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# THE CREATION OF DOMINANT FIRM MARKET POWER IN THE COCONUT OIL EXPORT MARKET

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DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

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*Abstract*--Legal and institutional changes that increased concentration in the Philippine coconut oil refining and exporting industries enabled the Philippines to exercise some of its potential dominant firm market power, raising the world price to 85 percent above the competitive level. If concerns about eating saturated fats cause the demand for coconut oil to fall slightly, the Philippine export revenues may increase; however, if U. S. demand for coconut oil in food uses falls by more than 20 percent, Philippine exports will fall.

# The Creation of Dominant Firm Market Power In the Coconut Oil Export Market

## I. Introduction

The Philippines, which supplies four-fifths of the world's coconut oil exports, made several fundamental legal and institutional changes to its export industry in the 1970s that may have created dominant firm market power. A model is estimated that allows us to determine whether these changes allowed the Philippines to be a dominant firm, exercise limited market power, or to remain a price taker.[1] The estimated model is then used to simulate the effects of reductions in demand due to health concerns about the saturated fat content of coconut oil.

In the second section, the world export market for coconut oil is described. The model is derived in the next section. In the fourth section, the model is applied to the coconut oil export market. The estimated model is used to show the size of the wedge between price and marginal cost under various market structures and to predict the outcome of the recent health warnings on world prices and Philippine revenues in the fifth and sixth sections. The summary and conclusions are presented in the final section. The data sources are listed in an appendix.

## II. The Coconut Oil Export Market

The Philippines is by far the largest producer and exporter of coconut oil. From 1976 to 1986, the Philippine share of world coconut oil exports averaged 79 percent.[2] In the 1970s, the Philippines export industry went from being atomistic to highly concentrated. Moreover, over time, other nations reduced their capacity to export coconut oil. Factors that may offset these effects that increase the Philippines market power are technological progress that allowed other oils to compete more closely with coconut oil, decreases in demand due to health concerns about the saturated fats in coconut oil, and the elimination of favorable tariff treatment of Philippines imports into the U. S.

The increased concentration in the Philippine coconut oil refining and export industries may have been due to a tax on copra sales and the creation of a centralized agency (Hawes, 1987). Before then, a large number of domestic and foreign-owned firms refined and exported coconut oil, with foreign firms accounting for the largest share of coconut oil exports. In 1971, a levy on the first domestic sale of copra was established. The proceeds from this levy went to finance production loans, industrial investments, and to support a producers' association, COCOFED. The levy's direct effect on market power is probably small, but its revenues were used by COCOFED to finance its other activities.

At the urging of COCOFED and others, the Philippine Coconut Authority (PCA) was created in June, 1973 by presidential decree (Hawes, 1987). The PCA was a centralized agency that eventually gained control of the levies on

coconut sales, seed research funding, new mill investment and the purchase of existing mills, subsidies for refining and export, and floor and ceiling price setting. By 1974, the PCA was controlled by COCOFED (3 members), another coconut planters' organization (1 member), Philippine National Bank officials (2 members), and a hybrid coconut seednut farm (1 member).

By 1980, the PCA controlled 80 percent of the Philippine refining capacity through its subsidiary, UNICOM, and dominated the coconut oil export market. This control was achieved by purchases financed through funds from the levies on coconut sales and arranged through the PCA's United Coconut Planters Bank. In short, the Philippine coconut refining and export industry went from one of relatively strong export competition to a highly concentrated industry within about six years.

Over time, the exports of the Philippines five major competitors in the export of coconut oil (Malaysia, Indonesia, Sri Lanka, Papua New Guinea and the Ivory Coast) fell. Coconut acreage in Malaysia and Indonesia, two of the largest of these fringe coconut oil exporters, decreased primarily due to government supported efforts to increase oil palm acreage.[3] Indonesia was the second largest coconut oil exporter in the 1950s and 1960s, but a 1968 revolution and the subsequent period of instability caused many existing coconut plantations to be neglected, permanently reducing tree-life span and hastening the replacement of coconut acreage by oil palm.

