AN EMPIRICAL ANALYSIS OF ASYMMETRIC DUOPOLY IN THE INDONESIAN CRUDE PALM OIL INDUSTRY

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Declaration

I hereby certify that the text of this study contains no material which has been accepted as part of the requirements for any degree or diploma in any university, nor does it contain any material previously published unless due reference to this material is made.

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Abstract

The apparent increase in market concentration and vertical integration in the Indonesian crude palm oil (CPO) industry has led to concerns about the presence of market power. For the Indonesian CPO industry, such concerns attract more attention because of the importance of this sector to the Indonesian economy. CPO is used as the main raw material for cooking oil (which is an essential commodity in Indonesia) and it contributes significantly to export earnings and employment. However, dominant producers argue that the increase in economies of scale and scope lead to an increase in the efficiency, which eventually will be beneficial for the end consumers and export earnings. This research seeks to examine whether the dominant producers do behave competitively and pass the efficiency gains to the end consumers, or they enhance inefficiency through market power instead.

In order to identify the most suitable model to measure market power in the Indonesian CPO industry, different market power models are explored. These models can be divided into static and dynamic models. In general, all of them accept the price–cost margins as a measure of market power. However, static models fail to reveal the dynamic behaviour that determines market power; hence the dynamic models are likely to be more appropriate to modelling market power. Among these dynamic models, the adjustment model with a linear quadratic specification is considered to be a more appropriate model to measure market power in the Indonesian CPO industry.

In the Indonesian CPO industry, producers can be divided into three groups, namely the public estates, private companies and smallholders. However, based on their ability to influence market price, smallholders are not considered as one of the dominant groups. By using the adjustment cost model, the market power of the dominant groups is estimated. The model is estimated using a Bayesian technique annual data spanning 1968–2003. The public estates and private companies are assumed to engage in a non-cooperative game. They are assumed to use Markovian strategies, which permit firms to respond to changes in the state vector. In this case, the vector comprises the firms and

their rivals' previous action, implying that firms respond to changes in their rivals' previous action.

The key contribution of this thesis is the relaxation of the symmetry assumption in the estimation process. Although the existence of an asymmetric condition often complicates the estimation process, the different characteristics of the public estates and private companies lead to a need for relaxing such an assumption. In addition, the adjustment system—which can be seen as a type of reaction function—is not restricted to have downward slopes. Negative reaction functions are commonly assumed for a quantity setting game. However, the reverse may occur in particular circumstances. Without such restrictions, the analysis could reveal the type of interaction between the public estates and private companies. In addition, it provides insights into empirical examples of conditions that might lead to the positive reaction function. Furthermore, the analysis adds to the understanding of the impact of positive reaction functions to avoid the complicated estimation of the asymmetric case.

As expected, the public estates act as the leader, while the private companies are the follower. Interestingly, results indicate that as well as the private companies, public estates do exert some degree of market power. Moreover, the public estates enjoy even higher market power than the private companies, as indicated by market power indices of -0.46 and -0.72, respectively. The exertion of market power by both the public estates and the private companies cast some doubts about the effectiveness of some current policies in the Indonesian CPO industry. With market power, the underlying assumption of a perfectly competitive market condition—that serves as the basis for the government interventions—is no longer applicable. Hence, many government interventions are unlikely to have the desired effect.

The Indonesian competition law that has been imposed since 1999 might be effective in preventing firms to sign collusive contracts. In fact, even without such an agreement, firms in the CPO industry are likely to exert some degree of market power. As an alternative, eliminating the 'sources' of market power might be a better solution. If the public estates have the aim of maximising welfare, privatisation might improve their efficiency, hence they have ability to suppress the private companies' market power. However, if in fact, the public estates deliberately reduce output to gain higher profit, privatisation might increase the degree of market power of both groups of companies even further. In such a condition, addressing the long term barriers of entry stemming from the requirement of high investment might be a better alternative to address the market power problem in the CPO industry.

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Chapter 1
Introduction

In recent decades, the problem of market distortion in the Indonesian crude palm oil (CPO) industry has been widely discussed. The issue is a source of public concern because CPO has been an important contributor to the Indonesian economy for at least three reasons. Firstly, cooking oil, an end product of the CPO industry, is an essential commodity in Indonesia. As an essential commodity, the fluctuations in cooking oil prices appear to influence not only economic stability in Indonesia, but also political stability. Secondly, the industry is a major contributor to Indonesia's exports. In 2002, palm oil exports grew by 93 per cent, which was the highest rate among all sectors contributing to export revenue (Indonesian Bureau of Statistics 2003). This has been the case both in periods of strong economic growth and during the economic crisis of 1997–1998 (Susila 2003). Finally, the CPO industry is a significant employer, which is important given Indonesia's large population. It is estimated that in 2002, 1.2 million people worked in the Indonesian palm oil production and processing industries, and that around 5.5 million people were being supported by this industry (Barlow *et al.* 2003, p. 9).

The CPO industry has been the focus of many acts of government intervention. The main purpose of these interventions has been to ensure that the cooking oil price remains stable, either by subsidising CPO and cooking oil prices, or by imposing CPO export taxes. However, these policies are not always effective. Although Indonesia is arguably known as the most cost efficient CPO producer in the world, the cooking oil price in the domestic market is often higher than that of in the international market's. Theoretically, efficient producers can sell their output at a low price. If producers are vertically integrated with the downstream industry, lower prices will be transmitted to the final output. However, such assumptions hold only when producers behave competitively. If the CPO producer exerts some degree of market power, prices will remain above the marginal cost of production. As a result, low production costs will not be followed by low market prices, nor will low intermediate output prices be transmitted to the final output prices. Arifin (2002) suggests that both government interventions and CPO producers' non-competitive behaviour might explain the distortions in the CPO market. While studies such as Larson (1996), Marks *et al.*(1998) and Hasan (2000) have scrutinised the impact of the government interventions, to date no study appears to have been addressed the impact of the CPO producers' behaviour on the market.

In Indonesia, CPO producers can be divided into three groups: public estates, the private companies and the smallholders. Before 1986, public estates were the dominant group in the Indonesian CPO market. Triggered by the 1986–1996 distribution of concessionary credits, in 2003, private companies and smallholders gradually increased their share, reaching 50 per cent and 40 per cent of the market, respectively (Indonesian Bureau of Statistics 2004). The public estates and private companies tend to be more integrated with both the upstream industry (such as the seed gardens) and the downstream industry (such as the cooking oil refineries). In contrast, smallholders do not possess such facilities. They also suffer from diseconomies of scale and are lack of joint marketing associations. Hence, although the total size of smallholders has reached 40 per cent of the market share, this group is not considered as one of the dominant groups in the industry.

A number of economists believe that this change in structure might allow the dominant producers to control market price, and hence exercise market power (Basri 1998; Pasaribu 1998; Rachbini 1998; Arifin 2001; Competition Indonesia 2001; Arifin 2002; Widjojo 2004; Syachrudin 2005). In 2001, the Indonesian Commission for the Supervision of Business Competition (2001) indicated that one of the largest and most vertically integrated firms in the palm oil industry might exercise market power, yet failed to provide empirical evidence to support this claim. In fact, high market shares and vertical integrations might increase firms' efficiency rather than market power. For this reason, empirical analysis is essential to an examination of market power. A likely complication is that market power, although well-defined, is not always easy to be measured. These concerns constitute the motivation for this research to model and measure market power in the Indonesian palm oil industry.

1.1 Basic research questions

Despite the importance of the CPO industry for Indonesia, and concerns over the presence of market power, to the author's best knowledge, to date no study has been taken to investigate market power in this industry. This research is designed to fill the void by modelling and measuring market power in this industry. Specifically, the following research questions are addressed:

- What is the most appropriate model to analyse and measure market power in the Indonesian CPO industry?
- Do the dominant players in the Indonesian CPO industry exercise market power?
- If these players do exert market power, does market power vary among them?
- What is the type of interaction between the players?
- What factors do affect the type of interaction between the players?
- What are the policy implications of the research findings?

The answers to the questions will provide useful information for promoting competition in the Indonesian CPO industry. Loughlin *et al*. (1999, p. 26) suggest that the understanding of competition issues among policy makers in Indonesia is often narrowed to market concentration or conglomerates, while in fact, competition is a more complex issue. A descriptive or statistical analysis that is often employed appears inadequately to prove whether producers in an industry behaved competitively or exercised some degree of market power. In contrast, a model could provide a measurement that reveals the behaviour of the producers, even that emerge from a non-cooperative mechanism. Although competition laws might not be able to address such tacit collusion, the evidence is useful for the policy makers in addressing the market power problems. Despite the fact that the competition issue in Indonesia has been widely examined from a legal perspective—especially after the introduction of the competition law—no market power model has been introduced as a tool to measure market power. The proposed analytical framework of this thesis is expected to give insights for modelling and measuring market power in the CPO industry.

1.2 Objectives of the study

Based on the previous research questions, the aims of this study are:

- To understand the relevant features of the Indonesian CPO industry in developing a framework for the theoretical and empirical model;

- To explore various market power models and to determine the most suitable model for the Indonesian CPO industry;

- To develop an empirical model to estimate the type of interaction and the degree of market power held by the dominant players, and to analyse possible factors that might explain the results; and

- To use the estimation results to assess the effectiveness of current government policies and to propose some alternative policies that might prevent the abuse of market power and increase social welfare.

1.3 Methods and data

The study employs a dynamic duopoly model to measure the market power of dominant players in the Indonesian CPO industry. Specifically, an adjustment cost model with a linear quadratic specification is considered mostly appropriate to capture the important features of the industry. In particular, the long maturation period and an extended economic life in the CPO production pattern induce the substantial adjustment costs associated with changing the level of production.

In this dynamic duopoly model, the reaction functions of the players are modelled through an adjustment system. In a static model, the slope of a reaction function is interpreted as conjectural variations, which show how a firm's (or group of firms') conjecture about its rivals' reactions causes the firm to change its own actions. The conjectural variation values are also interpreted as the market power index. In contrast, in this dynamic model, the slope of a reaction function is the actual response rather than the conjecture of the response. The market power index is not directly inferred from but is calculated using the value of the slope. The index nests all possible behaviours, from perfectly competitive to perfectly collusive.

In order to capture the specific characteristics of each duopolist, the symmetry assumption—that is common in the previous studies—is relaxed. With a symmetry assumption, the responses of both firms will be identical. Therefore, it can only show whether the firms interact cooperatively or non-cooperatively. Without the assumption of symmetry, the slope of a firm's reaction function will show the firm-specific response. Hence, a more complex pattern of interdependence will be revealed (Gollop and Roberts 1979). The relationship between the firms' degrees of market power and the type of interaction between the firms provides insights into possible sources of the market power.

The linear quadratic specification is useful as it allows the estimation of the market power index without using any cost data. Ideally, firm-level data would provide the best information about market power in the industry. However, firm-level data are insufficient, and therefore group data are used as an alternative.

1.4 Organisation of the study

A plethora of approaches to modelling market power are reported in the literature, focusing on different aspects of the problem and using different frameworks. In order to identify the most suitable model to the Indonesian CPO industry, the main features of the industry are explored in Chapter 2. This chapter explains the reasons behind setting the public estates and private companies groups as the dominant players in the industry. The different characteristics of these groups are discussed, highlighting the requirement of an asymmetric duopoly model. In addition, the existence of an intertemporal link is also presented.

In Chapter 3, various models of market power are explored. In comparing these models, the chapter focuses on the main factor that determines market power in an oligopolistic (duopolistic) market, which is the ability of oligopolists (duopolists) to respond to their rivals' actions. These models are divided into models using the structure–conduct–performance approach and the new empirical industrial organization (NEIO) approach. The structure–conduct–performance approach includes various static models, while the NEIO approach includes both static and dynamic models. In addition, the NEIO static models are grouped into the comparative and conjectural variations models, while the NEIO dynamic models are grouped into the repeated-game and the state-space game models. The assumptions employed in each model are discussed to determine the appropriateness of its application in certain cases.

Chapter 4 explores the theoretical and empirical models in greater details. The theoretical model provides the foundation of the state-space game framework. Three different strategies—the open-loop, closed-loop and Markovian strategies—widely used in previous studies are discussed. This is followed by a discussion of the Lagrangean multiplier and dynamic programming as the tools for obtaining the optimal solution. The empirical model presents the adjustment cost model with a linear quadratic specification. The relevance of this model for the CPO industry and the importance of its specification for market power estimation are discussed. The reasons for relaxing the symmetry assumption in the Indonesian CPO industry case are highlighted. The model is estimated using a Bayesian technique in order to impose the stability, convexity and market power properties of the model. In the last section of Chapter 4, the estimation procedure is presented.

The model is estimated by using annual data for the period of 1968–2003. The estimation results are presented in Chapter 5. Firstly, the results of the demand equation and the adjustment system are presented. The results from the adjustment system provide insights into the impact of positive reaction functions in avoiding the complicated estimation of the asymmetric case. Secondly, given these estimates, the adjustment cost parameter and market power index are calculated. The Monte Carlo numerical integration results are examined, including a possible explanation of the rejection of the stability, convexity and market power index properties. This is followed by a discussion of the accuracy of the estimation. Finally, the type of interaction and the degree of market power exerted by the dominant groups are detailed.

Based on these findings, several policy implications of the analysis are considered in Chapter 6. The effectiveness of the subsidy and export tax policies is examined. The role of the public estates and the effectiveness of Law No.5/1999 as an instrument to suppress market power in this industry are also discussed. Then, some possible alternative policies to address the market power problem are provided. Limitations of the study are outlined, leading to some avenues for further research. Finally, a number of concluding comments are made.

Chapter 2
The Indonesian Crude Palm Oil Industry

The structure of the Indonesian crude palm oil (CPO) industry has undergone a number of significant changes since the first large-scale establishment of an oil palm plantation in 1911. The public estates' share of production is decreasing, overtaken by a group of private companies (Directorate General of Plantation 2004), and vertical integration among oil palm plantations, crude palm oil millers and cooking oil refineries is increasing (BIRO 1999). Also, the regulatory environment in this industry appears to be moving towards free trade, by reducing the palm oil export taxes (Tomich and Mawardi 1995, cited in Sugiyanto 2002, pp. 18-19).

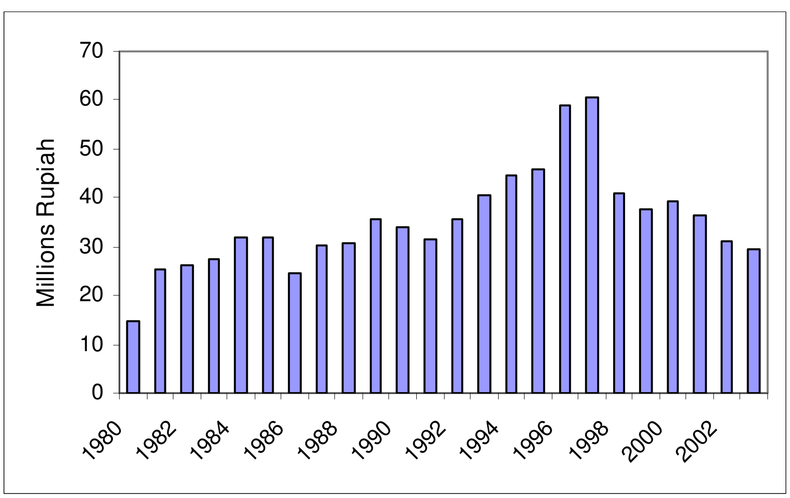
On one hand, these changes may increase cost efficiency, as they increase economies of scale and scope, which in turn may benefit consumers through lower output prices. Noor *et al*. (2004) show that the cost of production index of fresh fruit bunches (FFB)—that is the output from the oil palm trees—steadily decreases from 100 to less than 80 with an increase in estate size from less than 100 ha to 3,500 ha. Similarly, the cost of processing index of CPO steadily decreases from 100 to 80 with an increase in CPO mill capacity from less than 20 tonnes of FFB/ hour to more than 50 tonnes of FFB/ hour. They show that, in general, non-integrated mills are more costly than their integrated counterparts. In addition, vertical integration between the oil palm estates and CPO mills allows the CPO mills to operate without interruption, which further increases the mills' efficiency. On the other hand, the increase in market share and vertical integration of large private companies in this industry might also provide them with an ability to control market prices and exercise market power (Basri 1998; Pasaribu 1998; Rachbini 1998; Arifin 2001; Competition Indonesia 2001; Arifin 2002; Widjojo 2004; Syachrudin 2005). However, these allegations could not be supported by evidence.

This research seeks out to model and measure market power in the Indonesian palm oil industry. The main features of the Indonesian palm oil industry are explored in this chapter. In section 2.1, the importance of the Indonesian palm oil industry is discussed. In section 2.2, the main features of the industry are described. These features will be useful later on in choosing the most appropriate model for the Indonesian palm oil industry. In section 2.3, possible factors that can lead to market power are examined. Finally, some concluding comments are presented in section 2.4.

2.1 The importance of the Indonesian crude palm oil industry

The importance of the CPO industry in the Indonesian economy arises from at least three conditions. First, CPO is used as the main raw material for cooking oil, which is an essential commodity in Indonesia. Demand for cooking oil is strong and has gradually been increasing as Indonesia's population growth and purchasing power increased (Amiruddin *et al.* 2005). Population increased from 150 million in 1980 to 217 million in 2003, and the real gross domestic product volume index (2000=100) almost tripled from 40 in 1980 to 114 in 2003 (International Financial Statistics 2006). Overall, cooking oil consumption per capita has significantly increased from 0.08 litre per capita in 1980 to 0.19 litre in 2003, resulting in an increase in CPO demand (2000=100) from the cooking oil refineries from 14.7 millions Rupiah in 1980 to 29.4 millions Rupiah in 2003 (Indonesian Bureau of Statistics various issues-a) as shown in Figure 2.1.

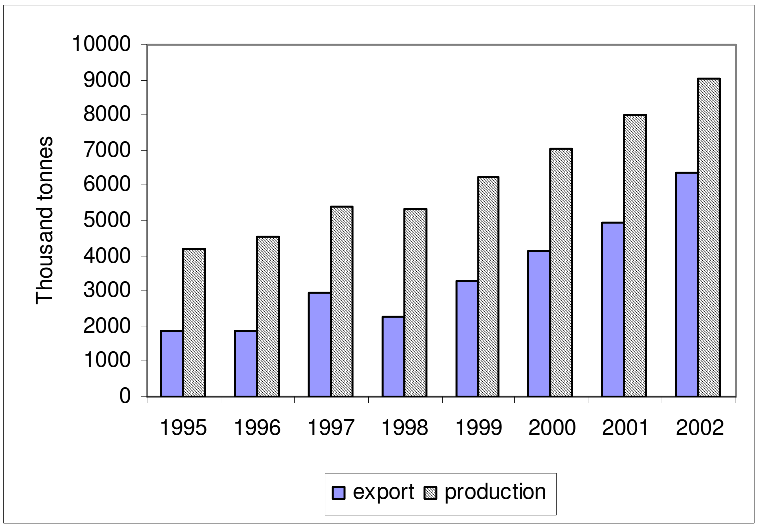
Figure 2.1 CPO real demand from the cooking oil industry, 1980–2003



Source: Bureau of Statistics, Indonesia in Suharyono (1996); CIC (2004).

Second, CPO is one of the main contributors to Indonesia's export revenue. From 1979 to 1987, the government limited CPO exports to ensure an adequate supply for the domestic cooking oil industry. Since 1988, when CPO production increased sharply, this restriction was no longer necessary and exports started to grow again. From 1995 to 2002, on average, more than half of the total CPO production was exported (see Figure 2.2).

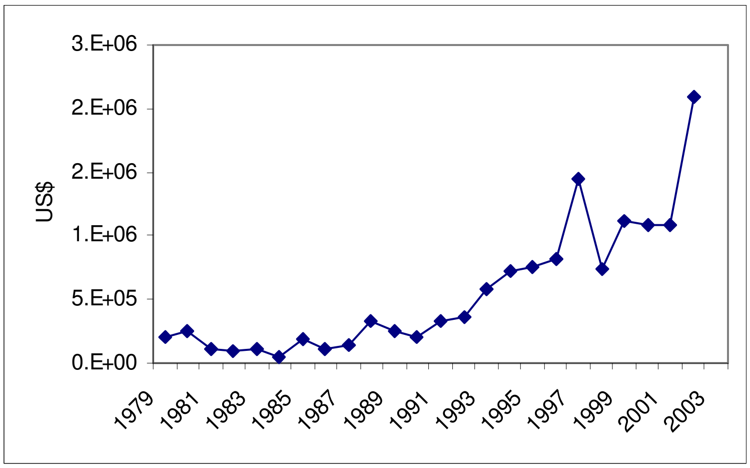
Figure 2.2 Indonesian production and export of CPO, 1995–2002



Source: Indonesian Bureau of Statistics (various issues-b).

The volume of CPO exports declined only during the economic crisis of 1997–1998, resulting from the imposition of the export ban and high export tax. During the economic crisis, the Rupiah–U.S dollar exchange rate significantly decreased, and selling in the international market became more profitable than selling domestically. CPO exports increased sharply, leading to a significant reduction in domestic supply. Coupled with the annual increase in domestic demand during New Year, Ramadhan and Eid Fitr (Muslim festive seasons), this led to a significant increase in the domestic price. To address this, the Indonesian government banned CPO exports from the end of December 1997 to March 1998. However, as the export ban significantly decreased national income and led to smuggling, in July 1998, the government lifted the ban and replaced it with an export tax of 60 per cent (Marks *et al.* 1998, pp. 53-54). Despite the decline in the volume of CPO exports, along with a significant increase in the CPO world price, the revenue from CPO exports during the economic crisis 1997–1998 was higher than the revenue before and after the crisis. As the second largest CPO producer in the world, the decrease in Indonesia's volume of exports during the export ban and high export tax significantly increased the CPO world price. When domestic prices returned to their pre-crisis level, the government gradually reduced the export tax. CPO exports rose and reached a 71 per cent share of total production in 2002. With a growth rate of 93 per cent, the CPO industry recorded the highest growth in export revenues among all the contributing sectors (see Figure 2.3).

Figure 2.3 Growth of palm oil exports, 1981–2002



Source: Indonesian Bureau of Statistics (various issues-b).

Third, the industry employs a large number of workers. This is important in Indonesia where a high unemployment rate is still a problem, especially since the economic crisis. In 2005, there were almost 11 million unemployed workers, resulting an unemployment rate of 10.26 per cent (Indonesian Bureau of Statistics 2006). In 1994, more than 250 thousand workers were recorded as permanent workers on the oil palm estates. Six years later, the number had almost doubled to more than 450 thousand (Indonesian Bureau of Statistics various issues-c). Permanent workers are estimated to comprise one third of total workers in the CPO industry. Including casual workers in estates and all workers in processing industries, the total number employed is between 1.2 and 2 million people (Barlow *et al.* 2003, p. 9; Goenadi *et al.* 2005).

In summary, the CPO industry plays an important role in the Indonesian economy. It affects consumers, the government and producers. For consumers, palm oil is important because it is used as the main raw material for cooking oil. For the government, it contributes to significant export earnings and employment. For producers, it is found to be a profitable business, both for large companies and for smallholders. Accordingly, if producers in this industry exercise some market power, the impacts can be wide ranging and significant. Thus, it is important to analyse the market power issue in this industry.

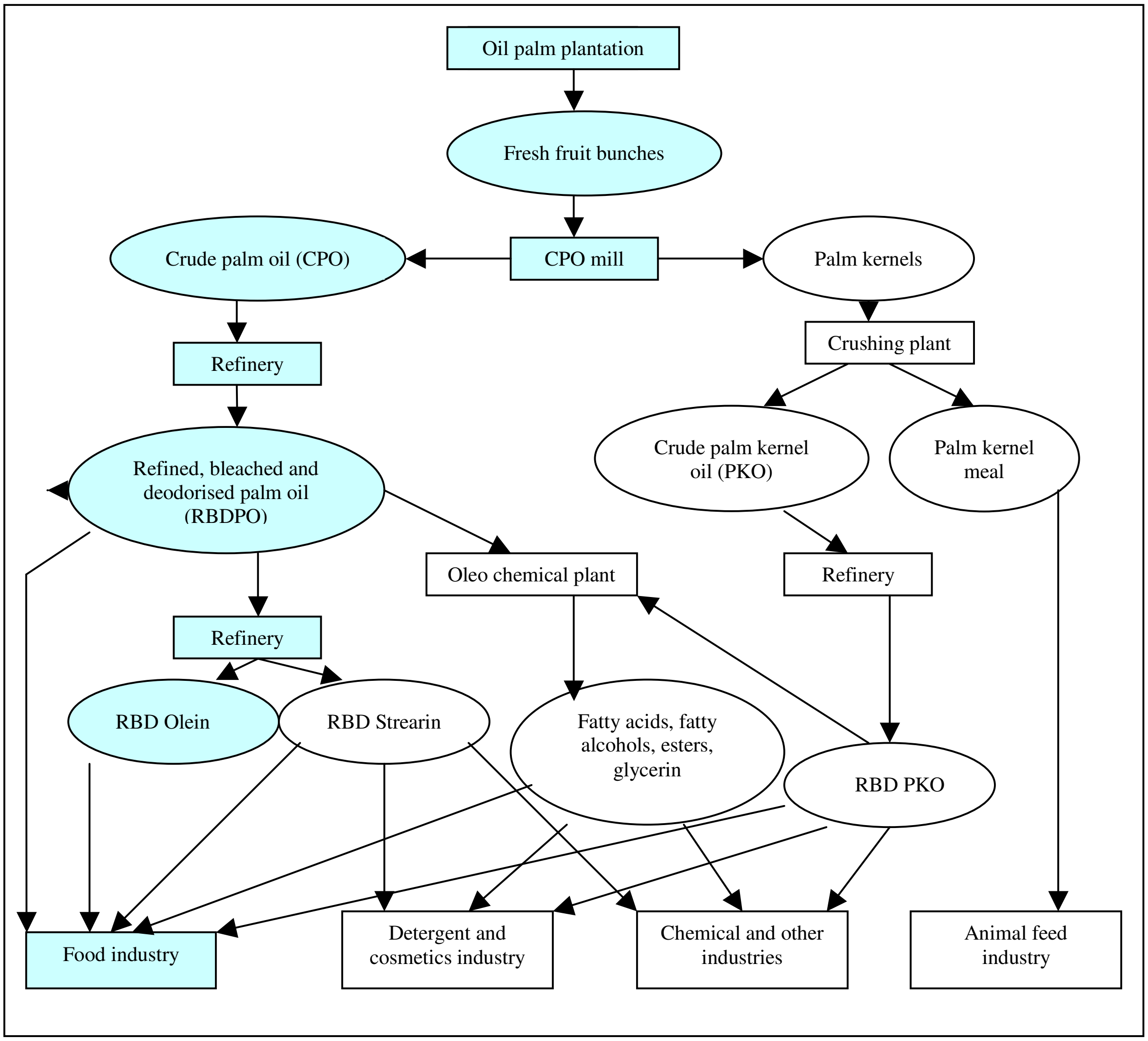
2.2 Features of the industry

2.2.1 The production pattern and homogeneity of the product

The palm oil industry is an industry which produces a huge range of commodities based on the fresh fruit bunches (FFB) (output from the oil palm/ *Elais guineensis sp*. tree). Among the various commodities, cooking oil appears to be most important to Indonesian economic sector. From 1993 to 2003, on average, the cooking oil industry accounted for 75 per cent of palm oil usage. The remainder was used in the oleochemical (13 per cent), soap (7 per cent) and margarine/shortening (5 per cent) industries (CIC 1994, 1997, 2003, 2004). This study focuses on the CPO industry as a part of the cooking oil production chain. Figure 2.4 illustrates the production chain of cooking oil (shown by the shaded area), as a part of the whole palm oil industry. After being harvested, FFB are processed in the mills to extract the CPO. Then, they are further processed in the refineries to produce the refined, bleached and deodorised olein, which in its pure form could be sold as cooking oil.

The production of FFB is a long term process. The maturation period between initial input and first output is about three years. Then, FFB yield gradually increases from eight tonnes/ ha/ year to 30 tonnes/ ha/ year at the age of 13. This peak production continues for about four years, then decreases slowly and remains steady at 16 tonnes/ ha/ year until the end of the oil palm tree's economic life at the age of 25 (see Figure 2.5). [1]

Figure 2.4 The palm oil industry



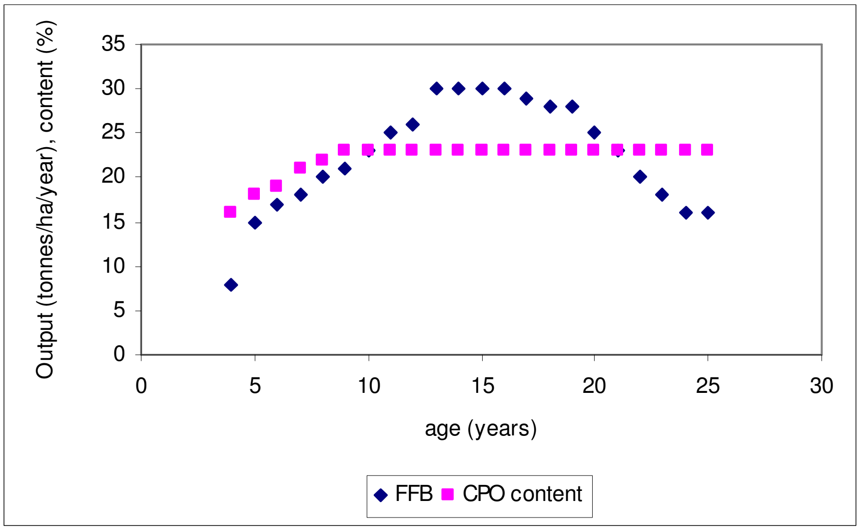
Source: van Gelder (2004, p. 3).

The mature age comprises three periods: the periods when the oil palm is considered young (3–8 years), prime (9–20 years) and old (>20 years). Each period has different levels of productivity and oil content. On average, the mature FFB contain 23 per cent

[1] With a production cycle that lasts for several years, capital used in the CPO production process can be seen as a quasi-fixed input. For such an input, it is more expensive to make changes quickly, hence they are spread over time (Perloff *et al.* 2005 chapter 7, p.3).This shows that the existence of quasi-fixed inputs in a production process induces the existence of non-linear adjustment costs (van Gelder 2004).

CPO, but this depends on when the FFB are harvested. To gain the maximum oil possible, FFB need to be picked at the right level of ripeness. However, the ripeness level changes quickly. Unless the FFB are processed within 24 hours of harvesting, the amount of free fatty acid (FFA) will quickly increase. The FFA reacts to oxygen and causes the oil to develop a rancid taste, thus damaging the CPO quality (van Gelder 2004, pp. 4-5).

Figure 2.5 The production stages of the oil palm tree



Source: Marihat and Plantation Research Centre cited in CIC (2004, p. 22).

Generally, CPO has a single standard quality and price in both domestic and international markets. The standard specifies FFA content of less than 5 per cent, moisture and impurity levels less than 0.5 per cent, and an iodine value of less than 51 per cent (Alibaba.com 2006). Hence, it would be reasonable to treat CPO as homogeneous product.

Another factor that determines palm oil productivity is soil condition. Initially most of the Indonesian oil palm plantations were located in Sumatra Island, because these areas have land highly suitable for oil palm trees. In 1984, 324,883 hectares of oil palm plantations had been established in Sumatra. Two decades later, the oil palm plantation area in Sumatra had increased more than sevenfold to 2,423,341 hectares (see Table 2.1).

Table 2.1 Geographical distribution of oil palm plantations

Island	1984		2003	
	ha	per cent	ha	per cent
Sumatra	324,883	95.41	2,423,341	82.91
Java	2,661	0.78	14,702	0.50
Kalimantan	11,244	3.30	391,840	13.41
Sulawesi	1,160	0.34	93,002	3.18
Others	563	0.17	n.a	n.a
Total	340,511	100	2,922,885	100

Source: Indonesian Bureau of Statistics (various issues-e).

Oil palm plantations on Sumatra were found to be more profitable than those in other islands because they yielded higher production at a minimum cost. Moreover, the infrastructure and services that were needed for the plantation establishment were already developed. However, as land became more limited in Sumatra, the plantation establishment was extended to other lands, especially those more suited to oil palm production, such as Kalimantan and Sulawesi. From 1984 to 2003 the oil palm plantation area in Kalimantan and Sulawesi islands had increased more than 30 (from 11,244 hectares in 1984 to 391,840 hectares in 2003) and 90 times (from 1,160 hectares in 1984 to 93,002 hectares in 2003), respectively. Given land suitability and low labour costs, in 1997, Indonesia was recorded as the most cost efficient CPO industry in the world. The cost of production was 14.3 per cent lower than the world average and 8.3 per cent lower than Malaysia's, which is the largest palm oil producer in the world (see Table 2.2).

