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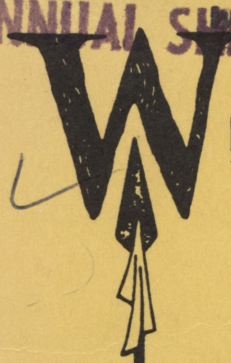
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# Evaluating Biotechnological Impacts: Empirical Results for Milk and Cotton

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## Potential Economic Impacts of the Use of Bovine Somatotropin in the U.S. Dairy Industry

The biotechnological innovation likely to produce the first widespread impacts on the U.S. agricultural sector is the use of bovine Somatotropin (bST) to increase milk output per cow. A hormone that occurs naturally in cows, bST currently can be produced in volume through standard genetic engineering techniques. When injected into a dairy cow, bST increases blood flow through the mammary glands, thereby enhancing the animal's ability to produce milk without apparent changes in the milk's composition or quality.

Although bST is not yet approved for commercial use, the Food and Drug Administration (FDA) has determined that milk from bST-treated cows is safe for human consumption. Milk from test herds is being sold (Fleming and Kenney, 1989).

Research on the effects of bST has been extensive. A recent USDA bibliography of bST research (Kenney and Fallert, 1987) includes 110 entries. Most of the studies have been of a physiological nature with only a limited number examining economic implications. Coppock's (1987) survey of production response studies shows that mean productive response to long term

use of bST to be about 14 percent on an annual basis. Individual studies have reported percentage increases in the high 30s to low 40s (Bauman and Eppard, 1985; Chalupa, 1987; Annexstad and Otterby, 1987).

## Econometric Results

Womack et al., using their FAPRI econometric model, have developed three scenarios to examine the possible economic effects of bST on the national dairy industry, the consumer, and on the U.S. government. They are a baseline scenario (no use of bST through 1996 and continuation of the current government dairy program under the Food Security Act of 1985), and two scenarios assuming that adoption of bST begins in 1990 (the government program also is continued). These analyses bracket the 14 percent mean response with 9 and 19 percent increases in production per cow due to bST adoption. These productivity increases correspond to assumed feed consumption increases of 3.3 and 6.7 percent respectively (Coppock, 1987).

The diffusion path utilized is based on the recent USDA publication bST and the Dairy Industry (Fallert et al., 1987). The primary distinction of the USDA diffusion path relative to those suggested earlier (e.g.

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Kalter et al., 1984) is a much lower maximum diffusion rate. In the current analysis, the bST diffusion path is assumed to begin at 10 percent in 1990, and following the traditional logistic relationship (Griliches, 1957), end at 43 percent adoption in 1993. No additional adoption occurs after 1993. Studies by Kalter et al. (1984), Yonkers et al. (1987), and Butler and Carter (1988), report that early and middle adopters are likely to have larger herd sizes than late adopters. Since the current study assumes, for convenience, equiproportionality of adoption and production by size of farm, the results obtained are more likely to underestimate than overestimate the aggregate production response for a given level of bST response. Thus, the 19 percent scenario is viewed as "most likely."

#### **Baseline Scenario**

Milk production increases 15 percent from 1987 to 1996 under the baseline of this analysis (table 1). In contrast to the early 1980s, however, increased commercial utilization should accompany the expansion in supply. Growth areas will be in the cheese, frozen, and fluid sectors. Per capita butter, powder, and evaporated use will decline.

Table 2 contains forecasted values for costs and returns of producing a hundredweight of milk under the assumptions of the baseline. Despite stabilization of receipts in 1990 due to government removals falling below five billion pounds in that year, increasing variable and fixed costs erode the profitability per hundredweight of milk. After 1989 each successive year brings lower returns per hundredweight.

Lower relative prices, a stable group of fluid consumers, and strength in the cheese and frozen sectors should enable government removals to remain below 5 billion pounds after 1989. Government costs associated with the dairy program should also

fall. However, the introduction of bovine growth hormone in 1990 could substantially alter the outlook for milk and dairy products thereafter.

#### **Nine Percent Scenario**

In the 9 percent bST scenario (table 1) total milk production is less than 1 percent higher in 1996 relative to the baseline. However, due to the FSA85 legislation prescribing a 50 cent reduction in milk support prices for any year in which net government removals are expected to exceed 5 billion pounds, the average farm price is \$2.00 per hundredweight lower from 1993 through 1996. Total returns to the dairy industry are projected to be substantially lower with bST relative to the baseline.

Table 2 contains forecasted values for costs and returns of producing a hundredweight of milk with an assumed 9 percent increase in production per cow due to bST adoption. This table suggests that, despite lower costs per hundredweight due to bST adoption, the declining milk support price more than offsets the lower costs of production. Although bST adopters receive greater net revenue per hundredweight in 1990 relative to the baseline, net revenue per hundredweight deteriorates quickly thereafter and is below baseline levels from 1991 forward. Through 1994, government removals are higher in the 9 percent bST scenario than under the baseline. However, the lower support prices from 1990 forward keep government costs close to baseline levels.

Total revenues to the industry are summarized in table 3. Under the 9 percent bST scenario, total revenues decline relative to the base beginning with adoption. Total net revenues are slightly higher than the base in 1990 because of the spreading of fixed costs per hundredweight. They decline relative to the base thereafter and become negative by 1994. Producers' surplus, that is, net

returns to the fixed factors of production, remain positive through 1996, but are below the base scenario. A lower, but not negative return on fixed capital is implied.

### **Nineteen Percent Scenario**

Results of the 19 percent bST scenario are also contained in table 1. While total production increases less than 4 percent above baseline levels in this scenario, the increased production causes government removals to exceed 5 billion pounds in every year of the forecast period. Therefore, the support price falls to \$6.60 per hundredweight by 1996 and the average farm price of all milk falls to \$7.95 per hundredweight; \$3.50 per hundredweight below baseline levels. Although government costs are over twice as large as baseline levels in 1992, they decline substantially after that and approximate baseline levels in 1996.

