ECONOMIC REPORT 78-8 OCTOBER 1978

MARKET SHARE ANALYSIS AND THE INTERNATIONAL MARKET FOR FATS AND OILS

By

James P. Houck and Mary E. Ryan

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

MARKET SHARE ANALYSIS AND THE INTERNATIONAL MARKET FOR FATS AND OILS

by

James P. Houck and Mary E. Ryan

October 1978

Department of Agricultural and Applied Economics

University of Minnesota

The research reported here is part of a joint project between the U.S. Department of Agriculture (USDA) and the University of Minnesota. The Forecast Support Group in the Commodity Economics Division of the Economics, Statistics and Cooperatives Service, USDA, provided both financial assistance and technical advice. The work was done in the Department of Agricultural and Applied Economics at the University of Minnesota with additional financial support from the University's Agricultural Experiment Station.

TABLE OF CONTENTS

MARKET SHARE ANALYSIS AND THE INTERNATIONAL
MARKET FOR FATS AND OILS

by

James P. Houck and Mary E. Ryan*

I. Introduction

Economic analysis in the international fats and oils sector always has been difficult. Actual and potential substitution among the various commodities in their end uses is a major cause of this difficulty. In addition, many leading fats and oils in world trade are produced as joint products with oilseed meals, meat, and dairy products. These links with other markets also add complexity to virtually any analysis of the fats and oils sector. (A representative selection of previous research studies is included in the References section.)

This study examines some of the economic relations in the fats and oils market from the standpoint of market shares and relative prices. There are two major purposes behind this effort. The first is to shed some new light on the demand and price-making forces at work in this sector. The second is to present and employ a particular line of methodology involving the analysis of market shares among highly substitutable commodities.

The following section of this paper is devoted to a fairly brief discussion of the basic analytical techniques to be employed in the empirical analysis. Then in the next section, market share and relative price concepts are applied to the fats and oils market.

---

*The authors are professor and associate professor respectively in the Department of Agricultural and Applied Economics, University of Minnesota. Helpful assistance and suggestions were offered by colleagues John Spriggs and Glenn Nelson. The usual disclaimers apply.

II. Market Share Analysis and the Form of Demand Functions

The basic line of argument developed in this section was suggested by a 1974 article in Econometrica written by J. Case. That presentation was generally theoretical and did not focus upon the development of statistically estimable functions. Market equilibrium and general market-clearing conditions were stressed. However, the market share demand functions and the role of relative prices used in this study clearly trace back to Case's work.

The Simple Two-Product Market

Consider a market in which two substitute products are sold. Let them be Q_1 and Q_2, and let their respective market shares be D_1 and D_2. The market share functions proposed by J. Case (hereafter called the "Case functions") are

$$(1) \qquad \begin{aligned} D_1 &= [1 + (p_1/mp_2)^{\alpha}]^{-1} \\ D_2 &= [1 + (mp_2/p_1)^{\alpha}]^{-1} \end{aligned}$$

where p_1 and p_2 are the prices of Q_1 and Q_2 and m and α are functional parameters. Equations (1) result from algebraic simplification of an underlying logistic demand function (Case). It is not difficult to show that when the prices and m are positive, $D_1 + D_2 = 1$ with both D_1 and D_2 being positive and less than 1.0. Notice that the market shares depend only on the price ratios and the parameters. As the price ratio approaches zero, the market share of the product whose price is in the ratio numerator approaches 1 and the other's share approaches 0.

Figure 1 illustrates the nature of a two-commodity market share demand curve. The curve passes through +1.0 on the horizontal axis and approaches the vertical axis asymptotically. Its position in the quadrant is determined by m and its slope by α and m together.

The value m is a scaling parameter which in some sense reflects consumer preferences between Q_1 and Q_2 as well as the nature of the substitutability between them. Notice that when $p_1 = mp_2$, the market is equally split between Q_1 and Q_2. Thus, m is a parameter which, apart

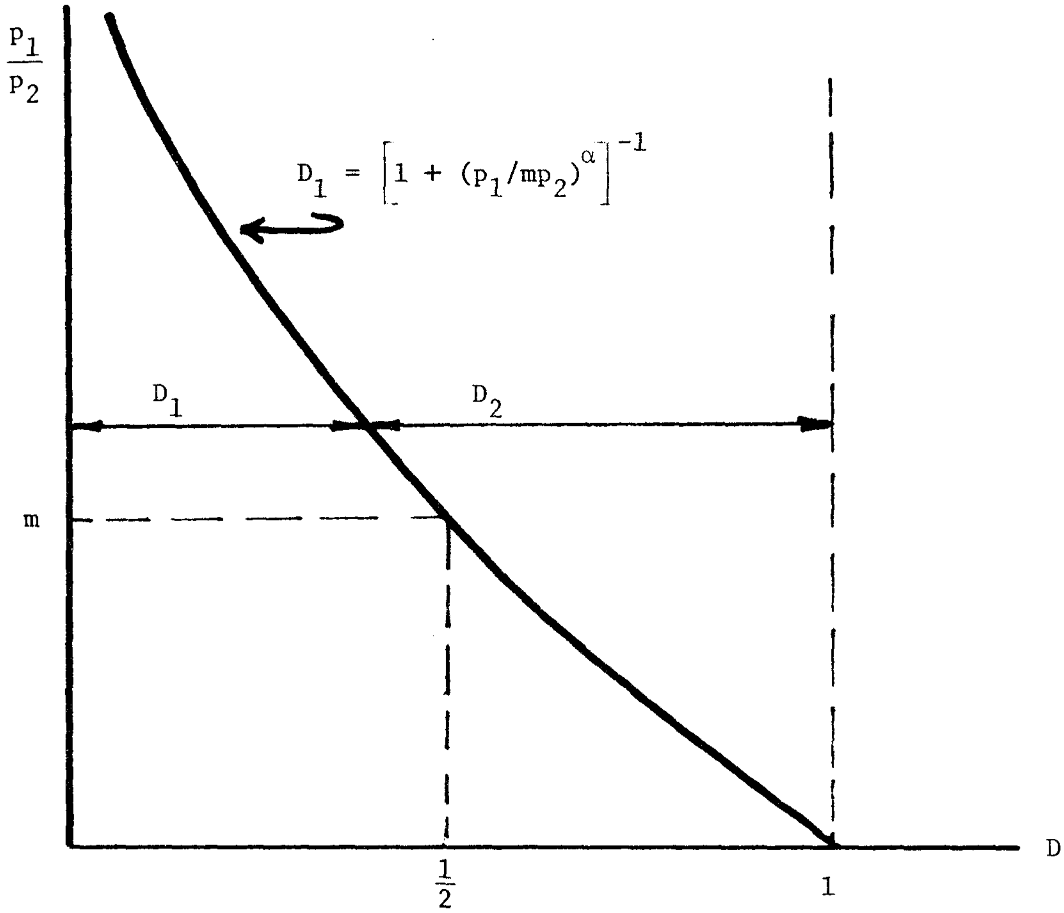


Figure 1

from units of measure, reflects the interchangeability of the two products in an economic context. The closer m is to +1.0, the more alike are Q_1 and Q_2 in end use.

The parameter α reflects the overall sensitivity of the market shares to changes in the price ratio. The slope of the market share demand curve, D_1, is proportional to α. In general, the algebraic expression of this slope is complex, but in the neighborhood where $p_1 = mp_2$ it becomes

(2) $$\frac{\partial D_1}{\partial (p_1/p_2)} = \frac{-\alpha}{4m} \qquad \text{(when } p_1 = mp_2\text{)}$$

The price elasticity of D_1 with respect to p_1 at any point along the market share curve is given by

(3) $$\eta_{11} = \frac{\partial D_1}{\partial p_1}\left(\frac{p_1}{D_1}\right) = -\alpha(1 - D_1) = -\alpha D_2$$

The similar cross elasticity of D_1 with respect to p_2 is

(4) $$\eta_{12} = \frac{\partial D_1}{\partial p_2}\left(\frac{p_2}{D_1}\right) = +\alpha(1 - D_1) = +\alpha D_2$$

The routine algebra of deriving these elasticities (not shown) is simplified by noting that the original expression of D_1 in equations (1) can be rearranged as follows:

(5) $$D_1(p_1/mp_2)^{\alpha} = 1 - D_1 = D_2$$

This equation allows the market share elasticities to be written as simple expressions of α and D_1 or D_2.

These market share equations are non-linear in the parameters. Moreover, there is no simple transformation that will make them linear for estimation purposes. However, a somewhat indirect procedure can be employed to generate estimating equations which are linear in m and α. First, re-write equation (5) as

(6) $$\frac{D_1}{D_2} = (mp_2/p_1)^{\alpha}$$

Next take the logarithm of equation (6).

(7) $$\log (D_1/D_2) = \alpha \log (m) + \alpha \log (p_2/p_1)$$

Equation (7) together with stochastic properties can be used as an estimating function with linear techniques such as ordinary least squares (OLS). With data on market shares and price ratios for Q_1 and Q_2, estimates of α and m can, in principle, be obtained when prices are given. Then estimates of market share elasticities and perhaps predictions of market share behavior can be calculated. In addition, there is no reason why equation (7) could not be rearranged so as to express the price ratio as a function of the market shares, much as traditional price-dependent demand curves are specified when quantities are given.

Equation (7) is similar in form to the estimating equations developed for measuring elasticities of substitution in international trade (Hickman and Lau, Leamer and Stern, Morrissett, Richardson, Johnson, and others). Measurements of this type flow from very special implicit elasticity constraints on ordinary demand functions of the products in question. For the market share analysis of this study, equation (7) follows directly from the particular logistic form assumed by equations (1) without further constraints.

Market Shares and Many Products

The simple two-product market share model extends readily to multiple commodities. The market share relation for the ith product in an n-product setting is

(8) $$D_i = [(m_i\ p_i/m_1\ p_1)^{\alpha} + (m_i\ p_i/m_2\ p_2)^{\alpha} + \ .\ .\ . + 1 + (m_i\ p_i/m_n\ p_n)^{\alpha}]^{-1} \qquad (i = 1, 2, \ldots n)$$

or $$D_i = \left[\sum_{j=1}^{n} (m_i p_i / m_j p_j)^{\alpha} \right]^{-1}$$

The same basic properties hold as with the simple Case function, but the presence of many products requires that the single m parameter of equations (1) be replaced with multiple m's, each attached to an individual product. Note that α remains a single parameter in this general expression.

The market share price elasticities for the multiple-product case can be rather easily derived. The direct price elasticity is

$$\eta_{ii} = -\alpha(1 - D_i) \tag{9}$$

and the cross elasticity is

$$\eta_{ij} = +\alpha(D_j) \tag{10}$$

Hence, equations (3) and (4) are clearly special cases of these more general elasticity expressions.

