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Impacts of Fuel Pricing and Non-Price Allocation Scenarios On High and Low Risk Crop Producers

by

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ABSTRACT

Since the substantial increases in energy prices and the realization that the United States economy is heavily dependent on foreign oil, there has been much debate on needed oil policies. These debates have centered primarily around two alternatives--price and non-price rationing. Absorption of these policy impacts are not necessarily uniform among firms.

This study summarizes the impacts on high and low risk crop producers as a result of governmental non-price fuel allocation levels versus fuel price increases to conserve fuel. For high risk crop producers fuel price increases had little or no impact on their fuel usage levels. Fuel prices and non-price allocation strategies were both effective in cutting fuel usage by low risk producers.

IMPACTS OF FUEL PRICING AND NON-PRICE ALLOCATION SCENARIOS ON HIGH AND LOW RISK CROP PRODUCERS

Introduction

Since the early 1970s there has been much debate and/or rhetoric on oil policy development within the United States. The United States is heavily dependent on oil as a source of energy for producing food, fiber, and manufactured goods, and generally, for providing the comforts of every-day living. Two points of concern are (1) oil is a stock rather than a flow resource, and (2) the U.S. economy is heavily dependent upon foreign oil. Supplies and prices for foreign oil are closely tied to economic and political stability in exporting countries--some of which can be unpredictable. Additionally, the foreign oil supply is controlled by the oil cartel OPEC, which has been increasing oil prices regularly. As pointed out by Breimyer, decisions regarding a depletable resource such as oil, involve how much to withold for later sale and how much to deliver (2).

U.S. oil policy debate has centered primarily around two basic approaches. One is to decontrol oil prices and allow prices to fluctuate according to supply and demand conditions. The second is to control oil prices governmentally and allocate oil supplies among consumers via non-price administrative rationing. With a non-price rationing procedure a mechanism would need to be devised that would allocate scarce fuel supplies among consumers in an equitable and socially beneficial manner.

All sectors of society are affected to varing degrees by either policy action. Recent research has focused on evaluating impacts on selected society sectors under specified oil use scenarios. These studies have ranged from policy implications of selected energy scenarios (5,12,13), energy usage in agricultural production and technology (1,4,6,8,14), and adjustments in farm businesses from energy price increases (9), to impacts on machinery technology in agriculture (11).

It has been indicated by government officials that agriculture will receive a high priority ranking in fuel allocation and receive adequate fuel for food production. Therefore, with a non-price administrative rationing program the first priority would be defining what is an adequate level of fuel availability. The meaning of ample fuel for food production is not completely clear. There can be fuel waste in food production just as in any other sector of society. It would not be in society's best interest to allocate fuel production for food production if food were produced through inefficient fuel technologies. Social benefits may be better served through governmental incentives that would promote more efficient use of scarce fuel supplies in food production. Examples would include tax incentives for more fuel efficient food production technologies; solar heating facilities for livestock production; solar drying of crops, etc.

Another aspect of energy policy is the policies impacts on risk management. Risks may be shifted between society sectors but risk levels to society tend to remain constant. When comparing effects of selected oil policies between sectors or possibly within subsectors of the economy, a measure of risk would increase its validity. When decisions are made at the macro (policy) level, impacts of those actions are absorbed by the micro units (firms or households) comprising the economy. In addition, absorption of the impacts of policy decisions is not necessarily uniform among crop producers. First of all, producers may have differing resource bases. Also, producers with similar resource bases may produce different crop mixes. Risk assessment and level of risk absorption are factors that cause these differences. When making policy decisions it is important that differences in these impacts be considered. Many studies, though they provide essential insights, were macro oriented and utilized methodologies that did not embody risk. Expected returns and costs are assumed to be known with certainty.

This study summarizes the incidence of impacts on high and low risk crop producers as a result of governmental non-price fuel allocation versus fuel price increases to conserve fuel.[1] These are two policy actions which will meet the broad policy goal of conserving fuel. Equitability of impacts under non-price fuel allocation and pricing scenarios are examined for farmers with different risk aversion levels. Equitability as used in this study refers to changes in expected income and the variability of that income.

