DEMAND AND SUPPLY RELATIONSHIPS FOR THE INDIAN VEGETABLE OIL INDUSTRY WITH PARTICULAR EMPHASIS ON ESTIMATION AND PREDICTION

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VEGETABLE oils occupy an important place in Indian economy. Knowledge of the forces influencing prices and quantities of vegetable oils is a prerequisite to the intelligent formulation of public and private policies for this economic sector.

The paper is organized into six sections. The first section presents an economic and statistical model of the vegetable oil industry. The results are presented in the second section. They are analyzed for their economic and statistical validity and compared with available parameter estimates. The next two sections present the alternative specifications of the model and objectively evaluate the accuracy of the economic predictions. Fifth section is devoted to the partial equilibrium analysis. The last section is concerned with the implications and conclusions that can be drawn from the results.

I. MODEL SPECIFICATION

A. *General Considerations*

An economic model is a representation designed to incorporate in a simplified way the underlying relations that reflect observable economic phenomena in some segment or the entirety of the economic system. Economic theory augmented by a priori knowledge of the sector to be portrayed, acts as an aid in the task of constructing economic models. For a given object system in the real world, specification of the models varies from investigator to investigator, and depends upon their individual considerations as to the appearance and the generation of the variables. As viewed by Haavelmo [7], the building and choice of models is not a problem of pure logic, but of knowing something about real phenomena and making realistic assumptions about them. The construction of economic model is perhaps the most important step in quantitative research.

The economic model used to represent the vegetable oils economy is based on the assumption that producers of each product maximize profits, produce essentially homogeneous product, and individually do not influence product or input prices. On the consumer side, it is assumed that all consumers face an equivalent price, that the average quantity response to income changes among consumers is a valid approximation of individual responses to income changes, that each consumer's preferences are independent of preferences of other consumers, and that each consumer maximizes his satisfactions subject to his income or budget constraints.

The basic model developed for the vegetable oils economy is a simultaneous model which allows for simultaneity between the supplies and demands. The model formulation is based on the argument of Haavelmo [8] and Cowles Commission for Research in Economics (now known as Cowles Foundation) who have supported that all variables in a system are simultaneously determined. An examination of the vegetable oil industry immediately suggests that the vegetable oil markets do not operate in an economic vacuum. General conditions in the economy affect the market for a particular vegetable oil sector through several other subsectors. In return, this subsector influences the other subsectors and the general economy. It is always difficult to know where to sever mutual dependence in an economic model. Much depends upon the purpose of the analysis, the data available, and the resources committed to the study. It is clear, however, that within the vegetable oils economy mutual influence and interdependence cannot be ignored, especially when analysis is cast in an yearly framework. To do so could seriously undermine the empirical relevance such a model might have.

B. *The Economic Model*

Three relations were constructed for each component demand of peanut oil, namely demand for direct liquid consumption, demand for vanaspati (hydrogenated vegetable oil) production, and export demand. The domestic demand for peanut oil for food was hypothesized as negatively related to the prices of peanut oil and positively related to the price of mustard oil, sesame oil, and disposable income (equation 1). A demand shifter, population, could be included directly as a variable or indirectly by expressing the relevant variables on a per capita basis. The later choice is, however, not appropriate. It does not make much sense to divide the exports as well as the quantity of oil used in vanaspati production by the population. A trend variable was introduced in the demand equation to represent the shift in quantity demanded due to changes in tastes and preferences. However, a high degree of correlation was found to exist between the trend variable, level of personal disposable income, and population level. To avoid the seemingly inescapable estimation problem encountered when several of the exogenous variables are approximate linear functions of one another, the attending exogenous variable may simply be deleted and replaced by a linear function of the others [2]. More simply, if it is further assumed that the linear function is the form $Z_i = \delta Z_j$ where δ is close to 1 between any two of the exogenous variables considered, one of the highly correlated variables can be designated as a proxy variable for the entire subset of variables in question. The fact that in small samples the accuracy of estimates is reduced if a high degree of multicollinearity between the exogenous variables exists is well documented [1].

The matrix of zero order correlation revealed that a correlation of approximately 1.0 exists between trend variable, income, and population. Since the parameter estimates associated with the first two variables are of secondary interest, personal disposable income was chosen as a proxy variable and trend and population variables were dropped from the equation.

