Appendix C

Detailed Farm Level Impacts of bovine Somatotropin and Other Emerging Technologies Under Alternative Policy and Demand Scenarios

The farm level impacts in chapter 5 were determined by a Monte Carlo simulation model known as the Farm Level Income Tax and Policy Simulation Model (FLIPSIM) developed by Richardson and Nixon (4) at Texas A&M University. The model is capable of simulating representative dairy farms in different regions of the United States under alternative policy and technology assumptions.[1]

Analyzing the consequences of alternative technologies on the economic viability of a representative farm involves several steps. First, data for the representative dairy farm that is using existing technologies must be developed. Second, modifications to the basic dairy farm's input/output coefficients must be made for each technology change to be analyzed. For bST, this is done by annually changing the milk per cow and the lactating cow ration and by increasing variable costs per cow to reflect bST purchases. The result is a new representative farm that has adopted bST. Third, projections for milk prices, feed prices, cattle prices, annual percentage changes in herd size, and macroeconomic variables (interest and inflation rates) for the policy/technology scenario being analyzed are merged with the farm's data. Projections of regionalized milk prices and feed prices are provided by the LIVESIM model (described in app. B), and macroeconomic variables are developed by the COMGEM/AG-GEM model (3).

Representative Dairy Farms

The regions for analysis are the Lake States, Northeast, Southeast, and Southwest. Two different-size dairy farms in each region—moderate and large farms-are considered. In the Lake States, the representative moderate-size farm owns 52 cows, and the large farm owns 125 cows; both farms own 185 acres of cropland and farmstead, with 155 acres devoted to the production of dairy feed (see table C-l). These farms are most representative of dairy farms in Minnesota. In the Northeast, the representative moderate-size farm owns 52 cows, and the large farm owns 200 cows. The moderate-size Northeast farm devotes 140 acres to the production of hay, corn silage, haylage, oats, corn, and pasture. The large Northeastern farm has 450 acres of hay, corn silage, haylage, oats, and corn, and 50 acres of pasture. The moderate-size farm is most representative of Pennsylvania dairy farms and the large farm represents New York dairy farms.

The moderate and large Southwestern dairy farms, respectively, own 350 and 1,500 milk cows (see table C-1) and only 25 acres of land. The two farms are representative of dairy herds in California and Arizona. The moderate-size Southeastern dairy farm has 200 cows and 388 acres and is most representative of farms in Georgia. The Georgia farm has 305 acres devoted to coastal hay and sorghum silage production and 50 acres devoted to pasture. The large Southeastern dairy has 1,500 cows and owns 873 acres, which are largely (750 acres) devoted to pasture. The large Southeastern farm is most representative of large dairies in Florida.

The initial debt-to-asset ratio was assumed to be 40 percent for all of the farms. All land, machinery, and livestock had 40-percent debt at the beginning of 1989 (see table C-l). This level of debt represents a moderate initial debt level. Each of the eight representative farms were simulated over the 1989 to 1998 planning horizon for alternative assumptions about the dairy farm program and the adoption of bST.

Technology Scenarios

The economic consequences of bST adoption were analyzed assuming bST was introduced in 1991, and the farm either adopted it in 1991 or did not adopt bST throughout the planning horizon. Initial milk production per cow was trended up at 1.5 percent per year in the base situation without bST (see table C-2). For the bST adoption scenarios, annual milk production per cow with bST was increased by 1,320 pounds each year from 1991 to 1998. This increase in milk per cow due to the adoption of bST assumes lactating cows are treated for 150 days during each lactation. All cows in the herd were assumed to be treated at an annual cost of $45 per cow.

The quantity of feed required for bST-treated cows increased marginally due to the increased milk production per cow. A linear program (LP) model in FLIPSIM was used to estimate a balanced dairy ration for the higher producing dairy herd. Research by Chalupa and Galligan (1) indicates that the nutritional requirements for bST-treated cows are the same as they are for naturally high

[1]This appendix is based on the OTA commissioned background paper "Farm Level Impacts of bovine Somatotropin Introduction and Adoption Under Alternative Farm Policies" prepared by James W. Richardson, Texas A&M University. It is available through the National Technical Information Service.

Table C-l—Characteristics of Representative Moderate-Size and Large Dairy Farms in the Lake States, Northeast, Southwest, and Southeast

	Lake States		Northeast		Southwest		Southeast	
	Moderate	Large	Moderate	Large	Moderate	Large	Moderate	Large
Number *of* dairy cattle:								
cows	52	125	52	200	350	1,500	200	1,500
Calves	21	48	20	75	130	495	75	432
Heifers	25	57	23	88	152	612	88	503
Bulls	0	0	0	0	7	25	0	25
Calves born	48	113	47	178	326	1,388	176	1,268
Assets ($1,000):								
Land	133.1	295.0	274.2	640.1	117.9	491.8	812.9	4,591.1
Buildings and machinery	262.8	482.6	260.8	503.0	467.3	1,080.8	487.0	1,139.2
Cattle	68.6	161.6	73.0	251.5	511.4	2,284.9	269.4	1,992.3
Total	469.5	940.2	608.0	1,394.6	1,096.6	3,857.5	1,569.3	7,722.6
Off-farm salary ($1 ,000)	9.8	0	9.8	0	0	0	0	0
Minimum family living ($1,000)	19.8	24.8	19.8	30.9	43.3	61.9	30.9	61.9
Labor costs ($1 ,000)	12.7	37.3	11.3	70.0	115.8	444.2	62.8	488.1
Milk/cow (cwt)	168.5	168.5	179.4	178.3	185.9	196.9	153.4	153.1

SOURCE: Office of Technology Assessment, 1991.

producing cows. Thus, it was not necessary to change the input/output coefficients in the ration-balancing LP—the increased milk production per cow caused the LP to feed the cow more protein, energy, and forage. In general, the ration for bST cows contained 7 to 10 percent more forage, 9 to 12 percent more grain, and 10 to 13 percent more soybean meal (or whole cottonseed) than the ration for control cows.

