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Input Price and Quantity Components in Low Cost/High Profit Grain Production

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ABSTRACT

This study examines the relationship between the level of chemical inputs and farm profitability. A positive approach is taken to examine the contribution of lower input prices and reduce quantities in low cost farms. We find that the lower cost producers achieve the cost savings and maintain profits through lower quantities of inputs. Moreover, the majority of the input reduction is in fertilizers.

INTRODUCTION

In recent years the environmental impacts of current farm production practices have received increasing attention from the public and the scientific community. Groundwater pollution by NO_3^- associated with crop production is currently regarded as a major national environmental problem (Office of Technology Assessment). A more recent nationwide study by the EPA reported 74 pesticides in groundwater of 38 states (National Governor's Association), and in the last several months the popular press has published survey results indicating fewer than 1% of sample wells exceed levels of concern for pesticides while about 2.5% exceed the level of concern for nitrate.

Increasing environmental awareness has led to an examination of alternative agricultural practices, including reducing tillage and lowering chemical inputs. However, many farmers are reluctant to adopt alternative agricultural systems because they feel that, though their profit margins are narrow, those margins depend on their current use of chemical inputs. From their point of view environmental concerns conflict with profitability. There exists a need to more closely scrutinize this apparent conflict and evaluate the impacts of reducing chemical inputs by adopting alternative production systems.

Griffin and Bromley, as well as Langham, have developed theoretical frameworks for evaluating policy impacts on nonpoint residuals and externalities. Their analyses recognize that policies targeted at specific pollutants may result in increasing use of other inputs--in effect trading the externalities associated with one input for those associated with another. Knutson et al. examined various scenarios surrounding complete bans of groups of chemicals such as herbicides, insecticides and inorganic nitrogen fertilizer. However, a complete ban of chemicals is probably not a realistic policy alternative. In their study, Knutson et al. acknowledge that partial bans would have less economic impact than the total bans examined.

Most discussion of production economics and the neoclasssical production function fail to include the implications and cost of externalities. While it is very difficult, if not impossible in many cases, to value the externalities, the theory does suggest directional changes in resource allocation if environmental costs or other externalities exist. Wintersteen and Higley have made such an attempt to measure and include environmental considerations in determining economic thresholds. However, they consider only the case of an increasing marginal cost of specific insecticides. Approaching the problem using the Langham concept of a residual input tax, and ingnoring possible increased externalities from other sources.

Koenigstein, Hornbaker, and Lins (KHL) examined the relationship between total revenue, investment in chemical inputs and per acre net returns. Their conclusions varied depending on the inherent productivity of the farm's soil. They found that on the more productive soils in Illinois many of the farms reflected an over use of chemical inputs. The farmers appeared to be allocating inputs ineffeciently, or perhaps over applying inputs in an effort to reduce risks to yield. In a follow-up study, Neff et al. evaluated a subset of the KHL sample and also found a systematic overuse of inputs. In this study, a non-parametric approach was used to measure the overuse of input classes including fertilizer, pesticides, seed, labor, capital and land. They concluded that more careful management of the chemical inputs can enhance both profitability and environmental quality.

As in many studies based on empirical data, KHL and Neff et al. did not have access to the specific types, prices and quantities of the chemical inputs. They were limited to examining revenue and expenditure data. Most studies which do evaluate specific chemicals take a normative approach using budgeting and/or simulation (Knutson et al. and Bouzaher et al.). That is, budgets are generated for specific crops, rotations, and/or tillage systems from which cost or profit functions are estimated or policy impacts simulated.

It was suggested in both KHL and Neff et al. that farmers are price takers and therefore that lower cost farms are using lower quantities of inputs. However, data were not available to test this hypothesis. Moreover, even if farmers pay the same price for specific inputs, the lower cost farms may simply be applying a different combination of chemicals or using less expensive chemicals such as atrazine and fall applied anhydrous ammonia rather than more recently released herbicides and spring applied liquid nitrogen.

