AN ECONOMETRIC ANALYSIS OF THE INDONESIAN PALM OIL INDUSTRY

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The main objective of this paper is to specify and estimate a structural model of the Indonesian palm oil industry. The principal variables considered are mature planted area, production of palm oil and domestic consumption of palm oil in Indonesia. The ordinary least squares (OLS) technique is used as equations for mature area and production have a recursive structure, and because domestic consumption of palm oil is related only to exogenous variables. The main results are as follows; Mature area is influenced inversely by lagged wage rates and directly by lagged investment in oil palm, two important determinants of planting decisions. The only variable that is significant in the estimated production function is the time trend variable, a proxy for disembodied technical progress. Finally, domestic consumption of palm oil is found to be highly elastic with respect to the own-price and the price of final goods.

INTRODUCTION

The first oil palm seeds were planted in Java in 1848, the palms being grown initially for ornamental purposes. Oil palm plantations producing edible oils were established in Sumatra in 1911 (Moll, 1987). The industry developed rapidly after the mid-sixties, especially after the launching of a series of Five-year Indonesian Development Plans (called *REPELITA*) beginning in 1969. Through government and private sector activity the planted area expanded at an average annual rate of 9.8% during the period from 1969 to 1986, from 118 940 hectares to 578 600 hectares. Oil palm cultivation also expanded to other islands of Indonesia rather than being concentrated in Sumatra as it was at first.

Expansion of the planted area was the major factor behind the increase in Indonesia's palm oil production at an average annual rate of 11.9% between 1969 and 1986: from 189 000 tonnes in 1969 to 1 269 000 tonnes in 1986 (*Table 1*). The increase in production was also due to rehabilitation programmes, the use of better management techniques and the planting of high-yielding materials. The rapid expansion in Indonesia's oil palm industry has made the country the second most important producer and exporter of palm oil in the world after Malaysia.

Palm oil is produced for domestic consumption and export (*Table 1*). Domestic consumption of palm oil fluctuated greatly during the 1970s depending on the availability of alternative oils, especially coconut oil, while in the 1980s it followed an upward trend. Domestic consumption grew at an average annual rate of 120.3% from 1969 to 1986. The domestic demand for palm oil is for both food and industrial usage. For food, palm oil is mainly used as a cooking oil and for the manufacture of margarine, while in industry it is used to make soap, animal feed, detergents and other products.

Before 1979, coconut was the main source of vegetable oil in Indonesia. However, changes in the policy on export of oils and fats have resulted in the switching of roles; palm oil is now mainly consumed domestically while coconut oil is mainly exported. Palm oil has been increasingly utilized as a buffer against imbalance between supply of and demand for vegetable oils, so that exports declined, especially after the introduction of the Government's allocation policy in 1981 (Moll, 1987), which was due to a price advantage in favour of coconut oil in the world market, *i.e.* since the international price of coconut oil was higher than that of palm oil price, it was advantageous to export more coconut oil.

TABLE 1. INDONESIA's PALM OIL PRODUCTION, DOMESTIC CONSUMPTION AND EXPORTS, 1969–1986
('000 tonnes)

Year	Production	Consumption	Exports	Exports as % of Production
1969	189	25.2	179.1	94.76
1970	217	26.1	159.2	73.36
1971	249	44.2	209.2	88.94
1972	270	33.2	236.5	87.56
1973	289	5.3	262.7	90.90
1974	348	89.5	281.2	80.80
1975	397	104.5	286.2	72.09
1976	431	29.2	405.6	94.11
1977	483	64.5	404.6	83.77
1978	532	127.5	412.1	77.46
1979	642	296.7	315.3	54.72
1980	701	178.5	320.9	43.21
1981	748	529.3	296.4	39.68
1982	884	666.5	259.5	29.36
1983	982	690.4	345.8	35.21
1984	1147	907.4	175.9	15.21
1985	1243	796.1	437.8	36.22
1986	1269	677.3	566.9	44.67

Source: Biro Pusat Statistik Indonesia, *Indikator Ekonomi*, various issues.

