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AN OVERVIEW OF POTENTIAL IMPACTS OF CHANGING PETROLEUM ENERGY PRICES ON GRAIN FARMS

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Abstract

Since the early 1970s world fossil fuel energy prices have risen dramatically. Assuming there is no significant breakthrough in energy technology, the world will see further increases in energy prices. These changes will likely lead to economic adjustments in U. S. agriculture. A firm level linear programming model is used to evaluate what some of these adjustments could be on a Missouri grain farm. To obtain expected energy price affects on production mixes, energy prices are changed parametrically. Potential crop adjustments are from corn to single-crop soybeans to wheat as energy prices increase. Fertilization adjustments are from chemical to organic. Fuel consumption was inelastic with respect to price. Overall energy utilization was most responsive at two price levels--a fourth above 1975 and three times 1975.

1. THE ENERGY SITUATION

Rapid industrialization during this past century has continually increased the rate of usage of world petroleum energy deposits. Projections have been made showing that: (7)

(1) 90 percent of the world initial supply of coal will be depleted by the year 2300 or 2400.
(2) 90 percent of the world initial supply of oil will be depleted by the year 2020 or 2030.
(3) 90 percent of the U. S. initial supply of oil will be depleted by the year 2000.
(4) 90 percent of the U. S. initial supply of natural gas will be depleted by the year 2015.

Based on this projection, fossil fuels will inevitably be exhausted within a few centuries or even decades for some fossil fuel types. Given these projections and the high rate at which fossil fuels are presently consumed suggests that major adjustments in sources of energy supply will have to be made in the future if present energy consumption rates are to be maintained or even increased.

1.1 OIL SITUATION

Prior to 1950, the United States was the world's major oil producer, producing almost 2/3 of the world output.(8) However, this situation has changed over the last 25 years to where the U. S. now produces

less than 1/4 of world oil output. Since 1970, U. S. oil output has decreased in absolute terms also and she has become a large net importer of oil.

Since 1973, the world oil market has been dominated by OPEC (Organization of Petroleum Exporting Countries) which controls 90% of oil international trade. With this type of control, OPEC has implemented large increases in oil prices. These prices have increased from $2.60/barrel in September, 1973 to $10.50 in 1974, and then $12.00 in 1976. Given the increasing dependency of the United States on the world oil market, the price of petroleum products in America is likewise very much affected by world oil prices. Considering this and that world oil price is likely to go up still more in the future, prices for American consumers will also increase in the future.

Therefore, unless there is a great technological innovation, the general trend of oil prices will be upward in the next few decades. In the long run, these higher energy prices will most likely increase the relative importance of energy for the agricultural production process. The relative cost of fuel for transportation, heating and drying, and of petrochemicals products such as nitrogen fertilizers and pesticides will rise. Farmers in turn will adjust to this new situation.

2. ADJUSTMENTS OF MISSOURI FARMS TO HIGHER ENERGY PRICES

2.1 INTRODUCTION

A recent study was made of the potential adjustments profit-maximizing Missouri grain farms would make in responding to relatively higher energy prices.(2) The objective was to estimate changes in selected production practices, resource uses, and enterprises which would accompany energy price changes at levels ranging from zero (free energy) to five times 1975 prices. Prices for products produced were assumed to remain constant at all energy price levels. Thus, in relative terms, the energy price increase represented a wide range. Results are applicable to relative input-output prices and not necessarily to absolute energy price levels.

The four input factors tied directly to petroleum energy price changes were fuel, propane, chemicals and nitrogen fertilizer. Each of these inputs are highly dependent upon fossil fuels as the base stock and there was assumed to be a direct relationship between these input prices and the price for fossil fuels. For example, it was assumed that a doubling of the energy price would lead to a doubling of the price of each of the four inputs. It is recognized that this assumption is influenced by changing short run and long run demand and supply conditions for each product as a result of changing input and output price levels. In addition, the amount of further processing of each product will affect this relationship. Prices for products such as chemicals and fertilizers which typically have a relatively greater amount of further processing than does fuel or propane would be affected to a smaller degree by a given change in energy prices.

