THE ECONOMIC AND ENVIRONMENTAL IMPACTS OF AN ETHANOL INDUSTRY ON WESTERN NEW YORK

Brian W. Gould

ABSTRACT

This paper examines the economic, environmental and energy use impacts of a corn based ethanol industry on Western New York State. A regional linear programming model is used. Five representative farm groups are used to describe the agricultural sector of the study region. Comparisons are made between a benchmark solution and model formulations that include conservation tillage practices, ethanol induced feed price changes, and the feeding of the feed by-product, DDG.

INTRODUCTION

In response to actions taken by OPEC, energy policy in the U.S. has shifted to one of promoting the development of our domestic energy resources. The use of biomass for the production of ethanol as a gasoline extender is being extensively investigated as a means of increasing our supplies of liquid fuels. The use of corn grain as an ethanol feedstock has received the most attention. This is due to the current availability of ethanol conversion technologies and the existence of a relatively small corn based ethanol industry (Kalter et al. 1981, OTA 1980, SERI 1981).

The commitment of large amounts of the agricultural sector's resources for the production of feedstocks, whether this feedstock is corn grain or any other form of biomass, has implications that concern both agricultural and energy policy analysts. Recent studies have analyzed some of these agricultural and energy issues which are of concern (Hertzmark et al. 1981, Meekoff et al. 1980, Hoff and Tyner 1981). The majority of these studies have concentrated on the agricultural sector at the national level. With respect to the use of corn grain, Hertzmark et al. notes that there exists a need for regional models in order to investigate important production shifts that may permit greater levels of the production of corn grain for both food and energy use (Hertzmark et al. 1980, p. 58). In addition, one area that has not been analyzed to any large degree at either the national or regional level is the environmental impacts of the development of a large scale ethanol industry.

The major environmental problems associated with corn based ethanol production are increased erosion of topsoil and increased environmental exposure to pesticides and fertilizers. These environmental changes will be important if there is extensive switching of land resources from forage crops and small grains so as to meet the feedstock demands of an ethanol industry. This is the result of corn grain requiring substantially more pesticides and fertilizers and producing higher rates of soil loss than the hay crops or small grains.

This paper discusses the potential impacts of ethanol production on the allocation of the agricultural resources in the corn producing region of New York State. A regional linear programming model is formulated which estimates the effect of a major ethanol industry on environmental quality, farm income, and energy use in the study region. The objective function of the model is the maximization of net farm income. The resource constraints are concerned with the supply of cropland and with the size of the study region's dairy herd (Gould 1982). Three ethanol industry scenarios are simulated. The first scenario is one where there is no ethanol production. A second scenario simulates the regional impacts of ethanol production occuring in the Midwest corn belt. The last ethanol scenario allows for both regional ethanol production in the corn grain producing region of New York State as well as the existence of a large Midwest ethanol industry.

DESCRIPTION OF THE REGIONAL MODEL

The decreases in petroleum prices that have occurred in the last year are not expected to continue. Recent actions taken by OPEC to decrease crude oil production have been implemented so as to eliminate the current surplus of petroleum products. With the expected increase in gasoline prices, there will be renewed interest in the use of corn grain as an ethanol feedstock. The most likely place for the development of a corn based ethanol industry is in the Midwest. Because of the importance of Midwest grain in determining the prices received for corn grain in New York markets, any price changes that occur in the Midwest as a result of the development of a large scale ethanol industry will be transmitted directly to the grain markets in New York State.

There has been recent interest in the use of New York State's agricultural resources for ethanol production (Kalter et al. 1981, Batista et al. 1982). If ethanol production is undertaken in the corn producing regions of the state, there will be the additional regional impact of producing a large supply of the high protein feed by-product, Distiller's Dried Grains (DDG). This feed by-product could affect resource use in the regions in which ethanol production occurs.

