Impacts of Substituting Plant Oils for Diesel Fuel

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A regional field crop and national livestock econometric model (TECHSIM) is used to examine the impacts of diverting plant oils (cottonseed oil and soybean oil) to use as a diesel fuel replacement. Two scenarios which represented a five and ten percent replacement of agriculture's diesel fuel use (1979) by plant oils are simulated for the period 1982–90. Results show that producers shift into cotton and soybean production and out of corn, small grains, and grain sorghum. Significant price shifts are observed for oilseeds and their meal and oil products. The annual net reduction in monetary measures of welfare is estimated at about $0.5 billion and over $1 billion for replacement of five and ten percent, respectively, of agriculture's diesel fuel use by plant oils.

In spite of depressed current energy prices, national interest in developing renewable fuels continues to be strong because of uncertainties involving the future availability of petroleum-based fuels. Although extensive interest during the past decade of research centered upon ethanol and methanol processing technologies and policies, more recent research emphasized the potential of plant oils as diesel fuel extenders or replacements [USDA, August 1981; Gavett; McIntosh *et al.*; Sims and Meister]. Proposals to grant excise tax exemptions (like those for gasohol) for diesel-plant oil blends have been tabled because national attention for the energy crisis has waned, but when the issue reemerges, renewed interest in soft energy paths can be anticipated.

Recent investigations of the feasibility of plant oil substitution for diesel fuel have been dominated by engineering studies of engine performance, wear, etc. Some technical aspects of using plant oils for diesel fuel require further study. For example, preliminary evaluations of sunflower oil/diesel fuel blends indicate that as sunflower oil content is increased, torque and power output decrease and fuel consumption and engine knock increase. It appears that improved engine performance with sunflower oil is expected with throttle and other engine adjustments.

In favor of plant oil substitution, the ratio of diesel consumption to gasoline consumption by agriculture continues to increase, thereby increasing the importance of identifying diesel substitutes, if only for emergency purposes. By 1974 diesel fuel had overtaken gasoline to become U.S. agriculture's primary source of energy [Kolmar]. During the latter 1970s, particularly 1979, there was national concern for an apparent shortage of diesel fuel, especially as it might have affected spring planting activities. Emergency allocation plans were formulated by the Department of Energy, and many producers chose to increase on-farm storage of diesel fuel. Unlike ethanol and methanol, which cannot be employed as stand alone fuels

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Technical Article No. 17889 of the Texas Agricultural Experiment Station. The work upon which this report is based was conducted by the Texas Agricultural Experiment Station with support from the Center for Energy and Mineral Resources, Texas A&M University and the Texas Energy and Natural Resource Advisory Council, Austin, Texas.

