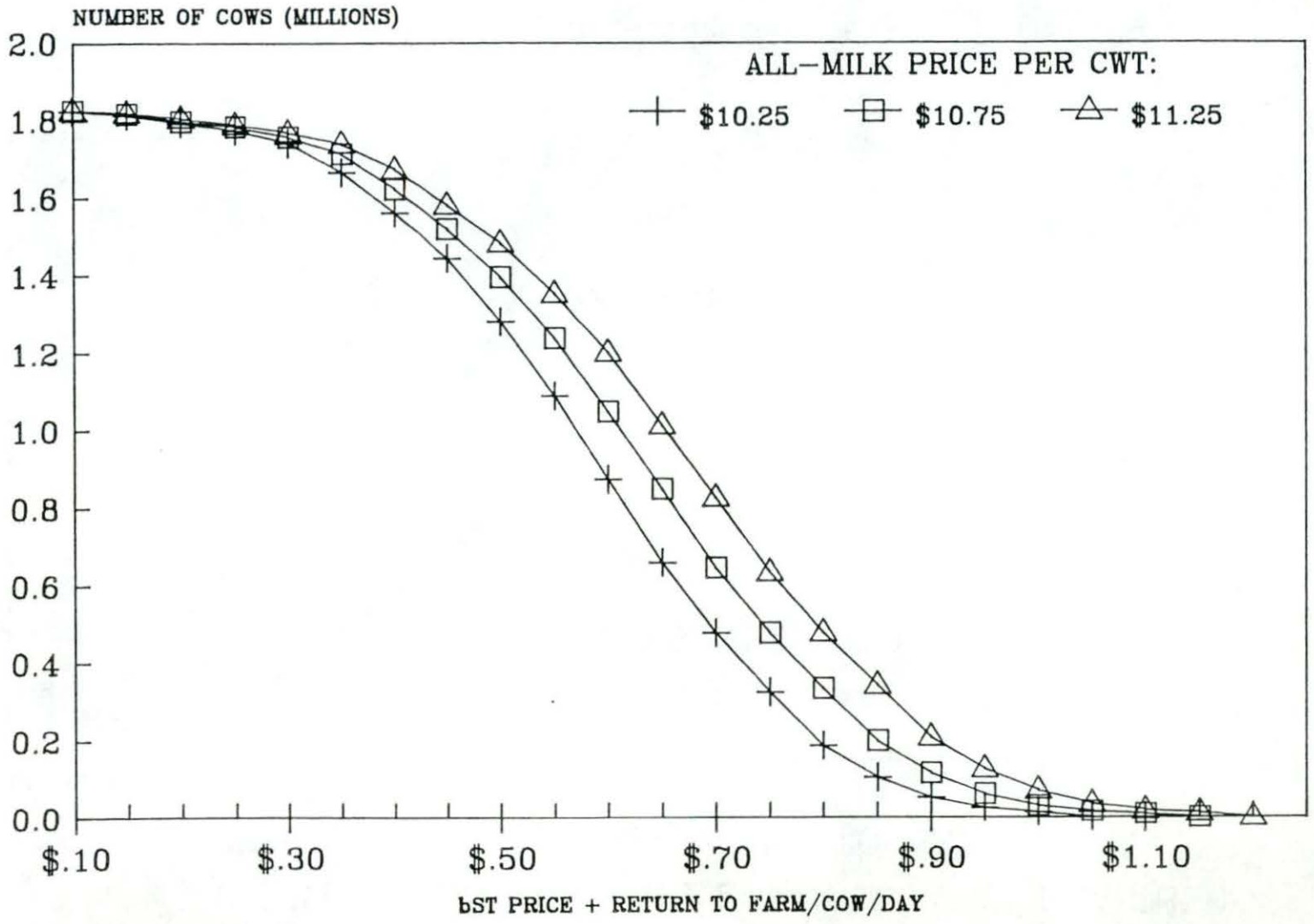
The previous sections have provided some indication of effects of varying the assumed values of the four key variables: production response to bST, milk price, bST price and the return required by farmers to adopt bST. Figures 1 and 2 are analogous to "potential" demand curves for bST under different economic conditions. Figure 1 holds milk price at $10.75/cwt. and examines the effects of four bST response rates on the number of Wisconsin cows on which bST is likely

FIGURE 1: ESTIMATED NUMBER OF WISCONSIN COWS IN 1990 ON WHICH bST WILL BE ECONOMICALLY FEASIBLE WITH DIFFERENT RESPONSES TO bST.



