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A linear-quadratic model to estimating market power in the Indonesian palm oil industry¹

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Abstract

Since it was first established as a large-scale operation in 1911, the Indonesian palm oil industry has undergone a number of structural changes. There have been allegations that some of these changes have led to a significant market power exertion in this industry. However, empirical evidence to support the allegation appears lacking. This paper seeks to make an attempt at modelling and measuring market power in the Indonesian palm oil industry. A dynamic adjustment model with open-loop and Markovian strategies is proposed to achieve this objective on the basis of annual data, covering the period 1969 to 2003. The model is assumed to be linear-quadratic. However, failing to meet the symmetry condition, only the open-loop model can be applied to this study. Some justifications for using the open-loop model are provided. As the estimation of market power indices do not appear to lie in the desired range, the results are inconclusive. A possible reason is proposed, but, in order to obtain a clear explanation, further research is required.

Keywords: market power, dynamic adjustment model, linear-quadratic specification, Indonesian palm oil industry

1. Introduction

Since the first large-scale establishment of an oil palm plantation in 1911, the structure of the Indonesian palm oil industry has undergone a number of significant changes. The share of government is decreasing, overtaken by the group of private companies (Perkebunan 2004). Vertical integrations among oil palm plantations, crude palm oil millers and cooking oil refineries in the production chain, are increasing (BIRO 1999,

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2004). The regulatory environment in this industry appears to be moving toward free trade by reducing the export taxes to a minimum rate (Tomich and Mawardi in Sugiyanto 2002, pp. 18-19). These changes may increase the cost efficiency as they increase the economies of scale and scope. In addition, it is also likely to provide the firms' with a higher flexibility and speed in responding to market fluctuations in the international market. Being a significant contributor to the Indonesian export market, such conditions will potentially lead to an increase in the national income. However, on the other hand, the increasing market share and vertical control in the supply chain may provides the dominant producers an ability to control market prices, and can lead them to exercise market power in the domestic market (Basri 1998; Pasaribu 1998; Rachbini 1998; Arifin 2001; Indonesia 2001; Arifin 2002; Widjojo 2004; Syachrudin 2005). Market power is considered as a problem because it can decrease efficiencies and welfare. Moreover, it can also raise the income distribution problem. In the case of the Indonesian palm oil industry, these impacts attract more attention because its main end product, cooking oil, is known as an essential commodity in Indonesia. In 2001, the Indonesian Commission for the Supervision of Business Competition indicated that the dominant firm in the palm oil industry might be exercising market power. However, empirical evidence is lacking. This paper seeks to make an attempt at modelling and measuring market power in the Indonesian palm oil industry.

This paper is organised as follows. In the next section, the Indonesian palm oil industry will be described, to illustrate its relevant to the linear-quadratic model. The model will be introduced in section 3, applying two strategies: the open-loop and closed-loop strategies. Section 4 shows the data and procedures used in estimating the model. Then, the results will be presented and analysed. Finally, it will be concluded in section 5.

2. Modelling market power in the Indonesian palm oil industry

Market power is understood as an ability to maintain prices above their marginal cost of production. A plethora of approaches to modelling market power has been reported in the literature. These can be divided into two approaches, namely the structure-conduct-

performance (SCP) and the new empirical industrial organization (NEIO) approaches (Tirole 1988). The SCP approach, pioneered by Mason (1939; 1949), assumes that firms behaviour or conduct, which shows whether they act competitively or not, can be easily implied from the relationship between market structure and performance. For example, a positive relationship between market concentration and profit is interpreted as an evidence of market power. This approach has been criticised for being descriptive rather than analytic. Moreover, it appears to have endogeneity problems. In this example, the variable of market structure, concentration, is assumed to be exogenous, while in fact, it is often endogenous. Instead of indicating market power, the high concentration may reflect the superior of efficiency of large firms (Carlton and Perloff 2005, chapter 8; Perloff *et al.* 2005, chapter 2).

The new empirical industrial organization (NEIO) approach is then addressed the SCP approach by being more analytic and explicitly measuring the market power. The NEIO models can be divided into the static and dynamic models. However, the static approach has also been criticised, as it tried to capture the dynamic phenomenon, reaction, with a static model. The dynamic considerations are then addressed by introducing at least two alternatives, namely the repeated games and the dynamic adjustment (Carlton and Perloff 2005, p. 279). The former model employs static game that played repeatedly over time, and history influences current decisions. Such model is appropriate to evaluate a collusive behaviour with a punishment mechanism. In this model, there is no physical link between periods. If, in fact physical link does exist, a dynamic adjustment is required.

Perloff *et al.* (2005) refer the physical link to strategic or fundamental reasons for dynamic models. The strategic reason is the consideration of a firm about the rivals' future response to its current action. If a firm finds that rivals also have the ability to influence market prices, such in the oligopolistic market, the rivals' responses will also influence the firm's profit. The fundamental reason is a consideration about the change of the firm's own future profit caused by its current decision. The fundamental reason underpins the production process with quasi-fixed inputs. The average cost of changing

the level of this input increases with the size and the speed of the change. Changing these inputs in the current time will affect the firm future output, thereby affect the future revenue, and at the same time this changing also affects the cost.

