Modeling Farm and Off-Farm Economic Linkages to Analyze the Impacts of An Area-Wide Insect Management Program on a Regional Economy

by

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Abstract

This study evaluated the impacts of the boll weevil eradication program at the farm level and on the west Tennessee region. Budgets, an acreage response model, and an input-output model were used to evaluate direct and indirect program impacts. The program generates small but positive economic benefits for the region.

Introduction

Because the boll weevil is a major pest in cotton production, farmers in west Tennessee are implementing the boll weevil eradication program (BWEP). The BWEP is a cooperative-government-and-grower-sponsored area-wide insect management program designed to eliminate the boll weevil. The program is being implemented across the U.S. Cotton Belt. Producers must vote to start the BWEP through a referendum. Once the program starts, all producers are required by law to participate. Farmers provide most of the funding for the program with additional funding from state and federal sources.

Prior economic analysis has indicated that the eradication program positively impacts yields, acreage, and production and reduces the cost of production in the areas where it has been implemented (Carlson et al.; Ahouissoussi et al.; Duffy et al.; Haney et al.; Tribble et al.). However, the formal analysis of the effects of the BWEP on a regional economy has been neglected in the literature. While to the individual farmer the BWEP may be economically feasible, its effect on the economic well being of a region is not clear. Information about the direct and indirect impacts of the BWEP on regional employment, output, and income would be useful for decision making. From the perspective of government and program officials, it is important to know the effects of the program in order to allocate limited resources and for planning based on the potential effects of the program on the economic activity of their region. For growers, knowing the effects of the program on the region may provide support for their participation decisions.

This study evaluates the expected economic effects of the eradication program at

the farm level and on the west Tennessee region. The basic premise is that changes in farm production and input use caused by the BWEP will ultimately bring about changes in output, income, and employment in the west Tennessee economy. The specific objectives are: (1) to identify the farm-level impacts of the BWEP; (2) to determine how regional production and prices respond to farm-level impacts of the program; and (3) to estimate the effects of the BWEP on regional employment, output, income, and value added.

METHODS AND DATA

Producers in southwest Tennessee voted to start the BWEP in August 1998. Growers in northwest Tennessee voted to start the BWEP in August 1999. Because the program is being implemented differently for the southwest and northwest regions, separate economic impact analyzes were conducted for these two cotton production areas.

A 10-year planning horizon was adopted for the analysis. The active eradication phase of the program is expected to last 5 years. By the end of this period, the full benefits of the BWEP should be realized. However, program costs are spread out over 7 years to keep the cost at a manageable level for producers. After the active phase is competed, a post-eradication phase is set to begin to prevent boll weevil infestations. Based on the payment schedule of the program, two analytical periods were considered: the BWEP period (years 1-7) and the Post-BWEP period (years 8-10).

Given the sequential relationship among the farm-level, aggregate supply, and regional impacts of the program, a methodological approach that integrates several techniques was developed to evaluate the sequential impacts of the BWEP. Figure 1

presents a schematic of the sequence of impacts triggered by the BWEP and identifies the different techniques used at each stage. The specific methods and data are described next.

Farm-Level Effects. To achieve the first objective of this study, budgets were developed to estimate cotton net returns with and without the BWEP. The baseline budgets denote the net returns in the absence of the BWEP. The baseline budgets were then modified to estimate the impact that the BWEP would have on net returns.

Baseline insect control costs were calculated using data reported by farmers in a 1997 survey about prevalent insect problems, number of insecticide applications, and typical insecticides used for control (Edens et al.). In general, boll weevil and other insect control costs were higher in the southwest because of higher insect pressures. Because of uncertainty about insect costs after implementing the BWEP, two insecticide usage scenarios were developed based on observed insect control trends in states that have eradicated the boll weevil and expert opinions. Under the high insecticide savings scenario, there will be about 51% less applications per year during eradication and 75% less after eradication. For the low insecticide savings scenario, the number of sprays during eradication will be reduced by 30% and after eradication by 65%.