Offsetting these changes that were favorable to the Philippines were three other factors that tended to lower the demand for coconut oil or increase the elasticity of demand. First, the technological ability to substitute other oils for coconut oil in various uses has increased over time. Coconut oil has both food (shortening, salad and cooking oils, margarine, and baked goods) and nonfood (soap, paint and varnish, fatty acids, resins and plastics, and lubricants) uses.[4] The tropical oils that are high in saturated fats (coconut, palm, and palm kernel) differ in taste, melting temperatures, and flash points from other oils. Over time, soybean, cottonseed, and other oils have become closer substitutes for the tropical oils through advancements in oil processing technology.[5] For example, oils that are low in saturated fats now can be hydrogenated to give them some of the physical characteristics of coconut and palm oil. Coconut and palm oils, however, still possess certain chemical properties that make them the oils of choice for some nonedible and processed food products.

Second, consumers have become increasingly concerned with the amount and type of fat in their diets. In 1961, the American Medical Association (AMA) announced guidelines for total and saturated fat in the diet. In the late 1970's, various groups (Rizek *et al.*, 1983) made stronger recommendations to reduce the intake of saturated fat, including the U.S. Senate Select Committee on Nutrition and Human Needs (in 1977), the American Heart Association (in 1978), the Surgeon General (in 1979), the AMA (in 1979), and the U.S.

Department of Agriculture and the Department of Health, Education, and Welfare (in 1980). Until recently, however, most consumers probably did not realize that coconut oil, palm oil, and palm kernel oil were high in saturated fats. In the last couple of years, pressure by health groups and Phil Sokolof (who, in the fall of 1988, paid for full-page advertisements in national newspapers criticizing manufacturers for using tropical oils) caused many major food processors to promise to substitute unsaturated vegetable fats for saturated tropical fats in their products (Time, 1989). Europeans are also becoming more concerned with the health implications of saturated fats. These health concerns eventually should reduce the demand for coconut oil in foods over time, though such a drop in demand may not be apparent for another few years.

Third, the United States gave the Philippines a waiver of the 3 cents per pound tariff on coconut oil imports (up to a quota limit) from 1921 to 1974, which resulted in the Philippines providing virtually all the coconut oil in the United States (Hawes, 1987, p. 60).[6] After 1974, a 1¢ per pound tariff was applied to Philippine coconut oil imports, while the tariff on coconut oil imports from other nations was gradually reduced to a level equal that of the Philippines. Given the long lags to bearing age (10 years) and the long life (60 years) of coconut palms (Woodroof, 1979, p. 38), the historical tariff differential, by encouraging the growth of the Philippine coconut oil export industry, is probably still having a substantial effect today, but this effect should diminish over time.[7] Before 1974, virtually 100 percent of U.S. imports were from the

Philippines, whereas over the last 5 (10) years the Philippines accounted for only (82) 87 percent of U. S. imports, even though its share of total world exports has risen over time.

## III. The Model

A generalized dominant firm-competitive fringe model is used to describe the world coconut oil export market, which allows for competitive, dominant firm, and intermediate types of behavior. It consists of a three-equation system: world demand, competitive fringe supply, and an equilibrium condition for the dominant firm based on its residual demand and marginal cost curves.

The world's market demand curve is

$$Q = Q(p,Z), \tag{1}$$

where Q represents world purchases, p is the price of this homogeneous product, and Z is a vector of other variables that affect demand. The competitive (price-taking) supply, $Q_f$, of the fringe is

$$Q_f = Q_f(p,X), \tag{2}$$

where X is a vector of other variables that affect the quantity exported.

