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Evaluation of the Economic Impact of a Dry Mill Ethanol Plant in Michigan Using Corn as a Feedstock

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Action by Congress in October 1990 had important implications for ethanol production and for the corn industry. The Omnibus Reconciliation Act of 1990 extended the blender tax credit and excise tax exemption to the year 2000. The Clean Air Act amendments of 1990 mandated oxygenated gasoline fuels in certain cities. Reasonably secure is the projected blender tax credit to the year 2000 and odds favor an extension of that subsidy. Less certain is the role ethanol will play in the provision for oxygenated fuels.

Nevertheless, bio-fuels are getting increased attention as a source of energy and a means to meet Clean Air Act objectives. However, technology has not yet generated processes which can provide ethanol to the market at competitive prices to petroleum based fuels. Conversion rates of corn to ethanol have improved and may make bio-fuels competitive in the future. This, of course, will depend on future petroleum prices relative to corn prices (or prices on other feedstocks).

A corn dry milling plant proposed for Michigan would produce 15 million gallons of ethanol annually. This plant would require about 5.8 million bushels of corn. As a by-product, about 50,000 tons of distiller's dried grain with solubles (DDGS) would be available.

To evaluate the economic impact of a dry mill ethanol plant in Michigan, assumptions have to be made about the value of products of such an operation relative to the cost of the inputs. Another question is what direct and secondary impacts the plant would have on the Michigan economy.

One approach is simply to measure, in a static sense, what value a dry mill plant might add to the quantity of the corn crop processed. This would depend on the price of corn, the price of ethanol, the

price of the major byproduct, distiller's dried grain, and technical conversion rates. Allowances would have to be made for costs of enzymes.

Disregarding the cost of enzymes and possible improvements in conversion rates, some measure of value added can be established. Assuming generally accepted conversion rates, a bushel of corn converts to 2.6 gallons of ethanol and 17.5 pounds of DDGS.

Price of Ethanol

Most difficult to estimate has been the price of ethanol in Michigan relevant to a dry mill plant. Based on surveys for mid 1995 as reported in Oxy-Fuel News, prices in Detroit and Niles ranged from $1.01 to $1.06 per gallon (Oxy-Fuel News). In the same period, however, Total Petroleum reported Lansing prices from New Energy (South Bend, IN) at $1.25 to $1.30 per gallon (Renke). Similar prices were obtained from the Michigan Farm Bureau (Boehm). This $.25 difference may be due to the terms of sale related to the size of the orders.

The series reported by Total Petroleum and Michigan Farm Bureau was selected to be the most representative selling price for the scale of operation contemplated for a dry milling plant. This series was on a monthly basis beginning in September 1993. For the period from August 1987 to August 1993, this series was linked to the Bureau of Labor Statistics' (BLS) Producer Price Index for denatured ethyl alcohol (Bureau of Labor Statistics). The resulting ethanol price series for the entire August 1987 to September 1995 period is charted in Figure 1.

As suggested by Ed Renke with Total Petroleum, another procedure to price ethanol in Michigan is to add the equivalent in blender tax credit to gasoline prices with allowance for the premium such blends provide. Specifically, he adds the $.54 per gallon credit to unleaded prices in Chicago (wholesale without taxes) plus $.06 per gallon to account for a blend premium.[1] This series labeled "value" is also plotted in Figure 1.

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[1]The $.54 per gallon is derived from the $.054 per gallon blender tax exemption if the product contains 10 percent ethanol. In effect, this provides a value to ethanol of $.54 per gallon ($.054 ÷ 10 percent).

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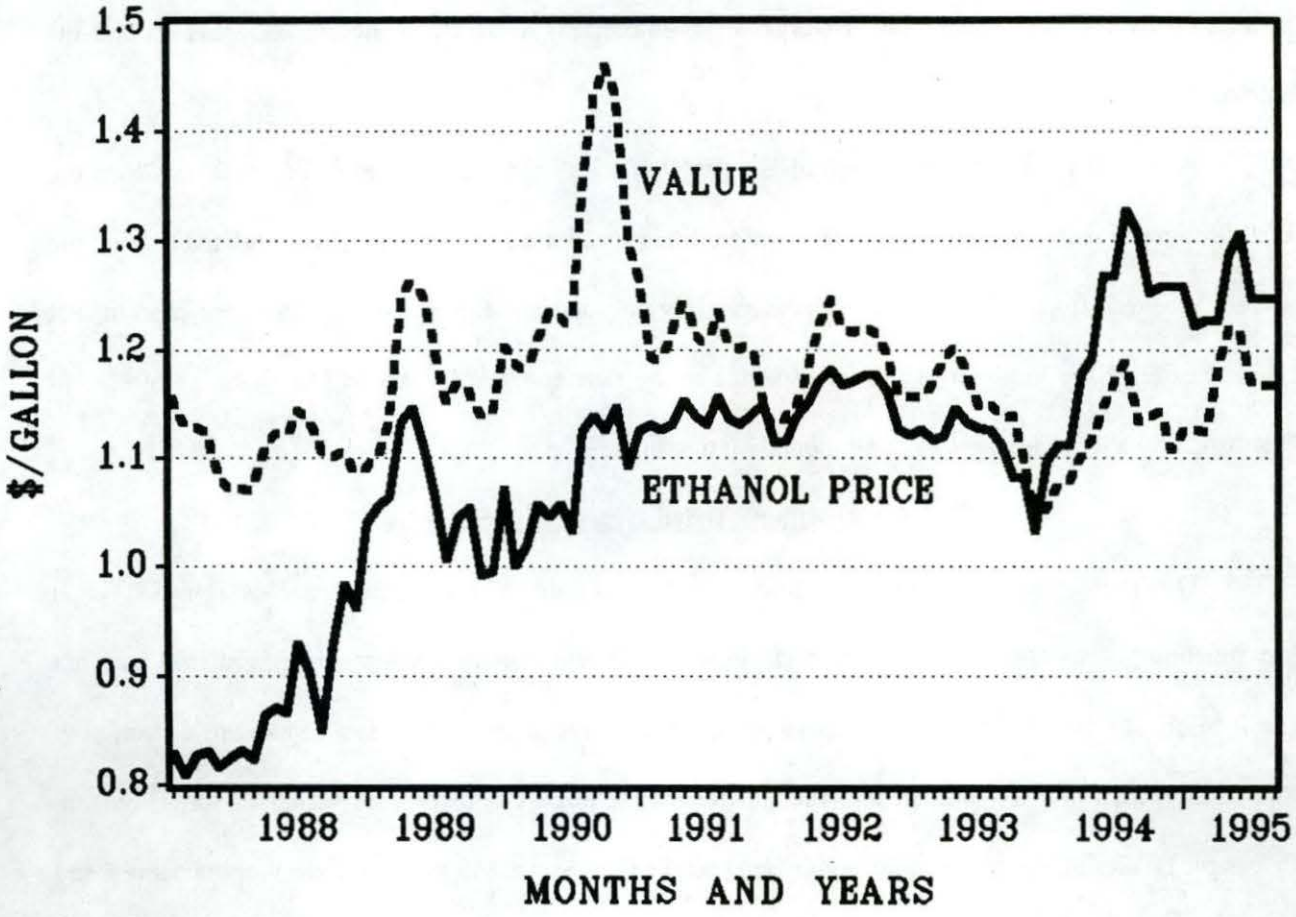
Figure 1