Data to estimate the yield gain from 100% boll weevil control came from a 1997 survey of cotton producers (Edens et al.). Based on the median values of yield damage estimates provided by producers, the yield gain due to the BWEP was assumed to be 70 lb/acre in the southwest and 55 lb/acre in the northwest. Because of uncertainty about how quickly farmers will realize the yield gain, the following scenarios were developed

using expert opinions. For the first year of the program, three yield gain scenarios were modeled: 0%, 50%, and 80% of the total potential yield gain. After the first year, it was assumed that farmers would realize 100% of the total yield gain.

The final item considered in budgeting the BWEP was the cost of the program paid by the producer. The Tennessee Boll Weevil Eradication Foundation, Inc. has projected farm-level program assessments totaling $156.76/acre spread over 7 years for the program in southwest Tennessee (Barker). Because of uncertainty about the farm level cost for northwest Tennessee, two farm-level program cost scenarios were considered: 1) $156.76/acre; and 2) $105.03/acre, which was 67% of $156.76/acre. These are feasible scenarios since boll weevil infestation is lower in the northwest and so the cost of the program is expected to be no greater than for the southwest. There is also an annual cost for containment programs during post-eradication (years 8-10).

Costs for each year of the 10-year period were estimated using the insecticide usage scenarios outlined previously and the APAC Budgeting System (Slinsky et al.). Cotton yield sand prices to estimate gross receipts under the baseline and BWEP yield gain scenarios were generated for a 10 year period using the Policy Analysis System (POLYSYS) model (Tiller et al.). POLYSYS projected yields and prices for each region based on trend projections and supply and demand conditions. For the BWEP scenarios, the same beginning lint yield values from the baseline situation were adjusted upward for each first year yield gain scenario. After year 1, 100% of the yield gain was assumed to be realized and followed trend projections thereafter. Cash inflows and outflows due to the

BWEP for the 10 year period were evaluated using the modified internal rate of return.

Aggregate Supply Effects. Once farm-level changes in costs, yields, and net returns due to the BWEP were determined, the next step was to identify the impacts on regional acreage, production, and prices for cotton and competing crops. To accomplish this objective, an acreage response model was developed for each region to forecast changes in acreage for cotton and competing crops due to changes in relative net returns at the farm level that are caused by the BWEP. The competing crops were corn, soybeans, and wheat. The predicted changes in acreage were then used as exogenous input in POLYSYS to estimate changes in production and prices due to the program.

The following acreage response model was estimated for each region:

$$(1) \qquad \left(\frac{A_{ik}}{TA}\right)_t = \alpha_{ik} + \beta_{ik}\left(\frac{NR_{ik}}{NR}\right)_{t-1} + \gamma_{ik}\left(\frac{A_{ik}}{TA}\right)_{t-1} + \delta_{ik} GP_t + \eta_{ik} T_t + \varepsilon_{ikt}$$

where i is the decision crop given alternative crop j, k is the production region, t is the crop year; $(A_{ik}/TA_k)_t$ is the ratio of planted acreage of crop i in region k to total planted acreage in region k for crop year t, $(NR_{ik}/NR_{jk})_{t-1}$ is the one-year lagged ratio of crop i net returns to crop j net returns both in region k, $(A_{ik}/A_k)_{t-1}$ is the one-year lagged acreage, GP_t denotes government programs at time t, T_t is a trend variable; and ε_{ikt} is the error term.

For each region, the system of equations in (1) was estimated using Seemingly Unrelated Regression and Tennessee yield, price, cost of production, and government program provisions (TDA; USDA-ERS; USDA-NASS). Coefficient estimates were used to predict acreage responses during the eradication and post-eradication periods using net

return ratios obtained for the baseline and program scenarios from POLYSYS projections.

Regional Economic Effects. To achieve the final objective of this analysis, a hybrid IMPLAN input-output (I-O) model was developed using the results from the farm- and aggregate-level analyses and from other information describing the west Tennessee economy. The I-O model was used to estimate the regional economic effects of the BWEP on employment, industrial output, total income, and value added.

