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A SUPPLY RESPONSE MODEL FOR

INDONESIAN PALM OIL

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Retno Agustina Ekaputri
December 1996

NO-VET-MED.
Thesis
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DEDICATION

This dissertation is dedicated for;

my husband;
Dr. Budiyanto

and our two beautiful children;
Kirana Widyastuti Budiyanto
and **Sarah Khairunnisa Budiyanto**

Also for my parent;
Prof. Dr. & Mrs. Soekotjo

and parent-in-law;
Mr. (Late) & Mrs. Sarjanto

ACKNOWLEDGMENTS

I would like to express my sincere thanks to my major advisor, Dr. Gregory Pompelli for his guidance, encouragement and invaluable help through my study at the University of Tennessee, USA. He served as an advisor and friend. I also thank Drs. Burton English, Kimberly Jensen and Jean Skinner who served on my Ph.D. committee and reviewed my dissertation.

I would like to thank Dr. Gary Schneider, Associate Dean of the College of Agricultural Sciences and Natural Resources, and Dr. Handy Williamson, Jr., Head of the Department of Agricultural Economics and Rural Sociology for their continuous support during my study at U.T.K. I am indebted to Universitas Bengkulu, Bengkulu, Indonesia for providing me the opportunity to pursue a doctorate degree at U.T.K., under USAID-HEDS project for its fellowship throughout my entire study.

Appreciation is also expressed to Mrs. Kandace Beal for typing the final draft of my dissertation and to Ms. Vicky Johns for editing my final draft of dissertation. Last but not least, I would also like to thank Chandra Tan, Marisa Ernst, Jose Velasques, Ralph & Ben McKosky and all of my friends at the Indonesian Student Association (PERMIAS) at Knoxville and the Department of Agricultural Economics and Rural Sociology for their friendship and encouragement.

Above all, I would like to thank God The Almighty for the strength and guidance to finish my study.

ABSTRACT

Indonesian palm oil producers are potentially effected by six factors. These six factors are: (1) changes in domestic palm oil sales and competition for hectarage from other domestically produced crops; (2) international demand for and supplies of palm oil and its substitutes; (3) technical advances; (4) health and nutrition driven changes in consumer demand; (5) government policies; and (6) the perennial nature of palm oil trees. Given that palm oil is an important agricultural crop in Indonesia and that the profitability of the palm oil industry is heavily influenced by domestic and international markets, this study examines how palm oil hectarage is affected by market forces, grower expectations, and governmental policy.

A double-log, ordinary least square analysis was used to analyze the hectarage response model for Indonesian palm oil. The variables incorporated in the model were in terms of two-year moving averages which captured grower expectations. The independent variables included two- year moving averages of hectarage, palm oil prices, coconut oil prices, Malaysian palm oil production and an interaction variable of Malaysian and Indonesian palm oil production. Results indicated that all estimated coefficients had the expected signs and were statistically significant at a 95 percent level.

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CHAPTER I

INTRODUCTION

Background

Indonesian palm oil producers' production decisions are potentially influenced by six significant domestic and international factors. First, palm oil producers' planting decisions are influenced by changes in domestic palm oil sales and competition for hectarage from other domestically produced crops. Second, international demand for and supplies of palm oil and its substitutes affect the Indonesian growers' production decisions. Third, technical advances have increased the degree of substitutability of different oils in food and nonfood uses. Fourth, and related somewhat to advances in food technology, Indonesian palm oil growers are faced with additional demand uncertainty due to health and nutrition driven changes in consumer demand for their products. Fifth, governmental policies have influenced, and continue to influence, growers' production and marketing decisions. Finally, growers' decisions are continually affected by the perennial nature of the palm oil tree, which introduces a multi-year horizon to growers' production decisions because initial production from new plantings takes place only after several years of maturation. This biological limitation means that Indonesian palm oil tree growers must base their decisions on their expectations of future domestic and international market conditions. This study attempts to assess the influence of these six factors on Indonesian palm oil producers' decisions using a

perennial supply response model.

Since 1980, Indonesia's palm oil industry has grown very rapidly. The area of production continues to increase and is projected to expand to 2.5 million hectares by the year 2005, more than double of the total area planted in 1990 (Lubis et al. 1993). Indonesia has increased its share of palm oil from 15.2% in 1985 to 28% in 1995. However, as of 1995, Malaysia remains the dominant palm oil producer.

Palm oil hectarage and, hence, production in Indonesia has increased considerably in the past two decades. More than 50% of palm oil production is used to meet domestic demand for edible oil. The lower price of palm oil has led domestic consumers to switch from traditional consumption of coconut oil to palm oil. Indonesia's export earnings from palm oil has become an increasingly important factor in its growth. As a result, government support for the export of nonpetroleum commodities has accelerated the development of the Indonesian palm oil industry.

Malaysia and Indonesia have a combined production of more than 70% of the world's total supply of palm oil. In 1994, exports of palm oil from four Southeast Asian countries (Malaysia, Indonesia, Papua New Guinea and Thailand) accounted for 32% of the world's fat and oil exports. In addition, Indonesia and the Philippines are the biggest producers of coconut oil. Given that palm oil, palm kernel and coconut oil are primarily produced for export, Southeast Asian countries provide about 40% of the world's trade in of fats and oil (Basiron, 1995).

Technical advances in food science and manufacturing have increased palm oil and other fats and oils in the food industry, as well as substitutability among new non-food uses.

This has compounded the interrelationships among fats and oils and led palm oil palm oil producers to attempt to adjust the quality and characteristics of their oil to meet changing consumer needs (deMan, 1992; Basiron, 1995).

Indonesia, with its large domestic market of 188 million people, is in a unique position to sell its palm oil in either international or domestic markets. This choice is typically a function of the price and availability of coconut oil. Due to the relatively lower price of palm oil compared to coconut oil and their similarities in uses, consumers may choose to substitute palm oil for coconut oil. In contrast, demand for coconut oil in international markets may lead Indonesian coconut oil producers to increase exports of coconut oil due to higher prices and expected growth in lauric oil prices (Anonymous, 1995; Lubis et al. 1993).

According to Lubis et al. (1994), the expansion in palm oil production in Indonesia is due to government incentives in the early 1970's which were initiated to overcome the domestic shortage in the coconut oil production. Government policies toward exports, such as lower interest loans for crops export and deregulation, have had a positive impact on palm oil plantations. During this period , palm oil hectarage and, hence, production increased considerably. Domestic price controls on palm oil were terminated in 1990, so the local market has become more attractive to palm oil producers (Lubis et al. 1994)

Given the perennial and initial nonbearing nature of palm oil trees, palm oil production is not as flexible as are annual crops in responding to fluctuations in demand or other market conditions. Palm oil production is also somewhat cyclical, primarily due to the tree age, maturity and alternate bearing production cycles. As a result, the supply of palm oil is relatively predictable once plantation age and area are known. Unfortunately, demand for

palm oil in the fats and oils market, in which palm oil competes, is much more complex. This study of the supply response of palm oil will provide understanding of the importance of domestic and international market forces and growers' expectations for producing palm oil.

Problem Statement

1. Indonesia's domestic market is large, but not large enough to consume Indonesia's palm oil production at prices that are profitable for Indonesian producers.

2. The international market for palm oil is very competitive. Palm oil competes for market share with palm oil from other regions as well as with different types of edible oils from Indonesia and other regions.

3. Palm oil is a perennial crop, which means that planting, removal and production decisions today affect the productive capacity of the industry for years. It also means that producers must base their planting, removal and production decisions on expectations about future market conditions and prices, including changes in technology and consumer demand.

4. Given that palm oil is an important agricultural crop in Indonesia, and the profitability of the palm oil industry in Indonesia is heavily influenced by items 1, 2, and 3, it is important to understand how palm oil hectarage is affected by market forces, growers' expectations and governmental policy actions.

Objectives of Research

The specific objectives of this study are:

1. To examine the palm oil industry in Indonesia, identifying changes in a domestic and international markets, competition in oil markets and the marketing situation for Indonesian palm oil producers;

2. To analyze possible responses by Indonesian palm oil producers resulting from changes in domestic and international market conditions by estimating a supply response model for Indonesian palm oil; and

3. To draw implications from the findings and recommend policy alternatives that both Indonesian policy makers and private businesses can apply to maintain or enhance the palm oil industries in Indonesia.

