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Abstract

This paper examines the impacts of energy price increases of the use of fertilizer and the allocation of crop acreages between corn and soybeans. Regression analysis is used to estimate yield responses to alternative fertilization levels. A Linear Programming was used to allocate crop acreages under alternative assumptions with regard to fertilizer prices and yield responses.

1. INTRODUCTION

The continued productivity of American Agriculture is highly dependent upon the availability of large quantities of fossil fuel.(4) This study examines the impacts of alternative national energy policies on commercial corn and soybean producers. Particular emphasis is placed upon the impacts of energy policies on the pricing and availability of fertilizers, especially nitrogen.

The implications of federal natural gas regulation policies is carefully documented.(5) "Natural gas is the primary fuel used to produce anyhydrious ammonia and accounts for 96 percent of the 40.9 million British Thermal Units needed to produce a ton of ammonia." (6) Harris points out that the potential for expanded production of natural gas is limited by price and environmental constraints.(3)

Peter Timmer of Stanford pointed out the lack of micro-macro approaches in dealing with fertilizer problems especially in the area of fertilizer demand.(7) Bradford et al. argue that there is a need of an analysis of the interface between national energy policy and agricultural production at the micro or farm firm level since such research effort is important in discerning the total impact of energy policy on the future availability of adequate food supply.(1) Moreover, since the production of corn normally requires heavy applications of nitrogen fertilizer, and the production of soybeans does not, the price and availability of nitrogen fertilizer becomes a major factor in determining whether to produce soybeans or corn.(1)

2. METHODOLOGY

Three distinct but interrelated phases were involved in this study. First, corn and soybean production functions representative of a commercial grain producer were estimated. Test plot data obtained from the Agronomy Department at the University of Kentucky were used in the estimation. Ordinary Least Squares procedures were used to fit a log-linear function of the form:

$$\text{Log } Y = \text{Log } A + \alpha_1 \text{Log } N + \alpha_2 \text{Log } P + \alpha_3 \text{Log } K$$

where,

Y = Some measure of output of corn or soybean

A = a positive constant

N = Some measure of quantity of Nitrogen Fertilizer

P = Some measure of quantity of Phosphorus Fertilizer

K = Some measure of quantity of Potassium Fertilizer

α_1, α_2, α_3 = the production elasticities of Nitrogen, Phosphorus and Potash.

The regression equations were used as the basis for determining corn and soybean yield levels that would conform to alternative application levels of N, P, and K.

In the second phase, alternative assumptions with regard to the pricing and availability of fertilizer that occur as a result of alternative national energy policies were identified. This literature dealing with fertilizer price levels, and projects developed by other authors was used as the basis for developing these assumptions.

Finally, yield levels of corn and soybeans, corresponding fertilizer quantity levels, assumed price for corn and soybeans and total dollar expenditure for each of the nutrients (N, P, K) corresponding to the various quantities of nutrient were developed into a matrix of policies. These assumptions were used in conjunction with a large scale linear programming model to simulate farmer behaviour under alternative energy policies.

2.1 THE LINEAR PROGRAMMING MODEL

The linear programming model used in the analysis was ideally suited for the examination of the impacts of the alternative energy policy assumptions on a commercial grain producer.(2) The basic linear programming model used in the anlysis simulated the management strategy pursued by a manager of a 500 acre farm suitable for corn and soybeans.

The program yields two plans. One plan called the "present plan" reflects the crop acreage allocation before optimation. The other plan is called the "optimal" plan and it shows the profit maximizing acreage allocation within certain acreage limitations. Information generated by the model consists of net returns to management before taxes, acreage allocation to crops and acres not used or rented, shadow prices of resources, labor and machinery utilization and a crop by crop profit and loss statement. In this study, only the information on profits and acreage allocation between corn and soybeans were analyzed.

2.2 ENERGY POLICY ASSUMPTIONS

The matrix of energy policy assumptions used in this study is outlined in Table 1. Prices of fertilizer nutrients are based on assumptions regarding a farmer's alternative price expectations. Total fertilizer expenditures for each crop enterprise were found by multiplying the price per unit of nutrient by the quantity of the nutrient. Crop prices were assumed constant at $2.80 for corn and $5.25 for soybeans. Corn and soybeans yields were derived from data in Figure 1. Hence, acreage allocations between corn and soybeans, total net returns for crops, and profits per acre were obtained from the program as a result of introducing assumptions about nutrient prices and quantities.

3. RESULTS

Results reported here illustrate the impacts of nitrogen price and quantity restrictions. A similar approach was also used to estimate the impacts of increases in phosphate and potassium prices. Crop prices were assumed to be constant at $2.80 per bushel of corn and $5.25 per bushel of soybeans.

