Modelling market power in the Indonesian palm oil industry*

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Abstract

A plethora of approaches to modeling market power has been reported in the literature. These can be broadly divided into one-side and two-side behavioral models. This paper uses versions of these models to develop a theoretical framework to test market power in the output and input markets in the Indonesian cooking oil production chain. The dynamic Lerner Index is also proposed as a reinforcing approach to measuring the degree of market power, and its consequential impacts. The implications of the analysis for further research will be explored.

Key words: market power, Indonesia, palm oil industry

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1. Introduction

Market power is broadly defined as the ability of firms to maintain prices above the marginal cost of production, and can be seen as a non-competitive phenomenon. It is one of the most frequently discussed issues in industrial organization, since market power leads decreases efficiency and welfare.

One of the indications of market power is the low price transmission condition. This is likely to appear in the Indonesian palm oil industry, particularly in the cooking oil production chain. In the upstream chain that is the crude palm oil (CPO) industry, Indonesia is known as one of the most cost efficient producer in the world, while in the downstream chain, that is the cooking oil, the output prices seems to be persistently higher than the international prices. To decide whether this can be seen as a market problem, a model is needed to measure it. However, modelling and measuring market power is not always easy. This paper is meant to represent an attempt at modelling and measuring market power in the Indonesian palm oil industry.

Firstly, the Indonesian palm oil industry, especially conditions that may possibly lead to market power exertion in this industry will be described. Secondly, a brief review of market power models will be presented. Finally, an attempt will be made to develop a model for measuring market power in the Indonesian palm oil industry.

2. The Indonesian Palm Oil Industry

The palm oil industry is an industry which uses oil palm (Elais Guineensis sp.) output, that is, fresh fruit bunches (FFB), or their derivatives as inputs to produce intermediate or final products. These final products represent a huge range of commodities manufactured by a large number of industries. Among these industries, the cooking oil industry appears to be the most important in the Indonesian economy. From 1996 to 2003, on average, this industry accounted for 75% of palm oil usage. The remainder was used in the oleochemical (11%), soap (7%) and margarine/shortening (6%) (Table1).

Table 1. Palm Oil Consumption by Industry in Indonesia

Year	CPO consumption by industry									
	cooking oil		margarine/shortening		soap		oleochemical		total	
	volume	%	volume	%	volume	%	volume	%	volume	%
1996	2,811,637	72	238,074	6	308,155	8	573,339	15	3,931,205	100
1997	3,051,897	74	246,882	6	314,274	8	538,866	13	4,151,919	100
1998	3,288,135	74	218,699	5	305,480	7	626,890	14	4,439,204	100
1999	3,625,303	76	262,438	5	322,390	7	569,070	12	4,779,201	100
2000	3,909,425	76	270,440	5	343,100	7	587,515	11	5,110,480	100
2001	4,082,813	77	285,162	5	353,952	7	578,591	11	5,300,518	100
2002	3,901,778	76	307,425	6	356,114	7	549,390	11	5,114,707	100
2003	3,910,656	76	324,333	6	368,578	7	552,184	11	5,155,751	100
rata-rata	3,572,706	75	269,182	6	334,005	7	571,981	12	4,747,873	100

Source: CIC 2004, pp.47, 71

Thus, the cooking oil production chain is the focus of this research. In this chain, market power can be stemmed from various sources, namely supply conditions, investment requirements, or even government policies.

The supply may cause market power for at least two reasons. Firstly, the supply of oil palm, as a raw material of palm oil, is relatively fixed. Oil palm needs at least three years to reach maturity; therefore, increasing output is not easy. Similarly, decreasing output is even harder, since the economic life of the oil palm is, on average, 20-25 years. Therefore, an increase in the supply of palm oil to the export market is equivalent to a decrease in the supply of same to refineries in the domestic market.

Secondly, most (if not all) big oil palm suppliers are integrated with CPO mills and cooking oil refineries. From 1998 to 2002, the refineries only utilise at maximum 53.92% of their production capacity (Table 2). This under-capacity condition which implies inefficient allocation of resources will not hold in a long-run competitive market.

Table 2. Utilization of the Indonesian refineries, 1998-2002

description	unit	1998	1999	2000	2001	2002
capacity	**ton**	7,855,372.00	7,855,375.00	8,200,000.00	8,200,000.00	8,200,000.00
production	**ton**	2,072,690.00	2,400,000.00	3,534,918.00	3,690,000.00	4,421,114.00
utility	**%**	26.39	30.55	43.11	45.00	53.92

Source: Centre of data and information- Department of Industry and Trade, 2002

The under-capacity conditions will give a leeway for the integrated suppliers to adjust their CPO sale distributions and to choose between the two options. Since 1998, the international market prices have been higher than the domestic ones (Figure 2). Therefore, producers prefer to sell more of their production in this market, and the domestic supply is treated as a residual of the export market. If their market shares were significant, the supply changes would also change market prices. In other words, they would have a certain ability to control market prices.