The new values for average annual milk per cow and bST costs were used to modify initial farm variables to account for bST adoption. All other variables for the representative dairy farms were assumed to remain constant at pre-bST levels. Of 16 representative farms, 8 adopt bST in 1991, and 8 do not adopt bST. The 16 farms were simulated under alternative dairy policy scenarios to quantify the interaction between technology adoption and farm programs.

Farm Program and Milk Demand Scenarios

Four farm programs were selected for the analysis: trigger price, fixed price support, production quota, and dairy termination program. Each of the policies was analyzed with a commodity-specific livestock simulation model, LIVESIM (discussed in app. B), under the assumption that the 1985 farm program for crops would continue through 1998 (2). The LIVESIM analyses of these four dairy policies were done for a no-bST scenario and for a scenario with a medium rate of adoption beginning in 1991. Three different milk-demand scenarios were analyzed to incorporate the possibility of milk demand changing in response to bST introduction.

The trigger-price dairy policy is similar to policy from 1985 to 1990 with the milk-support price decreasing 50 cents per hundredweight (cwt) each year that the Commodity Credit Corporation (CCC) milk purchases are expected to exceed 5 billion pounds of milk equivalent. The support price is increased 50 cents per cwt if CCC purchases of milk are expected to fall short of 2.5 billion pounds. This policy is also similar to the producer assessment option in the 1990 farm bill because the assessment will effectively trigger reductions in producer returns as milk price declines. The fixed support policy assumes that the dairy support price is held constant for all years of the planning horizon. The production-quota policy calls for the continuation of the trigger-price policy with provisions for a quota to be imposed if CCC milk purchases exceeded 7.0 billion pounds of milk equivalent. Similarly, the dairy termination program would continue the trigger-price policy but permit a one-time dairy termination if CCC milk equivalent purchases exceed 15.0 billion pounds in 1 year. The dairy termination program is analyzed only for the large demand decrease scenario, as this is the only demand situation that triggers the termination.

The three milk-demand scenarios respectively assume constant demand, a slight decrease in demand, and a significant decrease in demand after the introduction of bST. The small demand reduction scenario assumes that milk demand will decrease 10 percent in 1991,5 percent in 1992 (i.e., demand increases from 1991 to 1992), and 2.5 percent each year from 1993 to 1998. The large demand reduction scenario assumes that milk demand is 10 percent lower than it currently is in each year from 1991 to 1998. The trigger price, fixed price support, and

Table C-2—Average Annual Production of Milk/Cow for Moderate-Size Representative Dairy Farms, in Selected Regions, With and Without bST, 1989-98 (cwt/year)

	Lake States		Northeast		Southwest		Southeast	
Years	No bST[a]	bST[b]	No bST	bST	No bST	bST	No bST	bST
1989	168.5	168.5	179.4	179.4	185.9	185.9	153.4	153.4
1990	171.0	171.0	182.0	182.0	188.7	188.7	155.7	155.7
1991	173.6	186.8	184.8	198.0	191.5	204.7	158.1	171.3
1992	176.2	189.4	187.5	200.7	194.4	207.6	160.4	173.6
1993	178.8	192.0	190.4	203.6	197.3	210.5	162.8	176.0
1994	181.5	194.7	193.2	206.4	200.2	213.4	165.3	178.5
1995	184.2	197.4	196.1	209.3	203.2	216.4	167.8	181.0
1996	186.9	200.1	199.1	212.3	206.3	219.5	170.3	183.5
1997	189.8	203.0	202.0	215.2	209.4	222.6	172.8	186.0
1998	192.6	205.8	205.1	218.3	212.5	225.7	175.4	188.6

[a]Output per cow increases 1.5 percent per year without bST.
[b]ST, introduced in 1991, increases output per cow 1,320 lbs. per year.

SOURCE: Office of Technology Assessment, 1991.

quota policies were analyzed with and without bST assuming no change in milk demand. The trigger price policy was analyzed for the small decrease and large decrease demand scenarios because this policy represents current policy under the 1990 farm bill. The dairy termination program was analyzed for the large decrease in milk demand and results were compared to those of the trigger price policy under this demand reduction.

The adoption rates for bST in LIVESIM differ by region and follow a sigmoid adoption function (see app. A). It is projected that 43.6 percent of the dairy farms in the Lake States would adopt bST by 1998. In the Northeast, 39.9 percent of farms would adopt by 1998; in the Pacific region, about 63 percent of farms would adopt bST by 1998; and 36.7 percent of those in the Southeast would adopt by 1998. Adoption by 1998 in the remaining regions ranged from 29.7 to 42.9 percent.

For the FLIPSIM analyses, cattle and feed price projections from LIVESIM were regionalized using simple regression relationships between National- and State-level prices. Milk-price projections were region specific so no adjustment was necessary. The LIVESIM projected annual changes in the dairy herd that were region specific; these projections were used to adjust the number of cows on the representative farms. It was assumed that each farm's herd size would change annually (1990 to 1998) proportional to the annual percentage change in the respective region's total number of dairy cows. Thus, the number of cows milked on the representative farms fluctuated annually with expected net returns in the region.