3.1 IMPACTS ON PROFITS

Figure 1 illustrates the impact of nitrogen quantity restrictions on profits at various nitrogen prices. Nitrogen prices tested were 0 cents, 14 cents, 25 cents and 30 cents per pound. Quantities of nitrogen applied and corresponding yield levels derived from the estimated corn and soybean functions were 3 pounds per acre and 51 bushels of corn, 50 pounds per acre and 97 bushels of corn, 100 pounds per acre and 119 bushels of corn, 150 pounds per acre and 132 bushels of corn and 200 pounds per acre and 137 bushels of corn. The quantities of phosphorus and potash were assumed to be 50 pounds per acre and a corresponding soybean yield of 42 bushels per acre.

If nitrogen were free, profit levels increase with increasing levels of nitrogen application and optimum quantity and profit levels are very high. If a 15 cents per pound nitrogen price is imposed, maximum corn profits is approximately $278 per acre and the optimum nitrogen quantity is approximately 172 pounds per acre. At 20 cents per pound of nitrogen, optimum corn profits decline by $8 per acre to about $270 with an optimum nitrogen quantity of 167 pounds per acre. Increasing the price of nitrogen to 25 cents per pound yields an optimum profit level of $626 with an optimum nitrogen quantity of about 155 pounds per acre. At 30 cents per pound, the optimum quantity of fertilizer applied is about 150 pounds per acre with an optimum corn profit level of $253 per acre.

Increasing nitrogen fertilizer application levels will increase profits up to a maximum beyond which profits will decline. The quantity level of nitrogen beyond which profits will decline is determined by the prevailing price of nitrogen. The higher the price of nitrogen, the lower the profit level beyond which further employment of additional nutrient will lead to a decline in profit levels. Thus, rising nitrogen fertilizer prices could be a real constraint on increased utilization of nitrogen fertilizer.

3.2 ACREAGE REALLOCATIONS

Assumed nitrogen prices of 15 cents, 20 cents and 30 cents per pound were used to test nitrogen quantity restrictions on acreage allocations between corn and soybeans. Nitrogen fertilizer quantities and the corresponding corn yield levels tested were 3 pounds per acre and a corn yield level of 51 bushels per acre, 50 pounds of nitrogen and corn yield of 97 bushels per acre, 100 pounds of nitrogen and a corn yield of 119 bushels per acre, 150 pounds of nitrogen and a corn yield of 132 bushels per acre, 200 pounds of nitrogen and a corn yield of 137 bushels per acre.

At all prices of nitrogen tested, optimal solutions yielded no acres to corn production when there is no nitrogen fertilizer applied, and 500 acres to soybeans. If the quantity of nitrogen is 50 pounds per acre, 61 acres of land is put into corn production when nitrogen is 20 cents per pound and 3 acres to corn production when nitrogen is 30 cents per pound. The corresponding soybean acres are 439 at 15 cents per pound or nitrogen, 495 acres at 20 cents per pound of nitrogen and 500 acres at 30 cents per pound of nitrogen. When the quantity of nitrogen is 100 pounds per acre, 262 acres are devoted to corn production at both 15 cents per pound and 20 cents per pound. Only 69 acres are devoted to corn when nitrogen is 30 cents per pound. Acreage allocations between corn and soybeans are the same at 15 cents and 20 cents per pound of nitrogen. When nitrogen is applied at a rate of 150 pounds per acre, 309 acres of corn are planted and 191 acres of soybeans are planted. When the nitrogen level is 200 pounds per acre, 310 acres go into corn production and 190 acres go into soybean production. At 30 cents per pound of nitrogen, there is no change in acres allocations if nitrogen application levels is increased from 100 to 150 pounds per acre. Corn acres increase from 69 to 288 acres if the nitrogen level is increased to 200 lbs. per acre.

Either rising nitrogen prices or restrictions in the availability of nitrogen and seriously affect grain production and ultimately our food supply. This is demonstrated by the wide shift in acreages between corn and soybeans with changing price and quantities of nitrogen. More acres are devoted to corn production with increases in nitrogen application levels, but corn production is reduced as nitrogen prices increase.

4. CONCLUSION

A methodological approach for assessing the microeconomic impacts of some macroeconomic issues relating to energy and the agricultural sector was developed. The procedure consists of (1) the identification of macroeconomic policy issues and the resultant meaning in terms of price and quantity restrictions on fertilizer. Parameters of a Cobb-Douglas production function were estimated via regression. Predicted crop yields from the production function representative of a Kentucky farmer producing corn and soybeans were generated. Finally, the fertilizer price and quantity information along with the crop yield estimates were developed into a matrix of energy policy assumptions. These energy policy assumptions were introduced into a linear programming model. Results were analyzed in terms of farmers' profits and acreage allocation between corn and soybeans.