Table 2.2 Comparison of CPO production costs, 1997

US$ per tonne	Colombia	Cote d'Ivoire	Indonesia	Malaysia	Nigeria	World Average
Establishment	71.2	69.5	64.3	60.7	224.5	72.1
Cultivation	91.2	136.1	72.5	75.7	113.7	79.3
Harvesting/transport	78.9	33.8	40.2	45.1	90.7	47.3
Milling costs	106.1	105.3	82.6	98.3	130.7	96.6
Kernel milling	6.9	7.7	7.2	7.6	8.2	7.5
Total	354.3	352.4	266.8	287.4	567.8	302.8

Source: PT Purimas Sasmita 1998 cited in Casson (2000, p. 15).

2.2.2 The strategic groups

In Indonesia, three different groups of CPO producers can be identified: the public estates, private companies and smallholders groups. The public estates group comprises 10 public estates with a single Joint Marketing Office. Hence, it is assumed that all of these estates act strategically as a coordinated group. The private companies are dominated by 10 conglomerates (Casson 2000). Unlike the public estate, they do not have a single marketing office. However, together with the public estates, these conglomerates are the members of the Indonesian Palm Oil Producers Association. The existence of such an association allows the members to homogenise their perceptions of both the market state and other firms' information (Clarke, 1983). Therefore, the private companies are also assumed to act strategically as a coordinated group.

The public estates and private companies are usually organised on traditional lines from president director to local supervisors. Most possess good infrastructure and operate estates with size more than the minimum efficient scale. On average, the size of an individual public or private estate is approximately 10,000–25,000 ha, and is usually a part of a larger group whose estates ranging from 100,000 to 600,000 ha (Casson 2000). Both public estates and private companies appear to be highly vertically integrated, from the seed gardens to the cooking oil refineries. They have good access to capital markets, new technologies and information. However, public estates tend to be more bureaucratic, less adaptable to change and consequently less efficient (Barlow *et al.* 2003, pp. 10-13; van Gelder 2004, pp. 31-45; LONSUM 2005).

Smallholders appear to have a different organisation from that of the public estates and private companies. In general, they tend to have a lack of technical knowledge, for example many of them could not distinguish poor and good seeds and periodically purchase the low yielding seedlings. Others plant without terracing or following the appropriate fertilizer applications. This leads the smallholders to produce crops of low yield and quality. While on average, the private companies and public estates could produce 20 and 15 tonnes per ha, respectively, smallholders could only produce 10 tonnes per ha (Barlow *et al*. 2003; Zen *et al*. 2003).

Smallholders can be divided into supported and independent growers. On average, the size of supported smallholders' individual plantations can be less than five ha, while that of the independent ones is less than 20 ha. Without sufficient economies of scale, smallholders are unable to operate their own CPO mills or other essential facilities, and do not have access to capital market to obtain credit for planting. Supported growers are integrated with public estates or private companies, with whom they often have verbal or written contract to sell their products. In contrast, independent growers cultivate their oil palm crops without any assistance and sell their Fresh Fruit Bunches either directly to local mills or through service providers. However, both the supported and independent smallholders often have problems in selling their products, especially in determining the quality and price of their products.

The quality of Fresh Fruit Bunches is mainly determined by their oil content or CPO rendement. Problems in determining the quality of their products stem from several factors. First, given a lack of knowledge to choose good seedlings and to apply the appropriate technique of production, many of smallholders produced Fresh Fruit Bunches with low level of oil content. Second, the rendement is not the same among each of the smallholders' products. Third, most of smallholders do not have enough knowledge to measure the rendement of the oil palm.

Similarly, problems in determining the price of their products arise from several factors. First, while market prices fluctuate in daily bases, prices offered to smallholders are calculated based on the 2-week average prices, hence current market prices are not always the same as prices received by the smallholders. This gives incentives for supported smallholders to break their agreement with the public estates or private companies and sell their products to other millers that offer higher price. Second, with no processing facilities and given the perishability of the Fresh Fruit Bunches, smallholders appear to have low bargaining power and often have to accept prices offered by the buyers (Susila 2004). Accordingly, in 1993, during the peak season, hundreds of tonnes of Fruit Fresh Bunches produced by the smallholders were spoiled as they were not processed within 24 hours. Capacities of the CPO mills were less than the Fresh Fruit Bunches production and they give priority to process Fruit Fresh Bunches produced by their integrated estates rather than that of the smallholders. However, after the implementation of *Otonomi Daerah* (Local Authority) in 2001, many independent CPO mills—which were not supported by oil palm estates—were established with permits from the *kabupaten* (regional) authorisation. In fact, such mills help smallholders to avoid delays in processing their Fresh Fruit Bunches production. Some of them even finally sign agreements to integrate with the independent smallholders.

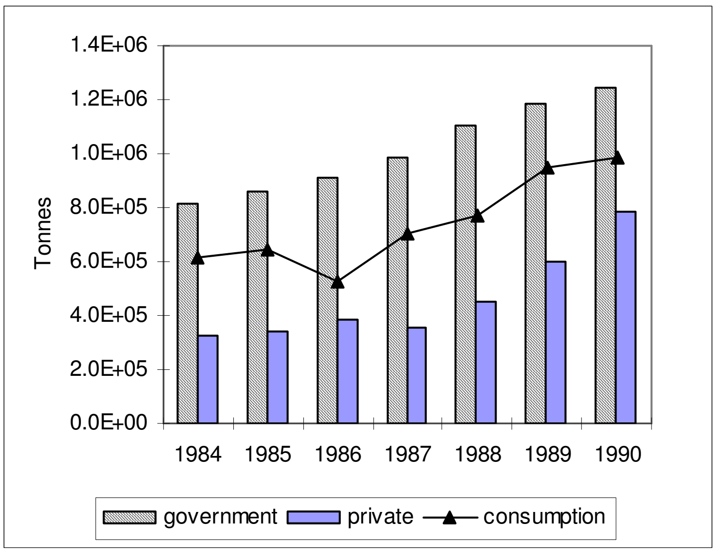
Smallholders do not have any joint marketing associations, and have areas less than 200 ha, smallholders are not listed as members of the Indonesian Palm Oil producers Association. In 2001, the government helped smallholders to establish their own association called Indonesian Association of Palm Oil Farmers (*Assosiasi Petani Kelapa Sawit Indonesia/ APKASINDO*). It accommodated some of the smallholders' inspiration, but this association still has not dealt with any marketing arrangement, hence smallholders do not act strategically. Together with the perishable characteristic of the Fresh Fruit Bunches and lack of processing facilities, smallholders appear to be price takers. Therefore, although the total size of smallholders' production has reached 40 per cent of the market share, we could argue that they are effectively a (high-cost) competitive fringe. Hence, this group is not considered as one of the strategic groups in the industry.

2.2.3 Government intervention

There has been a high degree of interference in the palm oil industry by the Indonesian government, including domestic market obligations, export taxes, subsidies, and plantation size limitations. The domestic market obligations and export taxes policies were imposed when the CPO international price significantly increased, giving incentives for the producers to increase their export, while there was a lack of CPO supply in the domestic market. As a result, the CPO domestic price increased, as did the cooking oil domestic price.

When this price remained high, say for a month, the government required CPO producers to distribute a certain amount of their production at a certain price to meet all domestic consumption. During 1984–1990, the public estates group was still the largest CPO producer. With adequate production from the public estates, the domestic market obligation policy was likely to be effective in increasing the domestic supply to meet all domestic consumption (see Figure 2.6).

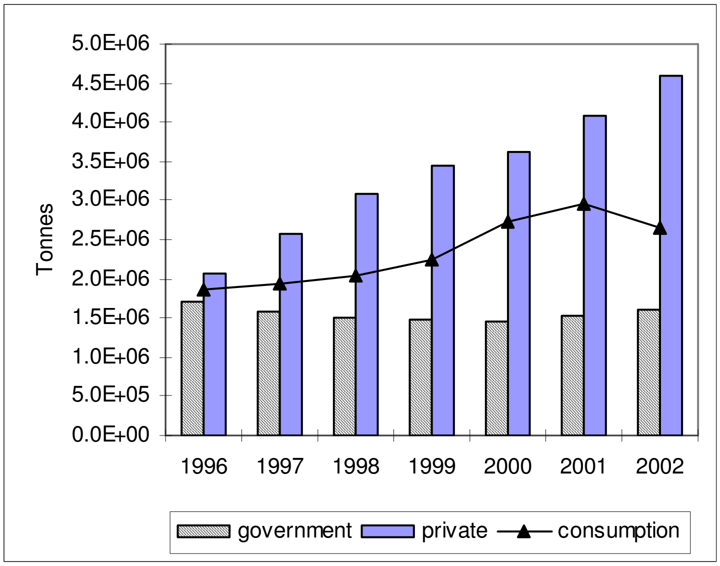
Figure 2.6 CPO production and palm cooking oil consumption, 1984–1990



Source: Indonesian Bureau of Statistics (2004); Oil World in KPB (various issues).

Since 1996, private companies have replaced the public estates' role as the main CPO producer. The public estates' share was no longer sufficient to cover all of the domestic consumption and needed some contribution from private companies' production (see Figure 2.7), whereas in fact, the domestic market obligations policy does not apply to private companies producers, as the government has no authority to control their sales.

Figure 2.7 Development of the public and private estates production and the palm cooking oil consumption, 1996–2002



Source: Directorate General of Plantation, Department of Agriculture (2004) and CIC (2003).

During this period, various schemes were still used to directly control the market distribution of CPO produced by the public estates. Table 2.3 shows the changes in the CPO distribution system determined by government policies. Each of the policies appeared to hold for a brief period, indicating that the DMO policy was no longer effective to stabilise the domestic price. For example, initially the CPO and cooking oil distributions were monopolised by BULOG (*Badan Urusan Logistik* or the Government Logistic Institution). In May 1998, the monopoly right was replaced by the State Joint Marketing Office (*Kantor Pemasaran Bersama*) and a state distribution company *PT Dharma Niaga*. But only two months later, BULOG was directed again to be involved in the state distribution of CPO, and the Indonesian Distribution Cooperative (*Koperasi Distribusi Indonesia*) replaced *PT Dharma Niaga*.

Table 2.3 Changes in the CPO Distribution System in 1998 and 1999

April 1998	State-owned plantation companies were told to supply their entire CPO production to the three government-owned refineries (which were supported by 12 additional refineries owned by smaller private producers), as opposed to 12 private refineries. Cooking oil produced by these refineries would be distributed by BULOG and other state-owned distribution companies to ensure price stabilisation in the market. Distribution of cooking oil processed by the private sector was independent of this system.
25 May 1998	The new Habibie government signed a Ministerial decree which revoked the exclusive rights given to private companies to process CPO produced by state-owned plantation firms.
27 May 1998	BULOG was stripped of its role to distribute CPO in the domestic market and the Government made the State Joint Marketing Office (*Kantor Pemasaran Bersama,* KPB*)* and the state distribution company *PT Dharma Niaga* responsible for ensuring the supply of cooking oil around the country. Under the new scheme, KPB would buy all the cooking oil from the Association of Indonesian Cooking Oil Industries (AIMMI) and sell it directly to market retail cooperatives (*Inkoppas*) in the city at a subsidised price.
July 1998	The government directed *PT Dharma Niaga* to sell olein at a subsidised price to the cooperatives, which were supposed to channel the cooking oil directly to retail consumers.
July 1998	The government instructed the KPB to buy 176,850 tonnes of palm olein from private companies at international prices. The palm oil would be sold domestically at a subsidised price. This move was made as an effort to curb smuggling.
July 1998	State plantation companies were ordered to sell their CPO to private refineries and BULOG was directed to buy it and sell it at a subsidised price. *PT Dharma Niaga* was then removed from the distribution chain.
7 Sept 1998	The government handed over the task of distributing cooking oil produced by state-owned refineries to the Indonesian Distribution Cooperative (*Koperasi Distribusi Indonesia*, KDI), with BULOG's assistance until the end of 1998.
June 1999	The government lifted the monopoly granted to KDI to distribute cooking oil from state-owned companies in the domestic market.

Source: Casson (2000, p. 28).

As an alternative, export taxes were used to limit exports, especially those from the private producers. Table 2.4 shows how the government applied CPO export taxes in response to the domestic cooking oil demand conditions.

Table 2.4 Indonesian CPO export ban and export tax

Date	CPO export tax/ban (per cent)
31 August 1994	10–12
4 July 1997	2–5
17 December 1997	40
24 December 1997	Export ban
7 July 1998	60
29 January 1999	40
3 June 1999	30
2 July 1999	10
12 September 2000	5
February 2001	3

Source: Department of Treasury (2000) in Arisman (2002, pp. 80-81); van Gelder (2004, p. 2).

Higher export taxes are expected to limit CPO exports, thus leaving adequate supply for the domestic market. By increasing CPO supply to the domestic cooking oil refineries, policy makers expected a decrease in CPO prices, and in cooking oil prices. In fact, increasing export taxes could only be justified for developing downstream industries that used CPO as their main input, but not for decreasing the final output price (Arifin 2007).

Table 2.4 indicates that this policy appeared to be reactive rather than long run strategic actions; the government admitted that the CPO export taxes policy was a short run policy, and was only temporarily imposed to stabilise the domestic price. Although export taxes did temporarily decrease the cooking oil wholesale prices, it was unlikely to stabilise the domestic cooking oil prices. The domestic cooking oil price still significantly increased, especially during New Year and Muslim festive seasons, indicating the failure of the market distribution to meet the market clearing level, or the gain from the low price CPO is not fully transmitted to the end consumers. The tax did discourage foreign investors and affected the competitiveness of the Indonesian palm oil industry. The export taxes that decreased the CPO supply to the international market appeared to lead to even higher increase in the CPO international price. Moreover, it harmed the oil palm estates—especially that of the smallholders that did not possess any CPO mills—as the price of Fresh Fruit Bunches was also determined by the level of export taxes (Mark *et al*. 1998;

Casson 2000, p.10; Hasan *et al*. 2001). As a result, CPO domestic supply was still low and its price was high.

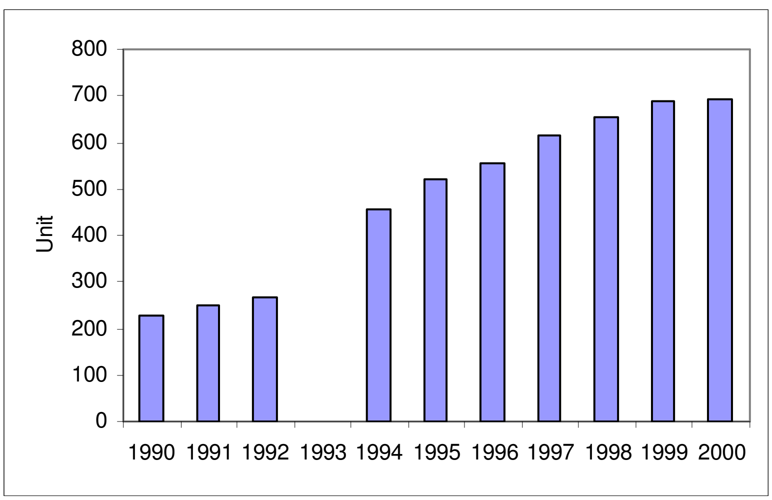
Both the DMO and export tax policies can be seen as government interventions that would indirectly influence the CPO and cooking oil domestic prices, as the price determination was still left to the market mechanism. Since they were unlikely to effectively decrease neither the CPO nor the cooking oil prices, the government imposed CPO and cooking oil price subsidies as an alternative policy. Subsidies were given when the domestic market price significantly increased as the demand increased during festive seasons. However, similar to the other policies, subsidies were not aimed at improving the market structure, but more as a response to the public demand for affordable cooking oil.

In this case, the amount of subsidy was understood as the difference between market prices with and without the government intervention, which could either be determined in absolute value or in percentage. For example, once market prices increased up to Rp8,500-Rp11,000 (about AUS$1.2 to 1.5) per litre, the government gave subsidies Rp2,500 per litre (Tempo 2007). At another time, the government reduced to 5 per cent (from 10 per cent) the cooking oil selling tax or the private companies cut their selling price by 30 per cent (Depkomfindo 2007). Although subsidies from the government appeared lower than those from the private companies, they were often available for a longer period. The government subsidies could be in effect for up to 4 months, depending on the market price and the government financial conditions (Bisnis Indonesia 2007). While CPO domestic prices are often compared to the international prices—as most of them are sold in the world market—cooking oil domestic prices are rarely related to the international ones because they are mainly produced for domestic consumption. CPO subsidy was distributed to the cooking oil refineries, while the cooking oil subsidy was either indirectly distributed to the end consumer through the retail distributor, or directly distributed to a target group—people that were considered poor—through market operations arranged by the public estates or private companies (Republika 2007). The source of the government's subsidy expenditure was CPO export tax earnings or government budget (Indonesia 2007; Indonesian Department of Finance 2007; Pikiran

Rakyat 2007). Therefore, while subsidies might increase the consumer welfare, they could also decrease the aggregate welfare. Most, if not all of the subsidy policies, which decrease market price, intend to help end consumers to meet their daily needs rather than to reach the competitive market condition.

The purpose of the plantation limitation policy was to reduce market concentration, and to prevent the dominance of a few groups of companies in the private sector. The size limitation varied across provinces, ranging from 20,000 ha to 100,000 ha. However, these groups still continued to acquire more land by establishing new companies (Casson 2000, pp. 12-13; van Gelder 2004, p. 28). From 1990 to 1996, the number of oil palm estates significantly increased from 226 to 555 units (see Figure 2.8). However, this did not reflect a more competitive industry because hundreds of new oil palm plantation companies were still controlled by only 18 Indonesian and 16 foreign business groups (van Gelder 2004, pp. 18,19,32).

Figure 2.8 Growth in the number of plantations, 1990–2000



Source: Indonesian Bureau of Statistics (various issues-d).
Note: Data for 1993 not available.

In summary, the Indonesian CPO industry is characterised by several main features:

(a) CPO has a single standard quality and market price, and thus can be seen as a homogeneous product;

(b) As a perennial crop, CPO has a long maturation period and economic life. Given this pattern, capital used in CPO production can be considered as a quasi-fixed input. 'The average cost of changing the level of quasi-fixed input increases with the size of the changing period' (Perloff *et al.* 2005 chapter 7, p.3). This indicates the existence of an intertemporal link and substantial adjustment costs in the CPO process;

(c) Indonesia's CPO producers can be divided into three groups, namely the government, private companies and smallholders. However, due to the absence of economies of size, skills and facilities, smallholders are unlikely to have an ability to influence market price. Hence, only the public estates and the private companies are considered as the dominant groups in this industry; and

(d) As an important sector, the CPO industry has been the subject of considerable government interference. The main purpose of these policies was to ensure that CPO and cooking oil domestic prices remained low. In addition, they also aimed to reduce the market concentration and the dominancy of a few companies in the private sector. However, these policies were not always effective.

2.3 Possible sources of market power

2.3.1 The requirement of high investment and market share

Oil palm plantations require a significant initial investment; Potter and Lee (1998) estimate that US$ 2,500–3,500 per ha is needed to establish a new plantation and another US$ 5 million to build a CPO mill (cited in van Gelder 2004, p. 22). Due to the lack of funds partly caused by economic crisis, plantation expansions were not always followed by the establishment of new mills, thus the growth in mills was not enough to meet the sharp increase in FFB production. Consequently, at least one million tonnes of FFB were wasted in 2003 due to the lack of milling capacity (van Gelder 2004, p. 28). Most of the wasted FFB were probably produced by smallholders, who did not own the mills.

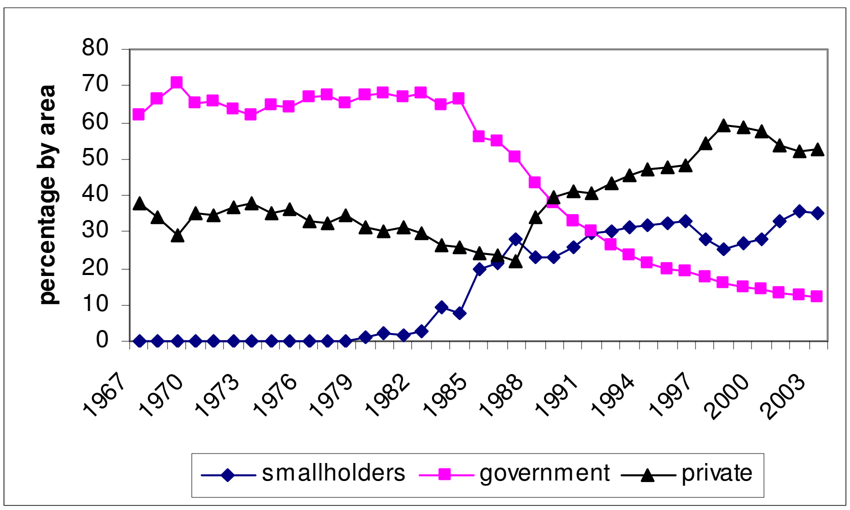
Given the long maturation period, the high investment requirement, and the perishability of FFB, developing palm oil plantations is considered a risky business. To reduce the investment risk and encourage CPO producers to increase their production, the government supported these producers with concessionary credits. Private investors could obtain concessionary credits at an interest rate of 11 per cent during land preparation and establishment and 14 per cent after the trees yielded, when the annual bank interest during that time was around 16–23 per cent. Hence, the concessionary credits gave significant benefit to the investors.

On average, each private company borrowed about 77 per cent of the total establishment cost of its plantation (Casson 2000). As a result, the private companies' plantation area increased rapidly, growing more than seven-fold, from just 143,603 ha in 1985 to 1,083,823 ha in 1996 (Directorate General of Plantation 2004). At the end of the concessionary credit period, on average, the size of individual private estates was approximately 10,000–25,000 ha, and they were mostly part of a larger estates group, ranging from 100,000 to 600,000 ha (Wakker 2004, p. 10). Ignoring other facilities owned by the integrated firms, this means that the more recent entrants needed at least US$250 million to US$2.1 billion of investment to compete with the incumbents. This amount will be much greater if other facilities such as CPO mills or cooking oil refineries are also taken into account.

Concessionary credits for smallholders were distributed in projects called *Perkebunan Inti Rakyat*. Credits were 'received' by the public estates and private companies, and were used for expenditure during land preparation, establishment and the maturation period. As smallholders did not have sufficient skills and facilities for running CPO businesses, the public or private estates acted as 'supervisors', providing them with managerial and technical expertise to reduce the probability of failure. During this period, the land was still controlled by the public estates and private companies. After three to four years, when the trees had reached maturity, the plots were transferred to the smallholders. FFB produced by the smallholders would be purchased, processed into CPO and sold by the public estates and private companies (Zen *et al.* 2005). With this credit, the smallholders' plantation area increased more than six-fold, from just 118,564 ha in 1985 to 738,887 ha in 1996 (Directorate General of Plantation 2004).

This concessionary credit led to changes in the share of oil palm plantation ownership. Figure 2.9 shows that the share of each group by area remained steady until 1985, before the credits were distributed. Thereafter, the share of both private companies and smallholders gradually increased, while that of the public estates decreased. When the credits were first distributed in 1986, the public estates still accounted for 54.8 per cent of the total oil palm area, but at the end of the credits, they had only a 19 per cent share. In contrast, the private companies' share increased sharply from 23.8 per cent in 1986 to 48.2 per cent in 1996, and that of smallholders from 21.4 per cent in 1986 to 32.8 per cent in 1996 (Indonesian Bureau of Statistics 2004).

Figure 2.9 The Indonesian oil palm plantation share by area, 1967–2003



Source: Indonesian Bureau of Statistics (2004).

Following the development of oil palm estates, CPO mills also grew from 82 units at a total capacity of 3,366 tonnes FFB per hour in 1990, to 179 units at a capacity of 6,596 tonnes per hour in 1995. These mills belonged to the public estates, foreign private companies and domestic private companies. Initially, the public estates had the largest share, but the domestic private companies gradually increased their capacity and reached almost the same share in 2003 (see Table 2.5).

Table 2.5 Growth in the number and capacity of CPO processing plants, 1990–2003

Description	Year	Public estates	Foreign private	Domestic private	Total
Companies (unit)	1990	11	5	20	36
	1993	13	5	55	73
	1995	13	5	76	94
	2003	13	37		50
Plant (unit)	1990	45	16	21	82
	1993	72	16	67	155
	1995	69	20	90	179
	2003	n.a	20	90	n.a
Capacity (tonnes FFB/hour)	1990	1,816	793	757	3366
	1993	2,423	793	2,415	5631
	1995	2,993	587	3,016	6596
	2003	3,003	587	3000	6590

Source: Directorate General of Estates in CIC (1994; 1997).

Similar conditions emerged in the downstream industry of cooking oil production. Although the refineries seemed to move towards a more competitive condition, with each brand in the palm cooking oil market having a share of less than 16 per cent, large companies often produced more than one brand. The concentration of the four largest groups (CR4) still accounted for 64.2 per cent in 1996 and only slightly less (58.1 per cent) in 2004 (see Table 2.6).

Table 2.6 Market share of the dominant cooking oil producer groups, 1996–2004

Dominant Groups	1996[a)]	1999[b)]	2002[c)]	2004[c)]
Prajona Nelayan/Wilmar	25.4	19.9	16.3	10.7
Musim Mas	15.3	20.4	10.9	11.8
Salim	12.5	n.a	n.a	n.a
Sinar Mas	11.1	11.6	15.5	7.9
Raja Garuda Mas	n.a	n.a	n.a	27.7
Hasil Karsa	n.a	12.6	14.1	n.a
CR4	64.2	64.5	56.8	58.1

Sources: a) AIMMI (1996) in Indiarto *et al*. (1996);
b) Asia Pulse Analysts (1999) in van Gelder (2004) c) CIC (2004).

2.3.2 Vertical integration

Traditionally, the main raw material in cooking oil in Indonesia was coconut oil. Due to the limited growth in coconut oil production, this oil could no longer meet the demand from the cooking oil industry. As an alternative, cooking oil producers then used palm oil, which enjoys higher productivity and lower prices. Since 1984, palm oil has replaced coconut oil as the main raw material for cooking oil. From 1984 to 1990, on average, the share of palm oil as a raw material for cooking oil is almost 60 per cent (Joint Marketing Office various issues). From 1996 to 2002, the share of palm oil increased even further, almost reached 80 per cent from the total raw material for cooking oil (CIC 2003). Unlike CPO, cooking oil could be quickly produced and stored in response to price fluctuations, as long as there was a sufficient amount of CPO and refinery capacity. From 1998 to 2002, the refineries utilised only up to 53.9 per cent of their production capacity (see Table 2.7).

Table 2.7 Utilisation of the Indonesian refineries, 1998–2002

Description	unit	1998	1999	2000	2001	2002
Capacity	tonnes	7,855,372	7,855,375	8,200,000	8,200,000	8,200,000
Production	tonnes	2,072,690	2,400,000	3,534,918	3,690,000	4,421,114
Utilisation	per cent	26.4	30.6	43.1	45.0	53.9

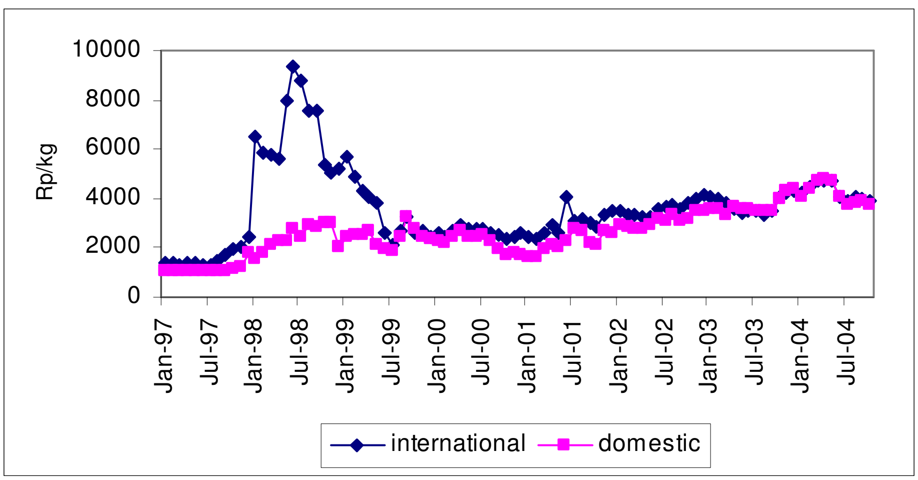
Source: Department of Industry and Trade (2002).

This under-utilisation condition was set to meet the higher demand during certain occasions, such as Ramadhan, Ied-Fitri and New Year. It also provided leeway for the integrated CPO producers, either to directly sell the CPO or to process it into cooking oil. Since most palm oil demand in international markets is in the CPO form, this also implies flexibility for producers to sell the product in the international or domestic markets.

The main factor that determines their sale decision is the price ratio of these two markets. Since 1998, international market prices have been higher than domestic ones (see Figure

2.10), giving the Indonesian producers an incentive to export more of their production. In the international market, CPO competes with various vegetable oils. Before the establishment of the World Trade Organization (WTO) in 1995, the soybean oil produced by the United States was highly subsidised and the United States became the dominant vegetable oil producer in the world. However, with the implementation of the WTO Agreement on Agriculture in 1995 domestic support for agricultural producers and the use of export subsidies in international trade have been progressively reduced (Young 1994; Hathaway and Ingco 1995; Tanner 1996). In accordance with WTO rules, massive subsidies in international trade have been restricted. This led to a decrease in soybean exports and an increase in palm oil exports, as the two oils are close substitutes (Othman *et al.* 1998).

Figure 2.10 Average CPO prices in the domestic and international market, 1997–2004



Source: Joint Marketing Office(2004); Oil World (2004).

From 1995 to 2002, the annual demand for palm oil in the international market increased from 14,710 tonnes to 24,952 tonnes. This increase enabled palm oil producers—including Indonesia's—to increase their exports. If the domestic market share of Indonesian producers was significant, providing an option to sell in the world market and giving them an ability to influence the domestic market price and exercise market power.

In summary, since the distribution of the concessionary credits in 1986-1996, the CPO industry appears to be more concentrated and vertically integrated. This might stem from the high investment requirement for establishing new plantations, mills or refineries. More recent entrants face even higher costs to enter because concessionary credits are no longer available, and hence the incumbents earn persistently higher profits than the potential entrant. The increase in market share may provide the incumbents with an ability to influence market price. The incumbents also appear to be more vertically integrated—from oil palm plantations to CPO mills and cooking oil refineries—creating a further barrier to the new entrants. In addition, having a leeway to sell outputs in both the domestic and international markets, the CPO might have more ability to influence the domestic market price, hence exert some degree of market power

2.4 Concluding comments

The CPO industry is an important sector in the Indonesian economy. The structure of the industry has undergone a number of changes, becoming more concentrated and vertically integrated. This condition can increase firm efficiency and profit through economies of scale, leading to an increase in national income. However, the highly concentrated and integrated market creates some barriers for new entrants; while at the same time may provide market power for the incumbents.

Chapter 3
Market Power Models: A Review

The previous chapter illustrates that the Indonesian palm oil industry has an oligopolistic (duopolistic) market structure. Unlike competitive and monopolistic markets, there is no single general model for an oligopolistic (duopolistic) market. Each oligopoly (duopoly) model focuses on certain aspects of the case being analysed to answer a particular set of the research questions. Therefore, in order to identify the most suitable model to the Indonesian palm oil industry, different models need to be explored. In comparing these models, this chapter will focus on one main feature that needs to be captured in each one of them, which is the ability of the oligopolists (duopolists) to respond to their rivals' actions (Gollop and Roberts 1979).

Specifically, this chapter is organised as follows. Section 3.1 illustrates the idea of market power and its well-known measure, the Lerner index. Sections 3.2 and 3.3 explore models that have been developed to measure market power, using the structure–conduct–performance (SCP) and the new empirical industrial organization (NEIO) approaches, respectively. The first approach is explored in Section 3.2, including related critiques. The second approach, covering static and dynamic models, is then discussed in section 3.3. The static models are grouped into the comparative static and conjectural variations models; the discussion is focused more on the conjectural variations models, as they appear to have been broadly used in previous studies. The dynamic models cover the repeated-game and state-space game models. Each has different assumptions, determining the appropriateness of its application to certain cases. Finally, in section 3.4, some concluding comments are presented.

