Boll Weevil Eradication

An Economic Evaluation

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Content

1. Introduction

In the past, researchers conducted many studies that attempted to estimate the economic value of boll weevil eradication. Analyses of the first treated areas, Virginia and North Carolina, showed significant economic benefits of boll weevil eradication (Carlson et.al. 1978 and 1983). Xian et.al. computed a cost-benefit analysis for boll weevil eradication in southern Oklahoma. Their study recommended the eradication program as the most economical technology.

However, most of the studies are limited in generality. For example, the above studies treat cotton production in other regions as a constant. More specifically, the Oklahoma study assumes constant cotton prices. These past studies also ignore the interactions of cotton production with other commodities. The weakness in the above studies lead one to question whether boll weevil eradication technology is justified.

In an attempt to answer this question, this study treats prices and quantities produced as endogenous parameters. It estimates the economic benefits or losses of boll weevil eradication technology. It considers both Beltwide eradication and eradication in Texas only, and involves two policy scenarios. The main tool for this analysis is a multicommodity agricultural sector model, which calculates welfare measures such as producer and consumer surplus, and government costs or revenues. A cost-benefit analysis provides an appropriate tool for program evaluation.

2. Tools

2.1. Boll Weevil Eradication Technology

History

About one hundred years ago, in the late 1890's, the boll weevil (Anthonomus grandis) began to immigrate from Mexico into the United States. By the 1920's, the insect pest occupied all cotton producing areas to the east, and by the early 1950's had infested West Texas.

Eradication in individual fields was not possible. The weevils moved to untreated neighboring fields and returned to infest the treated fields again as soon as the insecticides were out of effect. Before eradication efforts began, the boll weevil cost about $300 million annually or about $30 in control costs and yield losses on average per acre. The annual losses in Texas alone ranged from $25 - 50 million.

In 1958, the National Cotton Council passed a resolution that led to the creation of the boll weevil eradication program. The objective was to conduct an organized eradication, that would lead to weevil-free cotton fields throughout the United States. The program began in North Carolina and Virginia in 1977, and was extended to South Carolina in 1983, and Georgia, Alabama, and Florida in 1987. Areas in the Far West, specifically in southwestern Arizona, southern California, and a portion of northwest Mexico, carried out their own eradication programs. Plans exist to eradicate the boll weevil from all remaining production areas. Mississippi, Texas and Tennessee are the currently the main focus.

Techniques

Boll weevil eradication technology targets a zero population density of the major cotton pest. The treatments of this eradication program include pesticide applications, trapping, and altered crop management. The crop management measures are planting times and treatment of crop residuals (stalk destruction) after harvest. The most common used pesticide is malathion.

The intensity of the eradication program differs within the Beltwide production area for cotton. Regions that are infested in the spring by overwintering populations require an intensive application of eradication techniques. Those areas that are infested later in the year by migrating weevils will be subjected to lower levels of trapping and insecticide treatment.

Almost all of Texas cotton areas will be infested in the spring. The eradication program time ranges between four and five years usually. Frisbie and Brazzel (1993) proposed a five-year eradication program for Texas.

There are two primary effects of the eradication. The absence of the boll weevil leads to an increase in yield (more exactly to a decrease in yield loss due to boll weevil damage) and to a decrease in variable costs (less chemical treatments). Thus, cotton production becomes more competitive. The shift in comparative advantage results in several secondary effects. These effects are changes in commodity prices and changes in resource allocation, production levels and land values.

2.2 Farm Program

The U.S. farm program incorporates several activities in order to support the price for certain agricultural commodities. The deficiency payment is one of the main features of this program. A target price is set by the government at a level, usually somewhat higher than the market price. This higher price is paid on farm program yield to participating farmers. However, participation imposes certain restrictions on farmers' activities. Farmers must set-aside land in order to get payments. Hence, the introduction of the farm program leads to a left hand side shift of the aggregate supply curve for cotton. The magnitude of that shift is weakened because a 1% reduction in planted area does not yield a 1% decrease of yield. This occurs because farmers first set aside the marginal crop land.

Table 2.1 shows the farm program parameters for cotton used for this analysis.

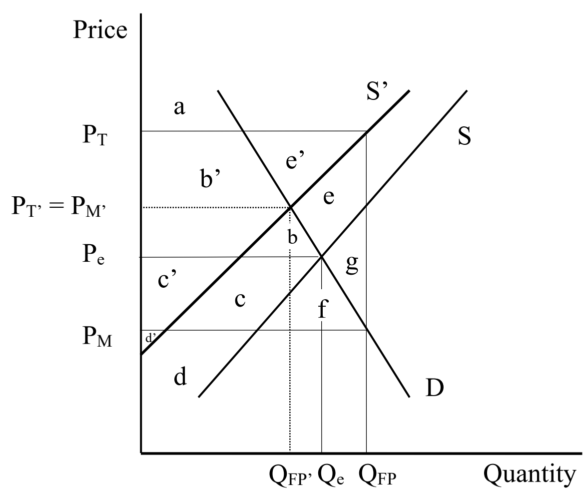
Table 2.1 Year 2000 - Farm Program Parameters for Cotton

Parameter	
Slippage	0.700
Setaside	0.070
Flexibility	0.150
Farm Program Yield	0.880
Market Loan	1.000
Target Price ($/Bale)	349.920
Loanrate	0.550

Source: ASM

Figure 2.1 illustrates the welfare, production, and price effects of the U.S. farm program. D and S represent an aggregate demand and supply curve. For simplicity, this study assumes a closed economy and linearity of supply and demand function. Under free market conditions (no farm program) producers' surplus equals area c+c'+d+d', and consumers' surplus equals area a+b'+b. After introduction of the farm program, the aggregate supply curve shifts from S to S'. The set-aside requirement that accompanies the farm program causes this shift. The analysis considers two such cases.

Figure 2.1 Welfare Analysis of Farm Program



The farm program may lead to an increase in production (target price equals P_T). Producers' surplus equals e'+b'+c'+d', while consumers' surplus changes to a+b'+b+c'+c+f. Government expenditure shifts from zero to b'+b+e'+e+c'+c+f+g. A comparison of both situations reveals that under the farm program assumption consumers gain (area c'+c+f), while the effect on producers' welfare is ambiguous. Producers gain b'+e', but lose c+d. If the shift of the aggregate supply curve is parallel, producers gain. Area e+g represents the dead weight loss of the farm program induced market distortion.

The farm program may also lead to a decrease in production (target price equals $P_{T'}$). In this instance, production is at $Q_{FP'}$. Consumers' lose (b+ part of b'), producers lose c+d and gain part of b from consumers. For the special case where the target price $P_{T'}$ equals the new market price $P_{M'}$, government expenditure remains at zero. The society, as a whole, loses b+c+d.

2.3. Agricultural Sector Model

This study uses the Agricultural Sector Model (ASM) of McCarl, et.al. to simulate the effects of boll weevil eradication technology. The model

> simulates the agricultural sector under a given set of supply and demand conditions. It disaggregates the U.S. into 10 large production regions which are further broken into 64 subregions for the endowment of land, labor and water. There are 32 primary commodities and 34 secondary commodities in the model. The farm program features in ASM include acreage set-aside, target prices, Commodity Credit Corporation (CCC) loans, generic Payment in Kind, acreage diversion, deficiency payment, and slippage. The model generates estimates of agricultural prices, quantities produced, consumers' and producers' surplus, exports, and imports. The objective function of ASM is the nonlinear sum of the area under domestic and export demand curves after subtracting the variable cost of production and the summed area under the factor and import supply curves. (Chang, et.al. 1992)

McCarl and Spreen (1980) provide a detailed mathematical description of the model. The ASM uses constant elasticity curves for domestic consumption, export demand, input supply, and import supply. Production is constraint to combinations of historical crop mixes. ASM results are of static nature. A quasi-dynamic analysis can be done by using different scenarios.