Western Journal of Agricultural Economics, 10(2): 401–412

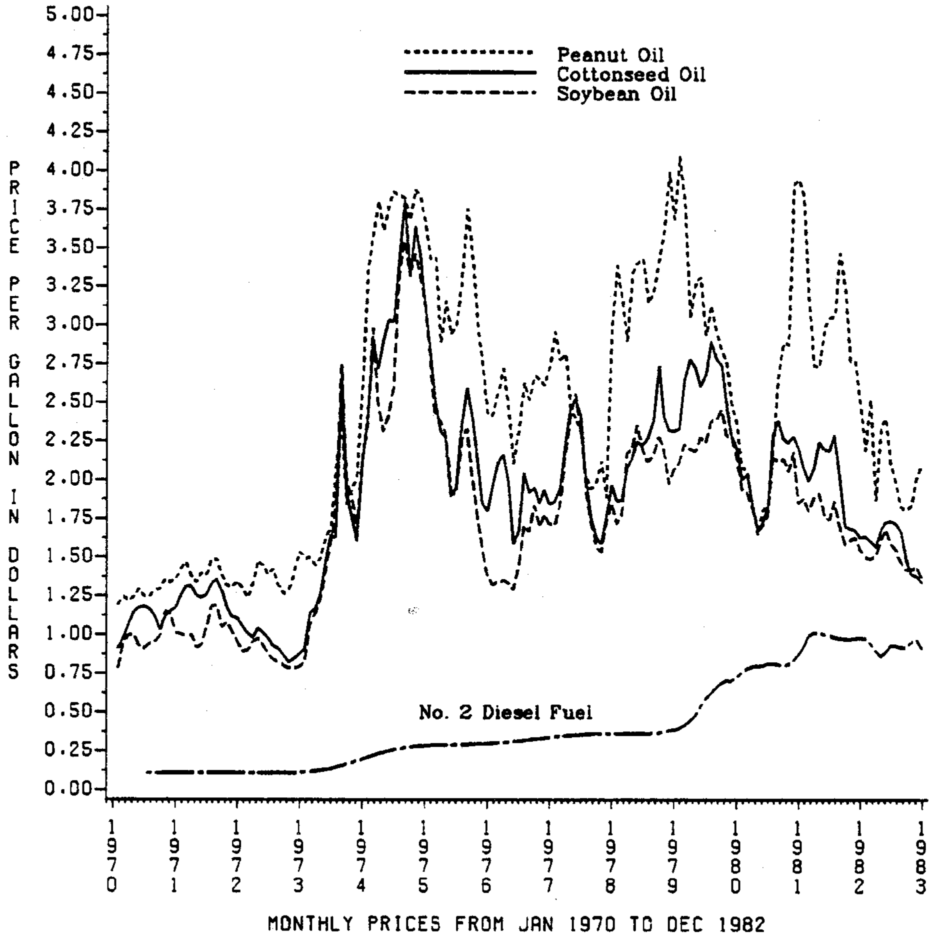

Figure 1. A Comparison of Cottonseed Oil, Soybean Oil, Peanut Oil, and Diesel Fuel Prices, 1970–82.

in unmodified gasoline engines, plant oils offer the potential for direct use as a diesel fuel substitute without requiring major engine modifications [Cruz *et al.*]. In addition, substantial industrial capacity for processing oilseeds to obtain plant oil currently exists [Griffin *et al.*].

To a large extent, the merit of additional engineering research on such problems depends upon economic issues. Historically, plant oils have cost two or three times as much as diesel fuel on a BTU basis although this gap has closed recently. In Figure 1 plant oil prices have been converted to a per gallon basis and adjusted upwards to account for the slightly lower BTU content of plant oils relative to diesel fuel. These adjustments identify historical **diesel equivalent prices,** the prices of obtaining the thermal equivalent of one gallon of diesel fuel from each plant oil. All prices are for wholesale, bulk quantities, and exclude taxes. Clearly, plant oils are not inexpensive substitutues for diesel fuel.

The influence of international disputes or oil cartels on the price and availability of crude oil may, however, change this situation. Should crude oil supplies be temporarily disrupted or if the price of crude oil gets high enough, the use of plant oils may be economically feasible. Of course, the mere availability of such sub-

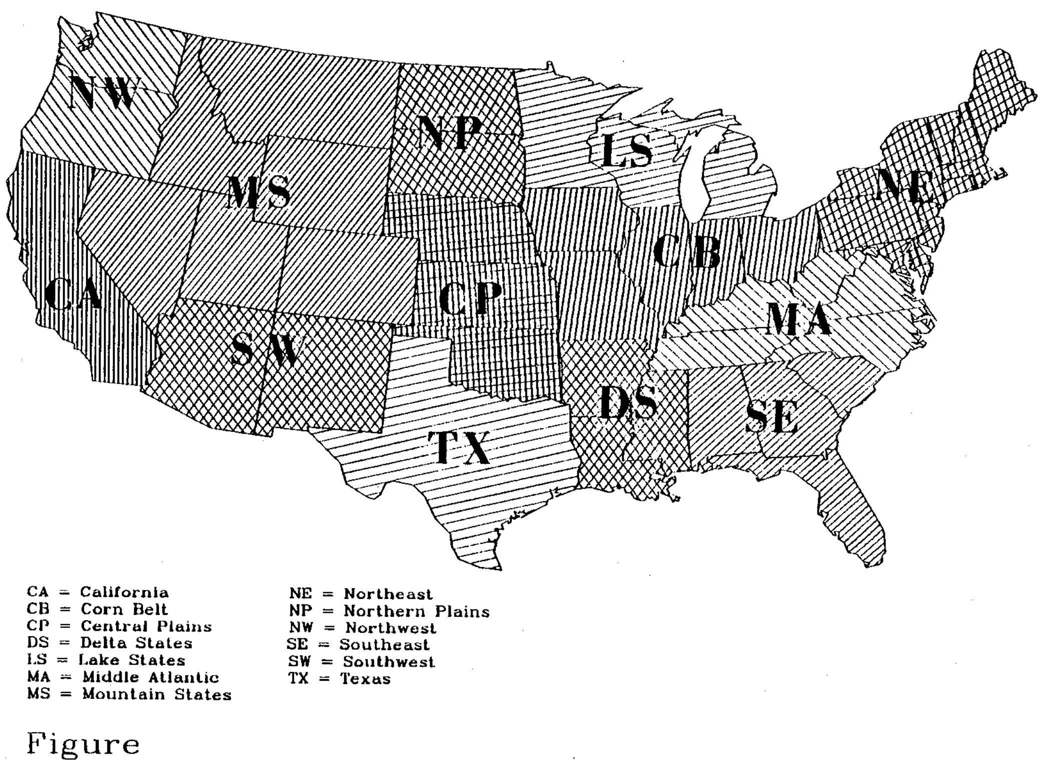

Figure 2. Production Regions within TECHSIM.

stitutes can have a beneficial influence by holding crude oil prices below a certain level. Because of the possibility of stochastic fuel shortages and the exhaustibility of oil and gas supplies, it is prudent to evaluate the implications and impacts associated with using plant oils as a diesel fuel.