The objective of this study is to further examine the relationship between the level of chemical inputs and farm profitability. Here we take the positive approach and analyze actual farm data--including information on type, quantity and price of chemicals. We are able to examine more closely the appropriateness of drawing conclusions about quantities from chemical expenditure data. In evaluating these relationships, an approach similar to that used by KHL is employed in which farms are stratified by expenditures on chemicals and seed. Earlier work considered only the relationship between total expenditures for chemicals and profit. This study attempts to determine whether the farmers' expenditures are lower (higher) on fertilizer and chemical inputs because of lower (higher) prices, lower (higher) application, or both.

This paper provides an initial view of the cost and quantities of chemical inputs. It will not answer all the issues summarized above, but it does suggest a procedure for addressing aggregate questions about the types and quantities of chemicals being used.

DATA

Two sets of data are used in this study. One set is four years of financial information from 2,248 farms, out of some 7,000 farms, that participate in the Illinois FBFM (Farm Business Farm Management) Associations. These farms were selected because they provided continuous records from 1987 to 1990. The data provided by the FBFM records are primarily year end financial records for the individual farms. Relevant data examined in the study are: gross crop returns, input expenses, other variable operating expenses, yields, crop acreage, and soil productivity ratings. The soil productivity rating is a 0 to 100 index which indicates, based on soil type, the relative inherent capacity for corn and soybean production. From these data the imputed interest expense and the net crop returns are calculated.

However, the FBFM financial records do not provide information on the prices and quantities of the individual inputs used by the farms. Therefore, in 1990 a subset of the 2,248 farms was surveyed to collect additional information on input prices and quantities, crop rotations, tillage practices, and commodity yields and prices. These records include an accounting of all chemical inputs used in crop production on each of 117 farms during the 1990 production season. The farm prices paid and quantities purchased were collected for fertilizers, herbicides, and insecticides.

PROCEDURES

A procedure similar to that used in the KHL study is used to stratify the 2,248 farms in the parent sample. Due to the range of soil types that exist in the state of Illinois, the farms in the study are first divided into two classes: those farms with a soil productivity rating greater than or equal to 80, and those below 80. Then the farms in each soil productivity class are stratified into quartiles based on the most recent (1987-1990) four-year average of their total expenditures for fertilizer, pesticide, and seed per tillable acre. All dollar values are converted to 1990 dollars using the Producer Price Index price deflator.

Using the more detailed chemical type, price and quantity information available from the smaller subset, three indices are calculated to assess whether farmers are paying a lower (higher) price than average, applying a lower (higher) rate than average, or both, for the chemicals that they use. The three indices are calculated for each of the farms in this subset. The 117 farms are then separated into their respective strata and the indices averaged for each expenditure quartile and productivity class.

Two indices are computed that relate to pesticide use. These indices are calculated on the basis of a bundle of the seven most reported pesticides in the 1990 survey of the subset of farms. Approximately half of these pesticides are used in corn and half in soybean production. Again, this is an initial examination of the price and quantity contribution to cost and later work will examine a more complete set of pesticides. The price and quantity indices are calculated for each farm by:

$$I_j^q = \frac{\sum_{i=1}^{k} \overline{P}_i X_{ij}}{\sum_{i=1}^{k} \overline{P}_i \overline{X}_i} \qquad\qquad I_j^p = \frac{\sum_{i=1}^{k} P_{ij} \overline{X}_i}{\sum_{i=1}^{k} \overline{P}_i \overline{X}_i}$$

where, I^q_j is the quantity index for farm j, I^p_j is the price index for farm j, P_{ij} is the price of the ith pesticide on the jth farm, X_{ij} is the quantity per acre of the ith pesticide on the jth farm, $\overline{P}_i$ is the average price of the ith pesticide, and $\overline{X}_i$ is the average quantity per acre of the ith pesticide. The average prices and quantities are weighted by the quantity of pesticide i used by all farms in the survey sample.

A quantity index is calculated for fertilizer to measure if a farmer is using more (less) than average of nitrogen, phosphorous, or potassium. In order to calculate this index, the actual quantities of nitrogen, phosphorous, and potassium contained in each fertilizer are used.
Fertilizer prices are not included in the fertilizer quantity index, nor is an index calculated for fertilizer prices, due to the difficulty in calculating the individual nitrogen, phosphorus and potassium prices in each fertilizer formulation.

$$I_j^{fq} = \frac{\sum_{i=1}^{k} X_{ij}}{\sum_{i=1}^{k} \overline{X}_i}$$

where, I^{fq}_j is the quantity index of fertilizer for the jth farm, X_{ij} is the quantity of the ith fertilizer for the jth farm, and $\overline{X}_i$ is the average quantity of the ith fertilizer.