2.2 THE MODEL

A firm-level linear programming (LP) model was used to analyze potential production adjustments to energy price changes. The model was structured to maximize income over variable costs subject to given resource constraints and selected input and output prices. An implicit assumption is

that the production mix chosen would not affect other (fixed) costs. Costs such as machinery depreciation and land charges are treated as fixed.

As a modeling tool, LP permits selected information within the model to be changed parametrically. In the study, the energy price was varied parametrically while holding other information and assumptions constant. The observed solutions were used to determine potential impacts of energy price relationships on production mixes and technologies.

Production activities studied were those typically found on a Missouri grain farm. Crops were corn, soybeans and wheat. Pasture, silage and hay production along with selected livestock operations were also taken into consideration. Production practice alternatives centered around fertilization, tillage, and chemical treatments. Data were obtained from farmers, technical specialists and cost of production studies. Prices received for products were average projected prices for the 1976-78 Missouri production period and were as follows: corn - $2.15 per bushel, soybeans - $4.75 per bushel and wheat - $3.00 per bushel. It was assumed that the farm included 400 acres of land with the labor and machinery complement equivalent to that commonly found in Missouri. Labor was divided into two month segments with 480 hours of labor available over each segment. All land was capable of continuous row cropping.

2.3 IMPACTS ON CROPS

As the relative energy price index increases, a noticeable acreage substitution occurs first from corn and double cropped soybeans-wheat to single-crop soybeans, then to single-crop wheat.* Corn, a large user of energy, is well suited to low energy prices whereas soybeans, which use relatively less energy, compete better at average energy prices (index of 100-300). Wheat, a relatively low energy-demanding crop, displaces both at the highest energy price levels (index of 300-500).

Although single-crop soybeans entered the plan only at the intermediate energy price level, soybeans double cropped with wheat came in at all energy price levels. However, double cropping became relatively less important at the higher energy prices.

At the high energy prices corn acreage became small with all the corn produced being utilized by a cattle feeding enterprise. Without the availability of livestock feeding, it is doubtful that any corn would remain at the highest price index levels.

2.4 LIVESTOCK IMPACT

The livestock activities were heavy feeders (Figure 2) following the trends of corn and corn silage used in cattle feeding.

Cattle feeding was most developed at the energy price index range between 120 and 320. Within this price range approximately 160 head of cattle were fed per year. Outside of this price range, cattle feeding (about 40 head per year) was of much less importance, either because it was more profitable to sell the corn (for a low energy price) or because corn was becoming too costly to produce (for a high energy price).

*The terms energy price and energy price index will be used as synonomous terms in this report. (See Figure 1.)

Figure 1. Energy Price Effects on the Crop Production Mix of a 400-Acre Missouri Grain Farm