If substantial amounts of plant oils are diverted from traditional markets for usage as fuel, the market impacts can be expected to be large and wide ranging. Many producer and consumer groups would be affected—some positively, others negatively. The importance of these impacts makes it imperative that some empirical results be obtained prior to the adoption of potential policies involving use of plant oils as diesel fuel substitutes. The purpose of this study is to estimate the expected impact of substituting cottonseed oil and soybean oil for diesel fuel. Other plant oils are not considered because 90 percent of all plant oils are produced from cottonseed and soybeans [USDA 1979–81].

Model Description

To examine the regional and national economic impacts of substituting plant oils for diesel fuel, an econometric model (TECHSIM) is used. This model was constructed for the purpose of examining a broad range of technological changes in agricultural sectors. Since little or insufficient data is usually available for incorporating direct shifters resulting from nonprice change, the model employs best estimates of per acre yield and/or variable cost changes to shift field crop or livestock supplies.

Because different climatic environments induce different production practices in the U.S., the field crop sector is separated into 13 producing regions (Figure 2). The field crop commodities included in the model (but not in all regions) are corn, grain sorghum, soybeans, cotton lint, cottonseed, wheat, barley, and oats. The last three crops are aggregated into a small grain category for each region. The model also contains the forward meal and oil products of cottonseed and soybeans. National livestock products in the model include fed beef, nonfed beef, pork, and sheep and lambs.

The simulation procedure traces throught the effects of a policy or technological change on crop and livestock production, prices, utilization, farm rents, and monetary measures of producer and consumer welfare. For the major field crops the model provides estimates of regional planted acreage, yield, production, producer net returns, and variable production costs. Aggregate estimates are also provided for total supplies, prices, domestic demands, exports, ending stocks, industry net returns, and welfare measures for the producers of specific field crops. For livestock, TECHSIM provides aggregate estimates for inventories, number of animals placed on feed, slaughter (live weight and carcass), imports, total supplies, domestic demands, exports, ending stocks, farm prices, retail prices, price margins, and welfare measures for each livestock industry group. These results are obtained by simultaneously solving all markets for equilibrium prices and quantities.

Structure of the Production and Consumption Sectors[1]

Previous econometric studies have used commodity prices as the primary explanatory variables in field crop and livestock supply equations. In TECHSIM, per acre and per animal net returns are emphasized. For field crop sectors there are two reasons for using the net-return specification. First, with limited acreage, profit-maximizing producers are expected to allocate acreage to alternative crops on the basis of per acre net returns (which is only partially dependent on price). Second, the net-return specification allows one to logically derive supply shifts resulting from yield and/or variable cost changes, while the price specification does not. Similarly, producers wishing to maximize profit from livestock production are expected to make production decisions based upon the expected net returns between livestock groups. For example, cattle producers attempt to allocate the number of head to be placed on feed or placed on range based upon the expected net returns of each production process. The livestock net-return specification also allows one to incorporate technological shifts by changing live weight yields or variable production costs.

The theoretical implications of specifying planted acreage equations as a function of net returns or specifying livestock production equations as a function of net returns can be examined by considering the following Lagrangian:

$$\Pi = \sum_i \pi_i A_i + \lambda \left[A_T - \sum_i A_i \right] \tag{1}$$

where π_i is expected net returns to crop i or expected net returns to livestock production alternative i, A_i is planted acreage of crop i or livestock production of livestock group i, and A_T is the crop land constraint or a constraint on the number of livestock for a particular livestock group. If farmers maximize equation (1), the behavioral choice functions of interest can be expressed as:

$$A_i = A_i^*(\pi_1, \ldots, \pi_n, A_T) \text{ for all i.} \tag{2}$$

Relying on the argument posed by Col-

[1] Most of the information for this section is drawn from Collins and Taylor.

lins and Taylor, estimation procedures maintain:

$$\text{[Own Effect]} \quad \partial A_i^*/\partial \pi_i \geq 0 \text{ for all i,} \tag{3}$$

and

$$\text{[Symmetry]} \quad \partial A_i^*/\partial \pi_j = \partial A_j^*/\partial \pi_i \text{ for all i} \neq \text{j.} \tag{4}$$