CHAPTER II

PALM OIL SITUATION

Domestic Production and Markets Factors

Currently, both private estates and small holders dominate palm oil production in Indonesia. As shown in Table 2.1, government holdings dominated ownership of the palm oil plantings until 1990, when the private estates accounted for a greater area than government ownership for the first time (Lubis et al. 1993). In the last decade (1985 to 1995) total hectarage expanded more than threefold, from 597,362 to 1,971,912 hectares. It is notable that the increase was higher in smallholder and private ownership rather than in government ownership. According to Moll (1987), palm oil plantations in Indonesia were established around 1911 in Sumatra. In 1938, oil palm plantings were about 90,000 hectares but declined in the following years because of Japanese invasion. Beginning in 1968, Indonesian government nationalized the Dutch estates and regrouped them into 28 independent management units as either a state estate company (PNP = Perusahaan Perkebunan Negara) or a state estate company with limited liability (PTP = Perseroan Terbatas Perkebunan). Other private estates (not owned by Dutch) were returned to the owners. These estates specialized in either rubber or palm oil. Technical and financial assistance from donor agencies such as the Asian Development Bank and the World Bank were accepted to implement the rehabilitation and development of estates. During the late 1960's and early 1970's palm oil was considered more profitable than rubber, so that many

Table 2.1. Ownership of Palm Oil (Hectarage)

Year	Ownership (Hectarage)			
	Smallholder	Government	Private	Total
1967	0	65,573	40,235	105,808
1970	0	86,640	46,658	133,298
1975	0	120,940	67,885	188,825
1980	6,175	199,538	88,647	294,560
1985	118,564	335,195	143,603	597,362
1990	294,956	372,109	476,685	1,143,750
1991	347,502	376,147	552,643	1,310,996
1992	439,468	389,760	638,241	1,467,469
1993	543,933	401,994	702,060	1,639,018
1994	585,062	411,360	795,991	1,792,413
1995	644,856	420,945	906,111	1,971,912
2000*	687,987	472,324	943,497	2,103,810
2005*	937,309	529,974	1,399,117	2,438,892

Source: Directorate General for Estate. "Estate Statistics". Various issues.
* projected value.

rubber estates were replanted with palm oil (Moll, 1987). Since then, palm oil estates have expanded very rapidly.

Domestic consumption of vegetable oil in Indonesia increased by 5.6% per year from 1987 to 1991 due to increases in population and per capita consumption (Lubis, 1993). After palm oil coconut oil is the second most consumed vegetable oil in Indonesia. The consumption of coconut oil since 1987 has been stable at around 600 thousand tons per year, on the other hand, consumption of palm oil has increased considerably, from 868 thousand tons in 1987 to 1,228 thousand tons in 1991. Per capita consumption of oil and fats is 12.7 kg/year, and about 75% is palm oil consumption. From 1990 to 1994 per capita consumption of palm oil increased by almost 50%, from 6.6 kg/year to 9.7 kg/year. Currently, Indonesia is a net exporter for palm oil, however, imports of palm oil usually occur during the Ramadan month, when most of the Indonesian Muslims (about 90% of the population) celebrate the Holy month (Lubis, 1995). This suggests that the marketing capacity of the palm oil industry, including oil products such as shortening, margarine, cooking oils, is not able to meet peak domestic demand. Production of palm oil is not sufficient to satisfy the increased demand during those periods, mainly because of lack of processing capacity.

As the second largest exporter of palm oil after Malaysia, Indonesia has the potential to increase its market share in the future. Indonesian palm oil exports in 1990 were 55% of total world exports, but have declined to around 50% since then (Table 2.2). One reason for the decline is the growing number of palm oil processing facilities in Indonesia, which process crude palm oil for domestic consumption. The large home market effect may, however,

Table 2.2. Indonesian Palm Oil Production and Exports (1000s tons)

Year	Production	Exports		Exports as % of Production
		Volume	Value (000 US$)	
1969	217	179.11	23978	82.54
1970	248	156.63	35063	63.16
1975	434	386.18	151639	88.98
1980	752	502.9	254739	66.88
1985	1280	616.77	238403	48.19
1990	2650	1460	247689	55.09
1991	2750	1207	335481	43.89
1992	3250	1717	366494	52.83
1993	3650	1850	582629	50.68
1994	4000	2050	717811	51.25
1995	4300	2200	*	51.16

Source: Indonesian Central Bureau of Statistics, "Statistical yearbook of Indonesia", various issues and USDA, "Production Supply and Demand (PS&D) Time Series (T.S.)", 1995.
Note: * indicates missing data

enable the Indonesian palm oil industry to grow even larger, especially as the use of new processing technologies enables processors to be more efficient and competitive in the international markets.

Most of the palm oil is processed as cooking oil. In Indonesia there are 45 cooking oil processing firms with 1,496,572 tons annual production capacities. Eight out of twenty-seven provinces in Indonesia have cooking oil processing firms. Those firms are located in the western part of Indonesia. It is expected that with a growing demand for cooking oil, some firms may move into other parts of Indonesia. As mentioned, cooking oil prices are no longer controlled by the government. As a result, new market entrants may have renewed interest in palm oil production and processing.

International Production and Market Factors

Worldwide, soybean oil dominates vegetable oil production, followed by palm oil (figure 1). However, in the past ten years palm oil production has grown faster than that of any other vegetable oil. Between 1985 and 1995, palm oil production increased by 90.98%, while rapeseed oil increased by 78.25%, soybean oil by 42.66%, sunflower oil by 30.90%, and cottonseed oil by 11.44%. During the same period, coconut oil and olive oil production decreased by 8.56% and 9.78%, respectively.

Malaysia and Indonesia dominate world palm oil production with 53.9% and 27.9% of world production, respectively, in 1995. Africa and Latin America accounted for only 8.6% and 5.5% each. Since the 1970's and 1980's palm oil production has declined in Africa

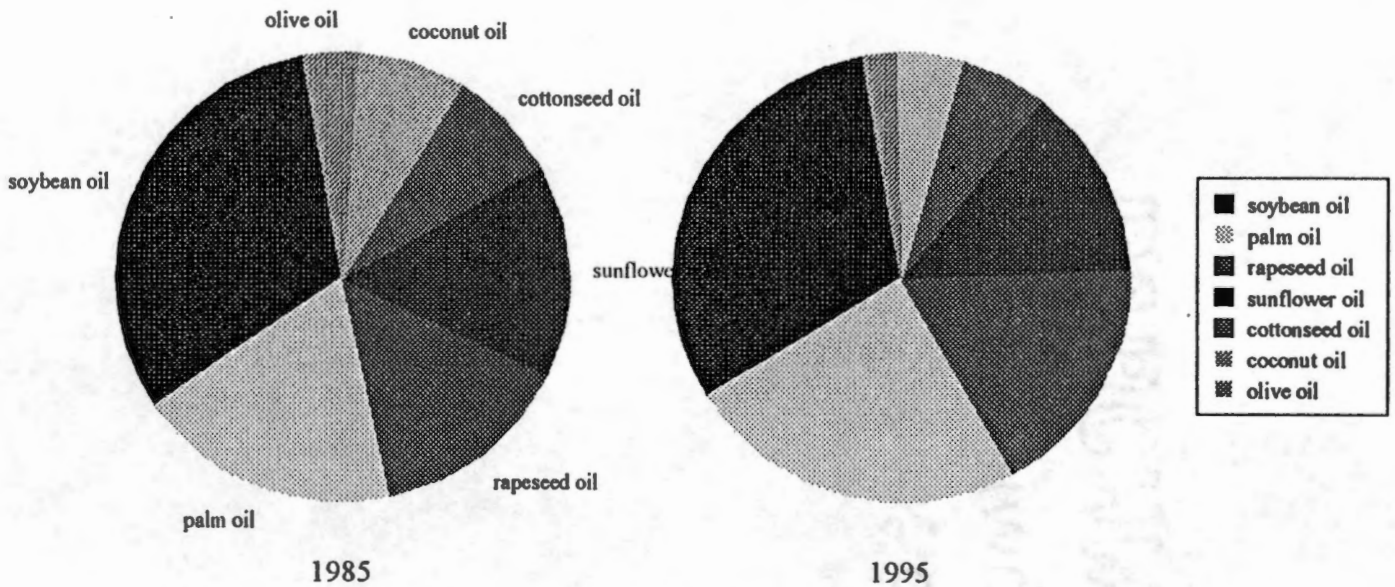

Figure 1. World's Production Share of Major Vegetable Oils

but increased in Southeast Asia (Malaysia and Indonesia). World palm oil production has increased from 8,056 thousand tons in 1985 to 15,385 thousand tons in 1995. The countries with the greatest production of each vegetable oil (Table 2.3) have remained the same since 1985: coconut oil, Philippines; cottonseed oil, Peoples Republic of China; olive oil, Italy; rapeseed oil, People's Republic of China.

Table 2.4 shows the world imports of palm oil through 1995. The European Union (EU-15), People's Republic of China and Pakistan are the major importers of palm oil, and each import more than 1 million tons each year. From 1980 to 1993 crude palm oils (CPO) prices acted as the floor price for soybean oil, sunflower oil and coconut oil (Table 2.5). Only in 1981, 1984 and 1987 were CPO prices higher than soybean oil prices. In 1981 the CPO price was also higher than the coconut oil price. The price increases were due to shortages in palm oil production.

Palm oil dominated world export of major vegetable oils in 1992 (Table 2.6). Palm oil exports were almost double the amount and value of soybean exported. Even though the volume exported was low, olive oil represented the third highest exported oil in terms of value, but represented only a minor exported oil in terms of volume.

Technological Advances in Palm Oil

The relationship among various forms affects competition in oil markets. Oil qualities such as odor, shelf life, and color indicate whether those oils are substitutes or complements

Table 2.3. Major Producers of Selected Vegetable Oils

Vegetable Oils /Countries	Production ---------1,000s tons(%)------ 1985	1995	% change 1985 - 1995
Soybean Oil:			
World	13785	19666	42.66
United States	5269	7119	35.11
Brazil	2319	3647	57.27
Palm Oil:			
World	8056	15385	90.98
Malaysia	4772	8300	73.93
Indonesia	1280	4300	235.94
Rapeseed Oil:			
World	6217	11082	78.25
China, People Rep.	498	2727	447.59
India	870	1680	93.10
Germany	n/a	1208	n/a
Sunflower:			
World	6670	8731	30.90
Argentina	1408	1780	26.42

Continued

Table 2.3 (Continued)

Cottonseed Oil:			
World	3478	3876	11.44
China, People Rep.	625	897	43.52
India	331	531	60.42
Coconut Oil:			
World	3296	3014	- 8.56
Philippine	1587	1231	-22.43
Indonesia	720	734	- 1.94
India	236	400	-69.49
Olive Oil:			
World	1626	1467	- 9.78
Italy	641	400	-37.60
Spain	397	350	-11.84
Greece	262	290	10.69
Tunisia	105	170	61.90

Source: USDA, Economic Research Service, 1995.