2.4. Application of ASM to the Boll Weevil Eradication Technology

This study analyzes six scenarios in order to draw conclusions about eradication technology. These involve combinations of farm program assumptions, eradication assumptions, and location assumptions (Table 2.2). The budget for the year 2000 is the basis for all scenarios.

Table 2.2 ASM Scenarios

	Boll Weevil Eradication		
	None	Texas only	Beltwide
Farm Program	1	2	3
No Farm Program	4	5	6
	2000	2000	2000
		Year	

To simulate the boll weevil eradication technology, both yield and variable costs of cotton production are changed within the ASM cotton budgets. The data are based on results found at the Texas A&M Agricultural Experimental Station, Corpus Christi. Columns 6 and 7 of Table 3.1 contain the data used for the adjustment of chemical costs and yield respectively. No losses to the boll weevil have been reported for North Carolina, South Carolina, Georgia, Virginia, Arizona, California, and New Mexico, where the boll weevil already has been eradicated.

2.5. Cost - Benefit Analysis

This study uses Cost-Benefit analysis to evaluate the economic consequences of boll weevil eradication. The net present value (NPV) is defined as the net benefit of the eradication program. It is computed over a time period of 30 years. The following equation has been used :

$$NPV_{t^*} = \sum_{t=1}^{t^*} \frac{B_t - C_t}{(1+d)^t} \qquad t = 1,\ldots,30$$

where t is the time after starting the eradication program, B_t and C_t are the program benefits and costs in period t, and d is the discount rate. The discount rate is set at a level of 4% for all thirty years. The ASM computes the benefits, which are the differences in net national welfare between the eradication and non-eradication scenarios. The ASM results, however, represent the final stage of boll weevil eradication (long run equilibrium after completion of the eradication program). These benefits include higher yields and lower costs. According to Texas A&M expert judgments, the benefits in year one to year five after program start correspond to 35%, 70%, 77%, 85%, and 95%, respectively, of the final (yield) benefits. After year six the benefits remain constant at 100%. The next chapter gives the calculation of the costs.

In each eradication scenario, 25% of the total area is added to the program in each year. If the program length is four years, the eradication will be completed on all cotton fields after a period of seven years.

3. Cost Analysis

3.1 Current Treatment Costs

The boll weevil program captures all measures against this insect pest. Therefore, the net costs of the program can be computed by subtracting the current treatment costs (conventional strategy) from the total program costs.

Table 3.2 shows current treatment costs per acre (column 4). They are calculated as the product of infested acreage (column 1) times the number of treatments (column 2) times the treatment costs (column 3). The cotton acreage of 1992 has been used to calculate the total treatment costs of the current technology.

3.2. Costs of the Eradication Program

The costs of the eradication program are shared by producers (70%) and the USDA/APHIS (30%).

Eradication costs depend primarily on program intensity. Table 3.1 gives the per acre cost estimates for both intensities. These estimates are for Texas (Brazzel 1989) and are applied to other states as well. Moderate costs are assumed for Oklahoma and Tennessee, and intensive costs for Alabama, Arkansas, Louisiana, Mississippi, and Missouri. This categorization reflects the way of infestation as mentioned in Chapter 2.1. In year 5 - 10 costs for monitoring and retreatment are necessary. Boll weevil costs after year 10 are assumed to be zero.

Most of Texas' cotton production areas fall into the intensive category. The eradication costs for the High Plains, Rolling Plains, and Edward's Plateau will be an weighted average of intensive and moderate control costs. The net per acre costs of the eradication program can be calculated as the difference between eradication costs and current treatment cost. The total net eradication costs (Table 3.5) are computed as the product of net per acre costs times acreage to be treated. The eradication acreage (Table 3.4) equals planting acreage times the adjustment factor for the planting system. For Alabama, Arkansas, Louisiana, Mississippi, Missouri, Oklahoma, and Tennessee, solid planting is assumed. Therefore, planting acreage equals eradication area. In Texas, the eradication acreage is higher than the planting acreage. Dry land cotton growers in the High Plains, Rolling Plains, and Edward's Plateau use a 2 by 1 row skip system. For these areas, the eradication acreage equals planting acreage times 1.5.

Table 3.1 Eradication Costs (in $ per Acre)

	Intensive Eradication	Moderate Eradication
Year 1	30.22	21.43
Year 2	19.95	14.14
Year 3	15.11	10.72
Year 4	7.56	5.36
Year 5 - 10	3.00	3.00

Source: Brazzel, 1989

Table 3.2 Current Treatment Costs and Yield Losses to Boll Weevil Damage (1990 - 1994 Average)

	Infested Acreage as Percentage of Total Acreage	Number of Treatments	Treatment Cost (Material & Application)	Current Boll Weevil Treatment Cost ($/Acre)	Percentage Savings of Total Chemical Costs plus Custom Charges	Percentage Yield Gain after Boll Weevil Eradication
	(1)	(2)	(3)	(4)	(5)	(6)
Alabama	69.6	2.0	2.25	3.13	19.1	1.95
Arkansas	90.7	2.2	5.75	11.47	17.4	1.23
Louisiana	98.1	4.2	4.25	17.51	14.7	3.51
Missouri	51.8	1.4	6.50	4.71	23.4	2.09
Mississippi	89.8	2.7	3.50	8.49	8.7	2.28
Oklahoma	72.9	1.6	6.00	7.00	27.4	2.51
Tennessee	68.8	2.3	5.25	8.31	48.9	6.12
Texas High Plains	12.6	0.2	5.00	0.13	1.1	0.25
Texas Rolling Plains	91.8	0.7	6.00	3.86	23.4	3.47
Texas Central Blacklands	58.6	1.7	7.00	6.97	15.0	4.24
Texas Coastal Bend	96.5	3.5	5.65	19.08	29.7	4.29
Texas Trans Pecos	41.8	0.7	6.25	1.83	30.4	1.56
Texas South Texas	97.0	3.5	7.00	23.76	38.4	3.29
Texas East Texas	13.4	2.6	7.00	2.44	35.5	4.35
Texas Edward's Plateau	99.7	1.9	5.00	9.47	44.2	5.89

Source: Texas A&M Agricultural Experimental Station Corpus Christi, 1995

Table 3.3 Per Acre Costs of Boll Weevil Treatment

State - Region	Current Costs	Gross Eradication Costs / Net Eradication Costs year 1	year 2	year 3	year 4	year 5,...
Alabama	3.13	30.22	19.95	15.11	7.56	3.00
		27.09	16.82	11.98	4.43	-0.13
Arkansas	11.47	30.22	19.95	15.11	7.56	3.00
		18.75	8.48	3.64	-3.91	-8.47
Louisiana	17.51	30.22	19.95	15.11	7.56	3.00
		12.71	2.44	-2.40	-9.95	-14.51
Missouri	4.71	30.22	19.95	15.11	7.56	3.00
		25.51	15.24	10.40	2.85	-1.71
Mississippi	8.49	30.22	19.95	15.11	7.56	3.00
		21.73	11.46	6.62	-0.93	-5.49
Oklahoma	7.00	21.43	14.14	10.72	5.36	3.00
		14.43	7.14	3.72	-1.64	-4.00
Tennessee	8.31	21.43	14.14	10.72	5.36	3.00
		13.12	5.83	2.41	-2.95	-5.31
Weighted Avg. Non-Texas	**9.86**	**28.47**	**18.79**	**14.23**	**7.12**	**3.00**
		18.60	**8.93**	**4.37**	**-2.74**	**-6.86**
Texas - High Plains	0.13	24.07	18.96	16.57	12.82	3.00
		23.94	18.83	16.44	12.69	2.87
Texas - Rolling Plains	3.86	24.07	18.96	16.57	12.82	3.00
		20.21	15.10	12.71	8.96	-0.86
Texas - Central Blacklands	6.97	30.22	19.95	15.11	7.56	3.00
		23.25	12.98	8.14	0.59	-3.97
Texas - Coastal Bend	19.08	30.22	19.95	15.11	7.56	3.00
		11.14	0.87	-3.97	-11.52	-16.08
Texas - Trans Pecos	1.83	30.22	19.95	15.11	7.56	3.00
		28.39	18.12	13.28	5.73	1.17
Texas - South Texas	23.76	30.22	19.95	15.11	7.56	3.00
		6.46	-3.81	-8.65	-16.20	-20.76
Texas - East Texas	2.44	30.22	19.95	15.11	7.56	3.00
		27.78	17.51	12.67	5.12	0.56
Texas - Edward’s Plateau	9.47	26.70	26.70	26.70	26.70	3.00
		17.23	17.23	17.23	17.23	-6.47
Weighted Avg. Texas	**4.27**	**25.28**	**19.39**	**16.62**	**12.29**	**3.00**
		21.01	**15.12**	**12.35**	**8.02**	**-1.27**
Weighted Avg. Beltwide	**6.75**	**26.69**	**19.12**	**15.56**	**10.00**	**3.00**
		19.94	**12.37**	**8.81**	**3.25**	**-3.75**