The substantially lower support prices in this scenario cause the percentage increases in production to fall to very low levels after the bST diffusion process is completed in 1993. Annual production increases per cow remain below 1.5 percent and total milk production increases by less than 1 percent per year. Removals fall from 12 to 6 billion pounds from 1993 to 1996. In other words, once the diffusion process is complete, the total supply of milk remains relatively constant and population and income related demand growth begin to bring the supply and demand situation into balance.

Costs of production fall even further in this scenario than under the 9 percent bST scenario (table 2). As a result, net revenues per hundredweight are higher in 1990-92 than under both the baseline and the 9 percent bST scenario. After 1992, however, the 50cent annual support price reduction drives net revenues per hundredweight below the levels realized under the baseline. Net reve-

nues on hundredweight are less than those realized under the 9 percent bST scenario after 1994.

As shown in table 3, total net revenues for the industry are above the base and the 9 percent scenario in 1990 when bST is first adopted. As bST use spreads, total net revenues remain above the 9 percent scenario through 1993, but are below the base. As use reaches the full 43 percent adoption rate, total net revenues become more negative than in the 9 percent scenario. Producers' surplus (net return to fixed capital) also originally rises above the base, remains greater than or equal to the 9 percent scenario through 1993, and then declines below producers' surplus generated under either of the low-use scenarios.

### **Implications**

While FSA85 and its support price adjustment mechanism are expected to bring supply and demand into balance by 1990 in the absence of bST, commercial introduction and adoption of bST beginning in 1990 will alter the adjustment process currently at work in the dairy industry.

Under the 9 percent bST scenario, total production increases in 1990-93 trigger support price reductions in each of those years. As a result, the average farm price of milk falls \$2.00 per hundredweight relative to the baseline. bST adopters are better off initially because of reduced costs per hundredweight of milk produced. However, the decline in milk prices quickly outstrips the production efficiency gains and net revenues per hundredweight are lower than the baseline from 1991 forward. Nonadopters, with higher production costs, are even worse off than adopters.

Under the 19 percent bST scenario, production increases bring support price reductions every year through 1996. The average farm price of milk falls to \$7.95 per

hundredweight in 1996. As in the 9 percent bST scenario, profit levels in excess of the baseline can be earned by early bST adopters. But these extra profits persist only through 1992. After 1992, net revenues per hundredweight for adopters of bST are substantially lower than the baseline, although still positive through 1994. Net revenues to nonadopters become negative after 1993. Total net revenues, and total producers' surplus to the industry is less than without the use of bST after 1993.

In the recent past milk production has shifted toward regions having larger average size farms with lower costs of production (Yonkers et al., 1987). In particular, the proportion of milk production in the Mountain and Pacific states has increased, offsetting proportional declines in the Corn Belt, Northern Plains, and Appalachian regions. Since larger farms are more likely to adopt new technologies (Kalter et al., 1984; Carley and Fletcher, 1986; Butler and Carter, 1988), it is likely that these regional shifts will be accelerated with bST use. In other words, while underlying economic conditions have determined the direction of change in regional production patterns, bST will likely increase the rate of those changes. The relative hesitancy of smaller farms to adopt new technologies will mean an accelerated decline in the number of moderate sized farms in all regions.

Government costs are not likely to change substantially due to bST use because increased removal levels will generally be offset by the lower prices paid for those removals. Unless consumers perceive milk produced using bST as inferior to milk produced without bST, consumers should be the major beneficiaries of bST adoption. Retail dairy product prices are projected to fall between 11 and 19 percent with bST relative to the baseline.

## Mathematical Programming Results

Chang, McCarl and Adams (CMA) use the same basic assumptions on bST adoption in their agricultural sector, regional mathematical programming model. Their model compares a 1986 base solution to solutions assuming a 43 percent adoption rate for bST use, with a 19 percent increase in production per cow where bST is adopted. These productivity increases correspond to a 6.7 percent increase in feed consumption. As with the FAPRI model they assume equiproportionality of adoption by size of farm. Solutions are obtained assuming the current farm program and assuming no farm program. The nine percent productivity scenario is not examined. Where the FAPRI model makes yearly projections, the CMA model produces only the base and the final solutions.

## Prices and Production

The projected effects on prices and production after bST adoption is completed is shown in table 4 by commodity group. Base milk production nationally is estimated as 1,437,787 thousand hundredweight—99.8 percent of reported milk production in 1986 (USDA, 1987). Price per hundredweight, as estimated by the model is about 70 cents higher than the 1986 actual. When adoption of bST is complete, milk production is projected to rise 6 percent while price falls by 8.7 percent.

Adjustments in the dairy industry may cause adjustments in other sectors of agricultural production as land and other resources are transferred to other uses, and other product prices are affected. A change in dairy productivity will have fewer effects on other sectors than a change in crop productivity where high quality cultivatable land is a larger direct component of production cost, but there still will be some indirect

impacts. In table 4, increased dairy production is projected to increase hay, silage, sorghum, soybean, and corn production and prices. These effects might be expected through their direct connection as feed. Cotton production and prices are also slightly affected – negatively – presumably as marginal cotton acreage shifts to feed grains.

### **Producer Effects by Region**

While milk producers as a whole are projected to suffer lower prices in response to increased use of bST, farmers as a whole would gain. Total national producers' surplus for all crop and livestock production in the model (fruits, nuts and vegetables are not included) is estimated at \$19.8 billion in the base year 1986 (table 5). Total producers' surplus is estimated to increase by 0.17 percent, with all regions except the Pacific and Northeast regions registering gains. The Pacific region would suffer a small loss; the Northeast region a little over 2 percent on a \$400 million base. Some producers would gain and others would lose. These estimates are the net gains and losses over all included crops.