As with the two-product case, the path to a linear estimating function is somewhat indirect. Let the ratios of the various m_i's be denoted as follows:

$$m_i/m_j = c_{ij}$$

which implies

$$c_{ji} = 1/c_{ij}$$

Since the m's always appear in ratios, nothing is lost by this substitution. Now equation (8) can be rewritten as

$$D_i = \left[\sum_{j=1}^{n} [c_{ij}(p_i/p_j)]^{\alpha} \right]^{-1} \tag{11}$$

Consider any product in the group other than that indicated by i, say the one denoted by k. Form the expression $[c_{ik}(p_i/p_k)]^{\alpha}$ and multiply both sides of equation (11) by it.

(12) $$D_i[c_{ik}(p_i/p_k)]^{\alpha} = \left[\frac{[c_{ik}(p_i/p_k)]}{\sum_{j=1}^{n} [c_{ij}(p_i/p_j)]}\right]^{\alpha}$$

Simplify the right-hand side by dividing the denominator by the numerator and noting that $c_{ij}/c_{ik} = c_{kj}$. The result is

(13) $$D_i[c_{ik}(p_i/p_k)]^{\alpha} = \left[\sum_{j=1}^{n} [c_{kj}(p_k/p_j)]^{\alpha}\right]^{-1} = D_k$$

or, slightly rearranged,

(14) $$\frac{D_i}{D_k} = [c_{ki}(p_k/p_i)]^{\alpha}$$

This equation shows that the ratio of any two market shares can be expressed as a function of the price ratio of only those two products--no other prices are involved.

The logarithm of equation (14) provides a linear estimating equation which corresponds exactly with the simple two-good case of equation (7)

(15) $$\log (D_i/D_k) = \alpha \log c_{ki} + \alpha \log (p_k/p_i)$$

As with the two-good case, estimates of the parameters (α and c_{ki}) may be calculated with ordinary linear estimation methods.

Notice that the parameter α appears in the estimating equation no matter which two products are considered as i and k. The constant term, however, contains c_{ki} and will be sensitive to the commodities being studied. This feature has at least two implications for statistical work. First, data on market shares and price ratios can be pooled across many pairs of competing products for the purpose of estimating α. Second, the estimates of α from various groupings and pairings of commodities could be tested for equality. Such a procedure might help in the classification of commodities into closely competing groups within which the market share principle is likely to operate. The empirical work reported later in this report employs both of these ideas.

Introducing Other Shift Variables

The addition of additional variables which might influence market shares among products can be readily accommodated *via* the c_{ki} parameter in equation (15). This parameter presumably reflects the attitudes and tastes of buyers. Hence it is plausible that variables such as income, prices of goods outside the group, trend and other factors could systematically affect the various c's.

A direct way to introduce other variables is in a constant elasticity fashion. Consider some variable X which is hypothesized to influence c_{ki} of equation (15)

(16) $$c_{ki} = r_{ki}\ (X)^{b_{ki}}$$

Then

(17) $$\log c_{ki} = \log r_{ki} + b_{ki} \log X$$

Inserting (17) into (15), the estimating equation becomes

(18) $$\log (D_i/D_k) = \alpha \log r_{ki} + \alpha b_{ki} \log (X) + \alpha \log (p_k/p_i)$$

Then, in principle, linear estimates of α, b_{ki}, and r_{ki} can be computed without much difficulty. Clearly, more than one shift variable could be added in multiplicative fashion to equation (16). The logarithmic expressions of equations (17) and (18) will simply have more additive terms in, say, X_1, X_2, X_3, *etc*.

Since $c_{ji} = 1/c_{ij}$, the following relations hold among the shift variables' parameters:

(19) $$r_{ji} = 1/r_{ij}$$

$$b_{ji} = -b_{ij}$$

Unfortunately, a simple expression for the market share elasticity of X does not exist. This elasticity involves the parameter α and a complex weighted average of the b_{ij}'s associated with X.

III. Market Share Analysis with World Fats and Oils Trade

The market share methodology described in the previous section was used in an empirical analysis of the world market for edible fats and oils. The main objectives were (1) to see if the market share analysis technique is a tenable method for measuring economic relationships among edible oils, and (2) to use the estimates to predict market behavior.

A focal point of this analysis is the role and position of soybean oil in the world market. Specifically, all of this market share work compares soybean oil with the other oils, individually and in various groupings. This is because soybean oil is by far the leading edible oil in world trade, because the United States is the world leader in the production and marketing of soybeans and their products, and because economic analysis of soybean oil exports has always been difficult with more customary techniques. But before statistical estimates of the market share equations are presented and discussed, a brief overview of the relevant market is presented.

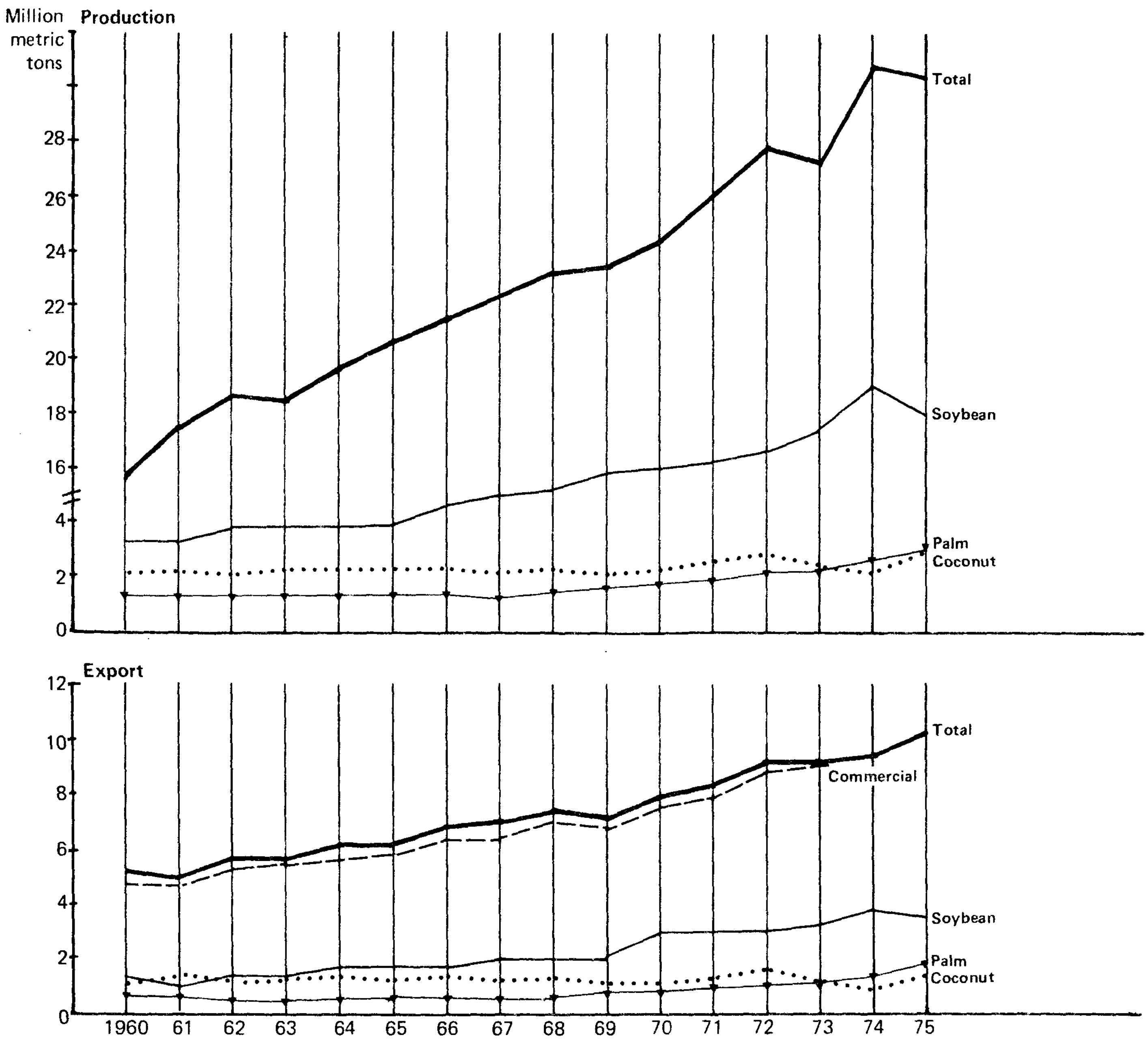
Fats and Oils Market

Soybean oil is a major component of the world edible vegetable oil sector. This sector includes oils from annual crops, palm oils, and the oil equivalent of oilseed and palm products. In turn, these products have links with the edible animal fats, mainly butter and lard.

World production and exports of edible vegetable oils grew at annual rates of approximately 3 percent and 5 percent respectively in the 1960-75 period. Except for production downturns in 1963, 1973 and 1975 and export dips in 1961 and 1969, growth was quite steady.

Figure 2 shows world vegetable oil production and exports together

Figure 2. World vegetable oil production and exports, 1960-75.



with exports of the three main export commodities. Production variability in the 1970's is in marked contrast to earlier years, and this variation is not reflected by exports. Moreover, export patterns are relatively more variable for individual oils than for the aggregate. One measure of the differences among oil export markets is their annual growth rates. For 1960-75, annual growth rates for exports of some major edible oils were

Oil	Export growth rate
rapeseed	17%
sunflower seed	8
soybean	8
palm	7
cottonseed	2
coconut	0
groundnut	-2

This lack of similarity suggests that the factors affecting their markets differ.

The dashed line in figure 2 beneath aggregate exports reflects total commercial exports. It excludes U.S. concessional soybean and cottonseed oil shipments under Public Law 480. Growth of commercial oils exports seem slightly smoother than the total. This is because concessional exports are chiefly policy-determined. As such they need not bear any stable relationship to the determinants of commercial exports.

Overall 30 percent of vegetable oil production is exported. Among commodities, however, there is considerable variation. Close to one-half of soybean oil, coconut oil, and palm oil production are exported either as oil or oil equivalent. Hence changes in international conditions will affect producers of these commodities to the extent that open markets operate. These three commodities accounted for half of world edible vegetable oil exports in 1975.

The remaining vegetable oils considered in this analysis are consumed heavily in the producing nations where internal determinants of supply and demand are very important. Nonetheless, when production short-falls or very high prices occur for a commodity, large purchases of other oils often are made on the international market to fill the gap. Then the world market is affected. Percentage shares of world exports by commodity are given in table 1. Of that total, 56 percent was exported as oil and 44 percent as oilseeds.

Table 2 presents production and export data for the major vegetable food oils in 1955, 1965, and 1975 including the main competing animal fats, butter and lard. While soybean oil production exceeded that of the other vegetable oils in each of the three decades, its dominance is especially notable in 1975. Most significant changes among the other oils were a relative decline in coconut oil production and a relative gain in sunflower seed oil output.

Some export oils, coconut, cottonseed, peanut (groundnut), and olive, have slipped in relative importance in the past two decades. Although their production expanded, a greater share was utilized domestically in 1975 than earlier.