The residual demand facing the dominant firm is the world demand minus the competitive fringe's supply:

$$Q_d(p,Z,X) = Q(p,Z) - Q_f(p,X). \quad (3)$$

The dominant firm maximizes its profits subject to its residual demand. If the dominant firm fully exercises its market power, its equilibrium condition is determined by equating its marginal revenue (corresponding to its residual demand curve) and its marginal cost, MC. More generally, its equilibrium condition is

$$p(Q_d + Q_f) - \lambda p'(Q_d + Q_f) = MC,$$

or

$$p(Q_d + Q_f) = MC + \lambda p'(Q_d + Q_f), \quad (4)$$

where $p(\bullet)$ is the inverse demand curve and $\lambda$ reflects the degree of market power (markup of price over marginal cost), ranging from 0 (competition) to 1 (monopoly with respect to the residual demand curve), so that $p(\bullet) - \lambda p'(\bullet)$ is its perceived marginal revenue taking into account the dominant firm's beliefs about its market power. Alternatively, $\lambda$ can be viewed as reflecting the dominant "firm's" ability to act monolithically. Our estimate of $\lambda$, given either interpretation, tells us the degree of dominant market power exercised.

Unfortunately, $\lambda$ is not identified for some functional forms, such as specifications that are strictly linear or log-linear. Just and Chern (1980), Bresnahan (1982), and Lau (1982), however, show that a sufficient condition for the identification of $\lambda$ is that the relevant demand curve is not separable in all

variables, X and Z. Because the relevant demand curve here is the residual demand curve, any X or Z variable that, loosely speaking, rotates the market demand curve without affecting the fringe supply curve is sufficient to identify $\lambda$.

To estimate this system of three equations, (1), (2), and (4), we use explicit functional forms. The world demand and fringe supply curves are assumed to be linear in coefficients but to contain interactive terms -- the products of pairs of variables -- that allow for the rotation necessary to identify $\lambda$.

The worldwide demand equation (1) is estimated as

$$Q = \alpha_0 + \alpha_1 p + \alpha_2 Z + \alpha_3 pZ_1, \qquad (1')$$

where Z is a vector of exogenous factors that affect demand and $Z_1$ is a subset of these factors that enter the equation as cross-products with the price.[8] The Z variables are the U. S. price of palm oil (the closest commonly - traded substitute oil),[9] the U. S. and EEC GNP per capita incomes,[10] the midyear U. S. and EEC population, a time trend for 1958-1976 (1 in 1958, 2 in 1959,...), a time trend for 1977-86 (1 in 1977), and the number of articles listed in the Reader's Guide to Periodic Literature on fats in the diet (a proxy for public concern about saturated fats). The time trend was split into two periods to capture changes in demand due to a large increase, starting in about 1977, in the number and severity of warnings by health groups. The $Z_1$ variables is a

single time trend (1 in 1959) that reflects a fall in demand for coconut oil over time due to changes in tastes (increasing avoidance of saturated fats) and the increased technical ability to substitute other oils in production not captured by the other Z variables.[11]

The fringe supply equation (2) is now written as

$$Q_f = \beta_0 + \beta_1 p + \beta_2 X, \qquad (2')$$

where X is a vector of exogenous variables: a dummy variable reflecting the change since the Indonesian revolution (1 from 1969 on), a time trend (1 in 1959), the time trend squared, the U. S. domestic-well crude oil price (crude oil is a substitute for coconut oil in some nonfood uses), and personal income measures for Malaysia and Sri Lanka. No appropriate income measure was available for the other major coconut oil exporting nations during the period of interest. As a result, the price of crude oil is also included, because it is the major export revenue source for Indonesia and Malaysia.[12]

The residual demand facing the Philippines is the difference between (1') and (2'):

$$Q_d = (\alpha_0 - \beta_0) + (\alpha_1 - \beta_1 + \alpha_3 Z_1)p + \alpha_2 Z - \beta_2 X$$

$$\equiv \delta_0 + (\delta_1 + \delta_2 Z_1)p + \delta_3 Z + \delta_4 X, \qquad (3')$$

where $\partial Q_d/\partial p = \delta_1 + \delta_2 Z_1$ is negative (the residual demand curve slopes down).

