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MODELING SUPPLY OF INDONESIAN COOKING OILS

Catur Sugiyanto[1]
Universitas Gadjah Mada

ABSTRAK

*Estimasi model penawaran untuk komoditi tahunan (*perennial crops*) terbukti tidak mudah. Estimasi terhadap model penawaran untuk berbagai komoditi telah dilakukan, namun tidak menghasilkan kesimpulan yang konklusif. Dalam paper ini dipaparkan hasil estimasi model penawaran minyak kelapa sawit dan kelapa untuk kasus di Indonesia dengan menggunakan metode ECM dan PAM. Ternyata model PAM masih lebih baik. Jumlah observasi yang sedikit dan begitu banyaknya intervensi pemerintah di sektor kelapa sawit dan kelapa mungkin menyebabkan lemahnya model ECM.*

Key words: *Supply, Perennial crops, ECM, PAM*

INTRODUCTION

Estimating demand and supply of commodities are key to analyzing welfare of the respective market participants. The consumers and producer's surplus, which are usually used as a welfare measurement, are calculated from these demand and supply estimates. Therefore, correct formulation of the demand and supply function become crucial to the analysis.

Commonly, previous studies have quantified supply responses of perennial crops in a partial adjustment context. While such a modeling strategy is commonly found in perennial crop literature (French and Matthews,1971; Askari and Cumming, 1976; French, King and Minami, 1985; French and Nuckton, 1991; and Alston et. al., 1995; among others), it has some limitations. For example, the adjustment should reflect movement in the exogenous variables that affect the target variables and the partial adjustment model may exclude important explanatory variables (Nickell,1985; Domowitz and Elbadawi, 1987; Mustacelli, 1988; Hallam and Zanoli, 1993). In addition, the use of a lagged dependent variable in the formulation can mask problems with non-stationarity in the data (Granger and Newbold, 1974; Phillips, 1986).

In addition, different approaches were used in estimating supply response. The long-run approaches define the supply response in terms of total planting or available mature trees. The farmers are assumed to harvest all of the available mature fruits, regardless of its price. Therefore, the available mature acreage is equivalent to the quantity of crude palm supplied if yield is constant. This approach is not justifiable, since farmers may not harvest when the price of crude palm oil is lower than the cost of harvesting. The second approach, the short-run approach, defines quantity of crude palm produced as the quantity supplied. This study follows the second approach because farmers may not harvest when the cost of harvesting is higher than the price of crude

[1] The author thanks to the reviewer for the useful comment. He is responsible for the remaining error and omissions.

palm oil received and harvest all of the fruits, otherwise.

Estimating supply of perennial crops, such as coconut and palm oil, is difficult. Several researchers attempted to estimate this function but the results were not conclusive. Supply of Indonesian palm and coconut oil were estimated by Suryana (1986), Larson (1990, and 1996), and Ekaputri (1996), among others. These authors used partial adjustment mechanism in their studies which may suffer from the above problems. The alternative approach to the problem is by specifying the models based on unit roots, co-integration, and error-correction mechanism.

This paper to attempts to analyze the Indonesian supply of palm oil and coconut oil based on time series properties of the data. The next section, section 2, provides review of the literature, followed by theoretical background and models used in this study. Section four describes data, method, and discussion on the findings. The last section, section five concludes.

LITERATURE REVIEW

There are two processes of producing palm oil and coconut oil: production of fruit and production of cooking oils. Activities to produce palm or coconut fruit are long-run processes due to the biological nature of production. Production of perennial crops is different from the production of annual crops because of the long gestation period between initial input and first output, the extended period of output flowing from the initial investment (planting) decision, and the gradual deterioration of the productive capacity of the plants (French and Matthews, 1971). Cooking oil production is a short-run process as it can be adjusted more easily in response to fluctuations in the economy.

1. Long-run Supply Function

A long-run supply function for perennial crops describes the factors affecting potential output. Key variables which define the potential output include the area planted, stock of trees, planting, or acreage change. We can consider these variables as capital, with the long-run supply function describing how agents accumulate capital overtime through planting and removal.

Planting of perennial crops can be viewed as acquiring capital. The decision to produce a perennial crop is similar to other investment decisions with a long-term plan. Therefore, planting (and removal) has been modeled based on investment theory. In general, any resource has alternative forms of use. The type of use chosen represents the best alternative. In the investment model, expected profits from perennial crops, expected profits from alternative crops, and other forms of land use determine the desired planting and removal area. The expected profits give guidance to the producers on the activity in which they should engage.

In practice, different ways to specify the planting equation have been used. Past profits and past investments (French and Matthews, 1971), deflated average prices (Carman,1981; French and Nuckton, 1991), past prices (Hartley *et.al.,* 1987),) expected net present value (Alston *et. al.*,1995), profit (Bellman and Hartley, 1985), and risk (Dorfman and Hein, 1989) have been used to specify planting. The specifications have varied depending on the specific producer decision process, the nature of cost and profit variation, and data availability.

The actual planting may deviate from the desired planting because of input restrictions, misjudgments, rigidities, inertia, and other frictions (French, King, and Minami, 1985). Any government intervention such as tax, subsidy, or license can affect expected profits and the use of resources. In the above studies, growers are assumed to change the desired (target) planting and harvesting based on the partial adjustment mechanism, and price expectations are specified by a variety of mechanisms, including naive expectations or adaptive expectations (Nerlove, 1958, 1979; French and Matthews,1971; Askari and Cummings, 1976; French, King, and Minami, 1985; and Alston *et. al.* ,1995), quasi-rational expectations (Hallam and Zanoli, 1993), and rational expectations, (Eckstein, 1985).

When removal is mainly due to biological factors, it is modeled in a slightly different manner to plantings. Its level is proportional to the total acreage, which varies with age distribution of the trees. However, if more concern is put on the optimum age of trees that need to be removed (and replanted), then factors affecting the decision to remove are similar to those of the decision to plant (invest).

Overall, planting commonly denotes a target of planting and is specified as a function of expected returns (prices or profits); returns of alternative crops, the size of plantation, and the government intervention. The partial adjustment and adaptive expectation framework are widely used to translate the desired variable into its actual value. Models are estimated in levels and deflated prices are used.

2. Short-run Supply Function[2]

In this study production is used to specify a short-run supply function. For perennial crops like palm oil and coconut, once trees are planted and start to bear fruit the next decision is whether to harvest or to leave the fruit on the tree. This decision is faced annually until the time to replace the tree arrives. A short-run supply function describes the quantity harvested (production). The quantity produced has been used to define supply response for perennial crops (Behrman, 1968; Bateman, 1968; Frederick, 1965; Wickens and Greenfield, 1973; Lopez and You,1993; Chan, 1962; Wharton, 1963; Stern 1965; Hartley *et.al.*,1987; and Fleming and Hardaker,1986).

The quantity of fruit that can be harvested is limited by the availability of ripe fruit. The size of the crop available for harvesting depends upon the profile of the tree stock: the age distribution, variation in yields for different ages of trees, production cycle, abandonment, and elimination.

The Nerlovian supply model, which employs a partial adjustment mechanism and an adaptive expectation, has been used to specify the short-run supply function (French and Matthews,1971; Askari and Cummings, 1976; and Hartley *et.al.*,1987). Any model which includes a partial adjustment mechanism and an adaptive expectation mechanism has a disturbance term that is serially correlated. Therefore, a single equation estimation method (the ordinary least squares, OLS) results in inefficient estimates. In addition, the partial adjustment mechanism assumes a static adjustment to a fixed planting target. This method has been called into question (Nickell, 1985; Domowitz and Elbadawi, 1987; Mustacelli, 1988; Hallam and Zanoli, 1993). The introduction of new government policy amongst various other disturbances may influence factors affecting the planting decision and change the target of output supplied. The adjustment should reflect movement in the exogenous variables that affect the target variables. In addition, the use of the lagged dependent variable in the partial adjustment model can mask problems with non-stationary in the data (Granger and Newbold, 1974; Phillips 1986).

The basic assumption is that the major variable influencing the harvest is the expected profitability of the commodity considered

[2] This section is taken from Sugiyanto (2001) “The Impact of Trade Liberalization on the Indonesian Palm Oil and Coconut Oil Markets,” Gadjah Mada International Journal of Business, vol. 3, no 3, pp 239-267.

(French and Matthews, 1971). The expected profitability is a function of expected prices and costs of harvest. In addition, the expected prices of the alternative commodities and government policies may influence profitability of the commodity concerned. Since continuous production cost data are usually unavailable, it is often necessary to develop some alternative means of approximating profitability. Some authors have used moving averages of the total revenue (Rae and Carman,1975), net revenue (French, King and Minami, 1985; French and Nuckton, 1991), or average prices (French and Matthews, 1971; Carman, 1981; and Albisu and Blandford, 1983). When data on profit is available then profit is used (Alston *et.al.*, 1995). The use of the current price as a basis for the harvest decision and past price to represent the planting decision is a common occurrence (Bateman, 1968; Behrman, 1968; Frederick, 1965; Wickens and Greenfield, 1973; Lopez and You, 1993; Chan, 1962; Wharton, 1963; Stern, 1965; Fleming and Hardaker, 1986; and Shively, 1998).