While aggregate production and exports were expanding rather evenly during 1960-75, there was no discernible trend in an overall index of international vegetable oil prices, in constant dollar terms, figure 3. After a peak in 1974, this index fell back into the range of earlier years. The absence of a long-term trend in prices suggests that aggregate supply and demand for vegetable oils have grown at about the same rates since the early 1960's.

Current prices of the three major export oils also are shown in figure 3. Relative prices vary from year to year, yet the general patterns are similar to one another and to the overall index in current prices. Simple correlation coefficients (r) between pairs of various fat and oil prices are given in table 3. They suggest significant substitutability among most oils. Of those listed, only prices of coconut oil and butter indicate especially unique qualities _via_ their correlation coefficients. The graph of butter prices in figure 3 clearly shows this commodity's individuality.

In sum, this overview of the international vegetable oil market highlights five characteristics.

1) The international vegetable oil market is composed of many closely related commodities.

Table 1. Percentage shares of world vegetable oil exports by commodity, average for 1972-74[a/]

	Percent
Soybeans (oil equivalent)[b/]	26
Soybean oil	12
Palm oil	14
Copra (oil equivalent)	5
Coconut oil	7
Sunflower seed (oil equivalent)	2
Sunflower seed oil	7
Rapeseed (oil equivalent)	6
Rapeseed oil	3
Peanut (oil equivalent)	3
Peanut oil	4
Cottonseed (oil equivalent)	c/
Cottonseed oil	3
Olive oil	3
Others[d/]	5
Total	100

[a/] In total about 15% of the oil equivalent of oilseed exports is re-exported as oil. Re-exports were not separated out for these computations.

[b/] Oil equivalent means the amount of oil contained in the product, e.g. the oil content of whole soybean exports.

[c/] less than 0.5%.

[d/] Includes palm kernel and palm kernel oil, sesame seeds, safflower seed and oil, corn oil and babassu kernels and oil.

Source: Food and Agriculture Organization of the United Nations

Table 2. World production and exports of fats and oils in 1955, 1965 and 1975
(in thousand metric tons, fat or oil equivalent)

Fat or oil	Production			Exports			Exports as a percentage of production		
	1955	1965	1975	1955	1965	1975	1955	1965	1975
soybean	2291	3934	8313	635	1769	3535	28	45	43
palm	1234	1257	2942	539	550	1773	44	44	60
coconut	2023	2180	2868	1240	1288	1544	61	59	54
sunflower seed	785	3134	3980	77	407	705	10	13	18
rapeseed	1098	1496	2609	43	286	615	4	19	24
peanut	1846	3364	3057	835	993	705	45	30	23
cottonseed	1882	2747	3294	358	411	415	19	15	13
olive	984	1004	1419	56	52	40	6	5	3
total vegetable[a/] (incl. palm)	13,216	20,646	30,215	4,227	6,293	9,902	32	30	33
butter	3511	4211	4544	454	537	758	13	13	17
lard	3152	3884	4424	356	317	516	11	8	12
total fats[b/] and oils	24,640	35,331	46,242	7,078	9,873	13,677	29	28	30

[a/] includes other oilseed and palm oils not listed

[b/] includes other oilseed, palm, marine and industrial oils and animal fats not listed

Source: USDA

Figure 3. Vegetable oil price index and prices of selective export fats and oils, 1960-75.

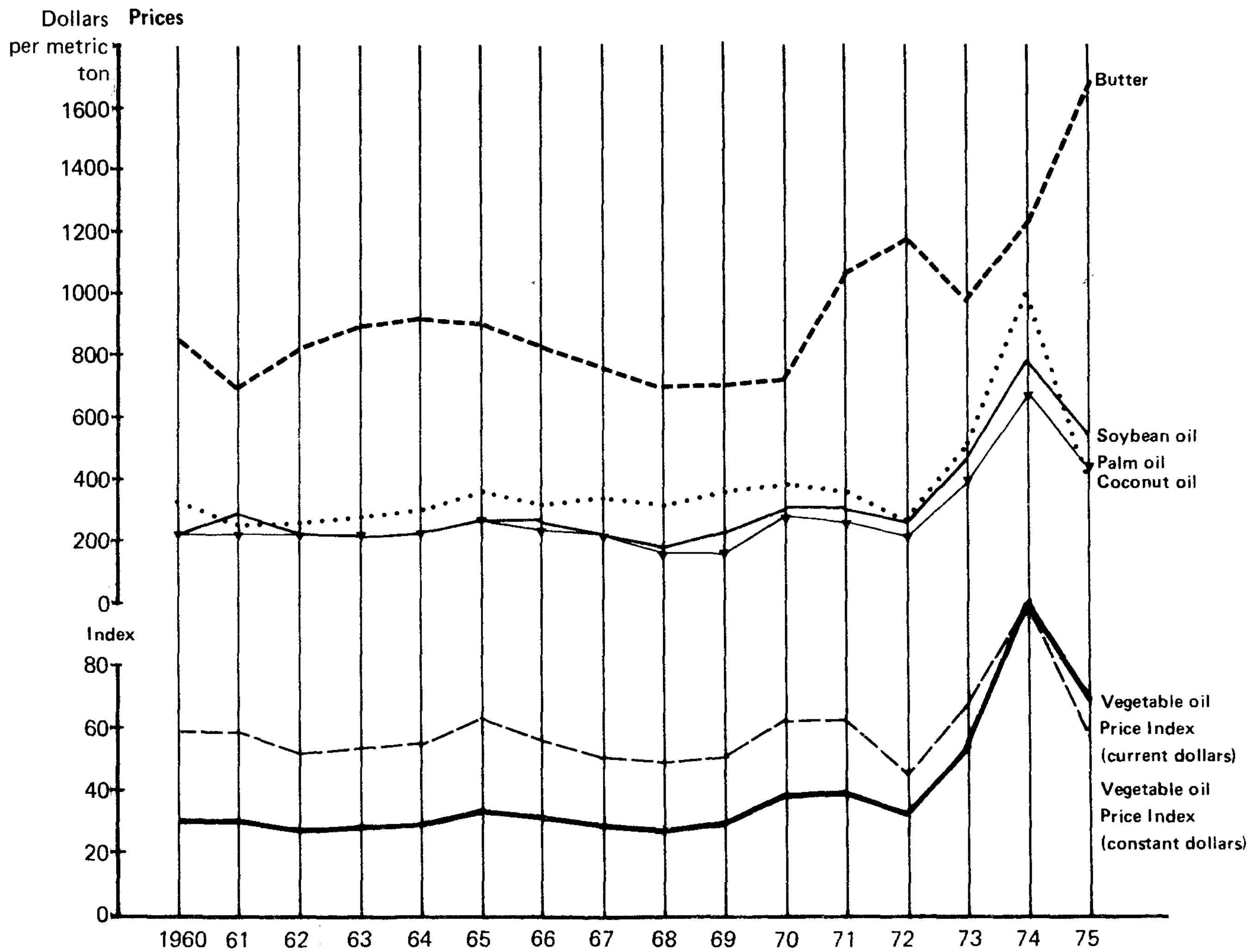


Table 3. Correlation coefficients (r) between selected fats and oils prices, annual 1960-75

	Soybean	Palm	Coconut	Sunflower seed	Rape-seed	Peanut	Cotton-seed	Olive	Butter	Lard
Vegetable oil price index	99	98	91	99	98	98	98	90	66	98
Soybean		97	90	98	98	97	97	90	64	98
Palm			92	96	97	94	94	84	60	97
Coconut				85	88	84	84	68	35	85
Sunflower seed					99	99	99	92	72	98
Rapeseed						97	97	88	65	97
Peanut							98	93	77	97
Cottonseed								93	71	95
Olive									85	90
Butter										72

2) Price movements are broadly similar among numerous products reflecting their substitutability.

3) Yearly changes in production, exports, and market shares differ by commodity.

4) Aggregate production and exports have grown steadily through time.

5) The rates of growth for aggregate supply and demand have been close enough to keep oil prices in the aggregate from any dramatic secular movement.

Statistical Analysis

Market share analysis suggested by the Case method was conducted for international trade in soybean oil and nine other fats and oils: palm, cottonseed, groundnut, sunflower seed, rapeseed, olive, and coconut oils, plus butter and lard. Other fats and oils were excluded because of their relatively minor roles in international trade. The basic estimating equation is shown below.

$$(20) \quad \log (D_i/D_k) = \alpha \log r_{ki} + \alpha b_{ki} \log (X) + \alpha \log (P_k/P_i) + e_{ik}$$

$$(i, k, = 1, 2 \ldots 9)$$
$$(i \neq k)$$

This is the same as equation (18) except that stochastic properties, denoted by e_{ik}, have been added. The error term, e_{ik}, is assumed to be a mean-zero, random variable with finite variance. The variable X denotes the possible use of one or more shifters of the simple market share function based only on price ratios, as equation (15).

The basic analytical premise is that there exist aggregate market share demand functions of the Case form for international trade in the specified fats and oils. To use ordinary least squares in the estimation process is to assume that price ratios and other factors are independent variables and that the market share ratios are dependent upon them. Obviously, this is a considerable simplification of the economic forces at work. No doubt market shares and prices are simultaneously determined. But this single equation application is designed to be a preliminary step to more comprehensive analyses. The goal is to see if these market share methods have a potential role to play in such analyses even at the expense of some possible bias in the estimates at this time. In any case, the simple predictive value of these estimates may be useful.

The analysis used annual data for 1960-75. The basic price and export quantity data are from official USDA publications. The prices from which the various price ratios are formed are specific average price quotations at important international trading locations.

A Single Group. To begin the investigation all 10 products were assumed to constitute a single group within which international export market shares are determined. Each price ratio included soybean oil price in the denominator, and each market share ratio contained soybean oil's share in the numerator. Thus, with 16 years of data (1960-75) the 9 ratios provided 144 observations. Data are in appendix B.

Since the α is constant across commodity pairs within a market group, all 144 observations can be used to estimate α within a covariance-regression framework. Zero-one variables were employed to permit individual estimation of the constant terms in equation (20). Moreover, a linear trend was included as a shifter (X) to allow for secular change, its estimated coefficient being permitted to vary across commodity pairs.

About 91 percent of the variation in market share ratios of the nine commodity pairs across 16 years can be explained by variations in price ratios, intercepts, and trend. The estimate of α is 0.511 with a t-value of 3.56. The market-share price elasticities of the ten fats and oils, considered as a single group, are listed below. They are calculated as in equation (9), using 1975 data for the appropriate D_i's.