In the Indonesian palm oil industry, both the fundamental and strategic reasons are likely to be relevant. The fundamental reason arises from its production pattern. There are two different stages considers in this palm oil industry study. First is the growing of oil palm tree, which produce the fresh fruit bunches (FFB), and second is processing of FFB into the crude palm oil (CPO). In this case, the fundamental reason for dynamic model is mainly stemmed from the first stage. The FFB production has a gestation period between the planting and first harvest for about three to four years, and the harvest continues up to 20 to 25 years. Such pattern suggests that the production process involves quasi-fixed inputs. The strategic emerges from the oligopolistic structure in the Indonesian palm oil industry. This industry is controlled only by 18 Indonesian and 16 foreign business groups (Gelder 2004, pp. 18,19,32). Each group owned an area ranging from 100,000 to 600,000 ha (Wakker 2004, p. 10), and as a group, the government estates is one of the greatest. The CPO produced by the member of this group, is jointly sold through a Joint Marketing Office. Given these conditions, the adjustment dynamic model is then considered as the appropriate approach in modelling market power in Indonesian palm oil industry. Therefore it will be used in this study.

3. The model

The adjustment dynamic model is based on the work of Karp and Perloff (1989; 1993) in the international market framework. This model is limited to the linear-quadratic specification, which quadratic in the value function and linear in the control rule. The details are as follows. Suppose there are n firms in an industry. Each firm sets output which can be at any level in between the price-taker and collusive level. Output is assumed to be homogenous, and all firms face the same market price p_t . In period t , firms face an inverse demand, which is

$$p_t = a_i(t) - bQ_t \quad (1)$$

where q_{it} and p_{it} are the output quantity and price, $a_i(t)$ and b_{it} are the intercept and slope of the inverse demand function., and Q_t is the total output of all firms. The demand intercept $a_i(t)$ refers to the effect of various exogenous variables, including demand from other industries which are not explicitly modelled.

At each time firm i decides how much to produce in the current period. This current output q_{it} is called as the firm's control variable. The decision determines the firm's change of output from one period to the next period, $u_{it} \equiv q_{it} - q_{it-\varepsilon}$, where $q_{t-\varepsilon}$ is the state variable and ε is the length of period or lag on adjustment. The cost of changing output or adjustment cost is assumed to be increasing with the speed and size of adjustment. Therefore, the convex adjustment cost or the quadratic form can be applied

$$\left(\gamma_{it} + \frac{\theta_i}{2} u_{it} \right) u_{it} \quad (2)$$

where γ_{it} and θ_i is the intercept and slope of the adjustment cost. Assuming that firm i has a quadratic production cost, the marginal cost $c_i(t)$ can change over time. The intercept of demand, $a_i(t)$, the marginal cost function $c_i(t)$ and the intercept of marginal adjustment cost γ_{it} imply that costs do not need to be identical across firms and over time (Perloff *et al.* 2005, p. 6, chapter 9).

When firm i makes decisions about its current production, it decides how to maximise the objective function. The objective function of firm i at an arbitrary time t is to maximise the present discounted value of profits,

$$\sum_{t=1}^{\infty} \delta^{t-1} \left[(p_t - c_i(t)) q_{it} - \left(\gamma_{it} + \frac{\theta_i}{2} u_{it} \right) u_{it} \right] \varepsilon \quad (3)$$

where δ is the discount factor. In matrix notation Equation (3) can be rewritten as

$$\sum_{t=1}^{\infty} \left(a_{it}' e_i' (q_{t-e} + u_t \varepsilon) - \frac{1}{2} (q_{t-e} + u_t \varepsilon)' K_i (q_{t-e} + u_t \varepsilon) - \frac{1}{2} u_t' S_i u_t \right) \varepsilon \quad (4)$$

where e_i is the i^{th} unit column vector (a vector of 0's with a 1 in the i^{th} position); K_i is defined as $b(ee_i' + e_i e')$, which is an n -dimensional matrix of 0's with b 's on the i^{th} column and the i^{th} row, except for the (i,i) element which contains $2b$; and S_i is an $(n \times n)$ matrix consisting of 0's except for the (i,i) element which contains θ .

As indicated previously, within an oligopolistic market, each firm's has an ability to influence market prices by deciding how much to produce. Considering this condition, a firm can either works cooperatively or noncooperatively with other firms. If firms choose cooperative games, they will decide their joint outcomes and share them among members. However, conflicts of interest among the members often appear and each firm will choose noncooperative games and will behave in its self-interest. All firms simultaneously will do whatever best for them individually. In doing so, a firm can use either the open-loop or the closed-loop strategies. With the open-loop strategy, each firm chooses a path of action based on the initial condition and commits to the path for the entire game. In contrast, with the closed-loop model, firms may change their decisions as a response to the changing of the state conditions. Many researchers apply the Markovian strategy as a special case of the closed-loop, to reduce the number of parameters and make estimating them easier. This strategy only considers the direct relevant information, because this information is suggested to be either the accumulated information of the whole history or the mostly influence the current behaviour. In other words, the t period decision depends on the $(t-1)$ condition, the $(t-1)$ depends on the $(t-2)$ condition, and so on. (Maskin and Tirole 2001, p. 192). As firms play a noncooperative game, rivals' actions are treated as given. The game reaches equilibrium conditions if no player can improve its payoff by deviating from the existing solutions, which is known as Nash equilibrium conditions.