The indices for the pesticides and fertilizers are calculated for each farm that was surveyed in the subset of 2,248 farms. With the index information for each farm, it is possible to evaluate why a farm is stratified into a particular expenditure quartile. It is anticipated that those farms in a lower expenditure quartile would have an index less than one. This is because each index is centered around the value one, with indices greater (less) than one indicating that the price or quantity is above (below) average.

RESULTS

A total of 1,141 farms with a soil productivity rating of greater than 80, are included in the first group to be evaluated. Table 1 is divided into quartiles using chemical and seed cost on a per-acre basis (standard deviations are not reported). Mean values for each quartile of farms are \$54.83, \$66.20, \$73.41, and \$86.33, respectively. The relationship of net crop return (gross crop return minus the listed variable costs) to the value of chemical and seed inputs are also depicted in Figure 1.

Based on the 4 year average values, it is clear that quartile 4, the quartile with the highest chemical and seed expense, has the lowest net farm income on a per-acre basis. Net farm income for quartile 4 is significantly lower than quartiles 1, 2, and 3. Also, farms in quartile 4 have the highest production costs per acre for chemicals, seed, machine inputs, interest, and other expenses. This indicates that higher input costs are not necessarily associated with increased overall farm profitability. Figure 1 also indicates that the highest net returns occur around \$60 per acre of seed and chemical inputs.

Farms in quartile 4 have a higher percentage of land in corn, and a lower percentage of land in soybeans than the other three quartiles. This suggests that farms in quartile 4 have higher fertilizer costs than farms in the other quartiles because corn production generally requires more fertilizer. Additionally, higher costs may be associated with a lack of a balanced crop rotation.

The pesticide and fertilizer indices suggest that the quantities of pesticides and fertilizers applied are the highest for quartile 4. Since the price index for pesticides is not significantly different from one, the differences between quartiles in pesticide and fertilizer expense are due to higher quantities being applied, rather than higher prices.

These results suggest that the farmers in quartile 4 can reduce their chemical inputs and increase profitability. Farms in quartile 4 can reduce expenditures on chemicals and seed up to 36% and increase profitability by approximately 5%. Additionally, farmers in quartile 3 can reduce their expenditures on chemicals and seed by 25% and maintain approximately the same level of profitability. Moreover, the price and quantity indices suggest that the majority of gain can be achieved by reducing pesticide inputs rather than fertilizer.

A total of 1,107 farms are included in the group of farms whose soil productivity rating is less than 80. Table 2 is stratified by chemical and seed cost on a per-acre basis. Mean values for each quartile of farms are $47.03, $61.47, $70.73, and $86.22, respectively. Results from this table seem to indicate that an intermediate amount of chemical and seed inputs leads to the greatest profitability.

Figure 1 and Table 2 indicate the farms with the highest chemical and seed expense, are not as profitable as those farms with lower expenses, in quartiles 2 and 3. In addition, the farmers in quartile 4 have the highest mean average for machine inputs, interest, and other expenses. The farmers in quartile 4 may be able to reduce their expenditures on chemicals and seed up to 18% or 29% and realize an increase in their profit of 5% or 3% respectively.

Quartile 1, the quartile with the lowest chemical and seed expenses, has significantly lower profit than the other quartiles. However, it must be noted that the mean soil productivity rating for this quartile is significantly lower than the other quartiles. This may explain why the returns are lower for the farms in quartile 1.

The pesticide and fertilizer indices show that between quartiles differences in prices are insignificant, but there are significant differences in quantities. Quartile 1 has the lowest fertilizer index number and quartile 4 has the highest index number. There doesn't appear to be any pattern between the quantities of pesticides used by the different quartiles because quartile 2 has the lowest index number and quartile 3 has the highest index number. Therefore, it appears that the differences between quartiles in pesticide and fertilizer expense are due to the quantities of fertilizer applied.