3.1 Market power

One of the main features of a competitive market is that firms behave as price takers and sell their output at prices equal to marginal costs. In an imperfectly competitive market, firms have the ability to influence price and sell their output at prices above marginal costs. This idea was formalised by Lerner (1934, p. 161) with an index (known as the Lerner index) $L \equiv \frac{p-c}{p}$, where p is the output price and c is the marginal production cost. A higher Lerner index is interpreted as a higher degree of market power: This interpretation needs to be used with caution, because the price–cost margins that determine the index can increase either with an increase in price or a decrease in marginal cost. The interpretation will be appropriate if the increase in the Lerner index is triggered by an increase in output prices. If the increase stems from a decrease in marginal costs, a higher Lerner index may reflect higher efficiency rather than market power. This ambiguity may arise if the observations are derived from single-period equilibria. The one-shot game framework of such equilibria precludes both the possibility of new entrants to the markets and firms' consideration of their rivals' responses. In a multi-period case, positive price–cost margins will attract new entrants to the markets, or give incentives for rivals to increase their output quantity. If there are no barriers to entry—as in competitive markets—this process may continue until prices equal marginal costs again in equilibrium. Therefore, the existence of a positive price–cost margin can only be considered as evidence of market power if its occurrence is persistent over time.

Although the Lerner index has been broadly accepted as a good measure of market power, most studies do not directly use it because marginal costs are usually difficult to determine. As an alternative, many models have been developed in order to measure market power. These models can be divided into the structure–conduct–performance (SCP) and the new empirical industrial organization (NEIO) approaches (Tirole 1988).

3.2 Structure–conduct–performance approach

The structure–conduct–performance (SCP) approach, introduced by Mason (1939; 1949), suggests that evidence of market power can be concluded from a positive relationship between structure and performance. In this approach, market structure variables—measured by market concentration, product differentiation, vertical integration, or barriers to entry—are treated as exogenous variables. Market performance variables—for which rate of return, price–cost margins or Tobin's *q* index can be used as proxies—are treated as the dependent variable. The structure variable is regressed on the performance variable to estimate the market power in the industries. As well as evidence of market power, this estimation also provides an explanation of the impact of changes in market structures on changes in market performance. Therefore, this model is often used to evaluate the impact on market performance of policies that change market structure.

The SCP approach has been criticised in at least three aspects. First, market structure variables are, in fact, not always exogenous. For example, market concentration—as one of the market structure variables—may be affected by firms' efficiency. Firms with higher efficiency will have lower costs, enabling them to sell output at lower prices. Less efficient firms can not do so without facing a loss, forcing them to exit from the market, which leads to an increase in market concentration. In this case, the relationship between market performance and market structure is the inverse of the idea in the SCP approach, that is, the former variable is determined by the latter one (Caves and Porter 1977, p. 241; Bresnahan 1989; Delorme *et al.* 2002, p. 13). As a result, suggesting that market power exists from a positive regression coefficient in such conditions may be misleading.

Second, both market structure and market performance variables are often difficult to measure. In market structure variables, market concentration is widely measured with the Herfindahl–Hirschman index (HHI). However, this index has been widely criticised for its sensitivity to the relevant market definition in both geographical boundaries and product homogeneity (Lijesen 2003, p. 123). Product differentiation is also often difficult to measure. Data on product differentiation strategies such as advertising, marketing or technical change are rarely available. In addition, there is product differentiation that is unique to market leaders in the buyers' perception, which is more difficult to measure. Even when in some cases these variables can be measured, their degree of differentiation may vary, as some firms may produce a product that is more differentiated than others (Rhoades 1985, pp. 344-347). Measuring vertical integration or barriers to entry is often problematic due to the lack of transaction costs data and the ambiguous interpretation. Economies of scale are not seen as a barrier to entry for the Chicago school because they affect equally the costs of both new and old firms when they have access to the same technology. In contrast, they are treated as a barrier to entry in the classic limit pricing model because it is assumed that incumbents will maintain their outputs and thus constrain the market available to new entrants (Gilbert 1989, p. 113; Meyer 2004, p. 328).

In the market performance variables, the rate of returns is often problematic, as capital data are usually reported using accounting rather than economic concepts. Price–cost margins are also difficult to calculate because marginal cost data are rarely available. As an alternative, average variable costs are often used as a proxy for marginal costs. However, unless the data are derived from a long run equilibrium, average costs may differ from marginal costs. Similarly, measuring replacement costs and expenditures on intangible assets (such as advertising and research and development) in the Tobin's *q* index, is often difficult (Boyer 1996, p. 116; Carlton and Perloff 2005, chapter 8; Perloff *et al.* 2005, chapter 2). Therefore, the market performance measures may be inaccurate.

Third, the SCP approach assumes that various industries—data from which are used as samples in the regression—have the same structure–performance relationships. In fact, each industry may have important idiosyncrasies. While in a regression analysis, the relationship between variables is supposed to be a causal effect between a dependent or explained variable and independent or explanatory variable, this needs not necessarily be true if data are collected from various industries with different structure and performance relationships. The relationship between variables could be interpreted as only correlation or descriptive analysis. As a consequence, a positive coefficient from such a relationship may not necessarily provide evidence of market power (Carlton and Perloff 2005, chapter 8; Perloff *et al.* 2005, chapter 2).

In the recent SCP models, the endogeneity problem is addressed by using a simultaneous-equations technique (Delorme *et al.* 2002). Another way is by carefully choosing the market—whose structure is set by the government rather than by other variables in the system—to avoid the endogeneity problem in the market structure variable (Brown and Brown 1998). However, even in these studies, the important idiosyncrasies and performance measures issues have not been considered. Therefore, the results may still be implausible.

3.3 New empirical industrial organization approach[2]

The weakness of the SCP approach has led to an alternative, namely the new empirical industrial organization (NEIO) approach. Perloff *et al*. (2005) argue that the NEIO approach is better than the SCP because models based on the NEIO approach provide direct estimation and tests of market power, are supported by clear theories, do not suffer from the endogeneity problem, include institutional factors in their analysis and do not rely on symmetry assumptions across industries. The NEIO approach includes both static and dynamic models. Basically, they measure market power by the deviation from the competitive price-taking behaviour, in which prices equal marginal costs. The deviation can be either examined by its movements or in its equilibria.

3.3.1 Static models

Static models can be divided into two different groups; namely, comparative static and conjectural variations models. Comparative static models employ a long run equilibrium assumption to indicate whether markets are in a competitive condition or not. In a competitive market, firms sell output at a price equal to marginal costs and produce at constant returns to scale. The two well-known examples of this comparative static model are the Hall (1988) test and Panzar and Rosse (1987) statistics. Hall (1988) determines market power by examining the movement of prices and marginal costs, while Panzar and Rosse (1987) examine the movement of revenues and input prices. The results of these comparative static models provide evidence about the existence but not the degree of market power. The conjectural variations models employ the profit-maximisation

[2] Some of symbols used in the models are modified from their original version, so that all models have the uniform symbols and are easy to compare.

condition to obtain a proxy for the Lerner index. Hence their results show the degree of market power of the case in question.

Comparative static models

The Hall test is a joint test of price being equal to marginal cost and constant returns to scale, in which both conditions are to be consistent with the long run equilibrium competitive market. It uses a single reduced form of a marginal cost or supply relation:

Equation 3.1 $c^* = c^*\left(K, L, w_K, w_L\right)$

where the original marginal cost function is $c_i = c_i\left(q_i, w\right)$ and the production function is $q_i = q_i\left(K, L\right)$. K and L are capital and labour, respectively, and they are assumed to exhibit constant returns to scale. w is a vector of factor prices that are exogenous to the firm. The growth rate of output–capital ratio will be:

Equation 3.2 $\Delta g_t = \alpha_t \Delta \eta_t + \theta$

where :

$\Delta g_t = \frac{\Delta q_i}{q_i} - \frac{\Delta K}{K} = \left(\Delta \log\left[\frac{q_i}{K}\right]\right)$ is the rate of growth of the output–capital ratio;

$\alpha_t = \frac{wL}{c_i q_i}$ is the share of labour cost to the total cost;

$\Delta \eta = \frac{\Delta L}{L} - \frac{\Delta K}{K} = \left(\Delta \log\left[\frac{L}{K}\right]\right)$ is the rate of growth of the labour–capital ratio; and

θ is the constant technology.

Defining μ_t as the ratio of price and marginal costs, Equation 3.2 can be written as:

Equation 3.3 $$\Delta g_t - \alpha_t \Delta \eta_t = (\mu_t - 1)\alpha_t \Delta \eta_t + \theta$$

When $\mu_t = 1$, price equals marginal cost and Equation 3.3 is identical with Equation 3.2. Therefore, assuming that constant returns to scale exist, the deviation from $\mu_t = 1$ is used to indicate an imperfectly competitive condition.

Another well-known reduced-form model is the Panzar and Rosse (1987) test. This model uses a single reduced-form revenue equation:

Equation 3.4 $$R_i^* = R_i^*(z, w, t)$$

where the original firm's revenue is $R_i = R_i(q_i z)$ and its cost function is $C_i = C_i(q_i, w, t)$, w is a vector of m factor prices that are exogenous to the firm, z and t are factors that shift revenue and cost functions, respectively. This test detects the competitive condition by examining the movement of revenues and factor prices. When constant returns to scale are present, prices equal marginal costs and normal profit $\pi_i = 0$ is observed. In such conditions, a one per cent increase in input prices always results in precisely one per cent decrease in firms' revenue. This is formulated as the Panzar and Rosse statistic:

Equation 3.5 $$\psi_i^* \equiv \frac{\%\Delta R_i}{\%\Delta \sum w_n} \equiv \frac{\partial R_i^*}{\partial w_i} \frac{\sum w_n}{R_i^*}$$

whose values equal one in competitive states. Assuming that constant returns to scale exist, the deviation from $\psi = 1$ is used to indicate an imperfectly competitive condition.

The above explanation illustrates that neither the Hall test nor Panzar and Rosse statistics take into account the transition process from short run equilibria to long run equilibria.

They assume that constant returns to scale exist in the period being analysed, so that prices being equal to marginal costs indicate a perfectly competitive condition. The exclusion of adjustment costs means that the demand function has a constant elasticity (Hall 2000, p. 2). In fact, such a condition is not established in every period of the real-world market: Bhuyan and Lopez (1997) found that for 82 percent of 40 industries in US tobacco and food manufacturing in the period 1972–1987, the constant returns to scale hypothesis was rejected.

Conrad and Unger's (1987) study of 28 German industries in the period 1960–1981 and Millan's (1999) study of 18 Spanish food industries in the period 1978–1992, also found that the existence of the long run equilibrium conditions was also rejected for most of the industries being analysed. In short run equilibrium, firms may exhibit either decreasing or increasing returns to scale. In such conditions, both the Hall test and Panzar and Rosse statistics can be misleading. The decreasing returns to scale may be caused by the existence of high fixed costs in the short run. In such conditions, prices may still equal marginal costs even if—in fact— firms suffer a loss. The increasing returns to scale may reflect a dynamic convergence towards the long run equilibrium, as increases in output may require some adjustment costs. This often appears in the real-world market: Hall (2002) found that adjustment costs are statistically significant from zero in US industries for the period 1962–1983. Berstein and Mohnen (1991) found that zero adjustment costs were also rejected for Canadian industries in 1962–1983. Adjustment costs associated with changes in the quasi-fixed factors cause short run marginal costs to exceed long run marginal costs. By excluding the adjustment costs from the model, prices may be greater than marginal costs even if—in fact—firms behave competitively. Hence, the deviation of prices from marginal production costs does not reflect market power, but rather adjustment towards the long run equilibrium (Berstein 1992)

The results of both the Hall test and Panzar and Rosse statistics do not provide any information about the degree of market power in an imperfectly competitive market. Other researchers have made attempts to develop these models in order to obtain a degree of market power from the tests. For the Hall test, Shapiro (1987) derived the degree of market power by employing the relationship between the mark-up ratio μ_t and a firm's elasticity of demand β:

Equation 3.6 $$\beta^* = \frac{\mu}{1-\mu}$$

If the industry is monopolised or all firms collude effectively to duplicate the monopoly outcome, the monopolist's demand elasticity will equal the market elasticity β. Therefore, he suggested that the ratio of the firm's and the market elasticities could be used to capture the firm's degree of monopoly power θ:

Equation 3.7 $$\theta = \frac{\beta}{\beta^*}$$

However, this measure is only appropriate when the demand function has an exponential or Cobb–Douglas form, and the demand elasticities are constant. Using the chain rule of the second–order condition of the profit function, Perloff *et al.*(2005, chapter 3, p.19) show changes in prices with respect to changes in marginal costs as:

Equation 3.8 $$\frac{dp}{dc_i} = \frac{dp}{dQ}\frac{dQ}{dc_i} = p'\frac{dQ}{dc_i} = \frac{p'(Q)}{2p'(Q)+Qp''(Q)}$$

where p is the inverse demand function, p' and p'' are its first and second derivatives, the numerator on the right-hand side is the slope of inverse demand and the denominator is the slope of the marginal revenue. If the elasticity of demand is constant, Equation 3.8 can be rewritten as:

Equation 3.9 $$\frac{dp}{dc_i} = \frac{\beta}{\beta-1}$$

where $\beta > 0$, as monopolists operate in the elastic portion of demand curve. In such conditions, the movement of price and marginal cost is merely determined by the demand elasticity. In fact, demand functions may have a linear or log-linear form. In a linear demand function, price always rises by half the increase in the marginal cost, and in a log-linear demand function, price always rises by the same amount as cost, so the results show a competitive condition. In such conditions, the movement of price and marginal cost is completely independent of the elasticity of demand. Therefore the ratio of a firm's and the market elasticities cannot be used to represent the firm's degree of monopoly power (Perloff *et al.* 2005)

For the Panzar and Rosse model, Shaffer (1983) obtained the degree of market power by deriving the relationship between the Panzar and Rosse statistic ψ^* and the Lerner index, whose indices for an individual firm and for the industry as a whole, respectively, are as follows:

Equation 3.10 $$L_i = \frac{1}{(1-\psi_i)}$$

and

Equation 3.11 $$L = \left(H + \sum_i s_i^2 \lambda_i\right) \Big/ \left[s_i(1+\lambda_i)(1-\psi_i)\right]$$

where:

$s_i = \frac{q_i}{Q}$ is firm i's market share;

$\lambda_i = \frac{\partial q_{-i}}{\partial q_i}$ is the change in other firms' output with respect to the change in firm i's output; and

H is the Herfindahl–Hirschman index of concentration = $\sum s_i^2$.

However, Lerner indices shown in Equations 3.10 and 3.11 apply only before entry and exit occur, and therefore correspond to the short run equilibrium (Shaffer 1983, p. 178) which is not consistent with the assumption used in the Panzar and Rosse (1987) model.

Despite such conditions, the Hall test (for example Delipalla and O'Donnell 2001) and the Panzar and Rosse statistics (for example, Fischer and Kamerschen 2003; Matthews *et al.* 2006) are still being used, mainly because they require less data and are easy to estimate. However, Panzar and Rosse (1987, p. 455) argue that a rejection of the hypothesis $\psi_i^* \leq 0$ suggested that the observed firms were influenced by the actions of others. This interdependency has not been addressed in their model. Therefore, they suggest that if data on equilibrium prices and quantities are available, conjectural variations models are likely to yield a sharper test.

Conjectural variations models

Conjectural variations, the underlying concept of which was first introduced by Bowley (1924), imply that the degree of market power is reflected in a firm's expectation about their rivals' response to a change in its output. If a firm has market power, market response to a change in its output will be limited, while if a firm has no market power, the response will be extensive (Hunnicutt and Weninger 1999, p. 2). Since they not only provide evidence of market power (as in other static models), but also provide a measure of the degree of market power, Panzar and Rosse (1987, p. 455) suggest that conjectural variations models give a sharper result than the comparative static models. In conjectural variations models, the market power parameter is derived from the first–order condition of a firm's profit function (Iwata 1974; Appelbaum 1982):

Equation 3.12 $$p(Q,z) - c_i(q_i,w) = \theta_i p'(Q,z) q_i$$

where z is a vector of exogenous variables that shift the inverse demand and θ_i is the ith firm's conjectural variations elasticity, that is, the market power parameter. In the Lerner Index form, Equation 3.12 can be rewritten as:

Equation 3.13 $$\frac{p-c_i}{p} = -\frac{\theta_i}{\varepsilon} s_i$$

where $\varepsilon = \frac{\partial p(Q)}{\partial Q}\frac{Q}{p}$ is the linear demand elasticity and $s_i = \frac{q_i}{Q}$ is firm i's market share.

Generally speaking, the θ_i parameter is obtained through solving simultaneously the inverse demand and supply relation equations using the two-stage least squares (2SLS) technique. Compared with reduced-form models, structural models provide a more rigorous and consistent result. Moreover, they characterise the underlying economic theory, so that an economically meaningful inference can be drawn. However, structural models require a lot of data and are sensitive to misspecification problems. Incorrect specifications lead to biased inferences about market power, while less specific functional forms—such as the translog form—substantially reduce the ability of these models to determine market power.

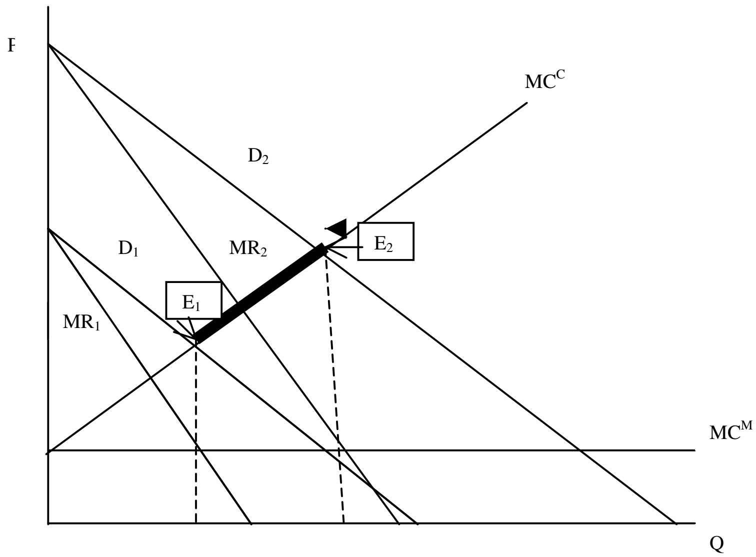
In some functional forms, such as the linear and log-linear forms, initially conjectural variations models cannot even identify the market power index (Hyde and Perloff 1995). Bresnahan (1982) successfully addressed this problem by including an interactive exogenous variable in the demand function, which is capable of both shifting the intercept and changing the slope of the demand function. Without any interactive exogenous variable, an example of a linear demand function can be written as follows:

Equation 3.14 $$Q = \alpha_0 + \alpha_1 p + \alpha_2 z + \varepsilon$$

In such a function, a change in the exogenous variable z leads to a change in the intercept of the demand function, say, from D_1 to D_2, with marginal revenue MR_1 and

MR_2, respectively (see Figure 3.1). E_1 and E_2 are equilibria in either competitive market $P = MC^C$ and monopoly market $MR = MC^M$. The bold line connecting these points shows the supply relation in both the competitive and the monopoly markets. Unless the marginal costs are known, price taker and monopolist hypotheses are not observable in such a condition.

Figure 3.1 Effect of changes in exogenous variable without interactive term on the demand function

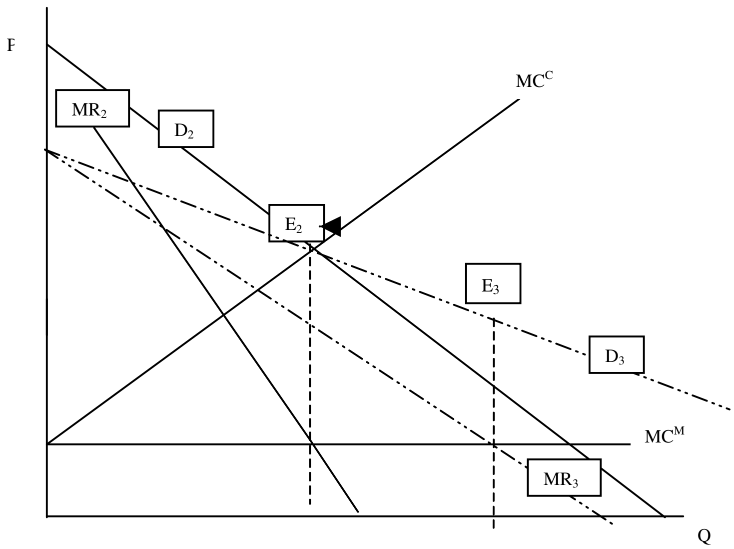


In contrast, with the addition of an interactive exogenous variable in the demand function, equilibria in a competitive market will be different from that in the monopoly market. Suppose that the linear demand function with an interactive exogenous variable is:

Equation 3.15 $Q = \alpha_0 + \alpha_1 p + \alpha_2 z + \alpha_3 pz + \varepsilon$

In this case, a change in the exogenous variable z not only changes the intercept but also the slope of the demand function, say, from D_2 to D_3, with marginal revenue MR_2 and MR_3, respectively (see Figure 3.2). Equilibrium in a competitive market $P = MC^C$ will no longer be the same as that of in a monopoly market $MR = MC^M$. Equilibrium of the competitive condition remains E_2, but that of the monopolistic condition will be E_3. Hence, the market power index can be identified.

Figure 3.2 Effect of changes in exogenous variable with interactive term on the demand function



The market power parameter θ_i can be interpreted in several ways (Perloff *et al.* 2005, chapter 3, p.7). First, θ_i indicates the gap between price and marginal cost. If $\theta_i = 0$, marginal cost equals price, which indicates a competitive market. Otherwise, a mark-up is observed. Second, θ_i gives an index of market power or structure, because it lies in the closed set $[0,1]$ and yields $L \in \left[0, -1/\varepsilon\right]$. Equation 3.12 shows that marginal revenue is $p(Q;z) - \theta_i p'(Q;z) q_i$. If $\theta_i = 0$, marginal revenue equals price; thus a competitive market is observed. If $\theta_i = 1$, marginal revenue will be $MR = p(Q;z) - p'(Q;z) q_i$, which equals the monopoly condition. Third, θ_i can be interpreted as a Lerner index adjusted by the market demand elasticity, in which $s_i = 1$, so that Equation 3.13 will be $L \equiv -\frac{\theta_i}{\varepsilon}$ and $\theta_i \equiv -L\varepsilon$. Fourth, θ_i can also be interpreted as a conduct parameter or a firm's beliefs about its rivals' reaction on its action (Dockner 1992, p. 377), as

$\theta_i = \frac{\partial(q_i + q_{-i})}{q_i} \equiv 1 + \frac{\partial q_{-i}}{\partial q_i} \equiv 1 + v_i$. $v_i = \frac{\partial q_{-i}}{\partial q_i}$ shows the change in a rivals' output with respect to a change in firm i's output. The indices $v_i = -1$, $v_i = 0$ and $v_i = 1$ imply a competitive, Cournot and a monopoly behaviour, respectively.

Combinations of the firms' v values determine the pattern of interdependence. By imposing a symmetry assumption, v values will be identical for all firms. In contrast, in asymmetric duopoly interactions, each firm may respond to its rival's action in a different way. The symmetry interactions comprise Nash Cournot, cooperative and non-cooperative patterns, values of which are $v_i = v_j = 0$, $v_i = v_j > 0$ and $v_i = v_j < 0$, respectively. In a Nash Cournot pattern, firms recognise their interdependence, but each of them believes that its rivals have given their best responses. Therefore, the rivals will not react to changes in its actions and change their output ($\partial q_{-i} = 0$), thus $v_i = 0$. In the cooperative pattern, firms accommodate their rivals' actions, while in the non-cooperative, they will compete with one another. The asymmetric interaction includes the leader–follower (Stackelberg) and dominant–fringe patterns. In the leader–follower (Stackelberg) pattern, if firm j has a leader role, it will set the price, so that it will not react to changes in its rival's action and $v_i = \frac{\partial q_j}{\partial q_i} = 0$, whereas as a follower $v_i \neq 0$. In the dominant–fringe pattern, firm j with a dominant share position will defend its market position by behaving non-cooperatively and $v_i < 0$, while the weaker or fringe firm i will accommodate its rival's action, thus $v_i > 0$ (Putsis and Dhar 1998; Putsis 1999).

Although conjectural variations models are designed to capture a dynamic phenomenon; namely, responses among firms, they are obviously static. Friedman (1983, p. 110) lists several arguments related to this static condition:

(a) the models are not actually dynamic, thus a dynamic interpretation is not possible;

(b) firms are assumed to maximise one-period profit rather than the discounted stream of profits over a given planning horizon; and
(c) firms' expectations about how their rivals will behave need not be correct.

All of these conditions may lead to inconsistent results of the conjectural variations estimation.

As well as their static framework, the static conjectural variations models are also problematic in their estimation technique. As noted previously, the conjectural variations θ_i are commonly obtained through the 2SLS technique. However, Corts (1999) demonstrates that results from this technique could be invalid, as it yields only an 'average conduct', which he named, the 'as-if conjectural variations':

Equation 3.16 $$\theta_i = \frac{1}{-p}\left[\frac{p(Q,z) - c_i(q_i,w)}{q_i}\right]$$

that is the average of price–cost margins for each output, normalised by the price level (which is similar to the Lerner index). Using the maximum likelihood estimation, Corts (1999) demonstrates that the conjectural variations are suppose to be a 'response or marginal conduct':

Equation 3.17 $$\theta = \frac{1}{-p}\left[\frac{d\left[p(Q;z) - c_i(q_i,w)\right]/dz}{dq_i^*/dz}\right]$$

that is the marginal change of the price–cost margins with respect to the inverse demand shock for each marginal change in output margins with respect to the inverse demand shock, and again, normalised by the price level. In other words, the 'as-if conjectural variations' are determined by the 'level' of the output and only show the 'level' of the price–cost margins, while the 'true conjectural variations' are fully determined by the ‘equilibrium variations’ of the output and show the responsiveness of the price–cost margins to such variations.

The ‘as-if conjectural variations’ are constant values, which are interpreted as the average of value of the conduct parameter (Bresnahan 1989; Genesove and Mullin 1998). In fact, the conduct values might change over time because a firm’s expectation about how its rival will behave might be incorrect. When a firm becomes aware of the error, it will revise the conjecture using current observations. The revision process continues over time until the conjecture precisely predicts others’ actions. In other words, the ‘as-if conjectural variations’ are inconsistent with rational behaviour except at the equilibrium point (Fellner 1965), which, in general, is not the average value. Empirically, Porter (1983) shows that estimation results of the conduct parameter from 2SLS and maximum likelihood techniques are different. The equilibrium point is reached when the conjecture precisely predicts others’ actions. In such conditions, each player achieves the highest discounted profits by playing his prescribed strategy and gains nothing by deviating from this strategy. This set of strategies is known as Nash equilibrium, which can be subgame perfect or not. It is subgame perfect if, for any subgame of a dynamic game that begins at any time t, no player can be better off by changing his strategy, otherwise it is not.

There are two different strategies that have been widely used; namely, the closed-loop and open-loop strategies. Within a closed-loop strategy, firms do not commit themselves to a particular path. They revise their decisions each period and choose optimal strategies, and the Nash equilibrium is reached at each time (subgame); thus it is a subgame perfect. Many researchers apply the Markovian strategy as a special case of the closed-loop strategy, which reduces the number of parameters and makes estimating them easier. This strategy considers only the directly relevant information, which is from the period earlier, implying that the tth period decision depends on the $(t-1)$ period information, and then the $(t-1)$ period decision depends on the $(t-2)$ condition, and so on. The rationale is that directly relevant causes should have a major effect, and vice versa. Therefore, this should have an appreciable influence on behaviour (Maskin and Tirole 2001, p. 192).
Dockner (1992) shows that the closed-loop steady state condition is:

Equation 3.18 $$p\left(1+\frac{s_i}{\eta}\left(1+\frac{\partial u_{-i}/\partial q_i}{r-\partial u_{-i}/\partial q_{-i}}\right)\right)=c_i$$

where:

$u_i(t)\equiv\dot{q}_i(t)$ is the rate of change of output of firm i at time t;

r is the discount rate; and

$\left(\frac{\partial u_{-i}/\partial q_i}{r-\partial u_{-i}/\partial q_{-i}}\right)$ is the conjectural variations.

In contrast, within an open-loop strategy, a firm chooses a path of action based on the initial condition and commits for the entire game. Firms do not respond and revise their decision in the subsequent periods although unexpected shocks to the state may occur; thus, it is not subgame perfect (Fershtman and Kamien 1987, p. 1154). Dockner (1992, p. 383) shows that the steady state open-loop equilibrium is identical with the solution of the static conjectural variations in Equation 3.13. In other words, this static conjectural variations parameter or 'as-if conjectural variations' will be consistent only when firms play the open-loop strategy.

The open-loop strategy is appropriate when the underlying event or the state of the world is not common knowledge at the beginning of each stage, where new information is not accessible or it takes a long time to be received. As only the old or initial information is available, players' decisions are conditioned exclusively by this information. This strategy may also be used when the rival groups consist of many small firms, so not a single rival can greatly affect a firm. In such conditions, either rivals may act as followers or their responses do not significantly affect the firm in question and can be negligible (Fudenberg and Tirole 1989, p. 296; Perloff *et al.* 2005, chapter 7, p.41). The open-loop strategy may also exist in long–run investment decisions, in which changing plans are difficult and incur very high costs (Flaherty 1980, p. 162). In addition, firms might use this strategy if either collusive arrangements are infrequent (Dockner 1992, p.

385), demand shocks are permanent (Corts 1999, pp. 228-229), or rates of time preference and of depreciation are sufficiently close to zero and one, respectively (Itaya and Shimomura 2001). However, in most cases, the closed-loop strategy is often taken to be more realistic.

Another factor that might lead to biased results from the 'as-if conjectural variations' is the assumption about the supply relation (Corts 1999). Suppose that the true cost function is linear, thus the marginal cost is not determined by q_i:

Equation 3.19 $$c_i\left(w\right) = c_0 + c_1 w_t$$

and the supply relation has a linear form:

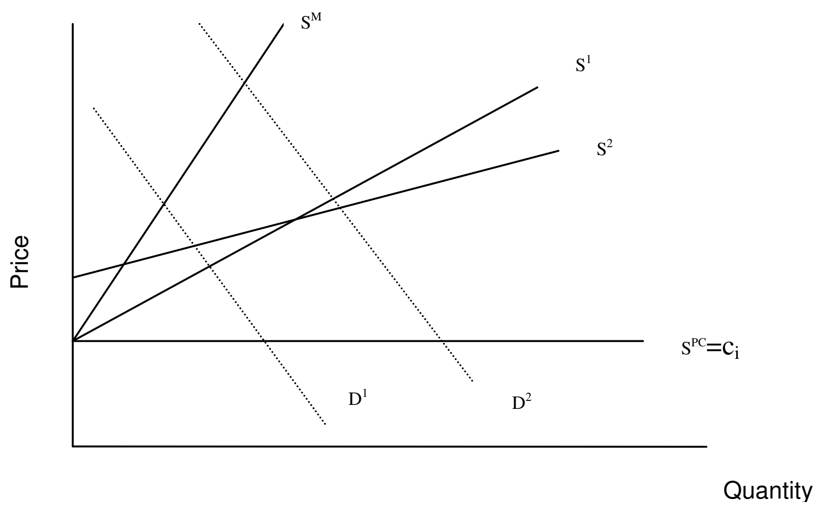
Equation 3.20 $$p_t = \alpha_0 + \alpha_1 w_t + \alpha_2 q_{it} + \xi_{it}$$

so that Equation 3.18 can be rewritten as:

Equation 3.21 $$p_t = c_i + \alpha_2 q_{it} + \xi_{it}$$

Comparing this equation with Equation 3.12 indicates that the 'as-if conduct parameter' is the coefficient of quantity in the supply relation α_2 scaled by the demand derivative $p'\left(Q,z\right)$. This means that the supply relation for a conjectural variations game is assumed to be a ray through the marginal cost intercept (see S^1 and S^M in Figure 3.3). In other words, the conduct parameter is only determined by the slope of the supply relations. While Bresnahan (1982) has addressed problems of estimating the conduct parameter stemmed from the demand function, the supply relation is still assumed to be a ray through the marginal cost intercept (see Figure 3.2). In fact, other non-conjectural variations models (see Gasmi *et al.* 1992, for example) can have supply relations with a different intercept (see S^2 in Figure 3.3). In such cases, the difference between price and the intercept is not the same as the price–cost margins. Hence, measuring the margins only from the slope difference could be misleading.