Government policy influences how the market operates. Any government intervention such as tax, subsidy, or license can affect expected profits. Any decrease (increase) of export tax, for example, can increase (decrease) the exporters price which influences the volume exported and affects the farmers in various ways through the changes in prices.

In any year, the producer sets the quantity produced or marketed to maximize profits. It is limited by the potential output (the availability of the ripe fruit) and varies with the average return, net return, and price. These variables are in real terms and the relationship has been estimated both in levels (Frederick, 1965; French and Matthews, 1971; Hartley *et.al.*, 1987) and in logarithms (Fleming and Hardaker, 1986; Lopez and You, 1993).

3. Previous Works on Estimating Indonesian Crude Palm Oil and Coconut Supply Functions

The above methods of specifying supply response have been implemented in analyses of the Indonesian palm oil and coconut oil markets (Suryana, 1986; Larson, 1990; Ekaputri, 1996). Larson examined the impact of an export tax on the Indonesian palm and coconut oil sectors for the period 1970 to 1988. He applied a vintage production function to model a potential output of palm oil. Potential outputs are yields multiplied by the acreage of bearing trees. The yield is assumed to vary with age distribution of the trees. However, limited data on age distribution of the trees meant that the above vintage production function could not be fully implemented, and yields were assumed invariant with respect to age distribution.

The area of coconuts was modeled by using a time trend because most of the growers are small-landholders. The time trend accounted for more than 90 percent of coconut variation throughout different areas.

For the short-run palm oil supply function, the quantity of crude palm oil supplied is the dependent variable. The independent variables include a yield cycle; measured by the ratio of actual to potential output lagged one year, an input price (the fertilizer price), and an output price (the world crude palm oil price). In addition, the area of bearing trees is included to represent production capacity. In the estimated relationship all coefficients in the crude palm oil supply function were incorrect: the yield cycle, the ratio of the actual to potential output lagged one year, and the output price (the world crude palm oil price).

In the short-run coconut supply function, the number of the coconuts harvested is the dependent variable. The area harvested, the previous level of production, and the coconut price are independent variables. In the estimated relationship, all the variables had correct signs, but only the area harvested significantly influenced supply.

Suryana (1986) focuses his study on the trade prospects of Indonesian palm oil. He based his analysis on annual data from 1970 to 1984. The Armington international trade model was used to describe the market of fats and oils for each country, a Nerlovian supply function was employed to model the palm oil supply function. The quantity supplied (i.e. the crude palm oil) was the dependent variable. The supply model was written as a single equation, and describes how the quantity supplied responses to variations in the mature acreage, price lagged for one year, last period stocks, lag of quantity supplied, and plantings lagged five years. Prices were deflated by the consumer price index. This modeling approach is similar to Larson's approach in the sense that it uses mature acreage and previous plantings to indicate potential output.

The supply model was estimated in levels, and was not initially very satisfactory. The Durbin-h statistic was -7.5 which confirmed a serial correlation problem, while the coefficient of determination (R^2) was 0.99 (almost perfect). These statistics indicate a spurious result. The variation in the supply was highly determined by the lag values of the quantity supplied. Acceptable estimates were obtained by correcting serial correlation using a NLIN procedure.

Ekaputri (1996) analyzes the impact of changes in international and domestic markets on the supply response of the Indonesian palm oil producers using annual data from 1967 to 1995. In contrast to Larson and Suryana, Ekaputri defined supply of palm oil in terms of acreage of oil palm trees, namely of two-year moving average of the acreage based on lags of two and three years. A single equation representing the Indonesian supply of palm oil was estimated. A two-year moving average of palm oil prices and coconut prices at lags two and three years were used to measure the returns of palm oil production. In addition, the influences of international markets were measured by similar two-year moving averages of the Malaysian palm oil production, the ratio of the Malaysian palm oil to the sum of the Indonesian and Malaysian production multiplied by palm oil price. A dummy variable to account for the presence of the Nucleus Estate Small-land holder program in 1978 was included. The use of the previous lagged values was meant to reflect the expectation and capture the availability of alternative crops.

A double log functional form without the dummy variable was the best estimated model among functional forms used. The dummy variable representing the government intervention in the sector (the Nucleus Estates Small-Landholder program) did not significantly affect supply (the size of the oil palm acreage) which is counterintuitive since the program was designed to expand the number of oil palm plantations. The regression statistics, a high R^2 and F-statistic were satisfactory, but serial correlation existed. As a result the Cohrane-Orcutt method of correcting the serial correlation problem was employed and reported short-run elasticities were based on the corrected equation.

The estimated elasticities of crude palm oil supplied with respect to prices are reported in table 1.

The differences in findings are not very surprising in light of the different variable definitions, and periods of analysis. With the above mixed result there is a need to carefully examine the supply of palm oil and coconut oil. One may include a policy changes variable in the model, and use time series properties specify models.

Table 1. Estimates of the Short-run Elasticities of the Indonesian Crude Palm Oil and Coconut Supply

Dependent variable	Palm Oil Price	Coconut Price
Crude Palm Oil Production 1970-1987, Larson (1990)	-.02 (P_{t-2})	-
Crude Palm Oil Production 1970-1984, Suryana (1986)	.09 (P_{t-1})	-
Acreage 1967-1995, Ekaputri (1996)	.36 ($P_{t-2,3}$)	-.13 ($P_{t-2,3}$)
Coconut Production 1970-1987, Larson (1990)- in a linear function	-	0.18 (P_{t-2})

Note: $P_{t-2,3} = (P_{t-2} + P_{t-3})/2$.

THEORETICAL BACKGROUNDS

This section outlines the theoretical background used to derive the empirical models for the Indonesian supply of palm oil and coconut oil in the short-run. Supply functions are derived by assuming profit-maximizing. The short-run supply function describes the relationship between the actual output and other economic factors including the potential output.

All models are aggregated: they explain the behavior of producers and consumers as a group based on certain assumptions about individual producers' and consumers' behavior. In particular, producers are assumed to face similar products and factor prices, to have similar production functions, and to attempt to maximize profits (or minimize costs), (French and Matthews, 1971).

1. Short-run Supply Function

The short-run supply functions are specified in terms of the quantity harvested or marketed. The quantity harvested is limited in any year by potential output (the size of ripe fruit). The crop available for harvesting depends upon the profile of the tree stock: the age distribution, variation in yields for different ages of trees, production cycle, abandonment, and elimination.

How much ripe fruit harvested depends upon the profitability of harvest, namely the output price and the cost of harvesting. Since a continuous data on harvesting cost are not available we will only use output price in the analysis. Consider there is a certain level of optimum output harvested Q^*_t which maximizes profits. This optimum level is a function of an expected price of output at period t, p^e_t and other variables which affect harvest decision such as government policy variables, denoted by a vector h_t. We can write it in a linear function as:

$$Q^*_t = \beta_0 + \beta_1 p^e_t + \beta_2 h_t. \qquad (1)$$

Due to imperfect information, shocks, and other rigidities Q^*_t may not be realized in every period. When the actual production deviates from its optimum the producer incurs some costs namely the opportunity costs of deviating from the optimum level of harvest (C_1) and the costs of adjusting the actual harvest toward the optimum level (C_2). The cost for being away from the maximum profits results from harvesting too much (or too little). Harvesting too much may need additional transportation fleet that increase cost, or harvesting too little makes the processing facilities underutilized. Also, rainfall can cause transporting fruit from the plantation to the processing point difficult, decreasing the amount of fruit to be harvested and to be processed. Similarly, looting can also reduce the amount of ripe fruit processed. For example, the adjustment cost takes the form of cost in rescheduling harvest which may require more workers to monitor harvest and ripe fruit, or adding and reducing the number of trucks to carry fruits. Differences in the optimum may be due to changes in exogenous variables. Then, the problem is how the producer achieves the optimum harvest to maximize profits.