Market power might also stem from the high investment requirements. It was estimated that US$ 2,500-3,500 per ha would be needed to develop a new plantation. On average, an individual private plantation has a size of 10,000-25,000 ha. The individual plantations are mostly part of larger plantation estates ranging from 100,000 to 600,000 ha. It is estimated that US$ 5 million would be required to build a CPO mill. This is important because after harvesting FFB have to be processed in the CPO mills within 24 hours to avoid a decrease in quality (Potter and Lee 2003 in Gelder 2004, p.22; Wakker 2004, p.10). The high investment requirements can create a barrier for new market entrants, whilst at the same time providing market power for the existing producers.

The third source of market power is the high government interferences that can lead to bias of market price from marginal costs. Due to its significance to the economy, the palm oil industry often attracts the government's attention. Usually the purpose is to lower CPO and cooking oil prices in the domestic market. The government uses both direct and indirect intervention in the domestic cooking oil industry, by determining the distribution system and CPO export tax, respectively.

3. Literature Review

A plethora of approaches to modeling market power has been reported in the literature. These can be broadly divided into the one-side and two-side behavioral models. The first model measures market power on only one side of the market, and assumes perfectly competitive behavior on the other side, while the latter makes no assumptions on either side of the market. The one side behavioral models can be further divided into three groups; namely models that only measure the monopoly/oligopoly power or only the monopsony/oligopsony power or both.

In the first group, the monopoly power parameter is obtained from the first-order condition of sellers' (upstream firms) profit function (Iwata 1974; Appelbaum 1982; Bresnahan 1989; De Mello 1999; Fischer and Kamerschen 2003).

$$P_u - \frac{\partial C_u(Y_u, w)}{\partial Y_u} + \lambda_m \left[\frac{\partial P_u(Y_d^*, v, Y_u)}{\partial Y_u} \right] Y_u = 0 \qquad \textbf{Equation 1}$$

where Y_u and P_u are the output quantity and price charged by the upstream firms, $C_u(Y_u, w)$ represents the monopolist'/ upstream firms' cost function, w is the vector of input prices, Y_d^* is the downstream firms' optimal output and λ_m is the parameter index of monopolistic market, which is bounded between 0 and 1. If $\lambda_m = 0$, the market is competitive, whereas $\lambda_m = 1$ implies a full monopoly condition. Other λ_m values between 0 and 1 show indicate degrees of oligopoly.

The sellers' power parameter can also be presented as a conjectural elasticity, which is the elasticity of conjectural variations. Conjectural variations are parameters that estimate other competitors' reactions if a firm change its output quantity or price. This parameter was first introduced by Bowley in 1924. The idea is to take into account the actions and reactions of other firms in the market, especially in an oligopolistic market. This measurement is also obtained from the first order condition of sellers' (upstream firms) profit function.

$$P_u\left(1 - \theta_u^j \varepsilon\right) - \frac{\partial C_u(Y_u, w)}{\partial Y_u} = 0 \qquad \textbf{Equation 2}$$

where ε is the inverse market demand elasticity, defined as $\varepsilon = (\partial P_u / \partial Y_u)(P_u / Y_u)$, and θ^j, defined as $\theta_u^j = (\partial Y_u / \partial Y_u^j)(Y_u^j / Y_u)$, is the conjectural elasticity of the total industry output with respect to the output of *j*th firm. This value is also bounded between

0 and 1. If θ_u^j=0, then the market is competitive, if θ_u^j=1, the market is purely monopolistic, and if $0 < \theta_u^j < 1$, the market is oligopolistic.

In the second group (Muth et al 1999; Koontz and Philip 1997), the monopsony power parameter is obtained from the first order condition of buyers' (downstream firms) profit function.

$$P_u + \frac{\partial C_d\left(Y_d^*, v; Y_u\right)}{\partial Y_u} + \lambda_s\left[\frac{\partial P_u\left(Y_u, w\right)}{\partial Y_u}\right]Y_u = 0 \text{ ....} \textbf{Equation 3}$$

where $C_d\left(Y_d^*, v, Y_u\right)$ represents the monopsonist'/ downstream firms' cost function, v is the vector of input prices, and λ_s is the parameter index of monopsonistic market, which is bounded between 0 and 1. If $\lambda_s = 0$, the market is competitive, whereas $\lambda_s = 1$ shows a full monopsony condition. Other λ_s values between 0 and 1 indicate various degrees of oligopsony power.

