RESEARCH BULLETIN 1171 MARCH 1985

The Impacts of Fuel Alcohol Production on Ohio's Agricultural Sector

NORMAN RASK

DOUGLAS D. SOUTHGATE

FRANCIS E. WALKER

STEPHEN L. OTT

The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

CONTENTS

** **

Introduction 3
The Model 3
The Objective Function 3
Production Activities 4
The Cropping System 4
The Livestock System 6
The Alcohol Fuels Industry 8
Set of Restrictions 8
Model Validation 8
Impacts of Alcohol Fuel Production on Ohio's Agricultural Economy 9
References 13
Appendix — Data Used to Specify Objective Function and Transportation Costs 13

ACKNOWLEDGMENTS

This research was supported by a grant from the Ohio Dept. of Energy. The authors would like to thank Mr. Michael McCullough and Dr. Saeed Nabaee-Tabriz for their help in developing the model. Of course, any errors or omissions in this text are the responsibility of the authors.

AGDEX 111/75-85

3-85-2.5M

The Impacts of Fuel Alcohol Production on Ohio's Agricultural Sector

NORMAN RASK, DOUGLAS D. SOUTHGATE, FRANCIS E. WALKER, and STEPHEN L. OTT[1]

INTRODUCTION

Ohio agriculture has experienced substantial change during the past 15 years, some of which reflects trends observed across the United States. From the late 1960's, for example, exports grew from a very small portion of output to well over one-fourth of the production of major crops. Other changes in Ohio's agricultural economy were the consequences of local events, such as the opening of a new grain marketing facility.

The recent initiation of fuel alcohol production in the state could have an impact on Ohio's agricultural economy. Converting corn and other crops into fuel-grade alcohol seemed very attractive immediately after the 1979/1980 rise in the price of oil. More recently, ethanol produced from agricultural commodities has achieved acceptance among American gasoline suppliers as an octane booster in lead-free fuels. An alcohol fuel industry began to develop in Ohio during the early 1980's. In late 1982, one plant capable of converting roughly 5% of this state's corn crop into 60 million gallons of ethanol began production at Southpoint, Ohio. Other locations around the state and close to its borders have been identified as possible sites for similar facilities.

Several adjustments in the state's agricultural economy can be expected to accompany this expansion in the alcohol fuel industry. First, demand for corn will increase. At the same time, increased quantities of by-product feeds will be produced by the alcohol fuel industry. These feeds substitute partially for soybean meal. Substitution will decrease demand for soybeans and hence the opportunity cost associated with switching land from the production of soybeans to the production of corn. The most pronounced changes in land use, commodity prices, and land values will be observed close to alcohol plants.

The Ohio Department of Energy (ODOE), wanting to know the impacts of ethanol production in Ohio, contracted in 1981 with the OSU Dept. of Agricultural Economics and Rural Sociology (AERS) to develop a mathematical programming model which could be used to estimate the impacts on Ohio agriculture of alcohol fuel production. In the second section of this bulletin, the basic structure of the model is outlined as are the procedures employed to develop it. Discussed in the third section are the projected impacts of ethanol fuel production estimated with the model.

THE MODEL

The mathematical programming model is designed to forecast the effects of shifts in demand and changes in production technology on equilibrium output, resource use, and commodity prices in Ohio's agricultural economy. The forecast is the equilibrium towards which this economy would move. The time path of change toward that equilibrium cannot be determined with this model.

Discussed in this section are the three basic components of the programming model: the objective function, which incorporates product demand functions; the technological coefficient matrix, which identifies the natural resource services and purchased inputs needed to produce agricultural commodities; and the set of restrictions imposed on the agricultural production system. In the last subsection, model validation is examined.

The Objective Function

Competitive equilibrium is determined by maximizing net social payoff subject to a set of constraints (page 8). Net social payoff is defined as the aggregation of the areas between the demand and supply curves for all crops and livestock produced.

Linear demand functions are specified for nine principal products: beef, pork, turkey and broilers, eggs, and milk, and exports of corn, wheat, soybeans, and soybean meal. All except a small share of Ohio's cropland is used to produce feed for cattle, hogs, and poultry and grains for export. Demands for all other included products (barley, rye, sheep, and horses) are exogenously determined in the model. The supply curve of non-land inputs is assumed to be perfectly elastic. Production costs vary because Ohio's land resource endowment is heterogeneous (page 4).

Competitive equilibrium production and prices of the nine principal commodities are determined endogenously within the mathematical programming model which maximizes net social payoff (13). Letting q be the vector of production of the nine principal commodities and y the vector of production of commodities with exogenously determined demand, the objective is:

$$\text{Max } Z = a' q + \tfrac{1}{2} q' Eq + d' y - c' n, \qquad (1)$$

where a and E are the coefficients of the price dependent linear demand functions,

$$p = a + Eq, \qquad (2)$$

and d represents the selling prices of commodities with exogenous demand and c consists of purchase prices of the non-land inputs (vector n). The first three terms on the right hand side of equation 1 are derived from demand (revenue), while the term involving n is derived from supply (cost).

---

[1]Professor, Assistant Professor, Professor, and former Graduate Research Associate, Dept. of Agricultural Economics and Rural Sociology.

The nine linear equations for Ohio products are developed from demand functions estimated for the United States. The assumption that Ohio production (q_o) accounts for a constant share of national production (q_n) of each of the nine principal products throughout the process of adjusting from one equilibrium to another is used to obtain the coefficients a and E in the demand function, equation 2. The proportional production assumption can be stated as follows:

$$q_o = S \cdot q_n , \qquad (3)$$

where S is a diagonal matrix in which the diagonal elements are ratios of Ohio production to national production. This assumption is justified because the same economic forces stimulating changes in Ohio's agricultural economy will be operating in other parts of the country. In particular, industrial demand for corn from alcohol and high fructose corn sweetener manufacturers has been growing throughout the Midwest in recent years (7).