Price of Ethanol in Michigan Compared with Values Based on Chicago Gas Prices Plus Tax Credit*



*Ethanol prices based on quotes from Michigan Farm Bureau and Total Petroleum for mid 1993 to mid 1995 and on the BLS' Producer Price Index in earlier months.

Note that ethanol prices have been increasing relative to their value based on gasoline prices plus the tax credit. Since mid 1994, ethanol prices have been maintained in a range of about $1.25 to $1.30 per gallon with the value in the $1.10 to $1.20 per gallon range. The rise in ethanol prices has been influenced by the implementation of oxygenate requirements in certain major urban areas around the nation.

A similar pattern between ethanol and gasoline prices can be observed in Figure 2, in which the BLS Producer Price Indices for those two commodities are plotted. Ethanol prices are related to gasoline prices, but are influenced by certain separate supply and demand forces. In any case, the margin that ethanol prices have held above the value series in the past couple of years in Michigan, as plotted in Figure 1, probably represents an upper bound on that difference.

Price of Distiller's Dried Grains with Solubles

The most widely quoted U.S. price on distillers dried grain with solubles (DDGS) is at Lawrenceburg, IN. This is a high quality (from whiskey), low volume product which probably does not reach Michigan in very large amounts. However, in a conversation with Steve Markham, Commodity Specialist with Pillsbury, he felt that the Lawrenceburg price would be representative for Michigan. Prices on DDGS at New Energy in South Bend tend to run about $10 per ton under Lawrenceburg and shipping costs from New Energy which supplies Michigan with DDGS are about $10 per ton to Greenville, MI, and $13 per ton to Marlette, MI (Markham).[2]

DDGS is a "middle protein" feed, testing around 29 to 30 percent crude protein when fed dry, compared with 44 to 48 percent protein for soybean meal. DDGS is mainly fed to dairy cattle and can replace all of the base protein feed in the ration and up to about a third of the energy feeds such as corn (Ensminger and Olentine), (Black).

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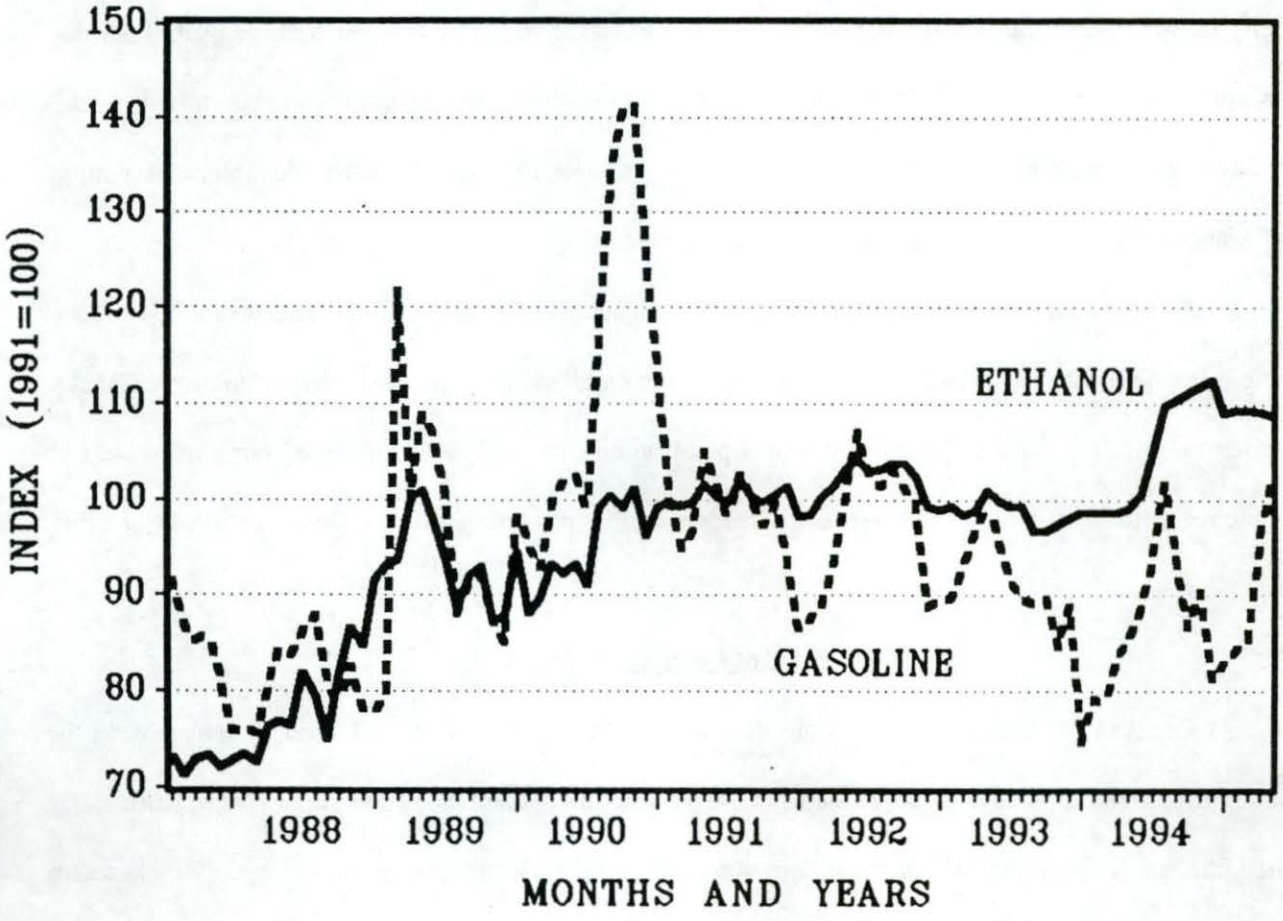
[2]Quotations for DDGS in Lansing by Northern Milling and Trading were $15-25 over the Lawrenceburg price, but were established only by an out-of-state basing point plus transportation and could not be verified.