Since the dependent variable observations are ratios of soybean oil exports to exports of each of the nine other fats and oils, the estimated trends (net of price effects) are of some interest. Soybean oil gained in market share relative to six of the nine other oils. This is reflected in six positive and highly significant trend coefficients. The positive trend estimate with palm oil was only slightly larger than

Oil	Market share price elasticity	Trend coefficient*
Soybean oil	-.35	--
Peanut oil	-.49	+.46
Cottonseed oil	-.50	+.31
Sunflower seed oil	-.49	-.14
Rapeseed oil	-.49	-.57
Coconut oil	-.45	+.46
Olive oil	-.52	+.27
Palm oil	-.44	+.10
Butter	-.49	+.25
Lard	-.50	+.36

*Trend of soybean oil's share relative to the given product.

its estimated standard error. The two negative trend coefficients indicate falling soybean oil trade relative to sunflower seed oil and rapeseed oil. The latter was highly significant, and the former only marginally so.

These results seem plausible and the strong explanatory power of the estimated equation was appealing. However, when the estimated market share ratios of the individual commodity pairs were plotted and compared with actual values, some of the original satisfaction with the method evaporated. The trends and intercept shifts across commodity pairs account for much of the high R^2 (.91) previously mentioned. Although the estimated price ratio coefficient (α) is significant at beyond the 1 percent level, much of the year-to-year fluctuation in individual market share ratios was not accounted for by the equation. Consequently, some further work was done to further segment the original ten-commodity group.

Forming Subgroups. If the ten fats and oils truly form a group whose market share demand function is of the Case type, then separate unconstrained estimates of α with the nine-commodity pairs should be similar to one another. To check this idea, the nine equations of the previous section were re-estimated by least squares allowing α to vary across the equations. (Recall that each of these equations contains soybean oil prices and market shares as part of the price and quantity ratios.)

Although the constrained estimate of α was +0.511 with a t-value of 3.56, the unconstrained estimates of α varied from a non-significant +.06 for butter/soybean oil to a highly significant +3.15 for sunflower seed/soybean oil. Moreover, the explanatory power of the nine separate equations ranged from R^2 = 0.37 with sunflower seed/soybean oil to R^2 = 0.81 with rapeseed/soybean oil. Consequently, it seemed reasonable to consider further sub-groupings of the 9 commodities as they relate to soybean oil.

The links between soybean oil and the other products seem to fall into three main categories on physical or technical grounds. The first is the relation between soybean oil and the saturated (solid at room temperature) fats; these are butter, lard, and coconut oil. The second involves relationships with five liquid, edible vegetable oils; these are peanut, cottonseed, palm, sunflower seed, and rapeseed oils. The third is the relation with the highly unique olive oil.

These technical categories also tended to be reflected in the various estimates of α calculated with unconstrained equations. The α values involving butter, lard, and coconut oil in relation to soybean oil were quite small, positive, and not significantly different from zero. The others were generally significant and ranged between +0.65 and +3.51.

Market Share Analysis with Subgroups. One of the attractive features of the Case demand function is that market shares, prices, and other variables can be analyzed for a number of substitute products with very few estimated parameters. What advantage is to be gained by forming sub-groups from an original set of substitute products? Furthermore, what interpretations can be drawn from analysis of subgroupings formed in relation to a single, "reference" commodity, in this case soybean oil?

The main advantage in forming subgroups with potentially different values for α is to analyze and predict year-to-year changes in market shares more accurately than might be possible with a single coefficient across all commodity pair price ratios. Soybean oil is the "reference" product for three reasons: (1) it is the largest single oil in world commerce, (2) it is the most important to U.S. agricultural trade, and (3) its technical and economic properties permit it to be substituted for other fats and oils to at least as great an extent as any other commodity in this group.

This part of the empirical analysis, therefore, focuses on how soybean oil competes in three sub-markets within the overall fats and oils group. An analogy might be helpful in visualizing this market share competition. Consider a large manufacturer of a nationally-distributed brand of some product, say, beer. The manufacturer wishes to assess the market share position of that brand relative to local competition in each of several geographic regions and within the context of regional demand conditions. The analysis of various regional Case demand functions could proceed using the national brand of beer as the reference product in the price and market share ratios for each region. Because market share ratios are used, any collection of two or more products from the original set can be used as a subgroup. The principle for forming the subgroups might be geographic, technical, or perhaps some other source of distinction.

Empirical Results with Subgroups. Recall that three subgroups were formed on technical grounds with respect to their relation with soybean oil.

1. Saturated fats: butter, lard, and coconut oil
2. Liquid vegetable oils: peanut, cottonseed, palm, sunflower seed, and rapeseed oils
3. Olive oil

In preliminary work with each of these subgroups, a few shift variables (X's) also were introduced into the function to sharpen the analysis. Natural logarithms were used throughout. The "best" equations for each subgroup follow. Graphic results are in appendix A.

The estimated function for the saturated fats in group 1 is shown in table 4. The estimate of α across this subgroup is +0.27. Its t-value of 2.4 suggests statistical significance.

Exports of U.S. soybean oil under P.L. 480 are determined administratively and have a significantly positive effect on soybean oil's

Table 4. Market share analysis for soybean oil exports relative to exports of saturated fats, coconut oil, butter, and lard, 1960-75

[Dependent variable = $\log(D_{soy}/D_i)$]

Independent variables	Coconut oil	Butter	Lard
	(regression coefficients with t-values in parentheses)		
$\log(P_i/P_{soy})$	--------------------	+0.27 (2.4)	---------------------
log(XPL)	--------------------	+0.19 (3.8)	---------------------
log(PM/PS)	NA	------- -0.36 (1.6)	---------
log(UP)	NA	NA	-1.11 (2.1)
T	NA	-0.05 (4.7)	+0.08 (7.9)
T^2	---------- +0.0059 (12.4)	-----------	NA

$\bar{R}^2$ = .95 (overall, 48 observations) t-values in parentheses

<u>Variables</u>

D_{soy}/D_i = Ratio of soybean oil export market share to export market share of product i.

P_i/P_{soy} = Price ratio of product i to soybean oil on world markets.

PM/PS = Price ratio of soybean meal to soybeans.

XPL = U.S. exports of soybean and cottonseed oils under Public Law 480.

UP = U.S. pork production.

T = Trend (1960 = 1, 1961 = 2, etc.).

NA = Not applicable.

market share relative to all three other products in this group. Preliminary analysis showed that the unconstrained estimates of this coefficient were similar for all three pairs, so they were formally constrained in this estimation.

In order to capture the cross effects of changes in the soybean meal markets, the price ratio of meal to beans was added as an independent explanatory variable. Its effect was negligible with coconut oil but marginally important with butter and lard relative to soybean oil. The higher the meal price relative to the total value of beans, the lower the estimated relative market share of soybean oil, other things unchanged. Since both oil and the oil equivalent of oilseeds enter into these market share variables, it is not clear whether this relation theoretically should be positive or negative. The negative relation is plausible since meal accounts for a much larger part of the total value of soybeans than is true with any other oilseed. Thus a high meal price, relative to oil, could reduce soybean purchases made mainly for the meal component.

Because lard is a fairly small portion of the total value of pork, the U.S. level of pork output was used to account for some of the fluctuation in lard market shares relative to soybean oil. The United States is a leading exporter of lard. As U.S. pork production increases the net effect on the soybean oil/lard ratio of market shares is negative as expected. The trend coefficients on T and T^2 account for other non-specified secular effects across the commodity pairs.

Table 5 contains the estimation results for the five liquid vegetable oils relative to soybean oil. The estimate of α is highly significant at +1.09 and is much larger than that for the saturated fat group. The export of vegetable oils (mainly soybean oil) under P.L. 480 had a positive but differential effect on the soybean oil market share relative to peanut and palm oils on one hand and sunflower seed oil on the other. The price ratio of soybean meal/soybeans influenced only the soybean oil/peanut oil market share in a significant way. As with the saturated fats, the trend coefficients on T and T^2 accounted for various non-specified secular effects across the commodity pairs in this group.

Table 5. Market share analysis for soybean oil exports relative to exports of liquid vegetable oils; peanut, cottonseed, sunflower seed, rapeseed and palm oils, 1960-75

[Dependent variable = $\log(D_{soy}/D_i)$]

Independent variables	Peanut oil	Palm oil	Cottonseed oil	Rapeseed oil	Sunflower seed oil
	(regression coefficients with t-values in parentheses)				
$\log(P_i/P_{soy})$	----------	----------	+1.09 (6.1)	----------	----------
log(XPL)	----- +0.9 (1.7)	-----	NA	NA	+0.41 (4.5)
log(PM/PS)	-0.58 (1.9)	NA	NA	NA	NA
T	----- +0.05 (7.2)	----	NA	--------	-0.27 (10.4) ----------
T^2	NA	-0.001 (2.3)	NA	0.011 (7.3)	0.017 (9.6)

$\bar{R}^2$ = .95 (overall, 80 observations)

Variables described in table 4

The price ratio of peanut oil to soybean oil was entered in the estimation only for the 1960-69 period.

The analysis of soybean oil exports relative to olive oil is summarized in table 6. Although the overall quality of this set of estimates is rather low, the estimated value of α is plausible at +.94 and relatively significant. Based on this estimate, it could be argued that for further work, olive oil could easily be included with the other liquid vegetable oils since the difference between +.94 and +1.09, the two estimates of α, is not statistically significant.

Market Share Price Elasticities. Using the calculations suggested by equation (9) for each of the three subgroups, market share price elasticities were calculated. They are shown in table 7. These estimates differ from those calculated earlier because (1) the values of α appropriate to each subgroup are different, (2) the market shares (D_i) differ because of the subgrouping, and (3) the estimating equations are somewhat more individually specified.

Each elasticity indicates the percent change in that product's subgroup market share as its price increases by 1 percent, holding all other prices and the additional specified variables constant.

IV. Concluding Comments

Market share demand functions, as suggested by J. Case, were employed as the basic analytical tool in this study of the international fats and oils sector. Statistically estimable equations were developed from the logistic form of the market share functions. The empirical application to fats and oils involved explaining variation in observed ratios of market shares by means of price ratios and other variables.

Estimates of market share functions and price elasticities were calculated for a 10-product group of internationally-traded fats and oils with emphasis on soybean oil. These results suggested segmentation of the original group into three sub-groups for further study. The three sub-groups involved the relative position of soybean oil with respect to saturated fats, liquid vegetable oils, and the unique olive oil. The statistical results from these preliminary models are plausible and suggest that this market share technique may be useful in more comprehensive studies of highly substitutable products.

Table 6. Market share analysis of soybean oil exports relative to olive oil exports, 1960-75

Independent variables	Regression coefficients with t-values in parentheses
$\log(P_i/P_{soy})$	+0.94 (2.3)
log(PM/PS)	-1.22 (1.6)
T	-0.02 (1.0)

$\bar{R}^2$ = .48 (16 observations)

Variables described in table 4.