Table 3.4 Calculation of Eradication Area

State - Region	Planted (1992)	Skip Row 2 by 1	Solid	Skip Row times 1.5	To Be Eradicated
	Acres				
Alabama	415,000	0	415,000	0	415,000
Arkansas	1,000,000	0	1,000,000	0	1,000,000
Louisiana	890,000	0	890,000	0	890,000
Missouri	335,000	0	335,000	0	335,000
Mississippi	1,350,000	0	1,350,000	0	1,350,000
Oklahoma	370,000	0	370,000	0	370,000
Tennessee	625,000	0	625,000	0	625,000
Total Non-Texas	**4,985,000**	**0**	**4,985,000**	**0**	**4,985,000**
Texas - High Plains	3,160,000	442,700[1]	2,717,300	664,050	3,381,350
Texas - Rolling Plains	1,041,000	986,000[2]	55,000	1,479,000	1,534,000
Texas - Central Blacklands	307,600	0	307,600	0	307,600
Texas - Coastal Bend	435,000	0	435,000	0	435,000
Texas - Trans Pecos	23,000	0	23,000	0	23,000
Texas - South Texas	333,300	0	333,300	0	333,300
Texas - East Texas	53,000	0	53,000	0	53,000
Texas - Edward’s Plateau	147,100	103,000[1]	44,100	154,500	198,600
Total Texas	**5,500,000**	**1,531,700**	**3,968,300**	**2,297,550**	**6,265,850**
Total Beltwide	**10,485,000**	**1,531,700**	**8,953,300**	**2,297,550**	**11,250,850**

[1] Skip Row Acreage = Dryland of Entire Region
[2] Skip Row Acreage = Dryland of Counties Briscoe, Floyd, Crosby, Dawson, Glassock, Midland

Table 3.5 Total Net Eradication Costs in Dollar

State - Region	Year 1	Year 2	Year 3	Year 4	year 5...
Alabama	11,242,350	6,980,300	4,971,700	1,838,450	-53,950
Arkansas	18,750,000	8,480,000	3,640,000	-3,910,000	-8,470,000
Louisiana	11,311,900	2,171,600	-2,136,000	-8,855,500	-12,913,900
Missouri	8,545,850	5,105,400	3,484,000	954,750	-572,850
Mississippi	29,335,500	15,471,000	8,937,000	-1,255,500	-7,411,500
Oklahoma	5,339,100	2,641,800	1,376,400	-606,800	-1,480,000
Tennessee	8,200,000	3,643,750	1,506,250	-1,843,750	-3,318,750
Total Non -Texas	**92,724,700**	**44,493,850**	**21,779,350**	**-13,678,350**	**-34,220,950**
Texas - High Plains	80,939,375	63,684,346	55,589,394	42,902,569	9,704,475
Texas - Rolling Plains	30,997,538	23,169,536	19,497,140	13,741,572	-1,319,240
Texas - Central Blacklands	7,151,700	3,992,648	2,503,864	181,484	-1,221,172
Texas - Coastal Bend	4,845,900	378,450	-1,726,950	-5,011,200	-6,994,800
Texas - Trans Pecos	652,970	416,760	305,440	131,790	26,910
Texas - South Texas	2,153,118	-1,269,873	-2,883,045	-5,399,460	-6,919,308
Texas - East Texas	1,472,340	928,030	671,510	271,360	29,680
Texas - Edward’s Plateau	3,422,672	3,422,672	3,422,672	3,422,672	-1,284,942
Total Texas	**131,635,613**	**94,722,569**	**77,380,025**	**50,240,787**	**-7,978,398**
Total	**224,360,313**	**139,216,419**	**99,159,375**	**36,562,437**	**-42,199,348**

3.3. Shortcomings

The above cost analysis involves some shortcomings due to risk and uncertainty of the boll weevil eradication that are not captured by this study. Unfavorable weather conditions and inappropriate program management may drastically increase the costs of the program. The mass spraying of insecticides kills not only pests, but also beneficials. Absence of beneficials makes cotton fields very sensitive to infestations by secondary pests and to reinfestations by the boll weevil. A warning example is the crop disaster in the Rio Grande Valley this year, where the first year of the eradication program accompanies one of the heaviest crop damages of the century. This year, 370,000 acres in the valley may produce no more than 150,000 bales of cotton (Pigg, June 1995). Breene (June 1995) estimates the possible loss to be between $100 and 200 million.

Entomologists also indicate the possibility of an increased activity of currently suppressed pests in the long run (O'Brien 1994). Fortunately, no such events have been reported for the first eradication areas as North Carolina and Virginia.

The gross eradication costs after year 4 are set to $3.00/acre for all following years. These costs include expenditure on monitoring and retreatment. Carlson (1985), however, calculated $0.78/acre, on average, as maintenance costs over a seven year history for North Carolina.