The Philippine marginal cost of producing and exporting coconut oil is

$$MC = \theta_0 + \theta_1 Q_d + \theta_2 W, \tag{5}$$

where W is a vector of exogenous variables that affect the marginal costs of producing and exporting coconut oil.[13] Included in W are a plantation wage index for the Philippines, the minimum monthly average rainfall for two reporting locations near Philippine coconut production areas (Davao City and Iloilo), a one-period lag of the minimum rainfall variable, and an ocean freight rate index for grain from the mouth of the St. Lawrence River to Antwerp/Rotterdam (the only bulk agricultural commodity shipping rate available for the entire period). The lack of steady rain lowers coconut production in the following period. Current minimum rainfall also was included to allow for immediate effects on production, though the justification for including it is weaker than for the lagged value.

Using (5) and (3'), the dominant exporting firm's first-order condition for profit maximization (4) can be rewritten as

$$\Delta p = \theta_0 + \theta_1 \Delta Q_d + \theta_2 W + \frac{\lambda}{\delta_1 + \delta_2 Z_1} Q_d \qquad (4')$$

By obtaining estimates of $\delta_1$ and $\delta_2$ from the residual demand curve, based on estimates of (1') and (2'), $\lambda$ is identified from the estimation of (4').

Because the legal and institutional changes in the Philippines may have affected its market power in the coconut oil market, our model allows the market power parameter, $\lambda$, to vary over time. In particular, we focus on the effects of the levy on copra (and hence coconut oil) sales starting in 1971 and the 1973 creation of the PCA. That is,

$$\lambda = \lambda_0 + \lambda_1 D_{1972} + \lambda_2 D_{1974}, \qquad (6)$$

where $D_{1972}$ and $D_{1974}$ are dummy variables that take on the value 1 after 1972 (the first full season after the levy was instituted) and 1974 (the first full season after the PCA was established) accordingly. Thus, $\lambda_0$ represents the market power prior to 1972, $\lambda_0 + \lambda_1$ is the market power in 1972-1973, and $\lambda_0 + \lambda_1 + \lambda_2$ is the market power from 1974 on.

## IV. Estimation

Did the concentration of control of processing and exports of the Philippines lead to market power in the sense that prices were driven above marginal cost? To answer this question, our model estimates the degree of market power using annual data on world coconut oil and coconut oil equivalent copra exports during the period 1958-1986.[14] The means and standard

deviations of the variables used are shown in Table 1. The sources of the data are given in the appendix.

The parameter estimates and their standard errors are given in Table 2. Based on the Wald-test statistic of 6.17, we can reject the null hypothesis of a zero slope for the demand curve (zero coefficients on the price and the price x time term for the entire period). The estimated demand curve has a negative slope for price for all but the first observation. The price of palm oil and the GNP per capita parameters have the expected signs but relatively large asymptotic standard errors. The difference in the coefficients for the two time trends (1959-1976 and 1977-1986) show that coconut oil demand fell starting in the late 1970s. The number of magazine articles on the health dangers of saturated fats, however, did not have a statistically significant effect. The $R^2$ measure is 0.52, but because NL3S was used, this number needs to be viewed with caution. The Durbin-Watson statistic indicates no autocorrelation problem.

The fringe supply equation estimates show that the fringe supply is inelastic with respect to price but that the quantity exported has been falling over time. The coefficient on the price of coconut oil is not statistically significantly different from zero (but has a negative point estimate). The 1969 dummy and time variables reveal that coconut oil exports by the fringe are declining (at a decreasing rate) for nonprice reasons. The price of crude oil has a statistically significant negative coefficient; whereas the income measure has a positive estimate, perhaps reflecting differing income elasticities in

domestic consumption in the various fringe countries. The $R^2$ measure is 0.81. The Durbin-Watson statistic indicates the possibility of some autocorrelation in this equation, but no simple attempts to correct for it (such as including other regressors) were successful.