Figure 2

Producer Price Index (1991 = 100) on
Ethanol and Gasoline*



*Based on the Producer Price Index series of the BLS of the USDL for denatured ethyl alcohol (2869-51212) and unleaded gasoline (2911-1341).

The price of DDGS is strongly tied to the concentrate feed market and the supply of DDGS relative to other feeds. The prices of corn and soybean meal in combination with the supply of DDGS relative to other protein feeds are the major factors which establish the price of DDGS. With 327,000 dairy cows on Michigan farms, each of which could be fed as much as 4 to 5 pounds of DDGS per day, an upper bound of about 270,000 to 300,000 tons would represent the annual market potential.[3] Such a market should easily absorb 50,000 tons annually from a 15 million gallon ethanol plant without substantial downward pressure on prices within the state.

Some Michigan dairy farmers have had experience with feeding DDGS. In addition to amounts being shipped into the state from New Energy, wet distillers grain is being imported from Canada. However, with the construction of a dry mill plant within the state, an educational program should be launched with dairy farmers and beef cattle feeders on the introduction of distillers grains, wet or dried, into the rations.

Price of Corn in Michigan

Because Michigan produces more than double the amount of corn utilized by livestock in the state, prices tend to be lower than in states to the South and East and along the major rivers, particularly the Ohio and Mississippi. Much of the corn moves to the poultry and hog operations in the Southeastern U.S. and to Atlantic ports for export. In the six crop years from 1988-89 to 1993-94, the price received by Michigan farmers averaged $2.28 per bushel, about $.15 per bushel less than prices received by farmers in Ohio, Indiana and Illinois.

With corn sales in Michigan heading mostly toward Toledo and secondarily toward Chicago and to a deficit region west of Grand Rapids, prices tend to vary within the state reflecting these movements. Prices at the Saginaw terminal tend to average about 10-15 cents per bushel under Toledo and 15-20 cents per bushel under Chicago.

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[3]Based on conversations with Herb Bucholtz, Professor in the Department of Animal Science Department, Michigan State University.

Estimation of Possible Value Added

Looking at past prices on ethanol, DDGS and corn in Michigan, some indication can be gained of the potential of a dry milling plant to add value to the corn crop. Using the conversion rates of 2.6 gallons of ethanol and 17.5 pounds of DDGS from a bushel of corn, Table 1 displays what might have been generated by a corn dry milling plant in Michigan in the crop years from 1987-88 to 1994-95. Any value for marketing of a minor byproduct, carbon dioxide, is excluded.

For these 8 crop years, the value of the product of such a plant would have averaged nearly $4.00 per bushel. With the season average price received by farmers for corn nearly $2.25 per bushel, the value added would have amounted to about $1.71 per bushel. This value added then would represent over 75 percent of the raw material value represented by the price received by farmers.

The existence of a 15 million gallon ethanol plant would have increased corn prices in the region around such a plant, perhaps as much as $.10 per bushel. The effect on the average price for all farmers in Michigan would be minimal. The input to the plant would be about 6 million bushels annually compared with the average size of the Michigan crop at about 250 million bushels over the 1993-95 period. Over 125 million bushels have been shipped out of the state in recent years.

Excluding the possible enhancement to average corn prices in Michigan, a 15 million gallon ethanol plant would have added about $1.71 per bushel to 5.77 million bushels in the 1987 to 1994 crop years. This would have amounted to about $10 million annually. Of course, any enhancement of the farm price would also be a part of this value added.

Applying the value added for 1994-95 of $2.02 per bushel, such a plant would have provided nearly $12 million directly to the Michigan economy.

Of course, more relevant is an assessment of future prices of ethanol, DDGS and corn in Michigan. The results of this analysis are appended at the bottom of Table 1 for the year 2010. If ethanol prices bear the same relationship to the price of gasoline, as observed over the 1993-94 and 1994-95 crop years, the real price is most likely to increase in the 1995-2010 period.

Table 1

Estimation of Possible Value Added by a Corn Dry Milling Plant for the Production of Ethanol in Michigan in 1987-94 Crop Years and Projected to 2010

Crop Year Beginning	Season Average Price Received by Farmers for Corn	Estimated Market Price of Ethanol in Michigan[a]	Bulk Price on Distillers Dried Grain at Lawrenceburg, IN	Value of Product per Bushel of Corn			Value Added per Bushel of Corn
				Ethanol	DDGS	Total	
	$/bu.	$/gal.	$/T	$/bu.	$/bu.	$/bu.	$/bu.
1987	1.97	.85	132	2.21	1.15	3.37	1.40
1988	2.53	1.04	141	2.71	1.23	3.94	1.41
1989	2.28	1.05	124	2.72	1.09	3.81	1.53
1990	2.21	1.13	127	2.94	1.11	4.05	1.84
1991	2.34	1.15	122	2.99	1.07	4.05	1.71
1992	1.95	1.13	123	2.94	1.08	4.02	2.07
1993	2.46	1.17	124	3.04	1.09	4.13	1.66
1994	2.15	1.25	105	3.25	.92	4.17	2.02
Average	**2.24**					**3.94**	**1.71**
Projected 2010	3.38	2.30	200	5.98	1.75	7.73	4.35

[a]Estimated from actual ethanol prices in Michigan in 1993-94 and 1994-95 crop years with earlier years based on the Bureau of Labor Statistics' Producer Price Index on denatured alcohol.