The restrictions given by equations (3) and (4) are imposed as prior information for each of the regional acreage equations in TECHSIM. Thus, according to equation (3), planted acreage for crop i must be positively related to own net returns per acre. Similarly, the i[th] livestock production alternative is positively related to own per animal net returns. According to the symmetry condition, equation (4), the change in planted acreage of crop i induced by a marginal change in the net returns of crop j is equal to the change in planted acreage of crop j caused by a marginal change in the net returns of crop i. A similar result holds for livestock. Although one can sign own partial derivatives of the acreage/livestock functions (2), other derivatives can have any particular sign. However, for both the field crop and livestock production sectors it is expected that cross signs would be negative since field crops compete for a fixed land base and livestock production processes compete for the total number of livestock which can be allocated between alternative livestock production processes.

The field crop and livestock demands in the model are aggregate equations for the nation. With the exception of livestock retail demands, all other demands are intermediate since additional processing is required before products reach final consumers. Restrictions are imposed on intermediate demands based upon the assumption that processors also maximize profit. Letting Y denote the netput vector ($Y_j < 0$ implies an input) and letting P denote the price vector, the general solution to such maximization problems,

$$Y_i = Y_i^*(P_1, \ldots, P_n) \text{ for all i,}$$

can be shown to possess these theoretical properties:

$$\begin{aligned} &\text{[Own Effect]} \quad \partial Y_i^*/\partial P_i \geq 0 \text{ for all i,} \\ &\text{[Symmetry]} \quad \partial Y_i^*/\partial P_j = \partial Y_j^*/\partial P_i \text{ for all i} \neq \text{j.} \end{aligned} \tag{5}$$

These general restrictions were imposed so that the parameters of the intermediate demands would be consistent with classical production theory.

The retail or final demands for livestock are estimated by imposing theoretically derived restrictions upon the following consumer demand functions:

$$X_i = X_i^*(P_1, \ldots, P_n, I) \text{ for all i,} \tag{6}$$

where X_i is the i[th] good demanded, P_i is the i[th] retail price, and I is income. The restrictions imposed on equation (6) are given by (7).

$$\begin{aligned} &\text{[Adding-up]} && \sum_i (\partial X_i^*/\partial P_i)P_i = 1, \\ &\text{[Homogeneity]} && \sum_j (\partial X_i^*/\partial P_j)P_j \\ & && + (\partial X_i^*/\partial I)I = 0, \\ &\text{[Symmetry]} && \partial X_i^*/\partial P_j + X_j^*(\partial X_i^*/\partial I) \\ & && = \partial X_j^*/\partial P_i + X_i^*(\partial X_j^*/\partial I). \end{aligned} \tag{7}$$

Given that the supply and demand systems developed in this model are incomplete, the decision to employ these restrictions is subjective but was deemed superior to omitting the conditions entirely.

Functional Form and Estimation Method

The model's equations were grouped into separate blocks and estimated for the period 1961–77 using restricted generalized least squares [Zellner]. This estimation technique accommodates correlation between the error terms in a set of estimated equations and the introduction of prior information. For example, error terms for acreage within a region are likely to be correlated because of a fixed land base, while deviations of yields are likely to be correlated as a result of weather. Furthermore, yield and acreage are likely related due to the heterogeneous quality of land in a region.

A variant of the generalized Leontief form [Diewert] was assumed for the objective function underlying most of the 172 equations in the model.[2] For each region this form implies the following indirect regional profit function:

$$\Pi^* = \sum_i \pi_i A_i^*$$
$$= \sum_i \sum_j \omega_{ij}\pi_i^{1/2}\pi_j^{1/2} + \sum_i \gamma_i \pi_i A_T.$$

The acreage equations for each region are:

$$\partial\Pi^*/\partial\pi_i = A_i^* = \sum_j \omega_{ij}\pi_i^{-1/2}\pi_j^{1/2} + \gamma_i A_T.$$

The restrictions which were imposed for this functional form are:

$$[\text{Own Effect}]\ \partial A_i^*/\partial\pi_i = \sum_j(-(\omega_{ij}/2)\pi_j^{1/2}\ \pi_i^{-3/2}) \geq 0,$$

and

$$[\text{Symmetry}]\ \partial A_i^*/\partial\pi_j = \partial A_j^*/\partial\pi_i \text{ or } \omega_{ij} = \omega_{ji}.$$

The generalized Leontief form was also used to estimate the parameters of the intermediate demands. For the final retail livestock demands, a double log form was used and the restrictions given by equations (7) were imposed at a single point (1977). Expected net returns for all crops and livestock are based on a one-year lag of net returns.