Results indicate a decline in farmers' profits with increasing nitrogen prices. The decline in profits is greater at high nitrogen application rates. Hence, government policies that place restrictions on fertilizer prices could ultimately destroy incentive bases and a decline in grain production. The results also indicate shifts in acreages between corn and soybeans with increasing nitrogen prices and quantities. There is a significant shift to soybean production with nitrogen price and quantity restrictions.

REFERENCES

(1) Bradford, G.L. and D. Debertin. "Impacts of Restricted Energy Inputs on Profitable Resource Allocation in Soybean Production." Proposal submitted to the Cooperative State Research Service. March 1, 1976. PP. 1-18.

(2) Debertin, D. et al. "Kentucky's Advanced System Approach for Improving Corn and Soybean Profits with Computer Software." University of Kentucky Agricultural Experiment Station, Lexington, Kentucky.

(3) Harris, W.L. "Energy and the U.S. Food System." Proceedings of Conference-Workshop. Southern Regional Education Board. Atlanta, Georgia. Oct. 1-3, 1975. PP. 90-98.

(4) Pagoulatos A. and John F. Timmons. "Alternative Scenarios of Energy Use in U.S. Crop Production." Southern Journal of Agricultural Economics. December 1977. PP. 9-16.

(5) Project Independence Report. Federal Energy

Administration, Washington, D.C. November 1974.

(6) Sub-Committee on Agricultural Credit and Rural Electrification Report. "The U.S. Food and Fiber Sector-Energy Use and Outlook." U.S.D.A. September 20, 1974. PP. V-IX.

(7) Timmer, Peter C. "The Demand For Fertilizer in Developing Counties." Food Research Institute Studies, XIII, 3, 1974.

BIOGRAPHIES

David L. Debertin is Associate Professor of Agricultural Economics at the University of Kentucky. He received his Ph.D. in Agricultural Economics from Purdue in 1973. His specialities are resources and production economics.

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Table 1. Matrix of Energy Policy Assumptions Used in the Analysis.

Price of Nitrogen Per lb.	Quantity of Nitrogen	Corn Yield Per Acre (bu.)	Soybean Yield Per Acre (bu.)	Acres of Corn	Acres of Soybeans	Profits Per Acre Corn	Profits Per Acre Soybeans
$.00	0	51	42	0	500	$ 0	$314
.00	50	97	42	0	500	0	314
.00	100	119	42	404	96	266	289
.00	150	132	42	319	181	297	103
.00	200	137	42	319	181	300	103
.15	50	97	42	62	438	203	103
.15	100	119	42	404	96	256	289
.15	150	132	42	386	114	275	103
.15	200	137	42	310	190	270	103
.30	50	97	42	0	500	0	342
.30	100	119	42	69	431	206	343
.30	150	132	42	69	431	253	265
.30	200	137	42	288	212	242	102

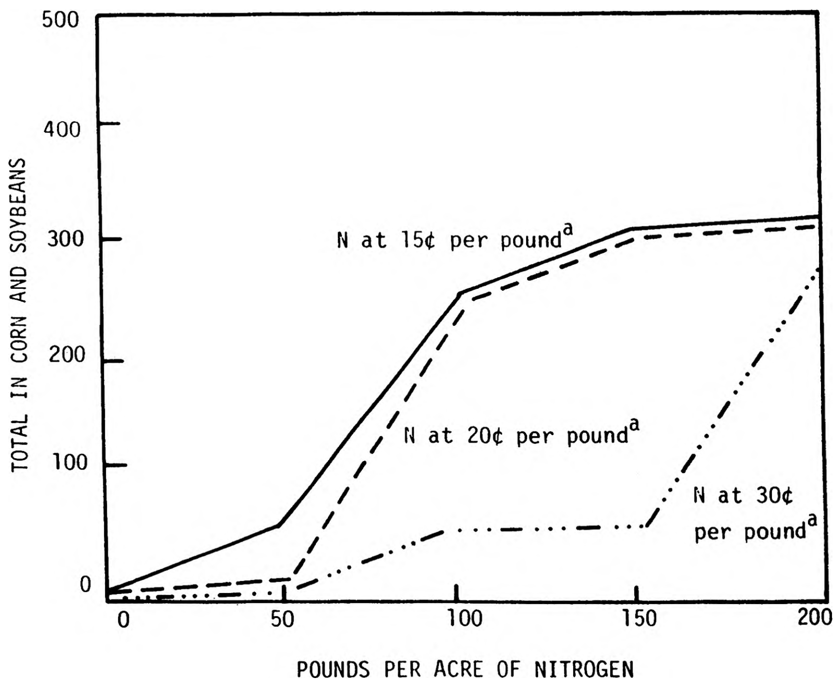

Figure 1. Effect of Nitrogen Restrictions on Corn-Soybean Acreage Allocations.