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Publication Date
1990-08-23

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WORKING PAPER NO. 554

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

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August 23, 1990

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July 1990

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Abstract — Legal and institutional changes that centralized control of the Philippine coconut oil refining and exporting industries enabled the Philippines to exercise some of its potential dominant-firm market power. If the elasticity of demand for coconut oil continues to increase, in part due to concerns about the health risks from eating saturated fats, Philippine exports will increase slightly while the price and Philippine revenue will fall significantly within the next decade.

Key words: dominant firm, market power, coconut oil, international trade

The Creation of Dominant Firm Market Power in the Coconut Oil Export Market

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 remain a price taker. 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.

Our model generalizes the monopoly/monopsony models of Just and Chern, Bresnahan, and Lau to allow for a dominant firm-competitive fringe market structure, using a residual demand (market demand net of the competitive supply of other firms) approach, and to enable the measure of market power to vary in response to institutional and legal changes. Baker and Bresnahan, Spiller and Favaro, and Karp and Perloff (1989b) have used residual demands to study oligopoly behavior; however, those papers do not model market power as a function of institutional and legal changes as we do here.

In the next section, the world export market for coconut oil is described. The derivation of the model is presented in the second section. In the third section, the model is applied to the coconut oil export market. The estimated

model is used to determine the magnitude of the wedge between price and marginal cost and to predict the outcome of the recent health warnings on world prices and Philippine revenues in the fourth and fifth sections. The summary and conclusions are presented in the final section. The data sources are listed in an appendix.

The Coconut Oil Export Market

Several important institution, legal, and economic changes affected the potential market power of the Philippines in the coconut oil export market. We first consider those factors that tend to increase Philippine market power and then those that tend to decrease it.

The Philippines has been and is by far the largest producer and exporter of coconut oil. From 1978 to 1987, the Philippine share of world coconut oil exports averaged 79%. Two factors apparently allowed the Philippines to exercise more dominant firm market power in recent years. First, in the 1970s, the Philippine export industry changed from atomistic to highly concentrated. Second, over time, other nations reduced their capacity to export coconut oil.

The Philippine coconut oil refining and export industries became more concentrated following the imposition of a tax on copra (dried coconut meat or kernel from which coconut oil can be extracted) sales and the creation of a centralized agency (Hawes). 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 and industrial investments, and to support the Philippine Coconut Producers Federation (COCOFED). The revenues from this levy were used by COCOFED to finance its activities toward gaining market power.

At the urging of COCOFED and others, the Philippine Coconut Authority (PCA) was created in June, 1973, by presidential decree (Hawes). The PCA was a centralized agency that eventually gained control of the levies on coconut sales, seed research funding, investment in new mills 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% of the Philippine refining capacity through its subsidiary United Coconut Oil Mills (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 changed 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. Oil palm trees reach maturity faster than coconut palm trees and are better suited to the climatic conditions in Malaysia and Indonesia. Indonesia was the second largest coconut oil exporter in the 1950s and 1960s, but a 1968 revolution and the subsequent period of instability (Bunge, 1984a) caused many existing coconut plantations to be neglected, permanently reducing tree-life span and hastening the replacement of coconut acreage by oil palm. Malaysia also suffered serious racial unrest beginning in 1969; its parliamentary government was consequently suspended until 1971 as a result of this unrest (Bunge, 1984b).

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.[1] 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. 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. Nonetheless, coconut oil's share of world edible oil exports has fallen over time: In 1961-1963, coconut oil was 15% of total world edible oil exports; in 1971-1973, it was 10%; and in 1981-1983, it was 7%.

Second, consumers have become increasingly concerned about the amount and types 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.*) 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 U. S. Surgeon General in 1979, the AMA in 1979, and the U. S. Departments of Agriculture and Health, Education, and Welfare in 1980. Until recently, however, most consumers probably did not realize that the tropical oils — coconut, palm, and palm kernel — were high in saturated fats.[2] In 1989, 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*).