The study area used for the present analysis is seven counties in Western New York State. This region is referred to as the Western Plains. The Western Plains region is chosen for analysis because of the current surpluses of corn grain that are produced in the ares. Since 1964, there has been a 211% increase in the acreage devoted to corn grain production. Thirty-six percent of the state's corn grain acreage is located in the seven county region which comprises only 20% of

---

The author is a Ph.D. candidate in Resource Economics, Cornell University.

the state's harvested cropland.[1] Riggins estimates that six of the seven counties that are included in the Western Plains region produce more corn grain than is used locally.

The agricultural sector of the Western Plains region is represented in the model by five representative farm groupings. Three of these groups correspond to the dairy farms in the region. These representative dairy farms are assumed to have average acreage totals of 150, 250, and 520 acres. The remaining two groups are used to represent cash grain farms. These two farm categories have average acreage totals of 230 and 450 acres. The resources of the study region are allocated to these five representative farm groupings according to cropland and livestock distributions given in the 1974 and 1978 Census of Agriculture (USDA 1976, 1980). The crops considered for production are hay, wheat, oats, and corn. Dairy production is the only livestock activity considered.

In addition to the use of conventional cropping practices, minimum and no-till technologies are included in the model to allow for the use of more energy and soil conserving crop production technologies. These conservation tillage practices are included because of recent interest by farmers in the region to use these practices to control soil erosion and improve yields.[2] The "benchmark" model allows only for the use of conventional tillage practices. The "full farm" model, in addition to conventional tillage, allows for the use of the minimum and no-till technologies. Using the full farm model, simulations are conducted so as to determine the impacts of ethanol production on resource use in the study region.

Approximately one million cropland acres are located in the Western Plains region. Of this total, over 615,000 acres are harvested by the cash grain and dairy sectors. This harvested cropland is divided between the five representative farm groupings. Four levels of soil productivity are determined for the soil mapping units in the Western Plains region. The soil mapping unit acreages are obtained from USDA data (USDA 1967, Fritschen and Hanson 1979). This acreage is updated to reflect the total cropland acreage given in the 1978 Census of Agriculture (USDA 1980). Seven erosion categories are established for the soil mapping units in the region. These categories represent the degree of erosivity of the soil mapping units. Thus, for each of the representative farms a "Productivity-Erosivity" matrix of cropland acreage is estimated. These matrices are used to distinguish cropland use not only by crop type but also by soil characteristic.

Environmental quality is measured by two variables. The first variable is gross soil erosion as represented by the Universal Soil Loss Equation (Wischmeir and Smith 1978). Second, environmental quality is represented by an index of the potential environmental exposure to pesticides. The value of the pesticide exposure index (PEI) is determined not only by the toxicity of a pesticide but also by its longevity in the environment (Alt, 1976).

Besides determining the impact of an ethanol industry on farm income and environmental quality, the effects of corn-based ethanol production on the levels of direct and indirect energy consumed by the study region's agricultural sector are examined. Direct energy is defined as the liquid fuels used in the production of crop and livestock products. This is converted to a diesel fuel equivalent basis. Indirect energy is defined as the energy encompassed in the fertilizer and pesticides used by the cropping activities considered in this study.

BENCHMARK AND FULL FARM MODEL RESULTS

Table 1 presents the land use patterns which are achieved under the benchmark solution for the Western Plains region. In this solution, 98% of the available supply of cropland is harvested. The remaining 2% is located on the least productive soils. When compared to the actual 1980 crop production and harvested acreage levels, the model does well in predicting the amount of corn silage, corn grain, and hay production. Again, the objective of the simulation model is to maximize net farm income subject to the availability of the region's land resources, current structure of agriculture in the region and being constrained to maintain the region's dairy herd.