Similarly, the buyers' power parameter can also be presented as a conjectural elasticity. This measurement is obtained from the first order condition of buyers' (downstream firms) profit function:

$$P_u\left(1 + \phi_u^j \eta\right) + \frac{\partial C_d\left(Y_d^*, v; Y_u\right)}{\partial Y_u} = 0 \text{ ....} \textbf{Equation 4}$$

where η is the inverse market supply elasticity, defined as, $\eta = (\partial P_u / \partial Y_u)(P_u / Y_u)$, and θ^j, defined as $\phi_u^j = (\partial Y_u / \partial Y_u^j)(Y_u^j / Y_u)$, is the conjectural elasticity of the total industry output with respect to the output of *j*th firm. This value is also bounded between 0 and 1. If ϕ_u^j=0, the market is competitive, if ϕ_u^j=1, the market is pure monopsony, and if $0 < \phi_u^j < 1$ the market is oligopsony.

Finally, in the third group (Azzam and Pagoulatous 1990; Sexton and Zang 2001) market power is measured from the first order condition of downstream firms' profit function.

$$P_d + \lambda_m \left(\frac{\partial P_d}{\partial Y} \right) Y - P_u - \lambda_s \left(\frac{\partial P_u}{\partial Y} \right) Y - \frac{\partial C_d}{\partial Y} = 0$$ ....**Equation 5**

or in conjectural elasticity form

$$P_d \left(1 - \theta_d^j \varepsilon\right) - P_u \left(1 + \phi_u^j \eta\right) - \frac{\partial C_d}{\partial Y} = 0$$ ....**Equation 6**

The interpretations of market power parameters in this model are similar to those in the monopoly and monopsony scenarios. If $\theta_d^j = \phi_u^j = 0$, the market is competitive or firms have no market power, if $\theta_d^j = 1$ and $\phi_u^j = 0$, firms exert monopoly power, if $0 < \theta_d^j < 1$ and $\phi_u^j = 0$, firms exert oligopoly power, if $\theta_d^j = 0$ and $\phi_u^j = 1$, firms exert monopsony power, if $0 < \phi_u^j < 1$ firms exert oligopsony power, and if $0 < \theta_d^j < 1$ and $0 < \phi_u^j < 1$, firms exert both monopoly and monopsony power,.

Two-side behaviour

The two-side behavioral models can be divided into two groups, namely the composite and dominant models. In the first model (Schroeter et al. 2000; Raper et al. 2000), both buyers and sellers are treated as a single integrated firm that jointly choose the optimal input and output levels to maximise their profits, while in the latter model (Buschena and Perloff 1991, Azzam 1996 and Murniningtyas 2000) each agent (seller or buyer) separately chooses their optimal input and output levels to maximize their profits. .

Schroeter et al. (2000) obtain the composite model by nesting three possible equilibrium conditions, that is bilateral price-taking (BPT), manufacturer price-taking (MPT) and retailer price-taking (RPT). The composite bilateral oligopoly equation becomes

$$\frac{P_r}{S} + \left[(\gamma + \lambda(1+\gamma))(a_1 + a_3 Z_3) - \frac{(b_1(1+\gamma) + (1+\delta)c_1)}{S} - c_3(1+\delta)\frac{V_3}{S} \right] Q - \frac{(b_0 + c_0)}{S} - b_2 \frac{W_2}{S} - c_2 \frac{V_2}{S} = (\eta + \mu)$$

....**Equation 7**

where the right hand side terms (η, μ) are random errors, P_r is retail price in nominal terms, S is appropriate price index, so that $\frac{P_r}{S}$ is the real price of the retail product; Q is quantity; Z_3 is an exogenous variable affecting the slope (elasticity) of demand curve, perhaps the price of a substitute product; W_2 and V_2 are exogenous factor prices in the retailers' and manufacturers' marginal cost function, respectively; V_3 is another exogenous determinant of manufacturers' marginal cost, perhaps another factor price; a_1, a_3 are parameters in the retail demand curve; b_0, b_1, b_2 are parameters in the retailers' marginal cost function; c_0, c_1, c_3 are parameters in the manufacturers' marginal cost function; λ, γ, δ are parameters for sellers' power in the retail market, sellers' power in the wholesale market and buyers' power in the wholesale market, respectively. $\gamma = 0$, $\delta = 0$ and $\gamma = \delta = 0$ correspond to price-taking behavior by manufacturers/ sellers, by retailers/ buyers and both sellers and buyers in the wholesale market.

Raper et al. (2000) obtain the composite model by using a two-stage game. In the first stage, the upstream and downstream firms (or organized group) jointly choose the optimal output and input levels as if they were a single integrated firm. In the second stage, firms negotiate a transfer price for the intermediate good that determine the profit split. The composite equation is obtained by simultaneously joining the first order condition of the upstream firms

$$P_u - \frac{\partial C_u(Y_u, w)}{\partial Y_u} + \lambda_m \left[\frac{\partial P_u(Y_d^*, v, Y_u)}{\partial Y_u} \right] Y_u = 0$$ ....**Equation 8**

with the first order condition of downstream firms

$$P_u + \frac{\partial C_d(Y_d^*, v; Y_u)}{\partial Y_u} + \lambda_s \left[\frac{\partial P_u(Y_u, w)}{\partial Y_u} \right] Y_u = 0$$ ....**Equation 9**