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, which imports 40% of the world's total shipment of coconut oil, 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. As a result, the Philippines provided virtually all the coconut oil in the United States (Hawes, p. 60). After 1974, a 1 cent-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, 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.[3] Before 1974, virtually 100% of U. S. imports were from the Philippines, whereas from 1982-1986 (1977-1986) years the Philippines accounted for only 87% (82%) of U. S. imports, even though its share of total world exports has risen over time.

The Model

A generalized dominant firm and competitive fringe model is used to describe the world coconut oil export market. The model allows for competitive,

dominant-firm, and intermediate types of behavior by the Philippines. A three-equation system is estimated: 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:

$$Q_d(p, Z, X) = Q(p, Z) - Q_f(p, X). \tag{3}$$

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

$$p(Q_d + Q_f) + \lambda p'(Q_d + Q_f)^* Q_d = MC.$$

or

$$p(Q_d + Q_f) = MC - \lambda p'(Q_d + Q_f)Q_d, \tag{4}$$

where $p(\cdot)$ is the inverse demand curve, $p'(\cdot)$ is the first derivative of the demand curve with respect to price, and $p(\cdot) + \lambda p'(\cdot)Q_d$ is its perceived marginal revenue taking into account the dominant firm's beliefs about its ability to exercise its market power (markup of price over marginal cost). That is, λ reflects the degree that its potential market power is exercised. If λ is 0, the Philippines behaves competitively; if λ is 1, it uses all its potential monopoly power with respect to its residual demand curve (standard dominant firm model); and if λ lies between 0 and 1, it exercises an intermediate level of market power. Alternatively, λ can be viewed as reflecting the ability of Philippine firms to act monolithically. That is, equation (4) may be viewed as only descriptive and not reflecting maximizing behavior. Given either interpretation, λ reflects the degree of potential dominant-firm market power exercised.

Whether λ is identified depends on the functional forms. For example, λ is not identified in strictly linear or log-linear specifications. Just and Chern, Bresnahan, and Lau show that, for a monopoly (monopsony), a sufficient condition for the identification of λ 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 rotates the market demand curve in price-output space without affecting the fringe supply curve is sufficient to identify λ. Alternatively, identification would be possible if either the fringe supply curve alone rotated or both the fringe supply and demand curves rotated. That is, there are more sufficient conditions for identification is in our dominant firm model than in the standard monopoly model.

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 λ.

The estimated world-wide demand equation (1) is

$$(1') \qquad Q = \alpha_0 + \alpha_1 p + \alpha_2 Z + \alpha_3 pZ_1 + \varepsilon_1,$$

where Z is a vector of exogenous factors that affect demand, Z_1 is a subset of these factors that enter the equation as cross products with the price, and ε_1 is a normal error term capturing random fluctuations in demand. The sources of the variables are listed in the appendix and Table 1 presents the means and standard deviations. The Z variables include prices of palm oil (the closest commonly traded substitute oil),[4] income measures in consuming nations (Gross National Product, GNP, in the United States and European Community, EC),[5] the number of articles listed in the *Reader's Guide to Periodical Litera-*

ture on fats in the diet (a proxy for public concern about saturated fats), and two time trends (other proxies for shifts in demand due to avoidance of saturated fats and the increased technical ability to substitute other oils in final products not captured by other Z variables). The time trend was split into two periods 1958-1976 and 1977-1987 (each starting at one and increasing by one each year) to capture changes in demand due to a large increase, starting in about 1977, in the number and severity of warnings concerning saturated fat intake by health groups. The Z_1 variables are the same two time trends.

The estimated fringe supply equation (2) is

(2') $$Q_f = \beta_0 + \beta_1 p + \beta_2 X + \varepsilon_2,$$

where X is a vector of exogenous variables: a dummy variable reflecting the decreased capacity due to the Indonesian revolution and Malaysian unrest (1 from 1969 on); a dummy variable indicating a return to normalcy in Malaysia (1 from 1972 on); a time trend (starting at 1 in 1958); the time trend squared; the time trend cubed, the freight rate; and ε_2 is a normal error term reflecting random fluctuations in fringe supply. The time trends are proxies for unavailable cost and weather measures.