Methodology and the Model

To evaluate these impacts, farm size was assumed to be 400 acres with all labor supplied by the operator and family. Machinery and equipment complements were assumed to be comparable to those available on a typical 400 acre Northwest Missouri crop farm. Crops produced were those common to the area--corn, sorghum, soybeans, and wheat. Tillage practices considered were chisel plow, disk and plant for wheat while conventional, reduced and no tillage were possibilities for the other crops. For soybeans both 15 and 30 inch rows were included. Coefficients for fuel, seed, fertilizer, chemicals, labor, etc. were obtained from crop budgets, farm management specialists, agricultural engineers, agronomists and producers in the study area.

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[1] High risk and low risk crop producers as used in this paper is a relative term. For similar expected incomes a low risk producer will select a cropping pattern with less income variability than will the high risk producer.

Quadratic programming (Q.P) was used to incorporate risk into the decision making process. A basic assumption behind the Q.P. model used in the analysis is that decision makers make decisions based on expected income and the variability of income.[2] Q.P. is utilized to determine the producers optimal production set given the set of resources available to the producer and the producers utility function U(E,V) consisting of expected income and income variability.

The objective function to be maximized is[3]:

$$E(U) = EI - \alpha\sigma^2$$

Where E(U) is expected utility, EI is expected income,

σ^2 is the variance of expected income or a measure of the variability of expected income, and

α is a positive coefficient indicating a linear relationship between expected utility and variability of income.[4]

It has been shown that Q.P. incorporates income variances and covariances with the ordinary production model to describe the variance efficient frontier (7). A coefficient which serves as a risk aversion parameter (if positive) has been incorporated into the quadratic part of the objective function.

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[2]For a mathematical interpretation of quadratic programming check with the following reference sources (3,7,10,15).

[3]An implied relationship is that as expected income (EI) is increasing, (σ^2) or the variance in income is also increasing.

[4]The two following conditions are satisfied by the above objective functions:

$$\frac{\partial E(U)}{\partial EI} = 1 > 0 \quad \text{and} \quad \frac{\partial E(U)}{\partial \sigma} = -2\alpha\sigma < 0$$

Assuming other things being the same these conditions mean:

(1) a larger expected income would be preferred to a lower one; and
(2) a lower level of risk would be preferred to a higher level.

Therefore, the objective function permits selection of efficient production combinations only.

Paraphrasing from Markowitz (10) a production combination is efficient if "it is impossible to obtain a greater expected return without incurring greater standard deviation; it is impossible to obtain a smaller standard deviation without giving up income on the average."

Expected enterprise returns and their variability (standard errors) are utilized in Q.P. In addition, the interrelationship of the variability of returns between enterprises is incorporated. Expected returns and the standard errors of returns were estimated from annual yields and prices which existed in the study area for the ten year period 1968-1977. Input cost data for this time period were obtained from Agricultural Statistics (16).

To evaluate impacts of increasing fuel prices on crop producers, fuel prices were varied from $.50 to $3.00 per gallon in $.50 increments. Crop input items whose prices were assumed to be affected directly by fuel prices were fuel, nitrogen, chemicals, fertlizer (phosphorous and potassium), and propane. Prices of these inputs relative to fuel over the period 1968-1977 were used to estimate these price relationships. These price combinations are shown in Table 1.

For evaluation of governmental rationing, fuel availability was varied from 500 to 1900 gallons per farm per year in 100 gallon increments while holding fuel price constant at $.50 per gallon.

Results

Fuel Price Increase Policy.

As fuel prices increased, optimal crop mixes for the 400 acre crop farm shifted from wheat to soybean production (Table 2). Most soybeans were produced with 15 inch rows for all risk and fuel price levels studied. As risk levels (expected income also) increased for selected fuel price

Table 1

Relative Nitrogen, Chemical, Fertilizer and Propane Prices for Selected Fuel Price Levels

Fuel ($/gal.)	Nitrogen ($/lb.)	Chemical $	Fertilizer[a] ($/lb.)	Propane ($/gal.)
.50	.22	1.00	.14	.40
1.00	.71	1.71	.41	1.57
1.50	1.07	2.13	.61	2.36
2.00	1.42	2.84	.81	3.14
2.50	1.78	3.55	1.01	3.92
3.00	2.13	4.26	1.21	4.71

[a]Fertilizer includes phosphorous and potassium.