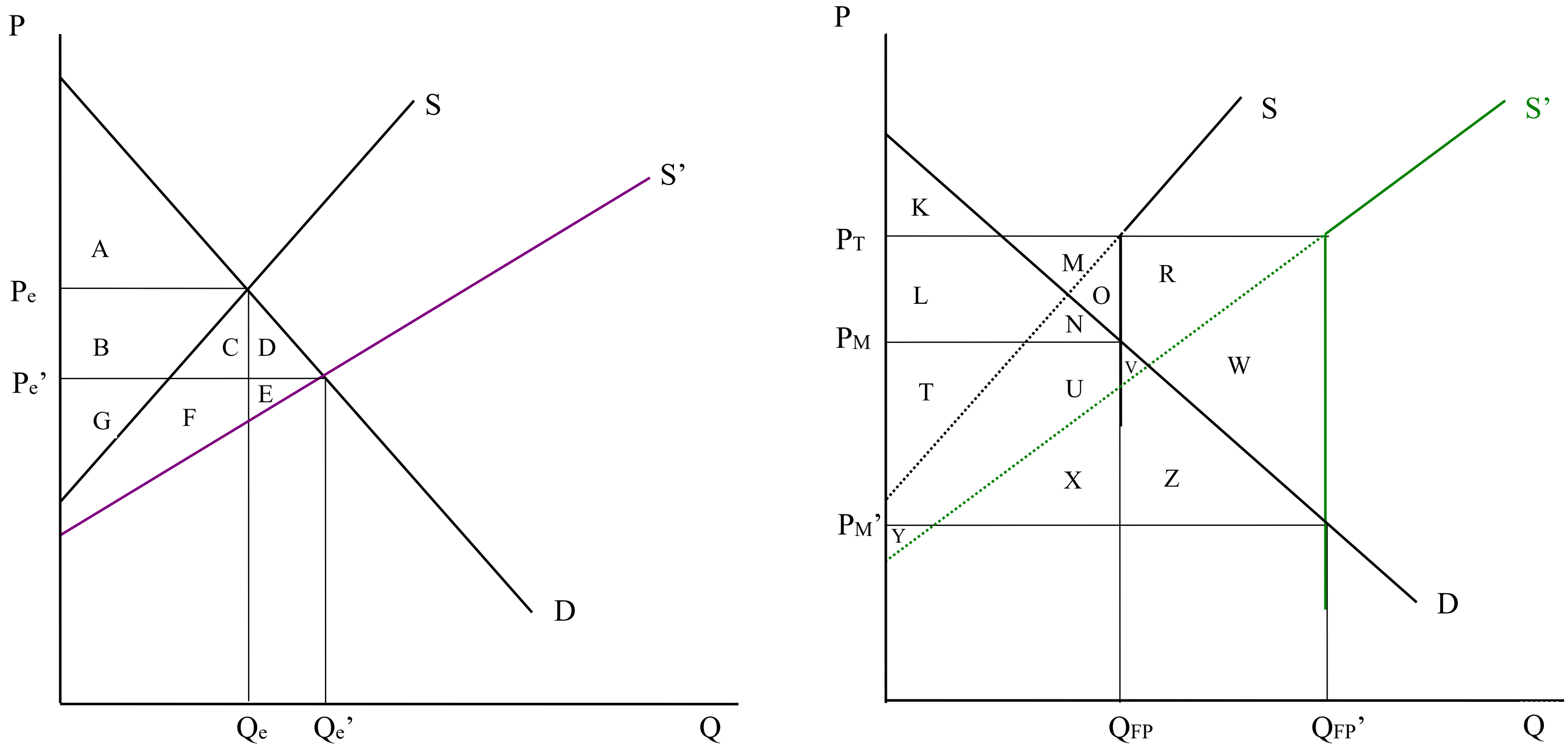
4. Graphical Analysis

The ASM results are sensitive to the assumptions mentioned before. If some of the assumptions do not match with reality, these results will become biased. A graphical analysis is an appropriate tool to make sure that the ASM results are in agreement with common economic theory.

Figure 4.1 shows welfare effects of technology change (boll weevil eradication) for both of the two farm program assumption. The undistorted market is represented in the the left panel. If technology improves, the aggregate supply curve for cotton shifts to the right (from S to S'). The new market equilibrium leads to a higher level of production (Q_e') and a lower market price (P_e'). Consumers' surplus increases by area B+C+D. Producers gain F+E but lose B. The net effect on producers' surplus is undetermined. Society, as a whole, gains F+E+C+D.

The right panel of Figure 4.1 illustrates the welfare effects of the farm program scenario. P_T and P_M represent target and market price, respectively. As before, technology improvement shifts the aggregate supply curve for cotton to the right. The new market equilibrium is determined by PT and QFP'. The welfare changes are as following: Consumers gain area N+U+V+X+Z. Producers' surplus will go up by Y+U+V+N+O+R. Government expenditure increases by T+U+X+R+V+W+Z. The country gains Y+U+W+V+O but also receives a dead weight loss of area W. Hence, the net effect is undetermined.

Figure 4.1 Welfare Effects of Boll Weevil Eradication Technology under both Farm Program Assumptions



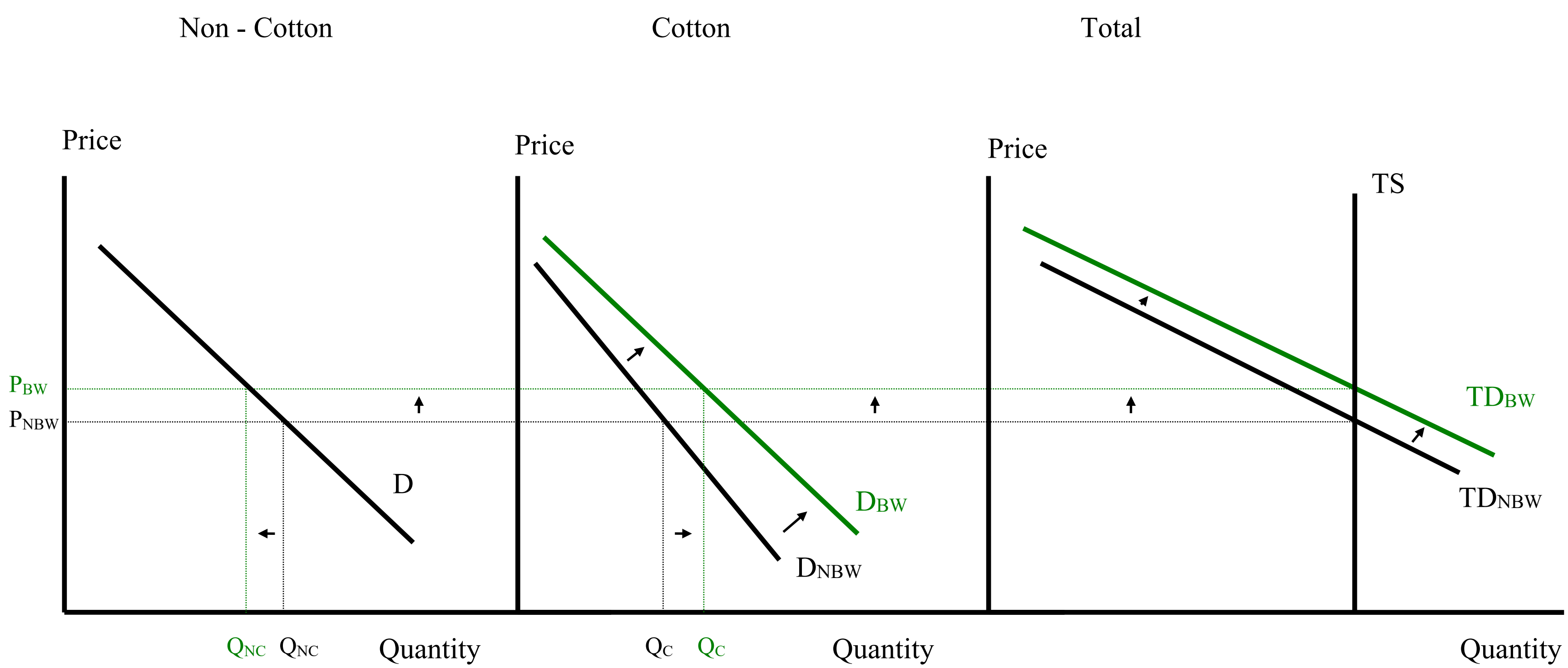
Summarizing both situations, researcher find that consumers always benefit from technology improvement. Cotton producers will benefit under the farm program assumption. They may or may not gain under free market conditions. Technolgy improvement will always raise societys' net surplus when the market is undistorted. The distorted market shows a wedge between positive and negative effects. The dead weight loss (the society's penalty for market distortion) always increases with technology improvement.

The effects of the farm program are analyzed in Chapter 2.2. The comparison of the welfare implications of farm program removal and boll weevil eradication reveals unique results for consumers. Thus, by combining both events consumers will gain even more. The effects on producers', governments', and the country's net surplus, however, are undetermined.

Figure 4.2 illustrates changes in landuse due to boll weevil eradication. D, TD, and TS stand for demand, total demand, and total supply of land respectively. TD is the horizontal sum of demand for cotton and non-cottonland. The total supply of land is assumed to be fixed. P is the price of land. The subscripts BW, and NBW denote boll weevil eradication and no boll weevil eradication.

If commodity prices do not change, boll weevil eradication will increase marginal revenues for cotton production. As a consequence, demand for cottonland will go up (demand curve shifts from D_{NBW} to D_{BW}). If demand for cottonland shifts, so will total demand (right panel). The new equilibrium will increase the price (value) of land. The land

Figure 4.2 Effects of Boll Weevil Eradication Technology on Land Allocation



input for cotton increases by Q_C' minus Q_C. Since total supply of land is fixed, landuse for non-cotton crops will go down by the equivalent amount (Q_{NC}'-Q_{NC}).

However, if we relaxe the assumption of constant commodity prices, the above effects will not necessarily be true. As production of cotton increases, the price of cotton will decline. The price drop will decrease marginal revenue and shift back the demand curve for cottonland. If the price effect is higher than the technology effect, land used for cotton production may even decline after boll weevil eradication. The net effect depends on the elasticities of supply and demand for cotton.