Results

The detailed results of simulating the representative farms with and without bST are summarized in this section. Simulation results for various scenarios are presented in terms of three probabilities and means for the probability distributions of four key output variables. The variables used for evaluating the economic impacts of the alternative scenarios are defined as follows:

- *Probability of* **Survival--chance that the individual farm will remain solvent through** 1998, i.e., maintain more than 10-percent equity in the farm.
- *Probability of* **Success--chance that the individual farm will earn a 5-percent or greater after-tax return on initial equity.**
- *Probability of Increasing* **Equity--chance that the individual farm will increase its net worth in real** 1989 dollars over the planning horizon.
- Net *Present* **Value—present value of annual changes in net worth plus family consumption minus off-farm income.**
- *Present Value of Ending Net Worth (PVENW)*- ending net worth for 1998 discounted to 1989 dollars, assuming a 5-percent discount rate.
- *PVENW as a Percent of Beginning Net Worth—* PVENW **divided by initial net worth indicates whether the farm increased (or decreased) net worth in real dollars.**
- *Average Annual Net Cash Farm* **Income—total cash farm receipts minus total cash expenses excluding family living, income taxes, and principle payments.**

Economic Payoffs to bST Adoption for Alternative Farm Policies

Tables C-3 through C-6 summarize the simulation results for representative dairy farms in the Lake States, Northeast, Southwest, and Southeast, respectively, assuming bST is introduced in 1991. Results are reported for the bST adopter and nonadopter. The adopter is assumed to use bST on all lactating cows beginning in 1991. The nonadopter does not adopt bST over the 1989 to 1998 planning horizon. The economic payoffs for bST adoption are reported for three different farm policies (see table C-6).

Table C-3-impacts of bST Adoption on the Economic Viability of Representative Lake State Dairy Farms Under Alternative Dairy Policies, Assuming No Change in Milk Demand Due to bST, 1989-98

	Policy scenario					
	Trigger price		Fixed price support		Quota	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
52-cow *farm:*						
Probability of survival (percent)..	58.0	**74.0**	**73.0**	89.0	**41.0**	52.0
Probability of success (percent)	58.0	**74.0**	**73.0**	89.0	**41.0**	52.0
Probability of increasing equity (percent).	**0.0**	**0.0**	**0.0**	1.0	**0.0**	**0.0**
Net present value ($1 ,000)	**25.2**	**67.6**	65.0	**105.6**	**–15.1**	9.8
Present value of ending net worth ($1,000)	**44.3**	**81.2**	75.9	**112.8**	**7.4**	**27.8**
Present value of ending net worth as a percent of beginning net worth (percent)	**15.6**	**28.6**	**27.1**	39.7	**2.6**	**9.8**
Average annual net cash farm income ($1,000)	**-2.0**	**1.9**	**1.7**	**5.8**	**-4.7**	**–2.3**
125-cow *farm:*						
Probability of survival (percent)..	**95.0**	**99.0**	**99.0**	**100.0**	85.0	92.0
Probability of success (percent)	**90.0**	**95.0**	**95.0**	98.0	67.0	78.0
Probability of increasing equity (percent).	**8.0**	**12.0**	**11.0**	18.0	**2.0**	**3.0**
Net present value ($1 ,000)	**194.8**	**271.9**	**265.0**	340.1	**68.7**	**127.7**
Present value of ending net worth ($1,000)	**329.1**	**396.4**	**386.9**	**451.5**	**211.9**	**263.7**
Present value of ending net worth as a percent of beginning net worth (percent)	**57.1**	**68.7**	**67.1**	**78.3**	**36.7**	**45.7**
Average annual net cash farm income ($1,000) . -.. .-.. .. ... -------	**23.1**	**33.4**	**32.1**	**43.0**	**11.2**	**18.2**

SOURCE: Office of Technology Assessment, 1991.

Table C-4—impacts of bST Adoption on the Economic Viability of Representative Northeast Dairy Farms Under Alternative Dairy Policies, Assuming No Change in Milk Demand Due to bST, 1989-98

	Policy scenario					
	Trigger price		Fixed price support		Quota	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
52-cow *farm:*						
Probability of survival (percent)..	**100.0**	100.0	**100.0**	**99.0**	**99.0**	**99.0**
Probability of success (percent)	**100.0**	**100.0**	**100.0**	**100.0**	**96.0**	**97.0**
Probability of increasing equity (percent).	**3.0**	**3.0**	**3.0**	**8.0**	**0.0**	**0.0**
Net present value ($1 ,000)	**232.3**	**253.9**	**254.6**	**277.5**	**110.8**	**117.0**
Present value of ending net worth ($1,000)	**268.3**	**286.4**	**285.6**	**303.7**	**169.0**	**174.7**
Present value of ending net worth as a percent of beginning net worth (percent)	**72.4**	**77.2**	**77.0**	**81.9**	45.6	**47.1**
Average annual net cash farm income ($1,000)	**14.5**	**17.9**	**17.8**	**21.4**	**-1.9**	**-0.9**
200-cow *farm:*						
Probability of survival (percent)	**100.0**	**100.0**	**100.0**	**100.0**	**88.0**	**91.0**
Probability of success (percent)	**99.0**	**100.0**	**100.0**	**100.0**	**64.0**	**72.0**
Probability of increasing equity (percent).	**43.0**	**53.0**	**50.0**	**66.0**	**1.0**	**3.0**
Net present value ($1,000)	**616.7**	**717.6**	**705.7**	**812.3**	**102.8**	**166.6**
Present value of ending net worth ($1,000)	**776.8**	**855.4**	**842.0**	**922.0**	**360.0**	**415.9**
Present value of ending net worth as a percent of beginning net worth (percent)	**92.3**	**101.7**	**100.1**	**109.6**	**42.8**	**49.4**
Average annual net cash farm income ($1,000)	**66.2**	**82.0**	**79.6**	**96.2**	**-1.5**	**7.3**

SOURCE: Office of Technology Assessment, 1991.