The national demand equations for the nine products are as follows:

$$p = a + E_n q_n . \qquad (4)$$

Substituting for q_n from (3), the Ohio demand functions (2) become:

$$p = a + E_n \cdot S^{-1} \cdot q_o = a + E \cdot q_o , \qquad (5)$$

where $E_n \cdot S^{-1} = E$ are the slope coefficients of the demand functions for Ohio (2). The intercepts of the demand functions are unchanged from the national demand functions.

Derivation of the coefficients, a and E, requires estimates of own- and cross-price flexibilities, F, observed when markets are in equilibrium. The price flexibility matrix F used in this study (Appendix Table A-I) was obtained from Heien (8) and Ray and Richardson (10). Define equilibrium prices as $\bar{p}$, equilibrium production in Ohio as $\bar{q}_o$, and national equilibrium production as $\bar{q}_n$ (the data $\bar{p}$ and $\bar{q}_o$ are reported in Appendix Table A-II). Then, consistent with equation 3, the matrix E of demand function coefficients is:

$$E = P\ F\ Q_o^{-1} = P\ F\ Q_n^{-1}\ S^{-1} , \qquad (6)$$

where P, Q_o, and Q_n are 9 X 9 diagonal matrices, the diagonal elements being the elements of $\bar{p}$, $\bar{q}_o$, and $\bar{q}_n$, respectively. The intercepts, a, of the demand functions (5) are determined as:

$$a = \bar{p}_o - E\ \bar{q}_o . \qquad (7)$$

The cost term $c'n$ in the objective function (equation 1) includes costs of all inputs to the production process other than land costs. The costs of transporting commodities among regions and outside the state are also included in that term. It is assumed that constant-cost industries supply non-land agricultural inputs. For this reason, the vector of non-land input prices, c, does not change. The total acreage of Ohio cropland is fixed under the assumption of no non-agricultural use; this fixed acreage is the only limited factor of production in the model (see Set of Restrictions, page 8).

Assumptions of the model, if too restrictive, impose limitations on its use. A summary of these limitations is given. First, given Ohio's proximity to major port terminals and to East Coast grain markets, equilibrium prices for the nine products are not identical in Ohio and in other parts of the country. Inclusion of transport costs in the model accounts for most of this difference, however. Second, determination of equilibrium prices is complicated by the fact that equilibrium in some product markets is greatly affected by public policy. For example, milk sales to the Commodity Credit Corporation account for a significant proportion of production. Third, to build the objective function, a linear demand function was obtained using price flexibilities which had been estimated with a model featuring log-linear demand functions. As market equilibrium changes from the price-quantity combinations used to specify the objective function, this approach becomes more limiting. The ultimate solution would be to use constant elasticity demand functions in the model.

Production Activities

A linear matrix describes how capital, labor, energy, and land can be combined to produce crops, livestock, and other agricultural outputs. Supply of each non-land input is assumed to be perfectly elastic. Costs of production differ across the state because of variations in the productivity of land.

We turn now to an overview of this model's production activities. Described in this subsection are cropping and livestock production activities and activities associated with the alcohol industry, along with the sources for quantitative specification of those production processes.

The Cropping System. To capture the diversity of crop production in Ohio, the state is divided into seven regions (Fig. 1). Each region is treated as a competitive farm with a limited number of cropping options available on a fixed land base and with a given array of crop transportation costs. Each region's agriculture is fairly homogenous with respect to land resources, type of agriculture, and likely marketing outlets.

Two sources were consulted when the state was divided into regions. Sitterley (11) identified 11 areas in the state. Within each area, there tends to be a prevailing type of agriculture (*e.g.*, dairy, cash grain, etc.) and relatively homogenous soil resources. Sitterley's boundaries, which follow county lines, are similar to the boundaries of the Major Land Resource Areas (MLRA's) which the U. S. Soil Conservation Service (SCS) has identified in Ohio. MLRA boundaries do not coincide with county lines, however.

It was determined that most of the diversity in Ohio's agricultural economy could be captured by specifying 7 rather than 11 regions. Limiting the number of regions also contained the size of the programming model. The boundaries of this model's seven regions resemble both those of Sitterley's areas and those of the MLRA's. Where a particular county could have gone into more than one region, Agriculture Census data (1) were consulted to determine which region's land use most closely resembled that of the "border" county.

Ten cropping options are included in the model: corn, corn silage, soybeans, wheat, alfalfa, oats, sunflowers, and grass hay, along with the two double-cropping options of wheat/soybeans and wheat/sunflowers. Labor, machinery, seed, and fertilizer inputs were obtained from Ohio crop enterprise budgets (4). Four energy inputs (gasoline, diesel fuel, liquid propane gas, and electricity) were obtained both from AERS (4) and from the Federal Energy Administration (FEA) (6). Yields for all options depend on the quality of land inputs. Data compiled by Triplett, *et al.* (14) and by the Soil Conservation Service have been used to divide land resources among five productivity classes. Table 1 reports the land productivity classes to which Ohio's major soil groups have been assigned. Per acre outputs of corn, soybeans, wheat, oats, and hay for each land productivity class are shown in Table 2.

The other type of production activity contained in this model's cropping system describes the processing of corn, soybeans and wheat. Milling of wheat into flour occurs in six of the seven regions. The processing of soybeans into meal and oil takes place only in Regions 1, 2, and 3, where soybean production is concentrated. The conversion of corn grain into starch, corn gluten meal, corn gluten feed, and corn oil occurs only in Region 2 (the state's major corn sweetener plant is located in Dayton). With the exception of ethanol production capacity, the above activities account for most of the crop processing which occurs in this state.

FIG. 1.—Ohio agricultural regions.