Market power parameters are estimated by simulating eight market structures, namely perfect competitive $(\lambda_m = \lambda_s = 0)$, monopolistic $(\lambda_m = 1; \lambda_s = 0)$, Cournot duopolistic $(\lambda_m = 0.5; \lambda_s = 0)$, Stackelberg duopolistic $(\lambda_m = 0.4; \lambda_s = 0)$, monopsonistic $(\lambda_m = 0; \lambda_s = 1)$, Cournot duopsonistic $(\lambda_m = 0; \lambda_s = 0.5)$, Stackelberg duopsonistic $(\lambda_m = 0; \lambda_s = 0.4)$, and cooperative bilateral monopolistic; even profit split, buyer or seller domination $(\lambda_m = \lambda_s = 0)$ or $(\lambda_m > 0; \lambda_s > 0)$.

In the second group (Buschena and Perloff 1991, Azzam 1996 and Murniningtyas 2000), each agent (seller or buyer) separately chooses their optimal input and output levels to maximise their profits. The first order condition of sellers' profit function gives the upper price of the intermediate good; prices that upstream firms/ sellers wish to set if they exert market power.

$p_i^u = (1+\theta^i \varepsilon^i)^{-1}(p^f + \theta^i \eta^i p^f + c^i)$ ....**Equation 10**

where θ^i are conjectural variations, ε^i are demand elasticities, η^i are supply elasticities and c^i are marginal costs. The first order condition of downstream firms/ buyers' profit function gives the lower price of the intermediate good; prices that buyers will accept if they exercise market power.

$p_i^d = (1+\theta^j \eta^j)^{-1}(p^j + \theta^j \varepsilon^j p^i + c^j)$ ....**Equation 11**

To take into account both sides of market power exertion, these prices are then collapsed in a single equation to determine which power is dominant.

$p_i = \alpha p_i^d + (1-\alpha) p_i^u$ ....**Equation 12**

If α<0.5, the upstream firm dominates the downstream firm, whereas if α>0.5, the downstream firm dominates the upstream firm. Particularly, α=0, α<0.5, α=0.5, α>0.5 and α=1 indicates the monopoly, oligopoly, competitive, oligopsony and monopsony, respectively. These results are expected to be more reliable, especially in cases that both buyers and sellers can potentially exert market power.

Dynamic Models

Although these models have considered both sellers' and buyers' market power, some authors argue that they may still give incorrect estimations of market power. The incorrect estimations can stem from the static framework of these models. Previous studies show that market power estimations in static models need not be correct (Friedman 1993, p.109; Deodhar and Sheldon 1995 and 1996).

A linear-demand and quadratic cost approach is broadly chosen in the dynamic model (Fershtman and Kamien 1987; Karp and Perloff 1989; Dockner 1992; Karp and Perloff 1993; Deodhar and Sheldon 1996). In this model, the profit function becomes

$$\sum_{t-1}^{\infty}\beta^{t-1}[(p_{(t)}-c^{j}{}_{(t)})y^{j}_{(t)}-\left(\alpha_{(t)}+\frac{\delta}{2}u^{i}_{(t)}\right)u^{i}_{(t)}]$$ ……………………..**Equation 13**

where β is the discount factor ($\beta=\frac{1}{1+r}$, r denotes the common discount rate), p is the real price and $\left(\alpha_{(t)}+\frac{\delta}{2}u^{i}_{(t)}\right)u^{i}_{(t)}$ is the quadratic adjustment cost. Defining $J^{j}(y_{t-1},\tilde{\lambda})$ as the present discounted value of firm j, with $\tilde{\lambda}$ as dynamic conjectural variations, we can rewrite the profit equation as

$$J^{j}(y_{t-1};\tilde{\lambda})=\max(p_{(t)}-c^{j}{}_{(t)})y^{j}_{(t)}-\left(\alpha_{(t)}+\frac{\delta}{2}u^{i}_{(t)}\right)u^{i}_{(t)}+\beta J^{j}(y_{(t)};\tilde{\lambda})$$ ……….**Equation 14**

The first two terms and the last term refer to the profits from the current period, and the present discounted value of the future profits as of the current period, respectively. The first order condition of (14) becomes

$$p_{(t)}=c^{j}+(1+\tilde{\lambda})p'_{(t)}+\alpha_{(t)}+\delta u_{(t)}-\beta\left[\frac{\partial J^{j}(y^{j}_{(t)};\tilde{\lambda})}{\partial y^{j}_{(t)}}+\frac{\partial J^{j}(y_{(t)};\tilde{\lambda})}{\partial y^{i}_{(t)}}\tilde{\lambda}\right]$$ ……..…**Equation 15**

If $\tilde{\lambda}=1$, firms in the market will collude, if $\tilde{\lambda}=-1$, firms act as price takers, and if $-1<\tilde{\lambda}<1$, an oligopolistic market structure may be implied. These studies, which use the linear demand and quadratic cost approach, show that the feedback strategy model implies a more competitive market structure than the estimated open-loop model. In other words, the static conjectural variations model may lead to biased estimations of market power.