Figure 3.3 Supply relationships under different models of conduct



In summary, the static conjectural variations models are problematic, either in their framework or estimation technique. Their one-shot game framework precludes both the possibility of new entrants to the markets and firms' consideration of their rivals' responses. The single-period equilibrium might differ from the multi-period equilibrium. Thus, results from the static models could be misleading. Using the 2SLS estimation technique, the models cannot be used to uncover dynamic behaviour, particularly the conjectural variations or firms' conduct that underlies the equilibrium outcomes (Slade 1995, p. 398). Accordingly, dynamic models, in which firms' continuous interactions are modelled explicitly and which show the process towards the consistent or steady state equilibrium, are needed.

3.3.2 Dynamic models

As indicated previously, the ability of each player to respond to other players' actions is one of the important characteristics of an oligopolistic market. The conjectural variations models were meant to capture this interdependency through their parameters, but failed to do so within the static framework.

Dynamic models can be established by including a time dependent parameter, so that future gains may be discounted. They can also be established by utilising game theory, particularly by either constructing a repeated-game or state-space game.[3] In dynamic oligopoly models, the interdependency between two or among more agents with conflicting objectives defines a game-theoretic situation. Hence the repeated-game and state-space game models are relevant (Karp and McCalla 1983, p. 641). Both explicitly include the best response of firm i to other firms' strategies, which can be either subgame perfect or not.

The repeated-game models capture the responses through the punishment mechanism. They have been widely used to study cartel stability or collusive agreement (Porter 1983; Lee and Porter 1984; Slade 1990). The sustainability of the cartel or collusive agreement is determined by many factors, including the learning process and capacity constraints, among other things. The learning process may increase firms' efficiency and decrease their costs. This makes the expected future profits higher than current profits, deterring firms from breaking the collusion and exploiting their short run profits, hence increasing the stability of collusion (Mookherjee and Ray 1991). Capacity constraints determine both the ability of a firm to deviate and punish. The greater the firm's capacity constraints, the lower the ability of a firm to deviate and punish would be. On one hand, this condition could increase the stability of collusion as the firm has a low ability to deviate. On the other hand, this makes the firm's threat no longer credible, increasing incentives for other firms to deviate, especially when output is homogeneous and market demand is strong (Rotemberg and Saloner 1986; Mookherjee and Ray 1991).

[3] See Slade (1990, 1995) for an excellent survey of empirical repeated-game and state-space game models.

Firms do not maximise only one-period profit because they take into account threats or possible punishments that may come from their rivals as a response to the deviation. In other words, firm i's action depends on past actions of all other players. The mechanism is not arbitrary but depends on the certain strategy rule chosen. The sequence of the actions is known as the path of action $A(\sigma)=\{a(\sigma)(t)\}_{t=1}^{\infty}$, where a is the action and σ is the strategy. These actions determine the firm's pay-offs, whose function is:

Equation 3.22 $$V_i(\sigma)=v_i\left(A(\sigma)\right)$$

The impact of action at time t is received at the end of period t. In other words, there is no physical link or tangible effect between periods in the repeated-game model. Thus, firms play a sequence of static game (Perloff *et al.* 2005, chapter 6). The one-shot first-order condition of a firm's profit function in this game is identical to that in the static model (see Equation 3.12). During collusive periods, firms behave cooperatively, maintaining their output or price level below that of a competitive level, with conduct $\theta_{it} < 1$, while during punishment periods, firms increase their output or decrease prices below that of a collusive level, with conduct $\theta_i > 0$.

Porter (1983) shows that the collusive and punishment periods are differentiated using a simultaneous equation switching regression model, in which parameters of the demand and supply functions are estimated by:

Equation 3.23 $$\log Q_t = \alpha_0 + \alpha_1 \log p_t + \alpha_2 D_t + U_{1t}$$

and

Equation 3.24 $$\log p_t = \beta_0 + \beta_1 \log Q_t + \beta_2 S_t + \beta_3 \theta_t + U_{2t}$$

where:

D_t is a vector of other demand shifters;

S_t is a vector of other supply shifters;

U_t is a vector of random shocks; and

θ_t is a conduct parameter, whose values equal zero in the collusive periods and one in the punishment periods.

In cooperative periods, the coefficient of the indicator variable is equal to $\log\left(\alpha_1 / 1+\alpha_1\right)$, indicating that the conduct parameter is determined by the responsiveness of equilibrium quantity to the demand shifter, which Corts (1999) suggests—as noted previously—as the accurate measure of conjectural variations.

In these repeated-game models, adjustments and their impact are assumed to materialise immediately. However, using macroeconomic US data covering the period 1948–1979, Rotemberg (1982) found that this assumption was rejected. This assumption may be appropriate in cases where changes in production leading to an instantaneous adjustment in price (Porter 1983), or inventories being non-durable, thus the long-lived effect is irrelevant (Rotemberg and Saloner 1989). These models may also be appropriate if changes in parameters over time are random, so that firms' optimal behaviour is myopic. That is, even though firms play an infinite sequence of games, they act as if they are always playing the current game (Slade 1989).

Similar to the repeated-game models, the state-space game models also include the responses through a path, which in these models is a control path $U(\sigma)=\{u(\sigma)(t)\}_{t=1}^{\infty}$. However, unlike the repeated-game models, there are intertemporal linkages in the state-space game models. These linkages appear through the evolution of state variables:

Equation 3.25 $\dot{x}_n(t)=g^n\left(t,x(t),u(t)\right), \quad n=1,2,\ldots,N$

where:

x is a vector of states;

u is a vector of control variables; and

g^n is the transition function.

Firm i's pay-off function in these models becomes:

Equation 3.26 $$\tilde{v}_i(\sigma; x_t) = v_i\left(U\left(\sigma\right); x_t\right)$$

showing that the total pay-off of each player i is not only a function of the set of strategies σ, but also that of a vector of state variables x_t.

Pindyck (1985, p. 194) argued that almost all real-world markets of both exhaustible and renewable resources had prices and production levels that were intertemporally determined. The intertemporal linkage may stem from a learning process, the presence of adjustment costs for quasi-fixed factor inputs or for inventory holdings, or the firms' response over time (rather than instantaneously) to changes in demand. This argument is supported by empirical studies in a number of industries: the coffee (Karp and Perloff 1993) and banana markets (Deodhar 1994), where the production process involves a maturation period and long periods of economic life; the potato-processing industry (Katchova *et al.* 2005), where output production is constrained by contract commitments or localised markets; the titanium dioxide industry (Hall 1990), where output expansion is constrained by high inventory costs; the cattle industry (Hunnicutt and Aadland 2003), where there is a lag between the need for an input and its availability, and the cigarette market (Roberts and Samuelson 1988), where there is a long-lived input effect from advertisements. In such cases, intertemporal linkages are important. Since they are not captured in the repeated-game models, an alternative model such as the state-space model is needed (Karp 1982, p. 7).

Most empirical applications involving state-space game models employ the linear quadratic specification, whose objective functions are quadratic in the state and control variables and the equations of motion are linear in these variables. This specification is broadly used because it constitutes a second-order approximation to other types of non-linear cost functions, and is analytically tractable (Basar and Olsder 1982, p. 184). If the present discounted value of firm i is defined as $J_i\left(q_{t-1};v\right)$, given the state vector $q_{t-1} \equiv \left(q_{it-1}, q_{jt-1}\right)$, the dynamic programming equation of firm i's objective function becomes: [4]

Equation 3.27 $$J_i\left(q_{t-1};v\right) = \max_{u_{it}} \left(p_t - c_i\left(t\right)\right)q_{it} - \left(\gamma_{it} + \frac{\theta_i}{2}u_{it}\right)u_{it} + \delta J_i\left(q_t;v\right)$$

where:

$\pi_i\left(q_t, u_t\right) = \left(p_t - c_i\left(t\right)\right)q_{it} - \left(\gamma_{it} + \frac{\theta_i}{2}u_{it}\right)u_{it}$ is the profit from the current period (which is the profit function in static model including adjustment costs);

δ is the discount factor;

$J_i\left(q_t;v\right)$ is the future profits;

v is an index of market power;

$\left(\gamma_{it} + \frac{\theta_i}{2}u_{it}\right)u_{it}$ is adjustment cost functions, whose intercept and slope are γ_{it} and θ_i, respectively; and

$q_t = q_{t-1} + u_t$ is the equation of motion, whose vector of state variables and control variable are q_{t-1} and u_{it}, respectively.

The first-order condition corresponding to Equation 3.27 is:

Equation 3.28 $$p_t = c_i\left(t\right) + \left(1+v\right)bq_{it} + \gamma_{it} + \theta_i u_{it} + \delta\left[\frac{\partial J_i\left(q_t;v\right)}{\partial q_i} + \frac{\partial J_i\left(q_t;v\right)}{\partial q_j}v\right]$$

[4] This model is based on Slade (1995) and Karp and Perloff (1993)

The market power index v_i is the dynamic analogue of the static models of oligopoly. Its value lies between competitive and monopolistic behaviour, whose indices are $v = -1$ and $v = 1$, respectively.

Although this state-space game explicitly models the intertemporal physical link that cannot be captured in the repeated-game model, a number of limitations have been suggested. First, the objective function is only constrained by the equations of motion. In fact, other constraints such as non-negativity of prices and inventories or finite capacities might be needed (Slade 1995, p. 388), but imposing them using a classical approach or testing them would be extremely difficult, if not impossible. Bayesian techniques can, however, be used as an alternative to do so (Karp and Perloff 1993).

Second, the models are limited to a linear quadratic specification, which is linear in the equation of motion, and thus quadratic in objective function. In fact, in some cases either the constraint could fail to be linear or the objective function could fail to be quadratic. The quadratic adjustment cost functions imply that adjustments are costly in speed and size, and always distributed smoothly over time. In fact, this is not always be the case. Not every adjustment needs to be distributed over time; for example, when the desired production level is below the minimum efficient scale (Hall 2000). In addition, not every adjustment can be distributed over time; for example, when there are lumpy inputs (Rothschild 1971; Nilsen and Schiantarelli 2003).

There are at least three alternatives that have been used to obtain more general functional forms, particularly the equation of motion. The first alternative is by using an algorithm that is capable of dealing with non-linearities, heterogeneity and discrete choice. Using such a general algorithm is complicated and it has not been applied for the oligopoly games. The second alternative is by using Euler's approximation. This is relatively easy but results would be biased if the function is non-linear. The third alternative is by using the linear quadratic approximation model, which is obtained by linearising the first-order condition of the function and iteratively solving the resulting linear quadratic game. With this model, the decision variables can either have a linear form or logaritmic form (Slade

1995, p. 390). Christiano (1990) demonstrated that results from both forms were remarkably accurate.

In summary, the preceding dynamic models have successfully addressed the important features of dynamic behaviour that failed to be captured in the static models. In particular, these models have explicitly modelled firms' long run planning horizon with multi-period interactions, and show the process towards the consistent or steady state equilibrium. These models also include state-space games models that would be needed when intertemporal links exist. Since, in general, market power appears to be a dynamic phenomenon, the dynamic version is likely to be a more appropriate approach to modelling market power.

3.4 Concluding comments

Market power is understood to be a firm's ability to maintain prices above marginal costs. Since marginal costs are usually difficult to determine, various models have been developed to measure this power. These models correspond to the SCP and NEIO approaches. They may have either a monopolistic or oligopolistic market structure framework. However, since monopolistic markets rarely exist in the real world, most empirical studies appear to have used the latter framework. The oligopolistic market differs from the monopolistic one because players in the oligopolistic market have some interdependency. Each firm has some abilities to respond to another firm's actions. The early NEIO studies made an attempt to capture this interdependency with a model called the conjectural variations model. However, because of its static framework, this model fails to capture the responses, which are clearly dynamic. Therefore, the use of the static model can be inappropriate and possibly misleading.

Game theory can be introduced to capture the interactions of two or more agents with conflicting objectives, thus providing a method for analysing the responses. Dynamic models may be divided into the repeated-game and state-space game models. Each model is appropriate for different situations. The difference is in the intertemporal linkages, which exist in the state-space game cases but not in the repeated-game cases. These dynamic models successfully reveal the dynamic behaviour that failed to be captured in a static framework. Therefore, in general, a dynamic model would be a more appropriate approach to modelling market power.

Chapter 4
Modelling Market Power in the Indonesian Palm Oil Industry

As demonstrated in the previous chapter, market power studies can be divided into static and dynamic models. Although static models may provide useful information about the outcomes, in general, dynamic models have been found to be more realistic. Within a multi-period framework, they address the important features of dynamic behaviour that are not captured by the static models. The dynamic models can be divided into repeated-game and state-space game models. In the repeated game, current actions affect only current profits, while in the state space, current actions affect profits of the subsequent period as well as the current profits. In the presence of such an intertemporal link in the palm oil industry, the state-space game model is likely to be a more appropriate model for this study.

The primary purpose of this chapter is to describe the analytical framework, assumptions and estimation techniques. In section 4.1, the theoretical framework of the state-space model is presented. In section 4.2 the empirical model, namely the adjustment cost model with a linear quadratic specification, is explored. Then, the estimation method is discussed in section 4.3. This comprises the discussion on the demand function, the adjustment system, Monte Carlo Numerical Integration and Bayesian inference. In section 4.4, the various types of interaction that can result from the estimates are analysed. Section 4.5 brings the chapter to a conclusion.

4.1 Theoretical model

The following discussion of the state-space game model is drawn from Caputo (2005), Chow (1997) and Slade (1995). Consider an oligopolistic market with *n* firms or players, whose objective is to maximise their discounted stream of profits over time. To achieve this, in each period, players choose the levels of certain variables, which are called the control variables. These variables can be output, investment in capacity or advertising effort. The players' choice is determined by the state variable, which summarises all history that is pay-off relevant. The players need to find an optimal decision rule or control function, so that when a state is determined and an initial condition is given, the objective function is maximised. The firm's objective function is:

Equation 4.1
$$\max_{u(.)} \sum_{t}^{T} \delta^{t} \pi_{it} \left(t, x(t), u(t)\right)$$
$$\text{subject to } x(t+1) = g\left(x(t), u(t)\right), x(t) = x_t, x(T) = x_T$$

showing the summation over t and the maximisation over u_t, where:

$t \in [0,T]$ is the planning period or planning horizon;

δ is the discount factor;

π_{it} is the instantaneous profit;

u is a vector of control variables; and

x is a vector of state variables.

In selecting the optimal control function, three different assumptions—namely, open-loop, closed-loop and Markovian strategies—have been widely used in previous studies. In an open-loop strategy, a firm ignores the possible changes in states, and chooses a path of action based only on the initial information and commits for the entire period. This means that the problem begins at $t = 0$ with state $x(t) = x(0) = x_0$, so that Equation 4.1 can be re-written as:

Equation 4.2
$$\max_{u(.)} \sum_{0}^{T} \delta^{t} \pi_{it} \left(t, x(t), u(t)\right)$$
$$\text{subject to } x(t+1) = g\left(x(t), u(t)\right), x(0) = x_0, x(T) = x_T$$

In contrast, in a closed-loop strategy, a firm may revise its decisions at any time as a response to changes in states. The problem can begin at any time $t \in [0,T]$ with state $x(t) = x_t$, so that Equation 4.1 does not change. A special case of the closed-loop strategy that has been widely used in previous studies is the Markovian strategy. Rather than taking into account the whole history, with a Markovian strategy, a firm considers only the directly relevant state. The rationale for this is that directly relevant causes should have a major effect, and thus have significant influences on behaviour. In practice, this reduces the number of parameters and makes estimation easier.

With the open-loop strategy a firm does not revise its decisions; hence the optimal solution refers to the solution of the entire time path. Use of the Lagrange multiplier, on the other hand, obtains the optimal solution from the necessary and sufficient conditions that can be used to find the optimal time path. Therefore, the Lagrange multiplier provides the tool to solve models using the open-loop strategy. The Lagrangean for firm i can be defined as:

Equation 4.3

$$L_i = E_0\left[\sum_{t=0}^{t=T}\delta^t\left\{\pi_i\left(t,x(t),u(t)\right)-\lambda_i\left[x(t+1)-g_i\left(t,x(t),u(t)\right)\right]\right\}\right]$$

where λ is the Lagrange multiplier and E_0 is Lagrange expectation value given information at time 0. The optimal control rule is obtained by solving the necessary conditions of the Lagrangean, that is, $\frac{\partial L_i}{\partial x}=0$, $\frac{\partial L_i}{\partial u}=0$ and $x_{t+1} = g_i\left(t,x(t),u(t)\right)$. In general, the expectation operator makes the problem complicated. However, when the control rule is linear, or equivalently the objective function is quadratic, once the least-square estimators are obtained, the error term can be replaced with its conditional mean value, which is zero, and hence the expectation operator is dropped.[5] This considerably simplifies the problem. As such, the linear quadratic form has been widely used in previous studies (Javier 2001, p. 24).

[5] This is known as the certainty equivalence principle.

In the closed-loop strategy, a firm may revise its decision to reach the Nash equilibrium or optimal solution in each period. Dynamic programming, on the other hand, obtains the optimal solution of a problem from the optimal solution of each of its subproblems. Therefore, dynamic programming provides the tool to solve models, using the closed-loop strategy. Defining $V_i(.)$ as the value function for firm i, the dynamic programming equation firm i can be specified as:

Equation 4.4 $$V_i(t, x_t, T) = \max_u \sum_t^T \pi_i(t, x(t), u(t)) + \delta E V_i(t, x(T))$$

$$\text{subject to } x(t+1) = g(x(t), u(t)), x(t) = x_t, x(T) = x_T$$

that is, the sum of the current profit and the discounted future values subject to the control function. E, as noted previously, is the expectation operator, which is then dropped for the same reason. The optimal control function that would maximise the value function is a function $x(.)$ that gives the optimal path of the control variable for the entire planning horizon. The optimal path is associated with the slope of the function at each point of time in the planning horizon, and is obtained by solving the Hamilton–Jacobi–Bellman partial differential equation:

Equation 4.5 $$\frac{\partial V_i(t, x_t, T)}{\partial t} \equiv \max_{u_t}\left[\pi_i(t, x(t), u(t)) + \delta \frac{\partial V_i(t, x(T))}{\partial t}\right] = 0$$

As the structures of the Markovian strategy (see Equation 4.1) and the open-loop strategy (see Equation 4.2) are identical, they will lead to the same optimal control function. However, because they have a different base time and base state, in general, the solution of each strategy will be different. The open loop may arise either because a firm can only observe the initial state at $t = 0$ or assumes that its decisions do not influence other firms' decisions. This precludes the ability to capture the 'off-equilibrium path' solution.[6] In contrast, within a closed-loop strategy, a firm revises its decisions as a response to the changing states until Nash equilibrium is reached. Figure 4.1 gives an illustration of such conditions in a duopolistic market.

Figure 4.1 Single-period pay-offs for a large firm and a small firm

Large Firm

Small Firm

	H	**L**
H	**(3,10)**	**(1,8)**
L	**(4,7)**	**(2,5)**

Suppose that there are two firms, namely a large firm and a small firm, engaged in a supergame with infinite time horizon. In each period, each firm can either use a high (H) or low (L) price strategy. Values in parentheses refer to the single-period pay-offs for each possible price combination. The first values in the parentheses show the pay-offs for the small firm, while the second values are those for the large firm. The large firm's dominant strategy is H, that is H maximises this firm's current period pay-offs regardless of the small firm's action. The small firm's dominant strategy is L, therefore, this firm prefers the (L,H) rather than the (H,H) price combination. With (L,H) the small firm's pay-off is 4, while with (H,H) this firm only receives 3. In contrast, with the former, the large firm's pay-off is 7, while with the latter this firm can gain 10. Therefore, to gain the highest possible pay-off it could reach, the large firm uses the punishment strategy by threatening to use L whenever the small firm uses L. Since the (L,L) pay-off is less than the (H,H) pay-off for both the large and small firms, both firms' best response will be the latter. The path in which both firms use H is called 'the equilibrium path'.

By choosing (H, H), the small firm's present discounted pay-off will be $\frac{3}{1-\delta}$, where δ is the discount factor. If the small firm cheats and uses L, it gets 4 during the deviation period (because the large firm still use H), but in the next period the large firm will

[6] Perloff *et al*. (2005) use this expression in explaining Figure 4.1. See Tirole (1988, pp. 245-6) for explanations about pay-offs in a supergame.

respond by using L forever, hence the small firm's present discounted pay-off after the deviation period will be $\frac{2\delta}{1-\delta}$ (as their price combination will be (L,L))[7]. If $\frac{3}{1-\delta} > 4 + \frac{2\delta}{1-\delta}$ (that is, if $\delta > 0.5$), the small firm will consider the large firm's threat and uses H.[8] Otherwise, the small firm prefers to deviate to obtain higher pay-offs.

The condition where both firms choose L is 'off the equilibrium path', but it is clearly an equilibrium. Within an open-loop strategy, the large firm will not respond to the small firm's deviation and continues to use H. In contrast, within a closed-loop strategy, the large firm will revise its decision by using L. This means that only the closed-loop strategy reaches equilibria in every period of the game, both along and outside the equilibrium path. Therefore, the closed-loop strategy can be seen as a subgame perfect equilibrium. Although the estimation of the closed-loop strategy is more complicated than that of the open-loop strategy, in general, the former appears to be more realistic than the latter. Hence the closed-loop strategy is chosen.

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[7] By choosing H, small firm's present discounted pay-off will be $3\left(1+\delta+\delta^2+\delta^3+\text{K}+\delta^T\right)=3\frac{\left(1-\delta^T\right)}{(1-\delta)}$. $T=\infty$ and $0<\delta<1$ gives $\delta^T=0$, hence the pay-off can be rewritten as $3\frac{\left(1-\delta^T\right)}{(1-\delta)}=\frac{3}{(1-\delta)}$. By deviating to L, small firm firm's present discounted pay-off will be $4+2\left(\delta+\delta^2+\delta^3+\text{K}+\delta^T\right)=4+2\frac{\left(\delta-\delta^T\right)}{(1-\delta)}$. Given $\delta^T=0$, hence the pay-off can be rewritten as $4+\frac{\left(\delta-\delta^T\right)}{(1-\delta)}=4+\frac{2\delta}{(1-\delta)}$

[8] Empirically, the magnitude of δ can be translated into the speed and strength of a punishment. The greater the speed and the strength of a punishment, the less the net gain from cutting price or increasing output, hence the less incentive for a competitor to deviate to obtain higher pay-offs (Church and Ware 2000, p.328).

4.2 Empirical model

The empirical model is based on Karp and Perloff (1993), who apply the state-space game model to measure symmetric duopolists' market power in the coffee export market. In the Indonesian crude palm oil industry, the duopolists represent the public estates and private companies. As described in Chapter 2, these groups are unlikely to be identical: the public estates appear to be more bureaucratic, less responsive to change and less productive than the private companies. Therefore, the symmetric assumption of the model is relaxed.

In each period, oligopolists choose the rate of their output as the control variable. Being a perennial crop means that firms run a long run production process. Inputs such as land or plant capacity, which are considered as fixed in the short run, are no longer fixed in the long run. They could be changed and adjusted but their full adjustments are reached in the long run. These quasi-fixed inputs are held constant in the short run due to the high cost of adjustment. The greater the size or speed of adjustment, the higher the costs should be expended. In other words, the average cost of changing the level of quasi-fixed inputs increases with the size of change or rate of adjustment.

In this study, CPO mills capacity can be seen as one of the quasi-fixed inputs. CPO mills capacity is a lumpy input, with level of 30, 45, 60 or 90 tonnes FFB per hour. Many firms prefer to choose a large capacity mill although they are not always supported with sufficient amount of FFB. The main reason is that establishing two small mills is much expensive than one large mill with a same level of capacity. The latter only needs additional machines to increase and to reach its full capacity, but the latter requires either additional buildings or total change in the small old mill due to the different characteristic of the large mill. Empirically, on average, a CPO mill with a capacity of 45 tonnes FFB per hour is established in 18 months. However, a big investor can build the mill only in 12 months. The difference stems from the investor's stock of materials that are needed to build the mill. Most investors do not have a sufficient level of stock due to the requirement of extra costs.

The model is adopted from the neoclassical models of investment, which uses at least a one period lag between incurring the costs of new investment and the addition of new investment goods to productive capital. Strictly convex adjustment cost function is then assumed to generate investment smoothing, which in turn provides a theoretical justification for the use of distributed lag in empirical work (Sanghamitra, 1991, p.268). Perloff *et al*. (2005, p.8) argue that their model needs the use of distributed lag for capturing delay in the rivals' response to their actions. Therefore, convex adjustment cost function is then used in their model.

As mentioned in the theoretical model, a linear-quadratic specification has been widely used in previous studies, as it considerably simplifies the estimation. In this case, the linear form refers to the adjustment system and the demand function, and the quadratic form refers to the objective and adjustment cost functions. Adda and Cooper (2001) suggest a more general adjustment structure by allowing the adjustment cost parameter to vary. However, such an approach might be difficult to apply in this model, as a constant adjustment cost parameter is needed to recover the market power index.[9] Therefore, the linear-quadratic specification is used in the following empirical model:

Equation 4.6 $$\sum_{t=1}^{T} \delta^{t-\varepsilon} \left(p_t - c_i\left(t\right)\right) q_{it} - \left(\gamma_{it} + \frac{\theta_i}{2} u_{it}\right) u_{it} \varepsilon$$

$$\text{subject to } q_t = g + G q_{t-\varepsilon}$$

where:

δ is the discount factor;

p_t is the linear inverse demand;

$c_i\left(t\right)$ is the constant marginal production cost;

q_{it} is the output;

[9] See Chapter 4 for details.

$\left(\gamma_{it} + \frac{\theta_{it}}{2} u_{it}\right) u_{it}\varepsilon$ is a convex adjustment cost, where $u_{it}\varepsilon \equiv q_{it} - q_{it-\varepsilon}$;

ε is the three-year length of maturation period;

$q_t = g(t) + Gq_{t-\varepsilon}$ is the adjustment system, where $g(t)$ is a column vector; and

G is a 2x2 matrix with elements G_{ij} $(i, j = 1,2)$.

Defining $J_i(q_t; v_i)$ as the present discounted value of group i, given the state vector $q_t \equiv (q_{1t}, q_{2t})$ and the group market power index v_i, the dynamic programming equation for group i is:

Equation 4.7
$$J_i(q_{t-\varepsilon}; v_i) = (p_t - c_i(t)) q_{it} - \left(\gamma_i + \frac{\theta_i}{2} u_{it}\right) u_{it}\varepsilon + \delta J_i(q_t; v_i)$$

that is, the sum of the profits of the current period and the present discounted value of future profits. The first-order condition of Equation 4.7 is:

Equation 4.8
$$p_t = c_i(t) + (1 + v_i) bq_{it} + \theta_i u_{it}\varepsilon - \delta\left[\frac{\partial J_i(q_t; v_i)}{\partial q_i} + \frac{\partial J_i(q_t; v_i)}{\partial q_j} v_i\right]$$

where:

$c_i(t) + \theta_i u_{it}\varepsilon$ is the total marginal cost, which is the sum of marginal production cost and marginal adjustment cost;

$p_t - (1 + v_i) bq_{it}$ is the marginal revenue;

$b = \frac{\partial p_t}{\partial q_{it}}$ is the slope of inverse demand;

v_i is the market power index; and

the term in brackets is the discounted shadow value of an extra unit of current output;

If $v_i = -1$, marginal revenue equals price, and there is no mark up, reflecting a competitive condition. While if $v_i = 1$, the slope of marginal revenue is twice the slope of inverse demand, and the monopoly mark up is observed.

In order to be interpretable, the estimates of this market power index v_i need to lie between these two extreme values. Although the dynamic market power index is similar to the static one, the relationship between the index and price–cost margin is not as simple as in the static model. In the dynamic model, firms do not only take into account the marginal production costs, but also the marginal adjustment costs of changing their production over time. In addition, firms care about the future $(\delta \neq 0)$ as well as the current condition. In such cases, firms will not exploit their current profits by increasing the current price. Therefore, the higher the discount factor δ, the lower the current market prices, and vice versa.

The linear-quadratic model refers to a linear relationship in the equation of motion and quadratic in objective function. In Equation 4.6, the linear equation of motion is stated by the constraint, while the objective function is a profit function. Inverse demand p_t is linear in output, so that revenue is quadratic in output. The linear quadratic problem has an important implication for the estimation of the adjustment cost parameter and market power index. In practice, adjustment cost data are rarely available. Therefore, they can not be estimated by using a single standard regression. As an alternative, the following structural approach is used. Given $u_{it} \equiv q_{it} - q_{it-1}$, defining $v = \frac{\partial q_{-it}}{\partial q_{it}}$, and setting

$\gamma_{it} = 0$ [10], the first derivative of firm i's discounted stream of profits with respect to q_{it} gives the optimal control rule as[11]:

Equation 4.9 $$q_t = g + Gq_{t-1}$$

where :

$$g = \frac{\left[p_t + \delta p_{t+1} - (1+\delta) c_i \right]}{\left[-\frac{(1+v_i)}{b} + (1+\delta)\theta_i \right]}$$ is the intercept;

$$G = \frac{\delta(1+v_i)}{\left[-(1+v_i) + b(1+\delta)\theta_i \right]}$$ is the slope;

b is the constant slope of the demand equation;

θ is the slope of marginal adjustment cost function; and

v is the market power index.

Given this, the slope of the control function G can be written as $G = f\left(b, \theta, v, \delta\right)$. In the case of a linear quadratic problem, this equilibrium value always exists. The recursive structure of the problem makes its optimal solution self-enforcing. In other words, as time advances, the player has no incentive to deviate from the original optimal rule. This property is known as Bellman's principle of optimality, and the control rules that satisfy this property are said to be time consistent (Javier 2001, p. 17). Under such a condition,

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[10] In this model, rate of production $u_{it} = q_{it} - q_{it-1}$ is used as an approximation for the adjustment variable, which is given as $\gamma_i u_{it} + \frac{\theta_i}{2} u_{it}^2$. The minimum adjustment cost would be reached if its first derivation $\gamma_i + \theta_i u_{it}$ equalled zero, thus γ_i is set to zero. This means that there would not be any adjustment cost if there were no adjustment or $u_{it} = 0$, which holds if firms reach the long run equilibrium condition (Berstein 1992). With no adjustment costs, if firms behave competitively $v_i = -1$, price will be equal to marginal production cost.

[11] The complete derivation is provided in Appendix 4.1

given $G = f(b,\theta,v,\delta)$, f can be inverted to recover a subset of parameters b,θ,v,δ. If independent estimates of G and b are provided and δ is known, the adjustment cost parameter θ and market power index v can be obtained. All constants included in the firm i's discounted stream of profits—the demand intercept and marginal costs—are no longer relevant to the optimal solution. Therefore, the optimal problems can be limited to only the quadratic part of the problem.

Taking the quadratic part of the problem, setting $\gamma_{it} = 0$ and defining the difference between the demand and cost intercept at time t as a_{it}, the solution of the Markovian strategy (see Appendix 4.2) gives parameters v_i and θ_i that satisfy:

Equation 4.10 $$\left[K_i + \delta W_i + \left(e_i e_i^{'} + \delta Z_i\right)\theta_i\right] v_i = G'^{-1} e_i \theta_i \equiv y_i^* \theta_i$$

where:

W_i is the inverse vectorisation of w_i, where w_i is defined as:

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

Z_i is the inverse vectorisation of z_i, where z_i is defined as:

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

$\otimes$ denotes the Kronecker product;

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 $b\left(e e_i^{'} + e_i e'\right)$, 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 (nxn) matrix consisting of 0's except for the (i,i) element which contains θ.

The derivation of Equation 4.10 does not depend on a symmetry assumption. However, such an assumption is needed for the estimation process. Symmetric matrices have two useful conditions. First, they only have real eigenvalues, that is, complex eigenvalues never occur. Second, they have enough independent eigenvectors to diagonalise the matrix (Simon and Blume 1994, pp. 620-621). Since matrix K_i is of rank 2, this assumption is required in order to obtain a solution. Otherwise, the number of unknown parameters is more than the number of equations; hence the system will either have no solution or infinitely many solutions (Simon and Blume 1994, p. 143; Perloff *et al.* 2005 chapter 9, p.18).

The symmetric matrix G implies that firms are treated as having identical behaviour, identical adjustment coefficients and identical cost structures. This assumption is relatively restrictive, but it has been used in all previous studies that employed this model (Karp and Perloff 1989, 1993; Deodhar 1994; Katchova *et al.* 2005). However, in a duopoly market where $n=2$, the number of equations is exactly the same as the number of unknown parameters, and thus the symmetry assumption is not required (see Appendix 4.3).