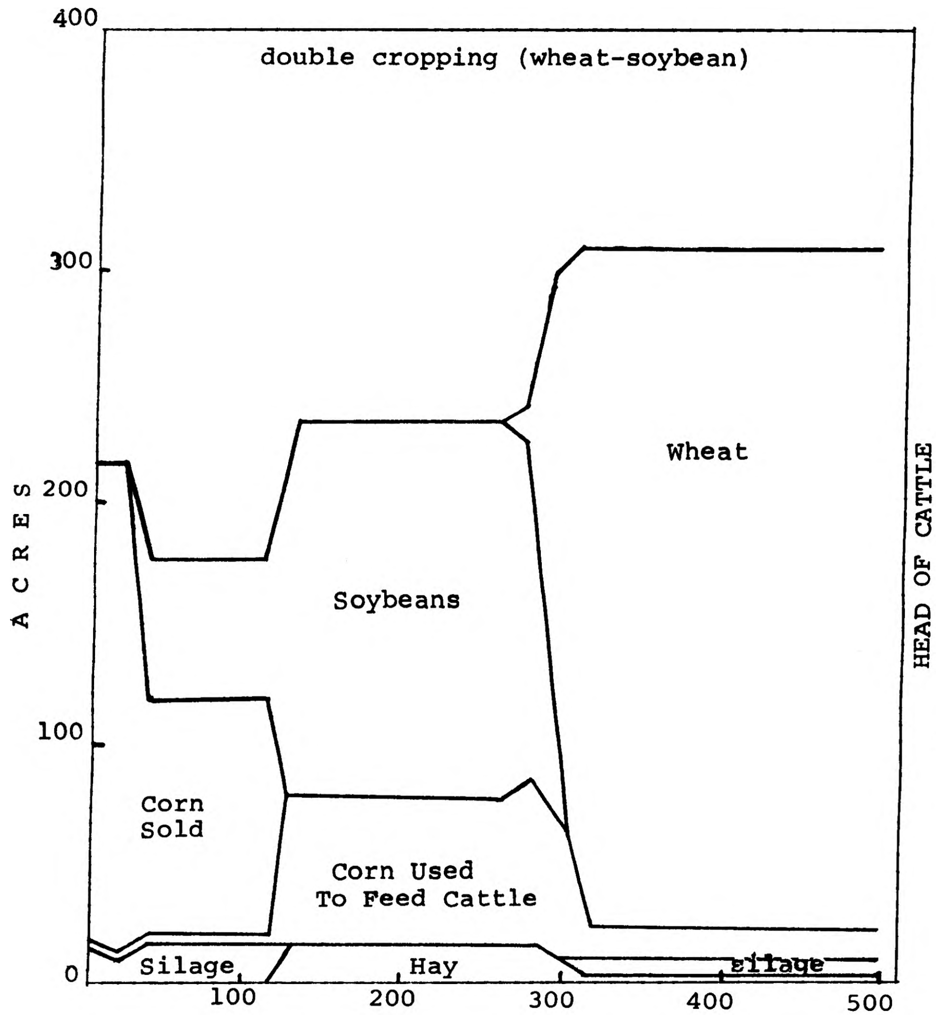
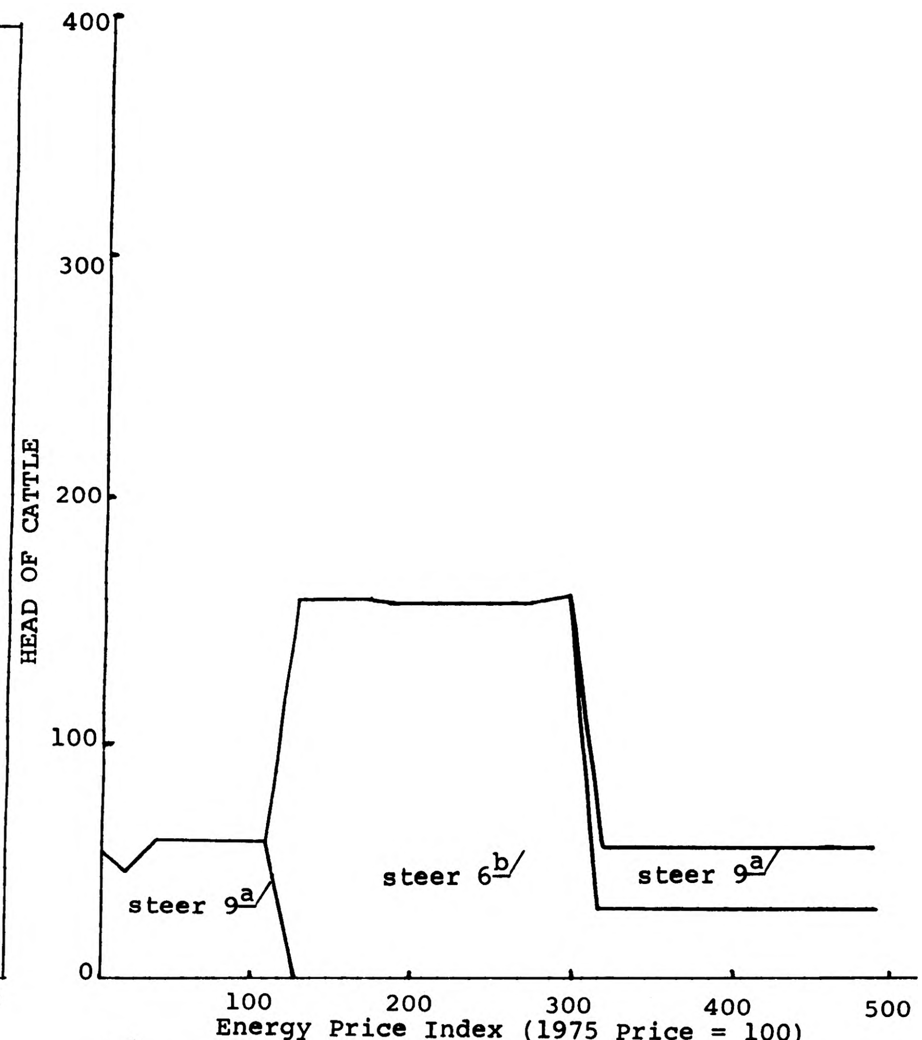