Table 2.4. World Imports of Palm Oil (1000s tons)

Country	1991	1992	1993	1994	1995
EU-15	1795	1745	2021	2025	2000
China, People Rep.	875	800	1420	1600	1600
Pakistan	935	884	1060	1210	1150
Singapore	900	940	975	975	975
India	165	30	200	520	525
United Kingdom	357	366	426	450	465
Germany	409	358	427	425	415
Netherlands	372	400	422	410	400
Egypt	305	325	420	350	390
Japan	327	339	348	350	350
World total	8595	9075	10783	10668	10956

Source: USDA, Economic Research Service, 1995.

Table 2.5 Price Comparison of CPO, Soybean, Sunflower and Coconut Oil's in US$/ton

Year	Soybean FOB Ex Mill	Coconut CIF Ex Rotterdam	CIF Rotterdam	CPO %of Soya	CPO %of Coconut
1967	761	1,150.5	784.6	103.1	68.2
1970	1,034	1,337.7	875.8	84.7	65.5
1975	1,035	658	583.5	56.4	88.7
1980	589	674	584	99.2	86.6
1981	507	570	571	112.6	100.2
1982	447	464	445	99.6	95.9
1983	527	730	502	95.3	68.8
1984	724	1,153	729	100.7	63.2
1985	572	590	501	87.6	84.9
1986	342	297	258	75.4	86.9
1987	335	455	344	102.7	75.6
1988	461	571	436	94.6	76.4
1989	430	516	349	81.2	67.6
1990	435	334	289	66.4	86.5
1991	484	429	339	70.0	79.0
1992	432	579	394	91.2	68.0
1993	594	449	377	63.5	84.0

Source : Gapki monthly bulletin, January 1994 (in Lubis et al, 1994), and World Bank, "Commodity Trade and Price Trends", various editions.

Table 2.6 World Exports of Majors Vegetable Oils in 1992

Commodity	Amount	
	Metric Tons	US$
Palm Oil	7881699	3123957
Soybean Oil	4208356	1933449
Olive Oil	717400	1753015
Sunflower Oil	2495099	1307245
Rapeseed Oil*)	1934961	966783
Coconut Oil	1562971	875012
Cottonseed Oil	289995	130643

Source: FAO. 1993. Trade Yearbook. Rome

*) Rapeseed and Mustard Oil

(Suryana, 1986). However, technological development may alter the relationship among oils. Edible palm oils may be used in salad and cooking oils, margarine and shortening. In general, vegetables oils and fats can be grouped into three groups based on their fatty acid composition (lauric acids, lenioc acids or erusic acids). Each group has different properties that lend themselves to different edible uses.

Beside edible uses, palm oil also has nonedible uses, including commercial printing inks, personal care products, pharmaceuticals, and most recently as a possible replacement for fuel in the petroleum-based cars in Malaysia (Anonymous, 1995).

Nutritional Aspects of Palm Oil Demand

Palm oil is a safe and nutritious source of edible oil for healthy humans (Cottrell, 1991). It is used worldwide in cooking oils, margarine or shortening, and as an ingredient by food industries. In many regions of the world, it is a good source for meeting dietary requirements for energy and essential fatty acid needs (Calloway and Kurtz, 1956). Palm oil is extracted from the fruit of the palm while palm kernel oil and coconut oil are derived from the palm seed. Some of the nutritional properties of palm oil include: no cholesterol, carotenoid, vitamin E antioxidants, linoleic acid, and balanced in fatty acid composition (Hirai, Okamoto, and Morimatsu, 1982; Cross, 1987; Wood, 1992).

Since the 1980's, producers have been challenged by health concerns about the saturated fat properties of palm oil. Despite a campaign which started in the United States in the late 1980's and described high levels of saturated fats in palm oils and other tropical

in the late 1980's and described high levels of saturated fats in palm oils and other tropical oils, recent studies suggest that palm oil saturated fat characteristics are balanced by other factors (deMan et al, 1992; Basiron et al, 1995). Current studies indicate that palm oil is not atherogenic; in fact, regular consumption of palm oil increased levels of HDL, the good cholesterol that reduces the tendency of blood platelet aggregation (Hayes et al, 1995; Wood, 1992; deMan et al, 1992). This finding is a promising feature for future uses of palm oil in foods. Nonetheless, palm oil processors continue to study ways to preserve the good properties of palm oil (e.g., stability) and eliminate the undesirable properties (e.g., degree of saturated fat).

Studies in human consumption and epidemic data reveal that palm oil does not raise blood cholesterol level in comparison with olive, canola and peanut oils (Wood, 1992; Ng et al., 1992). In animal studies on hamsters, a palm oil-enriched diet was found to induce the highest level of protective HDL- cholesterol and greatest production of LDL receptors; both are essential in removing harmful LDL-cholesterol in blood (Lindsey, 1995). In another animal study, it was found that a palm oil-enriched diet reduced the tendency for blood clotting in the rat (Hornstra, 1988).

Indonesian Government Policies on Palm Oil

From 1978 to 1987, the Indonesian government's policy regarding palm oil was to secure domestic supplies and stabilize edible oil prices (Lubis et al., 1994; Tomich and

Mawardi, 1995). Tomich and Mawardi stated that after 1987, the Indonosian government's palm oil policy was to promote exports, and that the driving force of the policy was the rapid growth of palm oil. The expansion of palm oil production shift the Indonesian's policy from meeting domestic consumption to more freer export to avoid domestic accumulation.

In Indonesia, the primary use of palm oil is for cooking oil. Since cooking oil has been categorized as one of nine essential needs of Indonesia, the government tightly controlled its price until 1990. According to Tomich and Mawardi (1995), 97% of domestic demand for manufactured edible oil in Indonesia was met by coconut oil and palm oil (refined, bleach, deodorized olein). Government policy on cooking oil basically was intended for (1) consumers' protection by ensuring adequate supply and provide affordable cooking oil; (2) cooking oil processors by guiding investment in processing capacity to meet consumers' need and promoting industrial development, and (3) edible oil producers by promoting investment in palm oil plantations to meet domestic demand while generating surplus for export, while also protecting coconut oil producers by supporting its prices (Tomich and Mawardi, 1995).

After 1990, because of the policy encouraging freer export of crude palm oil (CPO), the gap between export and domestic prices narrowed. In 1980 the export price was almost $5 per ton higher than the domestic price, but in 1985 the export price was lower about $13 per ton than the domestic price. Form 1990 to 1993, the domestic price continued to be higher than the export price, except in 1991 when the export price was $2 per ton higher than the domestic price. The most current deregulation package was enacted in June 1991. The package permits private firms to export as much CPO as they wish.

Biological Nature of Palm Oil Production

The size of cultivated land predetermines palm oil supplies by the level of mature palm oil trees. The economic life cycle of palm oil tree is about 25 years; trees reach maturity four years after planting and reach peak production in eight years (Table 2.7). The palm oil industry also exhibits a high yield cycle every four years, especially when the peak of the cycle coincides with favorable weather (Basiron and Abdullah, 1995). Basiron and Abdullah (1995) also noted that following peak years, there is usually a slight decrease in production due to the stress experience in the previous year.

Moll (1987) specified ecological requirements for growing palm oils. Climatic requirements included; (1) average annual rainfall of 2000 mm or more preferably distributed evenly throughout the year, (2) mean maximum temperature of 29 to 30 °C and mean minimum of 22 to 24 °C, and (3) sunshine of at least 5 hours per day throughout the year. Palm oil requires an adequate supply of soil moisture. According to Moll (1987), soils that were unfavorable were poorly drained soils, lateric soil that contains concretionary ironstone, very sandy coastal soil and deep peat. He indicated that suitable zones for palm oil were

> ...Africa, the coastal belt in West Africa from Guinea to Zaire, the Congo River Basin and the east coast of Madagascar; Central America, the Caribbean coastal area from south Mexico to Panama except the Yucatan Peninsula; South America, extensive areas in the Amazon Basin in Brazil, Colombia, Ecuador and Peru, and several other countries in these areas; South-East Asia, Malaysia and Indonesia ...; South Pacific, the Solomon Island... (Moll, 1987).

Table 2.7. Expected Yield by four-year period (tons of f.f.b./ha)[1]

Number of years after planting	Yield	
	Average	Changes
4	6	
		19
8	25	
		-2
12	23	
		0
16	23	
		-1
20	22	
		-2
24	20	
		-2
28	18	

Source: Marihat Research Station, Indonesia (in Moll, 1987).
[1] f.f.b = fresh fruit bunch.

CHAPTER III

SUPPLY RESPONSE MODELS

This literature reviews is divided into three parts: early studies of perennial supply response (prior to 1980's); perennial supply response studies in the 1980's; and current study of perennial supply response (1990's).