Furthermore, during the years from 1969 to 1986 the production of coconut oil grew at a slow rate of 3.2% per year while that of palm oil increased at 11.9% annually. The slow rate of growth of coconut oil output was mainly due to a decline in yields because of the advanced age of most coconut trees. (Coconut production is mainly a smallholder activity). Government programmes to encourage replanting with high yielding varieties can begin to affect yield only after a significant time lag. (Coconut palms begin producing at about the age of six years; maximum yield occurs around the twelfth year). As a result coconut production has not been able to meet the domestic demand for vegetable oil.

The imposition of export quotas and price control on palm oil resulted in a substantial rise in the domestic usage of palm oil: it increased from 178 500 tonnes in 1980 to more than 500 000 tonnes in 1981. As a proportion of production, domestic consumption increased drastically, from a mere 25.5% in 1980 to about 70.8% in 1981. Prior to 1979, more than 70% of the palm oil produced was exported. With the introduction of export restrictions, a much lower proportion is exported, in order to cater for domestic requirements.

Domestic consumption of processed fats and oils, especially cooking oil, has been growing steadily over the years, with an average annual growth rate of 6.7% during the period 1969 to 1986. Since Indonesia has a growing population of more than 200 million, this means that the domestic market for oils and fats has a tremendous potential in the future. The slow growth in production of coconut oil also provides a good growth potential for palm oil.

The main objective of this paper is to specify and estimate a structural model of the Indonesian palm oil industry. The variables to be discussed are mature planted area, production and, domestic consumption. The model specified and estimated in this study differs from that in Shahrir and Erna (1989). They estimated two relationships to explain production of crude palm oil and the value of Indonesian crude palm oil exports. But the equation for domestic production of palm oil fails to distinguish between production and supply, which are two different concepts. The inclusion of both price variables (domestic price of crude palm oil, domestic price of copra, export price of palm oil) and shift variables (population and GDP per capita) is difficult to justify *a priori*.

The first section below describes the specification of the model. This is followed by a description of the sources of data and an analysis of empirical results. The final section gives the conclusions.

The model

The model specified below is basically a market econometric commodity model (Labys, 1973; Adams and Behrman, 1978). Its basic structure is based on Mohammad *et al.* (1987) and it attempts to capture the salient features of the Indonesian oil palm industry outlined earlier. A more detailed description of the model is given in Sya'ad (1989).

The model consists of three behavioural equations, each set out in log-linear form as follows:

$$\log MA_t = a_0 + a_1 \log PO_{t-4} + a_2 \log PS_{t-4} + a_3 \log W_{t-4} + a_4 \log INV_{t-4} + u_{1t} \quad (1)$$

$$\log Q_t = b_0 + b_1 \log MA_t + b_2 \log L_t + b_3 \log F_t + b_4 \text{ TIME} + u_{2t} \quad (2)$$

$$\log C_t = c_0 + c_1 \log PO_t + c_2 \log PF_t + c_3 \log PC_t + c_4 \log GNP_t + c_5 D_t + u_{3t} \quad (3)$$

Where,

C = Domestic consumption of palm oil ('000 tonnes)

D = Dummy variable to represent export restrictions (D = 1 for 1979 –1986; 0 otherwise)

F = Fertilizer applications

GNP = Gross National Product (US$)

INV = Investment in oil palm (US$)

L = Number of workers (thousands)

MA = Mature cultivated area under oil palm ('000 hectares)

PC = Domestic price of coconut oil (US$)

PF = Price of final goods proxied by soap price index (1980 = 100)

PO = Price of palm oil (US$/tonne)

PS = Price of natural rubber (US$/tonne)

Q = Production of palm oil ('000 tonnes)

TIME = Time trend variable

u_i = Stochastic error terms (i=1,2,3)

W = Wage rate

The log-linear specification is chosen because of its ease of interpretation, the slope coefficients being elasticities; also it is a second-order approximation of any functional form.

Equation (1) is the mature hectarage function. Mature area is the result of past planting or investment decisions. It is hypothesized that the decision to plant depends on the price of palm oil, the price of a competing crop, the availability of capital and the prices of inputs. The competing crop is natural rubber, which competes with oil palm in land use. The wage rate proxies for the price of labour input. The explanatory variables are lagged four periods to take into account the fact that an oil palm takes four years to bear fruit after planting. The dynamic specification is simple, in that planting decisions made five years ago or more are ignored. This amounts to imposing, *a priori*, zero restrictions on the coefficients of the explanatory variables for lags five and beyond. A similar approach was adopted by Mohammad (1985).

