Fuel

Market Implications of Soybean Oil Use As a Diesel Fuel Substitute

by

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ABSTRACT

Soybean oil is being considered as a diesel fuel substitute by both the United States and Brazil. Impacts of a fuel substitution program by each country on the U.S. soybean industry are evaluated. Export values and oil prices increase, but there are negative impacts on the meal sector.

BIOGRAPHICAL NOTES

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Introduction

The agricultural impacts of rising energy prices and unstable supplies have been pervasive. While a good deal of research has been devoted to alcohol-based fuels produced from farm products to ease farm energy problems, the overall economic and energy efficiency of alcohol fuels has been questioned. Furthermore, such fuels are likely to be a better substitute for gasoline than diesel, even though diesel fuel has rapidly replaced gasoline as the primary power supply for agricultural production. Diesel use on U.S. farms in 1979 was estimated to be three billion gallons (Barton).

Several recent technical and popular articles (Erickson and Goodier) suggest that direct combustion of vegetable oils may be a better substitute for diesel fuel than alcohol-based fuels. Considerable interest in vegetable oil fuel use has been expressed both in the United States and in Brazil (FAS). The level of their use as fuels depends in part on government policies and in part on the price spread between diesel and vegetable oils. Vegetable oil is not currently an economically attractive fuel in the U.S., but current projections are that world petroleum prices will continue to rise and perhaps close the gap in relative fuel prices.

The prospect of diverting large quantities of U.S. vegetable oil from conventional channels into fuel use raises some interesting questions concerning overall impacts on the oilseed industry. For example, U.S. production of soybean oil in 1979 was 1.6 billion gallons (12.1 billion pounds), about half of the amount which would be required for agriculture to totally switch to vegetable oil from diesel. Should a large amount of vegetable oil be diverted to replace U.S. diesel fuel used in agriculture, the impact on the oilseed industry would obviously be substantial. What would be the impact on the domestic oil market and how would bean and meal prices be affected? Would U.S. balance of payments problems be alleviated through reduced petroleum imports, or worsened though decreased oilseed and vegetable oil exports? How would the long-run and short-run impacts differ? How would the U.S. market be affected if Brazil diverted its soybean oil supplies to domestic fuel uses?

These questions relating to the macro-level impacts of using vegetable oil as a diesel fuel substitute are the subjects of this paper. Attention will be focused on soybeans, the most important of U.S. oilseed crops.

Overview of Soybean Market Forces

The analysis of impacts of soybean oil as an agricultural fuel must take into account the relatively complex nature of the soybean market. Houck, Ryan, and Subotnik list four characteristics of the market which will in various ways affect this analysis.

The first is that soybean oil and soybean meal are joint products of soybean crushing. The proportions are relatively fixed, so any change in the supply of one product will necessarily entail a similar change in the supply of the other. As a result, the prices of meal and oil move in opposite directions whenever the demand for one (in bean equivalents) substantially exceeds the demand for the other.

Second, beans, meal, and oil each have several market outlets. For oil, principal outlets are domestic use, exports, and stocks. About 75 percent now goes to such domestic uses as margarine, cooking and baking oil, salad dressing, and ready-to-eat manufactured products. Exports have increased to about 20 percent of total disappearance. Since soybean oil keeps better than meal, inventories can at times play an important role in demand. Approximately three-fourths of the meal produced is used domestically and about one-fourth is exported. The principal uses of beans are for crushing, export and inventories. Usually more than half of the soybean production is crushed and 35 to 40 percent is exported. The meal and oil content of soybean exports is more than three times that of the product exports.

Third, soybean products are interdependent with larger economic sectors. This is particularly true of oil. In many cases, various vegetable oils can be regarded as almost perfect substitutes.

