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A THREE-YEAR LEVEL STUDY OF THE PROFITABILITY OF CORN AND SOYBEAN PRODUCTION

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A THREE-YEAR PRODUCER LEVEL STUDY OF THE PROFITABILITY OF CORN AND SOYBEAN PRODUCTION

Crop producers face many decisions each year about the quantity and quality of inputs to use, the purchasing of these inputs, and the timing of production operations. Because their time for gathering and analyzing information on which to base management decisions is limited, they need to know which decision areas have the greatest impact on profitability.

A set of detailed and accurate records of production, costs, and returns from a group of producers growing corn and soybeans in Iowa over a three-year period was available from Iowa State University Extension. This information was used to assess the relative importance of various management areas on the profits earned. By comparing time series as well as cross sectional data, the influence of random annual events such as weather is diminished.

The objectives of the analysis that is summarized in this paper were:

(a) to test the stability of the relative economic results of a set of crop producers over time.

(b) to quantify the relative impact of various crop management areas on profitability.

(c) to test the relationships among the various management areas themselves.

Source of Information

The Iowa State University Extension Service began helping Iowa crop producers keep detailed crop enterprise record information in 1986. The program has been refined and expanded over the years. The number of cooperators peaked at 192 in 1992,and included producers from several specially funded integrated crop management projects. Information on costs and returns was summarized by crop, and by fields or other land units defined by the producers.

Gross income from crops consisted of the value of the harvested grain dried to a standard moisture level, the value of any insurance indemnity payments received, and the value of any secondary products such as corn fodder.

Records were kept only through the harvesting season, so the crop was valued at the price actually received if it was sold at or before harvest, or at a standard harvest time price if it had not been sold. This was necessary in order to summarize the results of all producers at the same time. Therefore, differences in profitability caused by post-harvest storage and marketing actions are not reflected in the results that were analyzed.

Production costs were divided into five categories: inputs, land, machinery, labor, and miscellaneous. ***Input*** costs included seed, fertilizer, herbicides and insecticides, crop insurance

premiums, and an interest charge against capital tied up in these inputs.

Land costs were measured three ways. For cash rented land the annual cash rent paid was used. For owned land, the estimated cash rent value of the land was used as a measure of opportunity cost. For crop share rented land, the value of the landowner's share of the crop and other income, minus the share of the input costs paid by the landowner, was used to measure the indirect land cost to the operator.

Machinery costs included both ownership and operating costs. An interest charge was calculated as 5 percent of the current market value of the crop machinery, depreciation was calculated as 10 percent of the same value, and housing was calculated as 10 percent of the current value of machinery storage buildings. These costs, plus the estimated insurance cost for machinery, were aggregated into total ownership costs. Other machinery costs recorded were machinery lease payments, custom hire or rental charges, fuel and lubrication, machinery repairs, and gas and electricity used for grain drying. For each of these the actual whole farm payments were allocated among crops and then among fields, using the recorded hours of field time for each field when available, or a set of standard factors that reflect relative machinery use for each crop.

Labor costs included the actual wages and other hired labor costs for crop production, plus the value of unpaid labor estimated at $1,500 per month. Only labor used for crop production was included. Time spent on crop marketing or livestock production activities was excluded. Labor costs were allocated among crops and fields in the same manner as machinery costs.

Miscellaneous costs included the cost of soil testing, scouting, supplies and small equipment, and other crop related expenses. The whole farm total was allocated equally over all crop acres.

Profit and return to management was the difference between gross income and total costs. In the original summaries government payments and the costs associated with set-aside acres were included with costs and returns to corn production, but they were not included in this analysis, in order to focus on production decisions.

Rankings of Producers

All the producers in the sample were ranked from top to bottom based on profit/return to management per acre. Separate rankings were done for corn and soybeans, and for each of the three years. Rank correlation tests were performed for each pair of years and each pair of crops. For corn, the 1990 ranking and the 1991 ranking were significantly correlated at the .01 level of significance (Table 1). The 1991 and 1992 corn rankings were also correlated at this level. Similar results were found for soybeans, as reported in Table 1. The average change in rankings (absolute value) was 11.4 places from 1990 to 1991, and 12.0 places from 1991 to 1992, in a sample size of 58. The average change in ranking for soybean

producers was 13.6 places between both pairs of years.