### **Total Social Benefits and Losses**

In table 5 estimates of aggregate benefits and losses are shown grouped by domestic and foreign producers and consumers. Total domestic producers' surplus rises as previously shown in table 4. Domestic consumers are by far the largest winners, showing a 1.19 percent increase in consumers' surplus on a large base of \$143.8 billion. Foreign producers suffer losses as imports are affected, and foreign consumers register a slight gain. Net total social benefits to all consumers and producers rise, with only foreign producers having losses.

All of these estimated gains and losses are generated against the backdrop of our current farm programs. The total cost of farms programs in the base year is a little

larger than total domestic producers' surplus. If it is assumed that loan payments eventually are fully recovered, and deficiency payments are the only real cost, net total social benefits are reduced to \$164.1 billion. With adoption of bST, deficiency payments are projected to rise, but net social benefits after government deficiency payments also rise.

The model was also solved under the assumption of a fully free market with no government program. Under those conditions, adoption of bST would affect both foreign and domestic producers negatively. Total social benefits would rise because of offsetting benefits to consumers.

Total social benefits would be over \$2 billion higher in the base year because of the deadweight loss created by the programs. Under the current farm programs, government payments make both domestic and foreign consumers' surplus, and domestic producers' surplus, larger than under a free market equilibrium. But, the sum of the increased consumers' and producers' surpluses is less than the total amount of government deficiency payments, creating a deadweight loss. Consumers have a net loss from government programs, since they pay in taxes all of their increased surplus, plus the majority of the producers' increased surplus, plus the deadweight loss.

## Potential Economic Impacts of Reducing Insecticide Costs for Growing Cotton in the U.S.

While the commercial adoption of biotechnically generated bST is almost upon us, most other agricultural biotechnical advances are much farther in the future. Our survey of the biotechnical research at The University of Arizona (Kulakowski, 1988) found that most potential applications are still speculative – particularly in the plant sciences. While work in the animal sciences is quite advanced, especially with growth hormones, the plant biologists still have much basic work to do before applied engineering becomes practicable.

One current project at The University of Arizona that the researchers themselves believe could produce a product for possible adoption in the “intermediate” future, is that of transplanting a gene from insects into cotton and alfalfa which prevents insects from digesting the plants. The transplanted gene controls the expression of a protein called a trypsin inhibitor. This protein, which exists in all animals, regulates digestion. A plant containing the gene controlling trypsin inhibitor transplanted from insects in its tissues cannot be digested by insects.

The researchers stated that their goal is to produce crop plants that are “naturally” resistant to insect pests. This resistance will allow farmers to sustain yield without having to apply chemical pesticides. “In approximately eighteen months we will have obtained seeds from the transformed plants. There will be about three years of corporate breeding, and one to two years to produce seeds. Farmers should be able to purchase cotton and alfalfa seed with the transplanted gene in five to seven years.”

These researchers further stated that “If our research continues to be successful

and pest-resistant plant strains are purchased by farmers, the cost of producing cotton and alfalfa should decrease by approximately thirty percent. This figure is based on the fact that chemical pesticides presently account for an average of one-third of the cost of production. Thus, if farmers no longer have to buy pesticides, they will spend about 30 percent less to produce the same crops.”

These statements are rough quotes from the biotechnical researchers actually involved in cotton and alfalfa research in a state – Arizona – where these two crops are the major agricultural sectors. We conclude that there is a real potential for reducing insecticide costs for growing cotton through biotechnological advance at some future date – but by how much and at what adoption rate is unknown.

### Mathematical Programming Analysis

The CMA model is used to examine the economic impacts of a 50 percent reduction in insecticide costs by all cotton farmers. This assumption is arbitrary, but within a reasonable range of possibility. To illustrate the advantages of early adoption, three analyses are compared. The three analyses have the alternative assumptions of adoption in all states growing cotton, by Arizona growers only, and by growers in all states except Arizona. The analyses are made with and without the current government farm programs (FSA 1985). The “with farm program” is emphasized in this paper.

### Price and Production

The projected price and production effects are presented in table 7. The base model is the same as the base model for the bST analysis. National cotton production in the base model is estimated as 94.3 percent of reported production for 1986 (USDA, 1987).

The projected direct results on the cotton industry illustrate the complexity of the possible adjustment process. Under the farm program, a 50 percent reduction in insecticide costs would make cotton extremely profitable. The current program allows base cotton acreage to be expanded over time, as the CMA model reflects. Thus, if growers in all states adopted the new technology and the government program remained in effect, production would increase by over 76 percent with only a 5.8 percent reduction in price. Clearly, cotton growers would benefit.

Very similar results would occur if all growers except Arizona growers adopted the new technology. Cotton production would rise almost as much and price would fall almost as much as if all growers were adopters. Arizona growers would suffer significant losses. Quite different results are obtained if Arizona growers were the only adopters. Increased Arizona production would cause a price reduction and total national production would fall. Arizona cotton growers would benefit at the expense of growers elsewhere.

Production adjustments in the cotton industry would cause adjustment in production of other crops. The largest reduction would be of wheat, with smaller reductions of barley and oats. Corn and sorghum production would increase under the assumption of national adoption of insect resistant cotton variety. Sorghum production would decrease if only Arizona adopted the new varieties.

### **Producer Effects by Region**

National adoption of insect resistant cotton varieties would have the largest percentage beneficial impact on delta-state farmers (table 8). Farmers in the southeast, the south plains, and the pacific region would also benefit significantly. These benefits are to farmers in general – not just cotton farm-

ers. Farmers in the northeast would suffer slight losses. The nationwide change in producers' surplus is 2.38 percent. If Arizona were the only adopter, national benefits would still be positive (0.36 percent), but the pacific and south plains would have slight losses.