MILK PRICE = $10.75/CWT

FIGURE 2 ESTIMATED NUMBER OF WISCONSIN COWS IN 1990 ON WHICH bST WILL BE ECONOMICALLY FEASIBLE WITH DIFFERENT ALL-MILK PRICES.



RESPONSE TO bST = 12%

to be economically feasible in 1990. Figure 2 assumes a 12 percent annual response to bST and examines the effects of three milk prices.

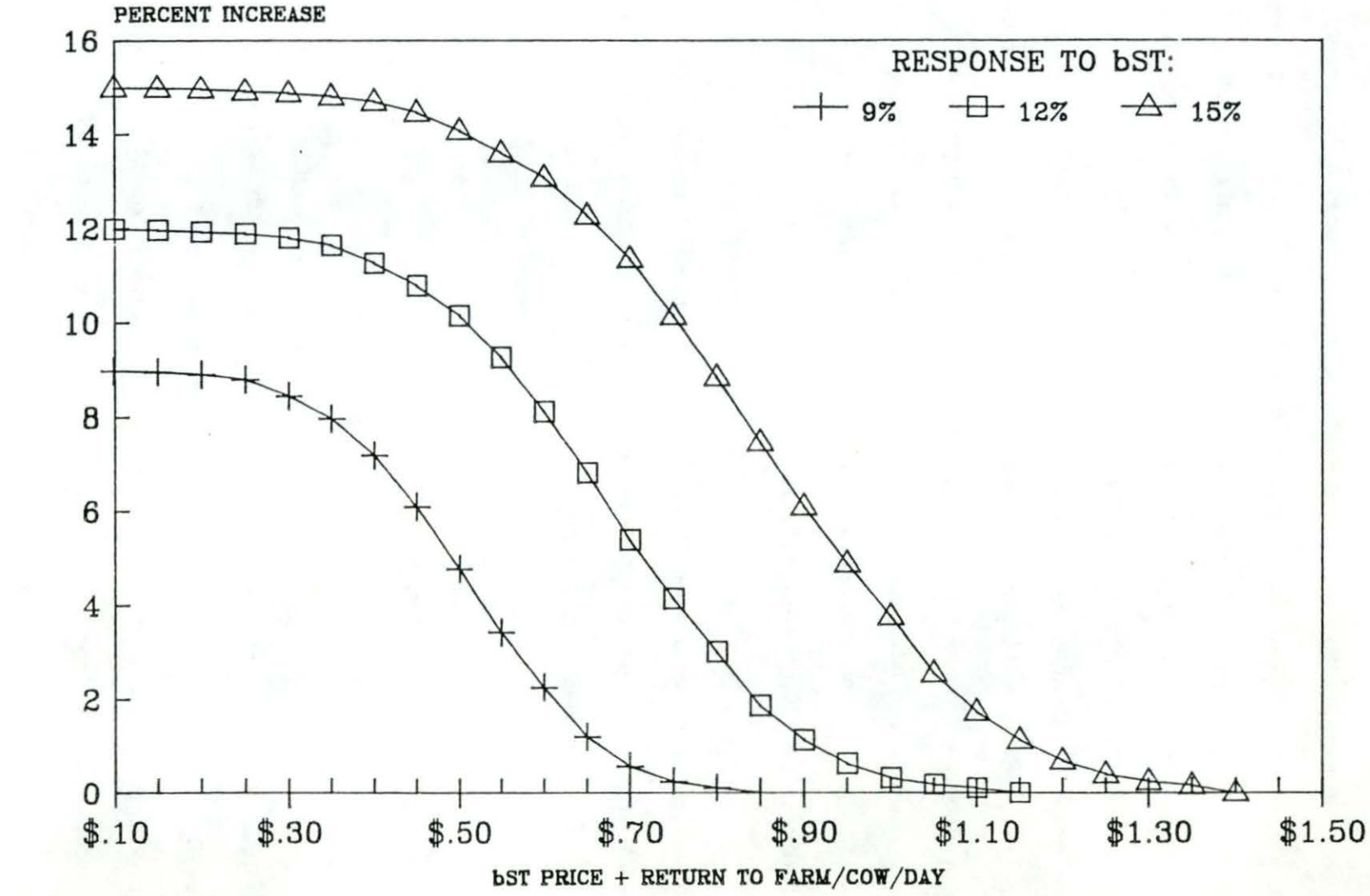
In both figures, bST price plus farm return is allowed to vary on the horizontal axis. We are particularly interested in the nature of the curves for bST price plus farm returns of 50 to 75 cents/cow/day. The lesson is clear. The economic feasibility of bST will be very sensitive to the values of key variables. For example, if the increase in production from bST under field conditions is only 9 percent, at 65 cents/cow/day for bST price plus farm return, bST would be economically feasible on 155,000 Wisconsin cows. However, if bST increases production by 12 percent, all else the same, bST would be feasible on 850,000 cows. Since the three milk prices examined involve much smaller relative variations than is true for the bST response rate, the impacts are also less dramatic. However, they are much larger impacts than those suggested by the representative farms examined by Kalter et al. (1984).