Following Domowitz and Elbadawi (1987), we can specify these cost functions for each time period as: $C_{t1} = \chi_1 (Q_t - Q^*_t)^2$ which reflects the cost for being away from the optimum and $C_{t2} = \chi_2 \{(1-L) Q_t - \varphi (1-L) x_t\}^2$ which represents the cost to adjust the production toward the optimum. Q_t denotes the actual harvest at period t, Q^*_t the optimum harvest in period t, and χ's are parameters. x_t is a vector of variables influencing the harvest and is assumed to be a linear function of p^e_t, the expected output price at period t, and h_t, other explanatory variables, which include government policy variables, φ is a row vector that weights each element in $(1-L)\mathbf{x_t}$ and L is a lag operator. Applying the Domowitz and Elbadawi's cost specification to the perennial crop case, the producer's total cost function becomes:

$$C_t = \chi_1 (Q_t - Q^*_t)^2 + \chi_2 \{(1-L)Q_t - \varphi(1-L)x_t\}^2. \quad (2)$$

Assume that the producer minimizes the total costs. Minimizing C_t with respect to Q_t, and solving for Q_t, results in:

$$Q_t = \chi Q^*_t + (1-\chi) Q_{t-1} + (1-\chi) \varphi(1-L)x_t \quad (3)$$

where $\chi = \chi_1 / (\chi_1 + \chi_2)$

Substituting Q^*_t in equation (1) into equation (3) yields:

$$Q_t = \chi (\beta_0 + \beta_1 p^e_t + \beta_2 h_t) + (1-\chi) Q_{t-1} + (1-\chi) (1-L)p^e_t + (1-\chi) (1-L)h_t. \quad (4)$$

In its general form, equation (4) can be written as an autoregressive-distributed lag AD(1,1) of the form:

$$Q_t = \alpha_0 + \alpha_1 p^e_t + \alpha_2 h_t + \alpha_3 Q_{t-1} + \alpha_4 p^e_{t-1} + \alpha_5 h_{t-1} + v_t \quad (5)$$

where

$\alpha_0 = \chi\beta_0$,
$\alpha_1 = \chi\beta_1 + (1-\chi)$,
$\alpha_2 = \chi\beta_2 + (1-\chi)$,
$\alpha_3 = (1- \chi)$,
$\alpha_4 = -(1-\chi)$,
$\alpha_5 = -(1-\chi)$, and v_t is a white noise.

Equation (5) is more general than a partial adjustment harvest equation which resulted by restricting $\alpha_4=\alpha_5= 0$ in equation (5). Moreover, equation (5) also encompasses several dynamic models as further special cases (Hendry *et. al.*, 1984, p.1042). Specifically, equation (5) can be rewritten as an error correction model (ECM) to obtain short-run elasticities of the supply function and avoid a spurious regression problem (Hendry *et. al.*, 1984, Domowitz and Elbadawi, 1987, Domowitz and Hakkio, 1990, Hallam and Zanoli, 1993). Consider

$$\Delta Q_t = \alpha_1 \Delta p^e_t + \alpha_2 \Delta h_t - \chi(Q_{t-1} - \beta_0 - \beta_1 p^e_{t-1} - \beta_2 h_{t-1}) + v_t, \quad (6)$$

where the next to the last term constitutes the lagged error term obtained from the optimum harvest of equation (1), when the optimum (Q^*_t) is equal to the actual harvest (Q_t). This is equivalent to having a co-integration regression based on equation (1) where (Q^*_t) is equal to the actual harvest (Q_t) and the lagged of the residual are put into equation (6). The α*'s* represent the short-run elasticities and β*'s* the long-run elasticities[3].

3.2. Empirical Models

The models are built from the previous works cited in the literature review, formulated to follow the above theory, and specified to make them relevant to the Indonesian palm oil and coconut oil markets. The econometric model of palm oil market and coconut oil market are similar. The economic activities in

[3] The long-run elasticity in the sense that the optimum and the actual output are equal in the long-run. This is different from the long-run potential output which is obtained from the long-run supply function: area of mature acreage x yield.

these markets are quite similar, including factors determine potential production, supply of cooking oils, and demand for cooking oils. The main differences between these two markets are the production gestation periods, the storability of the commodity, and the degree of government intervention (the export tax in the palm oil market). This study refines the previous researches by introducing the time series properties of the data in the estimations.

2.1. The Short-run Supply of Crude Palm Oil, Coconut Oil, and Coconut Models

Supply models of palm and coconut oils have been estimated both in the quantity of output supplied (Larson, 1990 and Suryana, 1986), and the change in acreage (Ekaputri, 1996). However, the outcomes from these models were not satisfactory. The supply model here is specified to incorporate recent policy changes and will consider the time series characteristics of the data. In line with Behrman (1968), Frederick (1965), Wickens and Greenfield (1973), Lopez and You (1993), Chan (1962), Wharton (1963), Stern (1965), Hartley *et.al.* (1987), and Fleming and Hardaker (1986), quantity supplied is the output supplied.

Consistent with Suryana (1986), Larson (1990), and Lopez and You (1993), the model is written in logarithmic values and prices are deflated by the consumer price index. Logarithmic transformation is used to obtained elasticities. The general form of the supply function of crude palm oil is

$$LQCPO_t = \beta_0 + \beta_1\, LQPCPO_t + \beta_2\, LWDCPO_t + \beta_3\, LXRATES_t + w_t, \quad (7)$$

where L denotes logarithmic values, $QCPO_t$ is the crude palm oil production, $QPCPO_t$ is the area of bearing oil palms that serves as the potential production of crude palm oil, $WDCPO_t$ is the price of crude palm oil, $XRATES_t$ is the US-dollar relative to rupiah exchange rates, and w_t is the disturbance terms.

For coconut oil, the supply function is

$$LQCOIL_t = \beta_0 + \beta_1\, LQCOCO_t + \beta_2\, LPCC_t + \beta_3\, LPDCO_t + v_t, \quad .....(7')$$

where L denotes logarithmic values, $QCOIL_t$ is the coconut oil production, $QCOCO_t$ is the coconut production representing the potential production of coconut oil, PCC_t is the coconut price representing cost of producing coconut oil, $PDCO_t$ is the domestic price of coconut oil, and v_t is the disturbance terms.

Finally, the supply function for the coconut is

$$LQCOCO_t = \beta_0 + \beta_1\, LQPCOCO_t + \beta_2\, LPCC_t + e_t, \quad (7''')$$

where L denotes logarithmic values, $QCOCO_t$ is the coconut production, $QPCOCO_t$ is the area of bearing coconuts, PCC_t is the coconut price, and e_t is the disturbance terms.

Previous studies have used a partial adjustment mechanism in transforming the target variable into the actual variable, as well as adaptive expectation mechanism in formulating price expectation. Several problems have been identified regarding the use of these mechanisms (Nickell, 1985, Domowitz and Elbadawi, 1987, Mustacelli, 1988, Hallam and Zanoli, 1993). The adaptive expectation model leads to autocorrelation problems in the error term which requires a special estimator. Therefore, we follow the Domowitz and Elbadawi's approach and specify dynamic behavior using an error correction model (ECM) to alleviate the above problems. The ECM requires that variables are integrated of the same order and are co-integrated (Engle and Granger, 1987). Note that we could also write the model in an autoregressive distributed lag, AD(1,1) model if the co-integration is confirmed (Johnston and Dinardo, 1997, and Banerjee *et.al.*, 1993). This approach also eliminates problems with nonstationarity in the data (Granger and Newbold, 1974, Phillips, 1986). Further, the AD(1,1) model is more robust (Hsiao and Fujiki, 1998).

The error correction forms of the above supply functions of crude palm oil, coconut oil, and the coconuts are as follows, respectively:

$$\Delta LQCPO_t = \alpha_0 + \alpha_1 \Delta LQPCPO_t + \alpha_2 \Delta LWDCPO_t + \alpha_3 \Delta LXRATES_t - \chi (LQCPO - \beta_0 - \beta_1 LQPCPO - \beta_2 LWDCPO - \beta_3 LXRATES)_{t-1} + w_t, \quad (8)$$

$$\_LQCOIL_t = \alpha_0 + \alpha_1 \Delta LQCOCO_t + \alpha_2 \Delta LPCC_t + \alpha_3 \Delta LPDCO_t - \chi (LQCOIL - \beta_0 - \beta_1 LQCOCO - \beta_2 LPCC - \beta_3 LPDCO)_{t-1} + v_t, \quad (8')$$

$$\Delta LQCOCO_t = \alpha_0 + \alpha_1 \Delta LQPCOCO_t + \alpha_2 \Delta LPCC_t - \chi (LQCOCO - \beta_0 - \beta_1 LQPCOCO - \beta_2 LPCC)_{t-1} + e_t. \quad (8'')$$

An important factor that influences the short-term agricultural supply for a semi-subsistence at the household level is the own-consumption (Flemming and Hardaker, 1986). However, the fresh coconut consumption has been very small (0.03 percent from 1970 to 1997), and there is no own crude palm oil consumption, so this problem can be set aside. The other factors that influence household supply include the change of mixed products consumed, the leaving of the crops in the field, the variation of harvest date, and the change of the level of input in production and marketing. The decision to collect or not to collect nuts can be determined by variable costs of coconut production and marketing, such as the costs of un-husking, harvesting, chopping, and drying the nuts into copra, as well as packaging and transportation costs. Since data on these costs may not be available, we can only use current price to identify profitability of harvest. Moreover, casual observation indicates that the cost of harvesting oil palm fruit is low compared to the world price of crude palm oil. Therefore, we can expect that ripe fruit will always be harvested[4].

Price expectation is based on lagged prices, and there may be a lagged response to expected prices. The lagged response may be due to inertia or habit formation.

Another issue related to the household supply function is the effect of an internal wage on output (Sonoda and Maruyama, 1999). Farmers may also work in off-farm sectors. Any exogenous shock (change) may affect the (real) wage received by these farmers. Such a change can affect the internal wage that determines the equilibrium of a labor market in the household. Response to any shock in the economy on the cooking oil sectors can be decomposed into two parts: direct and indirect effects. The direct effect influences the price and output supplied. The indirect effect influences the internal wage, consumption, and labor supplied. In this research, it is assumed that the direct effect (a positive influence of price on output supplied) dominates the indirect effect (an increase of price reduces real wages, labor supplied, and consumption).