The demand for peanut oil in vanaspati production was postulated to be inversely related to the prices of peanut oil and positively related to the prices of competing oils, sesame and cottonseed oil, and to the price of finished product, vanaspati (equation 2). A trend variable was used to reflect the level of technology exhibited by manufacturers of vanaspati industry, utilizing peanut, sesame, and cottonseed oils as factors of production. The export demand function (equation 3) expresses the quantity of peanut oil exported as a negative function of Indian peanut oil price and a positive function of the African peanut oil price and the United States soybean oil price. The export relation should also include the demand shifters for peanut oil in importing countries such as population increases, income, and changes in tastes and preferences. Any meaningful specification of such factors is a difficult task in itself and a trend variable was specified to measure their effect on peanut oil exports.

In the supply relationship (equation 4) the quantity of peanut oil was postulated as a function of the price of the input (peanuts), the prices of the joint products, peanut oil and peanut meal, and the level of technology characteristic of the industry.

The remaining structural equations are essentially the same as those just described. Equations (5) and (8) describe the liquid demand relationship for sesame and mustard oil, respectively, while equations (6) and (10) pertain to the industrial demand relationship of sesame and cottonseed oil, in the order mentioned. The rest of the equations (7), (9), and (11) are, respectively, the supply relations for sesame, mustard, and cottonseed oils.

C. *Sources of Data*

The analysis pertains to the years 1947–64. The selection of empirical variables used in estimating the parameters of the structural equation was made on the basis of approximating, as closely as possible, the variables specified in the theoretical model. The data on domestic prices, production, utilization, and exports were compiled from the various publications of the Directorate of Economics and Statistics and Director General of Commercial Intelligence and Statistics. The data on national income were obtained from Central Statistical Organization, and Planning Commission. The source of data of U.S. soybean price was USDA, *Fats and Oil Statistics. International Trade Statistics* of the United Nations were used to collect the price of African peanut oil.

The most appropriate price that should be used for the purpose of consumption-price relationship appears to be retail prices. The data on retail prices, however, were not available for all the vegetable oils over the entire period of analysis. This necessitated the use of wholesale prices series. Deflation of the relevant price variable was deemed inadvisable. It was hypothesized that producers and consumers make marketing decisions in terms of actual prices. In addition, even if deflation is considered advisable in a behavioral context, it may be theoretically invalid procedure to pursue. That is to say, to avoid a specification error, each price variable deflated prior to its introduction into the analysis must be a linear homogeneous function of the deflating variable [14]. Furthermore, irrespective of how the variable is introduced into the analysis, a statistical downward bias in the regression coefficient results if the index number utilized contains the price of the commodity with which the analysis is concerned [4]. There is very little a priori economic evidence to suggest what mathematical form the equations in the system should possess. Each equation was estimated as a form linear to the logarithms of the variables. One reason for performing this transformation is that primary attention is focused on the elasticity as opposed to the slope of the demand relationships. In addition to being computationally convenient, this procedure provides unbiased estimates if the assumptions which accompany the estimation procedure are fulfilled. In any case, if a linear demand function does, in fact, characterize a particular demand relationship, a logarithmic form can closely approximate it.

D. *The Statistical Model*

There are eleven equations in eleven endogenous variables; the system is complete. The error terms, U_i, are assumed normally distributed, with a zero mean and constant variance. According to the order condition for identifiability, all behavioral equations are over identified. Ordinary least squares estimates would be biased; indirect least squares cannot be used because of over identification. Two-stage least squares estimation, the next simplest method, was used. It gives asymptotically unbiased estimates and seems to perform well for small sample sizes [12, Chap. 10]. The complete statistical model is now presented:

$$B_{11}Y_{1t}+B_{14}Y_{4t}+B_{17}Y_{7t}+B_{19}Y_{9t}+\gamma_{11}Z_{1t}+\gamma_{10}=U_{1t}, \qquad (1)$$

$$B_{22}Y_{2t}+B_{24}Y_{4t}+B_{27}Y_{7t}+B_{2,11}Y_{11t}+\gamma_{22}Z_{2t}+\gamma_{20}=U_{2t}, \qquad (2)$$

$$B_{33}Y_{3t}+B_{34}Y_{4t}+\gamma_{31}Z_{1t}+\gamma_{33}Z_{3t}+\gamma_{3,12}Z_{12t}+\gamma_{30}=U_{3t}, \qquad (3)$$

$$B_{4i}\sum_{i=1}^{3}Y_{it}+B_{44}Y_{4t}+\gamma_{44}Z_{4t}+\gamma_{45}Z_{5t}+\gamma_{40}=U_{4t}, \qquad (4)$$

$$B_{55}Y_{5t}+B_{54}Y_{4t}+B_{57}Y_{7t}+B_{59}Y_{9t}+\gamma_{51}Z_{1t}+\gamma_{50}=U_{5t}, \qquad (5)$$