TABLE 2

Impact of Energy Price Incearses on Expected Income and Deviation, Fuel Use, and Crop Mix for a 400 Acre Crop Farm

Fuel Price ($/gal.)	Expected Income (dollars)	Standard Deviation (dollars)	$\frac{SD}{EI}$ [a]	Fuel Use (gallons)	Crops (Acres)					
					Wheat	SB_1 [b]	SB_2 [b]	SB_4 [b]	SB_5 [b]	SB_6 [b]
$ .50	$36,638	$4,057	.111	1419	242.19	2.23	2.49	64.62	66.21	21.26
	38,601	4,325	.112	1485	206.86		2.23	86.18	88.06	16.67
	42,134	4,957	.118	1615	143.32			123.58	126.07	7.04
	44,523	5,476	.123	1701	100.40			148.30	151.30	
	49,671	6,756	.136	1862				196.60	203.40	
	49,968	7,858	.156	1264					400.00	
$1.00	33,485	5,556	.166	1654	80.55		2.76	141.20	148.29	27.20
	39,397	6,602	.168	1788			1.58	182.16	191.36	24.90
	40,175	6,759	.169	1845				192.30	207.70	
	40,756	7,868	.193	1264					400.00	
$1.50	30,879	6,752	.218	1819			7.83	183.64	208.53	
	30,944	6,758	.219	1817				183.24	216.76	
	31,774	7,868	.248	1264					400.00	
$2.00	21,810	6,784	.311	1782			.92	171.53	227.55	
	21,758	6,787	.312	1781				171.19	228.81	
	22,792	7,868	.345	1264					400.00	
$2.50	12,810	6,904	.539	1664				132.49	267.51	
	13,810	7,868	.570	1264					400.00	
$3.00	4,828	7,868	1.630	1264					400.00	

[a] SD ÷ EI = Standard Deviation ÷ Expected Income. This is a measure of relative risk. The higher the value the higher the level of risk.

[b] SB_1 = Conventional tillage soybeans, 30" rows; SB_2 = Reduced tillage soybeans, 30" rows; SB_4 = Conventional tillage soybeans, 15" rows; SB_5 = Reduced tillage soybeans, 15" rows; SB_6 = No-till soybeans, 15" rows.

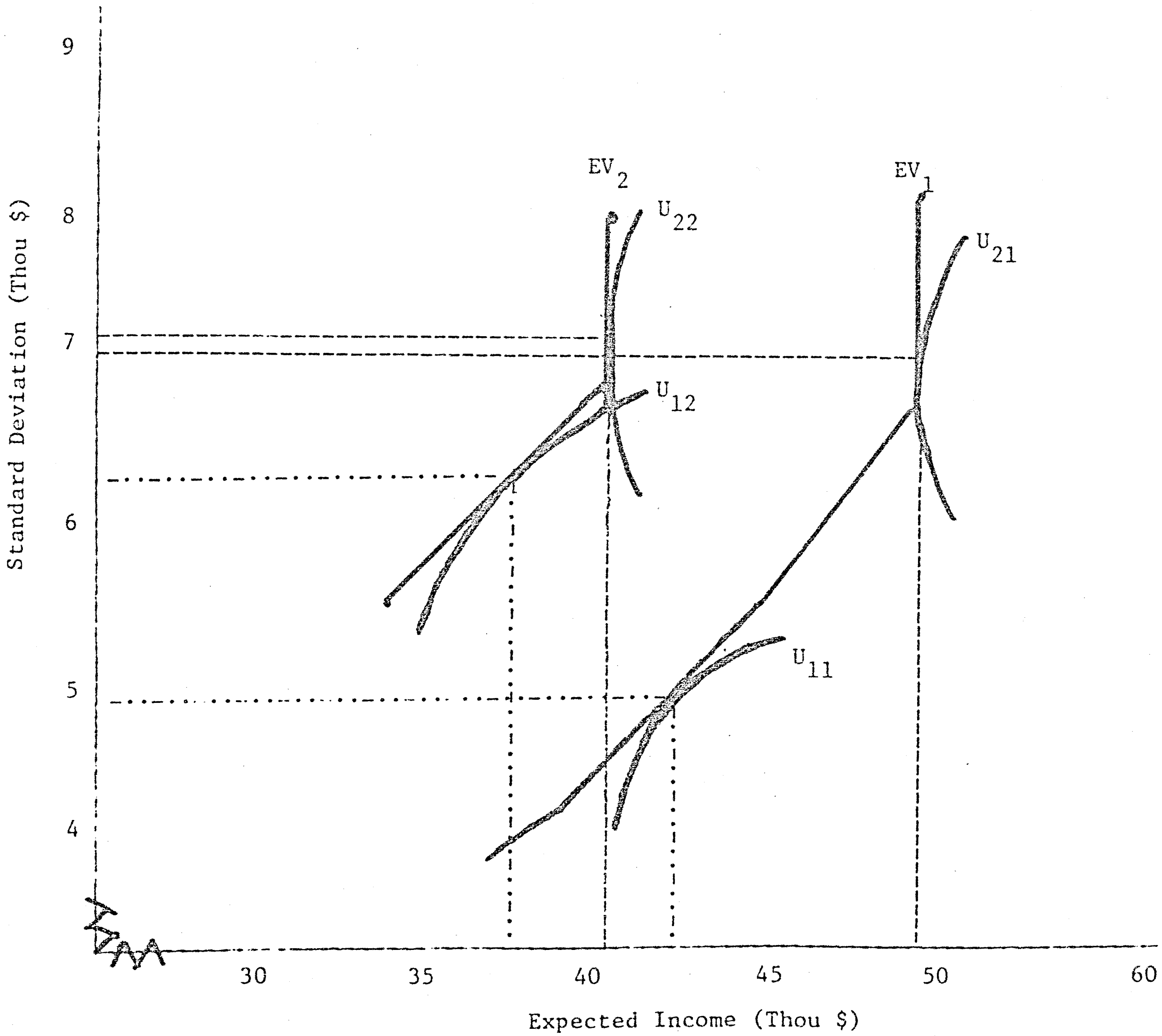
levels, the optimal crop mix shifted from the combination of conventional and reduced tillage soybeans to all reduced tillage soybeans. No-till soybeans entered the optimal plan only at the low fuel price and relatively low risk levels.