5. ASM Results

5.1. Welfare Implications

Producer Surplus

Table 5.1 summarizes the technology-induced welfare changes from the ASM results under boll weevil eradication for Texas and Beltwide eradication.

Under the 1990 farm program provisions, producers lose for both Texas and the Beltwide eradication. The loss in producer surplus is slightly higher for the Texas scenario ($1,271,518 or 2.68%) than for the Beltwide eradication scenario ($1,216,352 or 2.56%). The elimination of the farm program leads to a loss in producer surplus of $2,240,737 or 4.71%. Without the farm program, the eradication technology improves producer surplus by 0.26% for Texas eradication and by 0.44% for Beltwide eradication. Hence, the base scenario where the farm program is in place but no boll weevil eradication program is realized gives the highest producer surplus.. The lowest level of producer surplus will be achieved if the farm program is eliminated and no eradication takes place. Boll weevil eradication reduces the difference of the surplus level between the farm program and non-farm program scenarios.

Consumer Surplus

Consumers gain both by elimination of the farm program and by realization of the boll weevil eradication. There is no cumulative effect. Without eradication, a gain in consumer surplus of 0.11% accompanies the elimination of the farm program. There is only a small difference in consumer surplus for all non-farm program scenarios. Texas or Beltwide boll weevil eradication decreases consumer surplus by $33,371 and $14,873, respectively. If the farm program is maintained, the eradication increases consumer surplus by $1,908,491 or 0.11% (Texas) and by $2,042,347 or 0.12% (Beltwide eradication).

Foreign Surplus

Eradication leads to an increase in foreign surplus by 0.39% for the Texas scenario and by 0.42% for Beltwide scenario if the farm program is maintained. Without the farm program, there is a much smaller change. Texas only eradication has no effect on foreign surplus. The difference between both scenarios is $ 3,667 billion or 0.0002%. Beltwide eradication increases foreign surplus slightly by 0.03%. The magnitude of change is approximately four times greater for the farm program scenario.

Government Costs

Government costs increase for the farm program scenario as eradication increases. Eradication in Texas raises the government expenditure by 82% and Beltwide eradication adds further 36%. For all non-farm program scenarios, of course, no government cost are involved.

Net Surplus

The net surplus for society is positive. Beltwide eradication without the farm program provisions results in the highest net social gain (862,775). The Texas only eradication (no farm program) yields the second highest level. The single effects of farm program elimination or boll weevil eradication lead to an increase in net social gain of 0.03% to 0.04%. However, the combination of eradication and farm program elimination produces only a small increase (not exceeding 0.01%) over the single effect.

Table 5.1 Welfare Effects of Boll Weevil Eradication (Year 2000) in $1000

	Boll Weevil Eradication					
	None	Texas	Beltwide	None	Texas	Beltwide
	Farm Program			No Farm Program		
Producer Surplus	47531935	46260417 -1271518[1] -2.68[2]	46315583 -1216352 -2.56	45291198 -2240737 -4.71	45417375 -2114560 -4.45	45455112 -2076823 -4.37
Consumer Surplus	1752186877	1754095368 1908491 0.11	1754229224 2042347 0.12	1754116137 1929260 0.11	1754082766 1895889 0.11	1754101263 1914387 0.11
Foreign Surplus	182305079	183011458 706379 0.39	183078318 773239 0.42	182468833 163754 0.09	182472500 167421 0.09	182526959 221880 0.12
Government Cost	803332	1459798 656467 81.72	1672909 869577 108.25	-803332 -100	-803332 -100	-803332 -100
Total Surplus	1982023891	1983367244 1343352 0.07	1983623125 1599234 0.08	1981876169 -147723 -0.01	1981972641 -51251	1982083335 59443
Net Surplus	1981220560	1981907445 686886 0.03	1981950216 729657 0.04	1981876169 655609 0.03	1981972641 752081 0.04	1982083335 862775 0.04

[1] Absolute Change with Respect to the No Eradication/Farm Program Scenario
[2] Percentage Change

5.2. Net Present Values

Table 5.3 shows the net present values (NPV) for all four eradication scenarios. The NPVs for the non-farm program scenarios are computed with respect to the non-farm program, no eradication scenario. This is to eliminate the effect of the farm program removal from the eradication effects.

The NPVs vary between farm program and non-farm program scenarios. Farm program scenarios show positive values even in the first year of eradication. In the short run (first five years), Texas only eradication yields higher NPVs. In the long run (years 5-25), however, Beltwide eradication turns out to be superior to Texas only eradication.

The non-farm program scenarios give significantly lower NPV estimates. The pattern is the same as for the farm program scenario. Beltwide eradication is superior to Texas eradication after five years. Both Beltwide and Texas eradication show positive NPVs first in the fifth year after program start.

Overall, results show that the optimal eradication scenarios differ between farm program and non-farm program scenarios. However, Beltwide eradication is always preferred. The results for the farm program scenarios are questionable. The positive net effects of eradication even in the first program year seem to be overstated.

For the non-farm program scenarios, the internal rates of return are calculated.The results are given in Table 5.3c. Because the farm program scenarios show positive net effects even in the first year, the calculation of internal rates of returns is irrelevant.

Table 5.2 Net Benefits over all Eradication Scenarios for 30 Years (in $1000) Assuming Annual Program Expansion = 1/4 of Total Eradication Area

	Farm Program		No Farm Program	
Year	Texas Eradication	Beltwide Eradication	Texas Eradication	Beltwide Eradication
1	24,851	1,109	-26,810	-44,609
2	116,689	80,703	-38,294	-56,450
3	224,416	181,752	-44,223	-55,982
4	352,129	311,524	-41,973	-37,239
5	**486,049**	**476,219**	**3,385**	**49,083**
6	561,232	570,601	34,288	104,278
7	620,528	643,529	59,635	147,162
8	659,837	687,733	76,803	171,773
9	668,088	695,904	77,674	173,413
10	**668,088**	**695,904**	**77,674**	**173,413**
11	686,886	729,657	96,472	207,166
12	686,886	729,657	96,472	207,166
13	686,886	729,657	96,472	207,166
14	686,886	729,657	96,472	207,166
15	**686,886**	**729,657**	**96,472**	**207,166**
16	686,886	729,657	96,472	207,166
17	686,886	729,657	96,472	207,166
18	686,886	729,657	96,472	207,166
19	686,886	729,657	96,472	207,166
20	686,886	729,657	96,472	207,166
21	686,886	729,657	96,472	207,166
22	686,886	729,657	96,472	207,166
23	686,886	729,657	96,472	207,166
24	686,886	729,657	96,472	207,166
25	686,886	729,657	96,472	207,166
26	686,886	729,657	96,472	207,166
27	686,886	729,657	96,472	207,166
28	686,886	729,657	96,472	207,166
29	686,886	729,657	96,472	207,166
30	686,886	729,657	96,472	207,166

Table 5.3a Net Present Values over all Eradication Scenarios for 30 Years (in $1000) (non-cumulative over years)

Year	Farm Program		No Farm Program	
	Texas Eradication	Beltwide Eradication	Texas Eradication	Beltwide Eradication
1	23,895	1,066	-25,779	-42,893
2	107,886	74,615	-35,405	-52,192
3	199,505	161,577	-39,314	-49,767
4	301,001	266,292	-35,878	-31,832
5	**399,497**	**391,417**	**2,782**	**40,342**
6	443,550	450,954	27,098	82,412
7	471,550	489,029	45,318	111,831
8	482,136	502,520	56,119	125,513
9	469,390	488,933	54,573	121,838
10	**451,337**	**470,128**	**52,474**	**117,152**
11	446,188	473,971	62,666	134,571
12	429,027	455,742	60,256	129,395
13	412,526	438,213	57,939	124,419
14	396,660	421,359	55,710	119,633
15	**381,403**	**405,153**	**53,567**	**115,032**
16	366,734	389,570	51,507	110,608
17	352,629	374,586	49,526	106,353
18	339,066	360,179	47,621	102,263
19	326,025	346,326	45,790	98,330
20	**313,486**	**333,006**	**44,029**	**94,548**
21	301,429	320,198	42,335	90,911
22	289,835	307,883	40,707	87,415
23	278,688	296,041	39,141	84,053
24	267,969	284,655	37,636	80,820
25	257,662	273,707	36,188	77,711
26	247,752	263,179	34,796	74,723
27	238,223	253,057	33,458	71,849
28	229,061	243,324	32,171	69,085
29	220,251	233,966	30,934	66,428
30	**211,780**	**224,967**	**29,744**	**63,873**