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[4]*The largest part of the cost of producing palm oil is the investment (including land acquisition, preparation, and planting). These are fixed costs. The Indonesian government provides cheap credits for such investment so that the fixed cost is reduced. Once the trees are planted, the cost of palm oil production is the only variable cost, which is less than $200 per ton of crude palm oil and does not fluctuate appreciably. Since the world palm oil price has been above $400 per ton, we can use the expected output price to evaluate the net present value of the oil palm plantation project.*

DATA, ESTIMATION, AND DISCUSSION

Data. Data are used in this study are published, secondary data. This study covers the period 1970 to1997 (annual). All of the data on quantities (production, consumption, exports, and imports) are from various issues of the *Oil World* publications and the Directorate General of Plantation Estates of the Government of the Republic of Indonesia. Data on prices are from *Oil World* and *Economic Indicators*. The deflator used is the consumer price index (CPI). The summary of the variables is reported in the Appendix 1.

Estimation. We started with the stationarily test of the data series. If their mean and variance are changing overtime, the series may not be stationary. A series is (weakly) stationary if its mean, variance, and covariance are constant for all time (t). In this situation, regression using non-stationary series may lead to a spurious result (Granger, 1981, Granger and Newbold, 1974). The series move together overtime but they are independent (no causal relationship). The regression often characterized by high coefficient of determination (R^2) but low Durbin-Watson statistic indicates serial correlation. Provided that the series are integrated of the same order, e.g., I(1), co-integrated, and the model is dynamic, estimating a model with standard procedures will give identical parameters and their variances (Johnston and Dinardo, 1997, Appendix 8.1 and Banerjee *et.al.*, 1993). Still, some of the standard multivariate test statistics are not appropriate.

The simple correlations among the variables used are small. This indicates that there is no multicollinearity problem. High correlations are found between the dependent variable and its lag. The small correlation between dependent variable and independent variables also indicate a weak explanatory power of the models. The correlation coefficient matrix is presented in the Appendix 2.

In any single equation, stationarily (time series) properties of the variable are examined. If all variables in the equation are non stationary, I(1), we proceed with testing the co-integration. If co-integration is confirmed, we can estimate the model either in the error correction form or in levels.

To assess the adequacy of a single equation regression we use joint tests: the joint conditional mean and variance test (Mc Guirk *et.al.*, 1993). The advantage of these tests over the individual test is that they allow us to implement tests with fewer maintained hypotheses. **The joint conditional mean test** includes tests of functional form, independence (auto correlation), and parameter stability, by assuming (maintained hypotheses) normality and a constant variance. **The joint conditional variance** simultaneously examines the static and dynamic heteroskedasticity as well as variance stability under the assumption that the model has correct functional form whose parameters are stable, with normal and independent residuals.

We compare the above models with the available estimates from the reviewed literatures. We consider the signs and the size of estimates as the key to evaluation. The statistical adequacy of the model is indicated by the p-values of the tests. A low p-value provides evidence against the null hypothesis.

1. Supply Models Under ECM

In this section we report the estimated models of: short-run supply of crude palm oil, coconut oil, and coconuts. Estimations are performed using the Shazam econometric program (White, 1993). For all cases, the model use of time series procedures does not help in specifying acceptable models. The difficulties associated with this procedure may be due to a number of reasons. The number of observations is too small for adequate use of these procedures, and there have been many changes occurring in these markets and in the country that undermine the capture of the underlying patterns in prices and quantities. Over the last thirty years the oil palm trade policy has changed several times, the government has intervened the market through the Joint Marketing Office to administer the allocation of crude palm oil and crude palm oil price, the export tax rate has changed, and the government has devaluated its domestic currency (rupiah). In addition, the power of the test procedure is low (Enders, 1995).

1.1. Supply of Crude Palm Oil

In this study, current prices of competing crops will be included to account for alternative returns from activities other than harvesting. The own prices enter as current price, lagged one year, and lagged k years where k be the gestation period of planting the crop. The error correction form of the supply for crude palm oil is written in equation (9):

$$\Delta LQCPO_t = \alpha_0 + \alpha_1 \Delta LQPCPO + \alpha_2 \Delta LWDCPO_t + \alpha_3 \Delta LWDCPO_{t-1} + \alpha_4 \Delta LWDCPO_{t-3} + \alpha_5 \Delta LXRATES_t + \alpha_6 \Delta LPDCO_t - \chi (LQCPO - \beta_0 - \beta_1 LQPCPO - \beta_2 LWDCPO_t - \beta_3 LWDCPO_{t-1} - \beta_4 LWDCPO_{t-3} - \beta_5 LXRATES - \beta_6 LPDCO)_{t-1} + v_t \quad (9)$$

where $LQCPO_t$ crude palm oil production (tons), LQPCPO the potential production of crude palm oil (tons), LWDCPO price of crude palm oil (Rupiah per kilogram), LXRATES the US dollar-rupiah exchange rates (Rupiah per US dollar), and LPDCO price of coconut oil (rupiah per bottle).

Palm oil and coconut oil are the main cooking oils in Indonesia. In the 1970s coconut oil was the most oil consumed, while in the 1980s and later period consumers substituted palm oil for coconut oil. Such change might be related to the increased of palm oil production, low price of palm cooking oil compare to coconut oil, and the government policy to limit exports of palm oil between 1979 and 1987. The prices of palm cooking oil and coconut oil can measure returns from selling crude palm oil.

The Indonesian government has been intervening the domestic market of cooking oils. For the last thirty years, three trade policy regimes have been implemented: from 1970 to 1978, the exports of palm oil were promoted while exports of copra and coconut oil were limited, in the second period, 1979-1987, exports of palm oil were limited and conversely export of copra and coconut oils were allowed, and the rest of the period, 1988 to present, indicated a transition toward policies to promote a free trade. We will include dummy variables to measure the impact of the above trade policies on supply of crude palm oil: D78 equal to 1, when export of crude palm oil were promoted between 1970 and 1978 and equal to 0 (zero) for the rest of the periods; and D87 equal to 1 when exports of crude palm oil were limited between 1979 to 1987 and equal to zero for other years.

The stationary tests show that LQCPO the crude palm oil production is integrated of order one I(1), and its first difference DLQCPO is I(0), LWDCPO and ln $LWDCPO_{t-1}$ the crude palm oil and its lagged are I(1), and their first difference DLWDCPO and DLWDCPO1, both are I(0). $LWDCPO_{t-3}$ lagged three years of crude palm oil is I(0). LQPCPO the potential production of crude palm oil is I(0), LPDCO price of coconut oil is I(0), LXRATES the US dollar-rupiah exchange rates is I(1) and its first difference DLXRATE is I(0). The results from the stationary tests are reported in appendix 3.

There was no evidence of co-integration among the above non stationary variables (LQCPO, LWDCPO, $LWDCPO_{t-1}$, and LXRATES). Therefore, we include these variables in their first difference. The estimated model of the supply for crude palm oil becomes:

$$DLQCPO = \beta_0 + \beta_1\, LQPCPO + \beta_2\, DLWDCPO + \beta_3\, DLWDCPO1 + \beta_4\, LWDCPO3 + \beta_5\, DLXRATE + \beta_6\, LPDCO + \xi_t, \qquad (9.1)$$

where DLQCPO the first difference of the crude palm oil production, LQPCPO the potential production of crude palm oil, DLWDCPO the first difference of the current price of crude palm oil, DLWDCPO1 the lagged of the first difference of the price of crude palm oil, LWDCPO3 the third lagged of the price of crude palm oil, DLXRATE the first difference of the US dollar-rupiah exchange rates, and LPDCO the domestic price of coconut oil.

The initial estimate of the above model has incorrect signs on parameters associated with DLWDCPO, LWDCPO3 (the crude palm oil prices), and DLXRATE (the US dollar relative to Rupiah exchange rates). There was also a weak evidence of non-normality (p-value = 0.05), and a large error on observation number 10. When we included a dummy variable (D10) to account for this large error, the non-normality problem was solved and only parameter associated with DLWDCPO had incorrect sign. This incorrect sign remain when we included dummy variables to account for change in trade policies which promoted export of crude palm oil between 1970 and1978 (D78) and restricted export of crude palm oil between 1979-1987 (D87).

We also tried to include lagged of crude palm oil production (DLQCPO1) and a time trend (YEAR), but the incorrect problem remains. When we dropped the crude palm oil price (DLWDCPO), the estimate model indicated problem of autocorrelation and incorrect signs on DLXRATE (the US dollar relative to Rupiah exchange rates) and LPDCO (the domestic price of coconut oil). Therefore, we keep the crude palm oil price (DLWDCPO) since its impact on the crude palm oil production is less than that of the lagged of the crude palm oil price (DLWDCPO1 and LWDCPO3), and there is no violation on the diagnostic tests.