Table C-5—impacts of bST Adoption on the Economic Viability of Representative Southwest Dairy Farms Under Alternative Dairy Policies, Assuming No Change in Milk Demand Due to bST, 1989-98

	Policy scenario					
	Trigger price		Fixed price support		Quota	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
350-cow farm:						
Probability of survival (percent)	95.0	97.0	99.0	99.0	95.0	97.0
Probability of success (percent)	95.0	97.0	99.0	99.0	95.0	97.0
Probability of increasing equity (percent)	60.0	79.0	81.0	89.0	40.0	56.0
Net present value ($1,000)	739.7	885.2	903.5	1,040.0	622.9	715.4
Present value of ending net worth ($1,000)	701.2	820.7	827.1	939.5	587.1	664.1
Present value of ending net worth as a percent of beginning net worth (percent)	109.5	128.1	129.1	146.7	91.7	103.7
Average annual net cash farm income ($1,000)	109.6	136.1	137.2	163.8	97.1	115.4
1,500-cow farm:						
Probability of survival (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Probability of success (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Probability of increasing equity (percent)	100.0	100.0	100.0	100.0	98.0	99.0
Net present value ($1 ,000)	4,062.8	4,548.7	4,633.6	5,148.7	3,532.5	3,853.0
Present value of ending net worth ($1,000)	4,323.0	4,751.1	4,795.4	5,249.3	3,808.5	4,091.2
Present value of ending net worth as a percent of beginning net worth (percent)	194.5	213.7	215.7	236.2	171.3	184.1
Average annual net cash farm income ($1,000)	713.9	804.4	808.5	900.2	604.8	666.0

SOURCE: Office of Technology Assessment, 1991.

Table C-6—impacts of bST Adoption on the Economic Viability of Representative Southeast Dairy Farms Under Alternative Dairy Policies, Assuming No Change in Milk Demand Due to bST, 1989-98

	Policy scenario					
	Trigger price		Fixed price support		Quota	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
200-cow *farm:*						
Probability of survival (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Probability of success (percent)	100.0	100.0	100.0	100.0	93.0	99.0
Probability of increasing equity (percent)	13.0	24.0	23.0	44.0	5.0	9.0
Net present value ($1,000)	453.3	601.5	559.9	712.0	333.3	446.7
Present value of ending net worth ($1,000)	727.9	854.3	815.3	940.5	615.2	712.8
Present value of ending net worth as a percent of beginning net worth (percent)	75.6	88.7	84.7	97.7	63.9	74.0
Average annual net cash farm income ($1,000)	17.3	39.2	32.5	55.3	2.6	19.8
1,500-cow *farm:*						
Probability of survival (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Probability of success (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Probability of increasing equity (percent)	88.0	99.0	97.0	100.0	75.0	91.0
Net present value ($1 ,000)	4,964.9	6,165.7	5,757.5	7,000.8	4,113.7	5,062.2
Present value of ending net worth ($1,000)	5,901.3	6,712.4	6,415.4	7,252.3	5,261.1	5,901.2
Present value of ending net worth as a percent of beginning net worth (percent)	129.4	147.2	140.7	159.0	115.4	129.4
Average annual net cash farm income ($1,000)	609.0	775.4	714.3	880.6	481.9	613.9

SOURCE: Office of Technology Assessment, 1991.

***Trigger Price*—Under the trigger-price program, the milk support price is decreased 50 cents per cwt each year the CCC purchases 5 billion pounds of milk equivalent. This option is similar to policy from 1985 to 1990 and to the assessment option in the 1990 farm bill-the assessment will effectively trigger reduction in producer returns as milk price declines.**

The average annual economic payoffs from bST adoption (change in average annual net cash farm income due to adoption), given a trigger price dairy policy, ranges from $3,400 for a 52-cow Northeastern dairy to $166,400 for a 1,500-cow dairy in the Southeast. Average annual net cash farm income for the 52-cow Northeast dairy increases from $14,500 to $17,900 due to bST adoption (see table C-4). The 52-cow Lake States dairy experiences a slightly greater economic payoff from bST adoption ($3,900) as net cash farm income increases from -$2,ooo to $1,900 (see table C-3). The greatest economic payoffs for bST adoption are earned by the 1,500-cow dairy farms in the Southwest and Southeast. In the Southwest, average annual net cash farm income increases $90,500 ($713,900 to $804,400) and in the Southeast, the increase is $166,400 ($609,000 to $775,400) (see tables C-5 and C-6). Absolute increases in real net worth are also greatest for these dairies; however, the greatest percentage increases are observed for the dairy farms in the Lake States, and for the moderate-size dairy in the Southwest.

Increases in average annual net cash farm income due to adopting bST lead to greater accumulation (or slower decline) in net worth which, in turn, leads to greater after-tax net present values for bST adopters. The 52-cow Lake States dairy producer who adopts bST has a $42,400 greater net present value than the nonadopter, and $36,900 greater present value of ending net worth (see table C-3). This pattern of greater net worth and net present values due to bST adoption is observed for all eight representative farms.

Increases in average annual net cash farm income due to bST adoption also leads to improved probabilities of survival, success, and to increases in real equity. Probability of survival increases from 58 to 74 percent for the 52-cow Lake States dairy as a result of adopting bST (see table C-3). Adopting bST increases the probability of increasing real net worth (equity) for five of the eight representative dairy farms. The three exceptions experienced no change in the probability of increasing real equity due to adopting bST.

***Fixed Price Support--Maintaining* the milk price support at the 1989 value through the 1989-1998 planning horizon results in higher milk prices and greater average annual net cash farm incomes than the trigger price policy (see tables C-3 to C-6). Economic payoffs from bST adoption are only slightly greater under the fried price-support policy than under the trigger price policy for six** of the eight farms. For example, the economic payoff for the 125-cow Lake States dairy increases only $600 from $10,300 to $10,9OO due to the policy change (see table C-3). (The two dairy farms that experience lower economic payoffs (Southwest 350-cow dairy and 1,500-cow Southeast dairy) experience very small reductions in their economic payoffs from bST adoption, $700 and $100, respectively (see tables C-5 and C-6).) These results suggest that the economic incentive to adopt bST would not be greatly increased by increasing the price of milk, i.e., freezing the milk support price at its 1989 level. Maintaining a fixed support price would result in a greater probability of survival, success, and increasing real equity (i.e., increasing a farm's economic viability) than observed for the trigger price scenario. For a 52-cow Lake States dairy farm that adopts bST, probability of survival increases from 74 to 89 percent, and for the nonadopter, the probability increases from 58 to 73 percent (see table c-3).