$$B_{66}Y_{6t}+B_{64}Y_{4t}+B_{67}Y_{7t}+B_{6,11}Y_{11t}+\gamma_{62}Z_{2t}+\gamma_{60}=U_{6t}, \qquad (6)$$

$$B_{7i}\sum_{i=5}^{6}Y_{it}+B_{74}Y_{7t}+\gamma_{76}Z_{6t}+\gamma_{77}Z_{7t}+\gamma_{70}=U_{7t}, \qquad (7)$$

$$B_{88}Y_{8t}+B_{84}Y_{4t}+B_{87}Y_{7t}+B_{89}Y_{9t}+\gamma_{81}Z_{1t}+\gamma_{80}=U_{8t}, \qquad (8)$$

$$B_{98}Y_{8t}+B_{99}Y_{9t}+\gamma_{98}Z_{8t}+\gamma_{99}Z_{9t}+\gamma_{90}=U_{9t}, \qquad (9)$$

$$B_{10,10}Y_{10t}+B_{10,4}Y_{4t}+B_{10,7}Y_{7t}+B_{10,11}Y_{11t}+\gamma_{10,12}Z_{2t}+\gamma_{10,0}=U_{10t}, \qquad (10)$$

$$B_{11,10}Y_{10t}+B_{11,11}Y_{11t}+\gamma_{11,10}Z_{10t}+\gamma_{11,11}Z_{11t}+\gamma_{11,0}=U_{11t}, \qquad (11)$$

where

t is the time period (year);

Y_1 is the wholesale demand of peanut oil for food, in 1,000 metric tons;

Y_2 is the wholesale demand of peanut oil for production of vanaspati, in 1,000 metric tons;
Y_3 is the exports of peanut oil under all forms, in 1,000 metric tons;
Y_4 is the wholesale price of peanut oil in rupees per metric ton;
Y_5 is the wholesale demand of sesame oil for food, in 1,000 metric tons;
Y_6 is the wholesale demand of sesame oil for production of vanaspati, in 1,000 metric tons;
Y_7 is the wholesale price of sesame oil in rupees per metric ton;
Y_8 is the wholesale demand of mustard oil for food, in 1,000 metric tons;
Y_9 is the wholesale price of mustard oil in rupees per metric ton;
Y_{10} is the wholesale demand of cottonseed oil for production of vanaspati, in 1,000 metric tons;
Y_{11} is the wholesale price of cottonseed oil in rupees per metric ton;
Z_1 is the per capita disposable income, in millions of rupees;
Z_2 is the wholesale price of vanaspati in rupees per metric ton;
Z_3 is the price of African peanut oil in dollars per metric ton, c.i.f. price in Europe;
Z_4 is the wholesale price of peanuts in rupees per metric ton;
Z_5 is the wholesale price of peanut meal in rupees per metric ton;
Z_6 is the wholesale price of sesame seed in rupees per metric ton;
Z_7 is the wholesale price of sesame meal in rupees per metric ton;
Z_8 is the wholesale price of mustard in rupees per metric ton;
Z_9 is the wholesale price of mustard oil cake in rupees per metric ton;
Z_{10} is the wholesale price of cottonseed in rupees per metric ton;
Z_{11} is the wholesale price of cottonseed meal in rupees per metric ton;
Z_{12} is the U.S. price of soybean oil in dollars per metric ton, midwestern mills;
U_t is the disturbance term.

II. RESULTS OF ESTIMATION

Results of estimation are as follows:

$$Y_1 = \underset{(0.2271)}{-0.4530Y_4} + \underset{(0.2655)}{0.3073Y_7} + \underset{(0.2369)}{0.2862Y_9} + \underset{(0.3984)}{1.4245Z_1} - 0.7096 .$$

$$R^2 = 0.77 .$$

$$Y_2 = \underset{(0.0798)}{-0.0868Y_4} + \underset{(0.2341)}{0.3036Y_7} + \underset{(0.0443)}{0.0645Y_{11}} + \underset{(0.2295)}{0.7994Z_2} - 2.3921 .$$

$$R^2 = 0.81 .$$

$$Y_3 = \underset{(0.2828)}{-1.6048Y_4} + \underset{(0.4059)}{0.9945Z_3} + \underset{(0.3650)}{0.8759Z_{12}} + 0.5449 .$$

$$R^2 = 0.78 .$$

$$\sum_{i=1}^{3} Y_i = \underset{(0.3357)}{0.5980Y_4} - \underset{(0.2818)}{0.0058Z_4} + \underset{(0.1229)}{0.1525Z_5} + 0.7668$$