The "reference case forecast" of the Energy Information Administration of the Department of Energy pegs the real price of motor gasoline (1993 base) at $1.30 per gallon in the year 2000, $1.36 in 2005 and $1.38 in 2010 (Energy Information Administration, DOE, 1995). These prices compare with $1.12 in 1993.[4] Their 2010 projection for low economic growth is $1.29 and for high economic growth is $1.52 per gallon.

The essence of these projections is that the Department of Energy expects the real price of gasoline at retail to rise over the 1993 to 2010 period. At the low end, real prices would increase slightly; in the "reference" case, increase 23 percent; in the high economic growth case, increase about 33 percent over 1993. In nominal terms, the DOE projects gasoline prices in the $2.25-2.80 range in the year 2010. Under the reference case, retail gasoline prices increase from $1.12 per gallon in 1993 to $1.55 in 2000, to $1.92 in 2005, and $2.30 in 2010.

Using the DOE's reference projection for nominal retail gasoline price of $2.30 per gallon in the year 2010, this amounts to an increase of $1.18 per gallon over 1993. If the 5.4 cent blender tax credit remains in effect beyond 2000, this would establish Michigan ethanol prices at about double the level for calendar 1993--or $2.30 per gallon.

With rising fuel and other energy prices, the cost of producing corn per acre and per bushel will also increase. However, because of the continued increase in efficiencies in producing corn and a persistent rise in yields per acre, costs per bushel in raising corn are not likely to increase as much as ethanol prices.

Real gross margins per acre over variable costs in corn production (gross margins divided by an indicator of inflation), have tended to decline over time. This is indicated in Figure 3 which plots average gross margins on corn in Michigan divided by the Consumer Price Index (1982-84 = 100 percent). Returns to participants and non-participants in the Feed Grain Program are differentiated.

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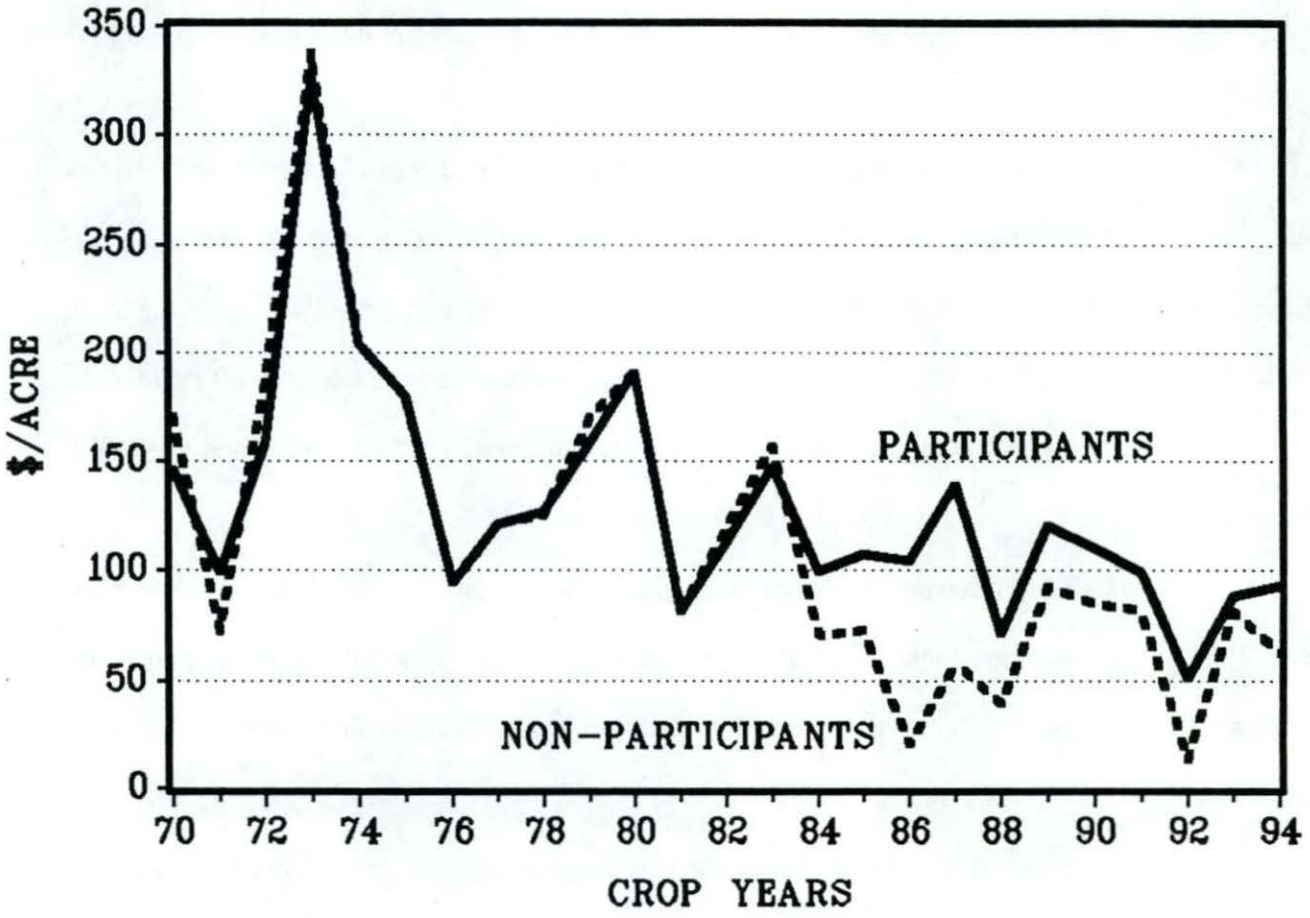
[4]Average U.S. retail price for all grades, and includes federal and state taxes.