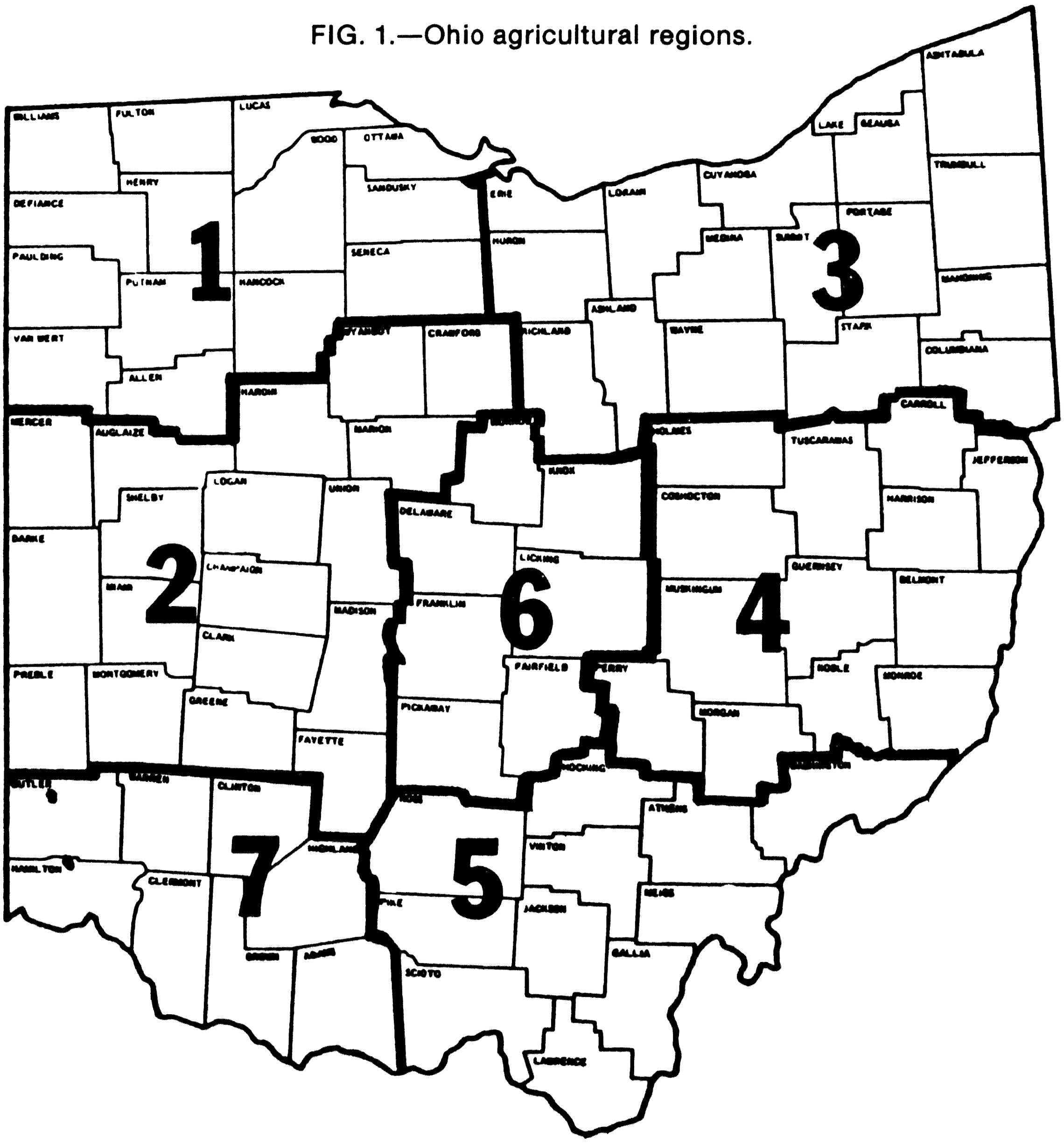


TABLE 1.—Land Productivity Classes of Major Ohio Soils.

Region	Land Productivity Class 1	2	3	4	5
1	Hoytville Pewamo	Blount Toledo	Paulding Nappanee		
2	Pewamo	Blount Crosby	Miamian	Morley Fox	
3		Canfield Ravenna	Wooster Mahoning	Sheffield Trumbull	
4		Wellston	Keene Westmoreland	Muskingum	
5		Pope	Monongahela		
6	Brookston	Cardington	Bennington		Fox
7		Fincastle	Clermont Russell		

TABLE 2.—Crop Yields by Land Productivity Class.

Land Productivity Class	Crop: Corn	Soybeans	Wheat	Oats	Hay
	(bu/acre)				(T/A)
1	130	41	50	75	5 0
2	115	36	45	70	4 5
3	100	31	40	65	4.0
4	85	26	35	60	3.5
5	70	21	30	55	3.0

Crop inputs and byproduct feeds of these processing activities were specified on the basis of interviews with Cargill, Inc. in the case of corn wet milling and on USDA data (15) in the case of soybean processing.

Finally, a set of activities describing the costs of shipping grain among regions, to export ports, and to the southern Ohio alcohol industry has been specified. Interregional transportation activities describe the inputs needed to move corn and feed byproducts by truck or train (whichever is the least-cost mode) from a central point in one region to a central point in another region. Figure 2 shows the interregional corn transportation flows which have been incorporated in the model. In general they run from the western (Corn Belt) counties to the eastern and southern counties. Costs associated with all of the model's transportation activities, which are reported in the Appendix, were obtained from industry interviews.

The four export commodities (corn, wheat, soybeans, and soybean meal) can be shipped from any regional mode to an East Coast port (Baltimore or Philadelphia) via unit train. Alternatively, those products can be shipped to export terminals located in Cincinnati or Toledo. Because wheat and soybean milling capacity exists in most parts of the state where those crops are grown, wheat and soybeans are not allowed to be shipped among regions for processing. Also, that portion of corn inputs into the Dayton corn sweetener plant which is produced in Ohio is asumed to come from Region 2. The only other type of cross-regional transportation activity is the transport of corn to the Southpoint ethanol plant. The modes for moving corn to the Southpoint plant (Fig. 2) are truck (if the shipments are made from Regions 5 or 7) and rail (if the shipments originate in Regions 2, 4, or 6).