Estimates of the optimality equation (4') show that the Philippine marginal cost decreases with quantity exported, increases with wages and freight rates, and decreases with an increase in lagged minimum rainfall (not statistically significant). The optimality equation also shows that there was little (if any) increase in market power after 1971 (following the imposition of the levy) but that a substantial increase in market power occurred after 1973 (following the creation of the PCA). The point estimates of the market power measure are $\lambda_0 = -0.0008$, $\lambda_1 = 0.0112$, and $\lambda_2 = 0.3209$ for the periods 1959-1971, 1972-1973, and 1974-1986, respectively. The first two estimates are not statistically significantly different from zero, so we cannot reject the hypothesis that $\lambda$ lies within the (0, 1) range predicted by theory in all periods. The $R^2$ is 0.67 and the Durbin-Watson statistic does not indicate an autocorrelation problem.

The estimate of market power of 0.32 affer 1974 reflects a substantial change in the behavior of the Philippine coconut oil industry. The hypothesis that the Philippines acted as a price taker ($\lambda_2 = 0$) cannot be rejected prior to 1974 but can be strongly rejected after 1974. We can also reject the hypothesis that the Philippines acted like a monopolist with respect to its residual

demand (was a traditional dominant firm). That is, we can reject the hypothesis that $\lambda_2 = 1$. The 95 percent confidence interval on $\lambda_2$ is (0.13, 0.51).

If the system is reestimated restricting $\lambda_0 = \lambda_1 = 0$ (competitive behavior through 1973), the estimate of $\lambda_2$, 0.31, is virtually unchanged. Its asymptotic t-statistic (against $\lambda_0 = 0$) is 3.44, and it has a 95 percent confidence interval of (0.13, 0.49).

## V. Market Power

How large a wedge between price and marginal cost does the estimated level of market power imply? Our estimates show price-taking behavior prior to 1974 ($\lambda_0$ and $\lambda_1$ are essentially equal to zero). The size of the effect from 1974 on (the PCA period) can be illustrated by comparing the estimated price to that if $\lambda_2$ is set equal to zero (price taker) or $\lambda_2$ is set equal to 1 (a dominant firm that acts like a monopolist with respect to its residual demand).

In 1980, the midpoint of our PCA period, Lerner's measure, $(p - MC)/p$, for the world export market was 0.46; that is, price was 85 percent above marginal cost. In contrast, if the Philippines acted like a traditional dominant firm (a monopolist with respect to its residual demand), Lerner's measure would have been 0.80; that is, price would have been 5 times marginal cost. Alternatively stated, we estimate that the Philippines acted as though it were a monopolist with respect to a residual demand curve with an elasticity of -2.16. The actual estimated elasticity of the residual demand curve, however, is -1.25.

Yet another way of thinking about the amount of market power exhibited by the Philippines is to calculate how many identical Cournot firms the PCA would have had to create to obtain the $\lambda_2$ observed. With n identical Cournot firms, $\lambda_2$ would equal 1/n, so, given our estimate that $\lambda_2$ is one third, the observed equilibrium is equivalent to that which would have occurred if the PCA had created three identical Cournot firms.

The effect of market power after 1974 is shown in Figure 1 where the actual exports and those simulated based on our model ($\lambda_0$ = -0.0008, $\lambda_1$ = 0.0112, $\lambda_2$ = 0.3209) are compared to the exports that would have been obtained if the Philippines had been a price taker ($\lambda_0 = \lambda_1 = \lambda_2 = 0$) or if it had acted like a monopolist with respect to its residual demand ($\lambda_0 + \lambda_1 + \lambda_2 = 1$). Our model's estimated exports are close to the actual exports (the simple correlation between the two is 0.55).[15] The figure shows that exports under the competitive model are above and rise much more than the actual or estimated exports, which are relatively constant over this period (slightly falling in the latter part of the period). The exports under the monopoly model, in contrast, are below the actual exports and fall over most of the period.

## VI. Health Warnings

Recently, health warnings designed to discourage the use of saturated fats such as are found in coconut oil have been widely disseminated. Our model can be used to simulate the effects on world prices and Philippine

revenues caused by a drop in demand for coconut oil due to health concerns.