Lerner Index

Lerner Index is broadly used as another market power measurement in previous studies. This measure of monopoly was introduced by Lerner in 1934, which is known as the Lerner Index of Monopoly Power. The formula is $LI=\frac{p-mc}{p}$, where p is the output price and mc is the marginal cost. Lerner (1934, p.161) defines the degree of monopoly power as a percentage of monopoly revenue per unit of output. It can also be seen as a percentage of markup above marginal cost. In a perfectly competitive market, there is no markup and the *LI* is zero, while in a pure monopolistic one, the LI is one.

In profit maximisation, where marginal cost equals marginal revenue, the LI equals the inverse of demand elasticity,

$$\frac{p - mc}{p} = -\frac{1}{\varepsilon}$$ .... **Equation 16**

According to this equation, a low elasticity of demand may give firms a high degree of market power. In a high demand elasticity, a price increase may incite consumers to greatly reduce their demand (Tirole 1988, p.66). Therefore, sellers would not be able to maintain high prices. The firm's demand elasticity depends on the market demand elasticity and other firms' supply elasticities; $\varepsilon_d^i = \frac{\varepsilon_D - \varepsilon_s^j - m^j}{m^i}$ (Landes and Posner 1981), thus Lerner Index can also be rewritten as

$$\frac{1}{\varepsilon_d^i} = \frac{m^i}{\varepsilon_D - \varepsilon_s^j - m^j}$$ ....**Equation 17,**

where m^i is firm i's market share, ε_s^j is the other firm's supply elasticity, and ε_D is the market demand elasticity.

In conclusion, all of the elasticities listed above, namely the firm's, the market demand and the fringe supply elasticities determine the degree of monopoly power. The greater the last two elasticities, the greater the firm's elasticity, and the smaller its monopoly power. This version of the LI is often used in examining the dominant firm's market power (Buschena and Perloff 1991; Akiyama and Larson 1994; Yang 2002; Alleman et al. 2003)

To address the reactions of other firms in the market in an oligopoly market, Appelbaum(1982) defines the degree of oligopoly power

$$\frac{p-mc}{p}=\frac{\theta^j}{\varepsilon}=\frac{(1+v)m^j}{\varepsilon}$$ …………………**Equation 18**

where $\theta^j=\frac{\partial y}{\partial y^j}\frac{y^j}{y}$ is the jth firm's conjectural elasticity, $v^j=\frac{\partial y}{\partial y^j}$ is the jth firm conjectural variations, and $\frac{y^j}{y}$ is jth firm's market share. It can be seen that, besides the demand elasticity (as in the monopoly situation), market shares and firm's expectations of its rivals' reaction (θ^j) also determine market power in an oligopolistic market.

The LI can also be modified as a measure of monopsony power (buyer power). In contrast with monopoly/oligopoly power, the buyer power measures an ability to purchase below the marginal value. Lerner (1934, p.161) explains this 'markdown' as the difference between average costs and marginal receipts, that is

$$\frac{mv-p}{p}=\frac{1}{\eta}$$ ……………………**Equation 19**

or $$\frac{mv-p}{p}=\frac{\xi}{\eta}$$ ……………………..**Equation 20**

for the degree of monopsony power or oligopsony power, respectively (Pindyck and Rubinfeld 2001, p.355; Sexton et al. 2003, p.9).

In the dynamic framework, from the first order condition of the adjustment costs model (Karp and Perloff 1989, 1993), the LI becomes

$$\frac{p_t-c_t}{p_t}=-\frac{\theta_{it}}{\varepsilon_t}+\Delta$$ ……..........................**Equation 21**

where $\Delta=\frac{\gamma_i+\delta u_{it}-\beta\left[\frac{dJ_i(q_t,v)}{dq_i}+\frac{dJ_i(q_t,v)}{dq_j}\right]}{p_t}$. Δ shows the difference between this index with the static one, where $\mu_{it}=q_{it}-q_{i,t-1}$ is the difference between the output in time *t* and *t-1*. In this dynamic index, market power is not only determined by the effect of firm j's reaction to the current quantity choice made by firm i ($\theta_{it} = \frac{\partial Q_t}{\partial q_{it}} = \frac{\partial(q_{it} + q_{jt})}{\partial q_{it}} = \frac{\partial q_{it}}{\partial q_{it}} + \frac{\partial q_{jt}}{\partial q_{it}} = 1 + v$) and market demand elasticity (ε_t), but also by the adjustment costs and the direct dynamic externality (DDE), that is the effect of i's future choices on its own choices $\left[\beta\left(\frac{dJ_i(q_t, v}{dq_i}\right)\right]$, and the indirect dynamic externality (IDE), that is, the effect of firm j's future choices on the firm i's current choices $\left[\beta\left(\frac{dJ_i(q_t, v}{dq_j}\right)\right]$