Impact of bST on State Milk Production

Figure 3 indicates the percentage increase in state milk production in 1990 with different bST response rates if bST is given to all cows on which it is economically feasible. An all-milk price of $10.75 is assumed. For bST price plus farm return of 50 to 75 cents per cow per day, the potential increase in state production ranges from 1 to 14 percent, depending on the production response to bST.

Given the uncertainties about the response to bST, the price of milk in 1990 and other factors, we have developed lower and upper

FIGURE 3 PERCENT INCREASE IN WISCONSIN MILK PRODUCTION WITH THREE DIFFERENT bST RESPONSE RATES, CIRCA 1990.



estimates of the percent of cows on which bST will be economically feasible, and the increase in state production that would occur if bST were given to all cows on which it is economically feasible. Our estimates are shown in Table 4. The lower estimates assume a Wisconsin all-milk price of $10.25 when bST is introduced and a production response to bST of 9 percent. Under these conditions, we allow bST price plus farm return to drop to 45 cents/cow/day. If farmers were willing to adopt bST for 20 cents/day/cow, the profit maximizing bST price for manufacturers would be 25 cents/cow/day under the conditions assumed for the lower estimate. The upper estimate assumes an all-milk price of $10.75 and a bST response of 12 percent. Table 3 indicates that manufacturer profits will be maximized under these conditions when bST price plus farm return is between 60 and 70 cents per cow per day.

Table 4 provides upper and lower estimates if bST were given to all cows on which it is economically feasible. However, universal adoption by all farmers with feasible opportunities is unlikely. Only 44 percent of the state's cows are currently enrolled in DHI, a program with proven benefits that may be somewhat similar to bST in the management changes required. This suggests that bST might not be used on more than 45 percent of the state's cows, at least during the first few years of commercial use. If this is the maximum percent of the state's herd that can realistically be expected to use bST, Table 4 indicates that state milk production will increase 5.0 to 6.5 percent, at most, due to bST. We believe this is the likely upper range of bST effects on state production during the first five years of introduction.

Table 4. Upper and Lower Estimates of Percent of Wisconsin Cows on Which bST Will be Economically Feasible in 1990.

bST Price Plus Farm Return Per Cow Per Day	Lower Estimate[a]		Upper Estimate[b]	
	% of Cows on Which bST is Feasible	% Increase in State Milk Production	% of Cows on Which bST is Feasible	% Increase in State Milk Production
.45	48%	5.2%	83%	10.8%
.50	32	3.8	76	10.1
.55	20	2.5	67	9.3
.60	10	1.3	57	8.1
.65	4	0.6	46	6.8
.70	2	0.2	35	5.4
.75	---	---	26	4.1

[a] bST response rate of 9% and all-milk price of $10.25/cwt.

[b] bST response rate of 12% and all-milk price of $10.75/cwt.