The cash grain sector devotes 75% of its cropland to corn grain production under the benchmark solution. Associated with this intensive corn production are higher rates of soil loss and pesticide use vis-a-vis the dairy sectors. Table 2 shows how the cash grain sectors contribute to the regional total of these variables as well as the amount of indirect energy and diesel fuel use for the benchmark solution. The levels of these variables on a per acre basis show that the cash grain sector has significantly higher rates of soil loss and pesticide use when compared to similar figures for the dairy sector This is due to the more intensive corn grain production occuring in the cash grain sectors. The large dairy farms have higher per acre rates of diesel fuel use than the smallest size dairy operations. This can be attributed to longer rotations of hay that occur in the smallest dairy farms. The shorter rotations of hay that occur in the larger dairy farms have higher average rates of diesel fuel use because of the greater amount of diesel fuel required in the establishment year of a stand of hay.

With the introduction of the conservation tillage practices into the model, there is little impact in terms of the relative contribution of the five agricultural sectors to the energy and environmental variables. The land use patterns do not change although 21% of the harvested acreage is using no-till. Farm income increases 10%

---

[1] Half of New York State's cash grain farms are located in the Western Plains region.

[2] For the most productive soils, research has shown that there is an increase in yields with the adoption of no-till when compared to yields obtained when using conventional tillage practices (Phillips and Young 1973).

Table 1: Land Use Pattern and Estimated Yields for the Benchmark Solution and Actual Crop Distribution (1980)

Crop	Benchmark Acres	%	Actual Acres	%	Yield Bench.	Yield Actual
Corn Silage	86,172	14	84,700	15	15.4	14.9
Corn Grain	278,823	45	244,689	42	89.6	93.1
Hay	227,732	38	185,250	32	2.9	2.2
Oats	6,217	1	50,892	9	55.0	71.3
Wheat	6,217	1	18,136	3	36.0	30.3
Harvested	605,161		583,667			

Source: Actual Totals - 1980 Agricultural Statistics; Benchmark - computed by the author.

Note: The hay and wheat yield and acreage figures are based on the 1978 Census of Agriculture due to the lack of sufficient detail in the 1980 Agricultural Statistics. The percentage figures refer to the percent of harvested cropland devoted to a particular crop. The yield figures for corn silage and hay are in terms of tons. Corn grain, oats and wheat are measured in terms of bushels. The "actual" acreage is for only the dairy and cash grain sectors. The yield figures are based on total production and acreage in the region.

Table 2: Energy Use and Environmental Quality for the Benchmark Solution of the Western Plains Region

Farm Type	Soil Loss (000 T)	Per Acre (Tons)	%	PEI (000)	Per Acre (Unit)	%	Ind. Ener. (Bill. BTU)	Per Acre (M.BTU)	%	Diesel (000 gal)	Per Acre (Gal.)	%
DAIRY FARMS												
One	50	.9	8	1,173	3.5	2	64	1.3	4	205	4.1	5
Two	234	1.7	11	923	6.6	12	263	1.9	15	1,067	7.5	26
Three	408	3.5	19	1,624	13.7	20	340	2.9	20	950	8.0	24
CASH GRAIN FARMS												
One	512	4.6	24	2,066	18.4	26	408	3.6	24	836	7.4	17
Two	798	4.4	38	3,137	17.2	40	631	3.5	37	1,327	7.3	28
Total	2,125	3.5		7,923	13.1		1,705	2.8		4,385	7.2	

Note: The percentage figures refer to the percent of the regional total. The diesel use totals are for the cropping activities only. PEI refers to the level of the pesticide exposure index.

over the benchmark solution to a level of $37.2 million. Soil loss and diesel use decrease 11% and 15%, respectively. Pesticide exposure and indirect energy demands increase 12% over the benchmark levels. Because of the use of no-till on the most productive soils, the relative changes in the energy and environmental variables are not surprising. That is, no-till requires increased use of pesticides and nitrogen fertilizers while at the same time results in decreased soil loss. In addition, a smaller number of tillage operations are necessary and hence there is a lower amount of diesel fuel used when no-till is adopted in place of conventional tillage practices (Phillips and Young 1973).