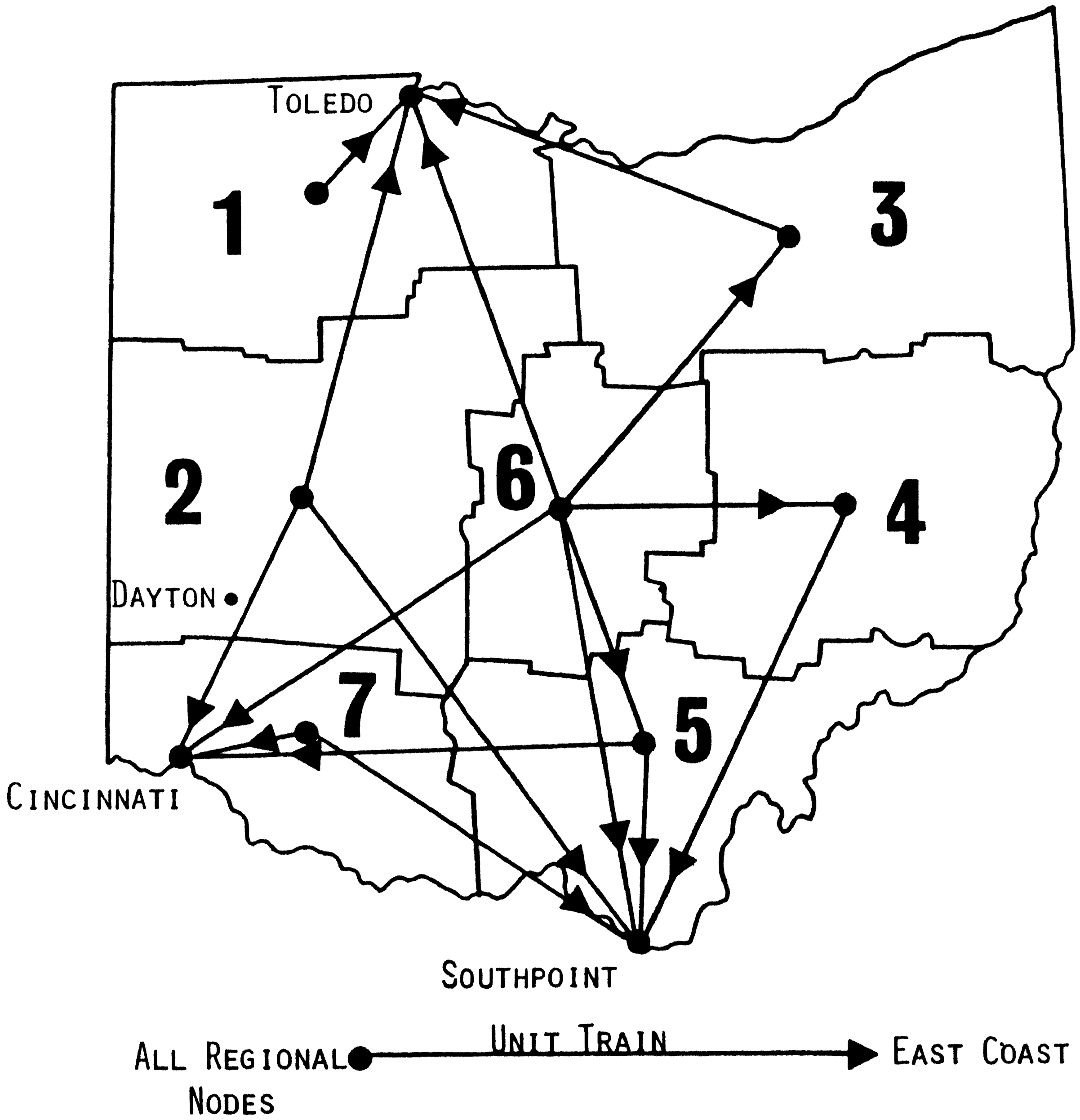
The Livestock System. The model includes eight types of livestock/poultry raising activities: dairy, beef finishing, cow-calf, sheep, swine, layers, broilers, and turkeys. With the exception of energy and certain concentrate portions, all input requirements were obtained from Ohio livestock enterprise budgets (5). Electricity, gasoline and other energy inputs were obtained from USDA (15) as well as from FEA (6).

The animal feed rations on which this model's livestock activities are based represent combinations of protein and energy needed to achieve a certain production level. For example, the per-cow production level for the dairy activity is 13,000 lb of milk per year along with 32% animal replacement of heifers for cows. Protein and energy come from two basic sources: corn and soybean meal (SBM). Energy is obtained from the former while protein is obtained primarily from the latter. In order to reflect current feeding practices (which in turn reflect animal nutrition requirements), the activities include certain feed inputs: wheat, oats, and forage. Including the latter inputs into livestock rations acts as a constraint on the model; the presence of dairy, cow-calf, and other operations forces the production of some minimum amount of forage. Constraints are also placed on the maximum percentage of forage which can be accounted for by any one crop (*e.g.*, pasture, hay, or corn silage).

Additional sets of livestock activities, which include as inputs the feed byproducts of ethanol production, have also been prepared. Substitution of those byproducts for corn and SBM is limited both by the animal's nutritional requirements and by the choice among alcohol production processes. Two such processes have been included in this model: conventional distillery and wet milling (see The Alcohol Fuels Industry, page 8). The byproduct of the former — distillers dried grains and solubles (DDGS) — cannot account for a high percentage of swine or poultry rations. On the other hand, cattle can be fed almost entirely on DDGS (although, beyond the point where an animal's protein requirements have been met, DDGS has value only as an energy source — *i.e.*, as a substitute for corn rather than for SBM). If the wet milling process is employed, corn gluten meal, starch, corn oil, and corn gluten feed are produced. These commodities substitute for soybean products in all livestock rations much better than DDGS does.