$$R^2 = 0.69 .$$

$$Y_5 = \underset{(0.4376)}{0.6489Y_4} - \underset{(0.5069)}{0.5268Y_7} + \underset{(0.0998)}{0.1282Y_9} - \underset{(0.0261)}{0.0267Z_1} + 0.8981 .$$
$$R^2 = 0.71 .$$

$$Y_6 = \underset{(0.0914)}{0.1181Y_4} - \underset{(0.1567)}{0.1809Y_7} + \underset{(0.1276)}{0.0948Y_{11}} + \underset{(0.2333)}{1.2435Z_2} + 0.0261 .$$
$$R^2 = 0.69 .$$

$$\sum_{i=5}^{6} Y_i = \underset{(0.1766)}{0.1846Y_7} - \underset{(0.3601)}{0.4001Z_6} - \underset{(0.2546)}{0.1806Z_7} - 0.8901 .$$
$$R^2 = 0.65 .$$

$$Y_8 = \underset{(0.1407)}{0.1631Y_4} + \underset{(0.3988)}{0.4481Y_7} - \underset{(0.3535)}{0.3930Y_9} + \underset{(0.5976)}{1.4074Z_1} - 0.0572 .$$
$$R^2 = 0.89 .$$

$$Y_8 = \underset{(0.1993)}{0.6737Y_9} - \underset{(0.2826)}{0.1180Z_8} + \underset{(0.1130)}{0.2728Z_9} - 0.2307 .$$
$$R^2 = 0.85 .$$

$$Y_{10} = \underset{(0.3509)}{0.7667Y_4} + \underset{(0.4705)}{0.6659Y_7} - \underset{(0.1370)}{0.2448Y_{11}} + \underset{(0.4611)}{3.1505Z_2} - 13.2711 .$$
$$R^2 = 0.86 .$$

$$Y_{10} = \underset{(0.3630)}{0.3897Y_{11}} + \underset{(0.1038)}{0.2509Z_{10}} - \underset{(0.2816)}{0.1542Z_{11}} - 0.6037 .$$
$$R^2 = 0.74 .$$

The price elasticity of demand of peanut oil, for direct liquid consumption, was −0.45. For sesame and mustard oils, the corresponding estimates of elasticity were, respectively, −0.53 and −0.39. The coefficient of the price variable for sesame and mustard oils included in the demand equation of peanut oil was positive, significant and smaller than 1.0; similarly the coefficient of the price of peanut and mustard oils in the demand function for sesame oil and the coefficient of the price of peanut and sesame oils in the mustard oil demand function were positive, significant, and smaller than 1.0. In accordance with Hicks's analysis of commodity groups, this means that peanut oil, sesame oil, and mustard oil are mutual substitutes [9, Chap. 4].

Estimated income elasticity of demand was positive and significant in the case of peanut and mustard oils and negative and significant with respect to sesame oil. Income elasticities were, respectively, 1.42, 1.40, and −0.027 for peanut oil, mustard oil, and sesame oil. These estimates compare very well with NCAER's income elasticities [16, p. 80]. The all India estimates by NCAER are 1.72 for peanut oil and 1.02 for mustard oil. No comparable estimates are available for sesame oil. FAO estimates for fats and oils are 1.20 [3, Table M4].

With respect to the demand for vegetable oils by vanaspati manufacturers, the direct price elasticity for peanut, sesame, and cottonseed oils were, respectively, −0.09, −0.18, and −0.24. The coefficient of the price variable for sesame and cottonseed oils included in the peanut oil demand relation, was positive and significant. The coefficient of the price variable for peanut oil in the sesame oil demand relationship was positive and significant while the cottonseed oil price coefficient was positive but insignificant. The cross-price elasticity of peanut and sesame oils, was positive and significant. These results suggest that peanut oil, sesame oil, and cottonseed oil are largely mutual substitutes in vanaspati production.

With respect to the product produced, the cross-price elasticity of vanaspati in peanut oil, sesame oil, and cottonseed oil demand relations were 0.80, 1.24, and 3.15, respectively. The trend coefficient, initially specified in the industrial demand equations, was found to be insignificant in all the equations. The price elasticity for exported peanut oil was -1.60. Higher prices of peanut oil are likely to have serious repercussions on the export market. U.S. soybean oil and African peanut oil were found to be important competitors. The trend variable in the export relation was found to be insignificant.

The results of supply analysis reveal that mustard oil has the highest price elasticity of supply (0.67) followed by peanut oil (0.60), cottonseed oil (0.39), and sesame oil (0.18). No comparable estimates are available for the supply elasticities of vegetable oils. However, estimates of supply elasticities for oilseeds which provide a framework for evaluating price control policies are available [15].