The sign of the dummy variable to account for the impact of export promotion policy from 1970 to 1978 (D78) was incorrect. Both policy dummy variables (D78 and D87) had statistically small effects on crude palm oil supply. We dropped them and the sign and magnitudes of the estimated parameter were not affected by much. We also dropped the time trend, since it has negative sign which is counter intuitive because there has been an increasing production of crude palm oil. The best estimated supply of crude palm oil as follows.

$$\begin{aligned} DLQCPO = {} & \underset{(-1.3)}{-0.27} \; \underset{(-2.1)}{-\,0.07}\, DLQCPO1 \; + \\ & \underset{(1.86)}{0.01}\, LQPCPO \; \underset{(-1.9)}{-\,0.053}\, DLWDCPO \\ & + \underset{(2.1)}{0.07}\, DLWDCPO1 + \underset{(1.3)}{0.04}\, LWDCPO3 \\ & + \underset{(0.69)}{0.03} LPDCO + \underset{(2.8)}{0.11}\, D10 \qquad ....(9.2) \end{aligned}$$

The estimated model has an $R^2 = .61$. Figures in the parenthesis are t statistics. The Jarque-Bera normality test is 0.43 (p-value = 0.80), confirms normality of the residuals. The joint conditional mean test is not rejected: there is no evidence of structural break (p-value = 0.44), no evidence of incorrect functional form (p-value = 0.68), and no evidence of autocorrelation (p-value = 0.36). The joint conditional variance test is not rejected which shows that there is no evidence of mid sample variance change (p-value = 0.16), no evidence of heteroskedasticity, both static (p-value = 0.64) and dynamic (p-value = 0.20).

As it was expected, the supply responses positively to the increase of potential production (LQPCPO), and price of the substitute (coconut oil, LPDCO). However, this model has negative elasticity with respect to its own price.

1.2. The Supply of Coconut Oil Model

Similar to the palm oil supply model, the quantity of coconut oil supplied is influenced by the short-run and long-run factors. The long-run factor is the potential coconut oil production which is reflected by the amount of coconuts produced each year. The short-run factors are the prices: the coconut price (LPCC), the coconut oil price (LPDCO), the palm oil price (LPPO), and the US dollar relative to Rupiah exchange rates (LXRATES). The error correction form of the coconut oil supply function in line with equation 9 is as follows.

$$\begin{aligned}\Delta LQCOIL_t = {} & \alpha_0 + \alpha_1\, \Delta LQCOCO + \\ & \alpha_2\, \Delta LPDCO_t + \alpha_3\, \Delta LPDCO_{t-1} + \\ & \alpha_4\, \Delta LPDCO_{t-7} + \alpha_5\, \Delta LXRATES_t + \\ & \alpha_6\, \Delta LPCC_t + \alpha_7\, \Delta LPPO_t - \\ & \chi\, (LQCOIL - \beta_0 - \beta_1\, LQCOCO - \\ & \beta_2\, LPDCO_t - \beta_3\, LPDCO_{t-1} - \\ & \beta_4\, LPDCO_{t-7} - \beta_5\, LXRATES - \\ & \beta_6\, LPCC - \beta_7\, LPPO)_{t-1} + v_t \qquad (10)\end{aligned}$$

where $LQCOIL_t$ be the coconut oil production, LQCOCO the coconut production (represents the potential production of the coconut oil), LPDCO the price of coconut oil, LXRATES the US dollar relative to Rupiah exchange rates, LPCC the coconut price, and LPPO the price of palm cooking oil.

In addition, an increase of palm oil price also can increase the quantity of coconut oil supplied. This is because palm oil is a substitute for coconut oil. An increase of palm oil price may induce consumers to switch from palm oil to coconut oil. The quantity of coconut oil supplied increases to fulfill this additional demand.

Similar to the case of supply for crude palm oil, we will include dummy variables to measure impacts of the change of the trade policies on supply of coconut oil: D78 equal to 1, when export of copra and coconut oil were limited between 1970 and 1978 and equal to 0 (zero) for the rest of the periods; and D87 equal to 1 when exports of copra and coconut oil were allowed between 1979 to 1987 and equal to zero for other years. We expect that D78 will be negative and D87 positive.

The stationary tests show that LQCOIL the quantity of coconut oil production is integrated of order 0, I(0); LQCOCO the coconut production is I(1) and its first difference DLQCOCO is I(0); LPPO the palm cooking oil price is I(1) and its first difference DLPPO is I(0); LPDCO the domestic price of coconut oil and its lagged price LPDCO1 are I(0); LPDCO7 the lagged seven years of the domestic coconut oil price is I(1) and its first difference DLPDCO7 is I(0); LPCC the coconut price is I(0); and LXRATES the US dollar relative to Rupiah exchange rates is I(1) and its first difference DLXRATE is I(0).

There was no evidence of co-integration among the non stationary I(1) variables: the quantity of coconut production (LQCOCO), the palm cooking oil price (LPPO), the lagged seven years of the domestic coconut oil price (LPDCO7), and the US dollar relative to Rupiah exchange rates (LXRATES). Therefore, we included these variables in their first difference. The supply of coconut oil model to be estimated becomes:

$$\begin{aligned}LQCOIL = {} & \beta_0 + \beta_1\, DLQCOCO + \\ & \beta_2\, LPDCO + \beta_3\, LPDCO1 + \\ & \beta_4\, DLPDCO7 + \beta_5\, LPCC + \\ & \beta_6\, DLXRATE + \beta_7\, DLPPO + \xi_t, \qquad (10.1)\end{aligned}$$

where $LQCOIL_t$ be the coconut oil production, DLQCOCO the first difference of the coconut production, LPDCO the price of coconut oil and its first and seventh lagged length (LPDCO1 and DLPDCO7), LPCC the coconut price, DLXRATE the first difference of the US dollar relative to Rupiah exchange rates, and DLPPO the first difference of the price of palm cooking oil.

The initial estimate of the above model has incorrect sign on the parameter associated with the palm cooking oil price (DLPPO). The model also indicates evidence of structural break (p-value = 0.001). The inclusion of dummy variables to account for trade policy changes (D78 and D87) helped to solve the structural break problem. However, the parameter associated with the palm cooking oil price (DLPPO) and the trade policy dummy variable which denotes the promotion of coconut oil export (D87) are incorrect. When we dropped this dummy variable (D87), the model become unstable (p-value = 0.01), has both static (p-value = 0.04) and dynamic (p-value = 0.04) heteroskedasticity. The inclusion of the lag of the dependent variable (the quantity of coconut oil supplied QCOIL1) helped removed these diagnostic problem but not the incorrect sign of the parameter associated with the palm cooking oil price (DLPPO).

We decided to include the price of crude palm oil (DLWDCPO) in place of the price of palm cooking oil (DLPPO) to relate the supply of palm oil and coconut oil. The sign of the parameter associated with the crude palm oil (DLWDCPO) is correct. However, the parameter associated with the coconut oil price (LPDCO) is incorrect. The estimated model with has a correct sign on the parameter associated with the coconut oil price (LPDCO) is obtained when we dropped variable which represents the potential production of coconut oil (DLQCOCO). For the case of the crude palm oil supply model, we could not obtain correct parameter associated with the current crude palm oil price (DLWDCPO) even when we dropped the potential production of crude palm oil (LQPCPO). We report this estimate as follows.

$$\begin{aligned} LQCOIL = {} & \underset{(3.8)}{3.68} + \underset{(2.6)}{0.35}\ LQCOIL1 + \\ & \underset{(0.28)}{0.05}\ LPDCO + \underset{(2.2)}{0.32}\ LPDCO1 + \\ & \underset{(2.1)}{0.14} DLPDCO7 - \underset{(-2.6)}{0.41}\ LPCC + \\ & \underset{(0.59)}{0.07}\ DLXRATE + \underset{(0.90)}{0.09}\ DWDCPO - \\ & \underset{(-2.4)}{0.17}\ D78 \qquad ....(10.2) \end{aligned}$$

where R^2 = .83 and figures in parenthesis are t statistics. The Jarque-Bera normality test is 0.86 (p-value = 0.65), which confirms normality. The joint conditional mean test confirms the model is stable (p-value = 0.10), has a correct functional form (p-value = 0.79), and is not serially correlated (p-value = 0.14). The joint conditional variance test shows there is no evidence of a mid sample variance change (p-value = 0.42), no static heteroskedasticity (p-value = 0.26), and no evidence of dynamic heteroskedasticity (p-value = 0.48). The above estimated model also has correct signs.

Similar to the supply of crude palm oil, the supply of coconut oil has a small size of elasticity with respect to its own current price (LPDCO) but high elasticity with respect to the lagged of its own price (LPDCO1 andL PDCO2). These estimates indicate that it takes some time for the producer to adjust their quantity supply in response to change in the current price. Once the adjustment is completed, the response of change in the quantity of coconut oil supplied increases.

The other variables indicate correct relationship: the coconut price (LPCC) has negative impact on the coconut oil production since coconut is the main inputs for production, the US-Dollar relative to Rupiah exchange rates (LXRATES) measures expected return from exporting coconut oil, and the crude palm oil representing the substitute fo the coconut oil. The supply of coconut oil response positively to increase of thee last two variables. Lastly, the limitation of copra and coconut oil export between 1970 to 1978 (D78) has negative impact on coconut supply.