Utilise the recursive principle, assuming $\gamma_{it}=0$, $\varepsilon=1$ and constant marginal costs, the discounted profit stream can be re-written as

Equation 4.11 $$\Pi_i=\left(p_t-c_i\right)q_{it}-\frac{\theta_i}{2}\left(q_{it}-q_{it-1}\right)^2+\delta\left[\left(p_{t+1}-c_i\right)q_{it+1}-\frac{\theta_i}{2}\left(q_{it+1}-q_{it}\right)^2\right]$$

Defining $\frac{\partial Q_t}{\partial p_t} = \frac{\partial Q_{t+1}}{\partial p_{t+1}} = \frac{\partial \bar{Q}}{\partial \bar{p}} = b$ and $\frac{\partial q_{jt}}{\partial q_{it}} = \frac{\partial q_{jt+1}}{\partial q_{it+1}} = \frac{\partial q_j}{\partial q_i} = v_i$, the maximisation of the discounted profit stream firm i will be:

Equation 4.12

$$\frac{\partial \Pi_i}{\partial q_{it}} = \frac{1}{b}(1+v_i)q_{it} + p_t - c_i - \theta_i q_{it} + \delta \frac{1}{b}(1+v_i)q_{it+1} + \delta p_{t+1} - \delta c_i - \delta\theta_i q_{it} = 0$$

and the current price will be

Equation 4.13 $$p_t^{mp} = -\frac{(1+v_i)}{b}\left[q_{it} + \delta q_{it+1}\right] + (1+\delta)c_i + (1+\delta)\theta_i q_{it} - \delta p_{t+1}$$

While if $v_i = 1$, the slope of marginal revenue is twice the slope of inverse demand, and the monopoly mark up emerges. If $v_i = -1$, marginal revenue equals price, reflecting a competitive condition and Equation 4.13 can be re-written as

Equation 4.14 $$p_t^c = (1+\delta)c_i + (1+\delta)\theta_i q_{it} - \delta p_{t+1}$$

Consumer surplus without subsidies will be

Equation 4.15 $$CS^c = \int_0^{q_t^c} f(Q_t)dQ_t - p_t^c q_t^c = \int_{p_t^c}^{p^0} g(p_t)dp_t$$

while that with subsidies will be

Equation 4.16 $$CS^c = \int_0^{q_t^{mp}} f(Q_t)dQ_t - p_t^{mp} q_t^{mp} = \int_{p_t^{mp}}^{p^0} g(p_t)dp_t$$

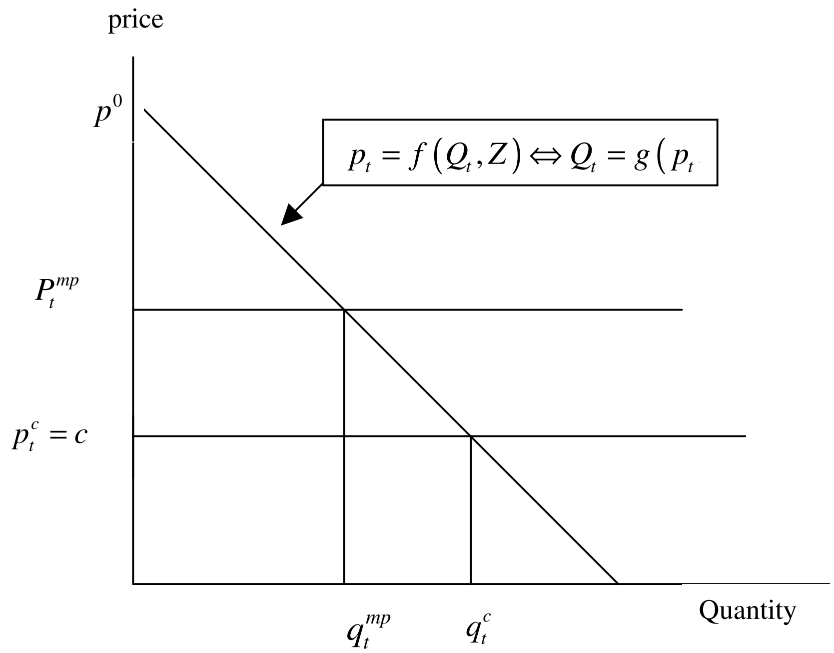
therefore, the change in consumer surplus will be

Equation 4.17

$$\Delta CS = CS^{c} - CS^{mp} = \int_{p_t^c}^{p^0} g\left(p_t\right)dp_t - \int_{p_t^{mp}}^{p0} g\left(p_t\right)dp_t = \int_{p_t^c}^{p^{mp}} g\left(p_t\right)dp_t = G\left(p_t^{mp}\right) - G\left(p_t^{c}\right)$$

This change in welfare can be illustrated by Figure 4.2.

Figure 4.2 Changes in consumer surplus



4.3 Estimation method

The adjustment cost parameter θ and market power index v are calculated by providing the estimates of the slope of the adjustment system G matrix, elements of which are G_{ij} , and the slope of the inverse demand b. The solution needs to satisfy three properties, which in the duopoly case are:

(a) the system needs to be stable: $-2 < G_{11} + G_{22} < 2$ and $-1 < G_{11}G_{22} - G_{12}G_{21} < 1$ (see Appendix 4.4);

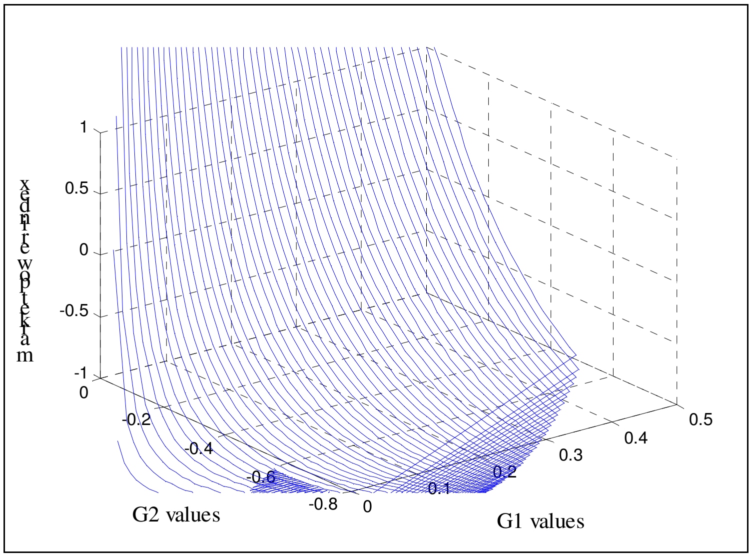
(b) the market power index needs to be interpretable: $-1 < v_i < 1$; and

(c) the adjustment cost function needs to be convex: $\theta_i > 0$.

In this model, the stability of the adjustment system leads to stable estimates of the market power index, since this index is determined by the coefficients of the system. An unstable market power index may indicate that a firm has incorrectly predicted its competitor's reaction (Karp 1982, p. 56). In a symmetric duopoly case, where $G_{11} = G_{22} = G_1$ and $G_{12} = G_{21} = G_2$, these coefficients need to satisfy $-1 < G_1 + G_2 < 1$ and $-1 < G_1 - G_2 < 1$. However, this does not ensure that the estimates of market power will be within the desired range, which is –1 and 1.

In static models, the desired range is obtained when firms have decreasing reaction functions, whose slopes G_{ij} are between –1 and 0 (see Appendix 4.5). Simulation results show that the market power index will be between –1 and 1 if and only if G_1 takes positive values between 0 and 1, and G_2 takes negative values between –1 and 0 (see Figure 4.3). These simulation results are supported by the empirical evidence of previous studies (Karp and Perloff 1989, 1993; Deodhar 1994; Katchova *et al.* 2005). However, in asymmetric dynamic cases, the relationship amongst the values is much more complicated, even if we assume that firms use the open-loop strategy. The desired v values are not determined by two (G_1, G_2), but by four G $(G_{ii}, G_{ij}, G_{ji}, G_{jj})$ values. Furthermore, they are also determined by the combinations of these elements (see Appendix 4.6 for the solution for the asymmetric dynamic case with an open-loop strategy). The simulation results show that the combinations can have either positive or negative G values between –1 and 1. No empirical studies of asymmetric cases appear, however, to have been conducted.

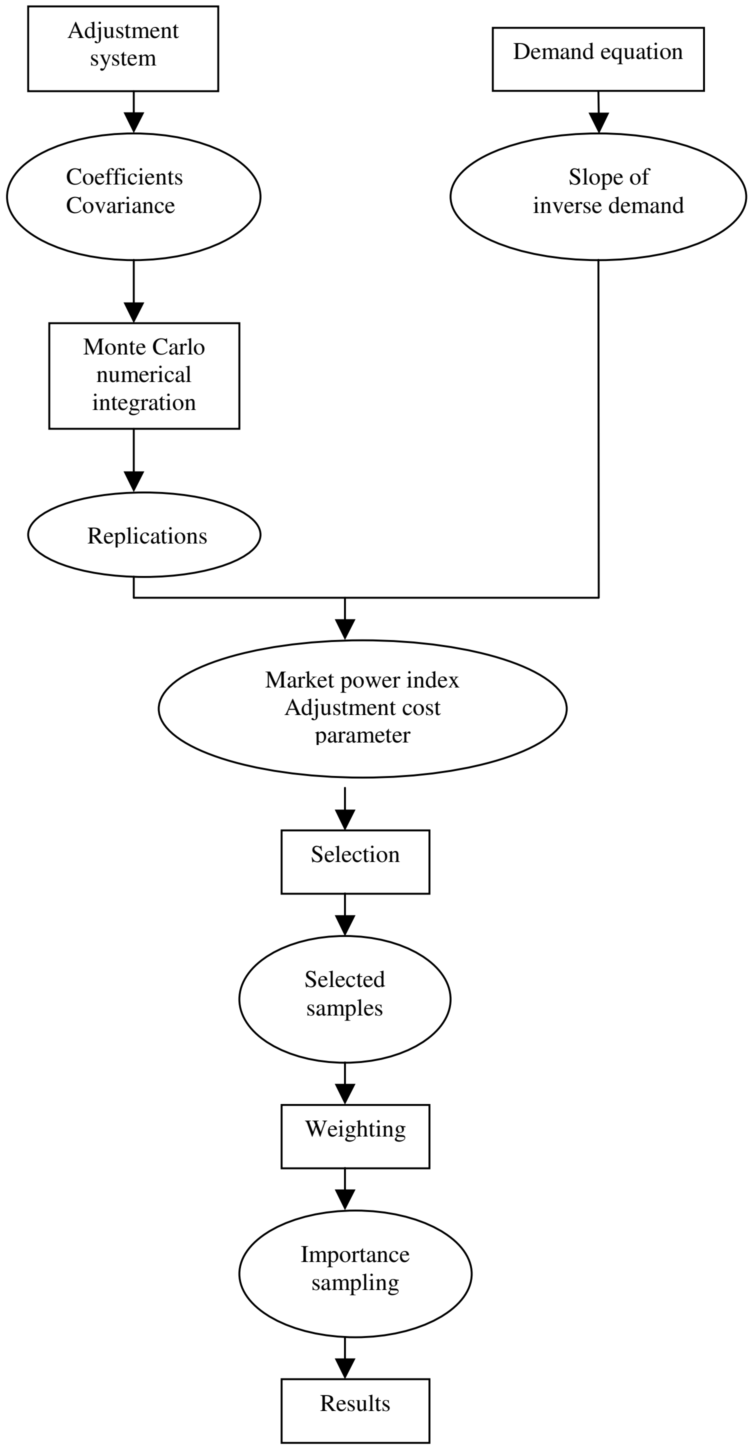
Figure 4.3 Relationship between v and G values



Imposing the three properties by using a classical approach would be extremely difficult, if not impossible. However, the Bayesian approach provides a relatively easy technique to do so (Griffiths 1988; Karp and Perloff 1993, p. 452). In the Bayesian approach, data are treated as fixed and parameters are random. Distribution of the parameters is generated using numerical integration. The properties are imposed on the parameters by selecting those that satisfy the restrictions.

Figure 4.3 shows the estimation process, which is based on Chalfant *et al*. (1991). First, a demand equation and an adjustment are estimated separately. Using the estimates and covariance from the adjustment system, parameters are replicated with the Monte Carlo numerical integration method. For problems with dimensions more than three, such as the parameter vector of adjustment system μ (see Equation 4.12), this method is suggested to be computationally more efficient than the other integration methods (Kloek and van Dijk 1978; Griffiths 1988; Geweke 1989; Chalfant *et al.* 1991, p. 480). The replications are then used to calculate the market power index and the adjustment cost parameter. Then the inequality restrictions are imposed. The G stability restriction can be checked directly from the values of each of the replications. The market power index and adjustment cost parameter are checked by calculating them from each of the replication. Results that satisfy the restrictions are selected, otherwise they are dropped. Using the importance sampling method, each selected replication is weighted to take into account the probability distribution of the data and the Bayesian point estimates are calculated.

Figure 4.4 The estimation process



The demand equation for CPO was treated as a derived demand for palm cooking oil, because CPO is used as the main raw material for this product. The demand equation is as follows:

Equation 4.18 $$Q = Q\left(P, P_1, PP_1, P_2, D, \varepsilon\right)$$

where:

Q is the demand of CPO from the cooking oil industry;

P is the price of CPO;

P_1 is the price of crude coconut oil;

P_2 is the price of palm cooking oil;

D is the dummy variable of the economic crisis 1997–1998; and

ε are the error terms.

The adjustment system comprises two adjustment equations from the public estates and the private companies. Although a direct relationship between these adjustment functions does not exist, each is likely to be influenced by the same variables, namely its own and its rival's previous production and the concessionary credit given to both of them in 1986–1996. Therefore, the error terms across the public estates and private companies' equations might be correlated, and the Zellner's seemingly unrelated regressions (SUR) technique could be applied to the following adjustment system:

Equation 4.19 $$q_{it} = q_{it}\left(q_{it-3}, q_{jt-3}, D_1, D_2, \mu, \varepsilon_{it}\right) \;\; ; \;\; i, j = 1, 2 : i \neq j$$

where:

q_{it} is the current output;

q_{it-3} is the three-year lagged output;

D_1 is the dummy variable for the concessionary credit period, whose values are zero before 1989 (three-year lagged after the concessionary credit periods) and one for the remainder;

D_2 is the dummy variable of economic crisis, which equals zero before 1997 and one thereinafter;

μ is a vector of parameters; and

ε_i are the error terms.

Within the Bayesian technique, the three properties (stability, interpretable market power index and convex adjustment costs) are treated as prior information. It is then combined with information from the data to form the posterior probability distribution function (pdf):

Equation 4.20 $$f(\mu|q)\,\alpha\, p(\mu)\, l(\mu|q)$$

where;

$f(\mu|q)$ is the posterior pdf of the vector of parameters from the adjustment system μ, given the sample information q;

α denotes proportionality;

$p(\mu)$ is the prior pdf for the vector of parameters μ; and

$l(\mu|q)$ is the likelihood function of the vector of parameters μ.

With a single point of the vector of parameters, and without any information about the mean and variance, it is impossible to evaluate the integrals analytically. Hence, numerical integration is used for finding the pdfs. A very large number of replications of the vector of parameters μ are generated from a multivariate *t*-distribution:

Equation 4.21 $$g\left(\mu|q\right)\alpha\left[\lambda+\left(\mu-\hat{\mu}\right)'\Sigma^{-1}\left(\mu-\hat{\mu}\right)\right]^{-(\lambda+J)/2}$$

where Σ is the variance–covariance matrix of the vector of parameters μ, $\hat{\mu}$ is the estimation of parameters and J is the number of parameters. Using the variance–covariance matrix of the vector of parameters $V\left(\hat{\mu}\right)$, the Cholesky decomposition matrix H, such that $HH' = V\left(\hat{\mu}\right)$, is estimated. Then, 14 random vectors—10 of the same length of parameters in the vector μ of the two share equations in the adjustment system, including the intercept $p \sim N(0, I)$, and four of the same length of the degrees of freedom $s \sim N(0, I)$—are drawn from a standard normal distribution. It is suggested that four degrees of freedom are used to ensure the relatively 'fat tails' to cover the posterior pdf of the vector of parameters μ. The latter draw is then used to calculate $r = \left[\left(s's\right)/\lambda\right]^{1/2}$, where λ is the degree of freedom. Then, the vector of parameters in the adjustment system is replicated using the formula $\mu^A = \hat{\mu} + Hp/r$ with its 'antithetic replications' $\mu^B = \hat{\mu} - Hp/r$, which is suggested to improve convergence.

Although the replications are generated from a multivariate *t*-distribution, in fact, the posterior pdf of the vector of parameters μ does not always follow such a distribution. In such cases, the expected value obtained from the multivariate *t*-distribution will be different from the 'true mean' (the expected value following the posterior pdf of the vector of parameters μ). To correct this, each of the replications needs to be weighted. Those which are closer to the 'true mean' receive a larger weight, whereas those which are further away have the smaller weight.[12] The weight is called the importance function, which is the ratio of the 'true' posterior pdf and the 'generated' posterior pdf (from the multivariate *t*-distribution). The prior density of the 'true' posterior pdf for both variance Σ and mean value μ are unknown, because the estimation results of the SUR provide

[12] This method is known as importance sampling, details of which are provided in Kloek and van Dijk (1978).

only a single value for each of the parameters of the adjustment system. This means the prior pdf $p(\mu)$ will be very flat, hence the 'function' will be a constant. Given such a diffuse prior density, the resulting 'true' posterior pdf for θ becomes:

Equation 4.22

$$f(\mu|q)\alpha p(\mu)l(\mu|q) = f(\mu|q)\alpha cl(\mu|q)\alpha l(\mu|q)$$
$$= f(\mu|q)\alpha|A|^{-T/2}$$

where A is an (mxm) matrix (m is the number of equations in the adjustment system), and T is the number of observations. The elements of matrix A are given by $a_{ij} = [(\varepsilon_i(G))^{'}(\varepsilon_j(G))]$, where $\varepsilon_i(G)$ is the vector of residuals for the share equation i in the adjustment system, evaluated using any value of θ where the posterior density is defined. Given Equations 4.21 and 4.22, the importance function becomes:

Equation 4.23

$$\frac{f(\mu \mid q)\alpha|A|^{-T/2}}{g(\mu|q)\alpha\left[\lambda+(\mu-\hat{\mu})'\Sigma^{-1}(\mu-\hat{\mu})\right]^{-(\lambda+J)/2}}$$

Using each of the replications, the adjustment cost parameter and market power index are calculated. Results that satisfy the restrictions are selected, otherwise they are dropped, giving the truncated densities for both $f(.)$ and $g(.)$, denoted by $f^R(.)$ and $g^R(.)$. The Bayesian point estimates of the adjustment cost parameter θ and market power index v are calculated using the selected samples and their corresponding weight from the truncated pdfs $f^R(.)$ and $g^R(.)$:

Equation 4.24

$$\bar{\beta} = \frac{\sum_{k=1}^{n} \beta_k \frac{f^R(\mu_k|q)}{g^R(\mu_k|q)}}{\sum_{k=1}^{n} \frac{f^R(\mu_k|q)}{g^R(\mu_k|q)}}$$

where n is the number of replications that hold all of the three properties. The ratio of these selected samples to the total replications shows the probability of holding the properties:

Equation 4.25

$$\hat{p}_D = \frac{\sum_{k=1}^{n} \frac{f^R(\mu_k|q)}{g^R(\mu_k|q)}}{\sum_{k=1}^{N} \frac{f(\mu_k|q)}{g(\mu_k|q)}}$$

where N is the number of all replications. Chalfant *et al.* (1991, p. 482) suggest that any pdf can be used as $g(\mu \mid q)$, because:

Equation 4.26

$$E(\mu) = \int \mu f(\mu) d\mu = \int \mu \frac{f(\mu)}{g(\mu)} g(\mu) d\mu$$

showing that the expected value obtained from the data density will be the same as the weighted value obtained from the replications. However, the choice of $g(\mu \mid q)$ determines the number of draws required to obtain a high numerical accuracy. The smaller the variance of $f(\mu \mid q)$ with respect to $g(\mu \mid q)$, or the more similar these pdfs, the fewer draws needed to obtain good or accurate estimates. Otherwise, an excessively large number of replications needs to be drawn in order to reach a desired precision or accuracy (van Dijk and Kloek 1980, p. 316; de Jong *et al.* 2000, p. 215).

In addition, $g(\mu \mid q)$ needs to have a tail that is fatter than $f(\mu \mid q)$. Otherwise, $g(\mu \mid q)$ will decline faster than $f(\mu \mid q)$, resulting in some of the weights becoming extremely large and dominating the results. Van Dijk and Kloek (1980) and de Jong *et al.* (2000) suggest that for $g(\mu \mid q)$ to be considered 'good', the centre and rotation must not be too dissimilar to $f(\mu \mid q)$. The accuracy of the selected samples proportion is measured by the numerical standard error (NSE):

Equation 4.27
$$NSE(\beta) = \left[\frac{\sum_{k=1}^{N} (\beta_k - \overline{\beta}_k)^2 \left(\frac{f(\mu_k | q)}{g(\mu_k | q)} \right)^2}{\left(\sum_{k=1}^{N} \frac{f(\mu_k | q)}{g(\mu_k | q)} \right)^2} \right]^{1/2}$$

while that of the point estimate is measured by the standard deviation of the posterior distribution:

Equation 4.28
$$s.d.(\beta) = \left[\frac{\sum_{k=1}^{n} (\beta_k - \overline{\beta}_k)^2 \left(\frac{f^R(\mu_k | q)}{g^R(\mu_k | q)} \right)}{\sum_{k=1}^{n} \left(\frac{f^R(\mu_k | q)}{g^R(\mu_k | q)} \right)} \right]^{1/2}$$

4.4 Types of interaction

Previous studies show that the types of interaction among firms can be determined with either the conjectural variations or the reaction function approaches. The former gives a parameter of conduct, indicating a firm's belief about how another firm will respond to its action. It is obtained from the first-order condition of a firm's profit function. The latter provides a coefficient of each player's 'best response', in which each firm's decision is expressed as a function of the other's. For consistent conjectural variations models, the conduct and response parameters produce identical estimates of competitive interaction (Putsis 1999, p. 298).

The signs or values of the conjectural variations or the coefficients of the reaction function indicate certain types of market interactions, which can be either symmetric or asymmetric. In the symmetric case, each firm responds to actions by its rival in a similar way. This can be in the same or opposite direction, implying a cooperative or non-cooperative interaction, respectively. There can also be a lack of response when a firm believes that all of its rivals have already given their best responses and produced the equilibrium quantities, hence none of them wants to change its output level. Such an interaction is known as the Cournot interaction, in which both firm's conjectural variations $v_i = \frac{\partial q_j}{\partial q_i}$ and slope of reaction function $\alpha_j = \frac{\partial q_j}{\partial q_i}$ will be zero.

In the asymmetric case, each firm responds to actions by its rival in a different way. This includes the leader–follower (Stackelberg) and dominant–fringe interaction. This means that the signs or values of the conjectural variations or the coefficients of the reaction function are different between firms. Sato and Nagatani (1967) suggest that if some of the coefficients are positive and some are negative, the negative ones play a more crucial role. For example, a dominant firm reacts in the opposite way to its rival's actions, while having an insufficient share to influence market prices. Fringe firms simply follow the dominant firm's actions. In other words, the coefficient of the reaction function of the dominant firm is negative, whereas for the fringe firm, is positive. In the conjectural variations approach, the fringe firms believe that the dominant firm will offset its action, so that market price remains unchanged. Hence, they will act as price takers with $v_{fr} = \frac{\partial q_d}{\partial q_{fr}} = -1$. Dominant firms could either behave competitively or exert market power, which depends on the supply elasticity of the competitive fringe (Gollop and Roberts 1979; Putsis and Dhar 1998; Putsis 1999).

In a leader–follower interaction, following firms' actions do not significantly influence a leading firm's profits, and thus, leaders do not react to followers' actions. In contrast, leading firms' actions influence the following firms' profits, hence followers respond to leaders' actions. Depending on the market conditions, the followers' response can either be 'cooperative' or 'non-cooperative'. This means that the coefficient of the reaction function of the leader $\alpha_L = \frac{\partial q_L}{\partial q_f}$ equals zero, while that of the follower can either be positive or negative. In the conjectural variations approach, the followers believe that the leader will not respond to their action, thus their conduct parameter is $v_f = \frac{\partial q_L}{\partial q_f} = 0$.

With a static framework, a firm's conduct parameter v_i does not change over time. With a dynamic framework a firm's conduct parameter v_i could either change or not change over time, depending on what strategy the firm uses in making its decision. Within an open-loop strategy, firm i makes decision based only on the initial information. Given the initial state information, the conduct parameter $v_i = \frac{\partial u_{jt}}{\partial u_{it}}$ is obtained by solving the first-order condition of the firm's objective function. Firm i assumes that its rival firm j does not respond to a change in its action, which means that this conduct parameter v_i does not change over time. Hence, the conduct parameter resulting from an open-loop strategy can be seen as the dynamic analogue of the static conjectural variations parameter.

In contrast, within a Markovian strategy, a firm i makes decision based on information in each period. The firm revises its decisions in each period as a response to changes in its rival's decision. Since the firm does not commit to a particular path, the conduct parameter $v_i = \frac{\partial u_{jt}}{\partial u_{it}}$ will change over time until it is precisely equal to the actual response of the firm j. This means that the conduct parameter $v_i = \frac{\partial u_{jt}}{\partial u_{it}}$ is not obtained by solving the first-order condition of the firm's objective function but rather by solving the equilibrium condition. Therefore, the conjectural variations interpretation is no longer relevant to the dynamic conduct parameter using the Markovian strategy. This means that this dynamic conduct parameter cannot be used as a tool for determining the type of interaction between firms. As an alternative, the reaction function approach will be used to assess the competitive interaction in this model. Here the adjustment system can be seen as a type of reaction function. Assuming a linear adjustment equation for a duopolistic market, the system will be:

Equation 4.29
$$q_{1t} = \alpha_0 + G_{11}q_{1t-1} + G_{12}q_{2t-1} + \alpha_i Z_i + \varepsilon_{1t}$$
$$q_{2t} = \beta_0 + G_{21}q_{1t-1} + G_{22}q_{2t-1} + \beta_i Z_i + \varepsilon_{2t}$$

where:

q_{it} is the current output;

q_{it-1} is the previous output;

Z_i is a vector of output shifters; and

ε_i are the error terms.

In this dynamic model, a firm does not respond to its rival's action in the same period of time, represented by the slopes of the reaction functions $G_{12} = \frac{\partial q_{1t}}{\partial q_{2t-1}}$ and $G_{21} = \frac{\partial q_{2t}}{\partial q_{1t-1}}$. These slopes show the actual response of firm i to the previous action of its rival j. This is different from the conjectural variations $\frac{\partial q_i}{\partial q_j}$, which shows the conjecture of firm j about the future response of firm i. The type of competitive interaction is then concluded from the combination of these coefficients. The different types of interaction can be summarised as shown in Table 4.1.

Table 4.1 Output response and implied market interactions

Competitive interaction	Output response
Symmetric interaction	
Independent	$G_{12}, G_{21} = 0$
Cooperative	$G_{21}, G_{12} > 0$
Non-cooperative	$G_{12}, G_{21} < 0$
Asymmetric interaction	
Firm 1 leader, firm 2 follower	$G_{12} = 0, G_{21} \neq 0$
Firm 2 leader, firm 1 follower	$G_{12} \neq 0, G_{21} = 0$
Firm 1 dominant, firm 2 fringe	$G_{12} < 0, G_{21} > 0$
Firm 2 dominant, firm 1 fringe	$G_{12} > 0, G_{21} < 0$

Source: Modified from Putsis and Dhar (1998, p. 273).

4.5 Concluding comments

This chapter provides a framework for measuring market power and the type of interaction of dominant firms in the Indonesian palm oil industry. A state-space game model, specifically the adjustment cost model, is selected because quasi-fixed inputs in the palm oil production system provide an intertemporal link. The solution of this adjustment cost model assumes that players use the Markovian strategy, as it is often argued to be more realistic. A linear quadratic form is chosen for the empirical model, as it has an important implication for the estimation of the adjustment cost parameter and market power index. Within this form, these parameters can be obtained by providing the coefficients of the adjustment system and the slope of the inverse demand. Using the Markovian strategy, the market power index no longer reflects the firm's response to its rival action. Hence this index cannot be used as a tool to determine the type of interaction between the firms. However, the adjustment system can be seen as a type of reaction function, therefore, they can be used as an alternative to assess the type of competition between the firms.

Appendix 4

Appendix 4.1 The derivation of the optimal control function

The discounted profit stream of firm i is given by:

Equation 4.30 $$\Pi_i = \sum_{t=1}^{T} \delta^{t-\varepsilon} \left(p_t - c_i(t) \right) q_{it} - \left(\gamma_{it} + \frac{\theta_i}{2} u_{it} \right) u_{it} \varepsilon$$

Using the recursive principle, assuming $\gamma_{it} = 0$, $\varepsilon = 1$ and constant marginal costs, Equation 4.30 can be re-written as

Equation 4.31 $$\Pi_i = \left(p_t - c_i \right) q_{it} - \frac{\theta_i}{2} \left(q_{it} - q_{it-1} \right)^2 + \sum_{t=2}^{T} \delta^{t-\varepsilon} \left(p_{t+1} - c_i \right) q_{it+1} - \frac{\theta_i}{2} \left(q_{it+1} - q_{it} \right)^2$$

$$\Pi_i = \left(p_t - c_i \right) q_{it} - \frac{\theta_i}{2} \left(q_{it}^2 - 2 q_{it} q_{it-1} + q_{it-1}^2 \right) + \delta \left[\left(p_{t+1} - c_i \right) q_{it+1} - \frac{\theta_i}{2} \left(q_{it+1}^2 - 2 q_{it+1} q_{it} + q_{it}^2 \right) \right]$$

$$\Pi_i = p_t q_{it} - c_i q_{it} - \frac{\theta_i}{2} q_{it}^2 + \frac{\theta_i}{2} 2 q_{it} q_{it-1} - \frac{\theta_i}{2} q_{it-1}^2 + \delta p_{t+1} q_{it+1} - \delta c_i q_{it+1} - \frac{\delta \theta_i}{2} q_{it+1}^2 + \frac{\delta \theta_i}{2} 2 q_{it+1} q_{it} - \frac{\delta \theta_i}{2} q_{it}^2$$

The maximum discounted profit stream firm i is obtained through its first derivation with respect to q_{it}:

Equation 4.32 $$\frac{\partial \Pi_i}{\partial q_{it}} = \frac{\partial p_t}{\partial Q_t} \frac{\partial Q_t}{\partial q_{it}} q_{it} + p_t - c_i - \theta_i q_{it} + \theta_i q_{it-1} - \theta_i q_{it-1}$$

$$+ \delta \frac{\partial p_{t+1}}{\partial Q_{t+1}} \frac{\partial Q_{t+1}}{\partial q_{it+1}} \frac{\partial q_{it+1}}{\partial q_{it}} q_{it+1} + \delta p_{t+1} \frac{\partial q_{it+1}}{\partial q_{it}} - \delta \frac{\partial \left(c_i q_{it+1} \right)}{\partial q_{it+1}} \frac{\partial q_{it+1}}{\partial q_{it}} - \delta \frac{\partial \left(\frac{\theta_i}{2} q_{it+1}^2 \right)}{\partial q_{it+1}} \frac{\partial q_{it+1}}{\partial q_{it}} + \delta \theta_i q_{it+1} - \delta \theta_i q_{it} = 0$$

Given $u_{it} = q_{it} - q_{it-1}$, hence $\frac{\partial q_{it}}{\partial q_{it-1}} = 1$ and $\frac{\partial q_{it-1}}{\partial q_{it}} = 1$, $Q_t = q_{it} + q_{jt}$, hence $\frac{\partial Q_t}{\partial q_{it}} = 1$,

therefore $\frac{\partial p_t(Q_t)}{\partial q_{it}} = \frac{\partial p_t(Q_t)}{\partial Q_t}\frac{\partial Q_t}{\partial q_{it}} = \frac{\partial p_t(Q_t)}{\partial Q_t}$, $\frac{\partial Q_t}{\partial q_t} = \frac{\partial Q_{t+1}}{\partial q_{t+1}} = \frac{\partial \bar{Q}}{\partial \bar{q}} = b$ and

$\frac{\partial q_{jt}}{\partial q_{it}} = \frac{\partial q_{jt+1}}{\partial q_{it+1}} = \frac{\partial q_j}{\partial q_i} = v_i$, Equation 4.32 can be re-written as

Equation 4.33

$$\frac{\partial \Pi_i}{\partial q_{it}} = \frac{1}{b}(1+v_i)q_{it} + p_t - c_i - \theta_i q_{it} + \delta\frac{1}{b}(1+v_i)q_{it+1} + \delta p_{t+1} - \delta c_i - \delta\theta_i q_{it} = 0$$

$$-\frac{1}{b}(1+v_i)q_{it} + \theta_i q_{it} + \delta\theta_i q_{it} = p_t + \delta p_{t+1} - c_i - \delta c_i + \delta\frac{1}{b}(1+v_i)q_{it+1} - \delta\theta_i q_{it+1} + \delta\theta_i q_{it+1}$$

$$\left[-\frac{1}{b}(1+v_i) + \theta_i + \delta\theta_i\right]q_{it} = \left[p_t + \delta p_{t+1} - c_i - \delta c_i\right] + \delta\frac{1}{b}(1+v_i)q_{it+1}$$

$$q_{it} = \frac{\left[p_t + \delta p_{t+1} - c_i - \delta c_i\right] + \left[\frac{\delta}{b}(1+v_i)\right]q_{it+1}}{\left[-\frac{(1+v_i)}{b} + \theta_i + \delta\theta_i\right]}$$

$$= \frac{\left[p_t + \delta p_{t+1} - c_i - \delta c_i\right]}{\left[-\frac{(1+v_i)}{b} + \theta_i + \delta\theta_i\right]} + \frac{\frac{\delta}{b}(1+v_i)}{\left[-\frac{(1+v_i)}{b} + \theta_i + \delta\theta_i\right]}q_{it+1}$$

$$= g_i + G_i q_{it+1}; \quad \text{where } g = \frac{\left[p_t + \delta p_{t+1} - (1+\delta)c_i\right]}{\left[-\frac{(1+v_i)}{b} + (1+\delta)\theta_i\right]} \text{ and } G = \frac{\delta(1+v_i)}{\left[-(1+v_i) + b(1+\delta)\theta_i\right]}$$

Appendix 4.2 The solution for the Markovian strategy[13]

Converting the objective function for a representative firm in the matrix form and writing it in continuous time give the following expression:

Equation 4.34 $$\int_0^{\infty} e^{-rt}\left(a_{it}e_i^{'}q_t - \frac{1}{2}q_t K_i\left(q_{t-1}+u_t\right) - \frac{1}{2}u_t^{'}S_i u_t\right)dt$$

where:

β is the discount factor that is written in terms of discount rate r;

$a_i = (\alpha - c_i)$ is the difference between the inverse demand intercept and the marginal costs ;

e_i is the ith unit vector;

q_t is the column vector of q_{it};

$K_i = b\left(ee_i' + e_i e'\right)$;

u_t is the column vector of u_{it}; and

$S_i = e_i e_i' \theta_i$, where θ_i is the adjustment cost parameter of the ith firm.