IMPLAN was adapted to the two west Tennessee regions by adjusting the regional gross absorption coefficients of the cotton sector production function. Budgets developed to assess the farm-level effects of the program were used in this adjustment. After these adjustments, the baseline output, employment, income, and value added, was obtained.

Based on the estimated farm-level and aggregate production effects, regional impacts were derived by translating those effects into exogenous changes in demand. In order to meet the new levels of demand, production must be readjusted and new output levels would be obtained. Such key relationships can be expressed in I-O terminology as:

$$\Delta X = (I - A)^{-1} \times \Delta Y, \tag{2}$$

where ΔX is the vector of changes in total output, ΔY is the vector of changes in final demand, and $(I - A)^{-1}$ is the inverse matrix of input-output multipliers.

Changes in relative input expenditures of cotton imply changes in intermediate demand of inputs. Expenditure distribution effects due to eradication were captured with the enterprise budgets and were used to adjust cotton sector absorption coefficients.

Sectors experiencing changes in intermediate demand were the input suppliers of cotton. Since changes in the cotton production function also alter the value added coefficients, another related set of impacts originated from changing levels of primary factor payments. These changes directly translated into final demand changes and were proportionally assigned to sectors representing major household consumption expenditures. Once the vector of changes in demand was constructed from the two sources discussed above, impacts on output and other endogenous variables were obtained from (2)

A final set of impacts arose from government funding to the BWEP. Like the farmer's assessment, these funds are used to pay for the operational expenses of the program. This extra funding was directly allocated to the Agricultural Services sector which include establishments engaged in performing insect control services for crops.

RESULTS AND DISCUSSION

Farm-Level Effects. Baseline and projected changes from the baseline for revenues, costs, and net returns during and after the BWEP are presented in Table 1. Results are given for the no first-year yield gain and low insecticide savings scenario (pessimistic scenario) and the high first-year yield gain and high insecticide savings scenario (optimistic scenario).

For the southwest, the BWEP is expected to increase receipts by 12-14% during eradication and by 14% after the program. Total costs rise by 3-5% during eradication but drop by 1-2% after eradication. Insecticide costs decrease by 28-41% during the program but are more than offset by cost increases incurred for program assessments and

ginning. After the BWEP, insecticide costs plummet by 58-67%. Given the expected changes in revenues and costs, net returns double during the BWEP and post-BWEP periods, rising by $39-51/acre (65-84%) and $73-76/acre(133-140%), respectively. The expected rate of return on farm-level investment in the program is 19-21%.

For the northwest, receipts rise by 10-11% during the program and by 11% after the BWEP. Total costs rise by 3-6% during the program and fall by less than 1% in the post-BWEP period. Insecticide costs decline by 20-46% during the BWEP and plunge by 49-65% after the program. Because yield losses and insecticide costs were lower in the northwest, the impact of the program on net returns was smaller. Net returns during the program rise by $25-43/acre (25-42%) and increase by $56-59/acre (58-62%) after the program. The expected rate of return on investment range from 16% to 22%.

Aggregate Supply Effects. The details of the estimated acreage equations are not presented because of space limitations; however, all coefficients had correct signs and had high SUR system R-squares. As an example of short-run elasticity of response, a 10% increase in the ratio of cotton-to-soybean net returns implies a 2.2% and 0.6% increase in cotton acreage shares for the southwest and northwest, respectively. Given that the program is expected to positively impact net returns, the BWEP is expected to expand cotton production in the southwest by 5-7% during eradication and 16% after the program (Table 3). In the Northwest, production is expected to increase 2- 3% during eradication and by 6-7% after the program. No price impacts were found with POLYSYS because of the small acreage response and the small share of U.S. supply produced by Tennessee.