Table 5.3b Net Present Values over all Eradication Scenarios for 30 Years (in $1000) (cumulative)

Year	Farm Program: Texas Eradication	Farm Program: Beltwide Eradication	No Farm Program: Texas Eradication	No Farm Program: Beltwide Eradication
1	23,895	1,066	-25,779	-42,893
2	131,781	75,681	-61,185	-95,085
3	331,285	237,258	-100,499	-144,852
4	632,286	503,550	-136,377	-176,684
5	1,031,783	894,967	-133,594	-136,342
6	1,475,333	1,345,921	-106,496	-53,930
7	1,946,883	1,834,950	-61,179	57,902
8	2,429,020	2,337,470	-5,059	183,415
9	2,898,410	2,826,403	49,514	305,253
10	3,349,747	3,296,532	101,988	422,405
11	3,795,935	3,770,503	164,654	556,976
12	4,224,962	4,226,244	224,910	686,371
13	4,637,488	4,664,457	282,849	810,789
14	5,034,147	5,085,816	338,559	930,423
15	5,415,551	5,490,969	392,126	1,045,455
16	5,782,285	5,880,539	443,634	1,156,062
17	6,134,914	6,255,125	493,160	1,262,416
18	6,473,980	6,615,304	540,781	1,364,679
19	6,800,005	6,961,630	586,571	1,463,008
20	7,113,491	7,294,636	630,599	1,557,556
21	7,414,919	7,614,834	672,934	1,648,468
22	7,704,755	7,922,717	713,641	1,735,882
23	7,983,442	8,218,758	752,783	1,819,935
24	8,251,411	8,503,413	790,418	1,900,755
25	8,509,074	8,777,120	826,607	1,978,466
26	8,756,826	9,040,299	861,403	2,053,189
27	8,995,050	9,293,356	894,861	2,125,038
28	9,224,111	9,536,680	927,032	2,194,123
29	9,444,362	9,770,646	957,966	2,260,551
30	9,656,141	9,995,613	987,710	2,324,424

Table 5.3c Internal Rates of Return for Non-Farm Program Scenarios

Included Time Period	Texas Eradication	Beltwide Eradication
10 Years	-0.25	0.08
15 Years	0.11	0.27
20 Years	0.18	0.31
30 Years	0.21	0.32

5.3 Change in Landuse Pattern

It is necessary to separate between farm program and non-farm program scenarios, when examing the effects of eradication. Figures 5.1 - 5.3 show the interaction between eradication and elimination of the farm program for different parameters and different commodities. The knowledge of the response of some production parameter to eradication under the farm program does not enable the researcher to forecast the response under the non-farm program scenario.

Farm Program +Boll Weevil Eradication

The eradication of the boll weevil from the cotton fields, leads the researcher to expect a change in the landuse pattern. In other words, cotton receives a comparative advantage which should lead to substitution processes towards more cotton production.

The total acreage used for crops increases by approximately 2,500,000 acres (0.80%) for the Texas scenario and by 1,700,000 acres(0.55%) for the Beltwide scenario, when each scenario is compared to the base scenario (farm program, no eradication). Looking at single crops (Table 5.4) the study finds that eradication increases corn and cotton production most significantly for both eradication scenarios. For the Texas only scenario, the response of corn is even higher than that for cotton. However, cotton acreage increases the most in percentage terms. Besides cotton and corn acreage, there is also a substantial increase in sorghum area. Soybean, hay, silage, oats and rice experience a somewhat smaller increase for the Texas scenario. For the Beltwide scenario, these crops, in general, show a lower response. Hay reacts even negatively for Beltwide eradication. The big loser of boll weevil eradication is wheat. Wheat area declines by 800,000 acres for the Texas scenario and by 950,000 acres for the Beltwide scenario. Barley loses about 130,000 acres. Overall, the acreage increasing effects exceed the decreasing effects.

Table 5.4 Absolute Change in National Harvested Acres (1,000 Acres)

	Eradication			
	Texas	Beltwide	Texas	Beltwide
	Farm Program		No Farm Program	
Cotton	1,035	1,234	101	-134
Corn	1,193	678	-36	21
Soybeans	208	-19	43	-47
Wheat	-796	-952	-229	-122
Sorghum	410	374	154	109
Rice	102	102	-1	0
Barley	-129	-124	-1	2
Oats	120	115	-8	16

To fully understand the underlying processes, it is useful to look at the production pattern in Texas. The increase in cotton acreage for the Southplains (Texas + Oklahoma) is greater than the nationwide increase. When cotton production technology changes only for Texas, cotton production shifts from locations outside of Texas to Texas. For the Beltwide scenario, cotton production in Texas increases by only 694,000 acres compared to the almost double amount before. The increase in Texas almost covers the total increase in cotton area for the Beltwide scenario. Thus, the net effect on cotton area outside Texas is approximately zero. Whereas corn and hay experience an overall net gain in area planted, they lose significantly in Texas for both scenarios. Wheat loss in Texas accounts for 2/3 of the nationwide wheat loss. Barley acreage increases by a small amount, which, is opposite of the national tendency.

Non-Farm Program +Boll Weevil Eradication

The most obvious difference between farm program scenarios and non-farm program scenarios is that the latter ones do not vary as much as the farm program scenarios over all eradication stages. A look at the effect on cropland reveals an absolute change of +100,000 acres for Texas eradication and -71,000 acre for Beltwide eradication. The absolute magnitudes of changes for the farm program scenarios are twenty five times as much as for the non farm program scenarios. In all cases, the researcher sees an increase in cropland for Texas eradication, but an offsetting effect for Beltwide eradication. In the non-farm program scenario, Beltwide eradication leads to an even lower absolute level of cropland acreage.

The single crops almost always reflect the overall trend. In Texas, cotton production and sorghum production increase significantly for the Texas eradication scenario. Wheat experiences substantial losses. Minor losses occur for corn, soybeans, hay, and oats. Beltwide eradication, offsets a large proportion of the initial change due to Texas eradication.