***Production Quota—A* quota that reduces the number of dairy cows to maintain milk prices at levels comparable to the fixed price support policy was analyzed. Results of the analyses reveal that a quota reduces average annual net cash farm incomes for adopters and nonadopters, relative to the other two dairy policies (see tables C-3 to C-6). Relative to the trigger price, the quota reduces net cash farm income about $15,000 per year for the 125-cow Lake States dairy farm that adopts bST, and about $11,900 for the nonadopter. The large Southeastern dairy that adopts bST experiences a $161,500 decrease in average annual net cash farm income under a switch from the trigger price to the quota policy (see table C-6). Such dramatic decreases in net cash farm income lead to lower probabilities of increasing real net worth for all eight farms, and lower the probability of survival for five farms.**

The economic payoffs from adopting bST while a quota policy is in effect are positive for all eight farms (see tables C3-C6). However, the absolute economic payoffs are less than under the trigger price policy. The large Southeastern dairy farm experiences an average annual economic payoff from bST of $132,000 under the quota, compared to $166,400 under the trigger price policy (see table C-6). Similarly, the 52-cow Lake States dairy experiences a decrease in bST economic payoffs from $3,900 to *$2,400* due to the policy scenario change (see table C-3).

The primary reason that the farms perform less favorably under the quota than the other two policies is that the total milk sold is reduced while fixed costs remain the same. Fewer cows and pounds of milk are available to spread out the fixed costs associated with the fixed plant size. If the dairy farms were able to utilize the resulting excess capacity for other purposes, the decrease in net cash farm income, net worth, and probabilities of survival and success would not be as great. However, the spe-

cialized facilities associated with modern dairy farming are not suitable for other enterprises.

Summary--Simulation results for representative dairy farms indicate that bST adopters enjoy a greater average annual net cash farm income than nonadopters across three different types of farm policies. In addition to increasing net cash farm income, bST adoption leads to greater real ending net worth, after-tax net present value, and probabilities of survival and success. Economic payoffs to bST adopters are greater for larger farms than for smaller farms. The increased net return for larger farms may accelerate the growth in average herd size as producers seek to reduce fixed costs per cow, and take greater advantage of high-level management practices associated with bST adoption.

The absolute economic payoff from bST adoption is about the same under a trigger price dairy policy and a fixed support price policy (see table C-7). Increasing the price of milk by maintaining the milk support price at its 1989 level does not greatly increase the economic incentive to adopt bST. On the other hand, the economic incentive to adopt bST is significantly lower if a production quota is in effect. All but one of the eight representative farms experienced a 20- to 40-percent decrease in the economic payoff to adopt bST under a quota. The exception (52-cow Northeast dairy) experienced a 70-percent decrease in the economic payoff associated with bST adoption. These results suggest that the rate of bST adoption would be slowed by imposing a strict production quota rather than a trigger price policy.

Table C-7-Comparison of Average Annual Economic Payoffs From bST Adoption for Eight Representative Dairy Farms Under Three Alternative Dairy Policies, Assuming No Change in Milk Demand, 1989-98[a] (in $1,000)

	Policy scenario		
Region/size	Trigger price	Fixed support	Quota
Lake States:			
Moderate	3.9	4.1	2.4
Large	10.3	10.9	7.0
Northeast:			
Moderate	3.4	3.6	1.0
Large	15.8	16.6	8.8
Southwest:			
Moderate	26.5	26.6	18.3
Large	90.5	91.7	61.2
Southeast:			
Moderate	21.9	22.8	17.2
Large	166.4	166.3	132.0

[a]Economic payoffs from bST are the average annual change in net cash farm income between a nonadopter and a bST adopter over the 1989-98 planning horizon. The payoff is net of the cost of bST, the added transportation costs for milk, and the additional feed.

SOURCE: Office of Technology Assessment, 1991.

Economic Payoffs to bST Adoption for Alternative Milk Demands

The introduction of bST may contribute to a change in the demand for milk and milk products, depending on the perception of consumers. To quantify the impacts of milk demand changes on the economic incentives to adopt bST, the eight representative dairy farms were simulated under three alternative milk demand scenarios, with a trigger price policy. Tables C-8 to C-n summarize the simulation results for the following changes in milk demand: no change, small decrease, and large decrease. For the no-change scenario, milk demand was assumed to be the same as under the no-bST scenario. A small decrease in milk demand is defined as a 10-percent decrease in 1991, a 5-percent decrease in 1992 (i.e., demand increases from 1991 to 1992), and a 2.5-percent decrease from 1993 to 1998. The large milk demand decrease involves a 10-percent decrease in demand persisting from 1991 to 1998.

Decreasing the demand for milk reduces the economic payoffs associated with bST adoption for all eight representative dairy farms (see tables C-8 to C-12). This result is observed for both small and large decreases in milk demand. For example, the economic payoff for bST adoption is $10,300 for the 125-cow dairy in the Lake States if there is no decrease in milk demand (see table C-12). If demand decreases slightly, the economic payoff falls to $9,200, and if the demand decrease is large, the economic payoff declines to $6,900 (see table C-12). Thus, the incentive to adopt and the rate of adoption would be reduced if milk demand declines due to consumers' reaction to bST.

The probabilities of survival and economic success are reduced as well by decreases in milk demand. These probabilities decline as lower milk prices lead to lower net cash farm incomes, net worths, and net present values. Examining the 350-cow dairy in the Southwest indicates that for the bST adopter, the probability of survival declines slightly from 97 to 94 percent if there is a small decline in milk demand (see table C-10). If the milk demand decrease is large, this farm's probability of survival falls to 69 percent. Because the economic payoff for bST adoption is positive (see table C-12), those producers who adopt bST will experience greater probabilities of survival and economic success than nonadopters.