Compared to the Markovian, the open-loop strategy is often argued to be an unrealistic strategy, because within this strategy firms do not think that their current actions will influence their rivals' future decision. However, empirically, the open-loop strategy might appear at least in three conditions. The first condition is when the underlying

event or the state of the world is not a common knowledge at the beginning of each stage, where new information is not accessible or it takes a long time for receiving it. As the old or initial information is the only available one, players' decisions are conditioned only on this information. The second condition is when the rivals' group is consisted of many small firms, so no one rival can greatly affect a firm. In such condition, rivals may either act as followers or their responses do not significantly affect the firm and can be negligible (Fudenberg and Tirole 1989, p. 296; Perloff *et al.* 2005, p. 41 chapter 7). The third condition is when the production has a long gestation period or heavily depends on the growing season (such in many agricultural production), so a firm's decisions are more influenced by their production pattern rather than other firm's action (Karp and Perloff 1989, p. 462).

The open-loop equilibrium is obtained by solving the restricted objective function, using the Lagrangean equation.

$$L_i = \sum_{\tau=t}^T \beta^{\tau-t} \left[-\frac{1}{2} q'_\tau K_i q_\tau - \frac{1}{2} u'_\tau S_i u_\tau + \lambda'_{i\tau} (q_{\tau-1} + u_\tau - q_\tau) \right] \quad (5)$$

Using the necessary conditions for an interior solution, that is $\frac{\partial L_i}{\partial u_i} = 0$ and $\frac{\partial L_i}{\partial q} = 0$, the

open-loop first order condition function with parameters market power index v_i , and adjustment cost θ_i , satisfies

$$K_i v_i = \left[G^{-1} (I - G) (I - \delta G) \right]' e_i \theta_i \quad (6)$$

The Markovian equilibrium is obtained by the simultaneous solution to the n dynamic programming equations. If the presented discounted value of firm i in (4) is defined as $J_i(q_t; v)$, given the state vector $q_t \equiv (q_{it}, q_{jt})$ and index of market power, the dynamic programming equation will be as follows

$$J(q_{t-1}; v) = \max_u \left[\left(a e'_i q'_t - \frac{1}{2} q'_t K_i q_t - \frac{1}{2} u'_t S_i u_t \right) + \beta J_i(q_t; v) \right] \quad (7)$$

The first order condition for the Markovian model can be presented in a matrix form as

$$\left[K_i + \delta W_i + (e_i e_i' + \delta Z_i) \theta_i \right] v_i = G^{-1} e_i \theta_i \equiv y_i^* \theta_i \quad (8)$$

W_i and Z_i are the “inverse vec” of w_i and z_i , where w_i and z_i are defined as

$$w_i = (I - \delta(G' \otimes G))^{-1} ([G' \otimes G'] [vec(K_i)])$$

$$z_i = (I - \delta(G' \otimes G'))^{-1} ([G' \otimes G'] - [I \otimes G'] - [G' \otimes I]) [vec(e_i e_i')]]$$

\otimes denotes the Kronecker product.

G is a matrix whose elements are the coefficient of the control rule or adjustment system which takes the linear form, $q_t = g_t + Gq_{t-1}$. In deriving Equation (6) and Equation (8), no symmetry assumptions are made in the G matrix. However, in order to calculate the parameters of market power and adjustment cost, symmetry conditions are imposed, such that the coefficients of the firms' own lagged production are equal across firms $G_{ii} = G_{jj} = G_1$, as are the coefficients of the other firms' lagged production $G_{ij} = G_{ji} = G_2$. The market power index v_i is the dynamic analogue of the static models of oligopoly. Its values lie in between the competitive and monopolistic behaviour, whose indices are $v = -1$ and $v = 1$, respectively.

4. Data and estimation procedures

Before calculating the parameters of market power index and adjustment cost, the slope of inverse demand equation and the adjustment system have to be estimated separately. Eviews 5.1 and Matlab 7 programs are used in estimating them. All data are annual for the period 1969-2003. They were collected from official national and international sources. The CPO domestic and international prices were collected from the Danareksa database and Oil World publication, respectively. The domestic prices of coconut oil, coconut and palm cooking oil were from the Indonesian Statistics. All domestic prices were deflated by the Indonesian Consumer Price Index, while the CPO international prices were deflated by the Netherlands Consumer Price Index. The former were

published by the Indonesian Statistics, whereas the latter were taken from the International Finance Statistics. The data of CPO demand by the cooking oil industry were collected from two sources; for the period 1969-1997 they were from Indonesian Statistics in Susanto (2000), and for 1998-2003 they were from the CIC (2003) publication. Finally, the CPO production data of each group were taken from the Indonesian Directorate General of Plantation, Department of Agriculture.