Expected income-variance curves for the \$.50 and \$1.00 per gallon fuel price levels are illustrated in Figure 1 as EV_1 and EV_2 respecitvely. To analyze the impacts of fuel price increases for a low risk and high risk producer, iso-utility curves are also needed. In Figure 1 iso-utility curve set U_{11} and U_{12} represents a relatively low risk producer, while set U_{21} and U_{22} represents a relatively higher risk producer. These iso-utility curves are hypothetical and represent relative levels of risk. The tangency points of the respective iso-utility curves with the expected income variance curves represents optimal expected income and income variance.

With a \$.50 per gallon fuel price, low risk producers had an expected income of \$42,400 and a standard deviation of \$5,000 as compared to \$37,000 and\$6,250 respectively when the fuel price was \$1.00 per gallon. For higher risk crop producers expected income declined from \$49,700 to \$40,300 while the standard deviation increased from \$7,100 to \$7,150 as fuel prices increased from \$.50 to \$1.00 per gallon. Thus, standard deviation levels increased by \$1,250 and \$50 respectively for the low and high risk producer. In contrast, expected income levels decreased by \$5,100 and \$9,400 respectively for the low and high risk producers. Standard deviation levels and in turn optimum crop mixes for the high risk producers were affected very little by fuel price increases while expected income was reduced substantially. Crop mixes for the low risk producer shifted to higher expected income and risk crops (from wheat to soybeans) as fuel prices increased. Fuel price increases forced the low risk producer into a higher risk venture.

FIGURE 1

Expected Income-Variance Curves and Hypothetical Iso-Utility Curves for a 400 Acre Crop Farm Under Fuel Prices of $.50 and $1.00 per Gallon



Similar results are shown by the SD/EI (standard deviation/expected income) column in Table 2. This value indicates the level of relative risk. An increase in the ratio indicates that the standard deviation is increasing at a faster rate than expected income. Table 2 shows that this value increases as the fuel price increased. In essence crop mixes are switching to higher risk alternatives.

In Table 2 the column on fuel use shows that under free market conditions fuel use is in part responsive to fuel price increases. For example, at the highest risk levels, fuel demand was 1,264 gallons for all fuel price levels. The highest risk producers do not reduce fuel use through fuel price increases. Maximum fuel demand was 1,862 gallons for some medium risk production levels when the fuel price was $.50 per gallon. Therefore, fuel use appears to be as responsive to the level of risk in production as to the fuel price itself.

Non-Price Fuel Allocation Policy.

For the relatively low fuel availability levels and risk levels wheat was the dominant crop. As risk levels increased the crop mix shifted to reduced tillage soybeans (15 inch rows) and then to no-till soybeans (15 inch rows) at the higher risk levels. As fuel availability increased, reduced tillage soybeans became relatively more important than no-tillage soybeans. This pattern was consistent for all fuel allocation levels below that demanded under free market conditions.