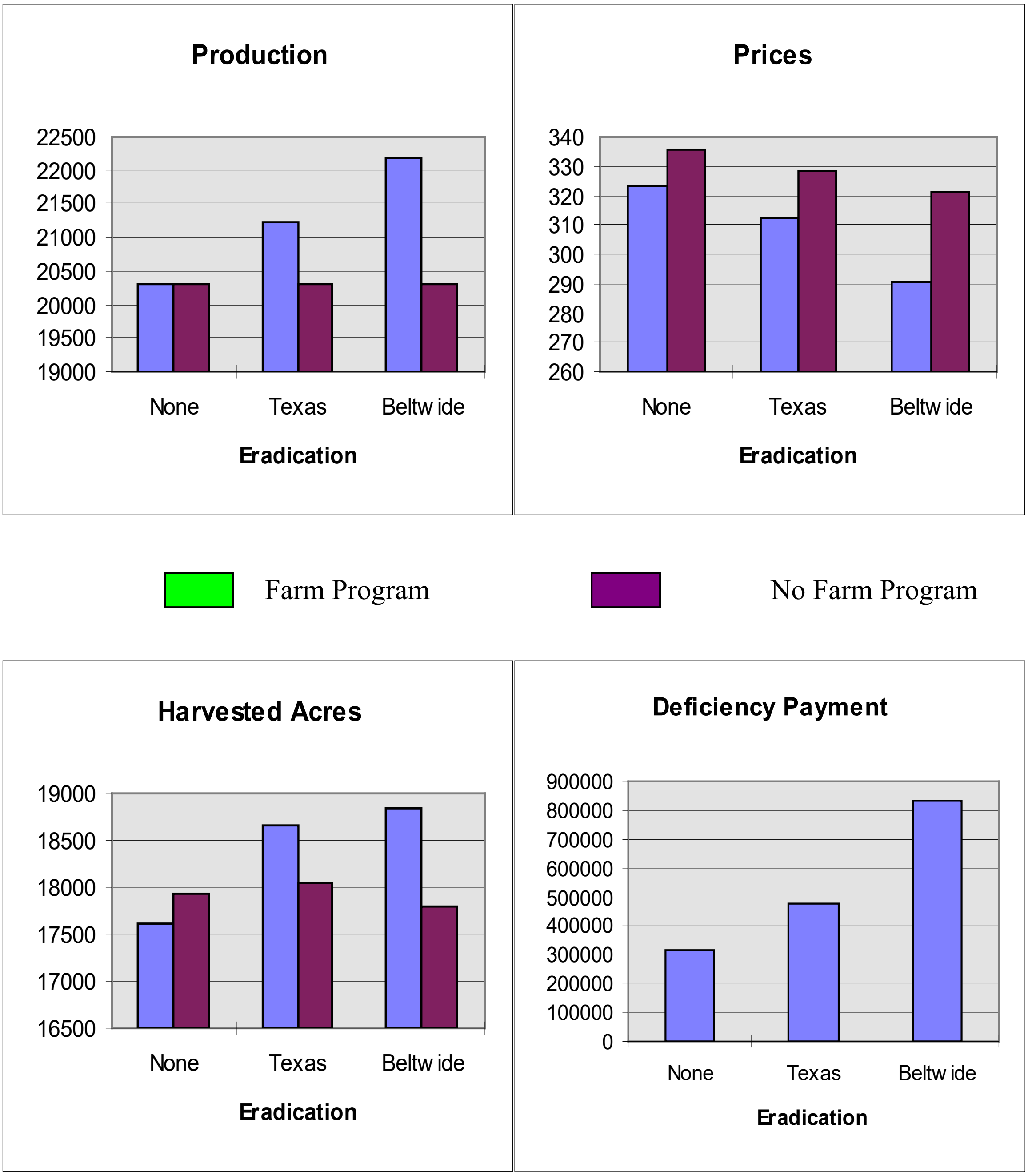
5.4 Effects on Production and Prices

5.4.1. Cotton

Under the farm program, production increases by 4.6% for Texas eradication and by 9.2% for Beltwide eradication. Domestic demand does not change for all six scenarios. The production surplus due to boll weevil eradication will be completely exported. By removing the farm program provisions, boll weevil eradication does not change the level of production. Since the potential yield is higher after eradication, either land or other inputs have to be reduced in order to get the same output as before.

The market price for cotton, naturally, has its highest level for the non-farm program scenario without any eradication. As eradication takes place, the cotton price will slightly decline up to fifteen cents per bale. This price effect is due to price changes of substitutes. The farm program scenarios show a small decrease in price, eleven cents for Texas eradication and twenty-one cents for Beltwide eradication.

Figure 5.1 Cotton - National Response to Boll Weevil Eradication



5.4.2 Production and Prices of Major Crops

Table 5.5 shows the estimated change in production due to boll weevil eradication. There is an obvious difference between farm and non farm program scenarios. Except for oats, the level of production for all major crops remains approximately unchanged under the non-farm program scenario. With the farm program in place, the production levels respond more significantly. Rice and sorghum production changes by about 4.2% and 4%, respectively. Oats production increases by 3.2% for the Texas only scenario and by 3.0% for the Beltwide eradication scenario.

Table 5.5 Percentage Change of Production

	Eradication			
	Texas	Beltwide	Texas	Beltwide
	Farm Program		No Farm Program	
Cotton	4.62	9.24	0.00	0.00
Corn	2.42	1.46	0.00	-0.01
Soybeans	0.08	0.08	0.00	0.00
Wheat	0.01	0.01	0.00	0.00
Sorghum	3.93	3.96	0.00	-0.01
Rice	4.24	4.22	0.00	0.00
Barley	0.16	0.15	0.00	0.00
Oats	3.19	3.03	0.29	0.47

Prices of crops react more sensitively to eradication than production (Table 5.6). Under the farm program provisions the change in the price of rice is the most dramatic.

Table 5.6 Percentage Change in Price

	Eradication			
	Texas	Beltwide	Texas	Beltwide
	Farm Program		No Farm Program	
Cotton	-3.54	-10.10	-2.04	-4.37
Corn	-2.65	-2.65	0.34	0.34
Soybeans	-1.31	-0.87	0.30	0.45
Wheat	-5.22	-4.44	1.07	0.80
Sorghum	0.00	-0.35	-1.74	-0.69
Rice	-17.32	-7.22	-2.48	-0.41
Barley	-5.15	-6.25	-2.97	-3.35
Oats	-8.85	-8.85	0.00	0.00

For the Texas only scenario rice prices decline by 17%. Beltwide eradication offsets about 10% of the initial price change, even though production differs only by 0.02% between the Texas and the Beltwide scenario.

The farm program scenarios show significant price effects for oats, wheat, and corn. These price drops are not necessarily related to increases in production. Wheat production stays almost constant for both boll weevil eradication scenarios. Nevertheless, prices for wheat falls by about 5% as eradication takes place. Soybeans, wheat, and rice have lower prices for the Texas only scenario than for the Beltwide scenario. Barley, cotton, and sorghum prices fall further for Beltwide eradication. The price for oats and corn stays the same for both scenarios.

In the non-farm program scenarios, prices of all crops, except the price of sorghum, react less sensitively to boll weevil eradication. All price changes stay within a 0-5% level. However, there are significant changes for all crops except oats. Whereas in the farm program scenarios all prices fall, the direction of price change is not unique for the non-farm program scenario. Prices for wheat, corn, and soybeans go up with boll weevil eradication. Prices for sorghum, barley, and rice go down. Price drops not due to changes in supply indicate that the particular commodity is a competitive good, whereas price raises indicate complementary crops. Prices for rice and barley respond strongly for the Texas scenario. Beltwide eradication offsets 83% of the price drop for rice, but the price for barley decreases further.