The number of farmers adopting bST will increase gradually. Many will wait to observe the experiences of early adopters of bST. In the first year of introduction, we expect bST to be used on only 5 to 10 percent of the state's cows. If all goes well in the early trials, adoption will increase in years 2, 3 and 4. An adoption rate that we consider optimistic is shown below. It suggests how much milk production in the state is likely to be affected over the first four years that bST is available.

	% of Cows on Which bST is Used By End of Year	Average % of Wisconsin Cows Using bST During Year	Approximate % Increase in State Milk Production
First Year	7%	3.5%	0.4 to 0.5
Second Year	20	13.5	1.6 to 2.1
Third Year	33	26.5	3.1 to 4.1
Fourth Year	40	36.5	4.3 to 5.6

This rate of adoption is a rough estimate. If problems emerge in the use of bST, the rate of adoption will likely be slower than the above figures.

Impact of bST on Milk Prices

Increased milk supply due to bST is one of many factors that will influence future milk prices. In this section, we attempt to assess the incremental impact of bST on milk prices.

We assume here that adoption rates of bST nationally are similar to Wisconsin. Although this may not be true, average production per cow in Wisconsin is about the same as the national average. There is

no compelling logic for expecting Wisconsin farmers to be either slower or faster than farmers in the remaining 49 states in adopting bST.

The estimated impact of bST on milk prices depends upon the federal dairy program in place during 1990-95. If the current program is continued in the next farm bill, federal support prices for manufactured grade milk will drop 50 cents/cwt. in any year in which government purchases of dairy products are expected to exceed 5 billion pounds. Under this scenario, it seems reasonable to project a 50 cent/cwt. decline in milk prices for every 5 billion lb. increase in U.S. milk production attributable to bST. If U.S. milk production in 1990 without bST were about 155 billion pounds annually, a 3.3 percent increase due to bST would lead to a 5 billion pound expansion in supply. The schedule of adoption rates, above, indicates it will probably take at least three years before bST expands Wisconsin supply by 3.3 percent. Assuming the same increase takes place nationally, milk prices would drop 50 cents/cwt. at that point. An additional 50 cent decline could eventually be triggered if, in time, bST were used on 45 percent or more of the nation's cows (assuming the same distribution as Wisconsin) or if it provided more than a 12 percent boost to production per cow.

The above analysis assumes that the present dairy program continues. An alternative dairy policy could allow prices to respond fully to market forces. With farm level price elasticity of demand for milk of roughly -0.3, a 3 percent expansion in supply would lead to a 10 percent decline in milk prices, or roughly $1.00 per cwt. A 4.5 percent increase in supply would cause farm prices to drop 15 percent,

or roughly $1.50 per cwt. Thus, a free market for milk would result in bST having about double the price depressing effects as the current dairy program. These estimates do not necessarily indicate that equilibrium prices will be $.50 to $1.50 below current prices since they ignore the supply reductions that would occur as prices fall and milk production increases from other sources.

Our estimates can be compared to those of the USDA report on bST (Fallert et al. 1987) that used simulation models to estimate the impact of bST over a seven year period, 1990-1996. If the current dairy program were continued, Fallert et al. estimated a support price of $9.60/cwt. in 1990 before bST is introduced (equivalent to Wisconsin all-milk price of $10.25). Without bST, no further reductions in price supports would be required according to USDA simulation models. With bST, the USDA results indicated price supports would drop to $9.10/cwt. in 1991 and to $8.60/cwt. in 1992. This is a much sharper reduction in milk prices than we project, in part because Fallert et al. assumed a very rapid rate of adoption and also because they assumed bST will be economically feasible for most dairy herds. Whereas the USDA projection would call for a Wisconsin all-milk price of $9.25/cwt. by 1992, we project a price of $9.75 to $10.25 in January 1993 after the first bST related price drop occurs.