Equation (2) specifies the production function for palm oil. Production is assumed to be a function of mature area (proxy for capital input), number of workers and fertilizer applications. These are major inputs in the production process. Mature area may be translated into stock of mature trees, the main capital input. A time trend variable is included as a proxy for disembodied technical progress.

Finally equation (3) specifies the domestic consumption of palm oil. Consumption is expected to be influenced by the local price of palm oil, the price of substitutes, income, and the price of final goods. Coconut oil is the main substitute for palm oil; hence its price is used as a proxy for the price of substitutes. Gross national product is used to proxy the income variable. The price of final goods represented by the price index for soap is included to reflect the industrial demand for palm oil in the production of manufactured consumer goods. A dummy variable is included to represent export restrictions, imposed from early 1979.

Data

The data used are from secondary sources such as publications from the Department of Agriculture Indonesia, the Central Bureau of Statistics, the Department of Trade, the Bank of Indonesia, and various other relevant government departments, and the FAO Monthly Statistical Bulletin (see the list of Other Sources). The data used in the estimation cover the period 1969 to 1986.

Empirical results

Equations (4), (5) and (6) report the OLS estimates of equations (1), (2) and (3) respectively. The original model has been modified after prior testing. OLS estimation yields consistent estimates of the parameters as equations (1) and (2) have a recursive structure and because domestic consumption of palm oil is related only to exogenous variables.

$$\log \hat{MA}_t = \underset{(8.77)}{7.655} + \underset{(0.17)}{0.0093} \log PO_{t-4} - \underset{(10.5)}{0.4328} \log W_{t-4} + \underset{(2.62)}{0.1174} \log INV_{t-4}$$

$$R^2 = 0.9638 \quad D.W = 1.73 \quad F = 33.69 \qquad (4)$$

$$\log \hat{Q}_t = \underset{(4.89)}{5.508} - \underset{(0.811)}{0.168} \log MA_t + \underset{(0.78)}{0.078} \log L_t + \underset{(6.103)}{0.119} TIME \qquad (5)$$

$$R^2 = 0.997 \quad D.W = 1.87 \quad F = 2492.5$$

$$\log \hat{C}_t = \underset{(1.99)}{153.18} - \underset{(2.56)}{5.05} \log PO_t + \underset{(2.59)}{6.24} \log PF_t + \underset{(0.64)}{1.12} \log PC_t + \underset{(1.63)}{3.22} \log GNP_t + \underset{(0.59)}{0.52} D_t \qquad (6)$$

$$R^2 = 0.8665 \quad D.W = 2.02 \quad F = 10.39$$

Figures in parentheses are absolute t-ratios.

The high R^2 values suggest that the estimated equations are good. First-order serial correlation in the residuals is not detected in any case, based on the Durbin-Watson statistics. All the coefficients of variables are correctly signed, *i.e.* are in accord with prior expectations.

The lagged wage and investment variables in the mature area equation are significantly different from zero, at the 1 per cent and 5 per cent level respectively. Planting decisions appear to be influenced by wage costs and the availability of investment capital. Current price does not influence planting decisions. This may be because the current price is a poor proxy or predictor for expected price, which really affects planting decisions.

The estimated intercept term is positive and significant at the one per cent level. The intercept represents the mean effect of omitted variables, the main ones being those that represent past planting decisions beyond lag four.

The only variable that is significant in the estimated production function is the time trend variable. There is an evidence of a secular long term growth in output due to technical progress, at an annual rate estimated at 12.6 per cent. The estimate of b_0, the efficiency parameter, is significant at the one per cent level. The logarithms of mature area and labour are not significant at the five per cent level, and we cannot therefore make any inference with confidence on the output elasticities and returns to scale. The high R^2 and highly significant F statistic indicate the presence of a multicollinearity problem[a]. The set of explanatory variables does influence the dependent variable, but the separate effects of each of the individual regressors cannot be distinguished (Intriligator 1978, p. 153). Finally the effect of the variable F, fertilizer applications, cannot be estimated because of the unavailability of data.