### **Total Social Benefits and Losses**

In contrast to the projected economic impacts of increased milk production, domestic producers rather than domestic consumers, are the largest beneficiaries of the improved cotton varieties (table 9). Producers' surplus increases by 2.38 percent while consumers' surplus remains almost constant under the "all states" adoption assumption. Foreign producers and foreign consumers both would lose. If only Arizona farmers were adopters, small gains by domestic and foreign producers would be balanced by small losses by domestic and foreign consumers for a zero percent change in net social benefits.

The farm program figures prominently in the results. Under the "all states" scenario total social benefits before adjusting for the farm program rise by 0.22 percent because of producer gains. After adjusting for deficiency payments, however, total social benefits actually fall by 0.22 percent.

These models were also solved under the assumption of a free market with no government agricultural program. Under that scenario, domestic producers' surplus would fall for all of the three adoption scenarios. Both domestic and foreign consumers' surplus would rise, and a net rise in total social benefits would result.

### **Summary and Comparisons of Results**

Estimates of the economic impacts on producers, consumers, and government of two distinctly different types of biotechnological change were made. The change

projected for the dairy industry is output increasing for the average cow, with relatively small cost increases associated with the input costs of feed and the bovine growth hormone bST. The change projected for cotton producers is cost reducing for the average acre, with yield per acre remaining constant. Two techniques were used. The dairy analyses used both econometric and mathematical programming techniques. Only mathematical programming was used in the cotton analyses. (Both types of analyses, while mathematical and computerized in nature, are highly labor intensive for labor with very specialized knowledge. The specialized labor for the cotton econometric analysis became unavailable.)

The econometric analysis starts with national data in order to generate national results for the directly involved dairy industry, with informed judgements about production and economic conditions in other industries and in the macroeconomic conditions of the U.S. economy serving as exogenous inputs into the analysis. The mathematical programming models build from representative farm models by production regions, yielding both individual product and regional results, and are aggregated to national results. Changing macroeconomic conditions are not an input into the analysis.

Both techniques of analysis for both types of biotechnological change yield the same general qualitative results. Regardless of whether the technology is "output increasing" or "cost reducing", aggregate outputs of the directly affected product rise and the price of that output falls. As these direct effects occur, early adopters can increase their net revenues significantly for a time before widespread adoption. After widespread adoption, milk producers in general would be worse off. Cotton producers in general could be better off, but only if the current government support program is maintained.

Consumers of the directly affected product will gain from the lowered price and greater quantities. They gain more from a product like milk that is more directly consumed than a product like cotton. Consumers would gain even more if government programs were not in place, but, given that the programs exist in the first place, they still are gainers from the improved technology.

None of these general qualitative results are unexpected. Of greater interest are the projected indirect impacts in the other production sectors in agriculture, on the distribution of aggregate gains and losses between regions, and on total net societal benefits. It could be argued that the econometric model may produce more accurate predictions of the directly produced effects than does the programming model since the former relies on observed behavior from the past while the latter relies on optimal behavior in the future. But the mathematical programming model allows greater examination of these sectorial and regional trade-offs.

For the bST milk models, producers and consumers in general, with the exception of foreign producers, gain in social benefits. Total benefits increase even after payment of increased farm program costs. Adoption clearly is an economic benefit for the U.S. as a whole, although producers in general in the pacific and northeast regions would be losers, in addition to the milk producers themselves.

In the cotton models, U.S. consumers and producers in general both would be direct winners with widespread adoption of the insect resistant varieties. Foreign consumers and producers would lose. However, after U.S. consumers pay their increased costs of the farm programs, they would become losers too. The change in total net social benefits would be negative. Producers in general in the northeast and the lake states would suffer losses while producers in

the other regions gained. If the farm programs remained in effect, some cotton producers would be winners and some losers. The largest winners would likely be in the delta states.

### Paretoality

These distributional benefits and losses are more clearly identified in figures 1 and 2. There, the absolute amounts of gains and losses are compared by sector, and the Indices of Paretoality computed. Results are displayed only for the mathematical programming cotton model under the current farm program.

Aggregate domestic producers' surplus under the assumption of adoption by all states showed not only the largest percent increase (table 9), but also is many magnitudes higher than the increase in domestic consumers' surplus (figure 1). Domestic producers gain by \$471 billion while domestic consumers gain by only \$13 billion. These two sectors' positive net gains are balanced by only \$84 billion of losses, to foreigners – mostly foreign consumers. The Index of Paretoality (IP) equals 0.826, indicating net benefits as 82.6 percent of positive benefits.

When all states except Arizona are adopters, the aggregate results appear similar, although total net benefits are somewhat smaller. If only Arizona farmers are adopters, the results are quite different. Seventy-two billion dollars of increases in domestic producers' surplus, plus \$1.0 billion of foreign producers' surplus, are balanced against \$67 billion of domestic and foreign consumer losses, leaving only \$6 billion of net social benefit. Domestic producers capture almost all of the positive benefits. The IP is only 0.082, indicating almost a complete distributional trade-off between sectors.

The aggregate of domestic producer benefits is broken into region benefits and losses in figure 2. Delta state producers are

shown to not only have the largest percentage gain (table 8), but also the largest absolute gain, under the assumption that all states adopt. While the southeast was second in percentage increase, it is only fourth in absolute gains, after the south plains and the pacific region. Every region except the northeast is a gainer. The IP is 0.998, indicating an almost perfect "pareto better" situation.

If only Arizona adopted the new technology, most producing regions still are winners. Only the south plains and the pacific region lose. It is the corn belt, with only a 0.33 percent increase in total output, that is the greatest absolute winner, however. Arizona and the other mountain states, with a larger percentage increase in producers' surplus is only the second absolute gainer. Producer benefits in total still are widely distributed and the IP equals 0.96.