Early Studies of Perennial Supply Response (Prior to 1980's)

Studies in the 1950's and 1960's

Nerlove (1956) estimated elasticities of cotton, wheat and corn. He argues against the previous study on supply response which suggested that farmers respond very little to prices in their decision on hectarage. He stated that

> Farmers react, not to last year's price, but rather to the price they expect, and this expected price depends only to a limited extent on what last year's price was. (Nerlove, 1956: p.498)

The formulation of his model is as follows:

$$P_t^* - P^*_{t-1} = \beta[P_{t-1} - P^*_{t-1}], \quad 0<\beta\leq 1 \qquad eq\ 3.1$$

where:

P_t^*= price expected this year

P^*_{t-1} = price expected last year

P_{t-1} = actual price last year

β = coefficient of expectation

Nerlove (1956) stated that farmers adjust their expectation for the coming period proportional to the error in predicting price during the current period. Acreage planted in the current year is formulated as a function of its expected price such that:

$$X_t = \alpha_0 + \alpha_1 P^*_t + u_t \qquad eq\ 3.2$$

where:

X_t = acreage planted in the current year.

By substituting P* into X_t :

$$X_t = \pi_0 + \pi_1 P_{t-1} + \pi X_{t-1} + v_t \qquad eq\ 3.3$$

where:

v_t = random residual ($v_t \neq u_t$)

Therefore, the model for acreage planted in the current year is a function of lagged acreage and lagged actual prices. Derivation includes β_1 which emphasizes weighted average of past prices. Actual acreage is equal to desired acreage and expected price is not equivalent to price lagged one year (Nerlove, 1956). Maddala (1992) stated that the Nerlove model is called adaptive expectation, in which "adaptive" refers to the most recent error adjustment.

French and Bressler's (1962) lemon cycle study was based on the hypothesis that the

lemon industry in California followed a cobweb condition in which producers made decisions based on recent past and current prices. They approximated an equation in linear form and posited that net response (acreage changes) was a difference between acreage planted and removed. Once the acreage changes were estimated, total output changes could be found by multiplying it with average yield. The proportion of acreage planted was a function of expected long-run profitability from growing lemons, proportion of age distribution of the tree, expected profitability of the alternative crops and other minor combined effects. French and Bressler used one period lag between new planting and profit and replacements to indicate that one year was the time required once a decision was made to obtain seedlings and plant. Expected profitability was approximated by an average of the past five years actual net returns per acre. The proportion of acreage removed was a function of the proportion of bearing acreage over 25 years of age, expected current short run profit and the proportion of acreage removed to urban expansion. The equations were then estimated with least square methods for the period 1947 to 1960. French and Bressler found that the variable proportion of bearing acreage over 25 years and expected current profits were not significant.

Bateman (1965) studied an aggregate and regional supply of Ghanian cocoa for the period from 1946 to 1962. The farmer's objective was assumed to maximize the present discounted value of the future stream of net returns from investment in the cocoa. Bateman specified the relationship of plantings and prices such that the number of acres planted was a function of mean value of discounted future price of cocoa and the mean value of discounted future prices of coffee. The rate of discount was based on the farmer's subjective rate of discount. Price expectation was based on the Nerlovian form that the mean value of

expected price this year minus the average of last year's average price is related to the difference between actual producer price this year and the mean value of last year's expectation. The relationship between planting and output was based on the nature of cocoa production, which Bateman divided into two periods with different rate of output growth. The final supply response model was formulated such that the change in cocoa harvested was explained by producers' prices, rainfall and humidity and lag changes in output. Lag producer prices were divided into two periods regarding the difference in the output growth for both cocoa and coffee. The equation was estimated with ordinary least square multiple regression (Bateman argued that this method may be applied as long as autocorrelation was not present). Seven regions were estimated separately two times each. The first estimate included all the variables in the model; after that, variables that were not significant was dropped from the equation. For all regions, cocoa prices and rainfall were found to be significant and have positive coefficients. Coffee prices and humidity had negative coefficients, although they were not significant factors in most of the regions.

In his model of cocoa supply response, Behrman (1968) tried to include international effect in the model. Monopolistic price in the cocoa market was characterized as having five major characteristics: (1) production was concentrated in a few less developed countries; (2) few standards had dominance in the standard grades in international market; (3) there was limited short-run supply response to economic incentives; (4) there was substantial long-run supply response to economic incentives; (5) government marketing institutions existed in some countries. Behrman's cocoa supply equation then was modeled such that the change in the quantity produced was a function of past changes in the quantity produced, expected

prices of cocoa and expected prices of coffee. Expected real prices of cocoa and coffee were hypothesized as a weighted average of all past actual real prices. Behrman used 1947/48 to 1963/64 data to estimate eight different major cocoa producers (Ghana, Nigeria, Ivory Coast, Cameroon, Brazil, Ecuador, Dominican Republic, and Venezuela). Ordinary least square estimates for the equations found that the coefficient of cocoa price changes were all positive, the coefficients for coffee prices coefficient were negative and the coefficient of past changes in the cocoa output varied between countries. The adjusted sum of square errors varied from 0.36 to 0.70.

Arak (1969) estimated a supply response model for Brazilian coffee from 1927 to 1959. The desired planting was a function of expected real coffee prices and the removal depended on the profit on existing trees compared to the profit from switching to other activities. Arak's supply response equation for the coffee was defined such that the change in the capital stock depended on the difference between actual and desired level of capital stocks. The equation was estimated for the maximum likelihood of each state with Quandt and Goldfeld algorithm; R^2 was 0.346 for Esprito Santo region and 0.256 for Minas Gerais. The coefficients of estimates were found to be positive and significant. Price elasticities were 0.54 and 0.28, respectively, for Minas Gerais and Esprito Santos.

Bateman (1969) formulated four different supply models to estimate perennial crops in less developed countries. Four different scenarios were:

(1) Gross investment was a function of price.

In this model, Bateman suggested that the primary factor causing a change in the farmer's price expectation is a change in the real producer prices. It was assumed that the farmer's

objective is to maximize the present discounted value from the investment. In other words, the expected profit is the expected price stream.

(2) Stock of trees was a function of expected prices.

This model suggested that the farmer adjust his stock of trees to price changes.

(3) Desired stock of trees was a function of prices.

In this model, it was assumed that there are certain constraints that keep the farmer from adjusting the actual stock of trees to the desired level given price changes.

(4) The liquidity model

The liquidity model which relates the planting to expected future prices and last period's income, was the final model. Estimation of four models for perennial crops found positive significant price elasticities between 0.32 to 0.87 for all estimates except for Malaysian's estate rubber for the period 1951 to 1961, which was found to be negative and not significant.

French and Matthews (1971)

French and Mathews (1971) provided a general framework for perennial supply response models which has been followed by many researchers. Their general framework involves five components: 1) desired production and acreage by growers; 2) a new planting function; 3) an acreage removal equation; 4) the relationship between observed and unobserved expectation variables; and 5) an equation to explain variation in the values of average yields. The changes in the acreage can be obtained from (2) and (3), while the total production is determined by multiplying acreage and yield.

The basic assumption of French and Matthews (1971) in developing the model was that expected profitability of the commodity is considered and the alternative commodities are the major variables that affect desired production and acreage. Desired production of the producers was stated as:

$$Q_t^* = Q_{t-1}^e + b_{11}(\pi_t^e - \pi_t^*) + b_{12}(\pi_{At}^e - \pi_{At}^*) + u_{1t} \qquad eq.3.4$$

where:

Q_t^* = desired production for year *t*

Q_{t-1}^e = expected average production with acreage at the actual level of *t-1*

π_t^e = expected long-run profitability per unit with production of Q_{t-1}^e

π_t^* = normal long-run profitability per unit of product

π_{At}^e = conditional expected profitability per unit of product for the alternative land use

π_{At}^* = normal long-run profitability per unit of product for the alternative land use

u_{1t} = a disturbance term

By rearranging the terms in equation 3.4, the desired acreage can be stated as;

$$A_t^* = \frac{Y_{t-1}^e}{Y_t^e} A_{t-1} + \frac{b_{11}}{Y_t^e}(\pi_t^e - \pi_t^*) + \frac{b_{12}}{Y_t^e}(\pi_{At} - \pi_{At}^*) + \frac{u_{1t}}{Y_t^e} \qquad eq.3.5$$

where:

Y_t^e = average yield

A_t^* = desired bearing age at t

A_{t-1} = actual acreage at t-1

To avoid heteroskedasticity problems due to Y_t^e, equation (3.5) can be approximated as:

$$A^{*}=A_{t-1}+b_{21}(\pi_t^e-\pi^{*})+b_{22}(\pi_{At}^e-\pi_{At}^{*})+b_{23}\Delta Y_t^e+U_{1t} \qquad eq.3.6$$

After desired acreage is determined then planting and removal can be formulated.

$$N_t^{*}=A_{t+k}^{*}-A_{t-1}+R_{kt}^e-N_{kt-1} \qquad (N_t^{*}\geq 0) \qquad eq.3.7$$

where:

N_t^{*} = desired planting in year *t*

k = interval of time between initial planting and production (bearing)

R_{kt}^e = total amount of acreage expected to be removed

N_{kt-1} = total nonbearing acreage at *t-1*

French and Matthews applied their model to estimate asparagus. Although they had a complete framework for the supply response model, they admitted that because of lack of data, modifications of their models had to be made. Their results indicated consistent estimates and provided a meaningful supply response model for asparagus. The coefficient of estimates for prices of asparagus were the positive and negative coefficient of the estimate for average harvested acreage during the last period. Coefficient estimates to explain the government program (Bracero) were found not significant.