Fuel allocations had a greater impact on low risk producers than on high risk producers. The level of fuel allocation proved to be important as the highest risk producers required less fuel than did lower risk producers. This is shown by examination of the 1900 gallon fuel allocation level in Table 3. The highest risk producers require 1264 gallons of fuel.

TABLE 3

Impact of Non-Price Fuel Allocation on Expected Income and Income Standard Deviation for a 400 Acre Crop Farm Under Varying Fuel Allocation Levels

Fuel Allocation Level (gallons)	Fuel Use (gallons)	Expected Income (dollars)	Standard Deviation (dollars)	SD[a/] / EI	Fuel Allocation Level (gallons)	Fuel Use (gallons)	Expected Income (dollars)	Standard Deviation (dollars)	SD[a/] / EI
500	500	$12,908	$1432	.111	1300	1300	$33,561	$3725	.111
	500	15,580	1804	.116		1300	36,709	4117	.112
	500	21,007	3095	.147		1300	47,624	6755	.142
	500	21,297	3191	.150		1300	49,457	7442	.151
	500	23,035	4315	.187		1300	49,950	7750	.155
	500	23,139	4409	.191		1264	49,968	7876	.157
700	700	18,071	2005	.111	1500	1419	36,637	4066	.111
	700	21,812	2526	.116		1485	38,601	4324	.112
	700	29,410	4334	.147		1500	38,984	4383	.112
	700	29,660	4411	.149		1500	48,440	6668	.138
	700	32,249	6041	.187		1500	49,850	7201	.145
	700	32,393	6172	.191		1264	49,968	7867	.157
900	900	23,235	2579	.111	1700	1419	36,637	4066	.111
	900	28,044	3247	.116		1615	42,133	4956	.118
	900	37,813	5572	.147		1700	44,472	5463	.123
	900	38,134	5671	.149		1700	49,255	6703	.136
	900	40,320	6871	.171		1700	49,750	6859	.138
	900	40,442	6966	.172		1264	49,968	7867	.157
1100	1100	23,398	3152	.111	1900	1419	34,637	4066	.111
	1100	34,276	3969	.116		1485	38,601	4324	.112
	1100	42,218	5721	.136		1615	42,133	4956	.118
	1100	45,518	6640	.146		1701	44,523	5474	.123
	1100	45,571	6656	.146		1862	49,668	6755	.136
	1100	45,676	6697	.147		1264	49,968	7867	.157

[a/] SD ÷ EI = Standard Deviation ÷ Expected Income. This is a measure of relative risk. The higher the value the higher the level of risk.

Fuel allocations above that level creates a surplus fuel situation for those producers. However, lower risk producers may demand as much as 1862 gallons or 47 percent more fuel than that required by the highest risk producers. Low risk producers produce crops which require more fuel per acre. Thus, they bear a greater burden as a result of non-price fuel allocation policies. Any fuel allocation level above 1264 gallons per year had no effect on the highest risk producer.

Conclusions and Implications

For high risk producers, crop mix, standard deviation of returns, and fuel use levels were invariant as fuel prices increased. Reduced tillage soybeans were produced in 15 inch rows on 400 acres. For given fuel price levels, the highest risk producer used less fuel than did any of the other producers. This suggests that, increases in fuel prices will have less of an overall impact on the high risk producers than lower risk producers.

For lower risk producers fuel price increases resulted in lower levels of fuel use, higher income variability and a higher risk crop mix. For example, when the fuel price was $.50 per gallon the lowest risk crop production mix utilized 1,419 gallons of fuel and a standard deviation in return level of $4,057. At a fuel price of $3.00 per gallon the lowest risk production mix used 1,264 gallons of fuel, and a standard deviation of $7,868. The standard deviation in returns essentially doubled for the low risk producer. Similarly the standard deviation relative to expected income (SD ÷ EI) value increased from .111 to 1.630.

As fuel prices increased low risk producers and high risk producers alike received a lower expected income. For given fuel price changes, expected incomes for high risk producers declined to a greater extent than did those for the low risk producers. Low risk producers were able to implement crop mix changes that increased the standard deviation while lessening the reduction in expected income. These standard deviation--expected income tradeoffs were not available for the high risk producer. Fuel price increases tended to force the low risk producer toward the high risk producers crop mix.