It is assumed that $\gamma_i = 0$, which implies that adjustment costs are minimised when there is no adjustment (see footnote 8). The explicit matrix forms for firm 1, in a duopoly market $(n=2)$ are as below:

$$e_1 = \begin{pmatrix}1\\0\end{pmatrix},\ e = \begin{pmatrix}1\\1\end{pmatrix},\ q_t = \begin{pmatrix}q_{1t}\\q_{2t}\end{pmatrix},\ K_1 = \begin{pmatrix}2b & b\\ b & 0\end{pmatrix},\ u_t = \begin{pmatrix}u_{1t}\\u_{2t}\end{pmatrix},\ \text{and } S_1 = \begin{pmatrix}\theta & 0\\ 0 & 0\end{pmatrix}$$

[13] Appendix 4.2 is drawn from Deodhar (1994) with some modification in the symbols to relate them to Equations in the chapters.

The stationary dynamic programming equation of Equation 4.34 will be:

Equation 4.35 $$-\frac{1}{2}q'_{t-1}H_i q_{t-1} = \max\left[-\frac{1}{2}q'_t K_i q_t - \frac{1}{2}u'_t S_i u_t + \delta\left(-\frac{1}{2}q'_t H_i q_t\right)\right]$$

$$= \max\left[-\frac{1}{2}q'_t\left(K_i + S_i + \delta H_i\right)q_t + q'_t S_i q_{t-1} - \frac{1}{2}q'_{t-1}S_i q_{t-1}\right]$$

The first-order condition of Equation 4.35 is:

Equation 4.36 $$v'_i\left(K_i + S_i + \delta H_i\right)q_t + v'_i S_i q_{t-1} = 0$$

Equation 4.36 can be re-written as:

Equation 4.37 $$Eq_t = Sq_{t-1}$$

$$q_t = Gq_{t-1}$$

where the ith row of E is $v'_i\left(K_i + S_i + \delta H_i\right)$, the ith row of S is $\theta_i e'_i$, and $G = E^{-1}S$. Substituting Equation 4.37 into Equation 4.35 gives:

Equation 4.38 $$\left(-\frac{1}{2}q'_{t-1}H_i q_{t-1}\right)$$

$$= \max\left[-\frac{1}{2}q'_{t-1}G'\left(K_i + S_i + \delta H_i\right)q_{t-1} + q'_{t-1}G'S_i q_{t-1} - \frac{1}{2}q'_{t-1}S_i q_{t-1}\right]$$

$$= \max\left[-\frac{1}{2}q'_{t-1}\left[G'\left(K_i + S_i + \delta H_i\right) - G'S_i - S_i G + S_i\right]q_{t-1}\right]$$

$$H_i = G'\left(K_i + S_i + \delta H_i\right)G - G'S_i - S_i G + S_i$$

Equation 4.38 is then vectorised and yields:

Equation 4.39 $vecH_i$

$$= vec\left[G'\left(K_i + S_i + \delta H_i\right)G - G'S_i - S_iG + S_i\right]$$

$$= vec\left[G'\left(K_i + S_i + \delta H_i\right)G\right] - vec\left[G'S_i\right] - vec\left[S_iG\right] + vec\left[S_i\right]$$

$$= \left(G' \otimes G'\right)vec\left(K_i + S_i + \delta H_i\right) - \left(I \otimes G'\right)vec\left[S_i\right] - vec\left(G' \otimes I\right)\left[S_i\right] + vec\left[S_i\right]$$

$$\left[vecH_i - \delta\left(G' \otimes G'\right)vecH_i\right] = \left[\left(G' \otimes G'\right)vec\left(K_i\right) + \left(\left(G' \otimes G'\right) - \left(I \otimes G'\right) - \left(G' \otimes I\right) + I\right)vec\left(S_i\right)\right]$$

$$\left[I - \delta\left(G' \otimes G'\right)\right]vecH_i = \left[\left(G' \otimes G'\right)vec\left(K_i\right) + \left(\left(G' \otimes G'\right) - \left(I \otimes G'\right) - \left(G' \otimes I\right) + I\right)\theta_i vec\left(e_i e_i'\right)\right]$$

$$vecH_i = \left[I - \delta\left(G' \otimes G'\right)\right]^{-1}\left[\left(G' \otimes G'\right)vec\left(K_i\right)\right] + \left[I - \delta\left(G' \otimes G'\right)\right]^{-1}\left[\left(\left(G' \otimes G'\right) - \left(I \otimes G'\right) - \left(G' \otimes I\right) + I\right)vec\left(e_i e_i'\right)\theta_i\right]$$

Equation 4.39 can be rewritten as:

Equation 4.40 $vecH_i = w_i + z_i\theta_i$

where w_i and z_i are the first and second term of right hand side of Equation 4.39, except θ_i. $vecH_i$, w_i and z_i are all $\left(n^2x1\right)$ column vectors. Therefore, Equation 4.40 can be converted back in the form of $\left(nxn\right)$ vectors by using inverse-vec(torisation) operation, yielding:

Equation 4.41 $H_i = W_i + Z_i\theta_i$

where W_i and Z_i are the transformed forms of w_i and z_i having the dimension $\left(nxn\right)$.

Given the i th row of as $v_i'\left(K_i + S_i + \delta H_i\right)G = \theta_i e_i'$, and substituting the value of H_i from Equation 4.30, gives the solution of the Markovian strategy as:

Equation 4.42
$$v_i'\left(K_i + S_i + \delta\left(W_i + Z_i\theta_i\right)\right)G = \theta_i e_i'$$
$$v_i'\left[K_i + \delta W_i + \left(e_i e_i' + \delta Z_i\right)\theta_i\right]G = \theta_i e_i'$$
$$G'\left[K_i + \delta W_i + \left(e_i e_i' + \delta Z_i\right)\theta_i\right]' v_i = \theta_i e_i'$$
$$\left[K_i + \delta W_i + \left(e_i e_i' + \delta Z_i\right)\theta_i\right]' v_i = G'^{-1}\theta_i e_i'$$

Appendix 4.3 Asymmetric condition in the duopoly model

Taking the quadratic part of the problem, the dynamic programming equation for the i th player becomes:

Equation 4.43
$$-\frac{1}{2}q_{t-1}' H_i q_{t-1} = \max_{q_{i,t}}\left\{-\frac{1}{2}q_t'\left(K_i + S_i + \delta H_i\right)q_t + q_t' S_i q_{t-1} - \frac{1}{2}q_{t-1}' S_i q_{t-1}\right\}$$

Appendix 4.2 shows that solution of Equation 4.43 is:

Equation 4.44
$$\left[K_i + \delta W_i + \left(e_i e_i^{'} + \delta Z_i\right)\theta_i\right]v_i = G^{'-1}\, e_i\theta_i \equiv y_i^*\theta_i$$

For duopoly cases, in which $G = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix}$, $G^{-1} = \begin{pmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{pmatrix} = y_i$, define matrix A as $bA_i = K_i + \delta W_i$ and B as $B_i = e_i e_i^{'} + \delta Z_i$, Equation 4.44, then, becomes:

Equation 4.45 $\left[bA_i + B_i\theta\right]v_i = G^{'-1}e_i\theta \equiv y_i^*\theta$

For firm 1, in which $e_1 = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $G^{-1}e_1\theta_1 = \begin{pmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{pmatrix}\begin{pmatrix} 1 \\ 0 \end{pmatrix}\theta_1 = \begin{pmatrix} y_{11} \\ y_{21} \end{pmatrix}\theta_1$, Equation 4.45 becomes:

Equation 4.46 $$\left[\begin{pmatrix} bA_{11} & bA_{12} \\ bA_{21} & bA_{22} \end{pmatrix} + \begin{pmatrix} B_{11}\theta_1 & B_{12}\theta_1 \\ B_{21}\theta_1 & B_{22}\theta_1 \end{pmatrix}\right]\begin{pmatrix} 1 \\ v_{12} \end{pmatrix} = \begin{pmatrix} y_{11}\theta_1 \\ y_{21}\theta_1 \end{pmatrix}$$

which gives two equations with two unknown parameters.

Appendix 4.4 Stability condition in an asymmetric duopoly case

Suppose that the adjustment system of the duopoly is:

Equation 4.47
$$\begin{aligned} q_{1t} &= g_1 + G_{11}q_{1t-1} + G_{12}q_{2t-1} \\ q_{2t} &= g_2 + G_{21}q_{1t-1} + G_{22}q_{2t-1} \end{aligned}$$

This dynamic system is asymptotically stable if the absolute eigenvalues of its coefficient matrix are less than one $|r| < 1$ (Simon and Blume 1994, p. 596). For coefficient matrix $G = \begin{pmatrix} G_{11} & G_{12} \\ G_{21} & G_{22} \end{pmatrix}$, the eigenvalues are obtained from the roots of the characteristic polynomial $\det[G - rI]$. For the asymmetric matrix, the characteristic polynomial is:

Equation 4.48
$$\begin{aligned} \det[G - rI] &= \det\begin{pmatrix} G_{11} - r & G_{12} \\ G_{21} & G_{22} - r \end{pmatrix} \\ &= (G_{11} - r)(G_{22} - r) - (G_{12})(G_{21}) \\ &= G_{11}G_{22} - G_{11}r - G_{22}r + r^2 - G_{12}G_{21} \\ &= r^2 - (G_{11} + G_{22})r - G_{12}G_{21} + G_{11}G_{22} \end{aligned}$$

Equation 4.48 can be written as:

Equation 4.49 $\left(r-r_1\right)\left(r-r_2\right)=r^2-\left(r_1+r_2\right)r+r_1r_2$

and hence $r_1+r_2=G_{11}+G_{22}$ and $r_1r_2=G_{11}G_{22}-G_{12}G_{21}$. With $\left|r\right|<1$ as the condition for stability, this gives $-2<G_{11}+G_{21}<2$ and $-1<G_{11}G_{22}-G_{12}G_{21}<1$.

Appendix 4.5 The range of G_{ij} and v_{ij} in static model

Suppose the inverse demand function is:

Equation 4.50 $p\left(Q\right)=a-bQ$

where $b>0$ and $Q=q_i+q_j$

The profit function of firm i is:

Equation 4.51
$$\begin{aligned}\pi_i &= pq_i-c_i\\ &=\left(a-bQ\right)q_i-c_i\\ &=\left(a-b\left(q_i+q_j\right)\right)q_i-c_i\\ &=aq_i-bq_i^2-bq_jq_i-c_i\end{aligned}$$

The first-order condition of Equation 4.59 is:

Equation 4.52 $\frac{\partial\pi_i}{\partial q_i}=a-2bq_i-bq_j-c_i'=0$

$$q_i = \frac{a - bq_j - c_i'}{2b}$$

The first-order condition of the profit function can also be written as:

Equation 4.53
$$\frac{\partial \pi_i}{\partial q_i} = \frac{\partial p}{\partial q_i} q_i + p - c_i' = 0$$

$$\frac{\partial p}{\partial Q}\frac{\partial Q}{\partial q_i} q_i + p - c_i' = 0$$

$$-b(1 + v_i) q_i + p - c_i' = 0$$

$$q_i = \frac{p - c_i'}{b(1 + v_i)}$$

Using Equations 4.52 and 4.53, we get:

Equation 4.54
$$\frac{a - bq_j - c_i'}{2b} = \frac{p - c_i'}{b(1 + v_i)}$$

$$2\left(a - bq_i - bq_j - c_i'\right) = (1 + v_i)\left(a - bq_j - c_i'\right)$$

$$2a - 2bq_i - 2bq_j - 2c_i' = a - bq_j - c_i' + v_i a - v_i bq_j - v_i c_i'$$

$$(2a - a - v_i a) - (2bq_j - bq_j - v_i bq_j) - \left(2c_i' - c_i' - v_i c_i'\right) = 2bq_i$$

$$q_i = \frac{(1 - v_i) a}{2b} - \frac{(1 - v_i) bq_j}{2b} - \frac{(1 - v_i) c_i'}{2b}$$

$$G_{ij} \approx \frac{\partial q_i}{\partial q_j} = \frac{(1 - v_i)}{2}$$

$v_i = -1$ gives $G_{ij} = -1$, and $v_i = 1$ gives $G_{ij} = 0$. Therefore, in order to obtain v_i values between -1 and 1, G_{ij} needs to be in between -1 and 0.

Appendix 4.6 G matrix and v_{ij} in the asymmetric open–loop solution

The Lagrangean for the i th firm's discounted profit stream is:

Equation 4.55 $$L_i = \sum_{\tau=t}^{T} \beta^{\tau-t} \left[-\frac{1}{2} q_\tau' K_i q_\tau - \frac{1}{2} u_\tau' S_i u_\tau + \lambda_{i\tau}' \left(q_{\tau-1} + u_\tau - q_\tau \right) \right]$$

where λ_{it} is a $(nx1)$ column vector. The first-order conditions of Equation 4.55 are:

Equation 4.56 $$-K_i q_t - \lambda_{it} + \beta \lambda_{it+1} = 0$$

and

Equation 4.57 $$-v_i' S_i u_t + v_i' \lambda_{it} = 0$$

where v_i is a $(nx1)$ column matrix with 1 in the i th row and v_{ij} in the j th row. The term v_{ij} will be $v_{ij} = \dfrac{du_{it}}{du_{jt}}$ if $\forall i \neq j$, and will be 1 if $\forall i = j$. For example, the vector v_i for firm 1 will be $v_i = \begin{pmatrix} 1 \\ v_{ij} \end{pmatrix}$. Assuming that λ_{it} is a linear function of q_t, which is $\lambda_{it} = H_{it} q_t$ for some (nxn) square matrix H_{it}, and letting $t \to \infty$, so that $H_{it} = H$, Equation 4.57 becomes:

Equation 4.58 $$-v_i' S_i u_t + v_i' H_i q_t = 0$$

$$v_i' H_i q_t = v_i' S_i u_t$$

Equation 4.58 can be re-written as:

Equation 4.59 $v_i' H_i q_t = \theta_i u_{it}$

$$v_i' H_i q_t = \theta_i e_i' u_t$$

Equation 4.59 conditions are stacked for all firms to get:

Equation 4.60 $Eq_t = Su_t$

where the i th row of E is $v_i' H_i$ and the i th row of S is $\theta_i e_i'$. u_t is defined as $q_t - q_{t-1}$, so that Equation 4.60 can be written as:

Equation 4.61 $Eq_t = S\left(q_t - q_{t-1}\right)$

$$\left(E - S\right) q_t = -Sq_{t-1}$$

$$q_t = \left(E - S\right)^{-1} Sq_{t-1}$$

Defining $\left(E - S\right)^{-1} S = G$, Equation 4.61 can be written as:

Equation 4.62 $q_t = Gq_{t-1}$

Using $\lambda_{it} = H_{it} q_t$, Equation 4.62 can be written as:

Equation 4.63 $-K_i q_t - H_i q_t + \delta H_i q_{t+1} = 0$

Using expression in Equation 4.62, Equation 4.63 can be re-written as:

Equation 4.64
$$\left(-K_i - H_i + \delta H_i G\right) q_t = 0$$
$$\left(-K_i - H_i + \delta H_i G\right) = 0$$
$$-\left(H_i - \delta H_i G\right) = K_i$$
$$H_i\left(I - \delta G_i\right) = -K_i$$
$$H_i = -K_i\left(I - \delta G_i\right)^{-1}$$

Rewriting the definition $\left(E - S\right)^{-1} S = G$ as:

Equation 4.65
$$S = \left(S - E\right) G$$
$$S - SG = -EG$$
$$S\left(I - G\right) G^{-1} = -E$$
$$E = S\left(I - G^{-1}\right)$$

pre-multiply both sides by e_i', and given the ith row of E as $v_i' H_i$ and the ith row of S as $\theta_i e_i'$, Equation 4.65 can be re-written as:

Equation 4.66
$$e_i' E = e_i' S\left(I - G^{-1}\right)$$
$$v_i' H_i = \theta_i e_i'\left(I - G^{-1}\right)$$

Using the definition of H_i in Equation 4.64, the solution of the open-loop strategy is obtained by re-writing Equation 4.66 as[14]:

Equation 4.67
$$v_i' K_i\left(I - \delta G\right)^{-1} = \theta_i e_i'\left(I - G^{-1}\right)$$

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[14] The steps of this derivation are drawn from Deodhar (1994).

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

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

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

Using the asymmetric condition $G = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix}$ and defining

$Z = \left[G^{-1} \left(I - G \right) \left(I - \delta G \right) \right]'$, we obtain:

$$Z = \left(\begin{pmatrix} \frac{G_{22} - G_{22}G_{11} + G_{12}G_{21}}{G_{11}G_{22} - G_{12}G_{21}} & -\frac{G_{12}}{G_{11}G_{22} - G_{12}G_{21}} \\ \frac{G_{21}}{G_{11}G_{22} - G_{12}G_{21}} & \frac{G_{21}G_{12} + G_{11} - G_{11}G_{22}}{G_{11}G_{22} - G_{12}G_{21}} \end{pmatrix} \begin{pmatrix} 1 - \beta G_{11} & -\beta G_{12} \\ -\beta G_{21} & 1 - \beta G_{22} \end{pmatrix} \right)'$$

$$= \begin{pmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{pmatrix}$$

In duopoly cases, the solution of the open-loop strategy of Equation 4.67 for firm 1 becomes:

Equation 4.68 $$\begin{pmatrix} 2b + bv_{12} \\ b \end{pmatrix} = \begin{pmatrix} z_{11}\theta_1 \\ z_{21}\theta_1 \end{pmatrix}$$

and for firm 2 becomes:

Equation 4.69 $$\begin{pmatrix} b \\ bv_{21} + 2b \end{pmatrix} = \begin{pmatrix} z_{12}\theta_2 \\ z_{22}\theta_2 \end{pmatrix}$$

where $v_{12} = \frac{z_{11}}{z_{21}} - 2$ and $v_{12} = \frac{z_{22}}{z_{12}} - 2$. To satisfy the market power index restriction in which $-1 \le v_{ij} \le 1$, the ratio of z_{11} and z_{21} need to be $-1 \le \frac{z_{11}}{z_{21}} - 2 \le 1$ or $1 \le \frac{z_{11}}{z_{21}} \le 3$, while the ratio of z_{22} and z_{12} needs to be $-1 \le \frac{z_{22}}{z_{12}} - 2 \le 1$ or $1 \le \frac{z_{22}}{z_{12}} \le 3$.

Chapter 5
Data, Estimation and Results

In this chapter, estimation and results of the model estimation are presented. In section 5.1, data sources and the description of variables used for estimating the demand function and the adjustment system are presented. In section 5.2, the estimation results are reported. From the estimates of the adjustment system, the type of interaction between the public estates and private companies is determined. The estimates of the adjustment system are then replicated using the Monte Carlo numerical integration method, results of which are presented in section 5.3. In section 5.4, the estimation results for the adjustment cost parameter and market power index are discussed. Section 5.5, completes the chapter with some concluding comments.

5.1 Data

The model was estimated using annual data for the period of 1968–2003. Discount rates and exchange rate data are from the International Finance Statistics. CPO domestic demand data were not available: CPO consumption data listed in the Oil World were used as a proxy. CPO domestic prices were constructed from two sources—the Indonesian Department of Agriculture and Oil World—while the crude coconut oil and palm cooking oil domestic prices were from the Indonesian Bureau of Statistics and Suharyono (1996). All price data were deflated by the Indonesian Consumer Price Index data reported by the Indonesian Bureau of Statistics.

In estimating the adjustment system, only the public estates and private companies were considered as the dominant groups. Due to diseconomies of size of each of the members, lack of processing facilities and trade associations, smallholders were unlikely to have an ability to influence market prices. Hence, they are not considered as one of the dominant. As CPO domestic supply data for the dominant groups were also not available, CPO production data were used as a proxy. These data were recorded by the Indonesian Directorate General of Plantations, Department of Agriculture. The relationship between the production and the domestic supply data is as follows (Suharyono 1996; Susanto 2000; Zulkifli 2000; ISTA Mielke 2004):

Equation 5.1 $$S = O + Q + M - X - E$$

where:

- S is the domestic supply;
- O is the opening stock;
- E is the ending stock;
- Q is the production;
- M is imports; and
- X is exports.

Q, M and X are the accumulation values for each year, while O and E are the stock values at the end of January and December, respectively. For the national level data, stock and import values are insignificant. Stocks are small because CPO is perishable and can not be stored for more than three months. Imports are also small because usually domestic production is more than adequate to supply the domestic demand. Excess demand occurs either when international prices are high, giving an incentive for producers to increase their export levels, or when domestic demand significantly increases due to feast months (Ramadhan, Ied-Fitr and New Year). The statistical summary of these data is shown in Table 5.1.[15]

Data of the CPO demand, real prices of CPO, crude coconut oil and palm cooking oil were used in the estimation of demand equation. Table 5.1 shows that all of these variables have large differences between their minimum and maximum values. The large differences between means and medians, and the non-zero values of skewness suggest the asymmetric distribution condition. Kurtosis values of all of these variables are greater

[15] The complete data set for both the demand equation and adjustment system is provided in Appendix 5.1.

than for the normal distribution, indicating distribution with the small variance and the slim or long tails. Finally, the Jarque–Bera statistics indicate rejection of the hypothesis that all of these data are normally distributed.

Table 5.1 Statistical summary of research data

Statistics	CPO demand	CPO real price	CCO real price	Palm cooking oil real price	Public estates group's production	Private group's production
Unit	Thousand tonnes/year	Rp/ tonne	Rp/ tonne	Rp/ tonne	Tonnes/ year	Tonnes/ year
Mean	1,025	94,997	108,486	119,305	1,118,954	895,268
Median	613	18,142	29,765	32,040	345,827	886,740
Maximum	4,083	815,546	929,105	822,027	4,627,744	1,706,852
Minimum	23	354	558	487	59,075	122,369
Standard deviation	1,251	196,328	213,545	228,273	1,423,874	567,736
Skewness	1.5	2.5	2.6	2.2	1.3	–0.0
Kurtosis	4.0	8.1	9.3	6.1	3.4	1.4
Jarque–Bera statistics	12.4	64.4	86.5	37.2	11.1	3.9
Jarque–Bera probability	0.0	0.0	0.0	0.0	0.0	0.1

Data of the CPO produced by the public estates and private companies were used in the estimation of the adjustment system. Table 5.1 shows that all of these variables have large differences between the minimum and maximum values. The skewness values and the large difference between the mean and median values indicate that these data are distributed symmetrically in the private production data but not in the public estates production data. The public estates data have a kurtosis value greater than the normal distribution, indicating a small variance and a thin tail, while that of the private data is smaller than for the normal distribution, indicating a large variance and a fat tail. Finally, the Jarque–Bera statistics indicate that the normal distribution hypotheses are rejected in all of these data.

5.2 Demand equation and adjustment system

To estimate the adjustment cost parameter and market power index of the model, the slope of demand b and the G matrix need to be provided. They were obtained from the estimation of the demand equation and the adjustment system, respectively. Both were estimated using the EViews 5.1.

The price of CPO, crude coconut oil, cooking oil and a dummy variable for economic crisis were chosen as regressors in the CPO demand function. In addition, an interactive term between the price of CPO and crude coconut oil was included to capture the possible market power effect. (see Chapter 3 for detail discussion suggested by Bresnahan (1992)). Except for the price of CPO, all of these variables were treated as exogenous variables. The price of CPO was suspected to be endogenously determined with the quantity of CPO through the CPO supply function. This hypothesis was then tested through the Hausman test.

To carry out the Hausman test, an instrumental variable—that is correlated with the suspect variable, CPO price, but not with the error tem of CPO demand equation—needs to be chosen. In general, the theory of supply states that the cost of factor of production is one of the most important variables in the supply relation (see Equation 3.20 $p_t = \alpha_0 + \alpha_1 w_t + \alpha_2 q_{it} + \xi_{it}$ as an example of a linear form of supply relation, where w is the price of factor production). In this case, the price of estates workers is an important factor of production in the CPO supply relation, as the expenditure for the workers contributes 30 per cent of the total production costs. Therefore it was used as the instrumental variable in the Hausman test.

The test comprises two stages: First, the suspect variable, CPO price, was regressed on all exogenous variables and the instrument variable, the price of estates workers, and the vector of residuals from this regression was retrieved. Then the CPO demand function was re-estimated by including the residuals from the first regression as additional regressors. The Hausman test result shows that the coefficient on the first stage residuals is not significantly different from zero; hence the exogeneity of the CPO price variable could not be rejected. Therefore, the demand equation was then estimated by using the instrumental variable technique.

Three different specifications, namely the linear, the double-log and the linear-log forms were estimated. In the last two forms, variables used in the adjustment systems are not linear, but their relationships are clearly linear. In other words, all of them represent a linear relationship between the control u_t, or in parallel q_t, and the state q_{t-1}. They can be seen as types of the linear equation of motion, whose specification is chosen in the theoretical and empirical models. Using time series data, a unit root and cointegration tests were conducted in order to avoid a spurious regression. The CPO demand data need to be in the same order and cointegrated with all the regressors. The Dickey–Fuller unit root test shows that all data are non-stationary.

In the linear forms, the time-series data have different orders of integration, and hence cointegration relationships do not exist. In the double-log and linear-log forms, the time-series data have the same orders of integration and cointegration. However, most coefficients in the former were insignificant, while most of the latter were significant. Therefore, the linear-log form is used for the final demand equation. The Durbin–Watson statistic was inconclusive, and thus the LM test was used as an alternative. The result shows no serial correlation in the system, and the $\bar{R}^2$ value is high. The estimated equation is as follows (see Appendix 5.2):

Equation 5.2

$$Q = 4835.28 - 1166.55P - 2280P_1 + 493.73PP_1 + 354.09P_2 + 41.53D$$

$$(6.05)^{***} \quad (-2.28)^{**} \quad (-7.23)^{***} \quad (7.91^{***}) \quad (1.23) \quad (2.04)^{**}$$

$\bar{R}^2 = 0.98$ *LM test, F-statistics* $= 6.06*$

*** and ** shows one and five per cent level of significance

where:

P is the log of the domestic price of CPO;

P_1 is the log of the domestic price of crude coconut oil;

P_2 is the log of the domestic price of palm cooking oil;

D is a dummy variable that represents the economic crisis period of 1997–1998. Before 1997 it is zero, otherwise it is one; and

numbers in parentheses are *t*-values.

Except for P_2, all estimates are significant at the one or five per cent levels. The insignificant coefficient of the price of palm cooking oil P_2 might be explained by the government intervention in setting the market prices. Larson (1996, p. 18) found that the export tax changed the relationship between the CPO and the cooking oil prices.

The coefficient of P_1 and PP_1 were used to calculate the cross price elasticity of CPO demand[16]. Figure 5.1 shows that until 1991, CPO and crude coconut oil are complementary goods, while afterwards they became substitute goods. This might be explained by the increasing market share of CPO over time. In the earlier period, when the crude coconut oil still dominated the vegetable oil domestic market, CPO was not used as the main raw material in the cooking oil production process. CPO was likely used in a relatively small amount as one of additive inputs in the process. While in the latter period, when CPO was largely used as the raw material, CPO and crude coconut oil then became substitute goods. A decrease in CPO demand from the cooking oil industry leads to a decrease in the supply of palm cooking oil, and thus an increase in its price. As consumers shift their demand to coconut cooking oil, the demand and price of the crude coconut oil are expected to increase.

Figure 5.1 CPO cross price elasticities of demand, 1969–2003

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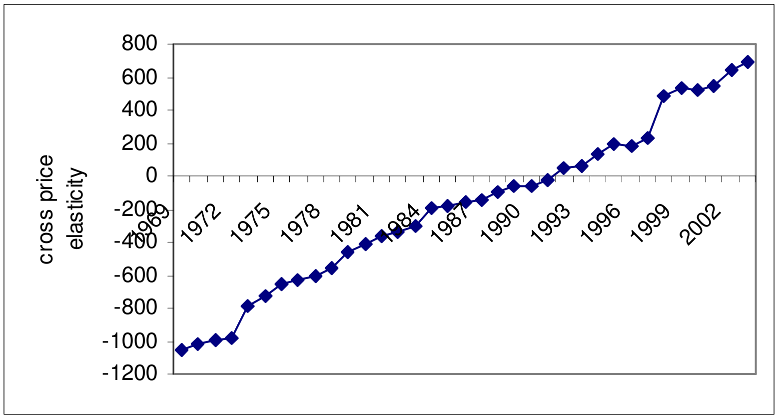
[16] The cross price demand elasticity is $\frac{\partial Q}{\partial P_1}\frac{P_1}{Q}$. Given the demand equation as $Q = \alpha_0 + \alpha_1 \log P + \alpha_2 \log P_1 + \alpha_3 \log P \log P_1 + \alpha_4 \log P_2 + \alpha_5 D + \varepsilon$, its derivative $\frac{\partial Q}{\partial P_1}$ is $\left(\alpha_2 \frac{1}{\ln 10}\frac{1}{P_1} + \alpha_3 \log P \frac{1}{\ln 10}\frac{1}{P_1}\right)$, hence the own price elasticity is $\frac{1}{Q \ln 10}\left(\alpha_2 + \alpha_3 \log P\right)$.



The coefficient of P and PP_1 were used to calculate the own price elasticity of CPO demand[17]. Figure 5.2 shows that the own price demand elasticities appear to be positive, indicating the nature of net price variable (Brown et al 1974). In this case, the net price refers to the actual price paid by the consumers, which is the CPO market price minus the subsidy. Due to the absence of subsidy data, the market price data used in the estimation do not take account of the subsidy data; hence these are not the net price variable. Therefore, an increase in the market price does not necessary mean an increase in the real price paid by the consumers. If in fact, the net price is actually decreased, an increase in the market price may lead to an increase in the quantity demanded. Hence, a counterintuitive positive own price demand elasticity will be observed.