Figure 2. Energy Price Effect on the Livestock Operation of a 400-Acre Missouri Cash Crop Farm



a/ steer 6= from 750 to 1125 lb. in 5-6 months, choice grade, fed with corn and a little hay.

b/ steer 9= from 750 to 1150 lb. in 7 months, fed with silage and a little corn.

2.5 ENERGY CONSUMPTION IMPACT

Energy consumption varied by type of energy product being used (Figure 3). For example, utilization of fuel (gasoline, diesel, and LP for tractors, trucks and combines) is affected very minimally by energy prices. Propane use, (primarily crop drying) on the other hand, is highly responsive to energy prices. For example, at an energy price index of 500, fuel consumption is about 85 percent of 1975 consumption, while at the same price index, propane consumption is only about 8 percent of 1975 consumption.

Estimated utilization of chemicals also proved to be quite responsive to price. Chemical usage of course varies with tillage practices. At the higher costs, the model chose less chemical-intensive production practices.

2.6 IMPACT ON FERTILIZATION

As an example of how energy prices affect rates of mineral fertilization, "best" solutions were calculated for corn. At low energy costs, nearly all the corn was fertilized relatively heavily (Figure 4). As energy price increased, the fertilization rate decreased. At the highest prices, all corn fertilization was organic, coming from the associated cattle feeding operation. No provision was made in the problem for purchase of manure.

2.7 IMPACT ON TILLAGE SYSTEM

The study revealed more about tillage systems when double-crop soybeans were evaluated. To interpret the results for double-crop soybeans, it must be recognized that no-tillage requires heavy applications of chemical herbicides. These chemicals incorporate much fossil fuel energy in their manufacture and are relatively expensive. At extremely low energy prices the preferred system was no-tillage with 15-inch rows (Figure 5). At a price index of 20-140 (which spans prices of recent years) the plan recommends minimum tillage with 15-inch rows. At a price higher than an index of 140 minimum tillage continued but with 30-inch rows--rows capable of being mechanically cultivated. With the 30-inch rows there is a mechanical for chemical weed control substitution occuring.

Hence we find a marked response to energy prices primarily through its effect on the price of chemicals. A no-tillage system uses a relatively large quantity of chemicals and it is selected only when energy prices are extremely low. At the higher energy price index, a switch is made to minimum tillage (15-inch rows), which is a lower chemical-using activity; and then (at highest energy prices) to 30-inch rows which substitute mechanical for chemical weed control.

Corn tillage systems followed fertilization patterns--no tillage being preferred with chemical fertilizers and conventional tillage with organic fertilization. Changes in tillage methods for organic fertilization were not allowed.