Dunn and Beilock (1979)

Dunn and Beilock (1979) provided a clear description of factors affecting the supply

of perennial crops (Figure 4). Because perennial crops are produced over a period of years, planting, removal and harvest decisions must take into account expected discounted net revenues of crop and alternative uses of land and resources (i.e. other crops). Whenever profit maximization is assumed, the expected revenue will be maximized subject to physical and financial constraints. They estimated a supply response model for Pennsylvania apples. They argued that models developed by French and Matthews (1971) and Bateman (1969) require data on price, quantity and acreage which generally were not available. Therefore, Dunn and Beilock created a method to estimate supply models for perennials without acreage data.

Dunn and Beilock (1979) treated yield as a function of the age of the plant, and said that quantity supplied of perennial was the number of plants times the average yield, thus:

$$Q_t = \sum_{j=s}^{DN_{t-j}} Y_j + u_t \qquad eq.3.8$$

where:

Q_t = quantity supplied at t

N_{t-j} = number of plants age j at t

Y_j = yield of plant at age j

s = the youngest bearing plants

D = the oldest bearing plants

u = a random term to capture variations in weather, harvest intensity, and soil quality.

They assumed that quantity not harvested (losses) would be negligible, so that planting was

formulated as:

$$N_{t-j}=\alpha \sum_{i=0}^{k} B_i R_{t-j-i}+\varepsilon_{t-j} \qquad eq.3.9$$

where:

α = a constant

R_t = net revenue at t

B_i = changes in N_t as a result of a unit change in R_{t-i}

k = number of lagged periods

ε_t = normally distributed error term

By substituting the right hand side of (3.9) into (3.8) and rearranging, the quantity supplied became;

$$Q_t=\alpha^*+\sum_{j=s}^{D} Y_j \sum_{i=0}^{k} B_i R_{t-j-i}+U_t \qquad eq.3.10$$

Furthermore by manipulation the final equation may be stated as;

$$Q_t=\alpha^*+ \sum_{i=0}^{k} B_i Z_{t-1}+ U_t \qquad eq.3.11$$

where:

$$Z_t = \sum_{j=s}^{D} Y_j R_{t-j}$$

Dunn and Beilock (1979) mentioned that the more general form of the equation is possible

whenever there are dramatic extensions in bearing life or midlife adjustments to the yield. are possible:

$$Q_t = \alpha^* + \sum_{i=D}^{D+k} R_{t-1} + U_t \qquad eq.3.12$$

They estimated the model in three general forms; geometrical declining lag, polynomial lag and regressed Q_t as a function of Z_t. Their result indicated that the explanatory power of the variables were good, especially for models which included a dummy variable for years of serious crop failures. The supply elasticity with respect to price over time increases from 0.01 in year 5 to 1.53 in year 31. Time trend coefficients were found to be positive for all the models. It was also found that the shortest lag period was more relevant than the longest lags.

Perennial Supply Response Models in the 1980's

Alston, Freebairn, and Quilkey (1980)

Alston, Freebairn, and Quilkey (1980) estimated a supply response model for the Australian orange industry. Annual data from 1961/62 to 1975/76 were used to estimate the model. Their study indicated that most of the variation in planting could be explained by the expected profitability of growing oranges, the current stocks of bearing and nonbearing trees

and removals of trees in previous year. Their model was based on French and Matthews (1971), but they treated investment in trees in a framework of input demand that emphasized the influence of age composition on the perennial planting decision.

They summarized their plantings, yields and removals equations as follow;

$$PL_t = a_0 + a_1\prod_t^e + a_2NB_{t-1} + a_3B_{t-1} + a_4R_{t-1} + v_t \qquad eq.3.13$$

$$R\text{-}t = dB\text{-}t + w_t \qquad eq.3.14$$

$$Y_t = g_0 + g_1K_t + g_2T_t + h_t \qquad eq.3.15$$

where:

PL_t = the number of tree planted in t

$\prod_T^e$= expected profitability of growing the crop in t

NB_{t-1} = the number of nonbearing tree in t-1

B_{t-1} = the number of bearing tree in t

R_{t-} = the number of tree removal in t-1

Y_t = average yield of bearing tree in t

K_t = proportion of bearing tree under 10 year in t

T_t = time trend

w, h, t are random disturbance terms

The expected profit was presented as:

$$\prod_t^e = (1/n) \sum_{j=1}^{n} \prod_{t=j} \qquad n\geq 2 \qquad eq.3.16$$

where:

$\prod_t = (P_t Y_t)/W_t$ = actual profit in t

P_t = actual price of crop product in t

W_t = average weekly earning as an index of input costs

n = is a length of moving average (varies from 2 to 6 years)

Expected services to perform during the future period are:

$$S^e_{t+b} = \sum_i z_i (N_{i,t-1} - R_{i,t-1}) \qquad eq.3.17$$

where:

S_{t+b}^e = expected level of service perform for the tree in the future t+b period

$N_{i,\,t-1}$ = starting number of tree at period t-1

$R_{i,t-1}$ = number of tree removed during t-1

z_i = expected value of tree age I in year t-1

In their specification, the expected supply of service was reduced because only three age categories were considered (0-4 years, 5-9 years and 10 years or older). Therefore, equation 3.17 was reduced into:

$$S^e_{t+b} = z_n\, NB_{t-1} + z_t\, YB_{t-1} + z_m\, MBt-1 - z_t\, R_{t-1} \qquad eq.3.18$$

where:

NB_t = number of nonbearing trees (trees 0-4 years)

YB_t = number of young bearing trees (trees 5- 9 years)

MB_t = number of mature trees (trees 10 years or older)

R_{t-1} = trees removal at t-1

The level of desired gross investment was:

$$I_t^* = S_t^* - S_{t+b}^e \qquad eq.3.19$$

where:

I_t^* = desired level of investment in t

S_t^* = desired level of service in t

S_{t+b}^e =expected level of services provided in by the target year t+b

The planting equation was modeled in four groups depending on the assumption of the adjustment process (complete adjustment, partial adjustment on net investment, partial adjustment on net and replacement investment and partial adjustment on all investment). The complete adjustment process was:

$$PL_t = b_0 + b_1 \Pi_t^e - z_n NB_{t-1} - z_y YB_{t-1} - z_m MB_{t-1} + z_t R_{t-1} + \mu \qquad eq.3.20$$

The partial adjustment on net investment was:

$$PL_t = \gamma b_0 + \gamma b_1 \Pi_t^e + [(1-\gamma)s_n - z_n]NB_{t-1} + [(1-\gamma)s_y - z_y]YB_{t-1}$$

$$+ [(1-\gamma)s_m - z_m]MBt-1 + z_{tR_{t-1}} + \gamma\mu_t \qquad eq.3.21$$

The partial adjustment on net and replacement investment was:

$$PL_t = \phi b_0 + \phi b_1 \prod_t^e - \phi z_n NB_{t-1} - \phi z_y YB_{t-1} - \phi z_m MB_{t-1} + z_t R_{t-1} + \phi \mu_t \qquad eq.3.22$$

The partial adjustment on all investmentwas:

$$PL_t = \psi b_0 + \psi b_1 \prod_t^e - \psi z_n NB_{t-1} - \psi z_y YB_{t-1} - \psi z_m MB_{t-1} + \psi z_t R_{t-1} + \psi \mu \qquad eq.3.23$$

The reduced forms of all the adjustments (eq.3.20 - eq.3.23) were:

$$PL_t = a_0 + a_1 \prod_t^e + a_2 NB_{t-1} + a_3 YB_{t-1} + a_4 MB_{t-1} + a_5 R_{t-1} + v_t \qquad eq.3.24$$

Removal and yield equations were defined as:

$$R_t = dB_t + w_t \qquad eq.3.25$$

$$Y_t = g_0 + g_1 K_t + g_2 T_t + h_t \qquad eq.3.26$$

Carman (1981)

Carman (1981) estimated the impact of tax reform provisions for the supply of California's citrus, almond and walnut crops. The structure of Carman's model was based on a simple recursive model which in turn was based on the lagged response of production to prices. Equations for planting, change in total acreage, yield and price were estimated for each crop (navel oranges, valencia oranges, lemons, almonds and walnuts). These equations

were used in a simulation model to estimate the impact of a tax reform provision. Planting equations were specified as a function of lagged average price or total revenue, divided by the index of prices paid by farmers for crop production, a dummy variable for income tax reform, farm labor availability and total or bearing acreage. Changes in total acreage were specified as similar to the planting equation except that changes in total acreage were regarded as net investments, whereas plantings were gross investments. Average yields were specified as a function of a time trend to account for the long-term trend in yield.

Carman estimated both linear and logarithmic forms and found that linear forms performed better. Prices were specified as a function of current production of the crop and its competing crops, consumer income, carryover, population and tastes and preferences (reflected by a trend variable). Price equations were estimated as a linear function of the independent variables using ordinary least square methods (Carman, 1981).

Carman estimated annual plantings and changes in annual total acreage equations for each crop and found that results from using both current and real prices and income indicated that current prices and income yielded the best statistical results (Carman, 1981). Tax reform (citrus/almond) coefficients were found to be negative for navel oranges, valencia oranges, lemons and almonds but positive for walnuts. Lags of farm labor index were negative for all coefficient estimates except for valencia oranges' planting equation. Lagged acreage also had negative coefficients for all estimates. Lagged average price and lagged average total revenue coefficients were positive. Most of the variables were found to be significant for at least a 95% level of confidence, except for lagged average of total revenue in total acreage changes for the walnut equation. R^2 were between 0.66 to 0.97.