Figure 5.2 also shows that the CPO elasticity changed significantly towards a more inelastic demand, reflecting the increase in the CPO dominancy as the raw material for cooking oil.

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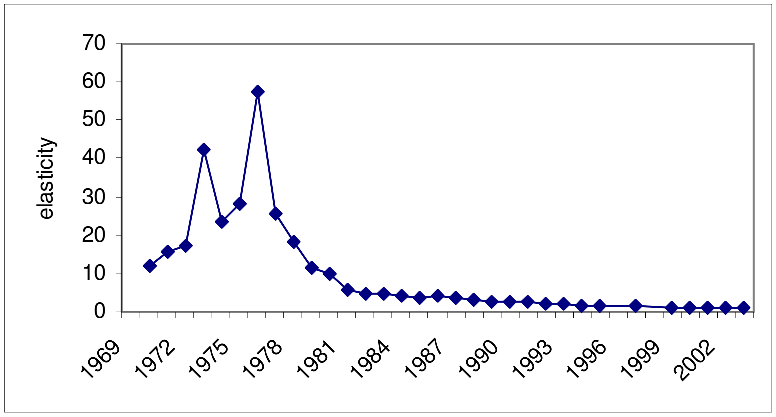
[17] The demand elasticity is the own price elasticity, the formula for which is $\frac{\partial Q}{\partial P}\frac{P}{Q}$. Given the demand equation as $Q = \alpha_0 + \alpha_1 \log P + \alpha_2 \log P_1 + \alpha_3 \log P \log P_1 + \alpha_4 \log P_2 + \alpha_5 D + \varepsilon$, its derivative $\frac{\partial Q}{\partial P}$ is $\left(\alpha_1 \frac{1}{\ln 10}\frac{1}{P} + \alpha_3 \log P_1 \frac{1}{\ln 10}\frac{1}{P}\right)$, hence the own price elasticity is $\frac{1}{Q \ln 10}\left(\alpha_1 + \alpha_3 \log P_1\right)$.

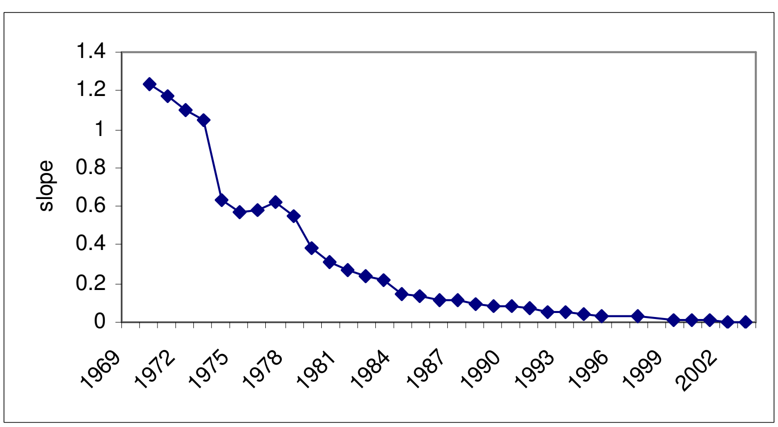
Figure 5.2 CPO own price elasticities of demand, 1969–2003



Source: Author’s calculations.

The coefficient of P was also used to calculate the slope of the CPO inverse demand b (see footnote 12), which is needed to estimate the adjustment cost parameter in the next section. Figure 5.3 shows that the slope changes with the changes of CPO price P over time. However, even with a constant slope, calculating the adjustment cost parameter and the market power index in an asymmetric dynamic model is complicated. Therefore, for computational ease, the average value of CPO price was used to calculate the constant slope (Gujarati 1999, p. 263). The difference between the maximum and minimum values of the slope is relatively small; hence using the average value is fairly reasonable.

Figure 5.3 Slopes of CPO demand function, 1969–2003



The adjustment system was estimated using the SUR. A similar argument was used in the estimation of demand function, on the basis of two different specifications, namely the linear and the double-log forms. For each group, output data were regressed on the three-year lag of their own and the other group output data. As both of the time series level data are non-stationary, $\overline{R}^2$ value appears to be extremely high. Unless the time series data are cointegrated, the relationship between them will be spurious.

The unit root test shows that all of the time series data are I(1), but the Johansen cointegration test result indicates that a cointegration relationship appears only in the double-log form. Therefore, it was used for the final estimation. As lagged dependent variables were included in the model, the Durbin–Watson test for autocorrelation is no longer applicable and needs to be replaced by Durbin's h-test. The result shows that there is no autocorrelation. Two dummy variables for the periods of economic crisis and concessionary credit were also included. Results are shown in Table 5.2 (see Appendix 5.3).

The G matrix was constructed from coefficients of the groups' own lagged (G_{11}, G_{22}) and other groups' lagged output (G_{12}, G_{21}). Table 5.2 shows that all elements of the G matrix, except G_{12}, are significant at the one per cent level. G_{11} and G_{22} are positive, indicating increasing growth in both the public estates and private companies output. The insignificant G_{12} indicates a lack of response from the public estates to the previous action of private companies, while the positive G_{21} shows that the private companies always accommodate the previous action of the public estates, and hence a leader–follower relationship is revealed.

Table 5.2 Estimation of the adjustment system

	Public estates	Private companies
Constant	0.45	0.31
	(3.32)***	(1.35)
Economic crisis 1997	-0.10	0.06
	(-3.68)***	(1.25)
Concessionary credit 1986–1996	-0.04	0.17
	(-2.14)**	(5.32)***
Own lagged output	0.90	0.70
	(16.24)***	(8.12)***
Other lagged output	0.05	0.25
	(0.89)	(2.61)***
Adjusted R-squared	0.99	0.99
Durbin–Watson	1.27	1.79
Durbin's h	12.07***	3.5***

Note : Numbers in parenthesis refer to *t*-statistics
*** and ** shows 1 and 5 per cent level of significance, respectively.

The asymmetric G matrix may complicate the estimation if real eigenvalues do not exist. However, such a problem does not exist in this case. Given the characteristic polynomial of the asymmetric G matrix as $r^2 - (G_{11} + G_{22})r - G_{12}G_{21} + G_{11}G_{22}$ (see Appendix 4.5) and using the quadratic function rule, the roots of the G elements will be:

Equation 5.3 $$r = \frac{1}{2}\left[(G_{11} + G_{22}) \pm \sqrt{G_{11}^{2} + G_{22}^{2} - 2G_{11}G_{22} + 4G_{12}G_{21}}\right]$$

To obtain real eigenvalues, the expression under the square root needs to be non-negative. As both G_{11} and G_{22} are positive, $G_{11}^{2} + G_{22}^{2}$ will always be greater than $-2G_{11}G_{22}$, and thus $G_{11}^{2} + G_{22}^{2} - 2G_{11}G_{22} > 0$. Combined with the positive G_{12} and G_{21}, the whole expression under the square root will always be non-negative, and hence using this G matrix in estimation is possible. Within an asymmetric condition, the property of stability will be $-2 < G_{11} + G_{22} < 2$ and $-1 < G_{11}G_{22} - G_{12}G_{21} < 1$, both of which are satisfied by this adjustment system (see Table 5.2).

While both dummy parameters of the public estates are negative, those of the private companies appear to be positive. The difference in the credit dummy estimates might stem from the amount and effectiveness of the credit received by each group. The public estates and the private companies received 15 per cent and 26 per cent of the total credit, respectively. While a one per cent increase in the credit boosted the public estates area by 0.4 per cent, that of the private companies can be expanded by 1.5 per cent (ADB 1997). On the other hand, the difference in the economic crisis dummy estimates might stem from the market distribution and in the efficiency of the public estates and private companies. During the economic crisis, the international–domestic CPO price ratio significantly increased, making exports more profitable. The public estates did not fully enjoy such a benefit because most of its output needed to be supplied to the domestic market. Although such a restriction was not imposed on the private companies, a similar barrier existed from the high export taxes imposed during the periods of economic crisis. However, many sellers appeared to smuggle their CPO to the international market, and thus enjoyed the increase in export values (Marks *et al.* 1998, pp. 53-54). At the same time, being more efficient, the private companies may also have minimised the increase in production costs due to the increase in imported input prices (Arifin *et al.* 1999).

5.3 Monte Carlo numerical integration

On the basis of the estimates of b and the G matrix, the market power index v and the cost of adjustment parameter θ were calculated using Matlab 7. The Monte Carlo numerical integration method was used to generate 200,000 replications of the G matrix, including 100,000 of their antithetics. This antithetic variates method was used in an attempt to reduce the variance of the replications of the G matrix, and hence increase the precision. 'The idea of antithetic variates relies on the intuition that extreme values can be made less harmful in a simulation by also using other extreme values to counteract them' (Fackler 2006, p. 5). The results are reported in Table 5.3.

Table 5.3 Results of the Monte Carlo numerical integration using asymmetric G matrix

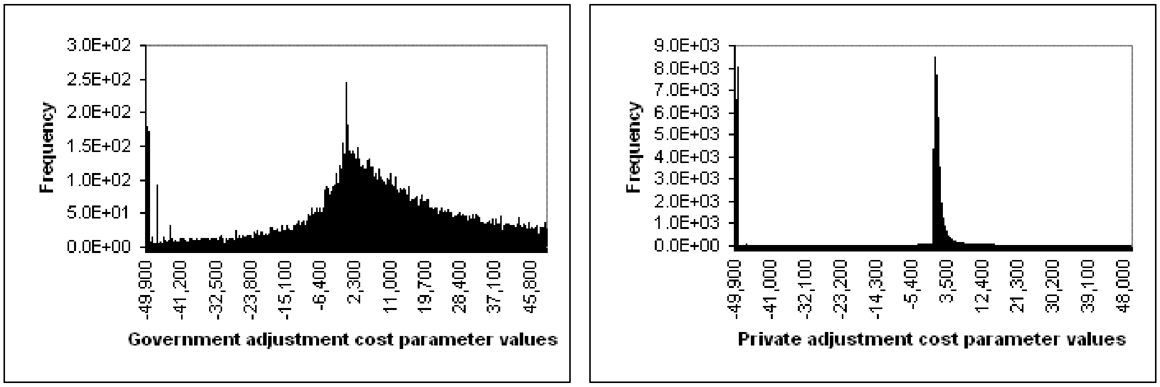
Properties	Selected samples
$-2 < G_{11} + G_{22} < 2$; $-1 < G_{11}G_{22} - G_{12}G_{21} < 1$	197,918 (99)
$\theta_i > 0$	152,912 (76)
$-1 < v_i < 1$	1,850 (0.9)

Note : Numbers in parentheses refer to the percentage of the selected samples as a percentage of the total replications (200,000).

Table 5.3 shows that the stability and the convexity properties hold in 99 and 76 per cent of the replications, respectively but the market power index property is satisfied in only 0.9 per cent of the replications. The posterior density for the adjustment cost parameter θ_i with no prior information is presented in Figure 5.4. Most of the values appear to be positive, so imposing the convex adjustment cost seems rather reasonable. The negative values of the adjustment cost parameters indicate some possibility of a non-convex condition, which might arise from various reasons. First, non-convexity might occur if inputs are indivisible, which in this case could refer to the machine capacity in the CPO mills (Rothschild 1971; Cooper and Haltiwanger 1993; Nilsen and Schiantarelli 2003; de Cordoba *et al.* 2005, p. 59). In this case, although the capacity data are not complete, the investment pause period[18] in the palm oil industry might reflect non-convexity condition.

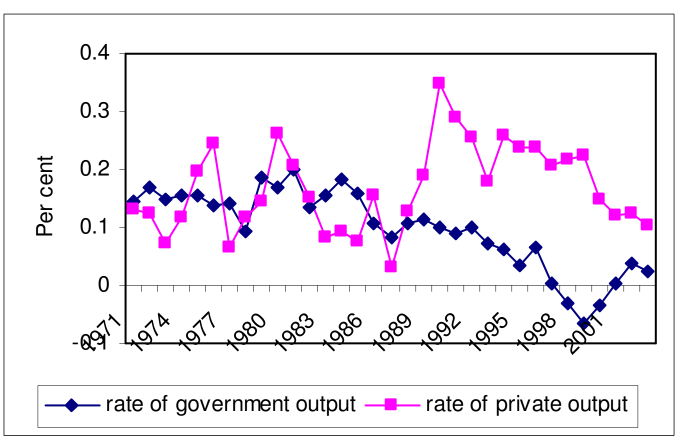
[18] In the palm oil industry, the different phases of investment occur due to the availability of capital and credit. In 1968–1996, they were more accessible through the World Bank aid and concessionary credits, but they were less accessible in 1997–1998 during the economic crisis (van Gelder 2004).

Figure 5.4 Probability distribution function of θ_1 and θ_2



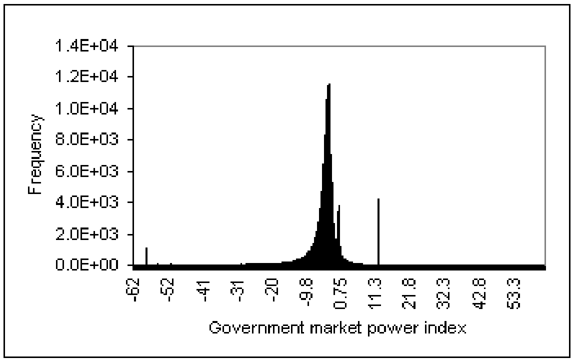
Second, the non-convexity might stem from a data problem. Using annual data, the impact of adjustment could materialise within the same period. In this study, adjustment costs could stem from changing the level of CPO mill capacity. On average, constructing a new CPO mill takes less than two years. Therefore, annual data cannot capture the increasing average cost condition of a convex adjustment cost function. Changes in annual rate of production data that are used as an approximation of the adjustment cost variable appear to have large changes in output from period to period for both the public estates and the private companies (see Figure 5.3). Previous studies show that changes in output rates not only exist in annual data, but also both in monthly and seasonal data (Lubis 1996; Simeh 2002; Abdullah 2003). Therefore, using monthly data might lead to a smooth graph and hence convex adjustment costs, as changes in output of more frequent data are likely to be much smaller than those for the annual data.

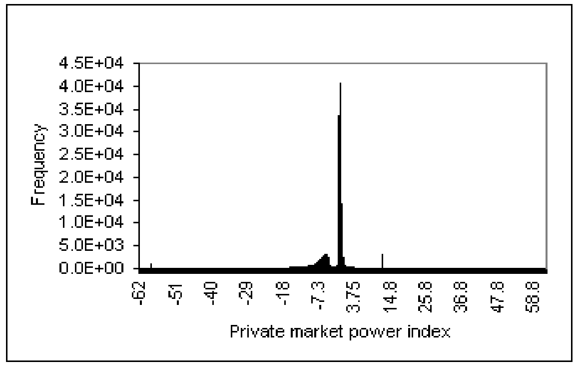
Figure 5.5 Rate of production of the public estates and private companies, 1971–2003



For the market index property, although the property includes both the positive and negative values, Figure 5.6 shows that most of the replications in the posterior density with no prior information lie outside the desired range.

Figure 5.6 Probability distribution function of v_1 and v_2





These replications appear to have values less than –1, with both distributions having long tails. Imposing the convexity property on both group parameters simultaneously reduces the space of the truncated version of the posterior density space significantly. The rejection may, in part, be explained by the occurrence of positive elasticities of demand, noted previously. This index is obtained under the assumption that the elasticity of demand is always negative, so that profit maximisation conditions can satisfy:

Equation 5.4
$$\frac{P-c_i}{P}=-\frac{(1+v_i)s_i}{\varepsilon}$$

where:

v_i is the market power index;

P is the output price;

c_i is the ith firm's marginal cost;

$s_i=\frac{q_i}{Q}$ is the firm's market share; and

$\varepsilon=\frac{\partial Q}{\partial P}\frac{P}{Q}$ is the elasticity of demand.

Given $-1 \le v_i \le 1$ and $0 < s_i \le 1$, positive demand elasticities will lead to a negative result of the left hand side. This means that market prices P will always be less than the ith firm's marginal cost, which is impossible, if firms are assumed to behave rationally. However, with a subsidy, a firm's marginal costs exceeds market prices, and the difference between the two is the amount of the subsidy (Pindyck and Rubinfeld 2001, p. 317).

The negative margins do not necessarily show a negative profit for the firm, as long as the amount of the subsidy is fully covered by other institutions such as the government. In Indonesia, the government imposed such a subsidy in two different ways. First, the government bought CPO produced by the privately owned estates at the international price and sold it at lower prices. Second, CPO produced by the public estates was sold at a lower price than the market price (Larson 1996, p. 11; Arifin *et al.* 1999). While for the first type, the subsidy was likely to have been fully covered by the government, this was unlikely for the second. In other words, it seems that the negative price–cost margins might arise more in the public estates than in the private companies. Since the market power index property needs to be satisfied in both groups, this might lead to a high rejection of this property. In addition, the negative price–cost margins do not necessarily show that the duopolists behave competitively. As policy makers have incomplete or no information about the groups' cost functions, the amount of subsidies given is unlikely to be determined by the difference between price and the groups' marginal costs. If the subsidies are greater than this difference, the groups might still enjoy some degree of market power.

5.4 Adjustment cost parameter, market power index and type of competition

Using the 200,000 replications, all of the three properties, namely, the stability, convexity and desired range of market power index were imposed to obtain the selected samples. The mean, standard deviation and numerical standard error (NSE) of market power index

v and cost of adjustment parameter θ of the samples were calculated. The results are shown in Table 5.4.

Table 5.4 Bayesian estimates

Parameters	Selected samples = 1310 , Probability = 0.0034		
	Mean	Standard deviation	NSE
θ_1	1.39E5	5.18E4	5E32
θ_2	1.77E3	278.99	4.98E29
v_1	-0.46	0.75	3.26E31
v_2	-0.72	0.15	6.29E26

Table 5.4 shows that jointly imposing three properties reduces the selected samples to only 1310 out of the 200,000 replications. The standard deviation of the adjustment cost parameters and market power index are relatively small, but their numerical standard errors are very large. Recall the formula of the NSE as:

Equation 5.5

$$NSE(\beta) = \left[\frac{\sum_{k=1}^{N} \left(\beta_k - \overline{\beta}_k\right)^2 \left(\frac{f\left(G_k | q\right)}{g\left(G_k | q\right)} \right)^2}{\left(\sum_{k=1}^{N} \frac{f\left(G_k | q\right)}{g\left(G_k | q\right)} \right)^2} \right]^{1/2}$$

where:

$N = 200,000$ is the number of replications;

β_k is the adjustment cost parameter or market power index calculated from each value of the parameter vector replications;

$\overline{\beta}_k$ is the mean value of the adjustment cost parameter or market power index calculated from the selected samples; and

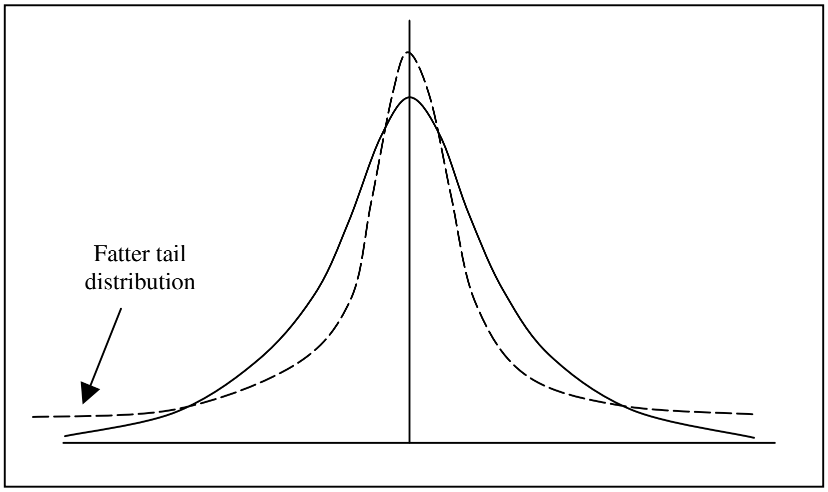
$\frac{f(.)}{g(.)}$ is the ratio of the diffuse and multivariate *t*-pdfs.

Equation 5.5 shows that the large errors might stem either from the large difference between β_k and $\overline{\beta}_k$, or from the great ratio $\frac{f(.)}{g(.)}$. The estimation results show that all parameters in $\beta_k = (\theta_{1k}, \theta_{2k}, v_{1k}, v_{2k})$ have large difference between their minimum and maximum values, which are [-7.5E10;1.7E10], [–3.7E9;2.4E9], [–6.4E5;2.3E5] and [–7.4E4;169.6E4], respectively. The small proportion of the selected samples relative to the total number of replication—which are 1310 out of 200,000—means that $\bar{\beta}_k$ only represents a small part of the entire possible values. Hence, most of the replications have a large difference between β_k and $\bar{\beta}_k$. In addition, most of the replications have large ratio $\frac{f(.)}{g(.)}$ (99.7 per cent of the total replications have ratio values more than 1E10). As both conditions appear this case, NSE values become extremely large, indicating that the mean value of the numerical integration imprecisely estimate the 'true' mean value. However, if the tail of $f(.)$ is fatter than the tail of $g(.)$, the NSE might not be reliable estimates of the true NSE (Barnett, Geweke and Yue 1988 in Chalfant *et al.* 1991, p. 483). In this so-called the 'thin tail' problem, the weights become extremely large (Matos *et al.* 1993, p. 2051).

The four degrees of freedom used in the multivariate t-distribution was suggested to be fat enough to cover most of the values in the actual posterior distribution, by accepting the loss of the extreme values (Chalfant *et al.* 1991; Chen *et al.* 2000). However, Figure 5.4 shows that most parameter replications that satisfy the market power index properties are located in the small probability region. While the importance sampling technique appears to be efficient in reducing the variance in the selected samples or the truncated density, the small portion of the truncated density makes this technique unlikely to be efficient in reducing the variance in the untruncated density. This is indicated by the small standard deviations and large NSE of the parameters. In fact, the difference between the parameters and their mean values reach as high as 8E20.

Molle (2002, p. 10) defines that a probability distribution is said to have 'fat tail' or 'heavy tail' or 'broad tail' if it exhibit a relatively large mass in its extreme ends. In addition, the thinner tail function decline faster than the fat tail distribution. He illustrates such conditions with an example of log functions as in shown in Figure 5.7.

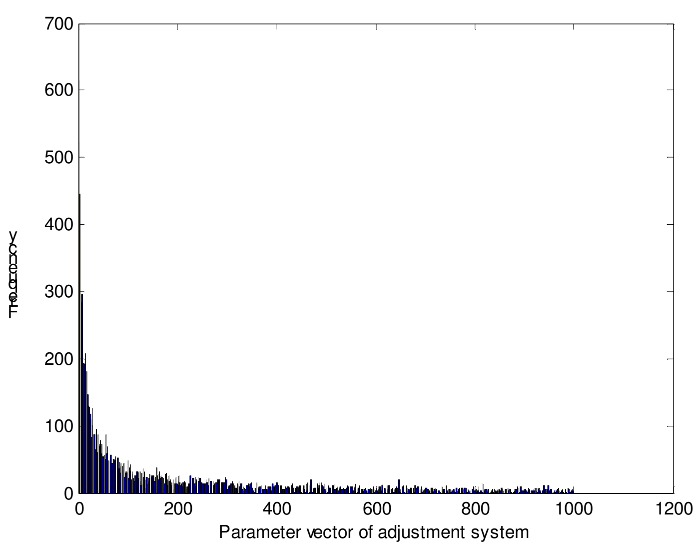
Figure 5.7 Log function distribution



Source: Molle (2002, p. 82).

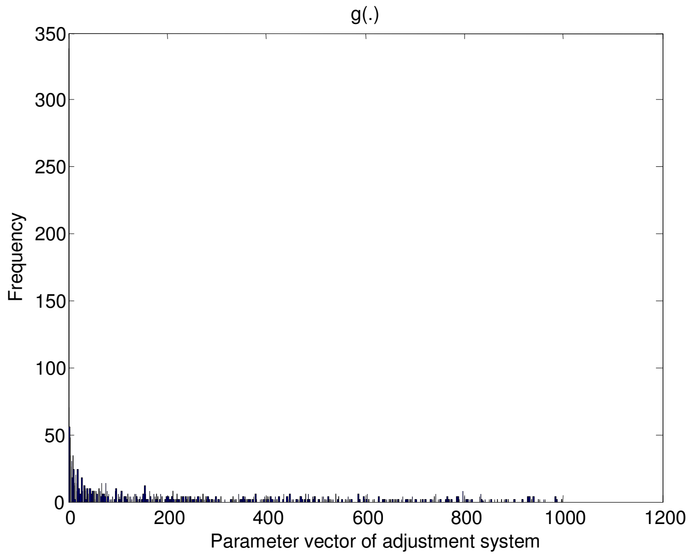
Using the proportionality function of $f(.)$ and $g(.)$[19], we obtain their distributions as shown in Figures 5.8 and 5.9.

Figure 5.8 $f(.)$ probability distribution function



[19] See Equation 4.20 and 4.21 in Chapter 4 for details.

Figure 5.9 $g(.)$ probability distribution function



These pdfs indicate that $g(.)$ decline faster than $f(.)$. In addition, $f(.)$ has a longer tail than $g(.)$, reflecting by their lower and upper bound, which are [7E–65 ; 5E44] and [4E–49 ; 1E–5], respectively. The four degrees of freedom used in the multivariate t-distribution was suggested to be fat enough to cover most of the values in the actual posterior distribution by accepting the loss of the extreme values (Chalfant *et al.* 1991; Chen *et al.* 2000). However, Figure 5.6 shows that most parameter replications that satisfy the market power index property are located in the small probability region.

Increasing the number of replications or decreasing the degrees of freedom might overcome the large numerical standard error problem (van Dijk and Kloek 1980, p. 316; Chen *et al.* 2000). The addition of 100,000 antithetic replications in this estimation might not be efficient because the pdfs are not symmetric (Kloek and van Dijk 1978). However, as the weight appears to be extremely large, the required increase in the number of replications might be infinite. In addition, the four degrees of freedom is already relatively small compared to the 30 degrees of freedom of a normal pdf. The asymmetric condition might in part stem from the skewed data used in the adjustment system (see Table 5.1). The log form used in the adjustment system—that is suggested to change the skewness of the distribution—is unlikely to be effective for this case (Chen *et al.* 2000, p. 2302)

The rejection of the market power index property leads to a low probability of the replications. The rejection might either indicate that the values of the index are unbounded, or there are some important variables that are not included in the model and estimation. If the values are unbounded, we do not need to impose the market power index property. However, this makes interpretation of the groups' behaviour very difficult, if not impossible. If the rejection of the market power index stems from missing variables—such as the marginal cost or subsidy data—we need to include them in the model and estimation. However, such data are not available. Therefore, the estimation of mean values of the adjustment cost parameters and the market power index are still used with caution.

The estimation result shows that the mean value of the public estates' adjustment cost parameter is higher than that of the private companies, which are 1.39E5 and 1.77E3, respectively. In other words, the public estates appear to be less flexible than the private companies. This might in part be explained by the bureaucratic structure of the public estates. Firms in the public estates group appear to have a more complex organisation structure than those in the private companies group, resulting in a longer administration lag in the decision making process. In addition, many government interventions were imposed on public estates, making them less flexible in responding to changing conditions.

The estimation result shows that the mean value of the public estates' market power index is -0.46, indicating that public estates exert some degree of market power, while that of the private companies group's is -0.72, which is much closer to -1, indicating that the private companies tend to behave competitively. In addition, the estimation result of the adjustment system (see Table 5.2) indicates a leader–follower relationship between the groups. In other words, the groups' relationship could be seen as a Stackelberg interaction, in which the public estates act as a leader and exert some degree of market power, while the private companies act as a follower and acts as a price taker.

Market power of the public estates in the Indonesian CPO industry might stem from at least two sources. First is the requirement of high investment, which may create some barriers to entry. It was estimated that US$ 2,500–3,500 per ha would be needed for developing a new plantation and US$ 5 million would be required to build a CPO mill. On average, the size of an individual plantation is approximately 10,000–25,000 ha, and it is mostly part of larger plantation estates ranging from 100,000 to 600,000 ha. In 1986–1996, such entry barriers were successfully eliminated by providing the potential entrants with some concessionary credits. On average, each of the entrants borrowed about 77 per cent of the total establishment cost of the plantation, leading to an increase in the oil palm plantation by almost seven-fold (Casson 2000; Potter and Lee in van Gelder 2004, p. 22; Wakker 2004, p. 10). Second is the existence of trade associations such as the Joint Marketing Office. Clarke (1983) suggests that such associations could facilitate collusion by allowing oligopolists to homogenise their perceptions of both the market state and other firms' information.

5.5 Welfare analysis

The market power indices v_i which is estimated to be more than -1 indicates that market price is higher than firms' marginal costs. To test this, three different scenarios (reflecting three different conditions in the analysis period) were simulated. Given two dummy variables, referring to the economic crisis and the concessionary credits, the periods of analysis can be divided into period one of 1969-1985, in which $D_1 = D_2 = 0$; period two of 1986-1996, in which $D_1 = 0$ and $D_2 = 1$; and period three of 1997-2003, in which $D_1 = 1$ and $D_2 = 0$.

Using the first scenario, in which $D_1 = D_2 = 0$, which implies no economic crisis and concessionary credits, the adjustment system can be re-written as

Equation 5.6 $$q_{1t+1} = 0.45 + 0.90 q_{1t} + 0.05 q_{2t}$$
$$q_{2t+1} = 0.31 + 0.25 q_{1t} + 0.70 q_{2t}$$

Given the results of demand function and adjustment system estimations, the difference between the subsidised and competitive prices faced by the public estates will be

Equation 5.7 $$p_t^s - p_t^c = -0.00071 - 0.003233 q_{1t} - 0.000078 q_{2t}$$

and that faced by the private companies will be

Equation 5.8 $$p_t^s - p_t^c = -0.00025 - 0.0002 q_{1t} - 0.001515 q_{2t}$$

The relationship between q_{1t} and q_{2t} is obtained by combining Equations 5.7 and 5.8

Equation 5.9 $$q_{1t} = 0.151665 - 0.4727 q_{2t}$$

Substituting this into Equations 5.7 and 5.8 gives

Equation 5.10 $$p_t^s - p_t^c = -0.00120 + 0.001450 q_{2t}$$

and

Equation 5.11 $$p_t^s - p_t^c = -0.00028 - 0.0014205 q_{2t}$$

Finally, combining Equations 5.10 and 5.11 gives $q_{2t} = 0.32$.

Due to the lack of subsidy data, market price data are not the net price data and could be treated as the subsidised price, hence the average price $\overline{p}$ was used as an approximation of p_t^s (see Figure 1). Plug $\overline{p} = 128120.97$ either into Equation 5.10 or Equation 5.11, to get the competitive price $p_t^c = 128121$. Following the same steps as in scenario 1, gives the same results for the competitive price in scenarios two and three. Therefore, it could be concluded that the competitive price p_t^c is likely to be higher than $\overline{p}$.

5.6 Concluding comments

This chapter has presented the estimation techniques and results of the model, which was specified in the previous chapter. The Bayesian technique was used as it has the ability to impose the three properties of the model, namely stability, convexity and interpretable market power index. While the stability and convexity properties hold in most of the replications, market power property appears to be strongly rejected. The public estates appear to act as the leader and have some degree of market power, while the private companies act as the followers and tend to behave competitively. This might be explained by the changes in both the demand and supply sides. On the demand side, the elasticity of demand changed from very elastic to inelastic, providing all sellers in the market with an ability to exert market power. On the supply side, the increase their market share and vertical integration provided the private companies with an ability to respond to the public estates' current actions, making the public estates behave more cooperatively. Given the fact that the public estates exert some degree of market power, indirect and direct policies that assume perfect competition appear no longer applicable.