Figure 5.2 Gross Revenue Comparison

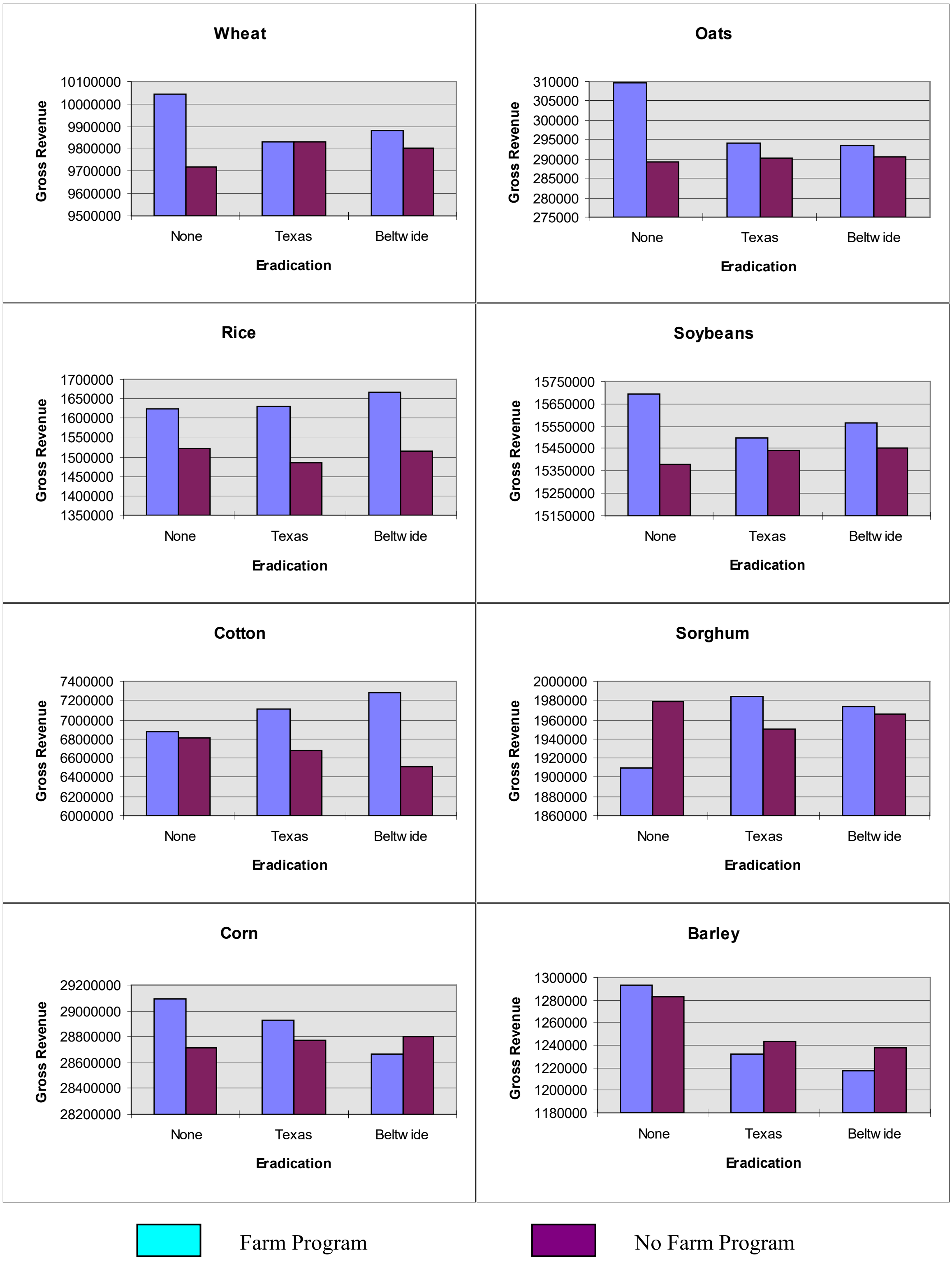
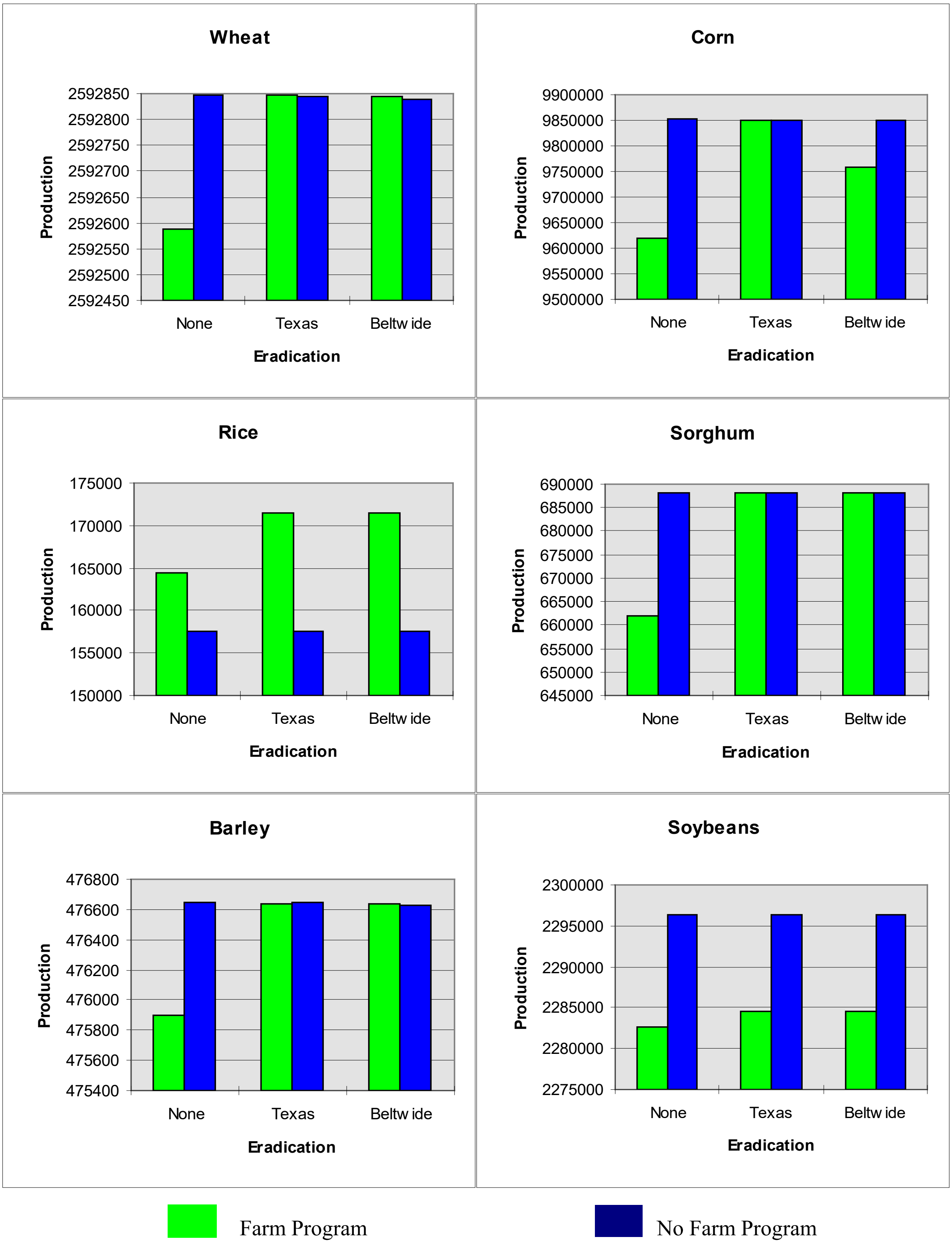


Figure 5.3 Production Response to Boll Weevil Eradication



6. Summary and Conclusions

Summary

This study deals with the economic evaluation of boll weevil eradication. It involves two eradication assumptions (eradication in Texas and Beltwide eradication) and two farm program assumptions (maintaining the current provisions, no farm program). And it uses a multicommodity agricultural sector model to compute the benefits of eradication. Net present values are calculated over a period of 30 years. Eventually, the study looks at effects of boll weevil eradication on prices, production, and resource allocation within the agricultural sector.

Conclusions

This study shows a positive monetary value of boll weevil eradication over all scenarios in the longrun. Therefore, boll weevil eradication is economically justifiable. The study also reveals significantly different welfare responses to the two farm program assumptions. Boll weevil eradication reduces the market distorting effects of the farm program. The difference between the two farm program scenarios is much smaller for the eradication scenarios compared to the base scenarios. Producers, in general, do not benefit from boll weevil eradication.

The question remains open if boll weevil eradication indeed leads to a higher social utility. The cost-benefit analysis does not account for losses due to inappropriate program management (as occurred this year in the Rio Grande Valley) and environmental consequences of the mass application of insecticides during the program time. Furthermore, the calculation of the net present values assumes no improvement of the alternative (current) boll weevil pest management. If integrated pest management can be improved, the benefits from boll weevil eradication will decline.

The responsible authorities should include the risk and uncertainty of boll weevil eradication in their decision. Applying the concept of decision making under uncertainty, the expected monetary gains from boll weevil eradication have to at least offset the decrease in utility due to risk. This decrease in utility is equivalent to the risk premium a risk averse society has to be paid to in order to accept the risky technology.

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