ILLINOIS AGRICULTURAL ECONOMICS STAFF PAPER

Series E, Agricultural Economics

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ARRANGEMENT AND ECONOMICS

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September, 1981

No. 81 E-191

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Despite a recent moderation in the price of oil, due in part to reduced U.S. imports, the deficit between production and consumption of petroleum still continues to be a major problem for the United States. Prospective price increases are expected to moderate this shortfall only slightly and temporarily (Shurr et al). In consequence, alternative sources of liquid fuel and ways to extend our petroleum supplies are increasingly attractive. Ethanol (grain alcohol) has been scrutinized closely in recent years as a substitute for and extender of gasoline. Among non-petroleum liquid fuels, the production techniques for making ethanol are relatively well-understood and widely used. They are essentially the same as the techniques used to make liquor from grain.

Many people believe that small-scale fuel ethanol plants can operate as competitive businesses in today's energy market. The purpose of this paper is examine, within an economic framework, the optimal arrangement of a small-scale ethanol production. The first is on-farm production. Most observers believe that on-farm production will not be undertaken widely due to technical disadvantages, low product yields, and significant demands on the time of farm operators. The second option is a small specialized production unit which though not actually part of a farm operation, has direct ties to the local economy for its inputs and outputs. Local grain feedstocks would be used. Protein-rich by-products could be fed to livestock in a feedlot associated with the plant or on nearby farms. Finally, the alcohol produced might be used locally. It is this small specialized production unit which serves as the basis for our analysis of the optimal arrangement of small-scale production.

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The Model

The enterprise described in general terms above will be analyzed in a simulation model that represents the operation of the ethanol plant over its lifetime. The model is run for a number of "price situations". The model contains two major subsections. In the first, the value of the distiller's by-product is calculated. This value depends on the type of feedstock, the stillage form and possible alternative uses, and also on prices of substitute animal feeds. In the model's second section, the production possibilities open to a small independent enterprise are analyzed using linear programming methods. Here, the optimal feedstock, ethanol production level, and use of by-products are computed based on the arrangement that maximizes the firm's income over direct costs.

The Ethanol Enterprise

The enterprise under consideration has the capacity to produce one million gallons of anhydrous ethanol annually from either corn or sweet sorghum. The ethanol can be sold on local markets at competitive prices. Stillage can be produced in any of four forms: (1) "whole" or 7 percent dry matter (DM); (2) "concentrated" or 12.3 percent DM; (3) "distillers wet grains" containing 40 percent DM; or (4) "dried distiller's grains with solubles" containing 93 percent DM. In order to determine the exact value of the stillage, rations that produce the same amount of product (meat or milk) for each of the types of livestock considered were formulated both with and without stillage. The stillage was then priced so that the "stillage ration" was of equal value to the "non-stillage ration". By-products of sweet sorghum have no value as animal feed (Jackson and Arthur). Along with the alcohol and stillage, the model also allows for beef, swine, or dairy to be produced by the firm. The livestock can fed either with or without stillage. Any stillage not used on-site, in a feedlot associated with the plant, will be sold or disposed of. A third product of distillation, carbon dioxide, was assumed not to be worth recovering in a plant of the size studied here.

Prices and Costs

The ethanol enterprise was evaluated under a variety of assumptions about input and output prices. The analysis begins with a "base" price scenario. Base figures for the more variable prices were set according to a 20-year real average. For those commodities whose prices do not tend to fluctuate widely, prices were set according to those prevailing in the last year. "High" and "low" prices also were determined for each input or output. Further more, two alternative assumptions about future price trends were made: (1) no change in real prices over the 10-year life of the enterprise, and (2) annual increases in real prices as shown in the "max % increase" column of Table 1.

In order to simplify the analysis, the activities open to the firm were grouped into 5 "price categories": (1) prices received for livestock; (2) price received for alcohol; (3) price paid for corn; (4) prices paid for feeds other than corn; and (5) production costs for livestock. Since the activities within each of these categories are substitutes for one another their prices will tend to move together. For each category, the prices for the activities within that category were then set either at the high, low, or average of their range. Subsequently, to examine price situations that the firm might face, different combinations of the "price categories" were run through the model.

Cases

The different combination of prices are stated in the following cases:

Case 1. The "base" case. Average prices, as shown in Table 1, were used for each of the 5 "price categories".

Case 2. A variation on the "base" case. The only difference is that minimum livestock prices are used; the other "price categories" remained unchanged.

Case 3. Another variation on the "base" case. However, the maximum livestock prices were used.

Case 4. The "best" case: maximum prices are received for livestock; the average (base) price is received for alcohol; and minimum prices are paid for corn, other feed ingredients, and livestock production.

Case 5. Same as case 4 except that average prices are received for livestock.

Case 6. A variation of case 4. Minimum price received livestock is used.