Finally, unlike the cropping system, the livestock system does not contain separate transportation activities. The prices for milk, meat, poultry, and eggs are farm prices; the model does not trace flows of those goods out into the livestock marketing system. No transportation costs are included for those feed inputs (*e.g.*, alfalfa, corn silage, oats, etc.) which tend to be grown on or near the farm. On the other hand, part of the cost of SBM and byproduct feeds from the alcohol industry is the expense of moving those items from processing plants to farms. That expense, which varies from region to region, has been incorporated directly into the feeding activities.

FIG. 2.—Corn transportation model.



The Alcohol Fuels Industry. The activity set which describes Ohio's agricultural economy must be augmented in two ways so that the impacts of alcohol fuels production can be analyzed. First, a set of production activities in which corn is the major input and ethanol and byproduct feeds are the major outputs must be specified. Second, a set of transportation activities which move corn to the alcohol plant(s) and byproducts to livestock feeding locations is also required. The latter activities have been discussed in the description of the cropping system. Since most planned ethanol production capacity lies in the vicinity of Southpoint, Ohio, that site was chosen as the alcohol industry demand point in this model. Linked to this demand point are five transportation routes (from Regions 2 and 4 through 7 — see Fig. 2), thus allowing for flexibility in the choice of how to supply corn to the new industry.

As noted, alcohol fuels production is allowed to occur either in a conventional distillery process or through a wet milling process. The input-output combination for the former, which yields ethanol and DDGS, was specified on the basis of interviews conducted with Pepco International, Inc. Information on the wet milling process, which produces starch, corn gluten meal, corn gluten feed, and corn oil in addition to alcohol, was obtained from Chemapec (2)

Set of Restrictions

This programming model contains three types of restrictions. First, minimum production levels are stipulated for certain products. Second, minimum crop deliveries are specified for certain demand points. Third, there is a land constraint.

Two types of minimum production constraints have been imposed. First, as mentioned under The Livestock System, page 6, there are indirect constraints on the production of certain feeds and forages (*e.g.*, oats and hay) because those commodities are included in livestock rations. Second, production of minor food crops, like barley and rye, and populations of sheep, horses, and mules are set equal to respective levels in 1978 (1).

There are four minimum delivery constraints in the model. First, the corn demand from the Dayton corn sweetener plant must be satisfied. The minimum level chosen in this model is 1982 consumption, 40 million bushels. Second, the model fixes corn demand of the ethanol industry. That demand level is allowed to vary among model runs (see final section of this bulletin). Third, certain food demands (*i.e.*, for milled wheat, corn, and oats) are fixed for those cases in which quantity demanded is small relative to the volumes of Ohio production channeled into other uses. Fourth, existing research on out-of-state deliveries for Ohio feed grains did not allow for estimation of the relationship between prices and quantities demanded. Accordingly, those shipments have been set equal to the levels observed during the late 1970's (9).

Each region's stock of cropland (Table 3) was determined using a two-step process. First, the two sets of soil survey data identified above were consulted in order to derive the percentage of any region's cropland which falls into a particular class. Second, those percentages were multiplied by estimates of the same region's total cropland. The latter estimates were obtained from the most recent Agricultural Census (1) rather than from the original surveys. The reason for this is that both surveys are dated; the SCS Conservation Needs Inventory was compiled in 1967 and the research by Triplett *et al.* was carried out in the early 1970's.

TABLE 3.—Cropland by Region and Land Productivity Class.

Region	Productivity Class 1	2	3	4	5	Total
			(000 acres)			
1	1,205	753	637	229	48	2,872
2	1,085	1,932	128	390	107	3,642
3	31	547	691	348	44	1,661
4	41	173	299	362	112	987
5	65	150	170	120	137	642
6	170	477	414	48	115	1,224
7	122	680	143	28	85	1,058
State	2,719	4,712	2,482	1,525	648	12,086

Model Validation

In order to determine how accurately the model simulates performance of Ohio's agricultural economy, a base run in which alcohol production was held to zero was compared with actual crop and livestock outputs and prices for the period 1978 through 1982 (Table 4). In general, the base run corresponded closely to actual performance. Simulated area planted to the state's three major crops — corn, soybeans, and wheat — was only 0.7% greater than average area planted during the period 1978 through 1982 (9,092,000 acres vs. 9,030,000 acres). Also, base run crop yields were very close to recent state averages. For instance, simulated corn production divided by base run corn acreage equalled 110 bushels/acre, which compares to state-wide averages of between 113 and 115 bushels/acre reported in 3 of the 5 years (3).

In general, simulated livestock outputs were about 95% of average output during the period 1978-82. Livestock production has not been profitable during recent years. Actual production remained higher than it would have been if all costs, not just variable costs, had been taken into account. There are some exceptions to this trend — poultry, for example. Those exceptions were reflected in the base run by outputs which exceed recent actual production.

Finally, simulated crop prices were fairly close to the levels which one would expect to observe in a year when both yields and acreages are normal (Table 4). Also, beef and pork prices are fairly close to their recent actual levels.

TABLE 4.—Comparison of Base Run with Actual Performance of Ohio's Agricultural Economy During 1977-1981.