Producers who were most profitable in corn production also tended to be most profitable in soybean production. Table 1 shows the correlation coefficients between the corn and soybean rankings, in the same year. In all three years the correlations were significant at the .01 level of significance.

One criticism that is often made of annual cross sectional comparisons of costs and returns to farming operations is that the same farms are not always in the same relative position every year, so that the differences between high and low profit farms may be exaggerated by looking at them one year at a time. The rank correlation tests show that farms do tend to hold their positions over time, despite random influences such as weather.

The variability in profits within the group in each of the three years was measured by computing the standard deviations. The highest standard deviations for both corn and soybean profits were in 1991, a year in which dry weather affected some, but not all, parts of the state. Weather conditions in 1990 and 1992 were more uniform across the state, and the standard deviations in profit among the producers were lower. However, the standard deviation among producers for the three-year average profit per acre was smaller than the standard deviation for any of the individual years, for both corn and soybeans. This indicates that using three-year average results eliminates some, though probably not all, the variation due to random influences such as weather, and more accurately portrays the range in profitability among producers than using single-year data.

Comparisons Among Profit Groups

A traditional approach to portraying the range of results obtained from a sample of producers is to divide them into three equal groups based on profit per unit, and compute the average results for each group. This type of analysis is summarized in Tables 2 and 3, for the data used in this study. The difference in average profit per acre between the high third and low third groups was about $79 for corn and $77 for soybeans. More of this difference was due to differences in gross income for soybeans ($41) than for corn ($34). On the cost side, the high third profit group had the largest advantage in machinery costs, $23 for corn and $19 for soybeans. The advantage in land costs was about $10 per acre for both crops. The high third corn producers spent about $4 less per acre on seed and other inputs than the low third producers, while the high third soybean producers actually spent $4 per acre more.

While comparison of profit groups is a convenient way to summarize the data and get a sense of which management areas are important, it treats all the producers in a group the same. All the variability among producers within each group is ignored. Fortunately there are statistical tools available which do analyze the variability of all the cases in the data set.

Factors Affecting Variability in Profits

When a dependent variable such as profit per acre is determined as an ***identity*** involving several independent variables, such as gross income and costs for inputs, land, machinery, labor, and miscellaneous items, ordinary regression methods yield coefficients of 1.0 for gross income and -1.0 for the various costs, with intercepts and error terms of zero. The regression coefficients can be placed in standardized form by multiplying each one by the ratio of its own sum of squares divided by the sum of squares of the dependent variable. This is equivalent to dividing the variance of each component of the profit identity by the variance of profit per acre, and shows the percent of the total variance contributed by each variable. Some of the total variance of profit per acre is also due to covariance among the independent variables, but if the correlations among these independent variables are weak, covariances will be small.

Table 4 summarizes the breakdown of the variance of profit and return to management per acre among the various cost and income components, for corn. Ignoring covariance, 45 percent of the variability came from differences in gross income and the rest from cost savings. Further, 95 percent of the variance in gross income came from the value of crop production, and the rest from other sources of crop income. Using a method suggested by Burt and Finley to separate the relative importance of two multiplicative variables on the variance of their product, the contributions of yield and price variability to the variability of value of crop production was estimated to be 90 percent and 10 percent, respectively. The low influence of price can be attributed to the fact that the same standard harvest price was assigned to all grain that was not sold at or prior to harvest.

Of the five major cost components cited earlier, machinery was the most important. It accounted for nearly 45 percent of the total variance in cost per acre, excluding covariance. Land, labor, and input costs were roughly equal in importance, contributing 19, 18, and 16 percent of the variance in costs, respectively. Miscellaneous costs accounted for less than 3 percent of the variance. It should be noted that correlation coefficients among each of the five major cost components were all insignificant at the .01 confidence level, allowing us to overlook the contribution of covariance to the total variance.

Corresponding information for soybeans is shown in Table 5. Gross income was a more important determinant of profits for soybeans than for corn, accounting for over 53 percent of the variance in profit per acre. Moreover, 93 percent of the variability in the value of crop production came from differences in yields. This, in turn, contributed 90 percent of the variance in gross income, and other sources (such as insurance payments) contributed 10 percent. On the cost side, machinery was again the most important variable, with land, labor, and inputs also having smaller but similar influences.