1.3. The Supply of Coconut

This quantity of coconuts supplied is influenced by both the short-run and long-run variables. The long-run variable is the potential coconut production (LQPCOCO): the availability of bearing coconut trees multiplied by yield. The short-run variables influence the decision to harvest coconuts or leave them on the trees. These variables are: the coconut price (LPCC), the coconut oil price (LPDCO), the palm oil price (LPPO), and the US dollar relative to Rupiah exchange rates (LXRATES). The error correction form of the coconut supply function is as follows.

$$\begin{aligned}\Delta LQCOCO_t &= \alpha_0 + \alpha_1\, \Delta LQPCOCO + \\ &\alpha_2\, \Delta\, LPCC_t + \alpha_3\, \Delta LPCC_{t-1} + \\ &\alpha_4\, \Delta LPCC_{t-7} + \alpha_5\, \Delta LXRATES_t + \\ &\alpha_6\, \Delta LPPO_t + \alpha_7\, \Delta LPDCO_t - \\ &\chi\, (LQCOCO - \beta_0 - \beta_1\, LQPCOCO - \\ &\beta_2\, LPCC_t - \beta_3\, LPCC_{t-1} - \beta_4\, LPCC_{t-7} - \\ &\beta_5\, LXRATES - \beta_6\, LPPO - \\ &\beta_7\, LPDCO)_{t-1} + v_t \qquad \ldots\ldots(11)\end{aligned}$$

where ln stands for logarithmic operator such that the estimated coefficients are elasticities. The variables are: $LQCOCO_t$ coconut production, LQPCOCO the potential production of coconut, LPCC the price of coconut, LXRATES the US dollar relative to Rupiah exchange rates, LPPO the price of palm oil, LPDCO the price of coconut oil, and v_t disturbance term.

The stationary tests show that LQCOCO the quantity of coconuts supplied is integrated of order 1, I(1) and its first difference DLQCOCO is I(0), LQPCOCO the potential production of coconut is I(1) and its first difference DLQPCOCO is I(0), LPCC the coconut price is I(0), LPCC1 the lagged of coconut price is I(0), LPCC7 the lagged seven years of the coconut price is I(1) and its first difference DLPCC7 is I(0), LXRATES the US dollar relative to Rupiah exchange rates is I(1) and its first difference DLXRATE is I(0), LPPO the domestic palm cooking oil is I(1) and its first difference (DLPPO) is I(0), and LPDCO the coconut oil price is I(0).

There was no evidence of co-integration among the nonstationary I(1) variables: LQCOCO the quantity of coconut supplied, LQPCOCO the potential production of coconut, LPCC7 the lagged seven years of the coconut price, LXRATES the US dollar relative to Rupiah exchange rates, and LPPO the domestic palm cooking oil. Therefore, we included these variables in first difference. The supply of coconut model to be estimated is as follows.

$$\begin{aligned}DLQCOCO &= \alpha_0 + \alpha_1\, DLQPCOCO + \\ &\alpha_2\, LPCC + \alpha_3\, LPCC1 + \alpha_4\, DLPCC7 + \\ &\alpha_5\, DLXRATE + \alpha_6\, \Delta DLPPO + \\ &\alpha_7\, LPDCO \qquad (11.1)\end{aligned}$$

where DLQCOCO is the first difference of the coconut production, DLQPCOCO the first difference of the potential production of coconut, LPCC and LPCC1 are prices of coconut (current and its first lag), DLPCC7 the first difference of the coconut price lagged seven years, DLXRATE the first difference of the US dollar relative to Rupiah exchange rates, DLPPO the first difference of the price of palm oil, and LPDCO the price of coconut oil.

The initial estimate shows that there is only one parameter has a correct sign (LPCC). Moreover, there are evidence of serially correlated disturbance (p-value 0.008), change of variance between the first and second half of the sample (p-value = 0.03), and a static heteroskedasticity (p-value = 0.006). We include the lag of the coconut supplied (DLQCOCO1) to account for the serial correlation problem. Still, the serial correlation (p-value = 0.02) and the static heteroskedasticity (p-value = 0.000) problems remain. The above incorrect signs problem also unchanged. The inclusion of the mid sample dummy did not help to solve the problems. We included the trade policy dummy variables (D78 and D87) to account for the impacts of these trade policies on the supply of coconuts, but it did not help.

A better estimated model was obtained when we dropped the above dummy variables and include a time trend (YEAR): the signs of the lagged of the coconut supplied (DLQCOCO1), the potential coconut production (DLQPCOCO), and the current coconut prices (LPCC) are correct. However, we still have five parameters associated with the lagged of the coconut prices (LPCC1 and DLPCC7), the first difference of the palm cooking oil price (DLPPO) and the US dollar relative to Rupiah exchange rates (DLXRATE) which are incorrect. In addition we have a static heteroskedasticity problem (p-value 0.0001). We included a dummy variable to account for a large disturbance on observation number 12 (D12), and obtained a model which has a change of the variance between the first and second sample (p-value = 0.004) but the above static heteroskedasticity problem is solved. However, the problem of incorrect signs are observed on the parameters associated with the potential of coconut production (DLQPCOCO), the US dollar relative to Rupiah exchange rates (DLXRATE), and the domestic price of coconut oil (LPDCO).

When we included a dummy variable to account for a large disturbance on observation number 7 (D7), the above change of variance problem was not completely solved (p-value 0.04). The incorrect signs problem are observed on the coefficient associated with the potential of coconut production (DLQPCOCO), the US dollar relative to Rupiah exchange rates (DLXRATE), the first difference of the palm oil price (DLPPO), and the domestic price of coconut oil (LPDCO).

The estimated model without any violation on the diagnostic tests was obtained after we include a dummy variable to account for a large disturbance on observation number 3 (D3). In this step we left with 2 problems: first, the problem of incorrect signs on the coefficient associated with the potential of coconut production (DLQPCOCO), the first difference of the coconut price lagged seven years (DLPCC7), the first difference of the palm oil price (DLPPO), and the domestic price of coconut oil (LPDCO) and second, a large disturbance on observation number 9. At last, we included a dummy variable D9 to account for this large disturbance and faced with the problem of incorrect signs on the coefficient associated with the potential of coconut production (DLQPCOCO), the first difference of the coconut price lagged seven years (DLPCC7), the first difference of the palm oil price (DLPPO), and the domestic price of coconut oil (LPDCO).

Since there is no violation on the diagnostic tests we started to drop variables from the model one by one to obtain an estimated model which has parameters with correct signs. We started with the first difference of the coconut price lagged seven years (DLPCC7) whose t-statistic is the largest, then the domestic price of coconut oil (LPDCO), the first difference of the palm oil price (DLPPO), and finally the potential of coconut production (DLQPCOCO). The size of the other estimated parameters were change in response to this removal process but the sign were remained unchanged. We also include a dummy variable to account for a large disturbance on observation number 4 (D4). There was no violation on the diagnostic tests along the process of reducing the number of explanatory variable. We end up with the following supply of coconut model.

$$\underset{(0.15)}{DLQCOCO = 0.01} + \underset{(0.3)}{0.002\ DLQPCOCO} + \underset{(0.93)}{0.001\ LPCC} + \underset{(10.6)}{0.14\ D12} + \underset{(8.8)}{0.12\ D7} + \underset{(5.3)}{0.07\ D3} + \underset{(4.3)}{0.06\ D9} - \underset{(-3.4)}{0.05\ D4} \quad ......(11.2)$$

where $R^2 = .92$ and figures in parenthesis are t statistics. The Jarque-Bera normality test is 1.65 (p-value = 0.43) which confirms normality. The joint conditional mean test confirms the model is stable (p-value = 0.90), has correct functional form (p-value = 0.10), and no evidence of autocorrelation (p-value = 0.12). The joint conditional variance test shows that there is no evidence of mid sample variance change (p-value = 0.64), no evidence of heteroskedasticity, both static (p-value = 0.70) and dynamic (p-value = 0.53).

In this study, a direct comparison may not be correct, because the dependent variable is the first difference of the quantity supplied (for the case of crude palm oil and coconut). We may state that the estimated parameters represent a short-run effect of the own price on the quantity supplied. An estimated coefficient of -0.05 means a one percent increase of the own price will cause the growth of the quantity supplied decrease by 0.05. In this case we found a - 0.05 for the case of crude palm oil and 0.001 for coconut supply. For the case of coconut oil, the estimate short-run elasticity with respect to the own price is 0.05, which fall within the above range.

Here we obtained a correct sign and size of the estimated elasticity supply of coconuts with respect to its own price. However, we need to take out several observations that may reduce the power of the estimation. The data are highly fluctuating that make estimation difficult and less reliable.

2. The Estimates of Supply Models with PAM

The partial adjustment models are used in response to the above difficulties in estimating the error correction model. The ease in estimation, consistent estimated signs of the parameters, simple and parsimoniousity is the advantage of this model.