Item	Actual Performance 1978	1979	1980	1981	1982	Average, 1978-82	Base Run
Land Use							
Corn (000 acres)	3,610	3,630	3,900	3,750	4,060	3,790	3 935
Soybeans (000 acres)	3,870	4,080	3 760	3,500	3,730	3,788	3 667
Wheat (000 acres)	1,080	1,320	1,370	1,650	1,250	1,334	1 308
Wheat/Soybeans (000 acres)							182
Crop Production							
Corn (million bu)	379	417	440	360	475	414	432
Soybeans (million bu)	128	145	135	100	138	129	142
Commodity Prices*							
Corn ($/ bu)	3 08	2 99	3 51	2 58	2 55	2 94	2 95
Soybeans ($/ bu)	9 17	7 63	8 58	6 43	5 60	7 48	7 40
Beef ($/ lb)	0 65	0 76	0 63	0 54	0 52	0 62	0 65
Pork ($/ lb)	0 64	0 52	0 42	0 46	0 54	0 52	0 50

*In 1982 dollars
Source Crop Reporting Service, U S Dept of Agriculture

IMPACTS OF ALCOHOL FUEL PRODUCTION ON OHIO'S AGRICULTURAL ECONOMY

The initiation of alcohol production in Ohio has two effects on agriculture in this state. First, there is a new marketing outlet (or demand) for corn. Second, alcohol production increases the supply of byproduct feed. All farmers in the state are not affected uniformly by these two events. Corn for the new alcohol plants is drawn first from farms located close to those plants. Similarly, high transportation costs dictate that the alcohol plants seek out local customers for byproduct feeds.

The impacts on Ohio agriculture of alcohol fuel production do not end with the two effects. An increase in total (*i.e.*, food plus feed plus energy) demand for corn generates added derived demand for agricultural inputs. Land currently used to produce other crops is converted to corn production and this increases the use of other inputs for corn production. Finally, some pasture, forest, and other land not presently devoted to crop agriculture is used to raise corn and other field crops. This last impact is of special interest since most of the planned alcohol production capacity is located outside of the Corn Belt (Fig 3).

The trade-offs implied by these shifts in cropping patterns are mitigated by the substitution of alcohol industry byproduct feeds for other sources of animal feed. The degree of substitution of these byproduct feeds for soybean meal depends both on the alcohol production process and on the allowable proportions of animal rations which can be byproduct feeds. Therefore, the opportunity costs (in lost feed) of a shift of 1 acre from soybean to corn production are equal to something less than the soybean meal and oil which can be obtained from that acre's crop.

That the trade-offs implied by switching land from the production of other crops (mostly soybeans) to the production of corn are greatly ameliorated by the substitution of DDGS for soybean products is seen by comparing three runs of the model in which the size of alcohol industry has been varied. The three alcohol output scenarios are:

I—Base Run, in which there is no alcohol production,

II—Present Industry, in which alcohol output in southern Ohio (Southpoint) equals 60 million gallons, and

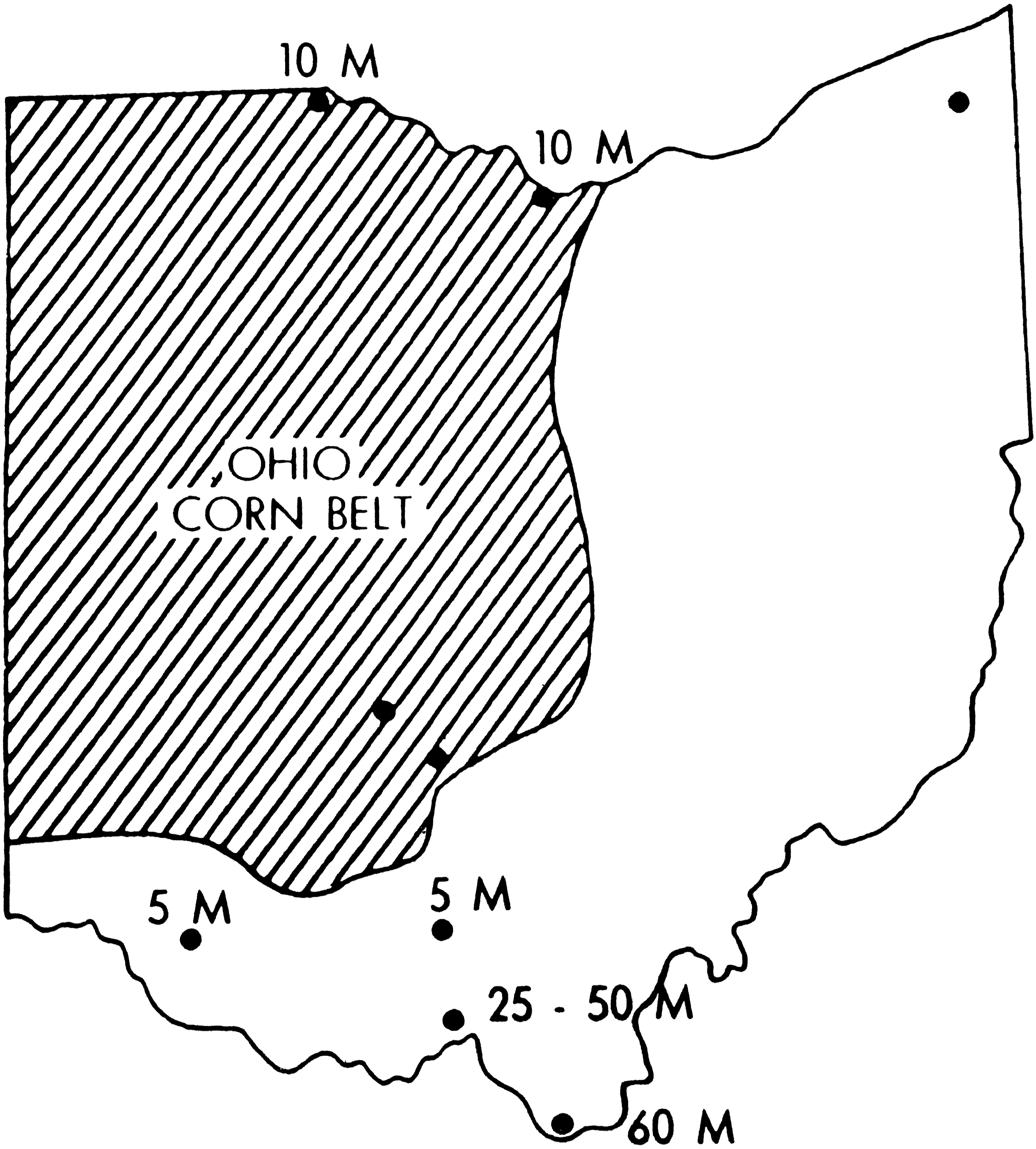
III—Moderate Industry Expansion, in which alcohol output in southern Ohio rises to an annual total of 100 million gallons.