Two of the major costs, inputs and machinery, were further broken down into their individual components. For corn inputs, over half of the total variance was due to differences in fertilizer costs, with herbicide expenses next in importance. For soybeans, herbicide costs

had the most impact, over 35 percent, with fertilizer costs a close second at 28 percent.

For machinery costs, roughly two-thirds of the variation was due to differences in ownership costs (depreciation, interest, insurance, and housing). These costs are directly related to the current investment in machinery per crop acre, and could be affected by the age of the machinery set, the degree of excess field capacity, the number of different field operations performed, and the number of different crops produced. Repairs was the next most significant category, accounting for about 14 to 16 percent of total variance.

Relationships and Trade-offs

Correlation coefficients were examined to assess the relationships among certain of the cost and return variables, and some other characteristics of the farms in the sample.

The various crop input cost components (seed, fertilizer, herbicide, insecticide, and crop insurance) were independent of each other for the most part. Exceptions were a positive association between seed and herbicide costs for soybeans, and a negative relationship between seed and insecticide costs for corn. Total input costs per acre were positively related to yield and gross income per acre for soybeans, meaning that producers who achieved higher average yields spent more on seed, fertilizer, and pesticides. This same relationship did not hold for corn, however. Yields and gross income were not significantly related to any other cost components for either corn or soybeans.

Trade-offs between machinery and labor resources in crop production are often assumed to exist. For the 1990-1992 Iowa data the correlation between machinery and labor costs per acre was insignificant for corn, and barely significant (.05 level) and positive for soybeans. This may be explained by the fact that much of the labor charged to crops was for activities other than machinery operations. In fact, both total machinery cost and total labor cost per acre for corn were negatively correlated (.05 level) with total crop acres, indicating that larger farms were spreading both fixed machinery and fixed labor costs over more acres. These same relationships were not significant for soybean production, however, nor were any other production costs per acre significantly related to farm size.

Another hypothesis is that higher fixed machinery costs per acre can be caused by newer machinery, which would in turn reduce repair costs and possibly even lower fuel costs. However, neither repair nor fuel costs were significantly related to machinery ownership costs in the sample. Fuel and repair costs were significantly related to each other at the .01 level, however. The number of field operations performed is one factor that would positively affect both of these variables. The number of field operations was not recorded in the data, however.

Conclusions

Both the separation of variance and examination of correlation coefficients point to

yields and machinery costs as major factors influencing crop profitability. No doubt weather has a significant and basically uncontrollable effect on yields, even when three-year average data is used. Yields are also affected by intangible management factors such as timing of applications, use of correct pesticide combinations, choice of seed, and quality of machinery operations, all of which are difficult to measure by standard accounting data, but make up a major portion of the vague concept called "management."

Machinery costs presumably are more under the control of the operator. However, since ownership costs in particular are not paid in cash every year (except for debt repayment), they may be less visible to the manager. They are also less easily adjusted, particularly downward, since changes in a machinery line usually involve replacing an older machine with a newer one. The authors are aware of some individual cases, however, in which producers who were participating in the Crop Enterprise Record program did reduce their machinery inventories after observing that their machinery ownership costs per acre were considerably higher than the group average. Thus, the ability of the records program to provide farmers with accurate information and a standard of comparison resulted in some profit increasing actions that probably would not have been taken otherwise.

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Table 1. Rankings of the Producers in the Sample, by Profit per Acre.

	1990 Rank vs. 1991 Rank	1991 Rank vs. 1992 Rank	Corn Rank versus Soybean Rank 1990	1991	1992
Corn					
Rank correlation coefficients (1)	0.637	0.626	0.508	0.611	0.479
Average absolute change in ranking	11.4	12.0			
Soybeans					
Rank correlation coefficients (1)	0.445	0.418			
Average absolute change in ranking	13.6	13.6			

(1)all significant at .01 level

	1990	1991	1992	Avg. Profit, 1990-1992	
Standard deviation of profit, corn	41.8	59.8	52.3	34.2	
Standard deviation of profit, soybeans	35.1	57.7	37.2	33.5	

Table 2. Income and costs sorted by profit , for corn ,1990-1992 averages.