REGIONAL IMPACTS FROM PRICE CHANGES ASSOCIATED WITH LARGE SCALE ETHANOL PRODUCTION

Simulations are conducted where the relative price changes associated with national ethanol production are applied to the Western Plains region. The percentage change in corn and soybean price associated with a 2 and 4 billion gallon ethanol industry are estimated by Meekoff et al. The above study is concerned with production and price changes that occur in the national feedgrain markets as a result of the development of a large scale ethanol industry. This production is seen to occur in the Midwest corn belt. The two ethanol industry sizes investigated by Meekoff et al., will be referred to as the "low" and "high" ethanol production levels in the present study. With a low level of ethanol production, corn prices are expected to increase 6%. Soybean prices are not affected. The high level of ethanol production raises corn prices 27% as well as increasing soybean prices 5% (Meekoff et al. 1980).

Table 3 shows that farm income increases above the benchmark and full farm solution values for each ethanol production level. The low production scenario results in substantial reductions in soil loss (10%). This decrease is due to increased adoption of no-till practices on the corn silage and corn grain acreage in the dairy sector. The percentage of cropland using no-till increases from the 21% for the full model solution, to 27% and 32% for the low and high ethanol production scenarios.

With the price effects of the high ethanol production scenario, the percentage of cropland devoted to corn production is projected to increase to 67% of the region's cropland. This compares to the 60% received under the benchmark and full farm model solutions. Both the cash grain and dairy sectors increase their corn grain acreages. This increase in corn production occurs while the acreage devoted to hay decreases. Thirty-eight percent of the harvested cropland is devoted to hay production in the full farm solution. This percentage decreases to 32%. These crop changes help explain the increased soil loss, pesticide exposure, and indirect energy demands.

REGIONAL IMPACTS OF FEED PRICE CHANGES AND REGIONAL ETHANOL PRODUCTION

The regional impacts of ethanol production in the study region are of concern because of the large amount of Distiller's Dried Grains (DDG) which may be produced from a corn based ethanol industry. Ethanol production in the Western Plains region is simulated through the establishment of one 25 million gallon corn based ethanol plant (Kalter et al. 1981).[3] This plant is assumed to be established at the same time that there is a large scale national ethanol program. For each gallon of ethanol, there is an associated production of 7-8 pounds (dry) of DDG. The present form of the simulation model assumes that all the "locally" produced DDG is fed to the region's dairy herd (Gould 1982). The ethanol plant used for the analysis is assumed to produce 109,000 tons of the DDG by-product as a result of the ethanol production process. DDG has the potential of supplying not only a large amount of the protein requirement of livestock rations, but as Hertzmark and Gould show, in the context of least cost dairy rations, DDG tends to substitute for corn grain as an energy source.

With the low and high ethanol production scenarios, it is hypothesized that the price of DDG will decrease by 30% and 55% (Hertzmark et al. 1980). Adding regional ethanol production to the above price changes makes the feeding of the by-product DDG result in a surplus of protein and net energy being supplied to the region's dairy and heifer herd. No excess protein is fed under the full farm solution. With regional ethanol production, there are 19.8 and 165 tons of excess protein in the region's dairy and heifer rations for the low and high ethanol production levels, respectively. In terms of net energy for lactation, 47.6, 71.1, and 121.7 million Mcal of excess energy are fed above the minimum required for milk production under the full farm and the above two ethanol scenarios.[4]

Table 3 shows that with ethanol induced feed price changes and regional ethanol production, pesticide exposure and indirect energy levels in-

[3] For a 25 million gallon ethanol plant, Kalter et al. found that the total annual operating costs are $52.9 million (1980). Over 30% of this total cost can be recovered through the sale of the DDG by-product.

[4] Without regional ethanol production the feed price changes associated with the low and high production scenarios result in 50.9 and 66.7 million Mcal of excess energy being fed to the region's dairy herd.