Even today, most American consumers are unaware that coconut oil is a saturated fat, that excessive consumption of saturated fats may be dangerous to their health, and that many processed foods use coconut oil (or other saturated fats). Only within the last couple of years (indeed after our sample period, which contains all years for which we have a complete data set) were warnings about the health dangers of tropical oil widely reported in the national media. These crusades against the use of tropical oils are having an effect on the use of these oils by processed food manufacturers. As of January, 1989, four major food companies: Keebler, Pepperidge Farm, Sunshine Biscuits, and Kelloggs announced their plans to switch from tropical to less saturated oils in their product lines within a few years. Thus, it seems likely that the demand for tropical oils for use in foods will diminish within the next few years.

The effects of such a decrease in demand depend on how the demand curve shifts. In the following simulations, we assume that the intercept of the total demand curve will fall, reflecting a parallel shift down of the demand curve. Suppose the use of coconut oil in foods in the United States decreases by $\alpha$ percent as a result of substitution by consumers and major food producers in 1986 (the last year of our sample). Then, since the U.S. imports about 38 percent of all coconut oil and about one-third of those imports were used in

foods, all else the same, the world demand curve's constant would fall by about $\alpha/8$.

The price and quantity effects of such a drop in demand are shown in Table 3. The price increases and the total quantity exported decreases. Philippine exports drop substantially and the fringe's exports are relatively constant. Given a 10 percent decrease in U. S. food demand (so the intercept in the world demand falls by 1.25 percent), the world price would increase by 36 percent and world exports would fall by a 17 percent. Most of this decrease in exports would be borne by the Philippines: its exports would drop 22 percent. Because world price rises by more than its exports fall, its revenues would increase by nearly 6 percent.[16] Given a 19.2 percent fall in U. S. food demand, there would be no change in the Philippine revenues. For larger decreases in demand, however, the Philippine revenues would fall as shown in Table 3.

## VII. Conclusions

The creation in 1973 of the Philippine coconut oil refining and exporting agency (PCA) allowed the Philippine coconut oil export industry to exercise some of its potential dominant firm market power. As a result, the world price rose 85 percent above the competitive level. Had the Philippines exercised all of its potential power, however, the world price might have been as much as five times the competitive price.

If recent concerns in the United States and elsewhere about the adverse effects of eating saturated fats cause the demand for coconut oil to fall slightly, the Philippine export revenues may increase. If, however, U. S. demand for coconut oil in food uses falls by more (over 20 percent), Philippine export revenues will fall.

## Appendix: Data Sources

The data used in this study came from a variety of published sources. The price of coconut oil is an unweighted average of monthly coconut oil prices at the U.S. Pacific Coast from the *CRB Commodity Yearbook* (Jersey City: Commodity Research Bureau, Selected Years). (The U.S. price is highly correlated with the European price.) Data on the U. S. domestic well crude oil price is also contained in that source.

The exports and imports of coconut oil by nation and the palm oil price at the Port of Rotterdam are from the Great Britain:Commonwealth Secretariat Commodities Division, *Fruit and Tropical Products* (London: Commonwealth Secretariat, various years). This source provides data only through 1986 at this time.

The freight rates for grain from the mouth of the St. Lawrence River to Rotterdam are listed in the World Bank, *Commodity Trade and Price Trends* (Baltimore: Johns Hopkins University Press, various years). The minimum monthly rainfall data are listed in the Republic of the Philippines, National Economic and Development Authority, *Philippine Statistical Yearbook* (Manila: National Economic and Development Authority, various years).

The Philippine farm wage index was constructed from two sources: the International Labour Office, *Yearbook of Labour Statistics* (Geneva: International Labour Office, various years) manufacturing wage index (1958-1981), and the *Philippine Statistical Yearbook*'s legislated Money Wage for non-

plantation agriculture (1972-1986). A regression of the wage index on the legislated money wage was used to create a continuous wage measure for the entire period. The correlation coefficient between these two wage sources is 0.88.