The most significant result for the demand-change scenarios is the dramatic reduction in the economic viability of dairy farms (probabilities of survival, success, and of increasing real net worth) associated with a large decrease in milk demand (tables C-9 to C-12). AU of the regions are affected by the lower milk demand, given a trigger price dairy policy. If a large decrease in milk demand is experienced, a dairy termination program

Table C-8—Effects of Milk Demand Changes on the Economic Viability of Representative Dairy Farms in the Lake States Who Adopt and Fail To Adopt bST, Assuming a Trigger Price Dairy Policy, 1989-98

	Demand scenario					
	No change in milk demand		Small demand reduction		Large demand reduction	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
52-cow *farm:*						
Probability of survival (percent)..	58.0	74.0	40.0	48.0	13.0	24.0
Probability of success (percent)	58.0	74.0	40.0	48.0	13.0	24.0
Probability of increasing equity (percent).	0.0	0.0	0.0	0.0	0.0	0.0
Net present value ($1,000)	25.2	67.6	–21 .8	4.7	-85.5	-63.4
Present value of ending net worth ($1 ,000)	44.3	81.2	7.5	27.6	-47.9	-32.2
Present value of ending net worth as a percent of beginning net worth (percent)	15.6	28.6	2.6	9.7	-16.9	-11.3
Average annual net cash farm income ($1,000)	-2.0	1.9	-6.8	-3.8	-12.1	-10.2
125-cow *farm:*						
Probability of survival (percent)..	95.0	99.0	85.0	91.0	46.0	61.0
Probability of success (percent)	90.0	95.0	68.0	82.0	37.0	47.0
Probability of increasing equity (percent).	8.0	12.0	2.0	7.0	0,0	0.0
Net present value ($1,000)	194.8	271.9	78.3	150.6	-126.8	-48.6
Present value of ending net worth ($1 ,000)	329.1	396.4	227.6	290.9	33.3	102.6
Present value of ending net worth as a percent of beginning net worth (percent)	57.1	68.7	39.5	50.4	5.8	17.8
Average annual net cash farm income ($1,000)	23.1	33.4	8.7	17.9	–10.7	-3.8

SOURCE: Office of Technology Assessment, 1991.

Table C-9—Effects of Milk Demand Changes on the Economic Viability of Representative Dairy Farms in the Northeast Who Adopt and Fail To Adopt bST, Assuming a Trigger Price Dairy Policy, 1989-98

	Demand scenario					
	No change in reduction		Small demand reduction		Large demand reduction	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
52-cow *farm:*						
Probability of survival (percent)..	100.0	100.0	100.0	100.0	100.0	100.0
Probability of success (percent)	100.0	100.0	100.0	99.0	99.0	100.0
Probability of increasing equity (percent).	3.0	3.0	1.0	2.0	0.0	0.0
Net present value ($1 ,000)	232.3	253.9	199.1	218.4	149.8	167.6
Present value of ending net worth ($1 ,000)	268.3	286.4	241.0	258.3	194.1	210.0
Present value of ending net worth as a percent of beginning net worth (percent)	72.4	77.2	65.0	69.7	52.4	56.7
Average annual net cash farm income ($1,000)	14.5	17.9	9.7	12.8	2.3	5.0
ZOO-COW *farm:*						
Probability of survival (percent)	100.0	100.0	100.0	100.0	98.0	99.0
Probability of success (percent)	99.0	100.0	98.0	99.0	91.0	94.0
Probability of increasing equity (percent).	43.0	53.0	26.0	45.0	9.0	17.0
Net present value ($1 ,000)	616.7	717.6	542.6	632.7	352.2	438.8
Present value of ending net worth ($1 ,000)	776.8	855.4	722.8	799.4	542.9	618.4
Present value of ending net worth as a percent of beginning net worth (percent)	92.3	101.7	85.9	95.0	64.5	73.5
Average annual net cash farm income ($1,000)	66.2	82.0	56.4	71.1	27.4	40.2

SOURCE: Office of Technology Assessment, 1991.

Table C-l O-Effects of Milk Demand Changes on the Economic Viability of Representative Dairy Farms in the Southwest Who Adopt and Fail To Adopt bST, Assuming a Trigger Price Dairy Policy, 1989-98

	Demand scenario					
	No change in milk demand		Small demand reduction		Large demand reduction	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
350-cow farm:						
Probability of survival (percent)	95.0	97.0	88.0	94.0	52.0	69.0
Probability of success (percent)	95.0	97.0	88.0	94.0	52.0	69.0
Probability of increasing equity (percent)	60.0	79.0	35.0	51.0	6.0	11.0
Net present value ($1,000)	739.7	885.2	506.5	655.9	70.2	233.2
Present value of ending net worth ($1 ,000)	701.2	820.7	508.3	630.9	98.9	236.5
Present value of ending net worth as a percent of beginning net worth (percent)	109.5	128.1	79.4	98.5	15.4	36.9
Average annual net cash farm income ($1,000)	109.6	136.1	70.5	94.7	17.6	34.7
1,500-cow farm:						
Probability of survival (percent)	100.0	100.0	100.0	100.0	98.0	100.0
Probability of success (percent)	100.0	100.0	100.0	100.0	96.0	98.0
Probability of increasing equity (percent)	100.0	100.0	96.0	98.0	53.0	70.0
Net present value ($1 ,000)	4,062.8	4,548.7	3,230.6	3,678.3	1,820.4	2,268.0
Present value of ending net worth ($1 ,000)	4,323.0	4,751.1	3,600.8	3,992.2	2,278.4	2,671.1
Present value of ending net worth as a percent of beginning net worth (percent)	194.5	213.7	162.0	179.6	102.5	120.2
Average annual net cash farm income ($1,000)	713.9	804.4	554.5	642.5	282.7	360.2

SOURCE: Office of Technology Assessment, 1991,

Table C-n-Effects of Milk Demand Changes on the Economic Viability of Representative Dairy Farms in the Southeast Who Adopt and Fail To Adopt bST, Assuming a Trigger Price Dairy Policy, 1989-98