4.1. The inverse demand equation

Initially, the inverse demand was estimated in a system that included three equations; the inverse demand of the CPO, the CPO supply and the cooking oil demand in the domestic market. The system was used in order to take into account the position of CPO demand as the derived demand of cooking oil, and the endogeneity possibility in the CPO and cooking oil prices. However, as multicollinearity problem appeared in the system, the single equation with instrumental variable was then used as an alternative. The instrumental variables were the price of the palm cooking oil and coconut cooking oil, the price of coconut oil, time and time squared. As an addition, the price of coconut oil, as the substitute input, was also entered interactively with the price of CPO. This variable made the exogenous variable not only capable of shifting the intercept of the inverse demand equation, but also of rotating it. The rotation will have no effect on the equilibrium if the market is competitive, but it will if there is market power (Bresnahan 1982). Therefore, to capture the possibility of market power, this interactive variable was included in the inverse demand equation.

The scatter plot graphs show that all demand variables have trends and a structural break in the economic crisis period in 1997-1998. The trends indicate that the variables violate the stationary condition, and have autocorrelation problems. As a consequent, the statistics such as \bar{R}^2 , F - and t -ratios will be overestimated. Therefore, the regression will be a spurious regression. This problem can be addressed by adding trend variables in the regression, or taking the differences in the variables. If the variables have trend-stationary conditions, the inclusion of trend variables will eliminate the autocorrelation. If the variables have difference-stationary conditions, taking their differences will eliminate

the autocorrelation. If the variables have the same order and are cointegrated, the regression will be the cointegrating regression, which estimators appears to be superconsistent. Transforming the data to their logarithmic forms did not eliminate their trends, but the trends disappeared as their first differences were taken. To obtain a formal conclusion of these stationary conditions, a unit root test, particularly the Augmented Dickey-Fuller (ADF) test was proposed. However, this test does not allowed any structural break in the data. Therefore, applying ADF test to the demand variables could be misleading. Perron (1989) suggested an alternative unit root test to address the problem. However, Perron's test does not involve a cointegration test. As an alternative, the dataset was then split into two periods, before and after the economic crisis, and the ADF unit root test and Johansen cointegration test were then used. The result show that all the data in the pre-crisis period had the same order and were cointegrated, but unfortunately the data in the post-crisis could not be tested because of the insufficient number of observations. Despite this incompleteness, the variables were then regressed and the estimation results are as follows

$$P = -4335.28 - 0.06Q + 0.37P_1 + 0.12P_2 - 0.42Z + 0.12PZ + 4.38T - 0.001TT \quad (9)$$

$$(4.61) \quad (-2.32) \quad (4.00) \quad (2.28) \quad (-5.34) \quad (7.17) \quad (4.63) \quad (-4.65)$$

$$\bar{R}^2 = 0.99 \quad DWstatistic = 1.99$$

P , P_1 and P_2 represent the domestic price of CPO, palm cooking oil and coconut cooking oil, respectively. Z is the price of the substitute of the CPO, which the coconut oil. T and TT are the trend terms in the linear and quadratic form. Originally, a dummy variable that represented the influence of the economic crisis was included in the regression. However, its coefficient was not significant, and the inclusion affected the significance of the other variables. Therefore, it was then eliminated from the final estimation. The figures in parenthesis refer to t -ratios, showing all parameters are significant in one and five percent level. The \bar{R}^2 value shows that these independent variables can explain 99% of the variation in the CPO price. This extremely high value can be suspected as an indication of a spurious regression. However, the $DWstatistic$ shows a rejection of autocorrelation, and moreover, variables are also cointegrated. Therefore, the spurious regression problem is unlikely exists in this equation, and the parameters can be seen as reliable estimators.

4.2. The adjustment system

The Indonesian CPO producers are divided into three groups, namely the government, private companies and smallholders. Mostly, firms in the first two groups have their own CPO, and smallholders often integrate with one of the groups. Only a small part of them establish their own mills, but based on the total capacity smallholders' mills capacity is unlikely to be significant. Therefore, it was not included in the adjustment system.

To obtain the ideal adjustment system parameters, the domestic supply data from each group are needed. However, such data are not available. Therefore, the group production data were used as a proxy. This proxy is obtained from the following formula, which is used in Oil World (ISTA Mielke 2004), previous studies (Suharyono 1996; Susanto 2000; Zulkifli 2000) and various estate firms reports in Indonesia.

$$Q = S^o + P + M - X - S^e \quad (10)$$

where Q is the domestic supply, S^o, S^e, P, M, X are opening and ending stock, production, export and import, respectively. P, M and X are recorded as accumulation values in each year, while S^o, S^e recorded as stock values at the end of January and December. The stock and import values are usually not significant, compared to the values of other components. Stocks are small because CPO is perishable, and can not be stored for more than three months. Imports are also small because usually the Indonesian production is more than enough to supply its domestic demand. Excess demand only occurs when the international price is high, giving an incentive for producers to increase their export levels, or when the domestic demand significantly increases due to feast months (Ramadhan, Ied-Fitr and New Year).