### Conclusion

As argued in the lead paper by Gum and Martin, the potentially complex interactions in the economy, resulting from a single technological innovation, are not always apparent. The larger the number of sectors that can be included in the analysis, the wider the appreciation of effects becomes. As more sectors are added. Sectors originally thought to be gainers may become losers and vice versa.

The two models used in the analysis of the potential impacts of the adoption of bST in the U.S. dairy industry and insect resistant varieties in the U.S. cotton industry offer realistic empirical examples. While milk producers as a whole will suffer losses from the new biotechnological advance, domestic farmers as a whole would gain, under current farm programs. If farm programs were abolished, producers would lose but consumers would gain.

In the case of cotton, lower production costs under current farm programs, would benefit farmers in general greatly, and consumers in general slightly, if all cotton states were adopters. But if only a single state, Arizona, adopted the new varieties, consumers would lose while producers in most regions gained. The cotton belt would be the largest gainer.

Every new technology will produce a distribution of winners and losers. It is only through use of models such as examined in these papers that the practical effects of technological change can be understood.

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Table 1. Milk Production, Milk Prices, and Government Costs.

	Baseline				9% bST				19% bST			
	1987	1990	1993	1996	1987	1990	1993	1996	1987	1990	1993	1996
Total Prod. (bil lbs)	142.46	149.76	157.00	163.61	142.46	150.60	159.81	165.02	142.46	152.15	166.30	169.58
Removals (bil lbs ME)	6.70	4.00	4.35	3.28	6.70	4.70	5.57	2.62	6.70	6.50	12.00	6.19
Govt. Cost (bil \$)	1.13	0.60	0.66	0.49	1.13	0.67	0.67	0.39	1.13	0.93	1.45	0.61
Support Price (\$/cwt)	11.29	10.10	10.10	10.10	11.29	9.60	8.10	8.10	11.29	9.60	8.10	6.60
Farm Price (\$/cwt)	12.53	11.45	11.40	11.50	12.53	10.95	9.45	9.45	12.53	10.95	9.45	7.95

Source: Womack, et al.

Table 2. Costs and Returns Per cwt. of Milk\* (\$/cwt)

Year	Total Receipts	Feed Costs	Other Variable Costs	Fixed + Replacement Costs	Total Cost	Net Revenue
-----Baseline-----						
1987	13.56	4.21	2.68	3.52	10.40	3.16
1990	12.48	4.67	2.55	3.66	10.88	1.60
1993	12.31	4.65	2.58	3.78	11.01	1.30
1996	12.50	5.21	2.74	4.21	12.16	0.35
-----9% bST-----						
1987	13.56	4.21	2.68	3.52	10.40	3.16
1990	11.98	4.43	2.38	3.36	10.17	1.81
1993	10.36	4.41	2.41	3.38	10.20	0.17
1996	10.45	4.94	2.56	3.76	11.26	(0.81)
-----19% bST-----						
1987	13.56	4.21	2.68	3.52	10.40	3.16
1990	11.98	4.19	2.23	3.08	9.49	2.49
1993	10.36	4.17	2.26	3.09	9.52	0.84
1996	8.95	4.67	2.39	3.45	10.51	(1.56)

\* Forecasted Values Under FSA85, 1987-1996

Source: Womack, et al.

**Table 3. Total Revenues to Milk Producers (\$ billions)**

	<b>Total Revenue</b>	<b>Total Net Revenue</b>	<b>Producers' Surplus</b>
<b>-----Baseline-----</b>			
1987	19.3	4.5	9.5
1990	18.7	2.5	8.0
1993	19.3	2.0	7.9
1996	20.5	0.6	7.5
<b>-----9% bST-----</b>			
1987	19.3	4.5	9.5
1990	18.0	2.7	7.8
1993	16.6	0.3	6.4
1996	17.2	-1.4	4.8
<b>-----19% bST-----</b>			
1987	19.3	4.5	9.5
1990	18.2	3.8	8.5
1993	17.2	1.4	6.5
1996	15.2	-2.6	3.3

Source: Womack, et al.

Table 4. The Effects on Prices and Production of Increasing Average Milk Production Per Cow Throughout the U.S Through the Use of bST.<sup>a</sup>

(Current Farm Program)

Commodity	Units	Base		Percent Changes in Prices and Production	
		Price	Production	Price	Production
		(\$)	(thousands)		
Cotton	bales	266.09	9,183	-0.23	-0.24
Corn	bu.	1.49	7,692,768	0.00	0.48
Soybean	bu.	4.69	2,143,658	0.21	0.64
Wheat	bu.	2.34	2,035,595	0.00	-1.00
Sorghum	bu.	1.36	1,144,681	0.00	1.70
Rice	bu.	4.86	136,697	-0.21	0.00
Barley	cwt.	1.56	528,014	0.00	0.07
Oats	bu.	1.15	467,965	0.00	-2.21
Other Livestock	GCAU	200.89	3,006	0.06	0.00
Cull Dairy	head	37.03	26,290	0.00	-2.10
Cull Beef	cwt. LW	37.03	30,878	0.00	0.13
Milk	cwt.	13.29	1,437,787	-8.73	6.01
Silage	tons	11.38	88,368	0.79	0.87
Hay	tons	58.12	112,620	0.12	0.34
Hog Slaughter	cwt. LW	49.22	194,178	0.02	0.01
Feeder Pig	cwt. LW	91.92	46,373	0.01	0.01
Live Calves	cwt. LW	53.84	64,677	0.09	-0.11
Beef Yearling	cwt. LW	52.65	170,783	0.00	0.22
Fed Beef Slaughter	cwt. LW	58.17	275,290	0.03	0.00
Cull Sow	cwt. LW	31.74	9,417	0.00	-0.24
Poultry	GCAU	271.39	30,789	0.07	0.00
Lamb Slaughter	cwt. LW	71.39	4,126	-0.15	0.00
Lamb Feeder	cwt. LW	57.50	4,536	0.00	0.00
Wool	cwt.	0.56	160,118	0.00	0.00
Wool Incentives	\$	1.10	112,474	0.00	0.00
Unshorn Lamb	\$	2.86	6,687	0.00	0.00

<sup>a</sup> Assumes a 43 percent adoption rate for bST use, with a 19 percent increase in production per cow where bST is adopted.