Table 3: Regional Impacts of Ethanol Production on the Western Plains Region

Scenario	Farm Income (000 $)	Soil Loss (000 T)	Pesticide Index (000)	Diesel Fuel Use (000 gal)	Indirect Energy (bil BTU)
Benchmark	33,500	2,125	7,923	4,385	1,705
Full Farm	37,161	1,809	8,893	3,879	1,901
Low Ethanol Prod.	41,070	1,646	9,129	3,790	1,945
High Ethanol Prod.	56,249	1,727	10,013	3,848	2,117
Low-Regional Prod.	50,344	1,704	10,299	3,972	2,131
High-Regional Prod.	73,155	1,848	10,510	4,135	2,184

Note: The low ethanol production refers to the 2 billion gallon a year ethanol industry while the high ethanol production refers to the 4 billion gallon a year industry. Regional production refers to there being one 25 million gallon ethanol plant located in the study region.

crease 16% and 12% for the two national ethanol production scenarios. Diesel use and soil loss remain relatively constant. The land use in the study region changes by means of the substitution of hay acreage for corn silage and corn grain production. For the full farm solution, 44.3% of the harvested cropland in the dairy sectors are associated with corn production. This increases to 48% and 55% with the price changes which may result from a national ethanol program. Adding regional ethanol production results in 59% of the dairy sector's cropland being devoted to corn production under both national production scenarios. Some of this increase in corn acreage is used for the production of corn silage. This corn silage is used to supply fiber to the region's dairy and heifer herd formerly supplied by the purchased corn grain and soybean meal.[5]

Under the full model solution, 16 thousand tons of corn meal and 25 thousand tons of soybean meal are purchased by the dairy sector. With the regional production of 25 million gallons of ethanol and a low level of national production, the corn meal purchases are decreased to 851 tons (a 95% reduction). There are no soybean meal purchases. With the price changes resulting from the high level of national ethanol production, there is no corn grain purchased by the dairy sector. All of the feed requirements are satisfied from the use of home grown feeds and from the use of the DDG by-product.

Concomitant with these changes in feed grain purchases, the increase in DDG feeding results in the amount of corn grain sold by the dairy sector to increase from the full farm level of 1.9 million bushels. The dairy sectors sell 2.16 and 3.23 million bushels of corn grain for the low and high production levels, respectively. Regional ethanol production increases the dairy sector's sale of corn grain to 6.6 million bushels for both the low and high levels of ethanol production.

With the increased sale of corn grain by the dairy sector under these scenarios, can the agricultural sector meet the feedstock demands of the region's ethanol industry? Because of the method by which the equilibrium corn grain prices are determined in the Western Plains region, no explicit requirements are made in the simulation model for the region's agricultural sector to supply the ethanol industry with "home-grown" corn grain. However, with the development of an ethanol industry, the above solution values indicate that the region could meet the industry's feedstock demands and still have a surplus of corn grain.

Assuming that for each bushel of corn used in the production of ethanol, 2.35 gallons of ethanol are produced, an ethanol plant with an annual capacity of 25 million gallons requires 10.6 million bushels of corn. The total amount of corn grain sold by the agricultural sector of the study region under the full model is 23.5 million bushels. With one ethanol plant in the study region there is an increase in the sale of corn grain to 29 million bushels. This may indicate that this region can meet the additional corn grain demands of a regional ethanol industry and still maintain a viable dairy sector.

SUMMARY OF THE IMPACTS OF ETHANOL PRODUCTION ON THE WESTERN PLAINS REGION

This paper has presented a discussion of how development of an ethanol industry may affect the corn grain producing region of New York State. These impacts are measured in terms of the changes in several environmental and energy use variables as well as land use patterns. With no ethanol production occuring in the Western Plains region of New York State, a major national ethanol industry would increase net farm income. Associated with this increase in regional farm income are increases in pesticide exposure and an increase in indirect energy usage. There is little effect on regional diesel fuel use and soil loss.

Having both regional and national ethanol production causes the pesticide exposure index, indirect energy usage, and net farm income variables to increase. These solutions also indicate that there may be sufficient corn grain production both to support a corn-based ethanol industry and to supply the feed requirements of the study region's dairy herd.