The government and the private production data was used as variables in the adjustment system. Although a direct relationship between these variables at time t is unlikely to exist, both are affected by the same factors. Therefore, the idea of Zellner's seemingly unrelated regressions (SUR) could be applied. Scatter plot of the data show that they appeared to have some trends, indicating the nonstationary conditions. The government data trend disappeared after taking its first difference, but the private needed to be

transformed to the logarithmic form first, before taking its first difference. The ADF and cointegration test showed that the variables had the same order and were cointegrated. Mark *et al.* (2003) demonstrated that, similarly to the single equation, seemingly unrelated cointegrated regressions also have the asymptotically efficient estimators. Therefore, the estimators will be superconsistent and reliable.

Comparing scatter plots of various specifications, the linear relationship between the government production and the logarithmic of private production, was likely to be better fit, and fulfils the linear-quadratic specification. Each group's production was regressed on its own lagged and its rival's lagged production. Initially, a trend time and a dummy variable for the period of 1989-1999 (expected concessionary credit effect period, after adding the three-year gestation lag) were both included as exogenous variables in the system. However, the dummy variable appeared to be insignificant, and was thus eliminated from the final equations. In order to test the symmetry assumption for the estimators, the Wald-test was used. However, with a Chi-square value of 9.54, the null hypothesis was strongly rejected, and symmetry condition could not be imposed on the system. The results are as follow

Table 1 Adjustment system estimations

	Private	Government
Constant	-19.97 (-1.86)	-41204519 (3.30)
Time trend	0.01 (1.91)	21787.58 (3.32)
Owns lagged production (G_{ii})	0.75 (8.46)	0.96 (15.69)
Other's lagged production (G_{ij})	8.18E-08 (1.56)	-352897 (3.42)
Adjusted R-squared	0.99	0.99
Durbin's h	0.46	0.50

Note : Figures in parenthesis refer to t ratio

All the parameters are significant at one and five percent, except for the coefficient of the other's lag to the private production, which is only significant at ten percent. As lagged dependent variables were included in the model, the DW test was not applicable, and the Durbin's h-test was used as an alternative. The Durbin's h figure indicated that autocorrelation problem still appeared in the system, thus a spurious relationship between variables and inconsistent estimators might exist. However, as variables were cointegrated, this problem was no longer relevant, and estimators would be superconsistent and reliable.

Table 1 shows that coefficients of its own lagged production, both in the private and government productions, have positive signs and relatively similar magnitudes. This might relate to the increasing in both the private's and government's production. However, the coefficients of the other's lagged production have different signs and magnitude for the private and government groups. The private's coefficient was close to zero, indicating that previous government's productions only marginally affect the private's decision. The private group's decisions might be influenced by other factors, such as international prices and its CPO mills capacity. Differently, the government group's coefficient shows a significant negative value, indicating an increase in previous private group's productions leads to a decrease in the current government's production. One possible explanation could relate to the government's role in securing CPO domestic supplies in order to stabilize cooking oil prices. As the government intends to move towards free trade, the production and distribution of the private group's production was no longer intervened by the government policies. Therefore, in order to meet the domestic demand, the government group needs to increase its supply if the private group's supply decreases. The different responses between the private and government group are likely lead to a rejection of the symmetry hypothesis.

4.3. Calculation of ν and θ and discussion

Given the estimates of the slope of the inverse demand equation, b and the asymmetry G matrix, the procedures were then continue to calculate of the market power index ν and adjustment cost parameter θ for the open-loop and Markovian models. For the open-loop model, a solution can still be obtained if the number of firms is not greater than two. Otherwise, the number of the unknown parameters ν_{ij} and θ_i will be larger than the number of equations, thus makes them impossible to be estimated. For the Markovian model, without the symmetry restriction on G matrix, the solution is impossible to calculate. Equation (8) shows that the calculation uses a Kronecker product on the G matrix, and then the product matrix is inverted. If the G matrix is symmetry, the Kronecker product will always be symmetry. Inverting a symmetric matrix can always be carried out in a symmetric matrix, because it is always non-singular. However, if the G matrix is asymmetry, the Kronecker product will not always be symmetry and non-singular, which in turn inverting it will be impossible. In this study, the Kronecker product of the G matrix appeared to be singular. As a result, the calculation of the market power index ν and adjustment cost parameter θ for the Markovian model could not be carried out. Based on the open-loop model, the estimation results are as follows

Table 2 The open-loop model results

	Government	Private
$G_{ii} + G_{ij}$	-3.53E+04	0.75
$G_{ii} - G_{ij}$	3.53E+04	-0.75
θ_i	-3.12E-06	1.34E+06
ν_i	-2.00	-2.64E+06

Karp and Perloff (1993, p. 452) suggest that for the estimated dynamic system to “make sense”, it must have three properties; First, the system is stable, whose values are $-1 < G_1 + G_2 < 1$ and $-1 < G_1 - G_2 < 1$. The stable condition shows that the steady state is reached. In such condition, “neither variations in circumstances nor new information occurs, so that the steady state variables and the steady state conjectures both remain unchanged” (Itaya and Shimomura 2001, p. 155), therefore, market power index will also be consistent. Second, the market power index be in between the collusion and price taking behaviour, whose values are $-1 < \nu < 1$. Finally, the adjustment cost is convex, whose parameter is positive, $\theta > 0$.