III. ALTERNATIVE SPECIFICATIONS

A. *Ordinary Least Squares (OLS)*

Two-stage least squares method was used for estimating the structural form of the simultaneous model. However, for pinpointing the specifications of the model, much preliminary work was done with ordinary least squares. In general, the estimation results from OLS and 2SLS were quite similar. However, 2SLS coefficients were found to have significant coefficients for most of the economic variables as compared to OLS estimates. In three cases the coefficient of variables estimated from OLS turned out to be insignificant although the sign of coefficients did not alter. These were: sesame oil price in equations (1) and (2), price of sesame meal in equation (7). In two cases the level of significance did not change but the sign of the coefficients changed from negative to positive. These were: price of mustard seed and price of cottonseed meal in equations (9) and (11) respectively. The coefficient of income for sesame oil demand in equation (5) was found to be positive but insignificant, a significant change. Some of these relationships warrant further study. OLS estimates are not presented due to lack of space.

B. *Distributed Lags*

So far the analysis had been carried out in a static framework. It was implicit in the behavioral relationships that consumers and producers adjust to changed conditions within the interval of observation instantaneously. Whenever it takes time for producers or consumers to adjust to changed conditions and whenever the period which is required for full adjustment exceeds the interval of observation, the statistical estimates tell us little about the long-run elasticity or any of the short-run elasticity. The real world presents us with a curious mixture of short and long-run adjustments. In order to disentangle the two, it is necessary to investigate the underlying long-run adjustments upon which short-run adjustments are superimposed [6]. Thus from the point of view of public policy and econometric technique, investigation of long-run elasticities is necessary and desirable. The problem involved is closely related to the problem of distributed lags. Following the approach originally proposed by Koyck [13] and further developed by Nerlove [17], distributed lag models were formulated.

Table I presents selected statistical results of the dynamic analyses. Since all the variables are in log form, λ is the elasticity of adjustment. The length of the adjustment period can be estimated by solving for N in the expression: $(1-\lambda)^N \leqq 0.05$, assuming complete adjustment to be 95 per cent or more within N time periods. This arbitrary specification is required because $(1-\lambda)^N = 0$ only for $N=\infty$. The elasticities of adjustment for demand relations range from 0.62 to unity. Since the elasticities of adjustment are quite large they indicate a swift rate of adjustment of the current quantity consumed to the long-run equilibrium quantity. The elasticity of adjustment for supply relations range between 0.38 for mustard oil to 0.93 for cottonseed oil.

The statistical evidence did not provide a strong support for the distributed lag hypothesis. The coefficient of lagged dependent variable was round to be significant at 5 per cent level only in two cases out of eleven. The R^2's tended to be higher for distributed lag model. The dynamic model in most cases reduced or eliminated the serial correlation found in the calculated residuals of regression

TABLE I

ESTIMATES OF DEMAND AND SUPPLY ELASTICITIES FOR VEGETABLE OILS: DISTRIBUTED LAG MODEL (SELECTED STATISTICS)

Commodity	Endogenous Variable	Short-run Price Elasticity	Long-run Price Elasticity	Coefficient of Adjustment (λ)	R^2	d	s
Peanut oil	Y_1	–0.4321	–0.5144	0.84*	0.88	1.38[i]	0.0760
	Y_2	–0.2864	–0.4695	0.62†	0.87	1.41[i]	0.1055
	Y_3	–1.4148	–1.4436	0.98†	0.79	2.01	1.1754
	E_S	0.4681	0.7550	0.62**	0.71	2.08	0.5628
Sesame oil	Y_5	–0.5234	–0.6797	0.77†	0.73	1.79[i]	0.1250
	Y_6	–0.2281	–0.2281	1.00†	0.74	1.55[i]	0.2107
	E_S	0.1841	0.4002	0.46*	0.72	0.88[a]	0.2180
Mustard oil	Y_8	–0.4350	–0.4350	1.00†	0.93	2.04	0.1108
	E_S	0.4116	1.0831	0.38†	0.87	0.55[a]	0.1816
Cottonseed oil	Y_{10}	–0.3451	–0.5229	0.66*	0.95	2.05	1.1805
	E_S	0.4211	0.4552	0.93**	0.83	2.45	1.2131

Notes: 1. R^2 is the coefficient of determination, d is Durbin-Watson statistics, and s is the standard error of estimate. For Durbin-Watson test symbol a is used to indicate an unfavorable test, i is used to indicate inconclusive results, and no symbol is used to indicate a favorable test result.