Summary Supply and Demand Elasticities

Because soybean oil and cottonseed oil are joint products with soybean meal, cottonseed meal, and cotton lint, additional incentives to produce plant oils will have a widespread influence on many markets. The substitutability of meals and feed grains also implies repercussions. To provide some indication of soybean and cotton supply responsiveness to changes in net returns, Table 1 relates regional acreage elasticities to own net returns. National demand elasticities are similarly reported in Table 2 for soybeans (SB), soybean meal (SBM), soybean oil (SBO), cottonseed (CTS), cottonseed meal (CTSM), cottonseed oil (CTSO), and cotton lint (CTL). Aggregate demand elasticities for these commodities appear to be reasonable.

[2] For a complete listing of the estimated equations in TECHSIM see Collins and Taylor.

TABLE 1. Own-Net Returns Acreage Elasticities.

Region[a]	Soybeans	Cotton
NW	—	—
CA	—	0.72
MS	—	—
SW	—	0.48
CP	1.13	—
NP	1.43	—
TX	1.23	1.91
LS	0.88	—
CB	0.74	—
DS	0.21	0.59
SE	0.61	0.53
MA	0.62	0.11
NE	0.77	—

[a] See Figure 2 for region abbreviations.

Plant Oils Program

In case of a temporary or permanent shortage of diesel fuels, government, industry, or agriculture could purchase plant oils in the marketplace, and these purchases could be processed to provide a substitute for diesel fuel. To minimize the costs of such a program, a reasonable social objective might be to purchase a target level of plant oils at least cost.

Since the target level is exogenous to the model, different assumptions and conditions can be simulated by changing the level of total energy that would be purchased as well as the frequency of purchases. For example, the government or industry may intervene only on spot oc-

TABLE 2. Own-Price Demand Elasticities.

Demand	SB	SBM	SBO	CTS	CTSM	CTSO	CTL
Elasticity	−1.54	−0.58	−0.10	−0.25	−4.88	−0.83	−1.22

casions when a shortage arises, or they may make purchases on a yearly basis to meet a targeted reduction of diesel fuel usage. The merit of relying on plant oils for alleviating acute short-term emergencies, as opposed to continued long-term use, has been questioned on technical grounds [Lipinsky *et al.*], and limited plant oil stocks may constrain an emergency program. Moreover, because historical patterns of behavior and expectations cannot be relied upon for the evaluation of short term plant-oil-for-fuel policies, this analysis highlights a yearly program.

In this situation, the program would logically minimize:

$$L = P_cQ_c + P_sQ_s + \lambda(T - \beta_cQ_c - \beta_sQ_s) \quad (8)$$

where P_c and P_s are the respective prices of cottonseed oil and soybean oil, Q_c and Q_s are the respective quantities purchased of cottonseed oil and soybean oil, λ is a Lagrange multiplier, T is the target BTU content of plant oils to be purchased, and β_c and β_s are the respective BTU contents of cottonseed oil and soybean oil.

Minimizing L yields the following first-order conditions:[3]

$$\partial L/\partial Q_c = P_c - \lambda\beta_c = 0, \quad (9)$$
$$\partial L/\partial Q_s = P_s - \lambda\beta_s = 0, \quad (10)$$
$$\partial L/\partial\lambda = T - \beta_cQ_c - \beta_sQ_s = 0. \quad (11)$$

The least-cost expansion path for purchases of plant oils is obtained by solving equations (9) and (10):

$$P_c\,\beta_s - P_s\,\beta_c = 0. \quad (12)$$

[3] A more general set of Kuhn-Tucker conditions would be required if a corner solution might apply (either $Q_c = 0$ or $Q_s = 0$). If T is large enough, however, the program guarantees that the price ratio between cottonseed oil and soybean oil will be determined by equations (9) and (10). Moreover, the price patterns illustrated within Figure 1 imply that T need not be very large to insure this result.

The BTU content of cottonseed and soybean oils (β_c and β_s) in equation (12) are shown in Table 3. To simulate a program of purchasing plant oils to substitute for diesel, equations (11) and (12) are added to the price solution algorithm in TECHSIM. This incorporates two additional unknowns, Q_c and Q_s, in two equations. Thus, the market equilibrium will also provide for the target plant oil program in a least-cost fashion.

Two scenarios are simulated based upon the total usage of diesel by U.S. agriculture. According to Kolmar, the total usage of diesel fuel by agriculture in 1979 was approximately 277 trillion BTUs. To prevent exceedingly large shocks to domestic plant oil markets, five and ten percent of the total usage was chosen to be the target purchase policies. These annual target levels are held constant during the simulation period for the two scenarios.