Table 2 shows that not all estimators fulfil the restrictions. In the government equation, all estimators violate the required properties, while in the private equation, only the market power index violate the restriction.

In a dynamic equation, a variable will reach a stable or steady state condition if all of its coefficients are smaller than unity in absolute value. Table 1 shows that the government's G_{ij} absolute value is far greater than unity. The consequences will not be severe if the explosive G_{ij} is followed by increasing returns. In such conditions, the firm might still obtain the highest possible expected sum of discounted return during the evaluated periods, therefore the firm's expectations are still approximately realized. Equivalently, the Lagrange method still yields an optimum control function and the estimators are still reliable for the evaluated periods. However, estimators could not be used for making predictions because the correct values only hold for previous years. The consequence will be severe if the instability materialises from the incorrectly perceived reaction functions. A firm makes decisions based on its conjecture about the other players' responses, which in turn depend on their perception of the other players' conjectures, and so on. If a firm does not have complete information, it might incorrectly predict others' response; hence the firm will revise its conjecture in the next period. The revision of the conjecture leads to a revision of the firm's decisions. Given the interdependency of the decision process, similar revisions also appear in other firms' conjectures and decisions. As a result, instability occurs and steady state is not reached. In such cases, the estimators are unreliable because the values are incorrect even for the current period (Karp 1982, p. 55; Chow 1997, p. 25).

In the palm oil industry, firms are unlikely to have complete information. One possible reason might be policies that appear to frequently change and are potentially inconsistent. For example, in 1997 and 1998 the Indonesian government imposed export taxes in order to limit the CPO export, leaving enough CPO for the domestic market. The export tax levels depended on the existing domestic CPO demand and supply condition. However, changes were unlikely to be based on a certain standard; In July 1997, export taxes were still fluctuating around 2-5 percent, but in December 1997 the tax jumped to 40 percent.

Still in the same month, the government even imposed an export ban to address the undersupplied condition. The frequent changes also appeared in the CPO distribution system. For example, initially the distributions of CPO produced by the state-owned plantation firms and cooking in the domestic market, were monopolized by *Badan Urusan Logistik* or the Government Logistic Institution (BULOG). In May 1998, the monopoly right for the CPO distribution was replaced by the State Joint Marketing Office (*Kantor Pemasaran Bersama*), and for the cooking oil distribution was replaced by a state company, PT Dharma Niaga. But only two months later, BULOG was directed again to get involved in the state CPO distribution and the Indonesian Distribution Cooperative (*Koperasi Distribusi Indonesia, KDI*) replaced the PT Dharma Niaga. However, in such conditions, firms still appeared to have an increasing return. Although detailed information for all firms is not available, data on four dominant firms in the following graph could be used as an approximation of the industry condition. Most of the firms seemed to have an increasing return. This implies that although the conditions were not stable, firms in this industry still gained increasing returns and firms' expectations were possibly still approximately realized. As indicated previously, in such conditions, the Lagrangean method still yields an optimal control function and the estimators are still correct for the evaluated periods.

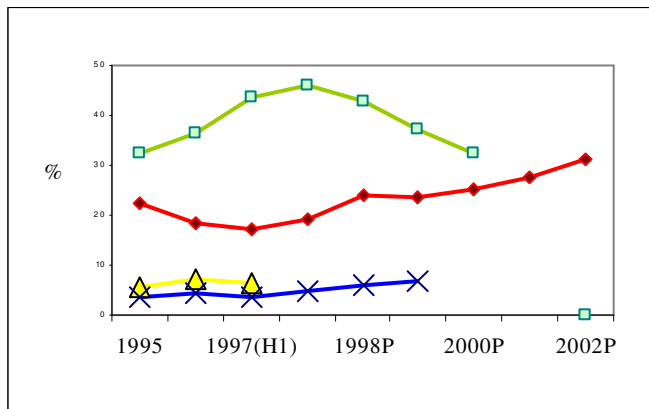


Figure 1 Net profit margin of four dominant firms in the CPO industry

The empirical explanation for the second property is not clear, because reliable adjustment costs are not available. Theoretically, the convexity of the adjustment cost

means that the adjustment is increasing with either the size or the speed of adjustment. In such conditions, the adjustment graph appears to be a smooth curve. As an opposite, if the adjustment cost is nonconvex, the graph will be nonsmooth. The nonsmooth graphs might appear if inputs are indivisible, which makes the adjustment unable to be spread smoothly across the time. The nonsmooth graphs might also appear if the adjustments are small, which makes spreading them across time will be more expensive, thus, adjustments will be undertaken instantly (Rothschild 1971; Nilsen and Schiantarelli 2003).