2. For λ values * indicates significant at 10 per cent level, ** indicates significant at 5 per cent level, and † stands for insignificant at 10 per cent level.

3. E_S stands for the supply relation.

based on static models. However, both of these statistics must be interpreted with caution. If economic variables have a high degree of inertia, lagging the dependent variable and using it as an explanatory variable will automatically give a high R^2 [9]. The test for serial correlation is also weak in the presence of a lagged dependent variable, and the lack of serial correlation in the calculated residuals does not provide conclusive support for the distributed lag hypothesis.

IV. THE MODELS AND PREDICTIONS

Three models were used to test the predictive capacity. Model I consists of the two-stage least squares reduced form estimates (2SLSRF) where every endogenous variable (Y_i) is expressed as a function of exogenous variables (X_i), due account being given to the restrictions imbedded in the structural relations. Model II consists of the unrestricted least squares reduced form estimates (ULSRF) where each endogenous variable is expressed as a function of all the exogenous variables. The prediction equation of Model III are estimated two-stage least squares structural estimates (2SLS).

The predicted values of the endogenous variables generated by the above three models were used to objectively evaluate the accuracy of the economic predictions. Two tests were employed for this purpose. The first of these tests evaluates the predictions on the basis of the direction of change in the endogenous variables. The other test involves the magnitude and direction of the deviations of observed values from predicted values of the endogenous variables.

In the evaluation of the forecasts in terms of the direction of change, an estimate is called correct if the predicted change from year "$t-1$" to "t" is the same direction as the observed change between the two periods. A binomial probability function was used to evaluate the number of correct predictions obtained from each of the predictive models [11]. Letting p be the probability of occurrence of a correct change by chance alone, and q be the probability of occurrence of an incorrect change by chance alone, the probability of occurrence of each term of the binomial distribution is given by $\binom{n}{r}p^r q^{n-r}$ where n is the total number of predictions and r is the number of correct predictions. Assuming an equal probability of occurrence by chance alone of a correct and incorrect change, $p=q=1/2$, the specific binomial distribution under consideration, when 17 values of an endogenous variable are predicted, is $\binom{17}{r}(1/2)^r(1/2)^{17-r}$.

The number of correct predictions and the related probabilities are presented in Table II. Of the 187 predictions generated by Models I and II, the direction of change of 146 of those from Model I and 156 of those from Model II were correct; hence, about four-fifths of the predictions generated by these models were correct in terms of direction of change. Model III performed less satisfactorily. Of the 77 predictions generated by Model III, 42 were correct, representing about one-half of the predictions generated. In general, ULSRF predicted the most number of correct changes for the greatest number of variables.

The ability of predictive model to predict the direction of change is one criterion for evaluation of a forecasting model. However, an analysis of turning points as the one presented above does not provide information about the magni-

TABLE II

NUMBER OF CORRECT PREDICTIONS OF DIRECTION OF CHANGE IN THE ENDOGENOUS VARIABLES AND RELATED PROBABILITIES

Endogenous Variable	Model I		Model II		Model III	
	Number of Correct Predictions	Probability	Number of Correct Predictions	Probability	Number of Correct Predictions	Probability
Y_1	15	0.0010	15	0.0010	16	0.0001
Y_2	14	0.0052	16	0.0001	14	0.0052
Y_3	15	0.0010	15	0.0010	13	0.0182
Y_4	16	0.0001	17	a	—	—
Y_5	12	0.0472	13	0.0182	10	0.1484
Y_6	9	0.1854	9	0.1854	10	0.1484
Y_7	13	0.0182	16	0.0001	—	—
Y_8	10	0.1484	12	0.0472	10	0.1484
Y_9	14	0.0052	15	0.0010	—	—
Y_{10}	13	0.0182	13	0.0182	11	0.0944
Y_{11}	15	0.0010	14	0.0052	—	—

Note: Model I=two-stage least squares reduced form estimates. Model II=unrestricted least squares reduced form estimates. Model III=two-stage least squares structural estimates.

[a] Less than 0.000008.

tude of miss when an incorrect change is predicted, nor does it provide information about the magnitude of the deviation between the observed and predicted changes when the direction of change is forecasted correctly. Quantitative tests which utilize information about the absolute discrepancies between predicted and observed changes provide information about how close predicted values are to observed values and permit comparisons of accuracy among alternative predictive models.