Figure 3

Real Gross Margins Over Variable Costs on Corn in Michigan for Participants and Non-participants in the Feed Grain Program*



*1982-1984 dollars.

The profit advantage to participating in recent years is apparent. For this reason, most of Michigan's corn base has been in the Feed Grain Program--usually 80 percent or more.

While real gross margins over variable costs have fluctuated substantially from year-to-year, trends since 1970 point to a gradual decline with returns to participants in the Feed Grain Program averaging about $100 per acre (1982-84 dollars) in recent years.

At the national level, the pattern on real gross margins over variable costs on corn has been very similar to Michigan (Figure 4). As in Michigan, about 80 percent of the U.S. corn base has been in the Feed Grain Program.

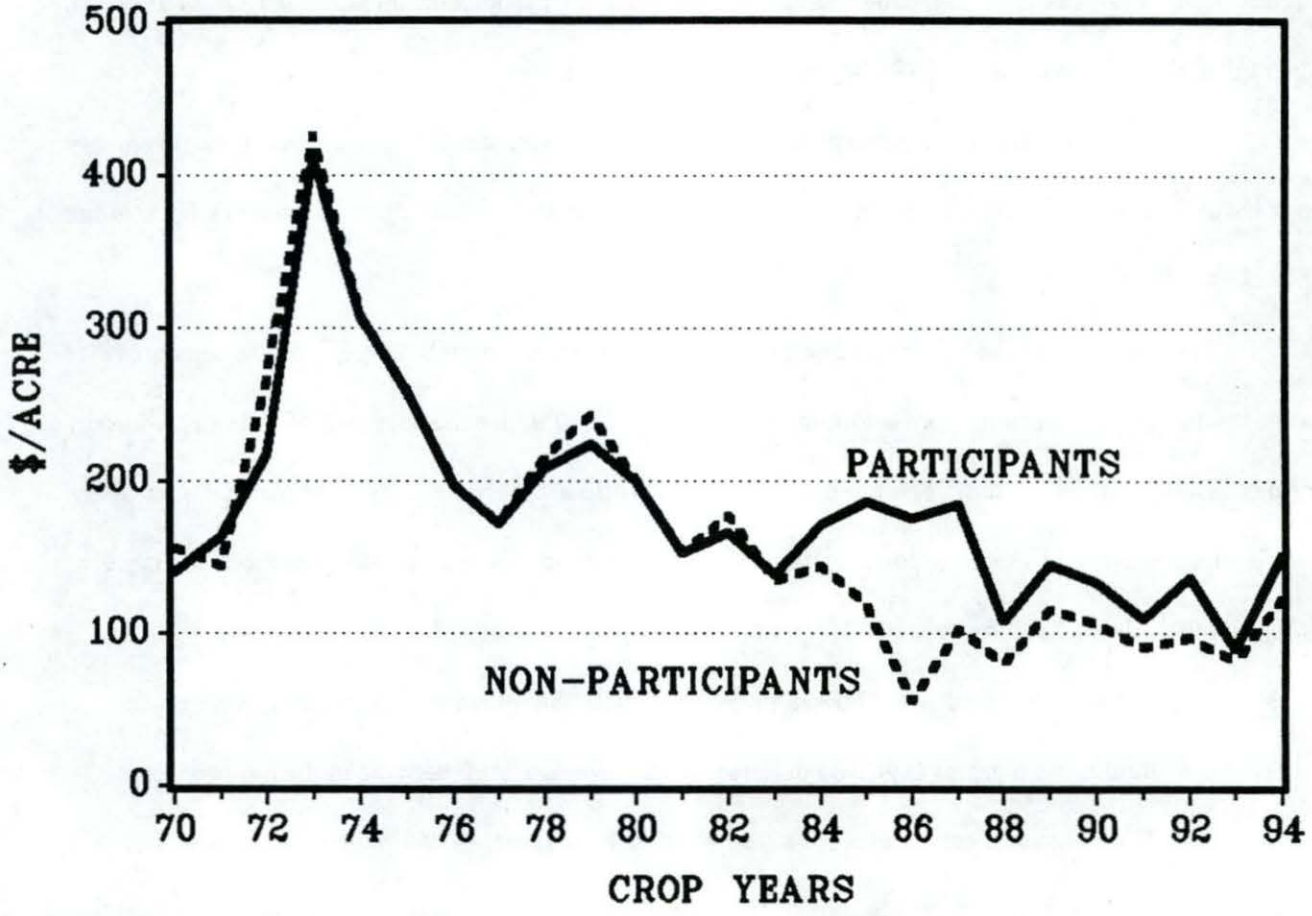
The convergence of real gross margins over direct costs to about $100 per acre on corn provides a means to project prices on corn and DDGS to the year 2010 under the scenario of rising real energy prices as conjectured by the Department of Energy. While a progressive and competitive agriculture could bring these real margins down to less than $100 per acre over time, the likelihood of margins holding much above $100 for an extended period would appear remote.

To project prices on corn and DDGS to the year 2010, the following assumptions were made:

1. Real gross margins (1982-84 dollars) on corn average $100 per acre at the national level.
2. The Consumer price Index (1982-84 = 100 percent) reaches 263 in 2010 compared with 148 in 1994 (based on projections by the DOE).
3. The U.S. refiner acquisition price of crude oil increases from $15.60 per barrel in 1994 to $40.30 per barrel in 2010 (based on projections by the DOE).
4. U.S. corn yields increase 1.86 bushels per year, reaching 154 bushels per acre by 2010.
5. The price of soybean meal (bulk, Decatur, IL, 44 percent) averages 10.9 cents per pound over the farm price of corn per pound.
6. The price of DDGS is determined by its feed value.
7. The Feed Grain Program will be phased out and income from corn will be based entirely on market receipts.