2.1. The Estimated Supply of Crude Palm Oil Model

The Indonesian government has influenced the market of palm oil. It required the state-own plantations and their small land holder partners to sell around 80 percent of their crude palm oil to the designated domestic processors at the set price. The rest of the domestic crude palm oil produced are free from this requirement. Therefore, the price of crude palm oil represents the weighted average of the world crude palm oil price, the domestic price at the free market, and the government price.

The short-run crude palm oil supplied is specified as the quantity of crude palm oil harvested. The estimated model of crude palm oil supply is

$$QCPO_t = \underset{(2.3)}{1.03} + \underset{(34.5)}{0.93\ QCPO_{t-1}} + \underset{(0.59)}{0.04\ WDCPO345} \quad .....(12)$$

where all variables are in natural logarithms, $QCPO_t$ the crude palm production (tons), *WDCPO345* the price of crude palm oil (a moving average of lag 3, 4, and 5 years) rupiah per kilogram.

The estimated model has adjusted R^2 of .99. The figures in the parentheses are t statistics. The Jarque-Bera normality test is 0.93 (p-value = 0.62), confirming normality of the residuals. The joint conditional mean test is not rejected; there is no evidence of structural break (p-value = 0.05), no evidence of incorrect functional form (p-value = 0.10), and no evidence of autocorrelation (p-value = 0.74). The joint conditional variance test is not rejected indicating no evidence of mid sample variance change (p-value = 0.89), no evidence of heteroskedasticity for both static (p-value = 0.89) and dynamic (p-value = 0.54).

2.2. The Estimated Supply of Coconut Oil Model

This study focuses on coconut oil produced by industrial sector. This oil is produced from copra (dried coconuts). On the average, 63 percent of the coconut produced between 1970 and 1997 was dried into copra. More than 80 percent of this copra was processed into coconut oil, while the rest was exported.

The estimated model of coconut oil supply is

$$QCOIL_t = 1.5 + 0.69\,QCOIL_{t-1} + \underset{(0.95)}{0.23\,RPDCO123} \quad \text{....(13)}$$
$$\qquad\qquad (1.4) \qquad (5.57)$$

where all variables are in natural logarithmic, *QCOIL* is the coconut oil production (tons) and *RPDCO123* is the domestic price of the coconut oil (a moving average of lag 1, 2, and 3 years) rupiah per kilogram.

The above equation has an adjusted R^2 of .52 and the figures in the parentheses are t statistics. The Jarque-Bera normality test is 0.44 (p-value = 0.80), confirming normality. The joint conditional mean test confirms that the model is stable (p-value = 0.10), has a correct functional form (p-value = 0.93), and is not serially correlated (p-value = 0.73). The joint conditional variance test shows no evidence of a mid sample variance change (p-value = 0.05), no static heteroskedasticity (p-value = 0.04), and no evidence of dynamic heteroskedasticity (p-value = 0.90).

2.3. The Estimated Supply of Coconut Model

The quantity of coconuts supplied in the market is the quantity of coconuts produced. On the average, 63 percent of the coconut production between 1970 and 1997 was dried into copra, which then either were exported or processed into coconut oil. The rest was either consumed as fresh in the form of coconut milk or processed food. The growers (farmers) might sell coconuts directly or dry them into copra and then ship to the market. It is expected that the quantity of coconuts supplied responds positively to the increase of coconut price. The estimated model of supply of coconuts is:

$$QCOCO_t = 1.34 + 0.9\,QCOCO_{t-1} + \underset{(1.85)}{0.004\,PCC789} \quad (14)$$
$$\qquad\qquad (2.1) \qquad (20.9)$$

where all variables are in natural logarithmic, *$QCOCO_t$* the coconut production (tons) and *PCC789* the coconut price (moving average of prices lag 7, 8, and 9 years) rupiah per unit.

The model has an adjusted R^2 of .98. The Jarque-Bera normality test is 0.27 (p-value = 0.87) confirming normality. The joint conditional mean test confirms that the model is stable (p-value = 0.53), has correct functional form (p-value = 0.69), and demonstrates no evidence of autocorrelation (p-value = 0.52). The joint conditional variance test shows no evidence of mid-sample variance change (p-value = 0.06), and no evidence of heteroskedasticity, both static (p-value = 0.017) and dynamic (p-value = 0.09).

We admit that only for the coconut model does these elasticities approach any degree of statistical significance. As discussed in the literature review, the above difficulties are also found in Suryana (1986) and Larson (1990). All of the models show high influence of the past (lagged) dependent variable. This confirms the strong effect of the partial adjustment mechanism. Overall, we obtain estimated parameters which are consistent with other findings. For the Indonesian case, the short-run crude palm oil elasticity with respect to its own price was 0.09 for the period of 1970-1984, as estimated by Suryana (1986); -0.02 for the period of 1970-1987 (Larson, 1990); and 0.38 (using acreage change) for the period of 1967-1995 (Ekaputri, 1996). The short-run own-price elasticity of perennial crops supply was around 0.5, for the less developing countries as reviewed by Askari and Cummings (1976). The range was between -0.001 (for the case of the Malayan rubber) and 0.69 (for the case of Nigerian oil palms). A more recent estimate that has a negative (-.12) short-run own-price elasticity of supply is also found in Lopez and You (1993) for the case of Haitian coffee. In this study, we obtain the short-run estimate of elasticities for palm oil of 0.04, coconut 0.004, and coconut oil 0.23, that fall in the above range.

CONCLUSION

Using annual data from 1970 to 1997, the theoretically motivated structure of the markets was estimated with both time series and conventional procedures. In almost all cases the modeling of these markets following the time series properties of variables did not produce acceptable findings in terms of signs of the coefficients. The failure of these procedures may reflect the small sample characteristics of the data and the number of changes that have occurred in these Indonesian markets.

In response to this difficulty, more conventional single equation relationships were used to obtain parameter estimates for policy analysis. Consistent with the literature, the lagged dependent variables were included, and time trends was used to reduce the effects of possible spurious regression. These led to parameter estimates that were more reasonable and consistent with apriori expectations.

The estimates of own-price supply elasticities for palm oil were 0.04 and 0.23 for coconut oil, which falls within the range of elasticities for less developing countries. The short-run own-price elasticity of perennial crop supply was around 0.5 for less developing countries (as reviewed by Askari and Cummings (1976)). The range was -0.001 in the case of the Indonesian rubber and 0.69 in the case of Nigerian palm oil.

The elasticity of crude palm oil exports, with respect to the world market price, was low (0.05) which may be interpreted as a result of the previous high level of control by the Indonesian government. The market may not have previously been able to fully respond to price fluctuations due to government control.

We encountered difficulties in estimating the model by using time series procedures. The limited number of observations and the presence of large structural changes may be the source of the problem. Moreover, we are also aware that the power of the time procedures has some limitations as well. Readers should be careful when applying this procedure in similar situations. Failure of time series procedures in this context should be carefully investigated.

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APPENDIX 1

The Summary Statistic of Variables Used in the Study

	N	MEAN	STD. DEV	VARIANCE	MINIMUM	MAXIMUM	UNIT	
ACM	28	1840532.69	526058.27	.276737E+12	938989.30	2580026.00	Hectare	Area Mature Coconut
PCC	28	163.11	134.26	18024.62	18.55	497.15	Rupiah/Unit	Domestic Price Coconut
PDCO	28	681.87	537.59	289001.50	78.99	1937.40	Rupiah/Bottle	Domestic Price Coconut Oil
QFC	28	598.85	110.07	12115.59	469.94	781.77	Ton	Volume Fresh Coconut Consumed
RICE	28	1012.75	845.91	715555.37	34.80	2964.90	Rupiah/Kg	Price Rice-Medium Quality
YR	28	150.64	177.89	31643.65	3.44	644.87	Index	Real Income 1985 constant price
PWCO	28	572.7857	222.2743	49405.88	215	1155	US$/ton	World Coconut Oil Price CIF-Rotterdam
APM	28	470813.46	433089.61	1.87567E+11	84500	1622503	Hectare	Area Mature Oil Palm
PPO	28	444.31	378.12	142972.58	65.54	1424.2	Rupiah/Kg	Price Palm Cooking Oil in Jakarta
PWCPO	28	46.09	14.45	208.81	21.1	72.9	US Cent/kg	Price Palm Oil CIF Rotterdam
XRATES	28	1329.00	1119.17	1252531.93	378	5700	Rupiah/US $	US Dollar-Rupiah Exchange Rates
PDCPO	28	478.84	452.00	204307.94	73.54	2345.57	Rupiah/Kg	Price Crude Palm Oil - fob Belawan, Sumatera Island
PRUB	28	1652.77	3082.58	9502291.15	102.74	16666	US Cent/lb	Price Rubber CIF Rotterdam
QCOCO	28	1915149	517160.2	2.67E+11	1202902	2828922	Ton	Total Coconut Production- Dir. General of Estates
QCPO	28	1666017	1550863	2.41E+12	216827	5385458	Ton	Total Crude Palm Oil Production-Dir. General Estates
WDCPO	28	520.75	531.69	282697.75	88.01	2758.43	Rupiah/Kg	Weighted Average Domestic CPO Price