	Demand scenario					
	No change in milk demand		Small demand reduction		Large demand reduction	
	Non-adopter	bST adopter	Non-adopter	bST adopter	Non-adopter	bST adopter
200-cow farm:						
Probability of survival (percent)	100.0	100.0	99.0	100.0	88.0	94.0
Probability of success (percent)	99.0	100.0	89.0	94.0	51.0	80.0
Probability of increasing equity (percent)	13.0	24.0	4.0	9.0	0.0	1.0
Net present value ($1,000)	453.3	601.5	259.9	400.4	8.0	147.2
Present value of ending net worth ($1 ,000)	727.9	854.3	562.1	685.6	321.5	444.2
Present value of ending net worth as a percent of beginning net worth (percent)	75.6	88.7	58.4	71.2	33.4	46.1
Average annual net cash farm income ($1,000)	17.3	39.2	–9.7	10.7	-42.7	-25.1
1,500-cow farm:						
Probability of survival (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Probability of success (percent)	100.0	100.0	100.0	100.0	89.0	99.0
Probability of increasing equity (percent)	88.0	99.0	65.0	86.0	19.0	50.0
Net present value ($1 ,000)	4,964.9	6,165.7	3,139.9	4,032.3	1,689.1	2,562.2
Present value of ending net worth ($1 ,000)	5,901.3	6,712.4	5,001.4	5,772.3	3,633.2	4,390.7
Present value of ending net worth as a percent of beginning net worth (percent)	129.4	147.2	109.7	126.6	79.7	96.3
Average annual net cash farm income ($1,000)	609.0	775.4	453.8	615.2	200.2	343,8

SOURCE: Office of Technology Assessment, 1991.

Table C-12—Comparison of Average Annual Economic Payoffs From bST Adoption for Eight Representative Dairy Farms Under Alternative Milk Demand Scenarios, Assuming a Trigger Price Dairy Policy, 1989-98[a] (in $1,000)

Region/size	No change	Demand reduction	
		small	Large
Lake States:			
Moderate	3.9	3.0	1.9
Large	10.3	9.2	6.9
Northeast:			
Moderate	3.4	3.1	2.7
Large	15.8	14.7	12.8
Southwest:			
Moderate	26.5	24.2	17.1
Large	90.5	88.0	77.5
Southeast:			
Moderate	21.9	20.4	17.6
Large	166.4	161.4	143.6

[a]Economic payoffs from bST are the average annual change in net cash farm income between a nonadopter and a bST adopter over the 1989-98 planning horizon. The payoff is net of the cost of bST, the added transportation costs for milk, and the additional feed.

SOURCE: Office of Technology Assessment, 1991.

Table C-13-Comparison of Average Annual Economic Payoffs From bST Adoption for Eight Representative Dairy Farms, Given a Large Reduction in Milk Demand, Assuming a Trigger Price and Dairy Termination Program, 1989-98[a] (In $1,000)

Region/size	Trigger price policy	Dairy termination program
Lake States:		
Moderate	1.9	4.1
Large	6.9	10.3
Northeast:		
Moderate	2.7	3.2
Large	12.8	15.3
Southwest:		
Moderate	17.1	25.4
Large	77.5	85.3
Southeast:		
Moderate	17.6	22.3
Large	143.6	172.7

[a]Economic payoffs from bST are the average annual change in net cash farm income between a nonadopter and a bST adopter over the 1989-98 planning horizon. The payoff is net of the cost of bST, the added transportation costs for milk, and the additional feed.

SOURCE: Office of Technology Assessment, 1991.

could be implemented (similar to the program in 1986) to bring production back into line with milk demand.

The LIVESIM model (app. B) analyzed a dairy termination program, given a large reduction in milk demand. The result was higher milk prices than under the trigger price policy, given the same demand scenario. If the dairy termination program is implemented in 1991 higher milk prices result from 1992 to 1998. Differences in milk prices between the dairy termination program and the trigger price policy declined from 50 cents per cwt in 1992 to less than 10 cents per cwt in 1998 as milk supply increased relative to milk demand.

The farm-level impacts of the dairy termination program are summarized in tables C-13 to C-17. The trigger price policy results assume the same milk demand (large demand reduction) and are used as a reference policy. The dairy termination program leads to higher probabilities of survival, success, and increasing equity than the trigger price policy for all eight representative dairy farms. The moderate-size farms had greater increases in probability of survival than the large farms from the dairy termination program.

As observed for the other policy and demand scenarios, bST adopters were more profitable than nonadopters. This result is summarized, in terms of the average annual economic payoffs for bST adoption, in table C-13. The economic payoffs for bST adoption are positive for the dairy termination program and they are greater for the dairy termination program than for the trigger price policy. For example, the economic payoffs for a moderate-size Lake States dairy that adopts bST are $1,900 for the trigger price policy and $4,100 for the dairy termination program. A large Lakes States dairy farm had an economic payoff of $6,900 for the trigger price and $10,3OO for the dairy termination program (see table C-13). In the remaining three regions, the large farms gained more from bST adoption than the moderate-size farms; this differential was greater under the dairy termination program than under the trigger price policy (see table C-13). This reflects the higher milkprices under the dairy termination program. It also suggests that bST adoption would be accelerated even in the face of declining milk demand if a dairy termination program was introduced.