With similar steps and interpretations, the measure of oligopsony power can be written as

$$\frac{mv_t - p_t}{p_t} = \frac{\phi_{it}}{\eta_t} + \Gamma$$ **……………………Equation 22**

where $\Gamma = \frac{\gamma_i + \delta u_{it} - \beta\left[\frac{dJ_i(q_t, v)}{dq_i} + \frac{dJ_i(q_t, v)}{dq_j}\right]}{w_t}$, mv_t is the marginal value at time t and p_t is the input price at time t

Another version of the dynamic Lerner Index is found in Hunnicutt and Aadland's (2003) study. They employ an inventory constraint to capture the dynamic condition and present the discounted profit as

$$\sum_{t=0}^{\infty} \beta^t [(p(y_t) - w(y_{g,t}, S_t)]y_t^j - c^j(y_{(t)}^j)]$$ **…………………Equation 23**

where *y, w* and *S* denote the aggregate input purchases or the output that is supplied in the period, the inverse supply function and the stock level, respectively. Given $R^j = \frac{dy}{dy^j}$ and $S_{t+1} = f(S_t, y_{g,t})$, the first order condition becomes

$$\{p_t - w_t - c_t^j\} + \{p_t^{'} - w_{y,t}\}y_t^j R_t^j + \beta\{p_{t+1} - w_{t+1} - c_{t+1}^j\}\frac{dy_{t+1}^j}{dS_{t+1}} f_y R_t^j$$

$$+\beta\left[\left\{p'_{t+1}-w_{y,t+1}\right\}y^j_{t+1}f_yR^j_t\left[\frac{dy^j_{t+1}}{dS_{t+1}}\right]R^j_{t+1}+\frac{\partial y^j_{t+1}}{\partial S_{t+1}}\right]-w_{S,t+1}y^j_{t+1S.t+1}f_yR^j_t=0 \quad \textbf{.........Equation 24}$$

Measuring the oligopoly power as the Lerner index, in this case it becomes

$$L^{cl}_t=\frac{p_t-w_t-w_{y,t}y^j_tR^j_t-c^j_t}{p_t}=-\frac{p'_t}{p_t}y^j_tR^j_t+\Delta=-\theta^j_t\varepsilon_t+\Delta \quad \textbf{........Equation 25}$$

$$\Delta=-\left(\beta f_yR^j_t/p_t\right)\left[A_{t+1}\left(dy^j_{t+1}/dS_{t+1}\right)+N_{t+1}(\partial y^i_{t+1}/\partial S_{t+1})-w_{S,t+1}y^j_{t+1}\right]$$

or as oligopsony power

$$M^{cl}_t=\frac{p_t-w_t+p'_ty^j_tR^j_t-c^j_t}{w_t} \quad \textbf{............................Equation 26}$$

$$=\frac{w_{y,t}y^j_tR^j_t}{w_t}-\frac{\beta f_yR^j_t}{w_t}\left[A_{t+1}\frac{dy^j_{t+1}}{dS_{t+1}}+N_{t+1}\frac{\partial y^i_{t+1}}{\partial S_{t+1}}-w_{S,t+1}y^j_{t+1}\right]$$

$$=\phi^j_t\eta_t+\Gamma,$$

where $\Gamma=-\frac{\beta f_yR^j_t}{w_t}\left[A_{t+1}\frac{dy^j_{t+1}}{dS_{t+1}}+N_{t+1}\frac{\partial y^i_{t+1}}{\partial S_{t+1}}-w_{S,t+1}y^j_{t+1}\right]$

These dynamic Lerner Indexes imply that, using a static model can lead to biased estimations of market power as much as Δ or Γ. Thus, in order to obtain a more reliable estimations, it is necessary to apply a dynamic model in market power studies.

Vertical structure

The relationship between vertical market structure and market power has been discussed since 1967 (Comanor). Nonetheless, the result of this relationship is still being debated (Schmalensee. 1973, Greenhut and Ohta. 1976, Waterson. 1982, Cook. 1997, Salinger. 1989, Ordover et al. 1990, Abiru et al. 1998, Riordan. 1998 and Brennan. 2001). Vertical market structure can be pro or contra to market competition. Comparing two cases from different industries (brewing and petrol in UK), Cook (1997, pp.163-4) illustrates these possibilities. The brewing industry exploited integration as a tool in enhancing market power, whereas the petrol industry utilised the efficiency effects to decrease the price. Therefore to get a complete picture of market power in an industry, we need to investigate both the horizontal and vertical market structure.