A limitation of this approach concerns the exogeneity of diesel price and diesel consumption. As a result, the two alternative program levels are allowed to influence commodity markets, but the implicitly higher value of diesel fuel is assumed to have no effect on crop or livestock supply functions through its impact on production costs. Similarly, final and derived demands for agricultural output are assumed to be independent of diesel fuel price. To a limited extent, however, the effect of diesel price is accounted for, in a general equilibrium sense, due to its cor-

TABLE 3. BTU Content of Selected Plant Oils.

Plant Oil	BTU Per Gallon	Gallon Per Pound	BTU Per Pound
Cottonseed Oil	129,555	0.12987	16,825
Soybean Oil	130,281	0.12987	16,920

TABLE 4. Regional Shifts in Acreage and Net Returns: 1983 and 1990.

		Regions[a]													
Policy	Year	US	NW	CA	MS	SW	CP	NP	TX	LS	CB	DS	SE	MA	NE
Five Percent Diversion															
Acreage (1,000)															
Corn	1983	−106	b	−3	−14	b	−35	−40	−21	−28	−899	−1	−7	−6	−6
	1990	−1,079	b	−2	−21	b	−188	−22	−25	−100	−696	−4	−7	−7	−5
Small Grains	1983	−27	6	2	3	−6	−96	b	−43	36	29	2	3	5	5
	1990	15	25	5	80	−3	−225	−1	−33	78	160	9	14	21	22
Grain Sorghum	1983	−36	0	−1	0	−21	24	b	−43	0	1	−1	2	3	0
	1990	60	0	−1	0	−17	44	−1	−9	0	42	−8	4	6	0
Cotton	1983	56	0	20	0	24	15	0	55	0	0	−42	−4	−12	0
	1990	81	0	16	0	17	11	0	39	0	0	−9	8	−1	0
Soybeans	1983	1,773	0	0	0	0	71	60	30	253	879	85	147	213	35
	1990	1,697	0	0	0	0	25	27	26	226	1,136	98	56	88	15
Net Returns (m. $)	1983	180	23	78	44	41	201	80	153	153	615	217	79	101	24
	1990	1,420	28	65	51	33	149	87	119	92	469	196	56	66	9
Ten Percent Diversion															
Acreage (1,000)															
Corn	1983	−1,844	b	−7	−22	−1	−69	−69	−48	−47	−1,550	−1	−11	−10	−9
	1990	−1,825	−1	−6	−29	b	−313	−34	−47	−143	−1,225	−4	−9	−9	−5
Small Grains	1983	−62	11	3	49	−19	−166	b	−74	59	48	3	6	9	9
	1990	124	42	7	125	−11	−456	−2	−68	111	268	13	23	36	36
Grain Sorghum	1983	−157	0	−1	0	−62	37	−1	−138	0	3	−2	3	4	0
	1990	34	0	−1	0	−48	61	−2	−64	0	81	−11	7	9	0
Cotton	1983	292	0	57	0	70	37	0	152	0	0	−37	21	−8	0
	1990	274	0	45	0	50	27	0	112	0	0	3	32	5	0
Soybeans	1983	2,912	0	0	0	0	121	104	50	441	1,471	75	232	357	61
	1990	2,865	0	0	0	0	54	52	53	447	1,966	1	97	165	30
Net Returns (m. $)	1983	3,773	37	197	73	109	374	137	352	304	1,283	477	171	209	50
	1990	3,113	47	170	89	89	289	152	296	215	1,043	420	130	148	25

[a] Regional delineation is shown in Figure 2.
[b] Field crop acreage changes are less than 1,000 acres.

relation with plant oil prices and other prices [Just *et al.*].

Results

A base simulation and each policy simulation are obtained for the years 1982–90. The base simulation assumes that no plant oils will be diverted to replace diesel fuel, whereas each policy simulation reflects a program of purchasing plant oils annually to meet targeted diesel fuel shortages. After simulating the base and policy scenarios, the differences between the base simulation and each of the two policy simulations provide estimates of multi-market impacts.