Regional Economic Effects. Total economic impacts of the BWEP are given by the summation of the impacts derived from the input adjustment, aggregate production, and the extra funding events. Output, employment, income, and value added by region is expected to expand in response to the eradication program (Table 3). Most of the total impacts are explained by the gain in cotton acreage net of the farm-level effects of the program. The expected gains in the economic activity during the Post-BWEP period are higher than during the eradication phase.

In the southwest, output will increase by $4.9- 6.5 million and employment will rise by 35-42 during eradication. For the northwest, output is expected to increase $4.6-6.7 million and employment rises by 49-57 during eradication. After the program, output is estimated to climb by $14.2-14.6 million and employment increases by 60-63 in the southwest. In the northwest, output is expected to increase by $13-14.1 million and employment climbs by 75-82 during the post-BWEP period. Likewise, personal income and value added will also report important gains. In relative terms, however, total impacts represent minor increases over the baseline indicators of the whole economy.

An analysis of sector impacts indicates most impacts will be felt by the cotton sector. Other sectors having sizable shares in total impacts include Agricultural Services, Wholesale & Retail Trade, Repair Shops, Farm Machinery & Equipment, and Services. These sectors have stronger linkages to the cotton sector. On an aggregate basis, the agricultural sector experienced the largest relative impacts followed by trade and services.

CONCLUSIONS

Changes in cotton yields and production costs due to the boll weevil eradication program are expected to positively impact farm-level net returns. Given the positive impact on farm-level net returns, farmers are expected to expand acreage by about 47,000 acres (8%) after the program. Input-output analysis indicates that the boll weevil eradication program will generate small but positive economic benefits for the West Tennessee region. Economic activity is expected to expand by about $27 million and total

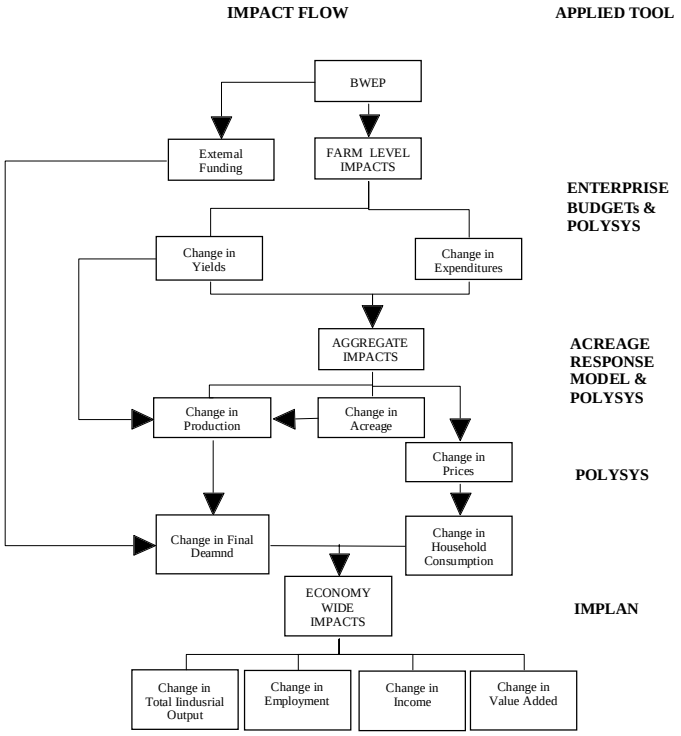

Figure 1. Schematic of the Analytical Framework to Evaluate the Sequence of Economic Impacts Due to the Boll Weevil Eradication Program (BWEP) in West Tennessee.

employment is expected to increase by about 135 after the program is implemented.

Table 1. Projected Changes in Revenues, Costs, and Net Returns for the Boll Weevil Eradication Program (BWEP) for West Tennessee.