In this study, the adjustment cost is a function of the changing of output level, which is relevant to the changing of the production area. To expand the area, a firm needs to obtain new licenses to open up conversion forest land for plantation estates. This process is found to be bureaucratic and costly for investors (Chandra 2005). As these conditions stemmed from the government policies, they are likely to affect the private rather than the government companies. This implies that, for the same size of adjustment, private companies need higher adjustment costs and a longer time than that the government companies need. In other words, the private companies need to spread their adjustment costs across the time, while the government companies do not have to do so. Therefore, the private companies are likely to have convex adjustment costs, while the government companies have the nonconvex ones.

Finally, both the government and private group's market power index results do not lie in the desired range, therefore they cannot be interpreted. Although the complete explanation is still not clear, this might be affected by the positive G_{ij} values, which exist in both groups (Table 1). This is supported by the simulations result; entering various positive G_{ij} values always yields out of range market power indices. Similar conditions also hold in Deodhar's (1994, p. 150) research. In the static model market power index will be bounded if and only if the firms have decreasing reaction functions, whose slopes bound in between -1 and 0 (appendix 1). Otherwise, market power indices will not be in between -1 and 1. Since this dynamic market power index is only affected by G matrix,

and can be seen as an analogue of the static index, similar arguments are likely could be applied.

Rather than running the classical estimation and hoping that the results lie in the desired range, Karp and Perloff (1993, p. 452) suggest that properties could be imposed by using a Bayesian technique. In this approach, properties are combined with the conventional uninformative distribution from the classical estimation. The posterior distribution is calculated, using Monte Carlo numerical integration that is drawn from the multivariate t -distribution (Chalfant *et al.* 1991). The result will give the probability of holding the properties in the estimation, and the average weighed values of the desired estimators. However, the Bayesian technique cannot be carried out, because the covariance of G matrix appears to be singular. Therefore, further explanations cannot be explored.

5. Concluding comments

Although it was limited to the linear-quadratic specification, this study used an adjustment dynamic model, to model and measure market power in the Indonesian palm oil industry. The model was chosen under two considerations. First, the production pattern suggests an involvement of quasi-fixed input, implying intertemporal adjustment costs. Second, the market is controlled by only a few business groups, implying intertemporal responses among them.

To obtain the solution for the model, the study proposed to employ two types of strategy: the open-loop and the closed-loop strategies. However, unless the symmetric assumption holds, only the open-loop strategy can be applied. Based on the open-loop model results, adjustment cost appears to be important only for the private companies, but the market power conditions seem inconclusive. In order to obtain a clear explanation, a further research either with an additional of data set or with a set of new assumptions is required. With interpretable market power indices, the estimation of the linear-quadratic model may no longer be limited to the symmetric assumption. The adjustment dynamic model

will also be potentially useful in indicating market power in the Indonesian industries. Currently, anti-competition cases in Indonesia heavily rely on the measures used in the SCP approaches, which are often criticised for the endogeneity problem. While a challenging exercise, this approach may yield better information that is potentially useful in the on-going competition policy debate in Indonesia.

Reference

- Arifin, B. (2001), 'Dilema integrasi vertikal berbasis perkebunan', *Kompas*, 27 January 2001. [Online]. Available: http://www.unisosdem.org/article_printfriendly.php?aid=161&coid=1&caid=23
- Arifin, B. (2002), 'Informasi Perdagangan Berjangka Komoditi', CPO dan distorsi pasar, Available: <http://www.bappebti.go.id/sisinfo/berita/k0209002.asp>
- Basri, F.H. (1998), *Betapa pahitnya didikte orang asing*, Jakarta. Available: <http://www.tempointeraktif.com/ang/min/02/46/utama1.htm>
- BIRO (1999), 'Prospect of the Plantation and CPO industry in Indonesia', Business Intelligence Report, Jakarta.
- BIRO (2004), 'Prospek Perkebunan dan Industri Minyak Sawit di Indonesia', Business Intelligence Report, Jakarta.
- Bresnahan, T.F. (1982), 'The oligopoly solution concept is identified', *Economics Letters*, vol. 10, pp. 87-92.
- Carlton, D.W. and Perloff, J.M. (2005), 'Modern Industrial Organization'.
- Chalfant, J.A., Gray, R.S. and White, K.J. (1991), 'Evaluating prior beliefs in a demand system: The case of meat demand in Canada', *American Journal of Agricultural Economics*, vol. 73.
- Chandra, A. (2005), 'Revitalisasi industri kelapa sawit nasional', *Kompas*, 17 May 2005. [Online]. Available: <http://www.kompas.com/kompas%2Dcetak/0505/17/ekonomi/1758890>
- Chow, G.C. (1997), *Dynamic Economics. Optimization by the Lagrange Method*, Oxford University Press, Oxford New York.
- CIC (2003), *Studi tentang industri dan pemasaran minyak goreng (kelapa sawit, kelapa dan nabati lainnya)*, Jakarta.
- Deodhar, S.Y. (1994), A linear-quadratic dynamic game approach to estimating market power in the banana export market, PhD Thesis, The Ohio State University, Ohio.
- Fudenberg, D. and Tirole, J. (1989), 'Noncooperative game theory for industrial organization: An introduction and overview', in Schmalensee, R. and Willig, R.D. (Eds), *Handbook of Industrial Organization*, Vol. I, Elsevier Science Pub. Co, Amsterdam, New York, Oxford, Tokyo.