**Table 5. The Effects on Producers' Surplus of Increasing Average Milk Production Per Cow Throughout the U.S. Through the Use of bST.<sup>a</sup>**

*(Current Farm Programs)*

Region	Base Producers' Surplus (\$ billions)	Percent Change in Producers' Surplus
Mountain	2.4	0.05
Pacific	1.5	-0.11
Northeast	0.4	-2.04
Lake States	2.2	0.22
Corn Belt	5.5	0.38
North Plains	3.2	0.20
Appalachia	1.4	0.27
Southeast	0.9	0.21
Delta States	1.0	0.42
South Plains	1.4	0.08
<b>Total</b>	<b>19.8</b>	<b>0.17</b>

<sup>a</sup> Assumes a 43 percent adoption rate for bST use, with a 19 percent increase in production per cow where bST is adopted.

Table 6. The Social Benefits of Increasing Average Milk Production Per Cow Throughout the U.S. Through the Use of bST<sup>a</sup>.

(Current Farm Program)

Benefits	Base Benefits <sup>b</sup> (\$ billions)	Percent Change in Benefits <sup>c</sup>
Domestic Producers' Surplus	19.8	0.17
Domestic Consumers' Surplus	<u>143.8</u>	1.19
Subtotal	163.6	
Foreign Producers' Surplus	2.8	-0.38
Foreign Consumers' Surplus	<u>13.9</u>	0.03
Subtotal	16.7	
<b>Total Social Benefits</b>	<b>180.3</b>	<b>0.96</b>
Costs of Farm Programs <sup>d</sup>	20.4	0.16
Deficiency Payments	16.1	0.25
Loan Payments	4.3	-0.16
<b>Total Social Benefits Less Deficiency Payments<sup>e</sup></b>	<b>164.1</b>	<b>1.03</b>

<sup>a</sup> Assumes a 43 percent adoption rate for bST use, with a 19 percent increase in production per cow where bST is adopted.

<sup>b</sup> The estimated distribution of domestic and foreign benefits associated with United States agricultural production in the base model year, 1986, before use of bST.

<sup>c</sup> The change in domestic and foreign benefits associated with 43 percent adoption of bST use by domestic producers.

<sup>d</sup> These payments make both domestic and foreign consumers' surplus, and domestic producers' surplus, larger than under a free market equilibrium. The sum of the increased consumers' and producers' surpluses is less than the total amount of government payments, creating a deadweight loss. Consumers have a net loss since they pay in taxes all of their consumer gain, plus the majority of the producer gain, plus the deadweight loss.

<sup>e</sup> Total social benefits adjusted for distorting effects of government payments. Assumes that loan payments are fully recovered.

Table 7. The Effects on Prices and Production of Reducing Insecticide Costs for Growing Cotton by 50 Percent.

(Current Farm Program)

Commodity	Units	Base		All States		Arizona Only		All States Except Arizona	
		Price	Production	Prices	Production	Price	Production	Price	Production
		(\$)	(Thousands)						
Cotton	bales	266.08	9,183	-5.84	76.66	-1.68	-3.73	-5.83	70.55
Corn	bu.	1.49	7,692,768	0.00	1.25	0.00	2.55	0.00	1.22
Soybean	bu.	4.69	2,143,658	0.21	-0.10	0.21	-0.02	0.21	-0.08
Wheat	bu.	2.34	2,035,565	0.00	-12.85	0.00	1.11	0.00	-10.81
Sorghum	bu.	1.36	1,144,661	0.00	2.88	0.74	-20.92	0.00	3.41
Rice	bu.	4.86	136,667	30.25	0.00	1.53	6.20	30.25	0.00
Barley	cwt.	1.56	528,014	0.00	-2.33	0.00	3.25	0.00	-2.23
Oats	bu.	1.15	467,965	0.00	-2.88	0.00	-0.48	0.00	-3.97
Other Livestock	GCAU	200.89	3,006	0.06	0.00	0.33	0.00	0.06	0.00
Cull Dairy	head	37.03	26,290	-0.05	0.00	0.00	0.00	-0.05	0.00
Cull Beef	cwt. LW	37.03	30,878	-0.05	-0.15	0.00	-1.38	-0.05	0.23
Milk	cwt.	13.29	1,437,787	0.00	0.00	0.15	0.00	0.00	0.00
Silage	tons	11.38	86,366	1.14	0.23	1.06	-0.40	1.14	0.39
Hay	tons	58.12	112,620	-0.84	-0.02	0.30	-0.42	-0.84	0.09
Hog Slaughter	cwt. LW	49.22	194,178	0.04	0.05	0.02	0.01	0.04	0.05
Feeder Pig	cwt. LW	91.92	46,373	0.07	0.05	-0.01	0.01	0.07	0.05
Live. Calves	cwt. LW	53.84	64,677	-0.04	-0.27	-0.09	-0.71	-0.04	-0.13
Beef Yearling	cwt. LW	52.65	170,783	-0.04	0.01	0.02	0.36	-0.04	-0.09
Fed Beef Slaughter	cwt. LW	58.17	275,290	0.00	0.00	0.05	0.00	0.00	0.00
Cull Sow	cwt. LW	31.74	9,417	0.03	-1.57	0.00	-0.45	0.03	-1.46
Poultry	cwt. LW	271.39	30,789	0.07	0.00	0.15	0.00	0.07	0.00
Lamb Slaughter	cwt. LW	71.39	4,126	0.21	0.02	-0.24	-0.02	0.21	-0.02
Lamb Feeder	cwt. LW	57.50	4,536	0.00	0.00	0.20	0.00	0.00	0.00
Wool	cwt.	0.56	160,118	0.00	0.00	0.00	0.00	0.00	0.00
Wool Incentives	\$	1.10	112,474	0.00	0.00	0.00	0.00	0.00	0.00
Unshorn Lamb	\$	2.86	6,667	0.00	0.00	0.00	0.00	0.00	0.00