APPENDIX 2

The Correlation Matrices

SUPPLY			
CRUDE PALM OIL	LQCPO	LQCPO1	LWDCPO35
LQCPO1	-0.99654	1	
LWDCPO35	3.19E-02	3.48E-02	1
COCONUT OIL	LCOIL	COIL1	LRPDCO13
COIL1	-0.68128	1	
LRPDCO13	-0.18183	0.31773	1
COCONUT	LQCOCO	LQCOCO1	RPCC789
LQCOCO1	-0.97591	1	
RPCC789	-0.14914	3.22E-03	1

APPENDIX 3

Results from Stationary Tests, using the Phillip-Perron's Method

1. Series in logarithmic values

Variable Name	Constant No Trend	Constant Trend	Conclu-sion	Variable Definition:
LIP	-2.15	-6.66	I(0)	Planting of palm
LIC	-5.52	-5.58	I(0)	Planting of coconut
LQPOC	-0.50	-2.26	I(1)	Volume of palm cooking oil consumed
LQCOC	-2.07	-1.92	I(1)	Volume of coconut cooking oil consumed
LQOTHER	-3.91	-4.5	I(0)	Volume of other oil consumed
LQCPO	0.08	-3.01	I(1)	Volume of crude palm oil produced
LQCPO1	0.28	-2.93	I(1)	Volume of crude palm oil produced lag 1
LQCOCO	-0.46	-2.80	I(1)	Volume of coconut production
LQFC	-0.76	-2.03	I(1)	Quantity of fresh coconut consumed
LQCOIL	-2.86	-4.0	I(0)	Coconut oil production
LQCOIL1	-3.09	-3.71	I(0)	Coconut oil production lagged 1
LQXCPO	-0.62	-2.80	I(1)	Volume of crude palm oil exports
LQXCO	-3.30	-4.61	I(0)	Volume of coconut cooking oil exports
LQPCPO	-0.34	-4.3	I(0)	Potential crude palm oil production
LQPCOCO	-0.5	-0.3	I(1)	Potential coconut production
LQTOTAL	-0.73	-2.8	I(1)	The Quantity Index
LSHPO	-0.32	-3.25	I(1)	Share of palm cooking oil consumed
LSHCO	2.87	-0.24	I(1)	Share of coconut cooking oil consumed
LSHOTHER	-3.88	-5.00	I(0)	Share of other cooking oil consumed
TAX	-2.61	-2.61	I(1)	Export tax on crude palm oil
LYR	-2.22	-1.53	I(1)	Gross domestic product 1985 price
LRQPOC	-7.3	-7.3	I(0)	Ln (QPOC/QOTHER)
LRQCOC	-5.1	-6.5	I(0)	Ln (QCOC/QOTHER)
LAP1	0.56	-3.8	I(0)	Lagged area of planted palm
LAC1	-2.95	-0.95	I(0)	Lagged area of planted coconut
LIC1	-5.6	-5.8	I(0)	Lagged planting of palm

I(0), and I(1) signify that the series are stationary, or nonstationary

2. Series in first difference of the logarithmic values

Variable Name	Constant No Trend	Constant Trend	Conclu sion	Variable Definition: First Difference of
DLQPOC	-6.17	-6.13	I(0)	Volume of palm cooking oil consumed
DLQCOC	-5.73	-6.41	I(0)	Volume of coconut cooking oil consumed
DLQCTOT	-6.05	-6.49	I(0)	Volume of total vegetable oil consumed
DLQCPO	-5.99	-5.91	I(0)	Volume of crude palm oil produced
DLQCPO1	-5.95	-5.92	I(0)	Lagged Volume of crude palm oil produced
DLQCOCO	-5.24	-5.12	I(0)	Volume of coconut production
DLQFC	-5.76	-5.69	I(0)	Quantity of fresh coconut consumed
DLQXCPO	-8.49	-8.43	I(0)	Volume of crude palm oil exports
DLQPCOCO	-6.6	-6.4	I(0)	Potential production of coconut
DLQCOCO1	-6.7	-6.6	I(0)	Lagged of potential production of coconut
DQTOTAL	-8.2	-8.1	I(0)	The quantity index
DQTOTAL1	-8.0	-7.9	I(0)	Lagged quantity index
DLSHPO	-7.05	-6.85	I(0)	Share of palm cooking oil consumed
DLSHCO	-5.85	-7.50	I(0)	Share of coconut cooking oil consumed
DTAX	-4.84	-4.74	I(0)	Export tax on crude palm oil
DLWM	-4.56	-4.94	I(0)	Rainfall in Medan
DLYP	-7.82	-8.27	I(0)	Yield of palm
DLYC	-6.72	-7.14	I(0)	Yield of coconut
DLYR	-3.59	-4.24	I(0)	Gross Domestic Product 1985 price

I(0), and I(1) signify that the series are stationary, or nonstationary.

3. Real price in logarithmic values

Variable Name	Constant No Trend	Constant Trend	Conclu sion	Variable Definition
LPPO	-2.16	-1.99	I(1)	Domestic price of palm cooking oil
LPWCPO	-3.13	-3.04	I(0)	World price of crude palm oil
LPDCPO	-2.82	-2.82	I(1)	Domestic price of crude palm oil
LPRUB	-1.75	-3.75	I(0)	World price of natural rubber
LPCC	-4.11	-4.06	I(0)	Domestic price of coconut
LPDCO	-3.60	-3.55	I(0)	Domestic price of coconut cooking oil
LPWCO	-0.73	-3.62	I(0)	World price of coconut cooking oil
LRICE	-7.61	-8.95	I(0)	Price of medium quality rice
LWDCPO	-2.50	-2.13	I(1)	Weighted average of crude palm oil price
LXRATES	-2.31	-1.96	I(1)	US-Dollar rupiah exchange rates
LCPI	-2.7	-1.8	I(1)	The consumer price index

I(0), and I(1) signify that the series are stationary, or nonstationary.

4. Lagged real prices in logarithmic values

Variable Name	Constant No Trend	Constant Trend	Conclu -sion	Variable Definition
LPPO1	-2.22	-2.00	I(1)	Domestic price of palm cooking oil
LPWCPO1	-3.27	-3.76	I(0)	World price of crude palm oil
LPDCPO1	-2.87	-3.66	I(0)	Domestic price of crude palm oil
LPRUB1	-2.04	-3.65	I(0)	World price of natural rubber
LPDCO1	-3.45	-3.39	I(0)	Domestic price of coconut cooking oil
LPWCO1	-1.42	-3.90	I(0)	World price of coconut cooking oil
LXRATES1	-2.31	-1.94	I(1)	US-Dollar rupiah exchange rates
LRICE1	-7.48	-8.77	I(0)	Price of medium quality rice
LPCC1	-3.79	-3.71	I(0)	Domestic price of coconut lagged 1
LPCC2	-4.1	-4.1	I(0)	Domestic price of coconut lagged 2
LPCC3	-4.9	-4.8	I(0)	Domestic price of coconut lagged 3
LPCC4	-4.8	-4.7	I(0)	Domestic price of coconut lagged 4
LPCC5	-4.8	-3.9	I(0)	Domestic price of coconut lagged 5
LPCC6	-4.75	-3.76	I(0)	Domestic price of coconut lagged 6
LPCC7	-2.3	-1.7	I(1)	Domestic price of coconut lagged 7
LWDCPO1	-2.76	-3.22	I(1)	Weighted average of crude palm oil price
LWDCPO2	-2.96	-3.94	I(0)	Weighted average of crude palm oil price
LWDCPO3	-3.74	-4.76	I(0)	Weighted average of crude palm oil price
LPDCO7	-1.7	-1.8	I(1)	Domestic price of coconut cooking oil

I(0), and I(1) signify that the series are stationary, or nonstationary.

5. First difference of prices and their lag in logarithmic values

Variable Name	Constant No Trend	Constant Trend	Conclu- sion	Variable Definition: the first difference of the
DLPPO	-5.60	-5.79	I(0)	Domestic price of palm cooking oil
DLPDCPO	-4.70	-4.73	I(0)	Domestic price of crude palm oil
DLWDCPO	-4.60	-4.73	I(0)	Weighted average of crude palm oil price
DLXRATES	-3.98	-4.16	I(0)	US-dollar rupiah exchange rates
DLCPI	-3.09	-4.18	I(0)	Consumer price index
DLWDCPO1	-3.91	-4.10	I(0)	Weighted average of crude palm oil price
DLPCC7	-4.47	-4.85	I(0)	coconut price lagged 7
DLPDCO7	-4.01	-4.02	I(0)	domestic coconut oil price lag 7

I(0), and I(1) signify that the series are stationary, or nonstationary.

6. The critical values of the τ-statistics

Model	$\alpha = 0.01$ (n=25)	$\alpha = 0.05$ (n=25)	$\alpha = 0.05$ (n=28)
Model with constant, no trend	-3.75	-3.00	-2.86
Model with constant, trend	-4.38	-3.60	-3.41

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