Albisu and Blandford (1983)

Albisu and Blandford (1983) developed a response model for Spanish oranges and mandarins. They estimated a single aggregate equation for the net effect of plantings and removals and formulated their model based on capacity utilization and expected profit theories. The capacity utilization theory holds that high levels of investment are associated with a high ratio of output to capital, and the expected profit theory identifies expected profits as the key determinant of investment.

They used lagged variables to estimate the net acreage change. Their independent variables were relative to real farmers' price lagged one, relative area equal to or more than 7 years lagged one, area more than 14 years lagged one, and dummy variables to account for data adjustment from government statistics records. Data were collected for the seasons of 1964/1965 to 1975/1976.

Albisu and Blandford indicated the net investment was the difference between the actual and desired capital stock:

$$I_t = K_t - K_{t-1} = I(K^*_{t-1} - K_{t-1}) \qquad eq.3.27$$

where:

I_t = net investment in t

K_t = actual capital stock in t

K^* = desired capital stock in t

Net investment in each period (season) was determined by calculating the difference in total

planted area:

$$A_{i,t} - A_{i,t-1} = A_{i,t}^{p} - A_{i,t}^{r} \qquad eq.3.28$$

where:

A = total area planted

A^p = plantings

A^r = removal

They hypothesized that farmers determined investment by comparing expected profitability among similar alternatives and capacity utilization of each variety or crop:

$$A_{j,t}^{p} = A_1(\pi_{j,t}^{*}, \pi_{i,t}^{*}, U_{j,t}) \qquad eq.3.29$$

where:

π^*_j = expected profits of jth variety

π^*_I = expected profits of ith variety

U_j = capacity utilization factor for jth variety

i,j = 1,...,n

Misra (1985)

Misra (1985) estimated short-run and long-run acreage response models for tea. In his models, Misra included time trend variables for both short- and long-term models. The short-term model estimated the yield of tea at *t* as a function of the price at *t*, price at *t-1*, and

time trend at *t*. Misra's long- term response models are based on the Nerlovian model. Misra specified his acreage equation as a function of the weighted average of the past six years' prices, estimated values of acreage, price at *t* and a time trend. The results indicated that time trend variables were significant in all estimates. Nerlovian specification estimation results indicated short term acreage price elasticities ranging form 0.08 to 0.14 and long-term acreage elasticities ranging from 0.12 to 0.19. In the short-term yield model price and one-year lagged price were found to be significant for all cases. The elasticity of yield to prices changes were low in both the short-term and long-term estimation. Misra mentioned that the low elasticity of yield to price was due to the nature of tea production as a perennial crop and limited varietal advances. Thus, grower decisions were less responsive to price changes once the decision to plant was made (Misra, 1985).

Akiyama and Trivedi (1987)

Another study on tea by Akiyama and Trivedi (1987) for Kenya, India and Sri Lanka modified the Nerlovian approach to incorporate a more detailed investment process. Three sets of equations were estimated: new planting, removal and replanting, and supply decisions. Akiyama and Trivedi (1987) indicated that careful attention must be exercised in modeling supply response models. They mentioned that there are four features in the production process in perennial crops; the existence of a biologically-determined gestation lag between planting and production; the dependence of current production on current and previous levels of output; the existence of significant cost of adjustment with respect to planting and removal

of trees; and the constraints on planting and removal resulting from past decisions and current non-negativity constraints of adjustment process. The implications of their notions were that investment behavior is not myopic and that relevant supply theory is intrinsically dynamic.

French and Willet (1989)

French and Willet (1989) estimated a total acreage response relationship involving lagged values for the combined average returns to growers for fresh and processed utilization for asparagus. Predicted total production was then obtained by multiplying acres by average yield, which was treated as an exogenous variable. Another set of equations was specified to allocate the predicted production among fresh market, canning and freezing uses.

The acreage equation was defined as:

$$A_t = A_{t-1} + aN_{t-k} - RM_{t-1} \qquad eq.3.30$$

where:

A = total bearing acreage

N = new plantings

RM = bearing acres removed from t-1 acreage

a = number slightly less than 1.0 to account for plantings removed prior to reaching bearing age

k = years from planting to bearing

Assuming initially that the planting and removal relationships can be approximated by linear functions, the acreage change identity (eq 3.30) may be transformed as follows:

$$A_t = A_{t-1} - (b_0 + b_1 A_{t-1} + b_2 R_{t-1} + V_{1t-1)} + (a_0 + a_1 R^{*}{}_{t-2} + V_{2t-2}) =$$

$$c + \mu A_{t-1} - b_2 R_{t-2} + V_t \qquad eq.3.31$$

Applying the Koyck transformation, the expected return becomes a geometric lag distribution of past and actual returns. As a result equation 3.1 may be expressed as:

$$A_t = c(1-\lambda) + (\lambda + \upsilon) A_{t-1} - \lambda \upsilon A_{t-2} - b_2 (R_{t-1} - \lambda R_{t-2}) + a_1 (1-\lambda) R_{t-3} + V_t - \lambda V_{t-1} \qquad eq.3.32$$

To account for the government's migrant labor program (Bracero effect) a 0-1 dummy variable was introduced. The linear estimation equation takes the form:

$$A_t = \beta_0 + \beta_1 (R_{t-1} - \lambda R_{t-2}) + \beta_2 R_{t-3} + \beta_3 D65 + \beta_4 D66 + \beta_5 D1 + \beta 6 T65 + (\lambda + \mu) A_{t-1} + (-\lambda\mu) A_{t-2} + U_t \quad eq.3.30$$

The Log linear form was used to approximate dynamic relationships and was computational much simpler. Therefore, the acreage adjustment model is respecified as:

$$lnA_t = \beta_0 + \beta_1 (lnR_{t-1} - \lambda lnR_{t-2}) + \beta_2 lnR_{t-3} + \beta_3 D65 + \beta_4 D66 +$$

$$\beta_5 D_1 + \beta_6 T65 + (\lambda + \mu) \ln_{t-1} + (-\lambda\mu) lnA - t - 2 + U_t \qquad eq.3.33$$

A similar model may be derived by combining a partial adjustment model for A (expressed in logs) with an adaptive expectations model modified to include R as a return variable affecting removals:

$$lnA_t = lnA_{t-1} + \alpha(lnA_t^* - lnA_{t-1}) \qquad eq.3.34$$

$$LnA_t^* = \gamma_0 + \gamma_1 lnR_{t-1} + \gamma_2 lnR_{t-2}^* + V_2 \qquad eq.3.35$$

By substituting this gives:

$$lnA_t = \alpha\gamma_0 + (1-\alpha)lnA_{t-1} + \alpha\gamma_1 lnR_{t-1} + \alpha\gamma_2 lnR_{t-2}^* + \alpha V_t \qquad eq.3.36$$

Taking the unconditional expectation (3.36) and appropriate substitution;

$$lnA_t = \beta_0 + \beta_1(lnR_{t-1} - \lambda lnR-_{t-2}) + \beta_2 lnR_{t-3} + \beta_3 D65 + \beta_4 D66 +$$

$$\beta_5 D1 + \beta_6 T65 + (\lambda + \mu)E(lnA_{t-1} + (-\lambda\mu)E(lnA_{t-2}) + e_t \qquad eq.3.37$$

Recent Studies of Perennial Supply Response (1990's)

Knapp and Konyar (1991)

Knapp and Konyar (1991) utilized a Kalman filter approach and iterative parameter search procedures to provide maximum likelihood estimates of the unknown parameters and

age group acreage. First, they developed a state-space model for perennial crops supply. Then, they formulated equations to capture new planting and removal acreage based on the existing acreage of the perennial crops. They applied the model to estimate alfalfa supply response. Knapp and Konyar (1991) assumed that growers' decisions about plantings and removals were the result of maximizing their profits over an infinite time horizon.

Knapp and Konyar's (1991) estimates were based on naive price and cost expectations and quasi-rational expectations. Their results indicated a reasonable fit for the data but naive expectation provided more consistent results than quasi-rational expectation. Under naive expectations the results showed negative price elasticity with respect to the competing crop prices which were expected, but under quasi-rational expectation the signs were positive for both short-term and long-term.