With non-price administered fuel allocations the allocation level was important. At relatively low fuel allocation levels all fuel was used by all producers at all risk levels. When fuel availability was low some acres were left unplanted at all risk levels. Fuel allocation forced more acres to be idle than with a fuel pricing policy.

At relatively high non-price fuel allocation levels--1300 gallons and above--the high risk producer had surplus fuel, while the lower risk producer used all allocated fuel. At those allocation levels low risk producers were more adversely affected by non-price fuel allocations than the high risk producers. At the extreme, high risk producers had more fuel than needed while the low risk producers were short of fuel. The level of equitability in non-price fuel allocation policy is related to the overall fuel allocation level. For a fuel allocation policy to be equitable for all producers, it would require that the non-price fuel allocation level be tied to the risk level of the producer.

For higher risk crop producers, a non-price fuel allocation strategy will be required to cut their fuel usage. For low risk producers fuel price increases as well as non-price fuel allocation provided incentives to shift to lower energy demand crops.

Given the presumption that there are producers with differing degrees of risk aversion levels, it appears that a combination of fuel pricing policy along with a non-price fuel allocation policy would be more fair in spreading the burden. A policy of this nature would cause the high risk producer to bear part of the burden through increased prices. In addition, the low risk producer's total burden may be lessened through the combination.

These results are based on the premise that the burden of adjustments is to be shared. It can be argued that the high risk producers should not be expected to share the burden. They are presently producing crops requiring less fuel per acre and adjustments in their crop mix may not be necessary. From the standpoint of fuel use per acre they are more efficient than the lower risk producers. Placing additional restraints on them may cause them to undergo adjustments such as ideling land---a move that doesn't increase fuel efficiency, but merily reduces fuel usage and, in turn, food production.

REFERENCES

1. Adams, R.M., G.A. King and W.E. Johnston, "Effects of Energy Cost Increases and Regional Allocation Policies on Agricultural Production," American Journal of Agricultural Economics, Vol. 59, No. 3, August 1977.

2. Briemyer, Harold F., "The Perverse Economics of Petroleum," Economics and Marketing Information, Department of Agricultural Economics, University of Missouri, Columbia, Vol. XXII, No. 6, June 1979.

3. Charnes, A., and W.W. Cooper. "Chance Constrained Programming," Management Science, 6:73-79, 1959.

4. Clark, S.J., and W.E. Johnson, Evaluating Crop Production Systems By Energy Used, Society of Automative Engineers Paper 740647, 1974.

5. Conner, L.J., "Agricultural Policy Implications of Changing Energy Prices and Supplies," Agriculture and Energy. Edited by William Lockeretz. New York: Academic Press, 1977.

6. Doster, D.H., "Economics of Alternative Tillage Systems," Paper presented to the Entomology Society of American Tillage Symposium, December 2, 1975.

7. Freund, Ruldolf J., "The Introduction of Risk into a Programming Model," Econometrica, 24:253-263, July 1956.

8. Heichel, G.H., "Agricultural Production and Energy," American Scientist, 64(1976): 64-72.

9. Kliebenstien, J.B. and J.P. Chavas, "Adjustments of Midwest Grain Farm Businesses in Response to Increases in Petroleum Energy Prices," Southern Journal of Agricultural Economics, Vol. 9, No. 2, December 1977.

10. Markowitz, Harry "Portfolio Selection," Journal of Finance, 7:77-91, March 1952.

11. Musser, Wesley N., and Ulysses Marable, Jr., "The Impact of Energy Prices On Optimum Machinery Size and the Structure of Agriculture," Southern Journal of Agricultural Economics, Vol. 8, No. 1, July 1976.

12. Penn, S.B., and G.D. Irwin, Constrained Input-Output Simulations of Energy Restrictions in the Food and Fiber System. Economic Research Service, U.S. Department of Agriculture, Agricultural Economics Report #280, 1977.

13. Pimental, David et. al., "Food Production and the Energy Crisis," Science, 182: 443-49.

14. Richey, C.B., D.R. Griffith, and S.D. Parsons, "Uields and Cultural Energy Requirements for Corn and Soybeans with Various Tillage-Planting Systems," Advances in Agriculture 29. Edited by N.C. Beady, New York: Academic Press, 1977.

15. Scott, John T., Jr., and Chester B. Baker, "A Practical Way to Select an Optimum Farm Plan Under Risk," American Journal of Agricultural Economics, 54:657-660, November 1972.

16. USDA Agricultural Statistics, U.S. Government Printing Office, Washington, D.C., 1978.