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

$$Q_d \equiv Q - Q_f = (\alpha_0 - \beta_0) + (\alpha_1 - \beta_1 + \alpha_3 Z_1)p + \alpha_2 Z - \beta_2 X + (\varepsilon_1 - \varepsilon_2)$$

or

$$(3') \qquad Q_d = \delta_0 + (\delta_1 + \delta_2 Z_1)p + \delta_3 Z + \delta_4 X + (\varepsilon_1 - \varepsilon_2),$$

where the slope of the residual demand curve, $\partial Q_d/\partial p = \delta_1 + \delta_2 Z_1$, is negative. The Philippine marginal cost of producing and exporting coconut oil is

$$(5) \qquad MC = \theta_0 + \theta_1 Q_d + \theta_2 W,$$

where W is a vector of exogenous variables that affect the marginal costs of producing and exporting coconut oil.[6] 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). A lack of steady rain lowers coconut production in the following period. Current minimum rainfall also was included to capture immediate effects on production, though the justification for including it is weaker than for the lagged value. A dummy variable for 1986 (one in 1986, zero otherwise) is included to capture increases in the marginal cost due to unrest during the transfer of power from President Marcos to President Aquino.

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

$$(4') \qquad p = \theta_0 + \theta_1 Q_d + \theta_2 W + \frac{\lambda}{\delta_1 + \delta_2 Z_1} Q_d + \varepsilon_3,$$

where ε_3 reflects random fluctuations in marginal cost or in maximizing behavior. Using the estimates of δ_1 and δ_2 from equations (1') and (2'), λ is identified in equation (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, λ, to vary with these changes. In particular, we focus on the effects of the levy, which was first collected in 1971, and the creation of the PCA in 1973. That is,

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

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, λ_0 is the measure of the degree to which potential market power was exercised prior to 1972, $\lambda_0 + \lambda_1$ is the measure for 1972-1973, and $\lambda_0 + \lambda_1 + \lambda_2$ is the measure for 1974 on.

Estimation

Did the concentration of control of processing and exports of the Philippines lead to market power in the sense that prices are above marginal cost? To answer this question, we estimated our model using nonlinear three-stage least squares based on annual data for 1958-1987. The parameter estimates and their standard errors are given in Table 2.

The estimated demand curve has a statistically significant negative slope (based on a Wald test using a critical value of 0.05) for price throughout the sample period. The coefficients for the price of palm oil and GNP have the expected signs; the income variables' coefficients are not strictly significantly different from zero. The coefficient for the time trends (1958-1976 and 1977-1987) were not precisely measured. The price-time trend interactions indicate that the indirect demand curve became increasingly more steeply sloped from 1977 on (the curve rotated over time), presumably reflecting substitution away from coconut oil towards other oils due to technological advances and fears about saturated fats. The number of magazine articles on the health dangers of saturated fats, however, did not have a statistically significant effect. The correlation between predicted and actual values is 0.57. The Durbin-Watson statistic does not indicate significant autocorrelation for the demand equation in this system.

The fringe supply curve is not statistically significantly different from a vertical one. Parameter estimates on the political dummy variables show that

the 1969 unrest in Indonesia and Malaysia caused a statistically significant reduction in exports; however, supply increased statistically significantly with the return to normalcy in Malaysia in 1971. The freight rate does not have a statistically significant effect. The correlation between predicted and actual exports is 0.83 and the Durbin-Watson statistic is 1.7.

Based on the estimates of the optimality equation (4'), the Philippine marginal cost decreases statistically significantly with quantity exported, decreases with higher lagged minimum rainfall and increases with higher levels of the freight rate. The wage, minimum rainfall, and the political unrest 1986 dummy coefficients were not precisely measured. The correlation between predicted and actual values is 0.77; the Durbin-Watson measure of 1.6 may indicate some positive autocorrelation.[7] The second-order condition for this optimality equation (first-order condition) to be a maximum is statistically significantly negative in each year of the sample.