All of the data on population and income--U.S. GNP per capita, EEC GNP per capita, U.S. population, EEC population, and the fringe (Malaysia and Sri Lanka) income--are contained in the International Monetary Fund. *International Financial Statistics* (Washington: IMF, various years). The number of published magazine articles concerning fat in the diet is a count of listings in the *Reader's Guide to Periodic Literature.*

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## Footnotes

[1] Our model is similar to those of Just and Chern (1980), Bresnahan (1982), and Lau (1982), but differs in that it allows for the measure of market power to vary in response to institutional and legal changes and permits dominant firm (rather than pure monopoly) behavior. Three other studies that use residual demands, rather than market demands, are Baker and Bresnahan (1984), Spiller and Favaro (1984), and Karp and Perloff (1989b).

[2] Both coconut oil and copra, which is dried coconut meat or kernel, are exported. In the following, copra exports are converted to their coconut oil equivalents (roughly 64 percent of copra is coconut oil, though the percentage varies over time). Extraction of oil also yields copra cake, which is fed to livestock. Most of the Philippine copra cake is exported to Europe, but is not discussed further in this paper.

[3] Oil palm trees reach maturity quicker than coconut palm trees and are better suited to the climatic conditions in Malaysia and Indonesia.

[4] In the United States, relatively small amounts of coconut oil imports are used in foods (27 percent in 1962 and 33 percent in 1986), whereas 75 and 67 percent of coconut oil imports of the United Kingdom and the Netherlands, respectively, were used in foods in 1962 (Woodroof, 1979).

[5] In 1961-63, coconut oil was 15 percent of total world edible oil exports; in 1971-73, it was 10 percent; and in 1981-83, it was 7 percent.

[6] The United States and the EEC each import about 40 percent of the world's total shipments of coconut oil.

[7] In addition to the results discussed below, we estimated a system of equations that included a 1974 dummy variable to account for the change in U.S. tariff policy toward Philippine coconut oil imports. Because the coefficient on this dummy was small and statistically insignificant at even the 0.10 level, the system of equations reported below does not include this variable.

[8] For the utility function to be concave in a linear expenditure system (LES), there cannot be inferior or complementary goods. Moreover, the LES model is one of a class of models in which there is proportionality between the own price and income elasticities (Deaton and Muellbauer, 1980).

[9] The correlation between the prices of various other edible oils is very high. As a result, no other oil prices were included in the equation.

[10] We include only nine countries in our EEC figures. We do not include Spain, Portugal, and Greece, which did not join the EEC until relatively late in our sample period.

[11] One alternative specification would be to interact the broken time trend with price, instead of using a single time trend. Doing so, the asymptotic t-statistic that the coefficients are equal is 0.89, so we chose to use just the single interaction term.

[12] In the last decade, Indonesia's petroleum and natural gas exports ac-

counted for nearly three-quarters of the total value of export, whereas in Malaysia, they accounted for over a fifth of total value.

[13] Our model treats the exporting problem as basically a static analysis where large inventory holdings are impractical and we do not have to simultaneously solve the problem of how much coconut oil to reserve for domestic use. An attempt to estimate a dynamic model analogous to Karp and Perloff (1989a) was unsuccessful. Because coconut palms do not bear until they are 10 years old and have a 50 to 60 year bearing life, treating planting decisions as predetermined is reasonable.

[14] The system of equations was estimated with the Jorgenson-Laffont nonlinear three-stage least squares (NL3S) method using the Time Series Processor (TSP) program.

[15] In 1976 and 1986 the actual quantity exported was higher than our model predicts. In 1976, coconut oil production reached record levels due to favorable weather not fully captured by our rainfall data. Political changes in the Philippines in early 1986 may have affected the export decisions of the PCA in that year. Our estimated prices also are close to the actual prices: the correlation coefficient is 0.68.

[16] The reason for the relatively small quantity effect is that our estimates show that the Philippines is operating in a region of increasing returns to scale (see Table 2).