CONCLUSIONS

In this study we use a sample of grain farms to examine relationships between input expenditures and farm profitability, and between prices paid and per acre quantities used. It seems critical, in relation to environmental issues, to discern whether low cost producers are achieving low costs from lower prices, lower quantities, different mixes of inputs, or a combination of all three. We find, in examining 4 years of continuous cost and production records from more than 2,200 farms, that the lower cost producers achieve the cost savings and maintain profits through lower quantities of inputs. Moreover, the majority of the input reduction is in fertilizers. The study also suggests that targeted policy could achieve chemical reduction of 15 to 35 percent. Still more work is needed, and underway, to examine the relationships between the mix of chemicals, tillage systems and policy options for reducing use of the more mobile and/or toxic chemicals.

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Table 1. Selected per Acre Operating Characteristics of Illinois Farms with a Soil Productivity Rating Greater than or Equal to 80 and Classified by Chemical and Seed Expense[1]

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Gross Returns	$296.71	$311.38	$317.38	$326.32
Fertilizer	24.38	30.82	34.70	42.33
Pesticides	15.68	18.68	21.12	24.40
Seed	14.77	16.70	17.59	19.60
Fuel and Oil	32.25	31.04	32.59	37.39
Interest	4.79	5.35	5.83	6.80
Drying and Storage	5.69	6.89	5.96	6.96
Net Returns	$199.15	$201.91	$199.59	$188.84
Soil Rating	88.34	89.37	89.33	89.28
Total Acres	614.81	630.57	675.97	596.41
Corn acres %	43.13	45.32	46.91	50.00
Soybean Acres %	40.17	40.28	39.02	33.97
Corn Yield	121.04	128.25	127.74	129.99
Soybean Yield	40.87	42.69	43.29	45.45
Pest Price Index	1.02	.99	1.01	1.01
Pest Quantity Index	.85	1.18	1.19	1.31
Fert. Quantity Index	.75	1.06	1.06	1.08

[1]Sample size = 1,141 Farms

Table 2. Selected per Acre Operating Characteristics of Illinois Farms with a Soil Productivity Rating Less than 80 and Classified by Chemical and Seed Expense[1]

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Gross Returns	$225.33	$260.33	$276.52	$292.37
Fertilizer	22.57	29.66	34.64	43.64
Pesticides	12.17	16.31	19.32	23.36
Seed	12.29	15.50	16.77	19.22
Fuel and Oil	35.99	37.71	40.59	47.32
Interest	4.57	5.45	6.12	7.34
Drying and Storage	2.37	3.36	3.66	4.19
Net Returns	$135.36	$152.33	$155.41	$147.31
Soil Rating	61.98	64.78	65.83	66.06
Total Acres	609.07	708.83	655.92	670.31
Corn acres %	32.06	39.30	41.63	45.12
Soybean Acres %	30.04	32.67	29.12	25.20
Corn Yield	102.81	109.50	113.38	115.91
Soybean Yield	32.61	35.65	37.98	39.93
Pest Price Index	1.00	1.01	1.01	1.00
Pest Quantity Index	.82	.48	1.03	.94
Fert. Quantity Index	.78	.93	1.15	1.31

[1]Sample size = 1,107 Farms

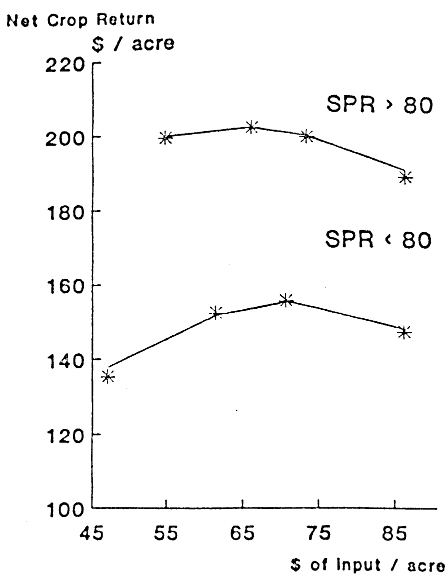

Figure 1. Relationship of net crop returns to value of chemical inputs.