Figure 4

Real Gross Margins Over Variable Costs on Corn, U.S., for Participants and Non-participants in the Feed Grain Program*



*1982-1984 dollars.

8. The farm price of corn in Michigan is about 6 cents per bushel under the national average.

Under these assumptions, the question is, "What would the nominal U.S. farm price of corn have to be in the year 2010 to generate real gross margins over variable costs of $100 per acre?" Variable costs in producing corn were projected by relating: (1) seed costs to inflation and corn prices; (2) energy based inputs to projections on crude oil prices and general inflation; and (3) other variable costs to general inflation. Variable costs for 1994 and projected to 2010 were as follows:

	1994 $/acre	2010 $/acre
Seed	23	42
Energy based[a]	90	177
Other[b]	25	49
Total	138	268

[a]Fertilizer, chemicals, fuel, lubricants, electricity.
[b]Custom operations, repairs, hired labor.

With the assumption that the Feed Grain Program will be phased out, projecting corn prices involves solving the following formula:

> Real Gross Margin over Variable Costs on Corn = (Farm Price of Corn x Projected Yield - Variable Costs in Corn Production) ÷ Consumer Price Index (1982-84 = 100 percent) = $100

Substituting in projected values,

> (Farm Price of Corn x 154 - 268) / 2.63 = 100

The price of corn which satisfies this equation is $3.44 per bushel for the U.S. The Michigan price would be about $3.38. If soybean meal is priced about 11 cents per pound over corn prices per pound, the result is about $341 per ton.

The price of DDGS was derived from both the energy and protein values of the feed. The prices of energy and protein were derived from corn and soybean meal prices. The resulting price in 2010 for DDGS at Lawrenceburg, IN, was $200 per ton compared with $105 per ton in 1994.

As shown in Table 1, the results of this set of projections to 2010 would nearly double the value of the product from a bushel of corn, with value added amounting to $4.35 per bushel. Value added

would equal 129 percent of the farm price of corn. Value added, increasing in nominal terms from just over $2.00 per bushel in 1994 to $4.35 per bushel in 2010, would also rise in real terms. In 1994 dollars, the added value in 2010 is $2.45 per bushel, 21 percent higher than in 1994.

Other assumptions could be made and alternative scenarios examined. Very likely, years of elevated corn prices will be experienced such as in the 1995-96 crop year. A robust world economy may challenge crop producers to meet demands for feed grains and protein meals for periods over the next 15 years. This happened in the early 1970's. However, as can be noted in Figure 5, the long-term pattern for real corn prices has been to "stair-step" down to lower levels.

On petroleum prices, as indicated by refiner acquisition costs on crude oil, prices retreated spectacularly from the highs of the early 1980's, but are projected to resume a secular rise (Figure 6). The "reference" projections of the Energy Information Administration of the U.S. Department of Energy places the real price of crude oil at $24.12 per barrel (1993 dollars) in 2010, which implies about $40 per barrel in nominal terms. This projection compares with a price of $16.41 in 1993, $15.59 in 1994 and $18.62 in mid 1995. With a low economic growth assumption, the DOE projection for real crude oil prices is $23.29 per barrel and $24.99 with high economic growth. In other words, even at the low end of their range of projections, real petroleum prices are expected to increase over the 1995-2010 period.

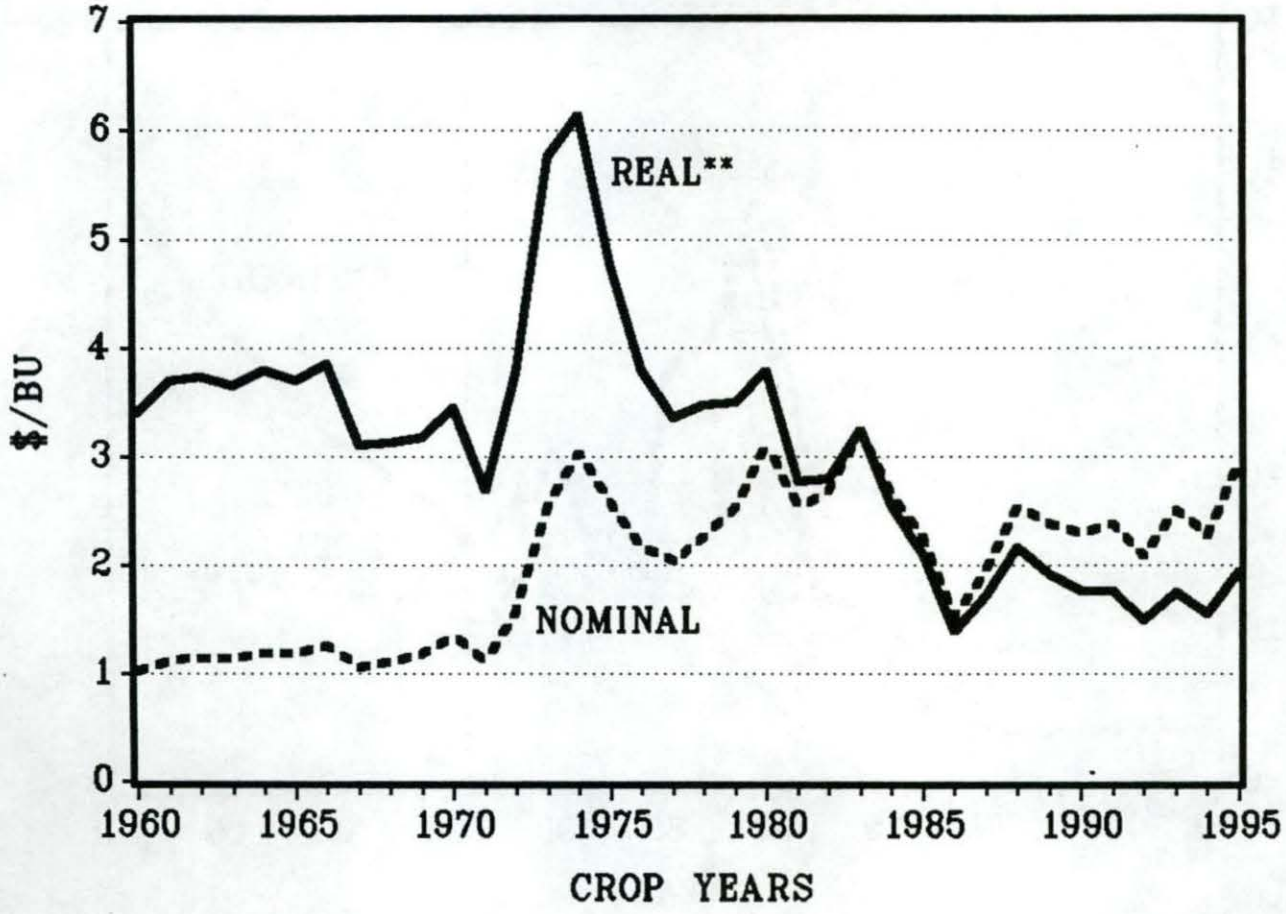
With the likelihood of some further decline in real corn prices and an increase in real gasoline prices, the real value added to corn prices from a dry milling operation should increase in 1995-2010. This would likely occur even with some modifications in assumptions underlying this analysis.