Region/Item	BWEP: Years 1-7			Post-BWEP: Years 8-10		
	Baseline	Changes from baseline		Baseline	Changes from baseline	
		Optimistic	Pessimistic		Optimistic	Pessimistic
			Southwest Tennessee			
Revenues:						
Gross receipts, $/acre	476.67	64.37	57.94	473.31	67.13	67.13
Variable costs:						
Insecticide, $/acre	28.75	−11.91	−7.91	28.75	−18.79	−16.67
Ginning, $/acre	48.12	6.51	5.88	50.85	7.21	7.21
Assessment, $/acre	NA	22.39	22.39	NA	7.50	7.50
Other, $/acre	225.81	−1.64	−0.60	225.81	−2.84	−1.96
Total, $/acre	302.68	15.35	19.76	305.41	−6.92	−3.92
Fixed costs:	111.98	−1.64	−0.90	111.98	−2.30	−1.53
Total costs, $/acre	416.20	13.76	18.86	418.93	−9.22	−5.45
Net returns, $/acre	60.47	50.66	39.08	55.92	76.35	72.58
			Northwest Tennessee			
Revenues:						
Gross Receipts, $/acre	504.27	52.96	47.91	500.71	55.51	55.51
Variable costs:						
Insecticides, $/acre	18.54	−8.54	−3.74	18.54	−12.12	− 9.15
Ginning, $/acre	48.12	5.06	4.60	50.85	5.64	5.64
Assessment, $/acre	NA					
Other, $/acre	223.80	−0.68	−0.16	223.80	−1.11	−0.92
Total, $/acre	290.46	10.84	23.09	293.19	−2.59	0.57
Fixed costs:	111.98	-0.66	−0.66	111.98	−0.77	−0.77
Total costs, $/acre	402.44	10.18	22.43	405.17	−3.36	-0.20
Net returns, $/acre	101.83	42.78	25.48	95.54	58.87	55.71

Table 2. Projected Changes in Planted Acreage and the Value of Production (1996 $) for Cotton and Competing Crops Caused by the Boll Weevil Eradication Program for West Tennessee.

Region/ Crop	BWEP: Years 1-7				Post-BWEP: Years 8-10			
	Optimistic		Pessimistic		Optimistic		Pessimistic	
	Acres	Value ($1,000)	Acres	Value ($1,000)	Acres	Value ($1,000)	Acres	Value ($1,000)
Southwest Tennessee								
Cotton	9,954	5,209	7,350	3,803	24,517	12,911	23,548	12,401
Corn	-1,338	-335	-980	-245	-2,780	-743	-2,745	-734
Soybeans	-819	-155	-623	-118	-1,693	-345	-1,669	-340
Wheat	-7,797	-1,085	-5,746	-800	-20,044	-2,908	-19,133	-2,776
Northwest Tennessee								
Cotton	10,841	5,843	6,911	3,692	25,446	13,792	23,504	12,739
Corn	-2,185	-678	-1,563	-485	-5,500	-1,820	-5,326	-1,763
Soybeans	-614	-127	-411	-85	-1,310	-292	-1,264	-281
Wheat	-8,041	-1,151	-4,935	-706	-18,636	-2,780	-16,914	-2,523

Table 3. Projected Total Impacts of the Boll Weevil Eradication Program on Economic Activity in West Tennessee, 1994 $.

Region/ Economic Indicator	Baseline Economy	BWEP: Years 1-7		Post-BWEP: Years 8-10	
		Optimistic	Pessimistic	Optimistic	Pessimistic
Southwest Tennessee					
Output, $	51,356,340,000	6,539,972	4,891,757	14,876,520	14,271,775
Employment	664,522	42	35	63	60
Personal Income, $	21,489,319,776	1,497,938	1,117,644	3,319,806	3,180,997
Value Added,$	28,992,470,000	2,055,403	1,509,084	4,725,146	4,525,129
Northwest Tennessee					
Output, $	16,756,060,000	6,718,986	4,614,318	14,149,129	13,004,432
Employment	224,384	57	49	82	75
Personal Income, $	6,669,960,840	1,743,707	1,262,994	3,422,135	3,144,270
Value Added, $	8,398,490,000	2,338,473	1,622,247	4,720,541	4,327,017

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