Formally, this model can be seen in Murray (1995. p.195). The objective function of the integrated operations is

$$\max_{X_M^W, X_I^W} \pi = PQ(X^W) - W^W X_M^W - C\left(X_I^W\right) \qquad \textbf{Equation 27}$$

where $Q(.)$ is the production function, P is the price of output, W^W is the market price for the input, X_M^W is the input bought from the open market, and $C(X_I^W)$ is the cost function of internally supplied inputs. Generally, vertical integration is effective in enhancing market power as long as the difference between the cost of internally producing input and buying it from open markets is great enough to still yield an equal or greater profit with a lower productivity.

4. A market power model for the Indonesian palm oil industry

In the Indonesian palm oil industry growers, or plantation industries are treated as upstream industry and processors (CPO millers and cooking oil refineries) or the cooking oil industry, as downstream industry. Growers are assumed to buy inputs from a competitive market, and end consumers and retailers are assumed to have no market power.

Following the Karp and Perloff (1993) model with adjustment costs as a dynamic variable, a linear-quadratic oligopoly model is built to measure the seller's power. The plantations' objective function is to maximise their discounted stream profits any time

$$\pi_i = \sum_{t=1}^{\infty} \beta^{t-1} \left[(p_t - c_t) q_{it} - \left(\gamma_i + \frac{\delta}{2} u_{it} \right) u_{it} \right] \qquad \textbf{Equation 28}$$

where p_t is the real FFB price at time t, c_t is the plantations' marginal costs, q_{it} is the firm i's output (FFB) at time t, and $\left(\gamma_i + \frac{\delta}{2} u_{it}\right) u_{it}$ is the adjustment cost (in static situations; $\gamma_i, \delta = 0$), and β is the discount factor

Following similar steps in the oligopoly model, a linear-quadratic oligopoly model is built to measure the buyer's power. Consider the processors' objective function which is to maximise their discounted stream profits. Modifying Karp and Perloff's (1993) model, the processors' objective function can be written as

$$\pi_i = \sum_{t=1}^{\infty} \beta^{t-1} \left[(p_t - w_t) q_{it} - \left(\gamma_i + \frac{\delta}{2} u_{it} \right) u_{it} \right] \quad \textbf{Equation 29}$$

where p_t is the real cooking oil price at time t, w_t is the real input price at time t, q_{it} is the firm i's output (cooking oil) at time t, and $\left(\gamma_i + \frac{\delta}{2} u_{it}\right) u_{it}$ is the adjustment cost (in static ; $\gamma_i, \delta = 0$), and β is the discount factor.

In the input (FFB) market, growers and processors interact. Since both might have possibilities to exert market power, the two-side behavioral model is used to test the power. The first-order conditions of the plantations' and processors' objective functions give the upper and lower prices, respectively. These prices are then collapsed into a single equation to determine which player is dominant. In the output (cooking oil) market, retailers and processors interact. Retailers are assumed to have no market power, thus the one-side behavior model is be used in this market. Market power will be estimated by the first-order condition of the processors' objective function.

Market power and welfare

Market power is often viewed as a problem, because it can decrease social welfare. It can also increase inequality in income distribution among economic agents. In this case, the changes in social welfare and income distribution will be estimated by the deadweight loss (DWL) and the distribution effect (DE), respectively. In a static monopolistic/oligopolistic market the DWL can be measured as

$$\int_{q^t}^{q^c} D(Q) - S(Q)dQ = \frac{(q^c - q^t)(p - c_i)}{2}$$

$$= \left(\frac{p - c_i}{p}\right)\frac{p(\Delta q)}{2}$$

$$= L\left(\frac{p\Delta q}{2}\right)$$

where $D(Q)$ and $S(Q)$ are the demand and supply functions as a function of the output. Both are bounded by monopolistic $q^m = q^t$ and competitive q^c quantity, which is the existing output at $p = mc$. The static formula can be changed to a dynamic one by aggregating the DWL over time, which is

$$DWL^{\infty} = \sum_{t-1}^{\infty} \beta^{t-1} DWL$$

$$= \sum_{t=1}^{\infty} \beta^{t-1} L\left(\frac{p\Delta q}{2}\right)$$

$$= L\sum_{t=1}^{\infty} \beta^{t-1}\left(\frac{p(\Delta q)}{2}\right)$$

or in a dynamic programming equation, it can be written as

$J(q_t) = Lp_t \frac{\Delta q}{2} + \beta J(q_{t+1})$**…………….Equation 30**

The distribution effect (DE) in this monopolistic/oligopolistic market is estimated by modifying the Pindyck (1985) model. In a static monopoly model, the DE can be measured as

$DE = (p - mc)q^m$, where $q^m = q^t$ if firms exercise market power

The static framework can be changed to a dynamic one by aggregating the DWL over time, which is

$$DE^{\infty} = (p_t - mc_t)q_t + \sum_{t=2}^{\infty} \beta^{t-1}(p_t - mc_t)q_t$$

or in dynamic programming equation, it can be written as

$$J(q_t) = (p_t - mc_t)q_t + \beta J(q_{t+1}) \text{..................................}\textbf{Equation 31}$$