Table 7. Market share price elasticities for the three subgroups, based on 1975 export shares

Item and subgroup	Elasticity $[-\alpha(1 - D_i)]$
Saturated fats and soybean oil	
Coconut oil	-.20
Butter	-.24
Lard	-.25
Soybean oil	-.12
Liquid vegetable oils	
Palm oil	-.83
Sunflower seed oil	-.99
Rapeseed oil	-1.00
Peanut oil	-.99
Cottonseed oil	-1.04
Soybean oil	-.59
Olive and soybean oils	
Olive oil	-.93
Soybean oil	-.01

APPENDIX A

Graphs of actual and estimated values of soybean oil's market shares, relative to competing fats and oils, 1960-75

Figure	Competing fats and oils
A-1	butter
A-2	lard
A-3	coconut
A-4	peanut
A-5	cottonseed
A-6	palm
A-7	sunflower seed
A-8	rapeseed
A-9	olive

Figure A-1. Ratio of soybean oil export market share to export market share of butter, actual and estimated values, 1960-75.

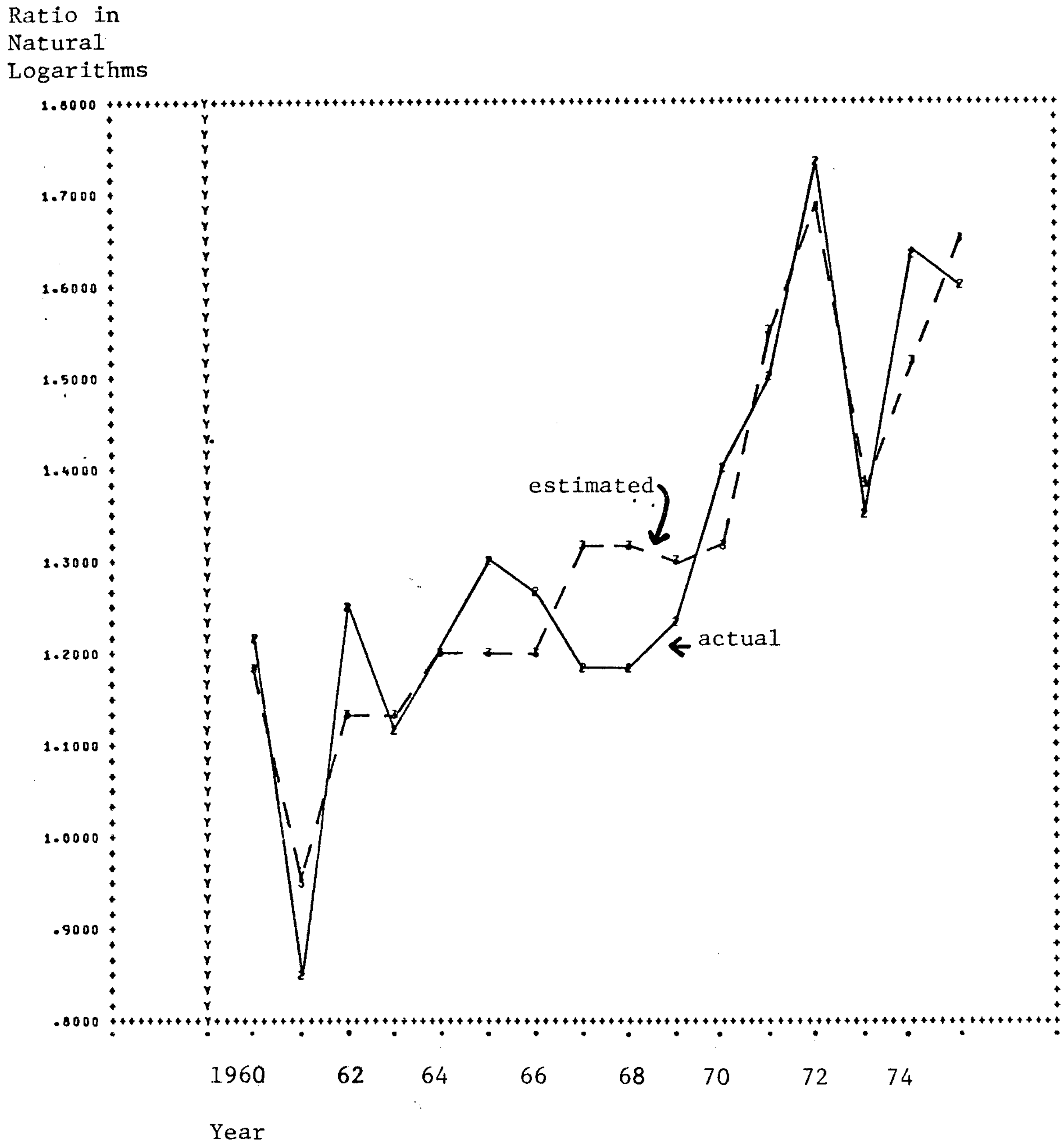


Figure A-2. Ratio of soybean oil export market share to export market share of lard, actual and estimated values, 1960-75.

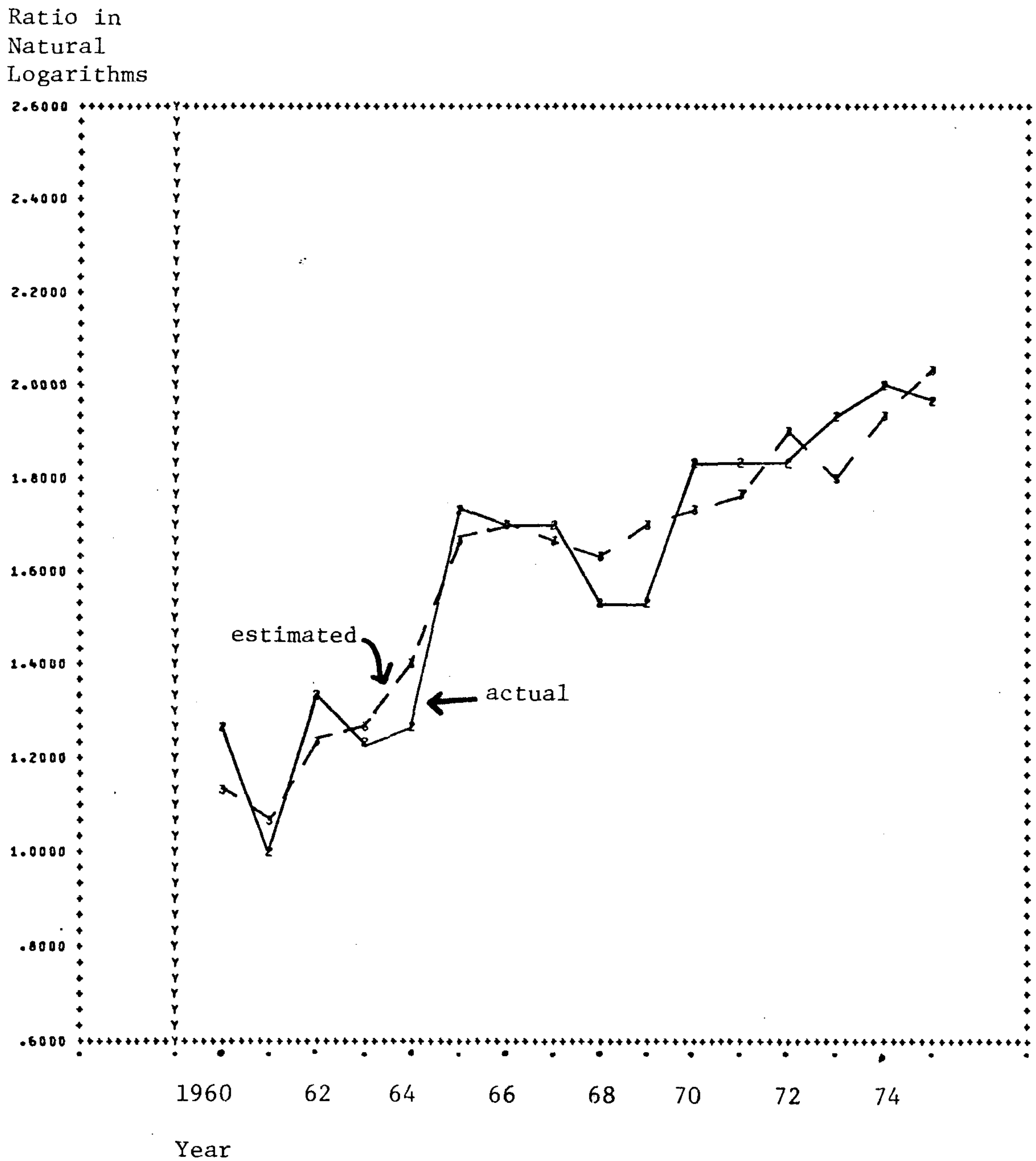


Figure A-3. Ratio of soybean oil export market share to export market share of coconut oil, actual and estimated values, 1960-75.

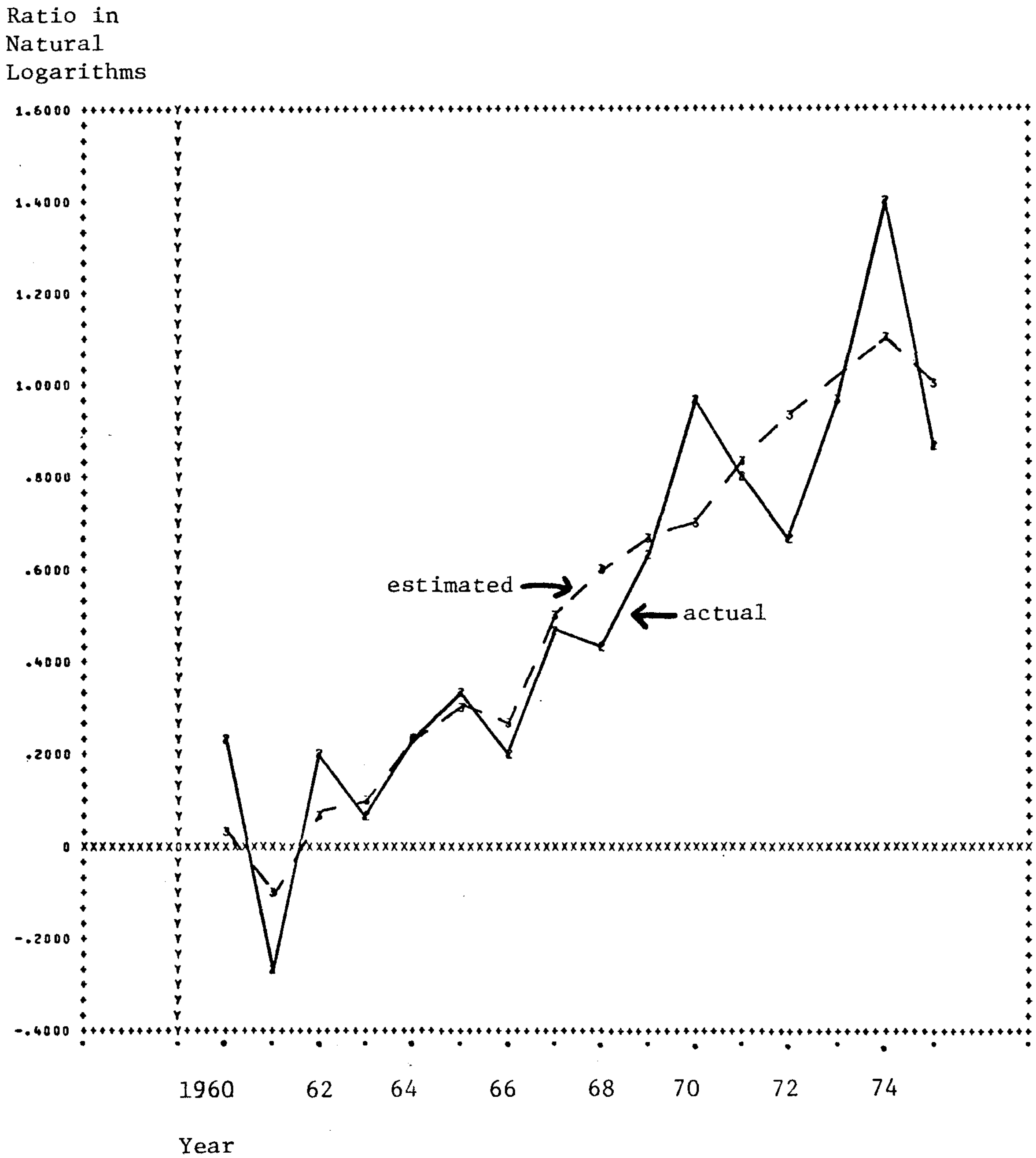


Figure A-4. Ratio of soybean oil export market share to export market share of peanut oil, actual and estimated values, 1960-75.