2.8 IMPACT ON PER ACRE YIELDS

As would be expected, energy price increases led to lower yields per acre. For corn, the basic factor leading to reduced yields was lower per acre fertilization rates-- more specifically, nitrogen. As the energy price increased, levels of chemical nitrogen application per acre declined from 200 pounds, to 150 pounds and then to 110 pounds. Respective yield reductions were from 110 to 100 to 90 bushels per acre. Yields for double cropped soybeans were influenced primarily by row width. As the energy price increased, row width went from 15 to 30

Figure 3. Response of Fuel, Nitrogen, Chemical and Propane Usage to Energy Prices for a 400 Acre Missouri Grain Farm.

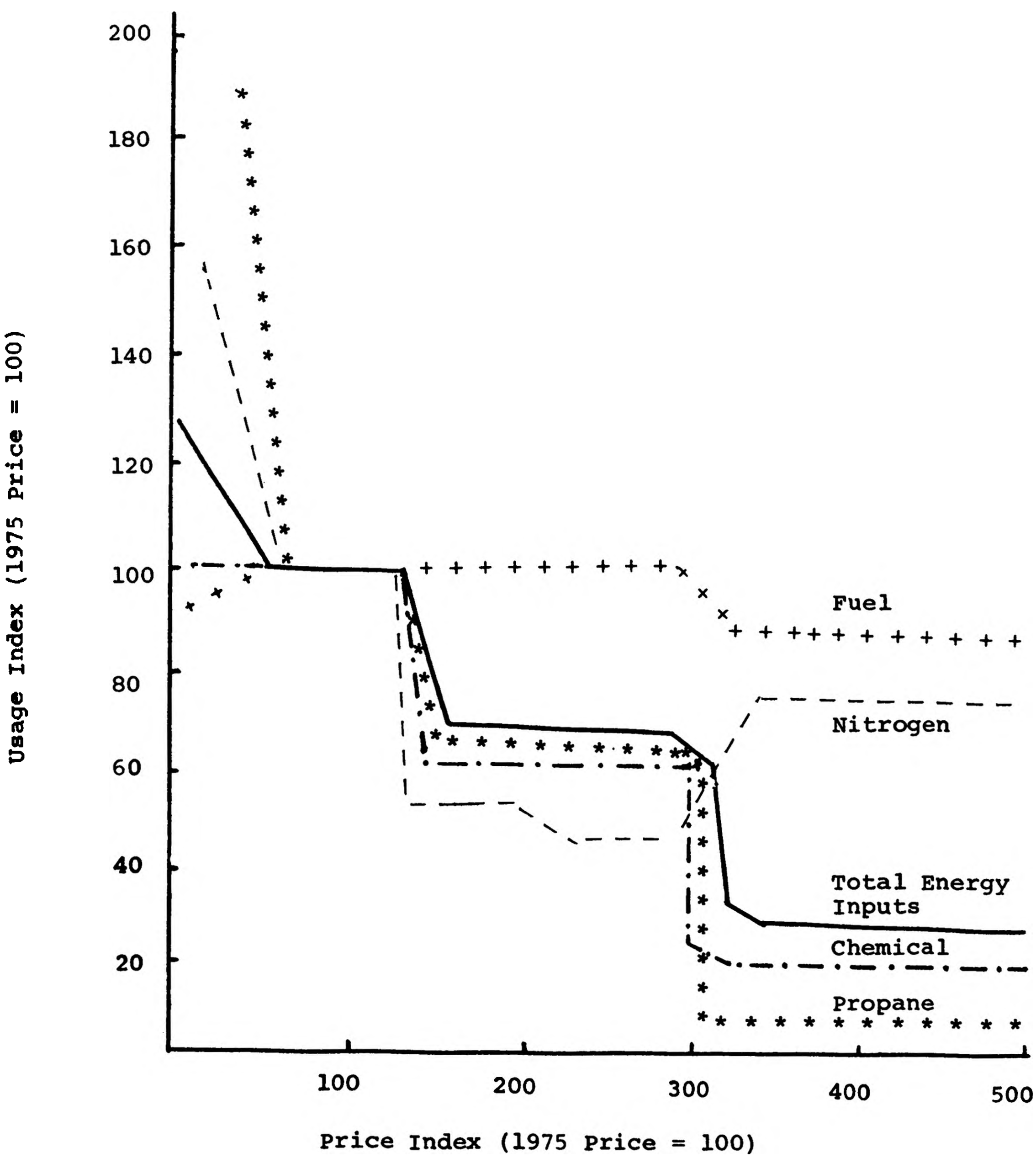
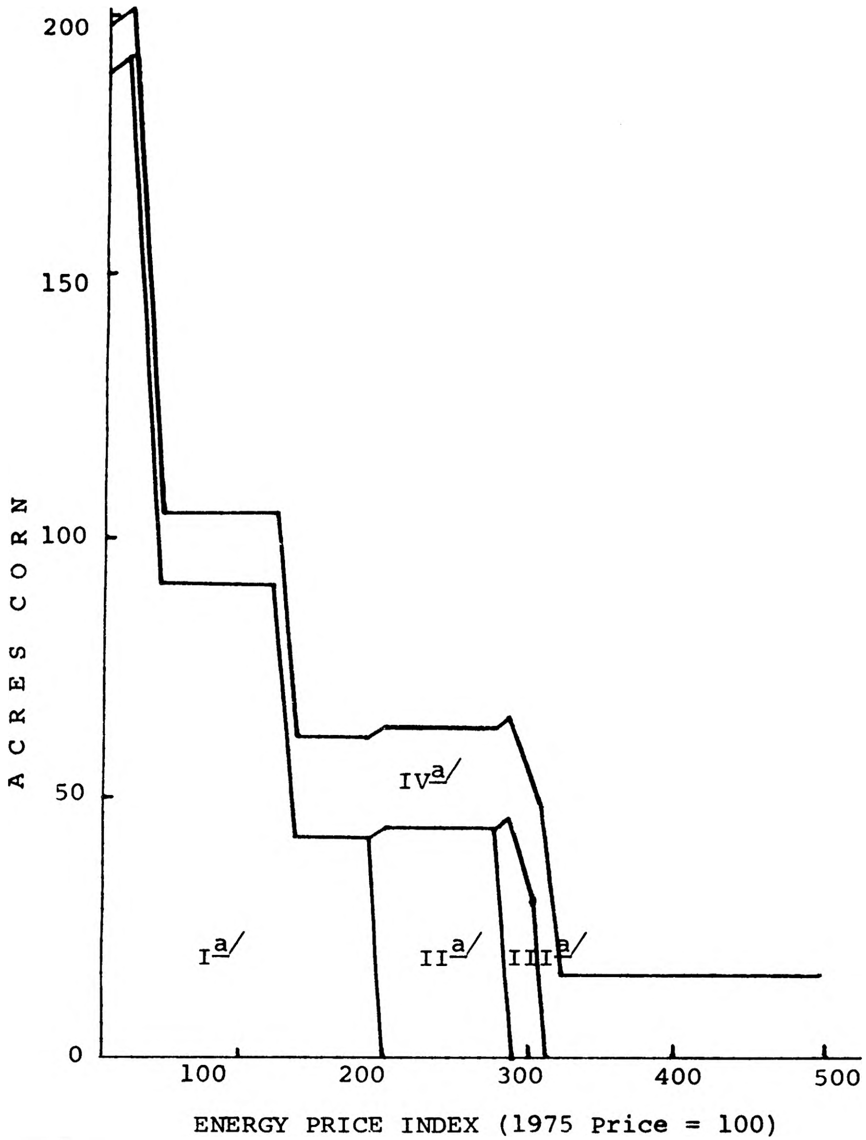
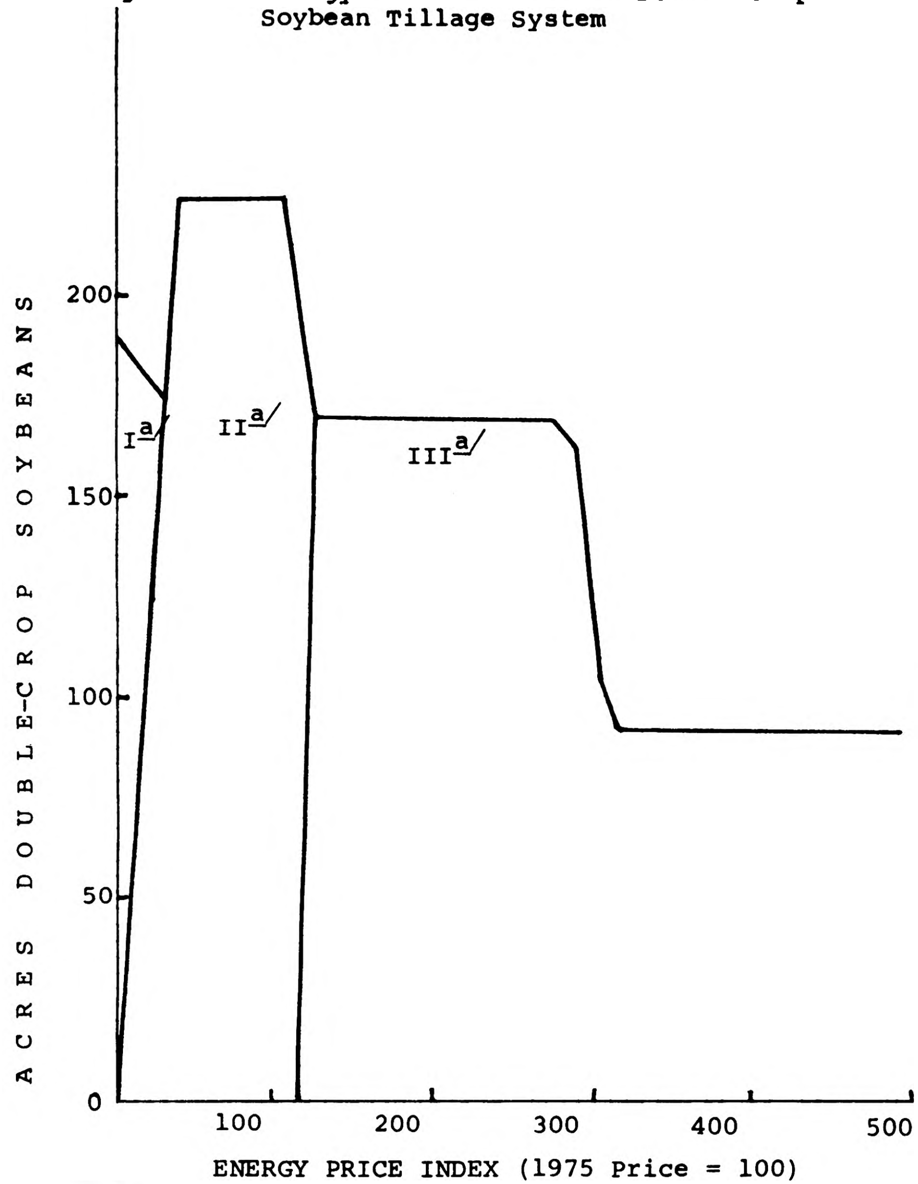