**Table 8. The Effects on Producers' Surplus of Reducing Insecticide Costs for Growing Cotton by 50 Percent.**

*(Current Farm Program)*

Region	Base Producers' Surplus (\$ billions)	Percent Change in Producers' Surplus		
		All States	Arizona Only	All States Except Arizona
Mountain	2.4	0.73	0.84	-0.11
Pacific	1.5	4.66	-0.21	4.66
Northeast	0.4	-0.12	0.36	-0.12
Lake States	2.2	0.20	0.28	0.20
Corn Belt	5.5	0.33	0.56	0.33
North Plains	3.2	0.40	0.10	0.40
Appalachia	1.4	0.65	0.34	0.65
Southeast	0.9	6.22	0.16	6.22
Delta States	1.0	22.20	0.67	22.20
South Plains	1.4	5.02	-0.01	5.02
<b>Total</b>	<b>19.8</b>	<b>2.38</b>	<b>0.36</b>	<b>2.28</b>

**Table 9. The Social Benefits of Reducing Insecticide Costs for Growing Cotton by 50 Percent.**

*(Current Farm Program)*

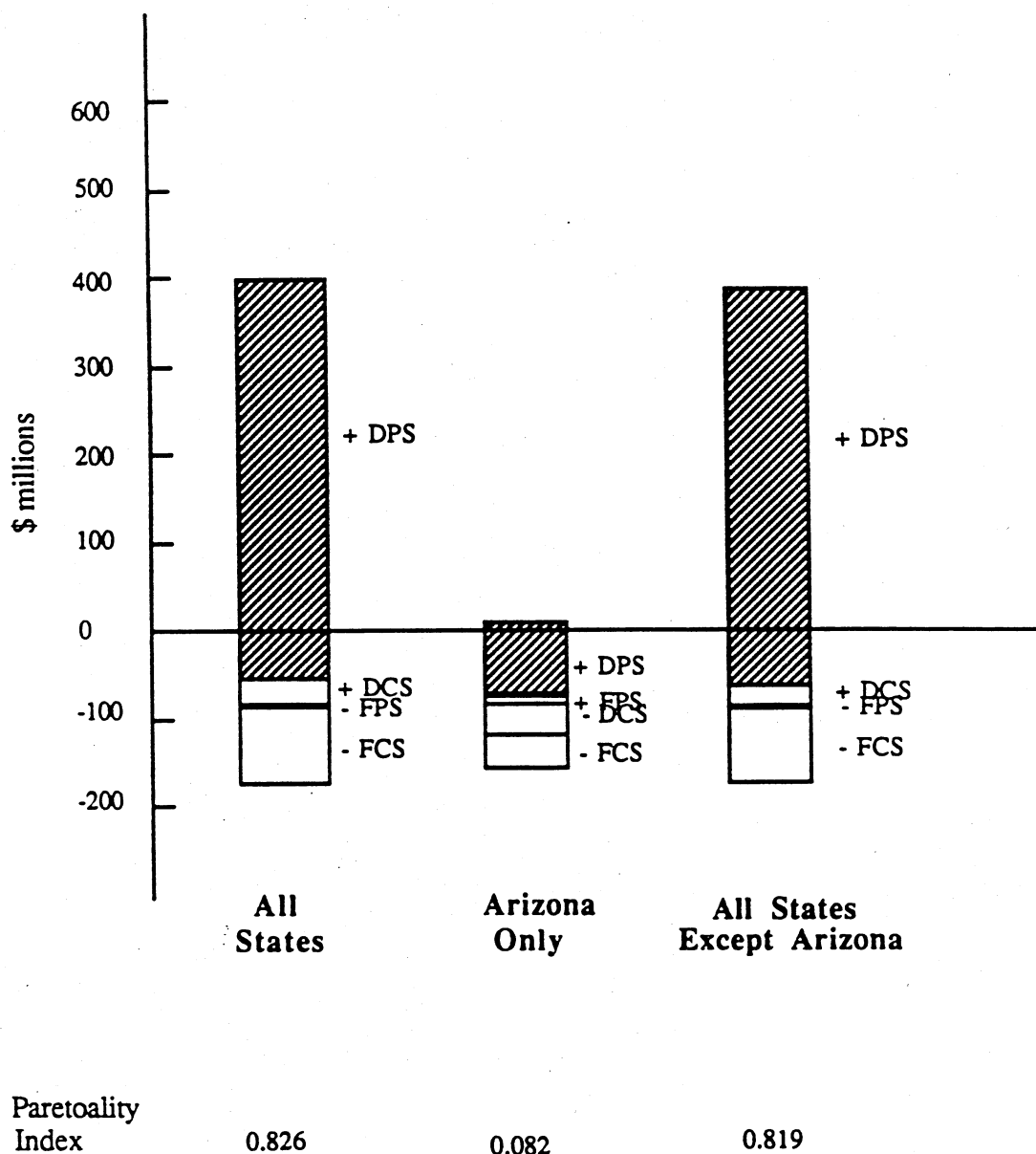
Benefits	Base Benefits <sup>a</sup> (\$ billions)	Percent Change in Benefits <sup>b</sup>		
		All States	Arizona Only	All States Except Arizona
Domestic Producers' Surplus	19.8	2.38	0.36	2.28
Domestic Consumers' Surplus	<u>143.8</u>	0.01	-0.03	0.01
Subtotal	163.6			
Foreign Producers' Surplus	2.8	-0.02	0.02	-0.02
Foreign Consumers' Surplus	<u>13.9</u>	-0.60	-0.21	-0.60
Subtotal	16.7			
<b>Total Social Benefits</b>	<b>180.3</b>	<b>0.22</b>	<b>0.00</b>	<b>0.21</b>
<b>Costs of Farm Programs<sup>c</sup></b>	<b>20.4</b>	<b>10.06</b>	<b>-0.22</b>	<b>9.81</b>
Deficiency Payments	16.1	4.77	0.07	4.72
Loan Payments	4.3	30.00	-1.33	28.94
<b>Total Social Benefits Less Deficiency Payments<sup>d</sup></b>	<b>164.1</b>	<b>-0.22</b>	<b>0.00</b>	<b>-0.23</b>