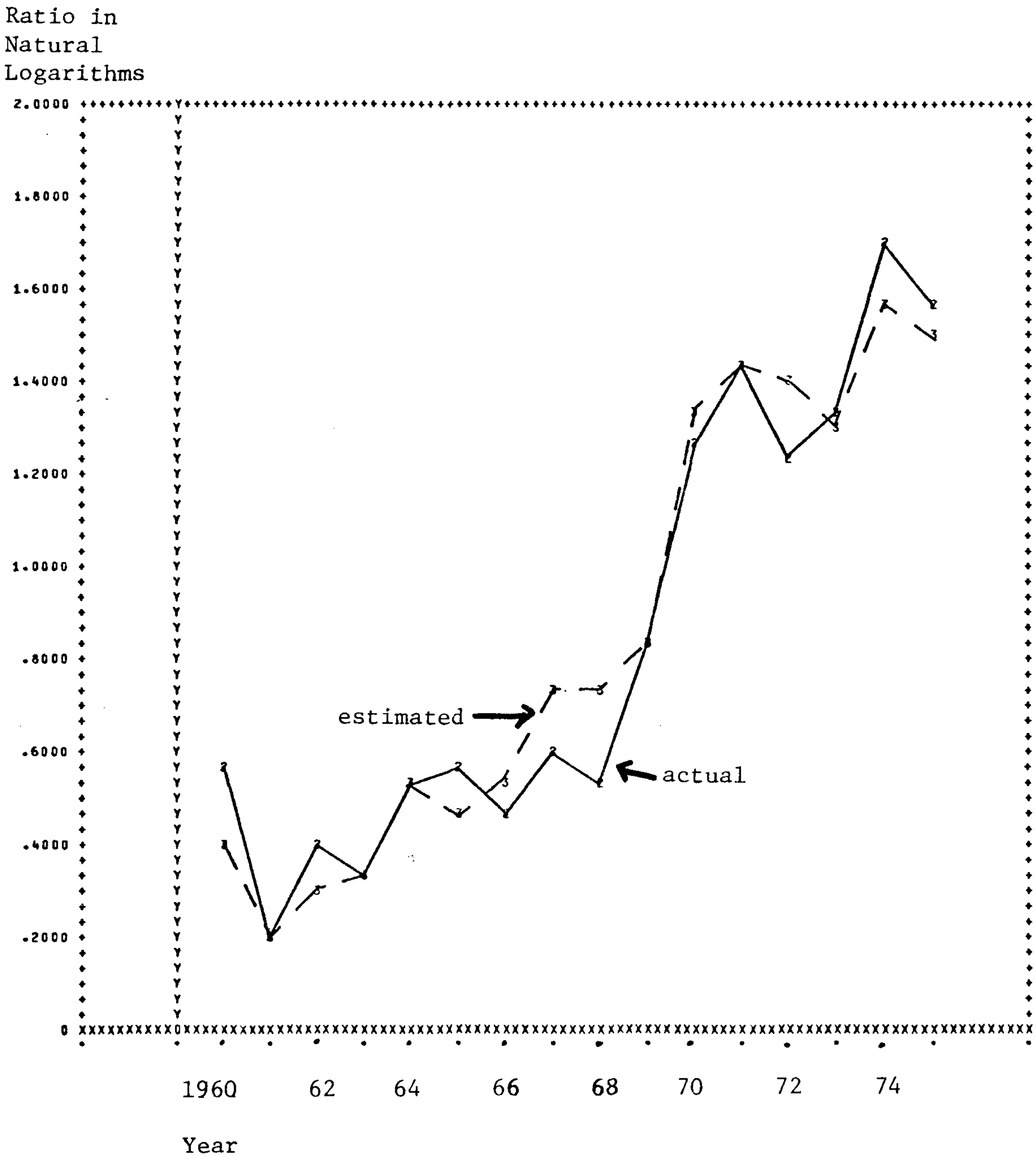


Figure A-5. Ratio of soybean oil export market share to export market share of cottonseed oil, actual and estimated values, 1960-75.

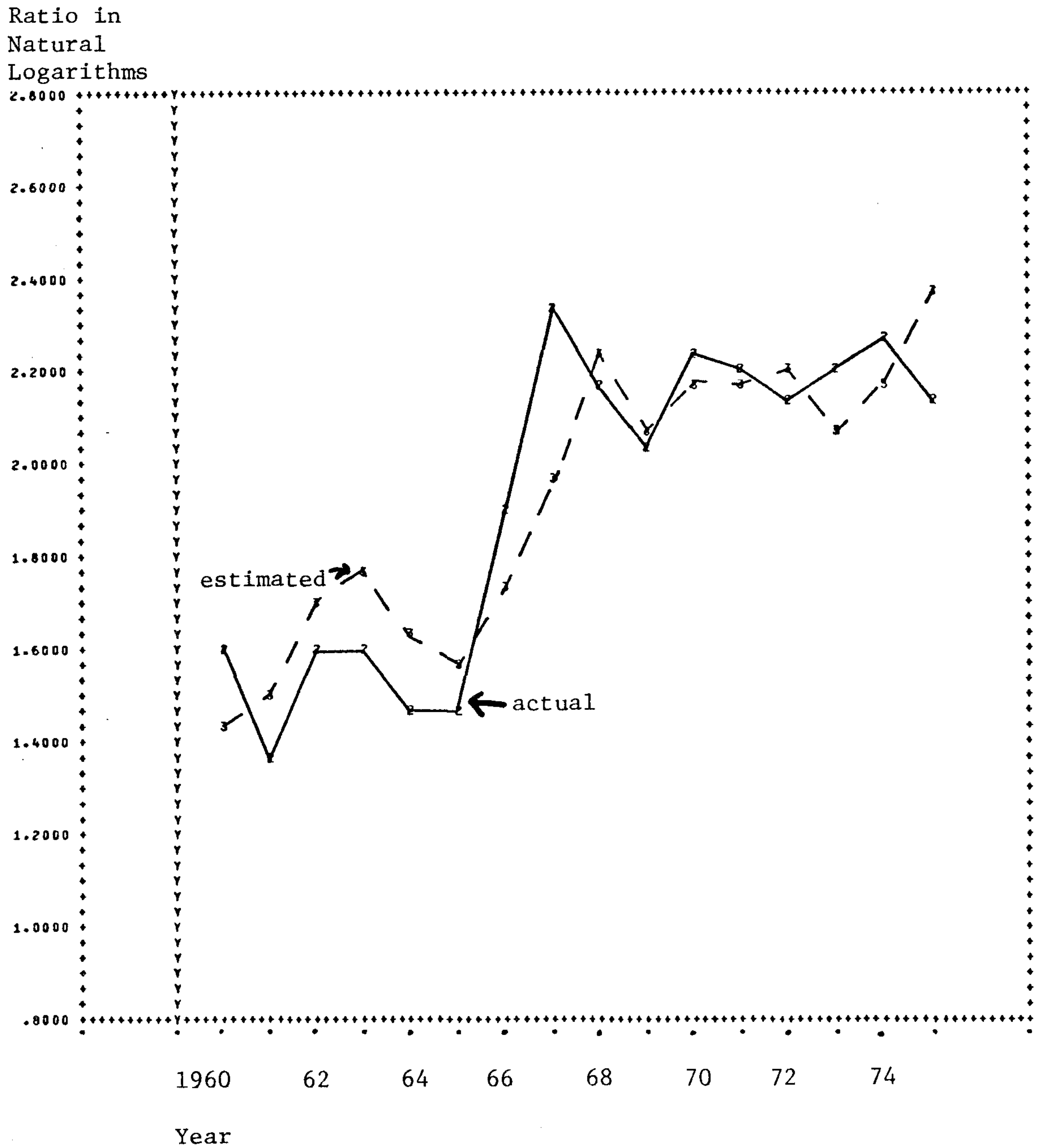


Figure A-6. Ratio of soybean oil export market share to export market share of palm oil, actual and estimated values, 1960-75.