		High Profit	Medium Profit	Low Profit	Difference High-Low
Number of farms		19	20	19	
Total crop acres on farm	acres	568	688	489	78.80
Acres planted to corn	acres	242	251	179	63.20
Harvested yield	bu/acre	150.9	142.6	136	14.90
Gross crop income	$/acre	$318.46	$302.29	$284.20	34.26
Value of Crop product	$/acre	313.34	298.65	279.04	34.30
Other crop income	$/acre	5.12	3.64	5.16	-0.04
Price of crop at harvest	$ per bu	$2.09	$2.11	$2.07	0.02
Economic costs					
Inputs	$/acre	$84.68	$90.18	$88.50	-3.82
Land	$/acre	98.35	101.74	108.04	-9.69
Machinery	$/acre	51.74	58.80	75.02	-23.28
Labor	$/acre	21.15	21.16	26.62	-5.47
Miscellaneous	$/acre	4.76	6.48	7.02	-2.26
Total economic costs	$/acre	$260.68	$278.36	$305.20	-44.52
Profit and management return	$/acre	$57.78	$23.93	($21.00)	78.78
Input Cost					
Seed	$/acre	$22.53	$22.03	$23.71	-1.18
Fertilizer and Lime	$/acre	30.26	32.47	30.65	-0.39
Herbicide	$/acre	18.87	20.79	21.55	-2.68
Insecticide and fungicide	$/acre	3.48	3.37	1.88	1.60
Crop insurance	$/acre	3.27	4.84	4.15	-0.88
Interest on input costs	$/acre	6.27	6.68	6.56	-0.29
Subtotal	$/acre	$84.68	$90.18	$88.50	-3.82
Machinery costs					
Machinery ownership costs	$/acre	$24.51	$28.59	$40.58	-16.07
Lease payments	$/acre	0.83	1.40	0.44	0.39
Fuel and lubrication	$/acre	5.90	6.29	6.95	-1.05
Repairs	$/acre	8.64	11.55	13.47	-4.83
Custom hire or rental cost	$/acre	3.11	2.76	5.01	-1.89
Variable drying cost	$/acre	8.76	8.21	8.58	0.18
Subtotal	$/acre	51.74	58.80	75.02	-23.28
Machinery investment	$/acre	$155.67	$194.02	$253.75	-98.08
Labor Cost					
Unpaid Labor	$/acre	$15.67	$17.53	$20.97	-5.30
Hired Labor	$/acre	5.48	3.63	5.65	-0.17

Table 3. Income and costs sorted by profit, for soybeans, 1990-1992 averages.

		High Profit	Medium Profit	Low Profit	Difference High-Low
Number of farms		19	20	19	
Total crop acres on farm	acres	630	526	579	51
Acres planted to soybeans	acres	189	155	171	18
Harvested yield	bu,ton/a	48.5	46.3	43.3	5.2
Gross crop income	$/acre	$276.64	$256.75	$235.27	41.37
Value of crop production	$/acre	268.12	252.58	230.50	37.62
Other crop income	$/acre	8.53	4.17	4.78	3.75
Price of crop at harvest	$ per bu.	$5.54	$5.46	$5.33	0.21
Economic costs					
Inputs	$/acre	$50.10	$49.76	$45.98	4.12
Land	$/acre	96.96	101.16	107.37	-10.41
Machinery	$/acre	40.49	52.86	59.30	-18.81
Labor	$/acre	18.46	24.27	23.71	-5.25
Miscellaneous	$/acre	3.90	5.48	9.22	-5.32
Total economic costs	$/acre	$209.91	$233.53	$245.58	-35.67
Profit and management return	$/acre	$66.73	$23.22	-10.31	77.04
Input costs					
Seed	$/acre	$15.10	$16.13	$13.42	1.68
Fertilizer and lime	$/acre	5.57	4.75	6.34	-0.77
Herbicide	$/acre	19.79	19.83	15.91	3.88
Insecticide and fungicide	$/acre	0.00	0.29	0.03	-0.03
Crop insurance	$/acre	5.93	5.07	6.87	-0.94
Interest on input costs	$/acre	3.71	3.69	3.41	0.30
Subtotal		$50.10	$49.76	$45.98	4.12
Machinery costs					
Machinery ownership	$/acre	$22.90	$32.91	$35.62	-12.72
Lease payments	$/acre	0.75	1.22	0.83	-0.08
Fuel and lubrication	$/acre	5.64	6.34	6.91	-1.27
Repairs	$/acre	8.92	9.66	13.50	-4.57
Custom hire or rental costs	$/acre	2.28	2.73	2.45	-0.17
Subtotal	$/acre	$40.49	$52.86	$59.30	-18.81
Machinery investment	$/acre	$154.13	$212.15	$220.19	-66.06
Labor costs					
Unpaid labor	$/acre	$12.59	$19.73	$21.39	-8.80
Hired labor	$/acre	5.87	4.53	2.32	3.55