Case 7. The "worst" case. In this scenario, minimum price received for livestock are combined with average alcohol price, and maximum prices paid for corn, other feeds, and livestock production.

Case 8. Similar to other variations, it is the same as case 7, except that average price received for livestock is used.

Case 9. The second variation of case 7. Maximum price received for livestock is used.

Case 10. The minimum price for sweet sorghum was combined with the "worst" case to see if sweet sorghum might be chosen as the more profitable feedstock. Even in this extreme case, corn was still more profitable.

Results

The specific results of each case listed above are summarized in Table 2 (assumptions used in Table 2 are listed in Table 3). Table 2 shows: (1) what type and how many livestock are produced in conjunction with the alcohol facility; (2) if all types of livestock would be profitable to produce on-site, given the price circumstances; (3) how much and to what end excess stillage was sold; and finally (4) what the Net Present Value (NPV) of the investment required for each case would be given either a 5% real discount rate or an 8% real discount rate.

Before drawing any conclusions, there are two items that should be noted. Each of the cases above assume that there is no real price increase in any of the variables. If the real maximum price increase (shown in Table 1) is used, all the Net Present Values would improve, but not enough to change any of the negative NPVs (cases 7,8 and 10. Table 2). The second item to note, is that the price of ethanol was never varied. It has stayed relatively stable over the last several years and if anything has improved recently over the $1.75 used.

A number of activities were maintained in all cases analyzed here. One million gallons of ethanol were always produced from corn. Second, "whole" stillage (7% dry matter) was produced in every case. Finally, if livestock were produced on-site, then they were always fed a "whole" stillage ration. Otherwise, the stillage was sold.

The price scenarios presented are meant to represent practically all the price situations the enterprise might face. Examining the results, several points can clearly be made. First, in all but the two "worst" cases, the investment has a positive NPV. Next, dairy production was the most profitable form of livestock in all but 2 situations. Only in the most extreme case, when prices received for livestock were at a minimum and feed and production costs were at a maximum, are dairy not profitable. Hogs are most profitable in the "best" case, but in all cases when livestock prices were "low" and in a variation of the "worst" case when pork prices were "average", pork production would not provide a positive income over direct costs. Another obvious item is that in every case, any "whole" stillage not used on-site was sold to local beef producers.

Even with 500 dairy cows being fed a "whole" stillage ration, over 9.6 million gallons of stillage were not used on-site. The shear bulk and handling problems associated with this much liquid could present trouble. However, with an added investment of $239,000, to add stillage drying capabilities, this problem could be greatly reduced without significantly changing the NPV of the total enterprise. This would concentrate the stillage into "Distiller's Wet Grains" (DWG). DWG are about one-fifth as heavy as whole stillage and are essentially solids. They are far easier to handle and transport.

The worth of the "corn" stillage to the total enterprise should not be underestimated. This fact is pointed out in case 10. Here, with a high corn price, low livestock prices, and low sweet sorghum prices, the model did not switch from corn to sweet sorghum as the primary feedstock. This is because sweet sorghum did not produce any feed by-products worth recovering. It's price was not low enough to offset the revenues lost in switching from corn.

One shortcoming of the model as it now stands is that optimal arrangement is based on maximizing income over direct costs. No attempt is made to control for the size of the investment. In examining the results, it can be seen that despite an increase in livestock prices from case 7 to 8, NPV fell. The reason for this is that in case 7 no livestock were being produced, while in case 8, up to 500 dairy cows could be fed. This raises the question: Might NPV be increased with a different or additional livestock capacity? Dairy provided more income to the firm than beef or hogs. However, if the sizes of the investments in all forms of livestock were the same, NPV might be maximized by switching away from dairy, since they required substantially more capital than beef or hogs (see Table 3).

Despite the shortcoming stated above, it is still true that the stillage, derived from fermenting and distilling corn into alcohol, is more valuable to dairy and beef than it is to hogs. Stillage is the link between livestock and ethanol production. Thus, when associated with an alcohol facility, dairy and beef are better investments than hogs in most every circumstance.

Conclusions

Low product yields, sporadic output, and the marketing of less than 200 proof ethanol are major concerns for many small production units. Due to technical sophistication, the size and type of enterprise described does not have many of the disadvantages associated with small on-farm production of ethanol; however, it does have some of its own problems.

At times, the livestock and ethanol activities may act to support one another, but they also make the entire enterprise less flexible. The livestock are dependent on the stillage from the alcohol production. If livestock are being produced on-site they must be fed stillage, thus alcohol must be produced so stillage will be available. In some ways, the firm might be better off not feeding livestock. Rather it could produce dried distiller's grains with solubles (DDGS) and not "whole" stillage or "distiller's wet grains". There is a very liquid market for DDGS, and this would allow the firm to remove itself to a large extent from the volatile livestock markets. Also, in the case where livestock are not being fed on-site, it would be possible for the enterprise to switch feedstocks. If corn prices were high and sweet sorghum prices were low enough to offset the revenue lost from sale of DDGS, then the firm could switch feedstocks without having to worry about feeding any livestock.