The base run constitutes a reference point against which equilibrium performance obtained when alcohol industry corn demand is positive can be compared. Scenario II corresponds to current conditions; the installed capacity at Southpoint has been fully employed since early 1982. Additional plants in the vicinity of Southpoint and Portsmouth, Ohio, are being considered (12). Scenario III corresponds to the case in which those plants come on line while the Southpoint facility continues to operate. The balance of this section's discussion is devoted to a comparison of the first and third scenarios.

To reach the 100 million gallon production level, corn acreage would have to increase by 314,000 acres or about 8% (Table 5). At this level of alcohol output, byproduct feeds would substitute for soybean meal and some feed corn. Thus, 264,000 soybean acres would be released to corn production. In other words, 84% of the area needed for additional corn land would be met by substitution of soybean land. The remaining new acreage would come from reductions in the land devoted to other crops.

Livestock production would show only very small decreases, the largest being 1% for beef. This corres-

FIG. 3.—Existing and proposed ethanol plants (September 1981).



*Capacities shown are in million gallons per year. Plants with no capacities shown have yearly output of less than 1 million gallons.

TABLE 5.—Simulated Land Use and Agricultural Production with and without Ethanol Production, Ohio Agricultural Model, 1982.

Item	Alcohol Use Level		
	I Base Run— No Alcohol	II 60 million Gallons Alcohol	III 100 million Gallons Alcohol
		(000 units)	
Land Use (acres)			
Corn	3,935	4,135	4,249
Soybeans	3,667	3,508	3,403
Wheat	1,308	1 295	1,294
Wheat/Soybeans	182	178	178
Hay	557	544	544
Total	9,649	9,660	9,668
Crop Production (bu)			
Corn Produced	431,911	450,554	462,273
Feed (Ohio)	100,709	100,002	99,846
Feed (U S)	61,791	61,406	61,406
Export	229,411	225,146	221,021
Alcohol		24,000	40,000
Corn Sweetener	40,000	40,000	40,000
Soybeans Produced	142,026	137,072	133,916
Processed	72,193	67,698	64,731
Exported	69,833	69,374	69,184
Livestock Numbers			
Dairy Cows	347	346	346
Beef	284	281	280
Cow/Calf	395	391	389
Swine	219	219	219

ponds to the minor change in feed availability which results from diverting some corn to alcohol production. Also, dairy and swine production would be reduced to the minimum amounts allowed in the model. These minimum production constraints were imposed to recognize the inertial tendencies of livestock producers (*i.e.*, collectively, only small changes in livestock production occur from year to year). Without these constraints, production of some livestock commodities would be lower.

Channeling 40 million bushels of corn to alcohol production would result in an overall rise in the price of corn from $3.22 to $3.28 per bushel (Table 6). Within the state, the price increase would range from 3 to 16 cents per bushel. The largest increase would be observed in Region 5 where alcohol production is located. This region would change from a net exporting to a net importing region for corn. Hence, the local price for corn would equal the price in an adjacent surplus corn region plus the transport cost of that corn to the plant minus transport cost from within Region 5 to the plant. The principal beneficiaries of alcohol-related commodity price increases would therefore be the farmers in Region 5.

Land rental rates would change to reflect the higher commodity prices, especially in Region 5 where they would increase by as much as 25% (Table 6).

Associated with the substitution of one crop (corn) for another (soybeans) would be a change in input requirements (Table 7). Nitrogen needs would increase by about 5% to reflect the greater planting of corn, while phosphorus use would remain constant and potash use would decline slightly. While total energy use remains nearly constant, LP gas use increases 6% to accommodate the drying of additional corn.

In summary, the modest levels of alcohol production projected for Ohio in the next few years will not place great stress on the agricultural sector. The principal change will be in the relative mix of soybeans and corn for cash grain farmers as more corn and less soybeans are produced. This will be especially noticeable in the vinicity of the ethanol plant, where the largest corn price changes will occur. Associated land values will also increase in this region.

If land use changes — from soil conserving crops (meadow) to more erosive row crops (corn) — are very pronounced in this non-traditional corn area, some land quality deterioration could occur. The model is being adapted to identify trade-offs between crop production and soil conservation goals in southeastern Ohio and elsewhere in the state.

TABLE 6.—Simulated Commodity Price Changes with and without Alcohol Production, Ohio Agricultural Model, 1982.

Item	Alcohol Use Level I Base Run No Alcohol	II 60 Million Gallons Alcohol	III 100 Million Gallons Alcohol
Land rental value* ($/acre)			
Region 1	$ 81	$ 84	$ 88
2	76	79	80
3	74	77	81
4	73	75	80
5	73	87	91
6	73	75	80
7	80	82	86
Corn ($/bu)			
Region 1	$2 96	$2 98	$3 01
2	2 92	2 94	2 95
3	2 88	2 91	2 94
4	2 88	2 91	2 94
5	2 88	3 01	3 04
6	2 88	2 91	2 94
7	2 95	2 97	3 00
East Coast	3 22	3 24	3 28

*Based on soil production, level 2 (see RaskTable 3), which represents 39% of the state cropland

TABLE 7.—Energy and Fertilizer Input Use, Ohio Agricultural Model, 1982.