Appendix 5

Appendix 5.1 Research data

Year	CPO nominal price (Rp/kg)	CPO demand (tonnes)	Crude coconut oil nominal price (Rp/kg)	Palm cooking oil nominal price (Rp/kg)	Government group's production (tonnes)	Private group's production (tonnes)
1968	#N/A	#N/A	#N/A	#N/A	122,369	59,075
1969	64.0	22.4	#N/A	87.2	128,561	60,240
1970	66.0	36.0	104.20	90.9	147,003	69,824
1971	74.0	30.4	110.05	169.9	170,304	79,653
1972	72.9	27.6	101.39	184.1	189,261	80,203
1973	90.7	25.6	182.43	200.0	207,448	82,229
1974	128.5	38.4	128.00	221.7	243,641	104,035
1975	148.4	38.4	161.56	239.4	271,171	126,082
1976	144.8	22.6	207.73	316.3	286,096	144,910
1977	144.1	60.8	303.66	455.8	336,891	120,716
1978	168.6	95.2	407.03	483.8	336,224	165,060
1979	206.7	160.0	396.62	498.1	438,756	201,724
1980	222.5	185.6	388.85	500.2	498,858	221,544
1981	245.3	359.2	426.85	476.9	533,399	265,616
1982	248.8	407.2	360.82	476.3	598,653	285,212
1983	276.7	478.4	550.68	648.0	710,431	269,102
1984	405.5	612.8	743.29	779.4	814,015	329,144
1985	421.5	642.2	691.50	569.7	861,173	339,241
1986	426.4	524.8	538.51	746.5	912,306	384,919
1987	427.0	702.6	625.63	762.4	988,480	352,413
1988	502.0	774.0	673.15	874.5	1,102,692	454,495
1989	547.5	948.0	774.91	905.8	1,184,226	597,039
1990	525.3	981.6	597.37	708.3	1,247,156	788,506
1991	572.5	990.4	967.56	822.6	1,360,363	883,918
1992	722.5	1211.2	996.12	961.4	1,489,745	1,076,900
1993	700.7	1427.2	985.11	987.7	1,469,156	1,190,272
1994	911.3	1588.0	950.85	545.5	1,571,501	1,597,227
1995	1,093.6	1692.3	1098.06	1362.6	1,613,848	1,864,379
1996	996.5	2022.3	#N/A	#N/A	1,706,852	2,058,259
1997	1,138.5	2208.4	2410.10	1959.2	1,586,879	2,578,806
1998	2,408.5	3,288.1	#N/A	#N/A	1,501,747	3,084,099
1999	2,435.4	3,625.3	1756.93	3398.0	1,468,949	3,438,830
2000	2,204.8	3,909.4	2248.86	3909.3	1,460,954	3,633,901
2001	2,220.8	4,082.8	2750.00	2402.4	1,519,289	4,079,151
2002	3,109.1	3,901.8	3542.00	2562.4	1,607,734	4,587,871
2003	3,704.4	3,910.7	3953.00	#N/A	1,543,528	4,627,744

Appendix 5.2 Estimation result for the demand equation

Dependent Variable: Q
Method: Least Squares
Sample (adjusted): 1970 2002
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGP	-1166.553	512.7563	-2.275064	0.0317
LOGP1	-2280.002	315.3408	-7.230280	0.0000
LOGP2	354.0936	287.5915	1.231238	0.2297
LOGPLOGP1	493.7347	62.44299	7.906968	0.0000
D3	414.5342	203.5406	2.036617	0.0524
C	4835.280	799.4283	6.048422	0.0000

R-squared	0.989727	Mean dependent var	1025.427
Adjusted R-squared	0.987673	S.D. dependent var	1252.898
S.E. of regression	139.1060	Akaike info criterion	12.88033
Sum squared resid	483761.8	Schwarz criterion	13.15788
Log likelihood	-193.6452	F-statistic	481.7333
Durbin-Watson stat	1.727595	Prob(F-statistic)	0.000000

Appendix 5.3 Estimation result for the adjustment system

System: MOTION4
Estimation Method: Seemingly Unrelated Regression
Sample: 1968 2003

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.446186	0.134205	3.324656	0.0016
C(2)	0.903125	0.055598	16.24371	0.0000
C(3)	0.045293	0.050994	0.888214	0.3782
C(4)	-0.040686	0.019012	-2.139990	0.0367
C(5)	-0.103981	0.028255	-3.680136	0.0005
C(7)	0.306430	0.227938	1.344357	0.1843
C(8)	0.246309	0.094430	2.608376	0.0116
C(9)	0.703124	0.086609	8.118380	0.0000
C(10)	0.171891	0.032291	5.323267	0.0000
C(11)	0.060158	0.047989	1.253592	0.2152

Determinant residual covariance 1.72E-06

Equation: LOGGT=C(1)+C(2)*LOGGT3+C(3)*LOGPT3+C(4)*D01+C(5)*D02
Observations: 33

R-squared	0.992531	Mean dependent var	5.886660
Adjusted R-squared	0.991464	S.D. dependent var	0.327913
S.E. of regression	0.030295	Sum squared resid	0.025699
Durbin-Watson stat	1.265200		

Equation: LOGPT=C(7)+C(8)*LOGGT3+C(9)*LOGPT3+C(10)*D01+C(11)*D02
Observations: 33

R-squared	0.993080	Mean dependent var	5.743803
Adjusted R-squared	0.992091	S.D. dependent var	0.578594
S.E. of regression	0.051455	Sum squared resid	0.074132
Durbin-Watson stat	1.787956		

Chapter 6
Policy Implications and Conclusions

In this chapter, the previous findings on price–cost margins, adjustment costs, the type of interaction and the degree of market power are highlighted. Based on these findings, the policy implications of the analysis are considered. In the next section, the negative price–cost margin condition is used to assess the effectiveness of a subsidy policy in the Indonesian CPO industry. The impact of adjustment costs on the effectiveness of policy pricing and on market power is examined in section 6.2. In sections 6.3 and 6.4, the leader–follower and market power results are discussed, particularly with regard of the public estates' role as the internal regulator. In section 6.5, the limitations of the analysis and possible avenues for further research are explored. Finally, in section 6.6, a number of conclusions are presented.

6.1 Subsidies, negative price–cost margins and market power

While average market price is higher than the competitive price, estimation results indicate that both groups of producers still enjoy some degree of market power. This might, in part, be related to the imposition of subsidies either in CPO or cooking oil prices. With a subsidy, the sellers' price might exceed the buyers' price (Pindyck and Rubinfeld 2001, p. 317). [20] Due to the paucity of subsidy data, the market price data used in the estimation are not differentiated with prices actually received by the producers. In such conditions, negative margins do not necessarily show a negative profit for the firm. If fact, the amount of subsidies is greater than the competitive and market price margin; sellers would receive prices higher than the competitive price and enjoy gaining some degree of market power.

[20] The seller's price refers to price being equal to the seller's marginal cost and the buyer's price is the same as the market price.

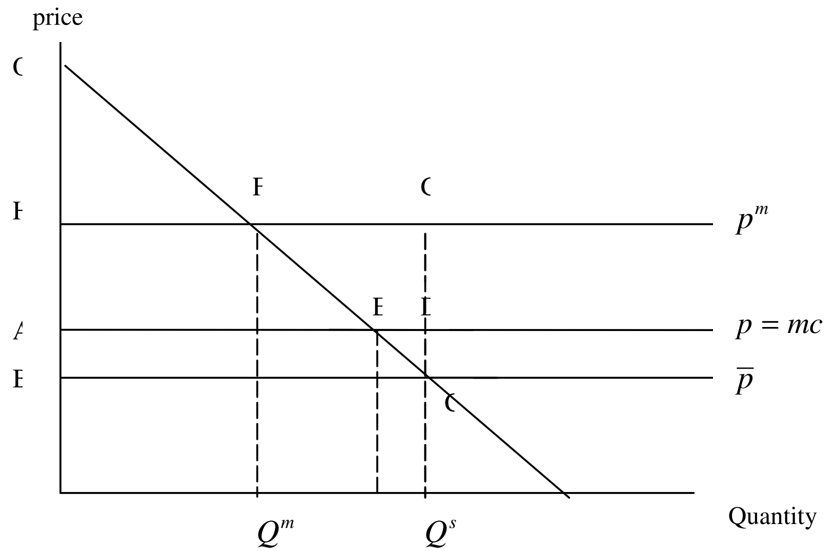
The estimation result shows that the slope of demand b is positive. While this can be explained by the nature of net price variable, positive b values make competitive market prices higher than non-competitive market prices. Recall the market power price

$$p_t^{mp} = -\frac{(1+v_i)}{b}\left[q_{it} + \delta q_{it+1}\right] + (1+\delta)c_i + (1+\delta)\theta_i q_{it} - \delta p_{t+1}$$

Given positive values of q and δ, with negative b and $v > -1$ (which refers to the non-competitive conditions), the first term $-\frac{(1+v_i)}{b}\left[q_{it} + \delta q_{it+1}\right]$ would be positive; hence competitive prices would be higher than the non-competitive ones. In the estimation process b was calculated by using the average market price $\overline{p}$. v_i values were obtained through the estimation of firms adjustment process and were not determined by the b value. The separate estimations of b and v_i values might lead to the condition of high competitive price.

With market power, subsidies are unlikely to have a desired effect. This can be illustrated in Figure 6.1. Suppose that the price and quantity without subsidies are p^m and Q^m, with subsidies are $\overline{p}$ and Q^s, and marginal cost is mc. Without subsidies, consumers could only receive a surplus as much as OHF, whereas with subsidies it could be as much as OBC. This means that subsidies increase consumer surplus as much as ABCE. However, the expense of subsidies $\left(p^m - \overline{p}\right)Q^s$ (which equals BCGH) is greater than the increase in consumer surplus. The difference CGF indicates that with market power, subsidies could reduce the aggregate welfare.

Figure 6.1 Subsidies and welfare



In Indonesia, the subsidies could be either covered by the government or the producer (either public estates or private companies). Without subsidies, producer surplus is $\left(p^m - mc\right)Q^m$ (see Figure 6.1). If the subsidies are covered by the government and the government does not know the producers' marginal cost, paying all the difference between the producer and the consumer prices, producers still receive prices at p^m. In such a condition, the subsidy does not change the margin, and the producers still enjoy some degree of market power. The producer's surplus increases as much as $\left(p^m - mc\right)Q^s$.

In contrast, if all of the subsidies are covered by the producers, producers receive prices at p^s, hence their price-cost margin will be negative and their surplus decreases as much as $\left(mc - p^s\right)Q^s$. Finally, the expenses of subsidies could also be divided for both the government and producers. If government expenses for subsidies are great enough to lead to a positive price-cost margin, producers will still enjoy some degree of market power. Such a condition might appear in the Indonesian palm oil industry, as policy makers have incomplete or no information about the groups' cost functions and the amount of subsidies given is unlikely to be determined by the difference between price and marginal costs.

If producers have different marginal costs due to the difference in efficiency, the subsidies might provide some degree of market power to the more efficient producer. The efficient producer has lower marginal costs, say $mc' < \overline{p} < mc$, than those who are less efficient. In this case, producers still gain extra profit and enjoy market power even though they have to cover all of the subsidies. In fact, the public estates appear to be less efficient than the private companies. On average, the production costs of the public estates were 36 per cent higher than those of the private ones.[21] Therefore, in order to be effective, government price intervention needs to be based on the marginal cost information of efficient producers.

In addition, subsidies would encourage the less efficient producers to remain in the industry. Green (1987, p. 487) suggests that there are two conditions that allow less efficient firms to remain in a market. First, there is no better potential entrants. In the palm oil industry, this might be attributable to barriers to entry that stem from the high investment levels required to establish a sufficient scale of oil palm estates and CPO mills. In 1986 the government attempted to address this problem by providing potential entrants with some concessionary credits. On average, each of the private companies borrowed about 77 per cent of its total establishment cost and increased the oil palm plantation area almost seven-fold. However, after 1996 these concessionary credits were no longer available (Casson 2000). This implies that the more recent entrants faced the higher costs of entry to the industry, and hence incumbents earned persistently higher profits than the potential entrants.[22] If such barriers can be removed, 'no one firm can succeed in the long run at earning profits that exceed costs without inducing additional entry'(Carlton and Perloff 2005, p. 77). Therefore, providing potential entrants with similar credits—so that firms can enter with identical cost—could lead the market to a

[21] De Fraja (1991) has used the average variable cost as the measurement of efficiency. The production cost of the private companies is approximated by the real average costs of a firm listed in the Jakarta Future Exchange during 1994–2003, and that of the public estates is approximated by the real average costs of plantation firms surveyed by Bureau of Statistics, Indonesia during 1994–2000.
[22] Carlton and Perlof (2005) defined such a condition as the long run barrier to entry.

more competitive condition, in which no inefficient firms can survive. This implies that the public estates would be forced to increase its efficiency to remain competitive. While an inefficient government firm can still improve consumer welfare by selling output at below its marginal costs,[23] this is obtained through a transfer from the rest of economy (for example, through general taxation), rather than from increasing total social welfare. In contrast, with low marginal costs, an efficient public firm can set a low price, forcing private firms to cut their price, which then increases the total social welfare (de Fraja 1991, p. 315).

The second condition allowing less efficient firms to remain in the market is the absence of competition among incumbent firms. Clarke (1983, p. 384) suggests that, in general, oligopolists have strong incentives to collude because they would gain profits by restricting their output and receiving a higher price. However, incentives to collude are often offset by the problems associated with detecting cheaters on the collusive agreement, which stem from the uncertain market conditions. One way to reduce market uncertainty is by homogenising the oligopolists' perception through a pooling mechanism, such as in the trade associations. Being a member of the same association (namely the Indonesian Palm Oil Producers Association) provides means for the public estates and private companies to improve their production or distribution processes as well as to promote technical or economic progress. However, at the same time, this allows the groups to homogenise their perception about the market condition and to share information about other firms. In the absence of the competitive behaviour, both the public estates and private companies may enjoy some degree of market power.[24]

Subsidies might also lead to a decrease in the elasticity of demand (Silvestre 1993, pp. 136-137). For example, if the demand curve is a straight line, moving down along the line leads to a decrease in the elasticity. Subsidies decrease prices that need to be paid by the consumers, hence increase quantities demanded by the consumers. In other words, subsidies move down the equilibrium point along the demand curve. For normal goods,

[23] Being instructed to maximise the social welfare is often used as a justification for the losses in the public firms (de Fraja 1991, p.316).
[24] Green (1994) calls this a supra-normal profit.

an increase in their market price causes consumers to shift their demand to other substitute goods. However, with subsidies consumers pay either the same or a slightly higher price, and hence their demand might remain the same or only slightly decreases. This implies that a 'change' in output price does not change, or only slightly changes, the demand, so that producers could increase price without losing a significant portion of demand. This provides producers with a chance to increase price above marginal cost and to enjoy the market power gain.

To conclude, while subsidies are imposed to increase the consumer surplus, they might actually decrease the aggregate welfare due to market power. In order to provide subsidies that could remove the imperfectly competitive market condition, policy makers need information on the marginal cost of the efficient producers. If the amount of the subsidy is exactly the difference between price and costs, the competitive market price will be observed. If the amount of subsidy is greater than the difference between price and costs, producers will still enjoy some degree of market power.

6.2 Adjustment costs and pricing policy

In an oligopolistic market with homogeneous products, each firm has an ability to influence market price by changing its output level. However, the existence of adjustment costs prevents the firm from changing its output level. The higher the adjustment costs of the firm, the lower its ability to influence market price (Cairns 1995, pp. 87-88).

The estimation results suggest that the public estates incur higher adjustment costs than the private companies. The government often used public estates as an instrument to influence market price. In particular, to ensure an adequate supply for the domestic market, the distribution of CPO produced by public estates is controlled by the government. When an increase in output was unlikely to decrease market price, the CPO produced by public estates was sold at less than the market price. These distribution and pricing strategies were designed to support the competitive condition in the domestic market. However, the high adjustment costs of the public estates make it more difficult for them to change their output level to influence market price. As a result, the effectiveness of government pricing policy in this industry is reduced.

High adjustment costs might stem from the bureaucratic structure of the public estates. Improving the organisational structure of the government companies and reducing intervention by policy makers might reduce the bureaucratic nature of public estates, and hence decrease their adjustment costs. As a result, this might increase the ability of the public estates to adjust their output and to influence market level. In addition, the government appears to have reduced the public estates' dominance by supporting the entrance of private companies in the CPO industry. Since 1986, the government has helped the private companies to expand their output level by providing them with concessionary credits. However, an increase in the private companies output does not necessarily increase supply in the domestic market, because they can also sell their output in the international market. Consequently, the public estates need to fill the gap between the market demand and the private companies' level of supply in the domestic market. The problem is that the public estates' share of output is no longer adequate to cover the entire domestic demand, hence, price is unlikely to be set at the market clearing level.

The high adjustment costs might also emanate from the absence of vertical integration between the public estates and the cooking oil refineries. The maturation periods of the fresh fruit bunches make it necessary for the government to have an adequate amount of stocks (Harris and Wiens 1980). Since CPO cannot be stored for more than three months without a reduction in quality, the public estates need to have the stock in the cooking oil form. This means that the public estates need either to be vertically integrated with more cooking oil refineries or to increase the capacity of their refineries.

In addition, imported cooking oil could be used as an alternative. The cooking oil price in the world market is likely to be more competitive than in the domestic market. The reason is that the world market is supplied with various types of vegetable oils, which appear to be highly substitutable for one another (In and Inder 1997). In such a condition, a small increase in a certain type of vegetable oil would lead to a high reduction in the quantity demanded. In other words, no single producer can increase price without suffering from a significant decrease in its profit. Hence, producers of the various types of vegetable oils would sell their outputs as low as the competitive levels.

6.3 The leader–follower relationship and the role of public estates as an internal regulator

Relaxing the symmetry assumption provides the estimation results in a broader type of interaction between the public estates and private companies. In particular, it includes the asymmetric interactions, such as the leader–follower relationship and the dominant–fringe relationship, as well as the symmetric interaction, such as the independent, cooperative and non-cooperative interactions (Putsis and Dhar 1998). The estimation results suggest that the public estates and private companies engage in a leader–follower interaction, in which the public estates act as the leader and the private companies as the follower. The public estates do not react to actions taken by the private companies, while as a follower; the private companies always accommodate output changes undertaken by the public estates.

Part of the leader–follower/ Stackelberg interaction might be explained by occurrence of positive reaction functions and asymmetry costs between the public estates and private companies. Suppose that the ith firm 's profit, $\pi_i(q) = q_i p_i(q) - c_i\left[q_i(p)\right]$, where p_i, q_i and $c(.)$ are the selling quantity and price and the cost function of the ith firm, respectively. p is determined by q, where $q = q_i, q_j$. Dowrick (1986) shows that the slope of firm i's reaction function is given by $-\frac{\pi_{ij}}{\pi_{ii}}$, where π_{ij} and π_{ii} are the second cross and own partial profit function partial derivatives, respectively. To satisfy the profit maximisation condition, π_i and π_{ii} need to be zero and negative, respectively. Hence, the sign of firm i's reaction function is merely determined by the sign of π_{ij}.

Negative reaction functions are commonly assumed for a quantity setting game. However, the reverse may occur if and only if $\pi_{ij} > 0$ or $p_{i.ij} > -{p_{i.j}}/{q_i} > 0$. As the product is homogeneous and thus $p_i = p_j = p$, this can be re-written as $p_{.ij} > -{p_{.j}}/{q_i} > 0$. Given the non-negative level of output q_i, the second term means that goods are normal, thus its first own partial derivative is negative $p_{.j} < 0$. The first term $p_{.ij}$ refers to second cross partial derivates. The first order condition of the firm's profit function shows the ratio between price and marginal costs, in which price must exceed marginal costs if output is positive, while that of the second order condition shows the ratio between the 'margin' of price and marginal costs. This means that $p_{.ij}$ is positive if the 'margin' of marginal costs is less than that of price, which can either emanate from the increase of the 'margin' of price or from the decrease of the 'margin' of marginal costs.

The increase of the 'margin' of price could occur, for example, if the market demand is increasing and inelastic. In this case, the estimation result shows that from 1967 to 2003, the CPO demand has been increasing and appears to be more inelastic. The increase in CPO demand stems from the increase of population and income, while the inelasticity could partly be explained by the increase in CPO dominancy as the raw material for cooking oil. The decrease of the 'margin' of marginal costs could occur, for example, if a firm has a decreasing marginal costs function. In other words, an increase in its output leads to a decrease in its marginal costs, implying that the firm still has not reached the minimum marginal costs.

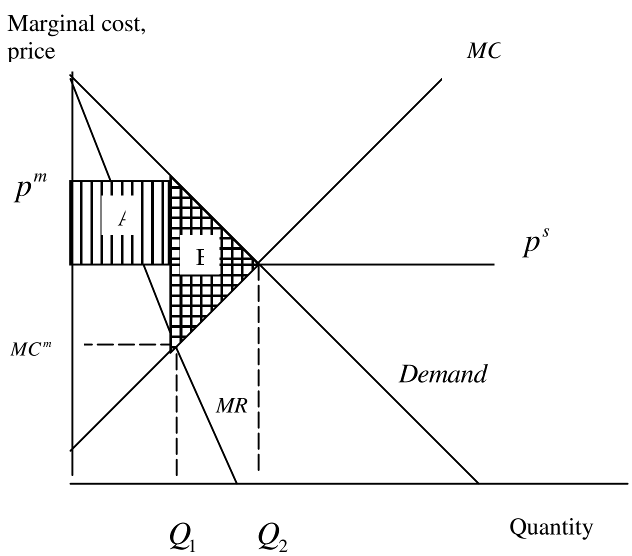
Theoretically, as a leader, the public estates can effectively help to suppress market power in the market. Cremer et al. (1989, p. 283) suggest that the public firm's role as a leader or first-mover, taking into account the reactions of the private firm, could be explained by its objective of maximising social welfare. In order to maximise social welfare, the public estates need to sell output equal to or greater than the competitive level. The public estates can announce their output policy and set their output level so that market price equals marginal costs. However, if the market price reaches the competitive level, the private companies will not obtain as high a payoff as when the market price is higher.

In such a condition, selling in the international market becomes more profitable than selling domestically, leading to a further decrease of supply and an increase of price in the domestic market. There are at least two factors that might explain the high price in the international market. First, given land suitability and low labour costs, Indonesia was recorded as the most cost efficient CPO producer in the world (see Table 2.2). This means that the Indonesian CPO producers' marginal costs are expected to be lower than those of other producers in the world. Second, CPO consumers in the international are likely willing to pay at higher prices either because the CPO is processed into outputs with higher added value than cooking oil—such as oleochemicals—or because the CPO consumer countries have higher purchasing power than that of the domestic market. As a result, the competitive price in the international market would be higher than that of in the domestic market. If, in fact, the increase in the private companies' export leads to a significant increase in the domestic price, the public estates might see this as a credible 'threat' from the private companies. Gaining an increase in market share and vertical integration makes the private companies' 'threat' credible, and hence deters the public estates from raising output to lowering the market price. As a result, both groups end up with selling outputs below the competitive levels and enjoying some degree of market power. Here, the role of the public estates as a leader does not suppress market power in the CPO industry, and there might be some social welfare loss in the industry.

Figure 6.2 shows an extreme example in which the duopolists perfectly collude and become a monopolist. Their total output will be Q_1 and they receive a transfer surplus from consumers as much as the area A. However, there will be a loss that is not offset by the surplus transferred to the monopoly, which may be as much as area B and is commonly known as the deadweight loss. Wien (1978) suggests that one way for the public firms to increase their output to the competitive market level is by giving the management incentives based on the companies' performance. Suppose that the monopoly gain is evenly divided between the duopolists, so that each of them receives

A/2. If the public firms have an adequate capacity to make up any difference between Q_2 and the private companies level of output and if policy makers can compensate the monopoly gain, then the public firms' production level could be pushed up to fill the gap to reach the competitive level. Such an intervention—that is, increasing the public firms' output to influence the behaviour of private counterparts—might be a better alternative than the pricing policy, as the government intervention to set prices below the market price appears to be ineffective in eliminating market power in the Indonesian CPO market.[25]

Figure 6.2 Monopoly price and social welfare



6.4 The existence of market power

The cost of market power is well-known: It can reduce social welfare (as shown by the area B in Figure 6.2) and can increase the redistribution of wealth (as shown in the area A in Figure 6.2). Posner (1975) argues that the 'traditional deadweight loss' (the area B) is

[25] Government interventions can be of two types. One is to appoint an economic commissar in charge of the industry, that is, the so-called 'regulatory authority'. The other is to produce the output provided otherwise by the private companies, that is, the so-called 'regulation by participation' (Sertel 1988).

likely to underestimate the social costs of monopoly. This is because the 'traditional deadweight loss' does not include the costs of establishing the monopoly itself, which can be as much as the monopoly profit (area A). With this in mind, in 1999, the government implemented Law No.5/1999 in order to deal with imperfect competition, which effectively discouraged the optimal allocation of resources and the implementation of more efficient technologies, and hence decreased social welfare. A Commission for the Supervision of Business Competition was established in order to ensure the implementation of the law (KPPU 2000).

According to Law No.5/1999, market share is used as a measure of a firm's dominant position, which might enhance the sellers' ability to influence prices in the market. Based on the market share of each of the public estates, the Indonesian Ministry of State-Owned Firms (2002) suggested that on average, these firms behaved competitively. With such behaviour, a decrease in their costs will lead to a reduction in their selling price. Furthermore, since they appear to be vertically integrated with the cooking oil refineries, this might also lead to a decrease in the cooking oil price. Given this assumption, many government policies were implemented to ensure that the cooking oil industry is supplied with an adequate amount of CPO at an affordable price. Since more than 70 per cent of cooking oil production costs come from CPO expenditure, it was expected that the impact would be significant (Indiarto *et al.* 1996, p. 217). Higher export taxes were imposed to limit CPO export, especially from the private companies, leaving an adequate supply for the domestic market. Subsidies for the CPO produced by public estates were provided to decrease the production costs of cooking oil refineries.

The fact that both groups appear to exert some degree of market power implies that the effectiveness of the price transmission mechanism is questionable. Empirically, Isdijoso *et al.* (cited in Susanto 2000, p. 2) found that supplying an adequate amount of CPO was no longer effective in stabilising cooking oil prices, while Mark *et al.* (1998) showed that the gain from a lower CPO price in the domestic market had not been passed on to the cooking oil consumers. McCorriston and Reyner (2001) suggest that the impact of the imperfect market on price transmission would be significant, given the existence of non-constant marginal costs.[26]

To deal with market power, Harris and Wein (1980, p. 131) list three possible solutions; namely, nationalisation of the industry, anti-trust policy and direct regulation. Law No.5/1999, which is used to address market power in Indonesia, can be seen as a type of antitrust policy. According to this law, firms are restricted from making an agreement to influence market price by controlling their production. This implies that, without any agreement, the law cannot be used to address such behaviour. Harris and Wein (1980, p. 131) suggest that anti-trust policy is ineffective in addressing the tacit collusion problem. The model used here assumed that firms behaved non-cooperatively, in which each of them behaved in its own self interest (Tirole 1988, p.206). This is reflected in the optimisation problem of the model; firms choose the level of their production given their rivals' output. Within this model, estimation of market power index does not exclude the collusive equilibrium. By responding to its rival's actions, the total output of the players could result in a collusive equilibrium. This can be either because the collusive behaviour provides the players with higher profits, or because one player has a credible threat that deters another player from deviating from the collusive behaviour. The Indonesian competition law that has been imposed since 1999 might be effective in preventing firms from signing collusive contracts. In fact, even without such an agreement, firms in the CPO industry are likely to exert some degree of market power. Therefore, eliminating the 'sources' of market power might be a better solution.

Another possible solution—nationalisation of the industry—might also be ineffective in addressing market power in the Indonesian palm oil industry, because the public estates also exert some degree of market power. This might arise from the inefficiency condition of the public estates. Haskel and Sanchis (1995) suggest that pure profit maximising leads the private companies to successfully bargaining for a higher effort from their workers, and thus gaining higher efficiency. In contrast, having broader social objectives—including the welfare of its workers—the public estates do not bargain for

[26] For the model, the non-constant marginal cost stems from the quadratic adjustment cost.

such high levels of efforts from its workers, which leads to a reduction in efficiency. To address this problem, the Indonesian government has made a long term plan to privatise some of the public estates which may potentially increase productivity and efficiency of the estates.

On one hand, privatisation is often considered as the 'no market failures' solution (Capuano and de Feo 2006, p. 5). On the other hand, de Fraja (1991) argues that a more efficient firm does not necessarily improve the efficiency of the industry. If each firm has an ability to influence market price, the profit maximisation objective might not only lead to higher efficiency, but could also lead to a reduction in output to gain higher prices. In fact, the private companies in the Indonesian palm oil industry appear to be more efficient and behave more competitively than the public estates. Therefore, privatisation could be an alternative solution in reducing inefficiency and market power problems in the Indonesian palm oil industry. To be more effective, this needs to be supported by introducing a more competitive condition, which could be achieved by at least two ways (Haskel and Sachis 1995, p. 303). First, this could be achieved by reducing barriers to entry coming from the high level of investment requirement for new entrants in the Indonesian palm oil industry. Second, with a significant and increase trend in market share, developing an effective smallholders' organization might lead them to be an influential strategic group, and to enhance the market competitiveness.

6.5 Limitations of the study and future research

Despite the increasing concern about market power in the Indonesian palm oil industry, no previous study appears to have been addressed this significant issue. This study is the first to model and measure market power in the Indonesian palm oil industry. In particular, it attempts to see whether or not dominant groups in this industry—namely, the public estates and the private companies groups—exert some degree of market power, and to study the nature of interaction between these groups. The findings show that both public estates and private companies do exert some degree of market power. Interestingly, public estates appear to have even higher market power. These findings are potentially useful in providing information for policy makers. Intuitive policies based on the assumption of perfect competition are unlikely to have the desired effect in imperfectly competitive markets. However, it is important to note that the findings of the study suffer from low probability and high numerical standard errors.

There are a number of reasons why this might be the case. First, there might be a data problem. Due to the lack of data, the adjustment system was estimated using group level data. This may not apply to the public estates group, as the CPO produced by its members is sold through the Joint Marketing Office. However, there is no clear information about the interactions among companies of the private group. In addition, the absence of some important data leads to a high rate of rejection of satisfying the convexity and market power index properties. For example, by failing to include subsidy data, price–cost margins of the public estates and private companies appear to have some negative values, leading to frequent rejections in the market power index property. As a matter of fact, the margins might either be zero if all the differences between price and costs were covered by the subsidies, or positive if the subsidies were greater than the costs. Therefore, a richer data set in the future could potentially improve the estimation results.

Second, there might be an estimation problem. The multivariate *t*-pdf with four degrees of freedom was used to generate the replications of the parameters in question. Four degrees of freedom were chosen to ensure that the tail of the multivariate *t*-pdf was thick enough to cover most, if not the entire, range of the actual posterior distribution. Actually, the posterior pdf appears to skew to the left and to have a very long tail. This makes the ratio between the multivariate *t* and posterior pdfs extremely large and hence increases the numerical standard errors. Using the assumption of an asymptotically normal distribution, the estimation is more focused on the central regions of the density function. However, the tail cannot be considered as less important because replications that satisfy the properties are located in this region. Therefore, future research that covers the tail regions is needed.

Finally, there might also be a minor modelling problem. Due to the indivisibility of inputs and discontinuity of adjustments, the model is found to be limited to a convex adjustment costs structure. This has an important implication for the estimation of the market power index. In particular, it makes the estimation of the market power index possible, even without using the cost function (see Chapter 4 for details). Adda and Cooper (2001) suggest a more general adjustment structure by allowing the adjustment cost parameter to vary. However, such an approach might be difficult to apply to a model that uses a constant adjustment cost parameter to calculate the market power index. Thus, future research that explores more flexible structures could provide further insights into modelling market power in the Indonesian palm oil industry.

6.6 Concluding comments

The increase in market share and vertical control in the Indonesian palm oil industry has given rise to concern about market power exercised by private producers in this industry. Despite its significant market share and apparent vertical integration, the public estates are often assumed to behave competitively and to maximise social welfare. Therefore, the existence of the public estates in this industry is expected to suppress the market power of the private companies. Many government interventions were undertaken based on these assumptions. In fact, the public estates enjoy some degree of market power. As a result, government interventions, in general, are unlikely to have the desired effect.

However, to determine whether a firm exercise market power or not is not always easy and practical. Although the price–(marginal) cost margin has been broadly accepted as a measure of market power, it is often not conducive to apply. The main practical obstacle is to determine firms' marginal cost. Hence, courts and policy makers in Indonesia often use other proxies—such as market share—to identify market power. Although this might be more practical, the results often appear to be problematic and misleading.[27] In contrast, using an appropriate market model might reveal more reliable information about a firm's behaviour in the industry, including that emerged from a non-cooperative mechanism. The information about the firms' behaviour would be useful for promoting

[27] See the SCP critiques in Chapter 3.

competition in the Indonesian CPO industry, as well as other industries. As indicated, the consequence is expected to be significant because of the importance of this industry.

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