Another problem with this size operation is that it does not have the diversity of many large commerical businesses. The absolute investment required is certainly not as great, but at the same time, this firm is less able to "protect" itself from "unfavorable" product markets. Many of the larger operations can produce a variety of mutually exclusive products for sale in essentially unrelated markets.

It is difficult to determine whether the disadvantages outweight the advantages. However, this analysis has shown that the enterprise considered here is profitable under most "price" situations, and thus its future potential should not be disregarded.

Price Assumptions

TABLE 1.

Activity	Base Price[a] ($'s)	Max. Price ($'s)	Min. Price ($'s)	Trend[b] % inc.	Max % inc. /year	Min. % inc. /year
Buy S.S.	.075	.083	.068		2.5	0
Buy Corn	2.87	4.00	2.30	.94	2.5	0
Hog. Prod.	55.00	60.00	50.00		2	0
D.C. Prod.	273.00	300.00	254.00		2	0
Beef Prod.	354.00	390.00	320.00		2	0
Sell Pork	47.94	60.00	36.00	1.27	2	0
Sell Milk	11.69	14.00	11.00	1.30	2	0
Sell D.C.	47.00	55.00	39.00		2	0
Sell Beef	61.54	70.00	53.00	.90	2	0
Sell Veal	66.86	90.00	45.00	.52	2	0
Sell S.S. Still	0					0
ETOH Prod.	.35-.44				3	0
Sell ETOH	1.75	1.90	1.60		3	0
Buy Brome	110.00	121.00	99.00		2	0
Buy Alfalfa	110.00	121.00	99.00		2	0
Buy Corn	2.87	4.00	2.30	.94	2.5	0
Buy Corn Sil.	25.00	35.00	20.00		2.5	0
Buy SBM	200.07	260.00	140.00	1.92	3	0
Buy Limestone	0.10	.011	.009		2	0
Buy Salt	.020	.022	.018		2	0
Buy Dical Phos.	.129	.142	.116		2	0
Buy TM Salt	.075	.083	.068		2	0
Buy Vit. A&D	.533	.586	.480		2	0
Buy Corn Cobs	25.00	27.50	22.50		2	0
Buy Def. R. Phos.	.150	.165	.135		2	0
Buy Vit. S. Mix	2.50	2.75	2.25		2	0
Labor	6.50	7.50	5.50		3	0

a. 1980 dollars.

b. For more volatile prices.

Summary of Results

TABLE 2.

Case	LIVESTOCK: Most Profitable	LIVESTOCK: Number Produced (per year)	LIVESTOCK: All Types Profitable	STILLAGE: Sold To	STILLAGE: Quantity (gals.)	Net Present Value (5%)[a]	Net Present Value (8%)[b]
1	Dairy	500	Yes	Beef	9,604,000	$2,661,000	$1,899,000
2	Dairy	500	Not Hogs	Beef	9,604,000	2,063,000	1,379,000
3	Dairy	500	Yes	Beef	9,604,000	4,140,000	3,184,000
4	Hogs	5000	Yes	Beef	10,620,000	4,888,000	3,974,000
5	Dairy	500	Yes	Beef	9,604,000	4,486,000	3,485,000
6	Dairy	500	Not Hogs	Beef	9,604,000	3,888,000	2,965,000
7	None	NA	NA	Beef	11,480,000	-126,000	-366,000
8	Dairy	500	Not Hogs	Beef	9,604,000	-858,000	-1,159,000
9	Dairy	500	Yes	Beef	9,604,000	622,000	126,000
10	None	NA	NA	Beef	11,480,000	-126,000	-366,000

a. real discount rate of 5 percent (production and tax credits not considered).
b. real discount rate of 8 percent (production and tax credits not considered).

TABLE 3: Assumptions Used in Table 2.

ALCOHOL PRODUCTION

Capital Costs:[a]

		Cost[b]
1.	7% DM Plant	$1,958,000
2.	12.3% DM Plant	1,958,000 (est.)
3.	40% DM Plant	2,197,000
4.	93% DM Plant	2,752,000
5.	Sweet Sorghum Plant	1,958,000 (est.)

Life of Plant:

10 years (no salvage value)

LIVESTOCK PRODUCTION

Capital Costs:[c]

1.	Dairy	$2400/head
2.	Swine	80/head
3.	Beef	200/head

Life of Facilities:

10 years (no salvage value)

Maximum Number of Livestock Allowed:

1.	Dairy	500 head(500 head feedlot)
2.	Swine	5000 head (1700 head feedlot)
3.	Beef	3000 head(2000 head feedlot)

a. Sources: USDA, Jackson & Arthur, U.S. National Alcohol Fules Commission
b. Adapted from 900,000 gal/yr. plant
c. Source: Hinton

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