Equation (6) shows the estimates of the domestic consumption of palm oil equation. The estimated coefficients have the appropriate signs. Both the own-price and price of final goods variables are significant at the five per cent level. The estimated own-price elasticity of demand is – 5.05. Demand for palm oil is highly price elastic. A one per cent increase in price leads to a 5.05 per cent drop in demand. An increase in the price of final goods which use palm oil as an intermediate input leads to an increase in domestic consumption of palm oil. The implied elasticity estimate of 6.24 indicates that demand for palm oil is highly elastic with respect to the price of final goods.

The price of substitutes, *i.e.* the price of coconut oil, is not significant at conventional significance level. The income variable as proxied by real GNP is significant at the ten per cent level (one-tail test). The income elasticity of demand at 3.22 is elastic. The insignificance of the income variable at conventional level is, however, rather disturbing. It is not consistent with the observed pattern of demand development for palm oil. In countries where per capita calories derived from oils and fats are below 400 Kcal/day, a small increase in income can trigger a very large increase in the daily intake of oils and fats. The bulk of the world's people, including those who live in China, India, Indonesia, Bangladesh, and in sub-Saharan Africa, fit this profile (Duncan, 1991).

Finally the dummy variable representing export restriction is insignificant at the 5 per cent level.

CONCLUSIONS

Indonesia's oil palm industry expanded rapidly after the mid-1960s, and Indonesia is now the second most important producer and exporter of palm oil in the world after Malaysia. Oil palm is the third largest cultivated crop in Indonesia, after rubber and coffee. Higher production of palm oil has helped to satisfy the ever-expanding domestic demand for cooking oil, and it has replaced coconut oil as a major source of oils and fats.

The main findings of the study are firstly, the planting decision is very much influenced by the availability of capital and the wage rate. The finding that the planting decision is not responsive to own-price may not be tenable as current price may be a poor proxy for expected price, which really affects planting decisions. Indonesia is well endowed with suitable land and climate for oil palm cultivation. The limited availability of investment capital and rising wage costs, especially as a result of competition from the manufacturing sector could constrain the expansion of the industry.

Second, the production function is not well determined, as both labour and mature area (proxy for capital input) are not significant. But this may be attributed to the multicollinearity problem as both variables are trending together. Expansion of output due to technical progress is detected.

Finally, domestic consumption of palm oil is found to be highly elastic with respect to the real domestic price of palm oil and price of final goods as proxied by the price index of soap. This means that the domestic consumption of palm oil is very responsive to its own price and price of final goods.

[a]The simple correlation between $\log(MA_t)$ and $\log(L_t)$ is 0.97965. The estimation of the production function in intensive form, *i.e.* assuming constant returns to scale, yield more sensible results. The estimates are as follows:

$$\ln\left(\frac{\hat{Q}}{L}\right)_t = 0.49485 + \underset{(5.4363)}{0.67676}\ln\left(\frac{MA}{L}\right)_t + \underset{(6.0586)}{0.033626}\ TIME$$

$$R^2 = 0.7099 \quad F = 39.1$$

Figures in parentheses are absolute t-ratios. The implied estimate of output elasticity with respect to the land input is 0.677.

High price of final goods could be due to high demand or low supply or both. This has encouraged manufacturers of final goods to increase production and this will entail higher demand for raw materials, including palm oil. Even though the price of substitutes (represented by price of coconut oil) and income are not significant, their coefficients have the right signs. The coefficient of the income variable is only significant at the ten per cent level.

One of the interesting results is that the dummy variable in the domestic consumption function, indicating the imposition of an export quota, is not significant. This means that export restriction is not an important determinant of domestic consumption of palm oil. The result shows that with or without export restriction, the quantity of palm oil exported is merely a residual of the system. This is probably because the implementation of other policies or incentives concurrently, such as the policy on domestic price of palm oil has, resulted in the export of palm oil becoming less attractive.

In conclusion, the rapid growth of palm oil production occurred at a time when domestic consumption of final goods of oils and fats was on the rise and when coconut oil production was showing a decline. In other words the emergence of palm oil was opportune for replacing coconut oil. At least for the time being the expansion in palm oil production is needed to meet the increasing domestic demand for oils and fats. It will not be therefore any threat to other palm oil producing countries in the near future.

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