<sup>a</sup> The estimated distribution of domestic and foreign benefits associated with United States agricultural production in the base model year, 1986, before insecticide cost reduction.

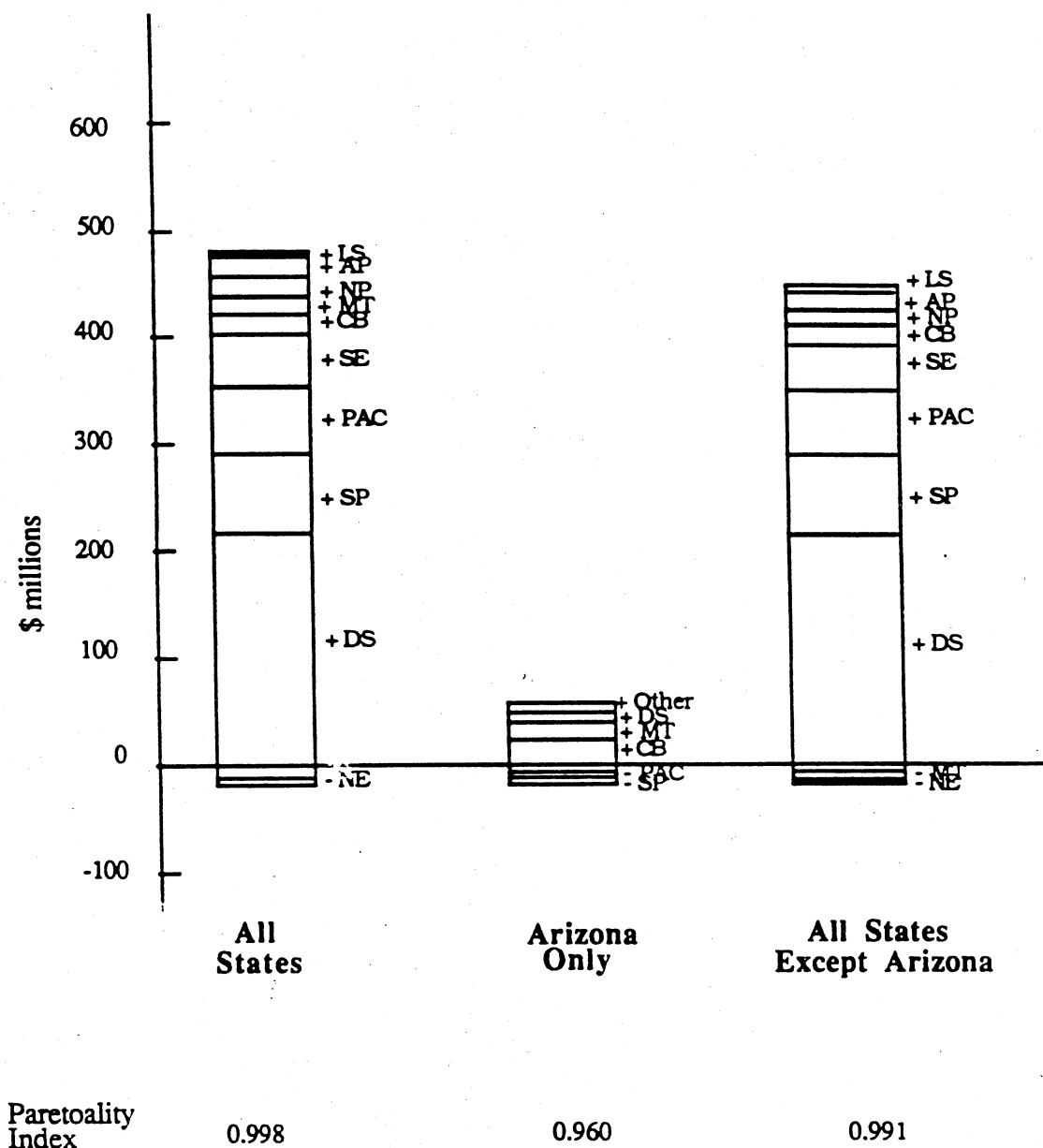
<sup>b</sup> The change in domestic and foreign benefits associated with reducing U.S. cotton insecticide costs by 50 percent.

<sup>c</sup> These payments make both domestic and foreign consumers' surplus, and domestic producers' surplus, larger than under a free market equilibrium. The sum of the increased consumers' and producers' surpluses is less than the total amount of government payments, creating a deadweight loss. Consumers have a net loss since they pay in taxes all of their consumer gain, plus the majority of the producer gain, plus the deadweight loss.

<sup>d</sup> Total social benefits adjusted for distorting effects of government payments. Assumes that loan payments are fully recovered.



**Figure 1. The Distribution of Benefits and Costs of Reducing Insecticide Costs for Growing Cotton by 50 Percent (Current Farm Program).**



**Figure 2. The Regional Distribution of the Change in Producers' Surplus from Reducing Insecticide Costs for Growing Cotton by 50 Percent (Current Farm Program).**