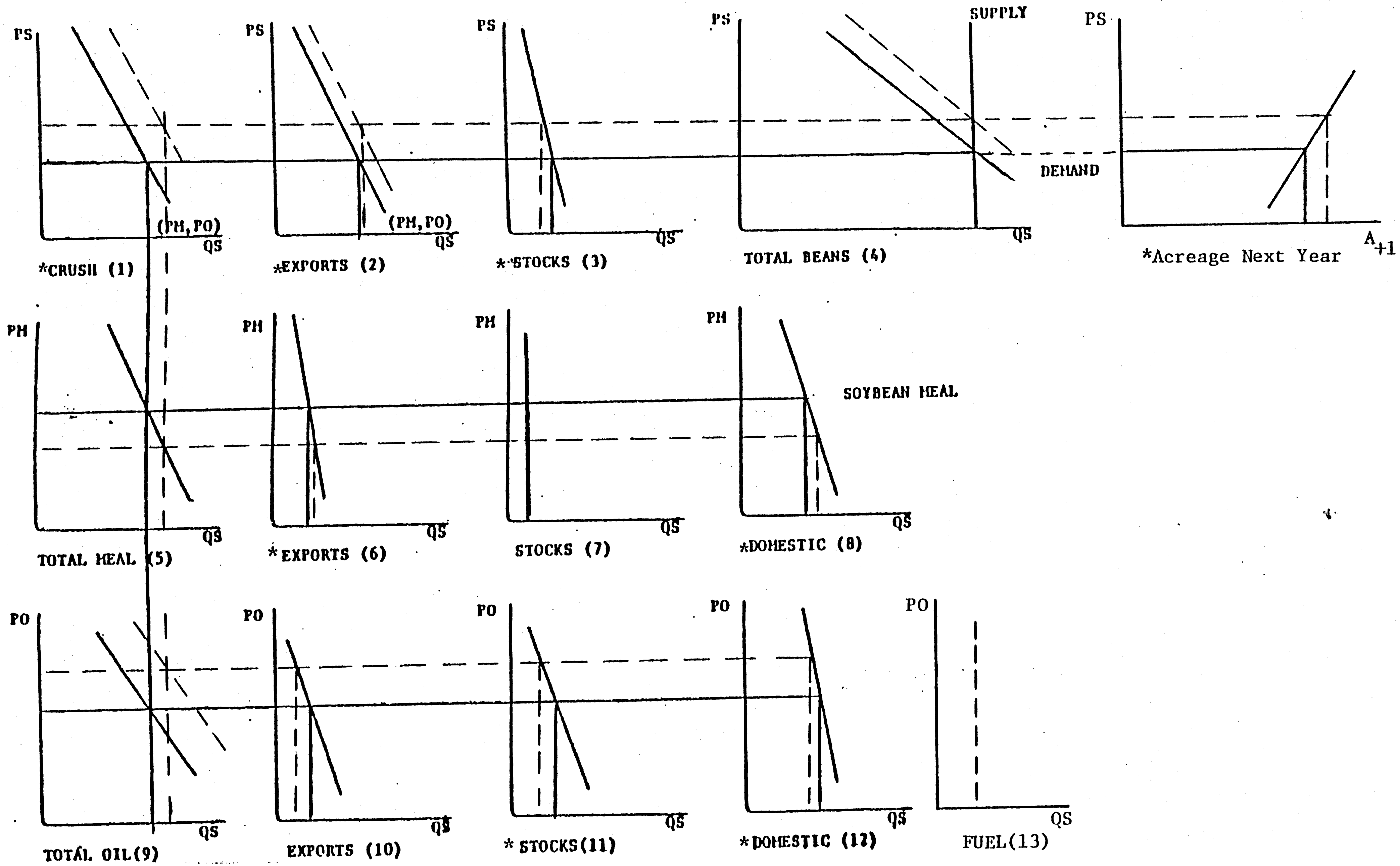
Finally, the simultaneous determination of product prices and utilization levels in the soybean sector rules out single equation methods of analysis. A system of several equations must be used, even if information on only a single component of the market is sought.

The Analytical Model

Houck *et. al.* laid a broad foundation for analyzing the soybean sector. The simultaneous equation model developed by Houck has recently been updated and expanded by Meyers and Hacklander. The Houck and Meyers models incorporate the major components of bean, meal and oil markets and simultaneously determine prices and utilization in all three markets. This model structure was judged to be suitable for the purposes of this study.