Based on an asymptotic t-test, we cannot reject the hypothesis that the Philippines acted as a price taker ($\lambda = 0$) prior to the imposition of the levy in 1971. The institutional changes ($\lambda_1 = -.088$) at the time of the levy do not appear to have a statistically significant effect. The changes after 1973 (following the creation of the PCA), however had a large, statistically significant effect ($\lambda_2 = 0.23$). The 95% confidence interval on λ_2 is (0.09, 0.37). Our estimate of Philippine market power from 1984 on is $\lambda_0 + \lambda_1 + \lambda_2 = 0.257$ with a t-statistic of 2.0475, which is significantly different from 0 (price taking) and from

1 (traditional dominant firm). Reestimating this system of equations assuming price-taking behavior through 1973 ($\lambda_0 = \lambda_1 = 0$), the estimate of λ_2 is .185 (asymptotic standard error = .067).

Market Power

How large a wedge between price and marginal cost does the estimated level of market power imply after 1974? As shown in equation (4), the wedge is $p - MC = \lambda p'(\cdot)Q_d$. One useful normalization of the wedge is Lerner's measure, $(p - MC)/p$. This measure is zero by definition under perfect competition where $\lambda = 0$. Lerner's measure was .33 for the entire sample period, .20 for the pre-PCA period (1959-1973) and .47 for the post-PCA period. That is, on average price was nearly twice (1.9) marginal cost after 1974; whereas prior to 1974, price averaged only 1.2 times marginal cost.

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 market power observed. With n identical Cournot firms, λ equals 1/n. Thus, the observed market power after 1974 is equivalent to that if there were 4 identical Cournot firms.

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 tropical oils that are high in 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 warnings 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 Kellogg's — announced their plans to switch from tropical to less saturated oils in their product lines within a few years.

The effects of such a decrease in demand depend on how the demand curve shifts. For example, suppose that this trend is capture by the time trend terms in our estimated demand curve. If these trends continue, the demand curve will become steeper.

We simulate what happens if these time trends continue from the last year in our sample, 1987, holding everything else constant at their 1987 levels. The effects over time of the shift in demand on Philippine exports (Q_p), fringe exports (Q_f), price (p), Lerner's measure, Philippine revenue and the residual demand elasticity are shown in Table 3 for five and ten years after 1987. The

simulations indicate that Philippine and fringe exports will remain relatively constant; Lerner's measure will decrease by a quarter or, equivalently, the residual demand facing the Philippines will be 13% more elastic; the world export price will fall by a quarter; and Philippine revenues will decrease by a fifth. In 1987, the price is 1.54 times marginal cost; whereas, if current trends in demand continue until 1997, price will be 1.36 times marginal cost. Thus, if current trends away from consuming saturated fats continue, the Philippines will lose market power and suffer a substantial drop in coconut oil export revenues.

Conclusions

The creation in 1973 of the Philippine coconut oil refining and exporting agency (PCA), allowed the Philippine coconut oil export industry to start exercising a substantial amount of its potential dominant firm market power. As a result, the Philippine's marginal costs were only half that of the world export price after the creation of the PCA. If health fears in the United States and elsewhere about the adverse effects of eating saturated fats continue to cause the demand for coconut oil to become more elastic, the world price, Philippine exports, and Philippine net revenues will fall substantially within the next decade.

Appendix

Data Sources

Several published sources were relied on to obtain the data used in this study. 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% 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. 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), deflated by the U.S. GNP deflator. The U.S. price is highly correlated with the European price.

The exports and imports of coconut oil reported 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). Because this source provides data only through 1987, our estimates only cover through 1987.

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). Rainfall levels for 1987 were not available; the mean minimum rainfall value for the 1958-1987 period was used for 1987.

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 nonplantation agriculture (1972-1987). 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 national income — U.S. GNP, EC GNP, 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 under key headings in the *Reader's Guide to Periodic Literature* (New York: H.W. Wilson Co., Various Issues).