- Gelder, J.W.v. (2004), 'Greasy palms: European buyers of Indonesian palm oil', Friends of Earth, London.
- Indonesia, C. (2001), Delapan perusahaan diduga monopoli, Jakarta. Available: <http://www.bpc.or.id/news-view.php?id=37>
- ISTA Mielke, G. (2004), *Oil World Annual 2004*, Oil World Annual, ISTA Mielke GmbH, Hamburg, Germany.
- Itaya, J.-i. and Shimomura, K. (2001), 'A dynamic conjectural variations model in the private provision of public goods: a differential game approach', *Journal of Public Economics*, vol. 81, pp. 153-172.
- Karp, L.S. (1982), *Dynamic Games in International Trade*, PhD Thesis, University of California, California.
- Karp, L.S. and Perloff, J.M. (1989), 'Dynamic oligopoly in the rice export market', *Review of Economics and Statistics*, vol. 71, pp. 462-470.
- Karp, L.S. and Perloff, J.M. (1993), 'A dynamic model of oligopoly in the coffee export market', *American Journal of Agricultural Economics*, vol. 75, pp. 448-457.
- Mark, N.C., Ogaki, M. and Sul, D., Sul (2003), 'Dynamic seemingly unrelated cointegration regression', Working paper no. 292, National Bureau of Economic Research, Cambridge. [Online]. Available: <http://www.nber.org/papers/T0292>
- Maskin, E. and Tirole, J. (2001), 'Markov perfect equilibrium', *Journal of Economic Theory*, vol. 100, pp. 191-219.
- Mason, E.S. (1939), 'Price and production policies of large-scale enterprise', *American Economic Review*, vol. 29, pp. 61-74.
- Mason, E.S. (1949), 'The current status of monopoly problem in the United States', *Harvard Law Review*, vol. 62, pp. 1265-1285.
- Nilsen, O.A. and Schiantarelli, F. (2003), 'Zeros and lumps in investment: Empirical evidence on irreversibilities and nonconvexities', *The Review of Economics and Statistics*, vol. 85, pp. 1021-1037.
- Pasaribu, C. (1998), Kekuatan nyata monopoli dan oligopoli, Available: <http://www.kontan-online.com/03/08/refleksi/ref2.htm>
- Perkebunan, D.J.B.P. (2004), 'Statistik Perkebunan Indonesia 2001-2003: Kelapa Sawit', Departemen Pertanian, Jakarta.

- Perloff, Karp, L.S. and Golan, A. (2005), *Estimating Market Power and Strategies*, draft (unpublished). [Online]. Available: <http://are.berkeley.edu/~perloff/MarkPow/>
- Perron, P. (1989), 'The great crash, the oil price shock, and the unit root hypothesis', *Econometrica*, vol. 57, pp. 1361-1401.
- Rachbini, D.J. (1998), Monopoli bisa beralih ke tangan swasta, Jakarta. Available: <http://www.tempointeraktif.com/ang/min/02/48/utama1.htm>
- Rothschild, M. (1971), 'On the cost of adjustment', *Quarterly Journal of Economics*, vol. 85, pp. 605-622.
- Sugiyanto, C. (2002), The Impact of Trade Liberalization on the Indonesian Palm Oil and Coconut Oil Markets, University of Illinois, Illinois.
- Suharyono (1996), Analisis dampak kebijakana ekonomi pada komoditi minyak sawit dan hasilindustri yang meggunakan bahan baku minyak sawit di Indonesia., Bogor Agricultural Institute, Bogor.
- Susanto, R.D. (2000), Analisis penawaran dan permintaan minyak sawit Indonesia, Master Thesis, Indonesian University, Jakarta.
- Syachrudin, E. (2005), 'Nurdin Khalid dan tiga naga', *Republika*, 29 March 2005. [Online]. Available: http://www.republika.co.id/cetak_berita.asp?id=192399& kat_id=16&edisi+Cetak
- Tirole (1988), *The Theory of Industrial Organization*, MIT Press, Cambridge, Massachusetts, London.
- Wakker (2004), 'Greasy palms: the social and ecological impacts of large-scale oil palm plantation development in Southeast Asia', friends of earth, Netherlands.
- Widjojo, E.S. (2004), 'Suara Karya online', Daya tarik saham Indofood di akhir tahun, Available: www.suarakarya-online.com/news.html?id=100343
- Zulkifli (2000), Dampak liberalisasi perdagangan terhadap keragaan industri kelapa sawit Indonesia dan perdagangan minyak sawit dunia, Dissertation Thesis, Bogor Agricultural Institute, Bogor.