The method used to evaluate the accuracy of the predictions generated by the three predicting models was to construct "inequality coefficient" developed by Theil [18]. The measure is defined by

$$U=\sqrt{\frac{1}{n}\sum(P-A)^2}\Big/\left(\sqrt{\frac{1}{n}\sum P^2}+\sqrt{\frac{1}{n}\sum A^2}\right),$$

where $P_1,\ldots,P_N$ are the predicted changes and $A_1,\ldots,A_N$ are the corresponding observed changes. The inequality coefficient can be thought of as a coefficient of deviation for pairs of predictions and realizations, P_i's and A_i's. Thus $U=0$ if all forecasts are perfect; and $U=1$ if there is a negative proportionality between P's and A's.

The values of the inequality coefficient pertaining to forecasts generated by various predictive models are given in Table III. The values of inequality coefficient derived from the three models were satisfactory for all the endogenous variables with the exception of one of the variable, the quantity of mustard oil demanded for food. The unrestricted least squares reduced form estimates were found to be more efficient for most of the variables.

TABLE III

INEQUALITY COEFFICIENTS (U) FOR VARIOUS PREDICTION MODELS

Endogenous Variable	Model I	Model II	Model III
Y_1	0.1053	0.2902	0.1253
Y_2	0.1349	0.1327	0.1825
Y_3	0.3161	0.2825	0.2379
Y_4	0.1691	0.1356	—
Y_5	0.2252	0.2081	0.2304
Y_6	0.2184	0.2663	0.2156
Y_7	0.3157	0.1863	—
Y_8	0.9492	0.9262	0.9167
Y_9	0.2467	0.2133	—
Y_{10}	0.4247	0.1833	0.2903
Y_{11}	0.2731	0.1743	—

Note: Model I=two-stage least squares reduced form estimates.
Model II=unrestricted least squares reduced form estimates.
Model III=two-stage least squares structural estimates.

V. PARTIAL EQUILIBRIUM ANALYSIS

The structural form gives the interaction of the different variables in the system. To permit study of the explicit dependence of the jointly dependent variables on the predetermined variables and the disturbances, the structural form is solved for the jointly dependent variables to obtain the reduced form. Having estimated the B's and γ's, the $\hat{\Pi}$ is derived from $\hat{\Pi}=-B^{-1}\,\Gamma$ and the reduced form from $Y=\hat{\Pi}Z$.

The derived reduced form estimates, incorporating restrictions, are more efficient—at least asymptotically—than the unrestricted estimates [5, p. 365]. The reduced form of the system is given in Table IV. The impact of a unit change in the j^{th} exogenous variable during a given time-period on the i^{th} endogenous variable during the same period is called the impact multiplier and is given by

$$\frac{\partial Y_i(t)}{\partial Z_j(t)}=\Pi_{ij}\,.$$

The impact of a change in personal disposable income on the jointly determined variables of the system is given by Π_{i1}. An increase in income (Z_1) is positively associated with all the jointly determined variables except peanut oil demand for exports. A 1 per cent increase in income will increase the liquid demand for peanut, sesame, and mustard oils by 2.02, 0.16, and 1.48 per cent, respectively. With respect to industrial demand, the largest increase will occur for cottonseed oil (1.23), followed by peanut oil (0.60) and sesame oil (0.14). The export demand of peanut oil will decline by 1.9 per cent. The largest increase in prices will occur for cottonseed oil (3.16) followed by mustard oil (2.19), sesame oil (1.64), and peanut oil (1.19). The impact of a change in

TABLE

THE ESTIMATES OF THE REDUCED

Endogenous Variables \ Predetermined Variables	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6
Y_1	2.0177	1.1942	0.0677	0.0004	−0.0104	0.2609
Y_2	0.5989	2.7824	0.2681	0.0016	−0.0411	0.3176
Y_3	−1.9063	−2.8972	0.0253	−0.0057	0.1486	−0.4215
Y_4	1.1879	1.8052	0.6039	0.0035	−0.0926	0.2627
Y_5	0.1603	−0.9315	0.0554	0.0003	−0.0085	−0.2320
Y_6	0.1427	1.7661	0.0805	0.0005	−0.0124	−0.0091
Y_7	1.6414	4.5213	0.7365	0.0043	−0.1129	0.8617
Y_8	1.4758	1.4655	0.2706	0.0016	−0.0415	0.2709
Y_9	2.1905	2.1753	0.4017	0.0023	−0.0616	0.4022
Y_{10}	1.2306	4.6342	0.5856	0.0034	−0.0898	0.4761
Y_{11}	3.1579	11.8917	1.5027	0.0088	−0.2304	1.2218

TABLE

THE EFFECT OF SPECIFIED CHANGES ON THE

Change	Price (Rs. per Metric Ton)				
	Peanut Oil	Sesame Oil	Mustard Oil	Cottonseed Oil	Peanut Oil
A	85.47	155.11	185.97	197.37	57.70
B	129.88	427.26	184.68	743.23	34.15

Note: A is the 5 per cent change in income. B is the 5 per cent change in vanaspati price.

vanaspati price (Z_2) is given by Π_{i2}. An increase in the price of vanaspati is positively associated with all the endogenous variables except the export demand of peanut oil and liquid demand for sesame oil.