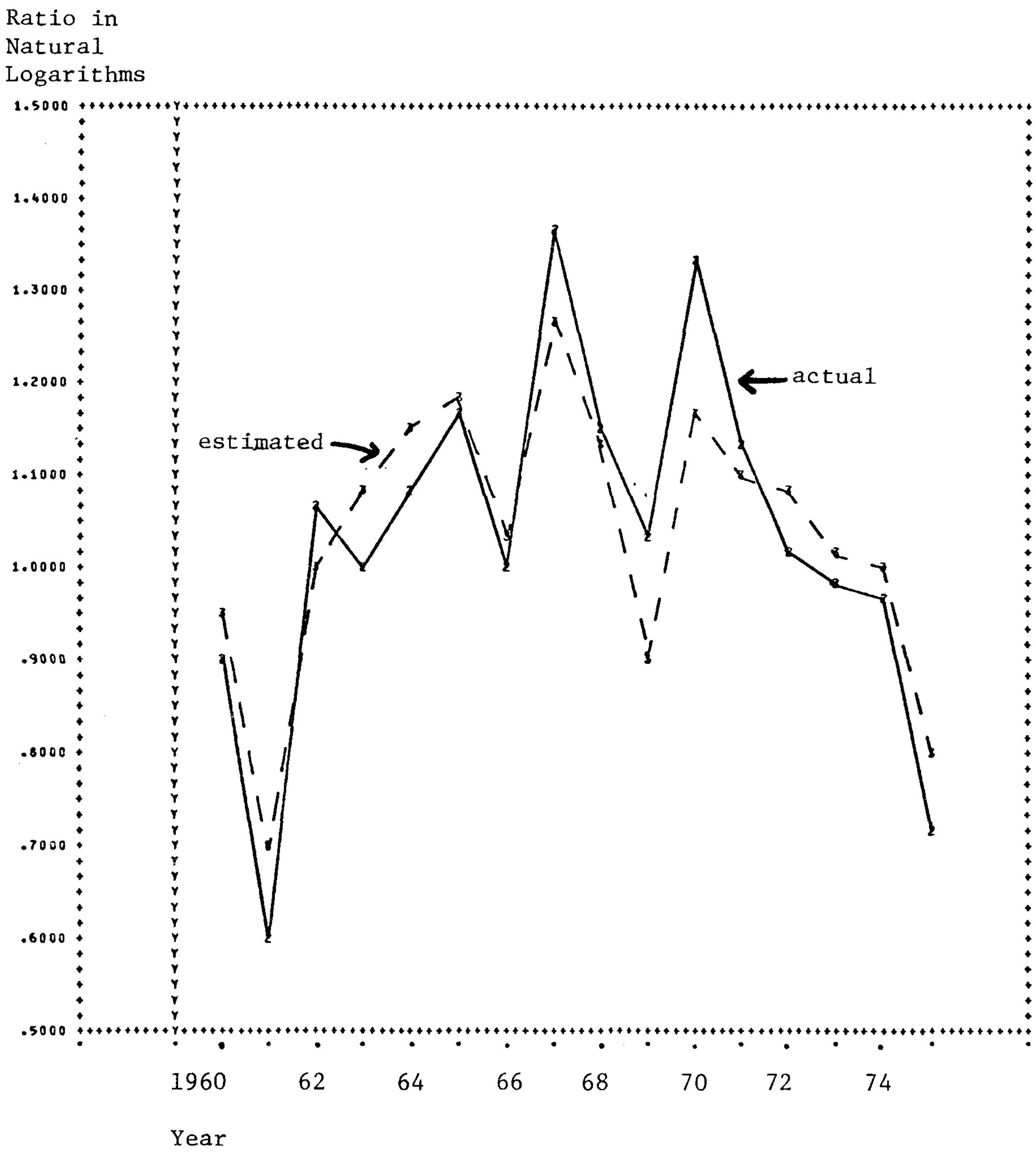


Figure A-7. Ratio of soybean oil export market share to export market share of sunflower seed oil, actual and estimated values, 1960-75.

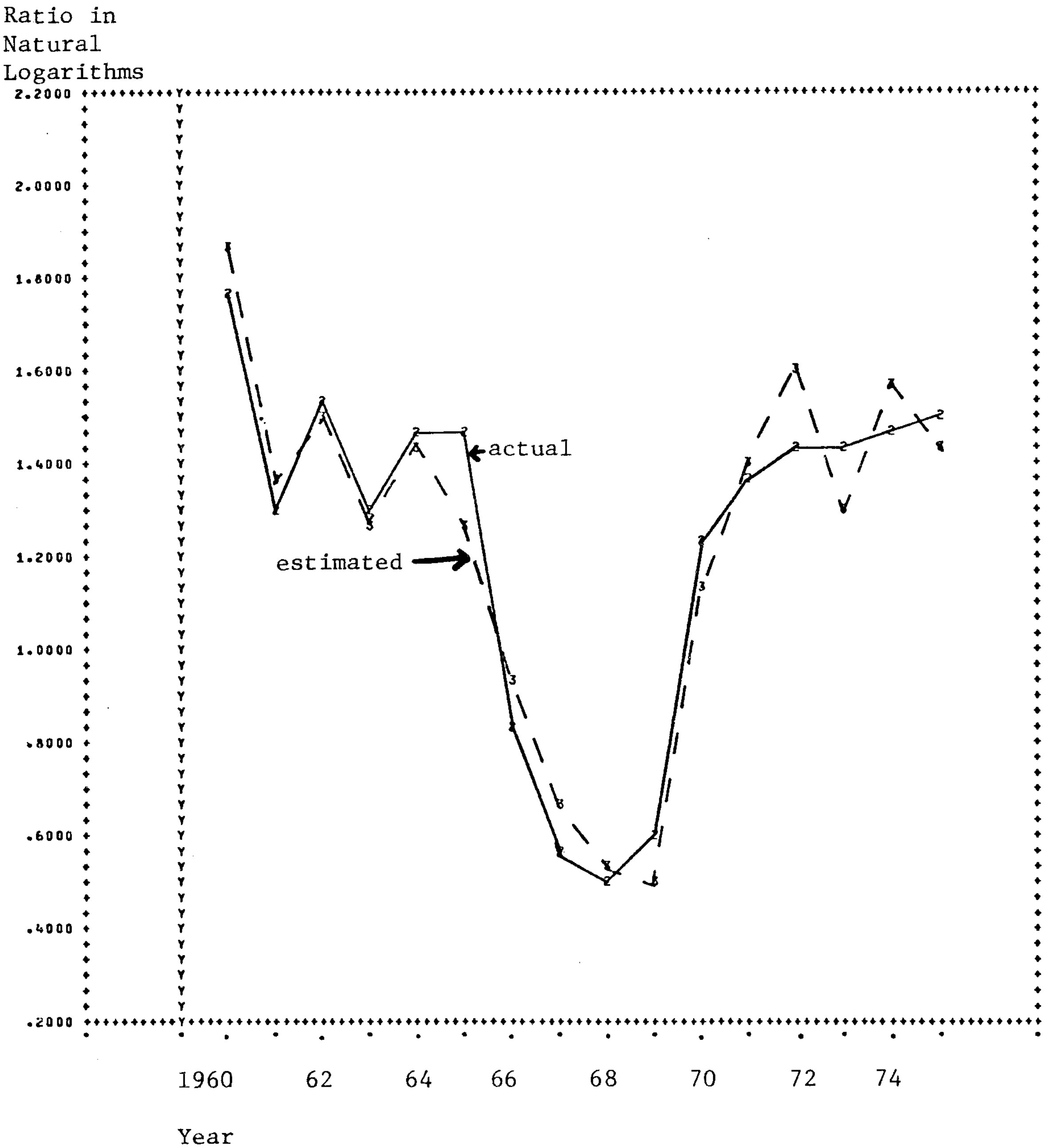


Figure A-8. Ratio of soybean oil export market share to export market share of rapeseed oil, actual and estimated values, 1960-75.

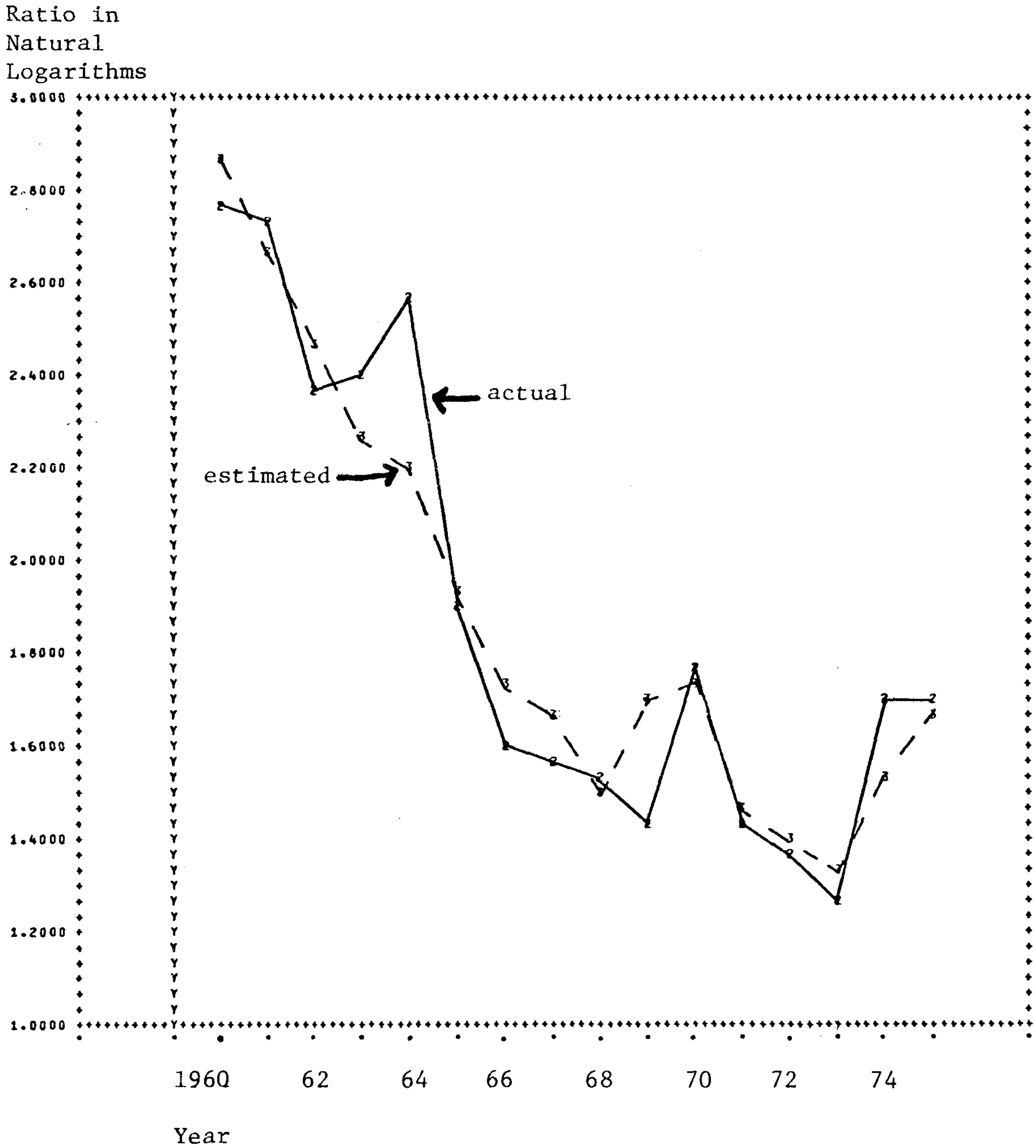
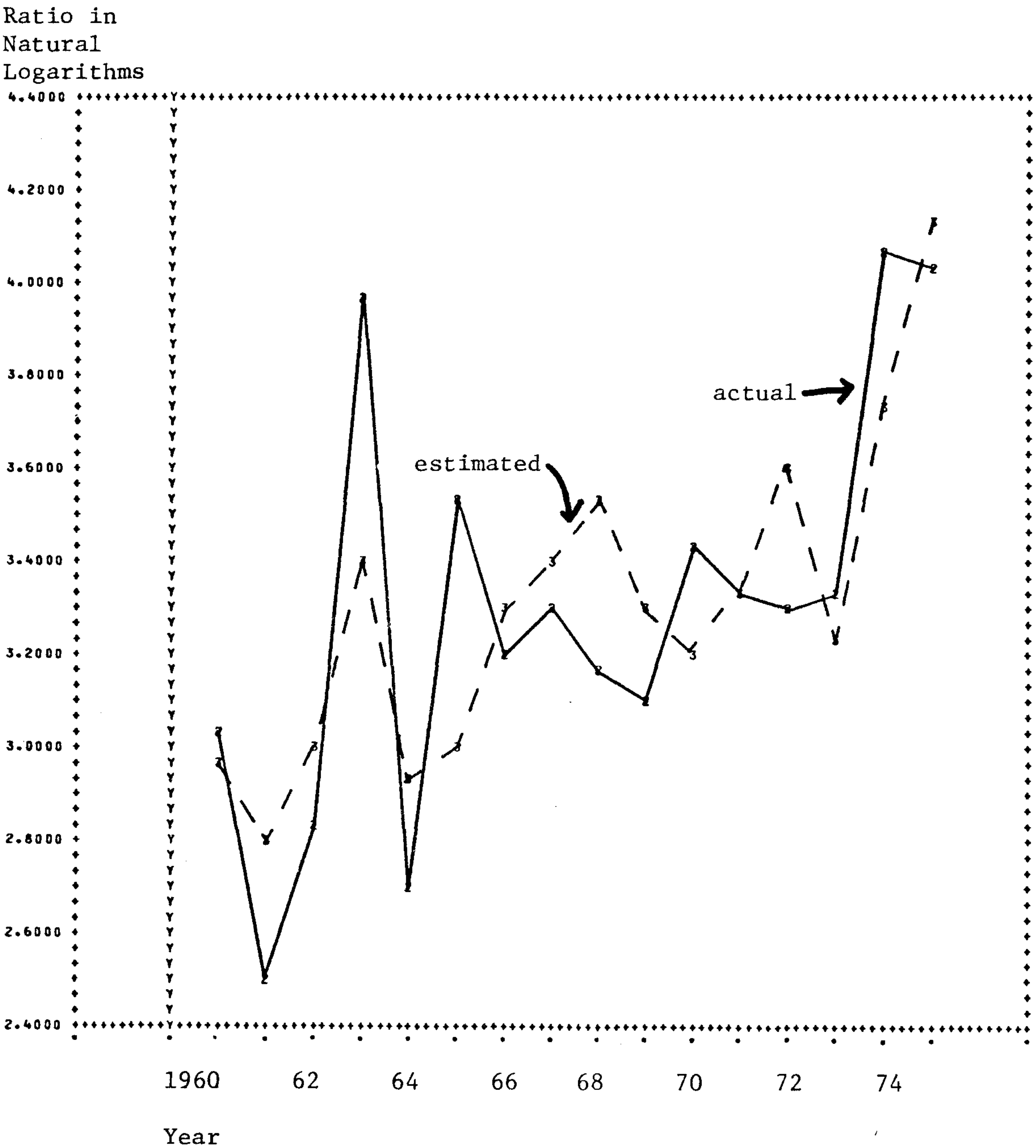