Pompelli and Castaneda (1994)

Pompelli and Castaneda (1994) developed an orange acreage response model for the western United States. They used data from 1962 to 1991 and incorporated Brazilian orange production for their estimates. Growers were assumed to make acreage decisions based on five factors: their expectations about returns, bearing acreage, nonbearing acreage, international factors and climatic factors. In addition, growers were assumed to utilize tree age information in making decisions about acreage removals. Their model measured the net effect of bearing acreage decisions, and was represented as follows:

$$\Delta B_t = B_t - B_t-1 + \varepsilon_t \qquad eq.3.38$$

where:

B_t = bearing acreage in year t

B_{t-1} = bearing acreage at previous year $(t-1)$

ε = random error term

They assumed that the net changes of bearing acreage were affected by the same factors that affect acreage additions and removals:

$$\Delta B_t = B(\pi_t, A_t, N_t, Z_t) \qquad eq.3.39$$

where:

π_t = expected return from perennial production

A_t = returns from alternative land uses

N_t = nonbearing acreage

Z_t = international, tax and climatic factors

Pompelli and Castaneda (1995) used two and three year lags rather than longer periods. They mentioned that longer period lags may reflect the absence of significant alternative crops alternatives as found in Misra (1985), whereas shorter lags periods indicate the presence of readily available alternatives (such as in Bateman, 1965; Carman, 1981). They approximated the grower returns (π_t) by real on tree returns:

$$DMP_t = P_{t-1} - ((P_{t-2} + P_{t-3})/2) \qquad eq.3.40$$

where:

DMP_t = grower returns variable

P_t = on tree returns in year t

To represent alternative opportunities they utilized citrus acreage prices and approximated the effect of urbanization and other opportunities beside citrus production:

$$DLN_t = LN_{t-1} - LN_{t-2} \qquad eq.3.41$$

They followed French and Matthews, utilizing a moving average of bearing acreage and non-bearing acreage to approximate information of age distribution of bearing acreage and non-bearing acreage:

$$MBA_t = (B_{t-2} + B_{t-3})/2 \qquad eq.3.42$$

$$MNB_t = (NB_{t-2} + NB_{t-3})/2 \qquad eq.3.43$$

Other variables used included a tax variable and a variable to capture the international effect. A dummy variable was used for tax variable, which is 1 for years before 1971 and 0 otherwise. A two-year moving average of the ratio of Brazilian orange production to total U.S. production was used to capture Brazilian orange production influences:

$$MPCTB_t = [\frac{BOP_{t-1}}{(BOP_{t-1}+USOP_{t-1})} + \frac{BOP_{t-2}}{BOP_{t-2}+USOP_{t-2}}]*.5 \qquad eq.3.44$$

Their complete equation for the change in bearing acreage was stated as:

$$\Delta B_t = \alpha_1 + \alpha_2 MBA_t + \alpha_3 MNB_t + \alpha_4 DMP_t + \alpha_5 TAX_t + \alpha_6 DLN_t + \alpha_7 MPCTB_t + \varepsilon_t \qquad q\ 3.45$$

Their estimation results indicated that growers' expected returns, Brazilian orange production and land value expectations had positive influences on bearing acreage changes.

Pompelli and Castaneda's results indicated that all of the coefficients estimated were positive. The moving average of bearing acreage lagged two years, was not significant and had the opposite coefficient as that previously expected. They suspected that other factors, such as the acreage shift from Southern to Central California and Arizona, had a greater influence on growers' decision. Two-year moving average of nonbearing oranges lagged two years. The grower return variable and orange acreage land value coefficients were positive and significant variables. The zero-one tax variable was not significant at 95% level of significance, but had positive coefficient as expected.

Gunawardana, Kindane, and Kulendran (1995)

A study of the Australian citrus industry by Gunawardana, Kindane and Kulendran (1995) used quarterly data from 1983 to 1993 to estimate a export supply response model. They found that domestic production capacity has a significantly positive impact on export

supply, and that the supply of citrus export with respect to its relative price was inelastic even in the long run. Their basic model of export supply response was specified as:

where:

$$QX_1 = f(RP_t) \qquad eq.3.46$$

Qx_t = quantity of fresh citrus exported

Rp_t = index of relative price of export, which was calculated as

$$RP_t = (PXIN_t / PDIN_t) x 100 \qquad eq.3.47$$

Their final model for empirical estimation was specified as:

$$LQX_t = L\alpha_0 + \alpha_1 LRP_t + \varepsilon_t \qquad eq.3.48$$

where L indicates log forms.

Forty-four quarterly data from March 1983 to December 1993 were used to estimate the export supply equation. They used ordinary least square method, and cointegration regression was estimated and then tested for stationarily. Results of the short-run export supply response equation indicated that all of the coefficients estimated were positive and that the variables were significant at 5 percent level and 1 percent level for variable first different of lag four period LQX and first different lag 8 period for LRP.

CHAPTER IV

METHODOLOGY

Objective 1 and part of objective 2 were accomplished by the description in the Chapter 2 literature review of current and past developments in the palm oil and other oils markets. The achievement of objective 2 will help in the development of a supply response model that will enable the accomplishment of objective 3 by using data from 1967-1995 to estimate a perennial supply response model.

Theory and Estimation Procedures

A single producer is considered the appropriate decision-making unit for this supply response approach. The underline assumption is that in making decisions about planting and removal, growers maximize profit over an infinite time horizon. Profits from perennial crops are a function of the cost of new plantings and removals, annual production costs, the opportunity cost of land planted to perennial crop, and revenue received (French and Matthews, 1971; Dunn and Beilock, 1971; Alston, Freebairn, and Quilkey, 1980; Pompelli and Castaneda, 1995).

Producer's profit maximization problem is defined by

maximizing:

$$\sum_{t=1}^{\infty} \alpha^t \pi(B_{1t}^a, \ldots B_{nt}^a, B_{1t}^R \ldots B_{nt}^R, P_t) \qquad eq.4.1$$

subject to:

$$B_{i,t+1}^a = B_{i-1,t}^a - B_{i-1,t}^R \qquad eq.4.1a$$

where:

α = the discount factor,

P_t = a vector of prices and other exogenous variables and

π = annual profits

$\alpha\pi$= present value of profits

$B_{1t}{}^a$ = new planting beginning of year t

$B_{it}{}^a$ = existing area of perennial crop at the beginning of year t which will be in the I year of production during year t if produced, I=2,...n

$B_{it}{}^R$= area of the perennial crop in the ith year of growth which is removed from production at the beginning of year t, I = 2,..., n.

$B_{1t}{}^R = 0$

and the non-negativity condition for acreage and price variables, holds.

The present value of profits in the future years under optimal operation may be written as:

$$J_t(B_{2t}^a, \ldots, B_{nt}^a; P_t, \ldots, P_\infty) = \sum_{s=t}^{\infty} \alpha^s \pi(B_{1s}^{a*}, \ldots, B_{ns}^{a*}, B_{1s}^r, \ldots, B_{n,s}^{r*}; P_s) \qquad eq.4.2$$

where:

B_{it}^{a*} = optimal level of the state variable

B_{it}^{r*} = optimal level of the control variable

J_t = function of the state variables and depends parametrically on prices and other exogenous variables = optimal value function

Optimal values for each year are used to maximize

$$\pi(B_{1t}^{a},\ldots,B_{nt}^{a},B_{1t}^{r},\ldots,B_{n,t}^{r};P_t)+\alpha J_{t+1}(B_{2,t+1}^{a},\ldots,B_{n,t+1}^{a};P_{t+1},\ldots,P_{\infty}) \qquad eq.4.3$$

subject to (1a) and the nonnegativity condition.

Thus, optimal values for B_{it}^{a*} and B_{it}^{r*} can be formulated as:

$$B_{it}^{a*}=f_t(B_{2t}^{a},\ldots,B_{nt}^{a};P_t,\ldots P_{\infty}) \qquad eq.4.4$$

$$B_{it}^{r*}=g_{it}(B_{2t}^{a},\ldots,B_{nt}^{a};P_t,\ldots P_{\infty}) \qquad eq.4.5$$

Following French and Matthews (1971) and Pompelli and Castaneda (1995), a moving average may be developed to approximate bearing acreage as follows:

$$MHA23_t=(B_{t-2}+B_{t-3})/2 \qquad eq.4.6$$

where:

$MHA23_t$ = moving average of hectarage

The choice of lag variables depends on the alternative hectarage uses availability. Shorter lags mean that alternative uses are readily available (Carman, 1981; Albisu and Blandford, 1983; Akiyama and Trivedi, 1987; Pompelli and Castaneda, 1995).

Following French and Matthews (1971) and Pompelli and Castaneda (1994), the expectation on producer returns (π_t) is approximated as palm oil price. A two years moving average of palm oil price is used:

$$MPP23_t=(P_{t-2}+P_{t-3})/2 \qquad eq.4.7$$

where:

P_t= return of palm oil in year t

Return for alternative land uses in the area may be approximated by return from coconut product because it represents a major competing crop. Before land clearing for palm estate, the area considered was mostly a mangrove forest and possible alternate land uses are other perennial crops such as coconut, rattan, and rubber.

$$MPC23_t=(PC_{t-2}+PC_{t-3})/2 \qquad eq.4.8$$

where:

$MPC23_t$=price of the coconut oil at t

As in the study of Pompelli and Castaneda (1995), the international influences were captured in the variable by incorporating them as a two-year moving average. In the Indonesian palm oil supply equation, Malaysian palm oil production may be incorporated using the following moving average:

$$MIMP23_t=[\frac{MP_{t-2}}{(MP_{t-2}+IP_{t-2})}+\frac{MP_{t-3}}{MP_{t-3}+IP_{t-3}}].*5 \qquad eq.4.9$$

where:

$MIMP23_t$ = proportion of Malaysian production over Indonesia and Malaysia

MP_{t-1} =Malaysian palm oil production in year *t*-I

IP_{t-1} =Indonesian palm oil production in year *t-I.*

Malaysian palm oil alone was also represented as a two-year moving avarage of Malaysian production (MMP23). This variable is defined as follows:

$$MMP23 = (MP_{T-2} + MP_{T-3})/2 \qquad eg.\ 4.10$$

where:

MP = Malaysian palm oil production

A dummy variable for government involvement in palm oil development was also developed. Beginning in 1990, the Indonesian government stopped controlling domestic palm oil prices. The variable designated to capture this situation is defined as follows:

$$GI_t=1 \quad if \quad t\geq 1990 \qquad otherwise\ GI_t = 0 \qquad eq.4.11$$

Finally, the change in bearing acreage of palm oil in Indonesia can be written as follows:

$$HA_t=\alpha_1+\alpha_2 MHA23_t+\alpha_3 MPP23_t+\alpha_4 MPC23_t+\alpha_5 MMP+\alpha_6 MIMP23+\alpha_7 GI_t+\varepsilon_t \qquad eq.4.12$$

Based on previous studies (Bateman, 1965; Behrman, 1968; French and Matthews, 1971; Dunn and Beilock, 1979; Pompelli and Castaneda, 1995), the expected signs of parameters

are that $\alpha_2 > 0$, $\alpha_3 > 0$, $\alpha_4 < 0$, $\alpha_5 > 0$, $\alpha_7 > 0$ and ε_t are distributed normally with $E(\varepsilon)=0$ and $E(\varepsilon\varepsilon')=\sigma^2 I$.