In a static monopsonistic/oligopsonistic market, the DWL can be measured as

$$\int_{q^t}^{q^c} MV(Q) - AE(Q)dQ = \frac{(q^c - q^t)(v_i - p_t)}{2}$$

$$= \left(\frac{v_i - p_t}{v_i}\right)\frac{v_i(\Delta q)}{2}$$

$$= M\left(\frac{v_i \Delta q}{2}\right)$$

where $MV(Q)$ and $AE(Q)$ are the marginal value and aggregate expenditure function as a function of the output. Both are bounded by monopolistic $q^m = q^t$ and competitive q^c quantity, which is the existing output and output at $mv = me$, respectively. The static framework can be changed to a dynamic one by aggregating the DWL over time, which is

$$DWL^{\infty} = \sum_{t-1}^{\infty} \beta^{t-1} DWL$$

$$= \sum_{t=1}^{\infty} \beta^{t-1} M\left(\frac{p\Delta q}{2}\right)$$

$$= M\sum_{t=1}^{\infty} \beta^{t-1}\left(\frac{p\Delta q}{2}\right)$$

or in a dynamic programming equation, it can be written as

$$J(q_t) = Mp_t \frac{\Delta q}{2} + \beta J(q_{t+1}) \text{................}\textbf{Equation 32}$$

The distribution effect (DE) in this monopolistic/oligopolistic market is estimated by modifying the Pindyck (1985) model. In a static monopoly model, the DE can be measured as $DE = (mv - p)q^m$, where $q^m = q^t$ if firms exercise market power. The static framework can be changed to a dynamic one by aggregating the DWL over time, which is $DE^{\infty} = (mv_t - p_t)q_t + \sum_{t=2}^{\infty} \beta^{t-1}(mv_t - p_t)q_t$

or in a dynamic programming equation, it can be written as

$J(q_t) = (mv_t - p_t)q_t + \beta J(q_{t+1})$ ....**Equation 33**

The DWL and DE show how severe the impact on income and income distribution is. The greater DWL implies the greater decrease of the total surplus in the market, while the greater DE shows the greater reduction in consumer surplus caused by selling power.

Vertical structure and market power

For testing the effect of vertical market structure of the palm oil industry on market power, this study will measure the change of processors' market power before and after the backward integration. After integrating and internally supplying some of its inputs, the processors' profit function becomes

$\pi_i = \sum_{t=1}^{\infty} \beta^{t-1} \left[p_t q_{it} - w_t q_{it}^1 - c_t q_{it}^2 - \left(\gamma_i + \frac{\delta}{2} u_{it} \right) u_{it} \right]$ ....**Equation 34**

where c_t is the marginal costs of producing internal input, $q_{it}^1 + q_{it}^2 = q_{it}$ is the total input. The one-side behavioral model will be applied again to estimate market power. The difference between the pre- and post-integration shows whether or not the vertical market structure enhances or reduces market power.

5. Conclusion

Market power is broadly defined as the ability of firms to maintain prices above the marginal cost of production, and can be seen as a non-competitive phenomenon. Market power is one of the most frequently discussed issues in industrial organization, as it leads to inefficiency and welfare loss. However, modeling and measuring market power is not always easy. A variety of approaches to modeling market power have been reported in the literature. These approaches can be grouped into one and two side-behavioral model.

The first model only measures the market power exerted by one agent or a set of agents, sellers or buyers, in the market, while the latter model takes into account market power exerted by both sellers and buyers.

In the Indonesian palm oil industry, market power may stem from various sources, including the supply conditions, the investment requirements, or even government policies. The power can be exercised by both sellers and buyers. In this case, plantation firms act as upstream firms and processing firms as downstream firms. In the input (FFB) market, upstream and downstream firms act as sellers and buyers, respectively. Since both sellers and buyers might have the possibility to exert market power, the two-side behavioral model is used to test market power in this market. In the output (cooking oil) market, downstream firms and retailers act as sellers and buyers, respectively. Assuming that retailers act competitively, the one-side behavioral model measures market power in this output market.

The dynamic Lerner Index is also proposed as a reinforcing approach to measuring the degree of market power, and its consequent welfare effects. The effects are measured by the deadweightloss and distribution effect, which implies the total and distributional surplus' loss in the market. Finally, to get a complete picture of market power, the similar one-side behavioral model is also applied to the vertically integrated market of this industry. The impact of integration is determined by the difference between the pre- and post-integration. A positive difference shows that the vertical market structure enhances market power and vice versa.

Market power in the Indonesian palm oil industry has been debated since it has led to a more concentrated and integrated market. A low price transmission along the production chain is suspected as an indication of market power. However, to test market power is not always easy. This paper is meant to represent an attempt at modelling and measuring market power in this industry. While a challenging exercise, it may yield information that could potentially be used to improve the competitiveness of the industry.

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