Effect of bST on the Structure of Wisconsin Dairy Farms

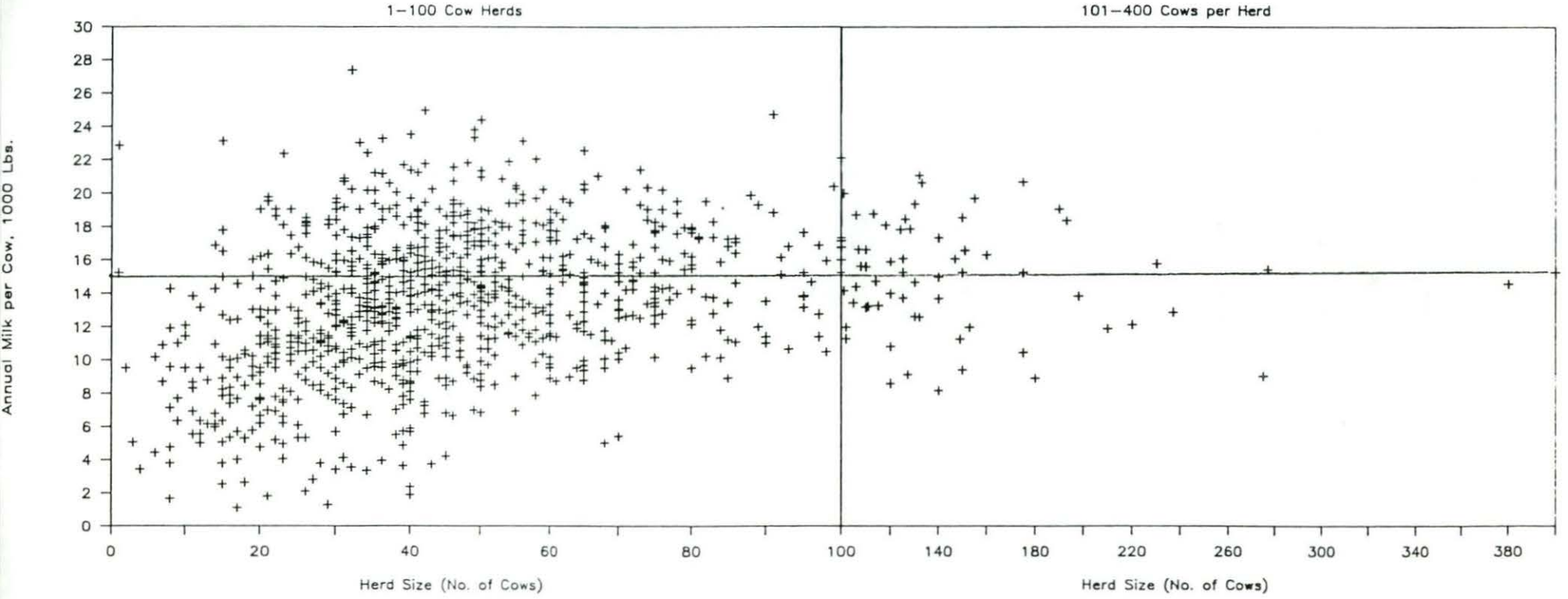
One of the issues surrounding bST is the effect of its adoption on the economic viability of different size farms. Will bST accelerate the long-run trend toward larger dairy farms?

The research results to date on bST indicate that adopting bST will not require large herds. That is, unlike the self-propelled combine and tomato harvester that are technologies with a clear large scale bias, bST -- in and of itself -- will not be strongly biased toward large scale operations.

Effective use of bST will require careful management and will likely be more economically feasible on herds with high-producing cows. Data on production per cow in Wisconsin indicates that small herds with 30 or fewer cows on average have significantly lower production per cow than larger herds. However, the positive relationship between herd size and production per cow occurs only up to herds with 40 to 45 cows (Figure 4 and Table 5). Beyond that, herd average production per cow levels off.

For all herd sizes, substantial variation exists in the average production per cow. Figure 4 plots the production per cow by herd size for the 1078 herds sampled in January 1987 by Wisconsin Agricultural Statistics Service. A horizontal line is drawn through the plots at 15,000 pounds annual production per cow as an illustrative level at which bST is economically feasible. In 1987, 43 percent of the cows were in the 37 percent of herds above this level of production. Although this figure indicates that a smaller proportion of the herds with fewer than 40 cows would find bST feasible, the pattern disappears at larger herd sizes. Indeed, the highest producing herds had 30 to 60 cows. The average production in smaller herds is pulled down by some very low producing herds -- producing less than 7000 pounds/cow/year.