The econometric model used for this analysis is illustrated in Figure 1 and described in greater detail by Meyers and Hacklander (see Appendix). There are eight behavioral equations (indicated by an aster-

FIGURE 1. GRAPHICAL REPRESENTATION OF THE SOYBEAN MODEL (ALL QUANTITIES IN BEAN EQUIVALENTS).



isk), one price linkage equation, three technical relationships (production of beans, meal and oil), and three market equilibrium identities (beans, meal and oil). The interdependence of the three markets is indicated by the influence of meal and oil prices on the demand for crush and for bean exports and by the direct effect of crush on oil and meal supplies. If an event or policy change impacts any one of the market components, the equilibrium is disturbed and all endogenous levels are altered.

The dashed lines in Figure 1 illustrate the kinds of changes that would occur as a result of diverting some domestic oil supplies to diesel fuel use. The impact can be described as a hypothetical sequence of events that occurs within one unit of time (one year for this model):

(1) Demand for oil is increased causing its price to rise.

(2) The crushing margin rises inducing greater demand for beans in the U.S. and abroad.

(3) Larger crushings increase supplies of oil and meal, thereby moderating the initial oil price rise and depressing meal prices.

(4) The net increase in soybean price reduces inventories and increases production for the following year.

(5) The lower price of meal induces greater domestic and export use.

(6) The higher oil price reduces oil exports, inventories, and domestic consumption; but part of the fuel requirement is met with the increased oil production.

(7) Impacts in the second and following years are influenced by the altered soybean production and by the changed levels of bean and oil inventories carried from year to year.

The probable impact of a Brazilian oil-for-diesel program can be described in a similar manner by shifting the oil export equation (10) to the right and tracing the effects.

Analysis of Results

The presentation in the previous section provides some indications of directions of change, but a model simulation is required to estimate the relative magnitudes of these changes. This was done by imposing a 500 million pound increase (enough to convert five percent of current U.S. agricultural diesel use to a 50-50 oil-diesel mixture) in oil demand every year for eight years so that the long-run as well as the short-run impacts could be determined. To evaluate the effect of a Brazilian program, a second run was made in which a 500 million pound shift to the right in the U.S. oil exports demand equation was imposed every year for eight years. The results of these scenarios are presented in Tables 1 and 2.

For the run in which U.S. soybean oil is diverted to fuel use, the increased demand for oil is partially offset in the short run by increased oil supplies (increased crushings). However, most of the oil fuel is drawn from reduced domestic and export use and reduced stocks. The price of oil increases by four to five cents per pound. In the meal sector, the largest impact is in the second year when price falls by $12.80 per short ton. The price of beans rises by about 30 cents per bushel in the first year, but the price effect is diminished by increased plantings of 1.83 million acres in the following year.

The long run situation (taken to be seven to eight years) shows the effects of increased plantings to meet the new demand. Downward pressure on soybean prices from the increased acreage entirely erases the short-run farm price gain for soybeans. The long-run increase in planted acres is about half that of the short-run. Oil supplies and prices remain relatively high, but prices in the meal sector continue

Table 1. Changes in selected variables for the U.S. soybean industry resulting from a 500 million pounds per year diversion of U.S. soybean oil to a domestic fuel program.

	1979/80[a/] Level	Year 1	Year 2	Year 7	Year 8
Oil (million pounds)					
Price (cents/lb.)	24.3	5.37	4.32	3.64	3.22
Supply	12,105	101	134	148	121
Domestic Demand	8,981	-143	-110	-66	-53
Exports	2,690	-157	-175	-230	-275
Stocks	1,210	-98	-81	-56	-51
Meal (1,000 short tons)					
Price ($/s. ton)	181.90	-5.6	-12.8	-11.9	-10.5
Supply	27,372	225	510	461	399
Domestic Demand	19,238	136	310	290	254
Exports	7,908	89	200	171	145
Beans (million bushels)					
Price ($/bushel)	6.28	.30	.04	.007	-.002
Supply	2,268	0	34.9	34.7	30.5
Crush	1,123	9.7	21.3	19.3	16.5
Export	875	5.2	13.3	11.1	10.5
Stocks	174	-14.9	0.3	4.4	3.5
Planted Acres (millions)	71.58	0	1.83	1.05	0.83
Export Value (million $)					
Beans	5,495	146.1	103.3	81.2	58.4
Meal	1,438.5	-8.0	-39.6	-34.7	-53.8
Oil	653.7	21.2	11.3	11.4	7.7
Total	7,587.2	159.3	75.0	57.9	12.3

[a/] Source: ESS, USDA.