Figure A-9. Ratio of soybean oil export market share to export market share of olive oil, actual and estimated values, 1960-75.



APPENDIX B

Data for figures and computations (all data are from USDA sources except the vegetable oil price index which is from the World Bank)

Table B-1. Production and export data in thousand metric tons, 1960-75

Year	World Vegetable Oil* Production	World Vegetable Oil* Exports	Soybean Oil Production	Soybean Oil Exports	Coconut Oil Production	Coconut Oil Exports	Palm Oil Production	Palm Oil Exports	Peanut Oil Production	Peanut Oil Exports	Cottonseed Oil Production	Cottonseed Oil Exports
1960	15520	5237	3295	1440	1960	1152	1250	587	2525	826	2165	294
1961	17480	4989	3290	1036	2195	1334	1245	565	2800	854	2165	263
1962	18530	5560	3850	1484	2035	1223	1255	508	2880	984	2190	297
1963	18300	5695	3810	1434	2130	1325	1265	529	2910	1015	2295	286
1964	19510	6150	3880	1700	2270	1335	1255	571	3005	1007	2400	388
1965	20680	6265	3934	1769	2132	1272	1278	550	3351	995	2755	411
1966	21410	6798	4624	1718	2232	1404	1321	633	3250	1084	2757	258
1967	22170	6915	5056	1950	2085	1210	1204	496	3285	1055	2461	186
1968	23130	7397	5275	1977	2124	1291	1396	628	3380	1166	2417	225
1969	23410	7153	5925	2059	2052	1096	1549	733	3074	905	2716	269
1970	24490	7924	6089	2938	2135	1135	1715	770	3271	827	2609	319
1971	26070	8382	6266	2972	2434	1318	1907	963	3368	710	2654	333
1972	27840	9109	6750	3054	2792	1584	2143	1097	3518	886	2929	359
1973	27310	9229	7413	3246	2414	1218	2250	1218	2924	863	3111	357
1974	30780	9473	9382	3794	2100	946	2594	1432	3009	704	3168	393
1975	30450	10134	8318	3560	2650	1475	2909	1735	3039	740	3260	415

Year	Sunflower Seed Oil Production	Sunflower Seed Oil Exports	Rapeseed Oil Production	Rapeseed Oil Exports	Butter Production	Butter Exports	Lard Production	Lard Exports	Olive Oil Production	Olive Oil Exports	US P.L.480 Shipments	US Pork Production
1960	1665	245	1105	92	3855	426	3733	407	1180	69	368	5265
1961	1930	285	1190	67	3895	445	3836	379	1345	85	190	5175
1962	2425	323	1215	138	3970	422	3875	387	1340	87	402	5365
1963	2380	396	1060	128	3970	472	3905	416	925	27	348	5637
1964	2290	387	1120	131	4040	510	3742	486	1700	113	477	5676
1965	3128	407	1450	261	4300	482	3884	317	1005	52	524	5054
1966	2978	751	1420	350	3900	482	3895	315	1235	69	323	5143
1967	3498	1096	1690	402	4000	596	4036	360	1205	71	501	5707
1968	3719	1181	1830	431	4340	603	4033	421	1335	82	371	5926
1969	3706	1123	1480	485	4189	601	3942	447	1385	94	338	5876
1970	3802	847	1878	500	4114	723	4099	463	1245	94	309	6095
1971	3612	760	2476	713	4097	667	4421	474	1452	107	358	6710
1972	3637	724	2556	772	4375	538	4369	483	1559	113	348	6187
1973	3576	783	2396	914	4525	840	4268	474	1445	114	154	5784
1974	4508	867	2396	700	4477	744	4534	521	1535	66	108	6262
1975	3972	790	2490	660	4520	717	4432	491	1379	63	45	5218

* Includes all edible vegetable and palm oils and oil equivalent of oil-bearing products

Table B-2. Price data, 1960-75

Year	Vegetable Oil Price Index, 1974=100		Prices of Fats and Oil, Dollars Per Metric Ton											
	Current Dollars	Constant Dollars	Soybean	Coconut	Palm	Peanut	Cotton-seed	Sunflower-seed	Rape-seed	Butter	Lard	Olive Oil	Price of Soybeans	Price of Soybean Meal
1960	30	59	225	317	224	326	235	244	219	853	253	624	92	91
1961	30	59	283	254	228	329	305	316	280	706	244	567	111	100
1962	27	53	218	252	210	274	266	241	221	820	217	651	100	106
1963	28	54	215	283	218	269	266	236	215	900	213	923	110	113
1964	29	55	228	296	234	313	243	254	252	930	251	585	110	112
1965	33	64	265	360	269	323	250	292	263	911	292	663	118	115
1966	31	57	259	311	233	296	278	262	244	838	282	660	125	98
1967	28	52	216	332	226	287	278	212	206	761	205	689	112	98
1968	27	50	177	320	167	239	279	172	160	704	168	677	106	98
1969	29	52	228	366	171	333	288	261	258	709	220	666	103	95
1970	38	63	293	378	279	341	389	368	361	730	268	697	117	103
1971	39	62	304	358	266	451	392	373	295	1053	265	740	126	102
1972	32	46	252	249	215	418	324	325	232	1187	249	922	140	129
1973	54	67	465	503	395	540	500	481	395	975	373	1355	290	302
1974	100	100	792	994	686	1091	894	978	782	1206	737	2108	277	184
1975	68	60	547	394	420	862	720	739	563	1654	479	2357	220	156

References

1. Adams, F. Gerald, "An Interrelated Econometric Modeling System for Fats and Oils Commodities," Economics Research Unit, University of Pennsylvania, Philadelphia, PA, Economics Department Discussion Paper No. 327, October 31, 1975.

2. Case, J., "On the Form of Market Demand Functions," Econometrica 42:207 (1974).

3. Duncker, J.W., "World Price Behavior of Edible Oils and Fats," Canadian Farm Economics 12:14-22 (1977).

4. Food and Agriculture Organization of the United Nations, Approaches to International Action on World Trade in Oilseeds, Oils and Fats, FAO Commodity Policy Studies No. 22, Rome, 1971.

5. Griffith, G.R., "Price Relationships in International Vegetable and Palm Oil Trade," N.S.W. Department of Agriculture, Australia, and University of Guelph. (Mimeographed)

6. Harberger, Arnold C., "Some Evidence on the International Price Mechanism," The Journal of Political Economy 65:506 (1957).

7. Hickman, B.G. and L.J. Lau, "Elasticities of Substitution and Export Demands in a World Trade Model," European Economic Review 4:347 (1973).

8. Houck, James P.; Mary E. Ryan; and Abraham Subotnik, Soybeans and Their Products Markets, Models, and Policy. Minneapolis: University of Minnesota Press, 1972.

10. Johnson, Paul R., Studies in the Demand for U.S. Exports of Agricultural Commodities, Economics Research Report No. 15, Department of Economics, North Carolina State University, Raleigh, NC, 1971.

11. Labys, W.C., "Dynamics of the International Lauric Oils Market," in W.C. Labys (ed.), Quantitative Models of Commodity Markets, Cambridge, MA: Ballinger, 1975.

12. Labys, Walter C., "Multicommodity Substitution Patterns in the International Fats and Oils Market," European Review of Agricultural Economics 4:75-84 (1977).

13. Leamer, E.E., and R.M. Stern, Quantitative International Economics. Boston: Allyn and Bacon, 1970 (Chapter 3).

14. Morrissett, I., "Some Recent Uses of Elasticity of Substitution," Econometrica 21:41 (1953).

15. Richardson, J.D., "Beyond (But Back To?) the Elasticity of Substitution in International Trade," European Economic Review 4:381 (1973).

16. Sirhan, Ghazi, and Paul R. Johnson, "A Market-Share Approach to the Foreign Demand for U.S. Cotton," American Journal of Agricultural Economics 53:593 (1971).

17. Vandenborre, R.J., "Economic Analysis of Relationships in the International Vegetable Oil and Meal Sector," Department of Agricultural Economics, Agricultural Experiment Station, University of Illinois, July 1970.