Table V provides the adjustments of the endogenous variables to hypothetical changes in income and vanaspati price. These results indicate that if the total personal income increases by 5 per cent annually, the total demand for vegetable oils will increase at an annual rate of 97,000 metric tons: 85,000 metric tons for liquid oil consumption and 12,000 metric tons for vanaspati production. The exports will decline by 7,000 metric tons annually. On the other hand, a 5 per cent increase in vanaspati price will increase the total demand for vegetable oils by 116,000 metric tons: 60,000 metric tons for liquid oil consumption and 56,000 metric tons for industrial consumption. The exports will decline by over 10,000 metric tons. More hypothetical situations could be set up and their impact traced through the system.

VI. SUMMARY AND CONCLUSIONS

The main objectives of this research were to acquire the knowledge of the

IV

FORM OF THE SYSTEM

Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	
0.1178	0.0431	–0.0996	–0.0262	0.0161	0.0595	–0.4443
0.1434	0.0198	–0.0458	–0.0621	0.0382	0.2358	–3.6101
–0.1903	–0.0458	0.1059	0.0644	–0.0396	0.0223	3.6606
0.1186	0.0285	–0.0660	–0.0401	0.0246	0.5311	–1.9411
–0.1047	0.0077	–0.0179	0.0203	–0.0125	0.0487	0.2581
–0.0041	0.0022	–0.0052	–0.0387	0.0238	0.0708	–1.3968
0.3890	0.0540	–0.1248	–0.0996	0.0612	0.6476	–1.3469
0.1223	–0.0253	0.0584	–0.0323	0.0199	0.2380	–0.7023
0.1815	0.1377	–0.3183	–0.0480	0.0295	0.3533	–0.6700
0.2149	0.0355	–0.0821	0.0372	–0.0229	0.5149	–11.9453
0.5515	0.0911	–0.2107	–0.5484	0.3371	1.3214	–15.1610

V

ENDOGENOUS VARIABLES OF THE SYSTEM

Liquid Demand (1,000 Metric Tons)		Industrial Demand (1,000 Metric Tons)			Export Demand (1,000 Metric Tons)
Sesame Oil	Mustard Oil	Peanut Oil	Sesame Oil	Cottonseed Oil	Peanut Oil
0.88	26.56	10.60	0.28	0.92	–6.77
–5.12	26.38	49.25	3.18	3.45	–10.29

structure of the vegetable oil industry that will help in decision-making relative to public and private policies. Economic models were built to provide the estimates of the parameters. They were based on economic theory, assumptions, and observations relative to the particular sector.

The models provide insight into some of the aggregate relationships in the vegetable oil industry and also provide a useful foundation for comparing alternative specifications and statistical techniques. The models performed adequately in terms of predicting within the time space of the data.

The results of demand and supply analysis indicate that both demand and supply, with the exception of peanut oil exports, are price inelastic. Income coefficients (with the exception of sesame oil) were three to four times larger compared to direct price elasticities, implying that liquid consumption of vegetable oils is more responsive to changes in income than to changes in prices. The results of demand analysis show a differential price effect on various uses. The estimated demand by households is relatively more price elastic as compared to industrial demand. This seems realistic because the higher prices of oil used as an intermediate can be passed to the consumer within limits. The tentative findings of Hindustan Lever [10] lend credibility to the estimates. The study shows that, in the past, industrial demands for vegetable oils have fluctuated almost independently of prices, showing a relative inelasticity with respect to prices. The relative elasticity of demand for vegetable oils by households can manifest itself in two ways. When prices rise, some households may curtail their consumption of oil; alternatively among the poor classes, oil may disappear from the diet. The results in times of short supply of oils, the sufferer will be the low income householder. Distribution through prices may not be the most equitable way of allocating scarce supplies where most of the householders live around the poverty line.

It should be noted that the entire vegetable oil industry is large and complex. The ties with other sectors are manifold and the number of exogenous variables is high even for relatively simple systems. An ideal model might be a complete Walrasian framework which would include all demand, supply, and spatial components. A willingness to settle for something slightly less grandiose led to a model designed to estimate only some of the most important demand and supply relationships.

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