Table 2. Changes in selected variables for the U.S. soybean industry resulting from a 500 million pounds per year diversion of Brazilian soybean oil to a Brazilian fuel program.

	1979/80[a] Level	Year 1	Year 2	Year 7	Year 8
Oil (million pounds)					
Price (cents/lb.)	24.3	4.06	4.26	3.21	2.55
Supply	12,105	76	123	122	95
Domestic Demand	8,981	-109	-110	-60	-43
Exports	2,690	259	309	231	186
Stocks	1,210	-74	-77	-49	-48
Meal (1,000 short tons)					
Price ($/s. ton)	181.90	-4.2	-10.9	-9.6	-9.1
Supply	27,372	170	432	369	340
Domestic Demand	19,238	103	265	232	220
Exports	7,908	67	167	137	120
Beans (million bushels)					
Price ($/bushel)	6.28	.23	.08	.03	-.02
Supply	2,268	0	26.4	25.9	24.7
Crush	1,123	7.3	18.0	15.4	14.1
Export	875	3.9	10.7	8.4	8.7
Stocks	174	-11.2	-2.3	2.1	1.9
Planted Acres (millions)	71.58	0	1.38	0.78	0.72
Export Value (million $)					
Beans	5,495	109.9	105.9	79.2	35.9
Meal	1,438.5	-5.9	-34.1	-27.5	-47.3
Oil	653.7	98.6	167.7	147.7	119.3
Total	7,587.2	202.6	239.5	199.4	107.9

[a] Source: ESS, USDA.

to be depressed because each pound of increased oil production adds almost five pounds of meal. Increasing supplies of meal from increased crushings are not compensated by meal demand growth, so price reductions continue to be necessary to clear the market through domestic and export channels. The situation is aggravated by the fact that meal, unlike oil, is not well suited to storage, so stocks can not be built up in anticipation of better prices.

In light of current concern for the U.S. balance of payments, the total effect on exports of a U.S. fuel program is of particular interest. The higher prices for beans and oil more than offset losses in meal export value, but the total change in value of soybeans and their products declines rapidly from about $160 million in the first year to near zero in the long-run. In the short run, oil exports are reduced by 160-175 million pounds, meal exports increased by 100-200 thousand tons, and soybean exports increased by 5-10 million bushels. These balance of payments changes are not significant in comparison to a total 1979 export value of $7.6 billion.

For the run in which U.S. oil export demand shifts upward as a result of a Brazilian fuel program, the results are similar to the first run except that oil exports are obviously much higher and the total value of soybean and soybean product exports is also much higher. In the short run U.S. oil and bean exports replace a little over three-fifths of the Brazilian oil. In the long run the replacement rate is less than three-fifths. By implication the remainder is replaced by other oils or by reduced consumption. It is interesting to note that depressed prices in the U.S. meal sector can be precipitated by a Brazilian fuel program as well as by a U.S. program.

Concluding Remarks

There are at least three important questions still to be answered before the market impacts of vegetable oil as a diesel fuel use can be fully assessed:

(1) What will be the effect on consumer behavior and food prices? Higher soybean oil prices will cause shifts to other vegetable oils for food uses in some cases, since vegetable oils are generally near perfect substitutes. Also, increased soybean oil prices will raise prices for such food items as cooking oil, shortening, and margarine. Neither of these two important effects were included in this analysis.

(2) Increased demand for vegetable oil fuels will be accompanied by increased vegetable oil prices. This will, in turn, make their use as fuels even less attractive than it is now, barring any drastic increases in diesel prices. To what extent is the government willing to subsidize the new energy source?

(3) What will be the response of other vegetable oil exporting nations to increased demands for vegetable oil? Also, over what range are the import demand elasticities assumed in this analysis valid? The change in value of U.S. exports in response to increased U.S. vegetable oil fuel use depends critically on these two questions.

In spite of these unanswered questions, the analysis of this paper clearly shows a need for more macro-level analysis of market effects before encouragement of widespread use of vegetable oil as a diesel fuel is adopted as part of an overall U.S. energy policy. The implications of a Brazilian program, whether or not the U.S. pursues this energy source, are also worthy of study. Particular attention should be paid to the impacts of lower meal prices on the feed grain and livestock sectors.

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