Acreage Shifts

Regional planting shifts due to simulating the two policy alternatives are shown in Table 4 for the years 1983 and 1990. All results corresponding to 1983 reflect the initial impact of diverting plant oils beginning in 1982, whereas 1990 depicts the simulated impact in the ninth year of these policies. Because planted acreage depends on lagged net returns, there are no acreage shifts in 1982. As expected, more cotton and soybeans are planted in most regions as a result of purchases of cottonseed and soybean oils. The largest single shift of planted acreage for both diversion policies is in the Corn Belt (CB) region. In this region, producers shift primarily from corn production to soybeans. Initially, U.S. field crop producers plant more acreage for all field crops except corn, small grains, and grain sorghum. However, only corn acreage decreases across all years for both plant oil diversion programs. Summing the changes in national planted acreage shows that approximately 705,000 and 911,000 more acres are planted in 1983 and 1990 with a five percent plant oil diversion policy. Similarly, approximately 1,141,000 and 1,472,000 more acres are planted in 1983 and 1990 when a ten percent diversion policy is adopted. Although these appear to be large acreage shifts, they represent only a three to six percent increase in acreage for the U.S.

Net Return Shifts

The total regional and national net returns or rents to fixed production factors are shown in Table 4. For each region these net returns represent the sum of the changes in net returns for all field crops in a region. The national net return figures represent the summation of all regional net returns. All rents are expressed in 1982 dollars.

All regions experience an increase in farmer net returns for both diversion policies. The largest increase is in the Corn Belt (CB) region, where producers gained 615 and 469 million (real) dollars in 1983 and 1990 with a five percent diversion policy and 1,283 and 1,043 million dollars in 1983 and 1990 under a ten percent diversion policy. This region accounts for approximately one-third of the total increase in the national net returns for farmers under both policies. In general, the Corn Belt (CB), Delta States (DS), Central Plains (CP), Texas (TX), and Lake States (LS) producers gain the most from diverting cottonseed and soybean oils to use as a diesel fuel substitute.

Price Shifts

The price shifts for each commodity are depicted in Table 5. Due to the purchasing activities for plant oils, the prices of cottonseed and soybean oils increase for both policy scenarios. This results in price increases for cottonseed and soybeans. These price increases provide incentives to increase planted acreage of plant oil crops. Because meal is a joint product with oil, the prices of cottonseed meal and soybean meal decrease. Similarly, because cottonseed and cotton lint are joint prod-

TABLE 5. Price Shifts for U.S. Field Crops and Livestock (1982 Prices).

Commodity	Unit	Baseline Prices		Five Percent Diversion		Ten Percent Diversion	
		1982	1990	1982	1990	1982	1990
Corn	($/bu.)	3.27	3.24	.04	.04	.07	.05
Small Grains	($/bu.)	2.93	2.69	.04	.15	.06	.26
Grain Sorghum	($/bu.)	3.21	3.19	.01	.07	.02	.14
Cotton Lint	(¢/lb.)	96.73	96.69	−.60	−1.95	−2.60	−3.10
Cottonseed	($/ton)	160.64	159.35	60.25	61.19	174.85	175.49
Cottonseed Meal	($/ton)	146.40	144.02	−27.10	−53.61	−43.70	−78.10
Cottonseed Oil	(¢/lb.)	46.19	45.71	7.52	7.86	21.81	22.62
Soybeans	($/bu.)	7.80	7.79	1.15	.50	2.00	.99
Soybean Meal	($/ton)	198.71	202.93	−35.90	−70.50	−57.70	−102.52
Soybean Oil	(¢/lb.)	34.43	34.14	19.58	19.73	33.95	34.58
Fed Beef	(¢/lb.)	74.59	74.66	−.13	−.02	−.22	−.03
Non-Fed Beef	(¢/lb.)	46.86	46.93	.03	.12	.05	.16
Pork	(¢/lb.)	62.60	62.35	−.89	−.98	−1.45	−1.37
Sheep	(¢/lb.)	79.14	79.11	−.84	−1.02	−1.37	−1.41

ucts, an increase in the production of cotton to produce more cottonseed depressed the price of cotton lint.

The prices of other field crops (such as corn, small grains, and grain sorghum) increase as a result of producers shifting from these crops into cotton and soybeans. The price shifts for these field crops are relatively small under both program scenarios.

The price shifts for the livestock commodities result from depressed prices for cottonseed and soybean meal feed-stuffs. This encourages livestock producers to increase the number of animals fed which leads to higher livestock production levels and lower prices. Only nonfed beef increases in price depicting the model's shift from nonfed livestock production to fed livestock production.

Welfare Shifts

In Table 6 the change in surplus measures of each diversion policy is presented. The first measure depicts the change in total crop producer net returns. These are the rents resulting from summing the change in total regional field crop rents. Total crop forward industry rents are the rents to intermediate industries plus final consumer surpluses of those industries which utilize field crops as inputs and which are not accounted for in other rent measures of Table 6. The total meal and oil industry rent depicts the rent to meal and oil processors plus forward industry rents and final consumer surpluses which utilize oil and/or meal as an input. The other rent measures in Table 6 reflect the change in rents to other agricultural industries in TECHSIM. The total cost of purchasing plant oils reflects the purchase price times the quantity purchased for both cottonseed and soybean oils. The total welfare measure is the sum of all rent measures in Table 6, less the cost of purchases for each policy. For a detailed explanation of how these rents were computed see Chavas and Collins.