Economic Impact

A 15 million gallon dry mill plant would involve about 75 jobs in the construction phase of about a year. The operation would employ about 30 persons on a permanent basis. Gross sales would be estimated at about $25 million. An advantage of an ethanol plant to a region is that a high proportion of the secondary effects remain in the region. The major input is corn and likely most of the hiring and capital would originate within the state.

Figure 5

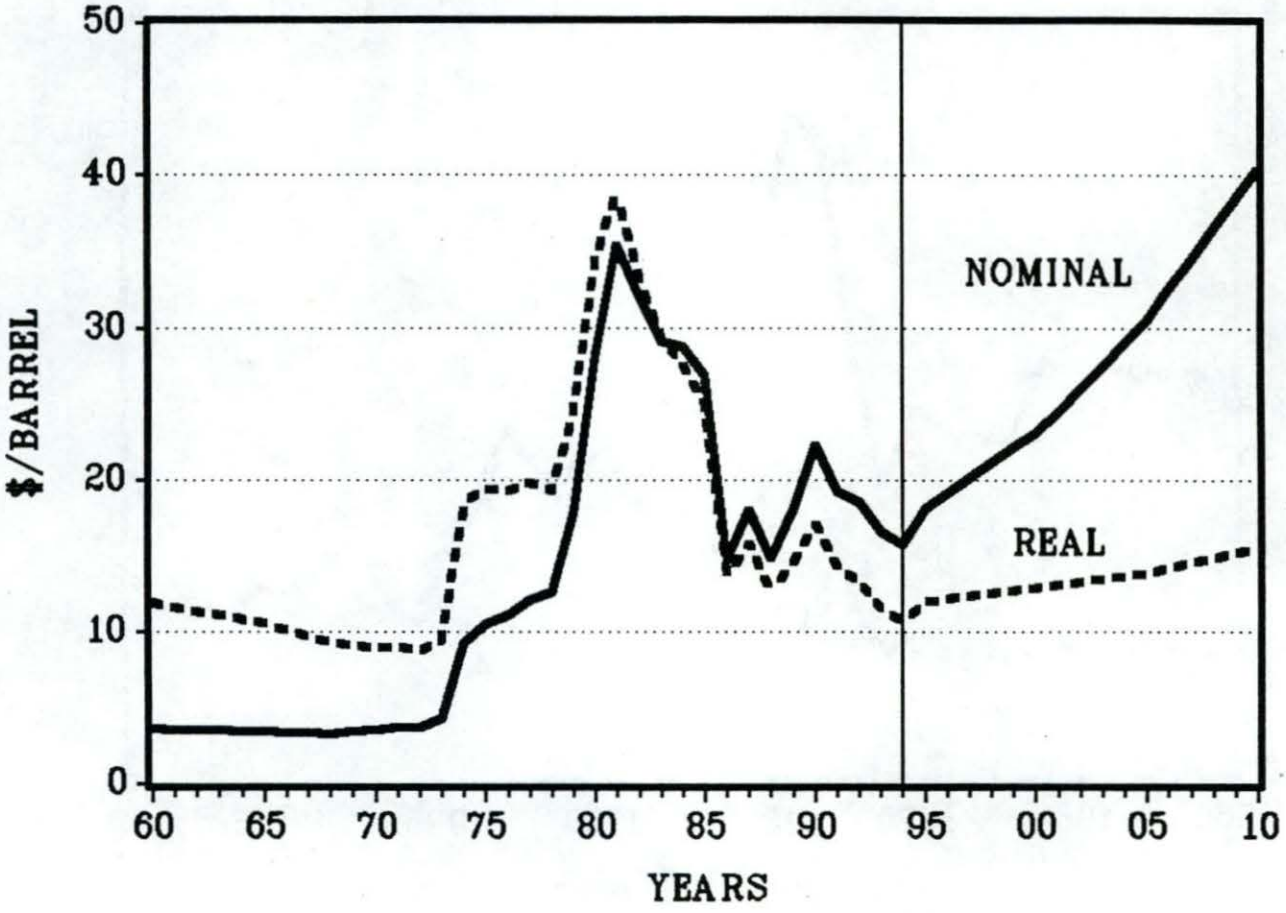
Average Price Received by U.S. Farmers for Corn
1960 to 1994 Crop Years and Forecast for 1995*



*Forecasts for 1995 from the World Agricultural Outlook Board, USDA.
**1982-84 dollars.

Figure 6

Refiner Acquisition Cost of Crude Oil
1960 to 1995 and Projected to 2010*



*Energy Information Administration, U.S. Department of Energy.