Appendix C References

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Table C-14-Effects of a Large Reduction in Milk Demand on Representative Lake States Dairy Farms Who Adopt and Fail To Adopt bST, Given a Trigger Price and a Dairy Termination Program, 1989-98

	Policy scenario			
	Trigger price policy		Dairy termination program	
	Non-adopter	bST adopter	Non-adopter	bST adopter
52-cow *farm:*				
Probability of survival (percent)	13.0	24.0	90.0	96.0
Probability of success (percent)	13.0	24.0	90.0	96.0
Probability of increasing equity (percent)	0.0	0.0	1.0	4.0
Net present value ($1 ,000)	-85.5	-63.4	111.9	146.9
Present value of ending net worth ($1,000)	-47.9	-32.2	117.2	147.5
Present value of ending net worth as a percent of beginning net worth (percent)	-16.9	–11 .3	41.3	51.9
Average annual net cash farm income ($1 ,000)	-12.1	-10.2	3.3	7.4
125-cow *farm:*				
Probability of survival (percent)	46.0	61.0	99.0	100.0
Probability of success (percent)	37.0	47.0	97.0	99.0
Probability of increasing equity (percent)	0.0	0.0	20.0	31.0
Net present value ($1 ,000)	-126.8	–48.6	326.1	395.6
Present value of ending net worth ($1,000)	33.3	102.6	438.0	498.6
Present value of ending net worth as a percent of beginning net worth (percent)	5.8	17.8	76.0	86.5
Average annual net cash farm income ($1 ,000)	-10.7	–3.8	35.9	46.2

SOURCE: : Office of Technology Assessment, 1991.

Table C-15--Effects of a Large Reduction in Milk Demand on Representative Northeast Dairy Farms Who Adopt and Fail To Adopt bST, Given a Trigger Price and a Dairy Termination Program, 1989-98

	Policy scenario			
	Trigger price policy		Dairy termination program	
	Non-adopter	bST adopter	Non-adopter	bST adopter
52-cow *farm:*				
Probability of survival (percent)	100.0	100.0	100.0	100.0
Probability of success (percent)	99.0	100.0	100.0	100.0
Probability of increasing equity (percent)	0.0	0.0	3.0	7.0
Net present value ($1 ,000)	149.8	167.6	245.5	265.1
Present value of ending net worth ($1,000)	194.1	210.0	277.6	294.4
Present value of ending net worth as a percent of beginning net worth (percent)	52.4	56.7	74.9	79.4
Average annual net cash farm income ($1 ,000)	2.3	5.0	15.4	18.6
200-cow *farm:*				
Probability of survival (percent)	98.0	99.0	100.0	100.0
Probability of success (percent)	91.0	94.0	100.0	100.0
Probability of increasing equity (percent)	9.0	17.0	55.0	68.0
Net present value ($1 ,000)	352.2	438.8	733.8	819.5
Present value of ending net worth ($1 ,000)	542.9	618.4	871.6	944.5
Present value of ending net worth as a percent of beginning net worth (percent)	64.5	73.5	103.6	112.3
Average annual net cash farm income ($1 ,000)	27.4	40.2	82.5	97.8

SOURCE: Office of Technology Assessment, 1991.

Table C-16--Effects of a Large Reduction in Milk Demand on Representative Southwest Dairy Farms Who Adopt and Fail To Adopt bST, Given a Trigger Price and a Dairy Termination Program, 1989-98

	Policy scenario			
	Trigger price policy		Dairy termination program	
	Non-adopter	bST adopter	Non-adopter	bST adopter
350-cow farm:				
Probability of survival (percent)	52.0	69.0	100.0	100.0
Probability of success (percent)	52.0	69.0	100.0	100.0
Probability of increasing equity (percent)	6.0	11.0	91.0	95.0
Net present value ($1 ,000)	70.2	233.2	1,104.0	1,094.9
Present value of ending net worth ($1 ,000)	98.9	236.5	984.3	1,094.9
Present value of ending net worth as a percent of beginning net worth (percent)	15.4	36.9	153.7	170.9
Average annual net cash farm income ($1 ,000)	17.6	34.7	158.8	184.2
1,500 -cow farm:				
Probability of survival (percent)	98.0	100.0	100.0	100.0
Probability of success (percent)	96.0	98.0	100.0	100.0
Probability of increasing equity (percent)	53.0	70.0	100.0	100.0
Net present value ($1 ,000)	1,820.4	2,268.0	5,241.5	5,735.8
Present value of ending net worth ($1 ,000)	2,278.4	2,671.1	5,263.1	5,693.9
Present value of ending net worth as a percent of beginning net worth (percent)	102.5	120.2	236.8	256.2
Average annual net cash farm income ($1 ,000)	282.7	360.2	882.1	967.4

SOURCE: Office of Technology Assessment, 1991.

Table C-17—Effects of a Large Reduction in Milk Demand on Representative Southeast Dairy Farms Who Adopt and Fail To Adopt bST, Given a Trigger Price and a Dairy Termination Program, 1989-98

	Policy scenario			
	Trigger price policy		Dairy termination program	
	Non-adopter	bST adopter	Non-adopter	bST adopter
200-cow farm:				
Probability of survival (percent)	88.0	94.0	100.0	100.0
Probability of success (percent)	51.0	80.0	100.0	100.0
Probability of increasing equity (percent)	0.0	1.0	45.0	68.0
Net present value ($1 ,000)	8.0	147.2	703.1	837.4
Present value of ending net worth ($1,000)	321.5	444.2	938.7	1,054.1
Present value of ending net worth as a percent of beginning net worth (percent)	33.4	46.1	97.5	109.5
Average annual net cash farm income ($1,000)	-42.7	–25.1	50.8	73.1
1,500-cow farm:				
Probability of survival (percent)	100.0	100.0	100.0	100.0
Probability of success (percent)	89.0	99.0	100.0	100.0
Probability of increasing equity (percent)	19.0	50.0	99.0	100.0
Net present value ($1 ,000)	1,689.1	2,562.2	5,470.5	6,459.4
Present value of ending net worth ($1,000)	3,633.2	4,390.7	6,946.5	7,798.4
Present value of ending net worth as a percent of beginning net worth (percent)	79.7	96.3	152.3	171.0
Average annual net cash farm income ($1 ,000)	200.2	343.8	867.7	1,040.4

SOURCE: Office of Technology Assessment, 1991.