Footnotes

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

[2] Coconut oil is higher in saturated fats, which are believed to be particularly harmful, than are most other dietary fats and oils. The percentage of saturated fats are: coconut oil, 77-92; butterfat, 54-66; palm oil, 51; beef fat, 51; lard, 41; animal fat shortening (precreamed), 44; lard, 41; chicken fat, 30; cottonseed oil, 27; margarine (fat), 18; soybean oil, 15; olive oil, 14%; peanut or corn oils, 13; sunflower oil, 11; safflower oil 9; and canola, 6.

3 In addition to the results discussed below, we estimated a system of equations that included a 1974 dummy variable affecting marginal cost 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, the system of equations reported below does not include this variable.

[4] Because the correlation between the prices of various other edible oils is very high, no other oil prices were included in the equation.

[5] Only nine countries are included in our EC figures. Spain, Portugal, and Greece, which did not join the EC until relatively late in our sample period, are not included.

[6] 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.

[7] Reestimating the system to allow for first-order autocorrelation in the optimality equation results in a $\rho = .79$ (asymptotic standard error = .18) but the resulting Durbin-Watson test statistic for the optimality equation was 2.34. Because of this "overshooting," we report the unadjusted equations.

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Table 1. Means and Standard Deviations

	Mean	Standard Deviation
Endogenous Variables		
Price of coconut oil (¢/lb)	45.35	18.45
Quantity, Philippines (1,000 metric tons)	874.72	251.22
Quantity of the fringe (1,000 metric tons)	314.09	111.51
Exogenous Variables		
Price of palm oil (¢/lb)	31.25	11.16
US Gross National Product ($ trillion)	1.77	.12
EC Gross National Product ($ trillion)*	.79	.60
Number of magazine articles		
on fats in one's diet	1.83	3.90
Philippines farm wage index	50.13	42.46
Minimum rainfall (millimeters)	20.20	12.90
Freight rate ($/metric ton)	13.55	5.07

* Does not include Spain, Portugal, and Greece, which joined the EC relatively late in our sample period.

Source: See the Appendix.

Table 2. Iterative Nonlinear Simultaneous Equation System Estimates

1959 - 1986 Annual Data

Demand equation (World coconut oil exports)

	Coefficient	Asymptotic Standard Error
Intercept	437.430	359.410
Price	-4.392	2.923
Palm oil price	17.347	5.523
US GNP	.169	.129
EC GNP	.210	.143
price x time trend for 1958-1976	-.197	.111
price x time trend for 1977-1987	-2.736	.852
time trend for 1958-1976	17.772	10.099
time trend for 1977-1987	31.071	46.080
Magazine articles	6.054	19.146

correlation between predicted and actual values = .57

D.W. = 2.11

Table 2 continued

Fringe Supply Equation (Fringe exports)

	Coefficient	Asymptotic Standard Error
Intercept	436.040	76.249
Price	-.315	.792
Time trend (1958-1987)	17.018	13.702
Time trend squared	-2.601	1.093
Time trend cubed	.068	.024
1969 dummy (1969-1987 = 1)	-171.680	43.032
1971 dummy (1971-1987 =1)	111.360	44.059
Freight rate	.552	2.243

correlation between predicted and actual values = .83

D.W. = 1.72

Table 2 continued

Optimality Equation (Price of coconut exports)

	Coefficient	Asymptotic Standard Error
Intercept	72.406	18.557
Quantity	-.059	.018
Farm wage	-.020	.088
Minimum rainfall	-.043	.167
Lagged min rainfall	-.369	.140
Freight Rate	1.080	.454
1986 dummy (1986 = 1)	12.960	11.220
λ_0	.114	.101
λ_1	-.088	.666
λ_2	.231	.081

correlation between predicted and actual values = .77

D. W. = 1.64

Table 3. Simulation of a Continuing Fall in Demand

	1987	1993	1997
Q_p (1,000 metric tons)	1023	1049	1057
Q_f (1,000 metric tons)	380	381	381
Price (¢/lb.)	22.01	18.42	16.72
Lerner's measure	.35	.31	.26
Residual demand elasticity	-2.86	-3.27	-3.78
Philippine Total Revenue ($million)	496.28	425.91	389.66