Item	Alcohol Production Level I Base Run No Alcohol	II 60 Million Gallons Alcohol	III 100 Million Gallons Alcohol
		(000 units)	
Fertilizer (tons)			
Nitrogen	306	314	319
Phosphorus	252	252	253
Potash	454	452	451
Energy*			
Gasoline (gal)	108,640	108,904	109,062
Diesel Fuel (gal)	76,271	77,317	77,709
L P Gas (gal)	78,771	81,951	83,912
Electricity (KWH)	317,692	317,658	317,574

*Includes energy inputs used to transport crops and feeds via truck within the state

REFERENCES

1. Bureau of Census. 1980. 1978 Census of Agriculture Preliminary Report: Ohio. U. S. Dept. of Commerce, Washington, D. C.
2. Chemapec, Inc. 1979. Industrial Alcohol by Continuous Fermentation and Vacuum Distillation with Low Energy Consumption. Woodbury, N. Y.
3. Crop Reporting Service, U. S. Dept. of Agriculture. Ohio Agricultural Statistics (selected annual issues). Columbus, Ohio.
4. Dept. of Agricultural Economics and Rural Sociology (AERS), The Ohio State University. 1982. Crop Enterprise Budgets. Columbus, Ohio.
5. Dept. of Agricultural Economics and Rural Sociology (AERS), The Ohio State University. 1982. Livestock Enterprise Budgets. Columbus, Ohio.
6. Federal Energy Administration (FEA). 1977. Energy and U. S. Agriculture: 1974 Data Base, Vol. I. Washington, D. C.
7. Gill, M. and A. Prato. 1983. Situation and Outlook for Alcohol Fuels from Grain. Econ. Res. Serv., U. S. Dept. of Agriculture, Washington, D. C.
8. Heien, D. M. 1982. The Structure of Food Demand: Interrelatedness and Duality. Amer. J. Agri. Econ., 64:213-221.
9. Hennen, G., E. D. Baldwin, D. W. Larson, and J. W. Sharp. 1980. Ohio Grain Flows by Mode of Transportation and Type of Grain Firms for 1970 and 1977: A Comparison. Ohio Agri. Res. and Dev. Ctr., Res. Bull. 1124.
10. Ray, D. E. and J. W. Richardson. 1978. Detailed Description of Polysim. Oklahoma State Univ., Agri. Exp. Sta., Tech. Bull. T-151.
11. Sitterley, J. H. 1976. Land Use in Ohio, 1900-1970. Ohio Agri. Res. and Dev. Ctr., Res. Bull. 1084.
12. Southgate, D., N. Rask, T. Ryan, and S. Ott. 1983. Projecting Food-Fuel Conflicts Resulting from Biomass Energy Development in Ohio. Energy in Agr., 2:307-317.
13. Takayama, T. and G. C. Judge. 1964. Spatial Equilibrium and Quadratic Programming. J. Farm Econ., 46:67-93.
14. Triplett, G. B., Jr., D. M. Van Doren, Jr., and S. W. Bone. 1973. An Evaluation of Ohio Soils in Relation to No-Tillage Corn Production. Ohio Agri. Res. and Dev. Ctr., Res. Bull. 1068.
15. U. S. Dept. of Agriculture (USDA). Fats and Oils Outlook and Situation (various issues). Washington, D. C.

APPENDIX
Data Used to Specify Objective Function and Transportation Costs

TABLE A-I.—Elasticities and Price Flexibilities Used to Formulate Objective Function.

Price Flexibilities — Non-Export Products

	Milk	Beef	Pork	Poultry	Eggs
Milk	−0.324	−0.043	−0.029	−0.012	−0.015
Beef	+0.015	−1.631	−0.035	−0.014	−0.015
Pork	−0.018	−0.997	−1.820	−0.261	−0.295
Poultry	+0.011	−0.788	−0.515	−2.051	−0.231
Eggs	−0.029	−1.016	−0.667	−0.266	−0.528

Source: Heien (8).

Elasticities — Export Products

Commodity	Elasticity
Corn	−0.50
Wheat	−0.50
Soybeans	−0.57
Soybean Meal	−0.57

Source: Ray and Richardson (10).

Cross-price flexibilities between any export product (*i.e.*, any grain) and all other products (both grains and livestock commodities) are assumed to equal zero.

TABLE A-II.—Production and Farm-Level Prices Used to Formulate Objective Function.

Commodity	Farm-Level Price†	Ohio Production
Beef	\$ 0.600/lb	603.8 mm lb
Pork	\$ 0.520/lb	667.4 mm lb
Poultry*	\$ 0.382/lb	155.3 mm lb
Eggs	\$ 0.580/doz.	183.4 mm doz.
Milk	\$13.50/cwt	4,338.0 mm lb‡
Corn	\$ 2.85/bu	230.0 mm bu**
Wheat	\$ 4.05/bu	26.5 mm bu**
Soybeans	\$ 6.95/bu	72.0 mm bu**
Soybean Meal	\$14.38/cwt	1,020.0 mm lb**

*A composite of turkey and chicken.

†The five livestock prices used to specify the objective function are the farm-level prices for beef, pork, poultry, eggs, and milk shown in this table. The four grain prices used are equal to the farm-level prices plus the cost of shipping grain from the Ohio corn belt (Regions 1 and 2) to the East Coast.

‡Equal to 90% of 1981 production. This adjustment is made because the milk market is not at equilibrium at the current support price; at that price, 10% of production is purchased and stored by the federal government.

**Equal to export quantities after U.S feed and processing demands have been met.

Source: Crop Reporting Service

TABLE A-III.—Crop Transportation Costs.*

	Origin							
ı	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Southpoint
			$0 469			$0.460		$0 652†
						0 350	$0.359	0 646†
	$0.643†	$0.646†		$0 385		0.428		0.652†
	0.646†	0 643†				0.381		0.646†
		0 643†						0.179†
	0.611†	0.466†						0.611†
		0 414†						0.643†
		0.249		0 236	$0.100	0.205	0 214	
	0.147	0.360	0.410			0.419		
		0 326			0 433	0.360	0 200	
	0.336	0 336	0.336	0.336	0.336	0.336	0.336	0.621†

ɔle shows all per-unit crop transportation costs included in the model. A blank space indicates the absence of a transportation activity.
ɾed in $/cwt. All other costs measured in $/bushel.