Table 4. Explanation of Variance, for Corn 1990-1992.

	Mean	Variance	Percent of Variance Within Group	Percent of Variance Within Costs	Percent of Variance in Profit
GROSS INCOME					
Harvested yield, bushels per acre	143.1	127	89.9%		
Price of crop at harvest	$2.09	0	10.1%		
			100.0%		
Value of crop production	$297.01	620	94.8%		
Other crop income	4.64	34	5.2%		
Covariance		-53			
Total crop income	$301.65	601	100.0%		45.1%
INPUT COSTS					
Seed	$22.76	7	7.6%		
Fertilizer and lime	31.12	48	53.1%		
Herbicide	20.40	16	18.3%		
Insecticide and fungicide	2.91	10	11.2%		
Crop insurance	4.09	8	9.2%		
Interest on input costs	6.50	1	0.7%		
Covariance		21			
Total cost of inputs	$87.78	112	100.0%	16.3%	
LAND COSTS	$102.84	131		19.0%	
MACHINERY COSTS					
Machinery ownership	$31.15	158	65.9%		
Lease payments	0.85	5	2.0%		
Fuel and lubrication	6.43	7	3.0%		
Repairs	11.22	33	13.8%		
Custom hire or rental costs	3.69	23	9.7%		
Variable drying costs	8.52	13	5.6%		
Covariance		68			
Subtotal	$61.85	307	100.0%	44.7%	
LABOR COSTS	$22.98	121		17.7%	
MISCELLANEOUS COSTS	$6.08	16		2.3%	
Covariance among economic costs		47			
TOTAL ECONOMIC COSTS	$281.54	733		100.0%	54.9%
Covariance, gross income and total costs		79			100.0%
PROFIT AND RETURN TO MANAGEMENT	$20.11	1,413			

Table 5. Explanation of Variance, for Soybeans 1990-1992.

	Mean	Variance	Percent of Variance Within Group	Percent of Variance Within Costs	Percent of Variance in Profit
GROSS INCOME					
Harvested yield, bushels per acre	46.0	23	92.8%		
Price of crop at harvest	$5.44	0	7.2%		
			100.0%		
Value of crop production	$250.43	736	89.5%		
Other crop income	5.80	87	10.5%		
Covariance		-63			
Total crop income	$256.23	759	100.0%		53.4%
INPUT COSTS					
Seed	$14.90	11	14.7%		
Fertilizer and lime	5.54	22	28.4%		
Herbicide	18.53	27	35.4%		
Insecticide and fungicide	0.11	0	0.3%		
Crop insurance	5.94	16	20.5%		
Interest on input costs	3.60	1	0.7%		
Covariance		27			
Total cost of inputs	$48.63	105	100.0%	18.0%	
LAND COSTS	$101.82	137		23.7%	
MACHINERY COSTS					
Machinery ownership	$30.37	125	68.0%		
Lease payments	0.96	7	3.5%		
Fuel and lubrication	6.34	6	3.4%		
Repairs	10.75	29	15.8%		
Custom hire or rental costs	2.50	17	9.2%		
Covariance		21			
Subtotal	$50.92	205	100.0%	35.3%	
LABOR COSTS	$22.18	117		20.1%	
MISCELLANEOUS COSTS	$6.19	17		2.9%	
Covariance among economic costs		81			
TOTAL ECONOMIC COSTS	$229.74	662		100.0%	46.6%
Covariance, gross income and total costs		-172			100.0%
PROFIT AND RETURN TO MANAGEMENT	$26.49	1249			