**Table 1**

**Means and Standard Deviations**

| | Mean | Standard Deviation |
|---|---|---|
| *Endogenous Variables* | | |
| Price of coconut oil (¢/lb) | 46.84 | 18.238 |
| Quantity, Philippines (metric tons) | 860.62 | 247.78 |
| Quantity of the fringe (metric tons) | 319.35 | 119.25 |
| *Exogenous Variables* | | |
| Price of palm oil (¢/lb) | 32.53 | 10.914 |
| US GNP per capita ($) | 7551.9 | 4789.7 |
| EEC GNP per capita ($) | 4589.6 | 4589.6 |
| US population (millions) | 209.35 | 19.71 |
| EEC population (millions) | 148.76 | 4.962 |
| Number of magazine articles on fats in one's diet | 1.2069 | 2.366 |
| Crude oil price ($/barrel) | 24.729 | 6.733 |
| Fringe national income ($ millions) | 10037. | 3731.2 |
| Philippines farm wage index (converted to US dollars using an exchange rate index) | 55.776 | 46.868 |
| Minimum rainfall (millimeters) | 19.66 | 13.242 |
| Freight rate ($/metric ton) | 13.99 | 4.861 |

**Table 2**

**Iterative Nonlinear Simultaneous Equation System Estimates**

1959 - 1986 Annual Data

*Demand equation* (World coconut oil exports)

| | Coefficient | Asymptotic Standard Error |
|---|---|---|
| Intercept | 3837.2 | 3890.8 |
| Price | 1.3612 | .9264 |
| Palm oil price | 5.6595 | 5.457 |
| US GNP per capita | .1309 | .0766 |
| EEC GNP per capita | .0373 | .0311 |
| price x time trend for 1958-1986 | -.7211 | .1340 |
| time trend for 1958-1976 | 6.6414 | 9.6849 |
| time trend for 1977-1986 | -144.74 | 73.824 |
| US population | -5.50 | 10.90 |
| EEC population | -30.431 | 27.449 |
| Magazine articles | -9.6341 | 18.369 |

$R^2$ = .52

D.W. = 1.90

Table 2 continued

*Fringe Supply Equation* (Fringe exports)

| | Coefficient | Asymptotic Standard Error |
|---|---|---|
| Intercept | 568.67 | 61.263 |
| Price | -1.5085 | .7164 |
| 1969 dummy | -178.32 | 39.345 |
| Time trend (1958-1986) | -28.103 | 8.1659 |
| Time trend squared | .3456 | .1900 |
| Crude oil price | -4.7283 | 2.1087 |
| Fringe income | .0364 | .0152 |

$R^2$ = .81

D.W. = 2.54

Table 2 continued

Optimality Equation (Price of coconut exports)

| | Coefficient | Asymptotic Standard Error |
|---|---|---|
| Intercept | 60.495 | 20.940 |
| Quantity | -.0596 | .0216 |
| Farm wage | .2331 | .0883 |
| Minimum rainfall | .0669 | .1764 |
| Lagged min rainfall | -.2325 | .1610 |
| Freight Rate | 1.280 | .5796 |
| $\lambda_0$ | -.0008 | .0097 |
| $\lambda_1$ | .0112 | .0948 |
| $\lambda_2$ | .3209 | .0960 |

$R^2 = .67$

D. W. = 1.75

## Table 3

### Simulation of Price and Quantity Effects due to a Drop in Demand

| Reduced U.S. Demand ($\alpha$) Due to Health Warnings | Price | Philippines Quantity | Fringe Quantity | World Quantity | Percentage Change in Philippines Revenues |
|---|---|---|---|---|---|
| No Change | 24.39 | 955 | 283 | 1238 | 0 |
| 5% decline | 28.26 | 861 | 278 | 1139 | 4.46 |
| 10% decline | 33.19 | 742 | 270 | 1032 | 5.73 |
| 15% decline | 36.00 | 673 | 266 | 939 | 4.02 |
| 20% decline | 39.88 | 580 | 260 | 840 | -0.70 |
| 25% decline | 42.91 | 506 | 256 | 762 | -6.78 |

Notes: Calculations are based on 1986 data. Quantities are in 1000 metric tons and prices in cents per pound.

Figure 1
Philippine Exports Under
Three Market Structures