[5] On a dry matter basis, DDG has only 2% fiber as compared to 10% and 7% for corn grain and soybean meal.

REFERENCES

Alt, F. An Economic Analysis of Field Crop Production, Insecticide Use, and Soil Erosion in a Subbasin of the Iowa River, unpublished Ph.D. dissertation, Iowa State University, 1976.

Batista, J., R. Boisvert, and R. Kalter. Assessing the Economic Impacts of Ethanol Production Using Agricultural Wastes as Feedstocks in Three Regions of New York, Report to the New York Energy Research and Development Authority, May 1982 (forthcoming).

Fritschen, J. F. and M. Hanson. "County Soils and Yield Data," Database No. 618, Lawrems Directory, Version 1, USDA, ESCS, January 1979.

Gould, B. W. The Economic, Environmental, and Energy Use Impacts of the Development of an Ethanol Industry on Western New York: A Programming Approach, unpublished Ph.D. dissertation, Cornell University, 1982.

Hertzmark, D., et al. The Agricultural Sector Impacts of Making Ethanol from Grain, Solar Energy Research Institute, SERI/TR-352-554, March 1980.

Hertzmark, D., and B. Gould. The Market for Ethanol Feed Joint Products, Solar Energy Research Institute, SERI/RR-352-357, October 1979.

Hoff, J., and W. Tyner. "The Feedback Effects of Higher Oil Prices on the Production of Biomass Alcohols and Synfuels," unpublished paper presented at the 1981 Summer meetings of the AAEA, Clemson, SC, July 1981.

Kalter, R., et al. Ethanol Production in Dutchess County, New York: Technical and Economic Feasibility, New York State Energy Research and Development Authority, Report 81-21, September 1981.

Meekoff, R., W. Tyner, and F. Holland. "U.S. Agricultural Policy and Gasohol: A Policy Simulation," American Journal of Agricultural Economics, Vol. 62, pp. 408-415, 1980.

Office of Technology Assessment, Energy From Biological Processes - Vol. I and II, U. S. Congress, Washington, July, 1980.

Phillips, S. and H. Young. No-Tillage Farming, Riemen Assoc., Milwaukee, 1973.

Riggins, S. The Corn Buying Market in Western New York, Department of Agricultural Economics, Cornell University, A.E. Ext. 77-30, Dec., 1972.

Solar Energy Research Institute, A Guide to Commercial Scale Ethanol Production and Financing, NTIS, March 1981.

United States Department of Agriculture, 1974 Census of Agriculture - New York State, 1976.

United States Department of Agriculture, 1978 Census of Agriculture - Preliminary Reports, New York State, 1980.

United States Department of Agriculture, Soil Conservation Service, Inventory of Soil and Water Conservation Needs, Syracuse, 1967.

Wischmeir, W. and D. Smith. Predicting Rainfall Erosion Losses - A Guide to Conservation Planning, USDA Agricultural Handbook No. 537, 1978.

The following papers, presented at the 1982 Summer Meeting in Vermont, will appear in the Spring, 1983, issue of the Journal:

RESOURCE ECONOMICS

The Hedonic Approach: No Panacea for Valuing Water Quality Changes

C. E. Willis and J. H. Foster

Estimating the Demand for Water Quality: Some Conceptual and Empirical Issues in the Use of the Probabilistic Rating Method

M. O. Ribaudo and D. J. Epp

Landowner Incentives to Participate in a Purchase of Development Rights Program With Application to Maryland

T. T. Phipps

Pennsylvania Farmland Prices as a Function of Land Quality and Distance from Metropolitan Areas

R. H. Downing and H. B. Gamble

SELECTED METHODOLOGICAL ISSUES

Modelling the Residential Demand for Electricity in New England

T. Young and T. H. Stevens

The Introduction of Administration and Research Activities into Regional Input-Output Models

S. M. Brucker and S. E. Hastings

Distortions Imposed by Inflation on Historical-Cost Depreciation

B. E. Bravo-Ureta