Figure 4. Average Production Per Cow by Herd Size, 1078 Wisconsin Herds, 1987.



The proportion of Wisconsin herds in each size class in 1990 that are projected to have average herd production greater than several production levels are shown in columns 4-8 of Table 5. These figures confirm the observation that fewer of the very small dairy farms (fewer than 30 cows) will benefit from bST because a smaller proportion have average production above the levels that are likely to be economically feasible. The introduction of bST will place added financial pressure on farms with low producing herds for two reasons: First, operators will not generally find bST use profitable.[3] Second, adoption of bST by farmers with high producing herds is likely to lead to lower milk prices. On average, herds with 40 or more cows do not appear to be at a disadvantage relative to larger herds. bST will provide an added incentive for farmers to increase the productivity of their cows and improve their management practices in order to take advantage of the new technology.

Conclusions

Most of the previous ex ante assessments of bST have concluded that bST will be profitable for most U.S. dairy farmers. However, these studies have assumed values for several key variables that may be unrealistic for 1990 when bST is expected to be introduced. Our analysis indicates that the economic feasibility and likely adoption of

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[3] Of course, the financial pressures are a matter of degree. Farms that are far below the breakeven production level will be at a greater disadvantage than those close to the breakeven level. At the breakeven level, farmers are indifferent between the returns they receive without bST and the returns, including compensation for administering bST, that they receive if they use it.

Table 5. Percent of Herds with Average Production Exceeding Various Production Levels by Herd Size, 1990 Projections

Herd Size (No. of Cows)	Nr. of Herds	Mean Production Per Cow/Year	Percent Exceeding Various Production Levels			
			12,000	15,780	18,765	22,000
1-10	23	9,187	26.1	8.6	4.3	4.3
11-20	82	9,528	29.3	12.2	4.9	1.2
21-30	159	11,863	54.7	24.5	13.2	0.6
31-40	224	13,215	68.3	35.7	14.7	5.8
41-50	206	14,632	82.5	50.5	23.3	5.8
51-60	125	14,571	88.0	44.8	23.2	4.0
61-70	78	13,968	79.5	50.0	16.7	3.8
71-80	61	15,745	95.1	60.7	34.4	1.6
81-90	30	14,567	83.3	43.3	13.3	0.0
91-100	25	16,010	92.0	72.0	20.0	8.0
101-150	45	14,973	88.9	57.8	24.4	4.4
>150	20	14,733	85.0	55.0	20.0	5.0
Total	1078					

bST will be very sensitive to: 1) the production response to bST; 2) milk prices; 3) the price that farmers will have to pay for bST; and 4) the returns required by farmers to adopt bST. Although our analysis did not examine the effects of increasing feed costs on the economic feasibility of bST, the drought of 1988 suggests this also warrants consideration.

We project a more gradual and less extensive adoption of bST and a more modest impact on milk production and milk prices than most earlier studies. The economic impact of bST will still be significant under our calculations, however. Our estimates indicate that if bST is used by one-fourth of U.S. cows (assuming a similar distribution of production/cow as in Wisconsin), milk supplies will increase enough to trigger a milk price decline of 50 cents per cwt. (assuming continuation of the current dairy program). The three-fourths of Wisconsin herds that have not yet adopted bST will suffer a decline in net income of roughly $100 million per year. The one-fourth of the state's herds that are early adopters of bST will increase their net incomes during the first three or four years before milk prices decline. After the price drop, these farmers will find their net incomes are about the same as before bST was introduced (see Marion, Wills and Butler for a fuller discussion). Our projected effects are very similar to Cochrane's comment that "technological advance puts farms on a treadmill" (Cochrane 1965, p. 66).

Although we believe our analysis employs more realistic assumptions than most previous studies of bST, the more important point may be that the results of such studies are very sensitive to the

underlying assumptions. Too little attention has been paid to this point. Given the speculative nature of all prospective assessments, much greater emphasis on sensitive analysis is warranted.

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