As shown in Table 6, all producer/consumer classifications are net losers with the exception of field crop producers and final consumers of livestock products. The crop forward industries loss results from more significant increases in crop prices than decreases. Cotton lint is the only field product which experiences a price decrease. Because field crops are basically intermediate products, higher crop prices

TABLE 6. Welfare Impacts of Diverting Plant Oils for Use as Diesel Fuel.

Rent or Cost Measure	Five Percent Diversion		Ten Percent Diversion	
	1982	1990	1982	1990
Total Crop Producer Rents (m. $)	1,914	1,420	3,666	3,112
Total Crop Forward Industry Rents (m. $)	−987	−788	−1,768	−1,477
Total Meal and Oil Industry Rents (m. $)	−1,297	−720	−2,565	−1,665
Total Livestock Producer Rents (m. $)	−63	−56	−104	−80
Total Livestock Wholesale and Retail Producer Rents (m. $)	−74	−65	−121	−92
Total Livestock Final Consumer Surpluses (m. $)	140	124	230	173
Total Program Cost of Purchasing Plant Oils (m. $)	429	428	1,095	1,103
Total Welfare = Sum of All Rents Less Program Purchase Cost (m. $)	−796	−596	−1,757	−1,138

imply higher input costs to those industries which process these products. Thus, rents to these industries fall.

Although not shown, the oilseed processors' proportion of the total meal and oil industry rent is positive. The increased prices of cottonseed and soybean oils also result in higher input costs to those industries which utilize these oils as inputs. Consequently, the total meal and oil industry rent is negative.

Total livestock producer rent is negative although some feed–stuffs decrease in price and livestock production increases. The proportional decrease in estimated livestock prices is greater than the lower feed input costs (resulting in rent losses). In addition to crop producers, final consumers of livestock products experience a positive increase in welfare due to lower livestock prices.

The program cost of purchasing plant oils ranges from approximately one-half billion dollars per year with a five percent diversion, to over one billion dollars per year under a ten percent diversion policy. The implied diesel equivalent prices for plant oils (per gallon) is as follows: for the five percent program, $4.43 in 1982 and $4.42 in 1990; for the ten percent program, $5.61 in 1982 and $5.63 in 1990. Although this study does not take into account the program revenue which would result from selling plant oils as diesel fuel, even if the program broke even (value of sales equalled cost of procurement), the total economic impact will be negative under both policy alternatives. While summing sectoral welfare measures is normatively suspect, as always, the disaggregated impacts identified in Table 6 are illuminating.

Implications

The two scenarios evaluated in this paper are designed to provide the thermal equivalent of approximately 100 and 200 million gallons of diesel fuel per year. The influence of such programs on oilseed, oil, and meal markets involve large price increases for oilseeds and oils with large price decreases for meals. Numerous other market prices are affected to various degrees, but changes are generally less than five percent from the base. When the simulated plant oil prices are converted to a diesel equivalent basis, the resulting values are four to six times greater than recent prices for diesel fuel. Excise tax exemptions for diesel/plant oil blends (similar to those for gasohol) could succeed in eliminating this gap, but the merit of such a proposal should be judged by its impacts on the many affected groups.

The large policy-induced price changes for selected commodities imply supply–demand equilibria outside the range of data. Welfare results are, nevertheless, indicative of relative impacts on certain producer/consumer categories. Crop producers are the primary beneficiaries of this program. Final consumers of meat products and oilseed processors are secondary gainers. As a group, consumers and processors of plant oils, meals, and crops other than oilseeds are impacted negatively. Losses by livestock producers, wholesalers, and retailers nearly offset the gains by livestock consumers.

The search for alternative fuels, particulary diesel substitutes, often does not address the economic issues. Although it possesses limitations, this analysis indicates some economic implications of substituting plant oils for diesel fuel. The results identify the critical nature of alternative energy policies in terms of aggregate economic implications and potential equity issues.

In light of the relative prices of plant oils and diesel fuel, there is little evidence that plant oils will become a competitive economic substitute for diesel fuels in the very near future. While a government policy can be developed to make plant oil an economically viable fuel source, simulation results suggest that even a modest program will have large and generally disadvantageous market impacts. As in all cases there will be winners and losers, and the real issue concerns who is to be favored.

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