Figure 4. Energy Price Effects on Corn Fertilization



a/ I corn, no tillage, NPK = 200-80-100 110 bu/acre
II corn, no tillage, NPK = 150-60-75, 100 bu/acre
III corn, no tillage, NPK = 110-44-55, 90 bu/acre
IV corn, conventional tillage, 20 T. manure/acre, 100 bu/acre

Figure 5. Energy Price Effects on Double Crop Soybean Tillage System



a/ I Soybeans - no tillage, 15" rows, 23 bu/acre
II Soybeans - minimum tillage, 15" rows, 23 bu/acre
III Soybeans - minimum tillage, 30" rows, 20 bu/acre

inches and per acre yields declined from 23 to 20 bushels per acre.

2.9 IMPACT ON THE PRICE OF FOOD: THE CASE OF CORN

The shadow price of corn produced on the farm increased from $2.15 to $2.79 per bushel as the energy price index increased from zero to 500. Keep in mind that once the shadow price for corn is above its market price ($2.15), the value is with respect to cattle feeding enterprise.

Above an energy price index of 100, the shadow price of corn increased rather steadily. Corn used to feed cattle becomes more valuable because cattle activities are affected to a smaller degree by the energy price increase as compared to other activities. This also means that when the energy price index increases beyond 100, the corn produced on the farm is not sold but used in feeding cattle.

Thus, given an increase in price of energy, one would expect an increase in the market price for corn. If not, it would be consumed on the farm in which it was produced and none would be sold.

In conclusion, higher energy prices would, in the short run, increase costs of production and decrease farm income. Over time, the market would react, and food prices would in turn increase, in the long run, especially if there is a strong demand for food products. However, the increase in food prices may not be uniform as it would be influenced by the respective elasticities and cross-elasticities of demand and supply.

3. SUMMARY AND CONCLUDING REMARKS

If there is no significant breakthrough in energy technology in the years ahead, the world is likely to see rather regular increases in the price of energy in its various forms. Farm input industries that use fossil fuels as feedstock will unavoidably be affected; and their cost increases will at least in part be passed on to the farmer. Therefore, the question is raised as to how farmers can and will adjust their production patterns to changing cost-price relationships.

According to the admittedly selective study reported here, potential adjustments for a Missouri grain farm would be a successive substitution from corn to single-crop soybeans to wheat. Fertilization adjustments would be from mineral to organic forms. However, this latter adjustment would be limited by availability of organic fertilizers. For double-crop soybeans, the data indicate a response in chemical practices and tillage methods, primarily a transition from less to more intensive tillage practices with higher prices. Specifically, lowest cost energy calls for no-tillage with chemicals; highest prices, minimum tillage with mechanical cultivation substituted for chemicals. Corn production responded with adjustments to less chemical fertilizers, and finally to organic fertilizers only at very high energy prices.

Silage and hay production on the grain farm was of little importance at any energy price level.

Beef production on grain farms in Missouri would depend heavily on the price of corn and on the amount of corn produced. As corn acres and yields decreased in line with high energy price, beef production also declined. Corn is a crop that is highly responsive to nitrogen fertilizer, a fertilizer obtained from natural gas.

Fuel consumption was found to be affected

very minimally by price increases while chemical, propane and nitrogen fertilizer consumption was affected to a greater degree.

The extent of change in cultural practices will be moderated somewhat as the price of food responds to the lag in production even as the pressure of population in the greater part of the globe will tend to hold demand up. The increase in food price will not be uniform. Among other reasons, the allocation of acres among different production systems will change.

The study was limited in scope, and only the more general indications are trustworthy. Nevertheless, the changing energy situation is likely to involve important shifts in economic relationships among the energy industry, the farm input industry, and farmers--and ultimately the food industry and consumers, too. Some of the changes in production on Midwest grain farms may go in the general directions described here. It will be a great challenge to avoid starvation in various parts of the world in a situation of increasing energy price.

Finally, given the expected energy situation, aside from usual concerns for efficiency in energy use, research should be directed toward improving energy conservation, with emphasis on:

(1) transference of the symbiotic nitrogen fixing micro-organisms of legumes to other plants;
(2) transference of the nitrogen fixing ability of these micro-organisms to other micro-organisms;
(3) augmentation of nitrogen fixing activity of micro-organisms in soils;
(4) improvement of efficiency of photosynthesis;
(5) improve reproduction of animals through genetics, to have a better utilization of feeds;
(6) methods of production of methane from farm waste, or alcohol from farm products.

Energy conservation may be a success in agriculture only if we utilize our growing scientific knowledge to bring about a new type of agriculture.

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BIOGRAPHIES

Jean-Paul Chavas is a Research Assistant at the University of Missouri-Columbia. A native of France, he received his Ingenieur en Agriculture Degree from the Institut Superieur d' Agriculture, Rhone-Alpes, Lyon, France. He is currently a research assistant working on his Ph.D. in Agricultural Economics at the University of Missouri-Columbia.

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