To evaluate the total impact of an operation such as a dry mill plant on a state's economy, estimates of multipliers are needed specific to a state. This is because the share of inputs from a given state vary from state-to-state. A model known as IMPLAN was reviewed for relevant multipliers. IMPLAN is a microcomputer program that performs regional input-output analysis (IMPLAN).

IMPLAN provides Michigan multipliers for "indirect effects," defined as production changes in backward-linked industries caused by the changing input needs of the given industry. Also provided are "induced effects" which are changes in state household spending patterns caused by changes in household income (generated by the direct and indirect effects). Direct effects are production changes associated with the immediate effects of final demand changes.

Unfortunately, IMPLAN does not have multipliers specific to corn dry milling, either at the national nor state level. At the national level, multipliers are available for wet corn milling as follows:

	Indirect Effect	Induced Effect	Total Effect
Output	1.31	1.77	3.07
Employment	8.38	14.81	23.20

To the extent that these multipliers would apply to a dry mill plant in Michigan, the implication would be that the combination of the indirect and induced effect along with the direct effect would have a total impact of $76.8 million on output (3.07 x $25 million). The total employment effect would be about 700 jobs (23.20 x 30). These are the impacts nationally. The effects in Michigan would be less.

The possible impact of construction can be gleaned from a North Dakota study of a large wet milling plant (Leistritz, April 1995). The Pro Gold plant in North Dakota is expected to cost $261 million, about 10 times the size of the Michigan dry mill plant. Using one-tenth of the impacts estimated for Pro Gold, Table 2 provides a rough guide for the spin-off effects of constructing a 15 million gallon per year dry mill plant and its annual operation.

Table 2

Estimated Direct, Secondary and Total Economic Impacts from a 15 Million Gallon Per Year Dry Mill Plant Using Wet Mill Data[a]

Input-Output Sector	Plant Construction			Plant Operation (Annual)		
	Direct	Secondary	Total	Direct	Secondary	Total
	$1,000					
Agriculture		1223	1223	1177	1608	2785
Construction		698	698	300	592	892
Transportation		113	113	120	81	201
Communication, utilities		906	906	942	716	1658
Manufacturing and agricultural processing		505	505	1163	1244	2406
Retail trade	5760	5718	11,478	0	5110	5110
Finance, insurance and real estate	400	1263	1663	50	1139	1189
Business and personal services		457	457	5	422	427
Professional and social services		702	702	20	580	600
Households	5200	5677	10,877	3756	5234	899
Government		831	831	50	759	809
Other		45	45	0	51	51
Total	**11,360**	**18,140**	**29,500**	**7583**	**17,536**	**25,199**
Employment	75	317	392	30	540	570

[a]Based on a study by F. Larry Leistritz for a wet corn milling plant in North Dakota.

The construction for a year, or possibly a little longer, would have a direct output impact of $11.4 million, a secondary impact of $18.1 million for a total effect of $29.5 million. The employment of 75 persons would radiate into a total employment effect totaling nearly 400 persons. Implied in these numbers is a total multiplier of 2.60 on output and 5.23 on employment.

For the plant operation detailed in Table 2, the direct output impact of $7.6 million is amplified to $25 million when adding the secondary effects. This implies a total multiplier of 3.31. On employment, the 30 permanent workers expands to 570 when the secondary effects are taken into account, for an employment multiplier of 19.

In another study by Leistritz in North Dakota, the economic impact of 2 dry mill ethanol plants were examined, each of which were approximately the size of the plant contemplated for Michigan (Leistritz, February 1995). In Table 3, Leistritz's data which would relate to a 15 million gallon plant were formulated.

The direct output effects would be calculated to be about $18.8 million annually and indirect effects at $40.3 million for a total of $59.1 million. This implies a total output multiplier of 3.15. The employment of 30 persons on a permanent basis would create 360 additional jobs for a total of 390. This represents an employment multiplier of 13.

In summary, from available sources, multipliers for a dry mill could be established as follows:

Source	Total Multipliers	
	Construction	
	Output	Employment
ND Wet Mill Study	2.60	5.23
	Operation	
U.S Wet Mill (IMPLAN)	3.07	23.20
ND Wet Mill Study	3.31	19.00
ND Dry Mill Study	3.15	13.00

The estimates are fairly consistent on the total multiplier for output in plant operation at just over 3. A conservative estimate of the employment multiplier would be the 13 from the ND dry mill study. The only construction multipliers available are from the ND wet mill study, which seem reasonable.

Table 3

Estimated Direct, Secondary and Total Economic Impacts from the Operation of a 15 Million Gallon Per Year Dry Mill Plant Using Dry Mill Data[a]

Input-Output Sector	Output			Employment		
	Direct	Secondary	Total	Direct	Secondary	Total
	$1,000					
Agriculture						
Livestock	0	1095	1095			
Crops	7185	898	8083			
Construction	1548	1334	2882		23	
Transportation	841	217	1058		36	
Communication and public utilities	2123	1580	3705		22	
Agricultural processing and miscellaneous manufacturing	0	1550	1550			
Retail trade	1130	11,116	12,246		55	
Finance, insurance and real estate	274	2379	4553		20	
Business and personal services	81	955	1036		32	
Professional and social services	226	1082	1308		43	
Households	1350	14,842	16,192			
Government	384	1697	2081		75	
Other	1737	1579	3316		54	
Total	**18,779**	**40,323**	**59,102**	**30**	**360**	**390**

[a]Based on a study by F. Larry Leistritz for 2 dry corn milling plants in North Dakota.

With these selections as a base in round numbers, we might conclude that construction of a 15 million gallon dry mill ethanol plant would add about $30 million to the Michigan economy and employ directly and secondarily about 400 persons over a period of a year or a little more. The operation would annually add about $20 million to the Michigan economy directly and another $40 million indirectly, for a total of $60 million. The employment of 30 persons on a permanent basis would radiate out to additional jobs, with the total effect also approaching 400 jobs.

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