Data Needs and Expected Sources

Data from 1967 to 1995 are used to estimate the model. Data on prices are from World Bank publications for 1967 to 1987, and for 1988 to 1995 are from Gapki monthly report (in Lubis, 1995). Data on area (hectarage), export quantities, and values are from various issues of Indonesian Bureau of Statistics publications (Statistik Perkebunan). Data on Malaysian palm oil production and exports (1967 to 1995) are from the USDA, Economic Research Service, 1996.

CHAPTER V

RESULTS AND DISCUSSION

The Model

As indicated in Chapter I, the Indonesian palm oil producers' production decisions are thought to be influenced by six domestic and international factors. These factors are: (1) changes in domestic palm oil sales and competition for hectarage from other domestically produced crops; (2) international demand for and supplies of palm oil and its substitutes; (3) technical advances that have increased the degree of substitutability of different oils in food and nonfood uses; (4) health and nutrition issues that relate to advances in the food technology; (5) governmental policies; (6) and the perennial nature of the palm oil tree. The choice of variables used in the estimated model attempted to incorporate those factors. Based on equation 4.12, the following variables were chosen for the estimation:

(1) The dependent variable used in the estimation was total hectarage of the Indonesia palm oil tree. Total hectarage was in thousands of hectares, and was a summation of smallholder, private and government ownership. Data was available from Indonesian Directorate General for Estate Publication (Staistik Perkebunan, various issues) for 1967 to 1994.

(2) A moving average of hectarage was chosen to represent domestic changes and past decisions that might affect growers' decisions. Several studies on acreage response have

used moving acreage variables as the independent variables (French and Matthew, 1971; Alston et al., 1980; Pompelli and Castaneda, 1994). Since bearing and non-bearing hectarage data were not available, total hectarage data were used. Data on the total hectarage were available from 1967 to 1994. Although the hectarage data were differentiated into three different types of ownerships - smallholder, government, and private - changes in hectarage controlled by these different owners were not found to play a significant role in explaining overall palm oil hectarage changes. A two-year moving average of hectarage with two and three-year lags performed better statistically than other moving average hectarage combination. Therefore, moving average hectarage lag two and lag three (MHA23) were used in the final estimation.

(3) A moving average of palm oil and coconut prices was chosen, following French and Matthew (1971) and Pompelli and Castaneda (1994). A moving average to approximate the influence of a substitute crop was calculated for prices lagged two and three periods. These prices may also incorporate domestic and international market factors. The price of palm oil data was derived from data on volume and value of export (Indonesian Central Bureau of Statistics, various issues). Data on the price of coconut oil were taken from the USDA publication (1995), which listed bulk crude price in the New York port.

(4) Another variable used to measure possible international influences was Malaysian production. Both Malaysia and Indonesia are the major producers of palm oil, their combined production represent 75 percent of the world's production. Therefore, Malaysian production was expected to affect Indonesian growers' decisions. Pompelli and Castaneda's (1994) study included Brazilian production relative to the total production of Brazilian

oranges and California oranges. Their study indicated that this interaction variable was a significant factor in growers' decisions on acreage. A two-period moving average of Malaysian production was chosen to represent this effect. Malaysian production also entered in an interaction variable (MIMP23) with reference to as its proportion to total production of Malaysia and Indonesia.

(5) A number of government policy variables were considered in the model's development. However, experiments in incorporating policy variables were not statistically significant. Carman's (1981) study on the influence of tax variables indicated that the measurement of government influence varies across crops. Certain governmental policy variables were found to be significant in some of the crops, but not significant in others. Nonetheless, Carman (1981) retained both significant and non-significant factors in order to be able to compare with and without government involvement variables. Following Carman's study, a government policy dummy variable (GI) was used in estimation.

The Results

Equation 4.12 was estimated with OLS on Shazam (1993), with variable specification as mentioned above. Initially, a linear estimation was used (appendix 5); however, a double-log model was found to more effectively capture Indonesia's palm oil hectarage chages. One reason for this may be because of changes in Indonesia's hectarage that took place during the period studied. The plot of hectarage over time (Figure 2) indicates that hectarage was stable during the earlier years and then about 1980 started to increase dramatically. This is

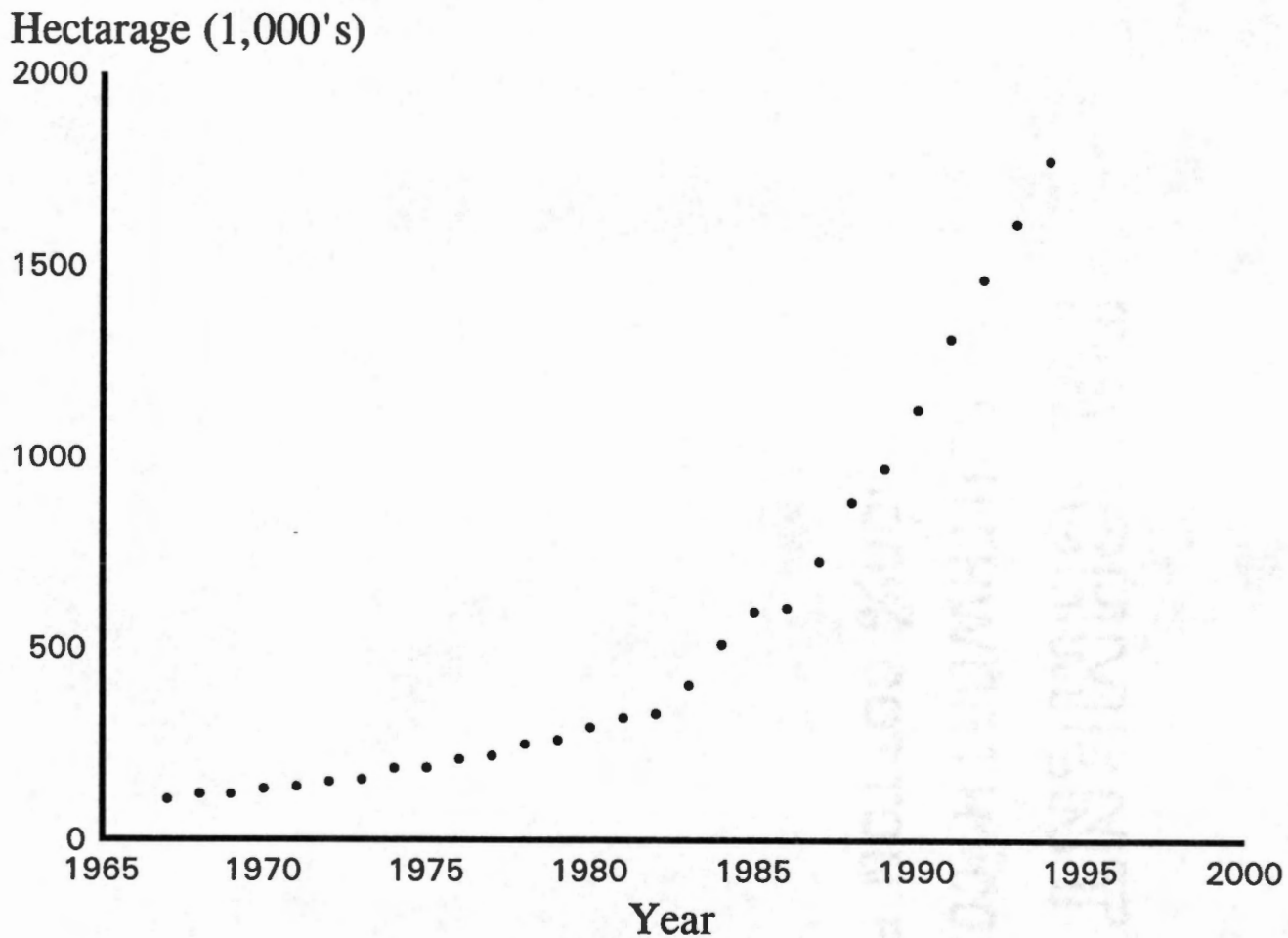

Figure 2. Indonesian Palm Oil Hectarage 1967 - 1994

consistent with government policy which in 1978/1979 stimulated private and smallholder hectarage increases. From the plot it was suspected that a non-linear form would perform better in explaining the relationship between dependent and independent variables. Semi-log and double-log estimates were performed, and the results indicated that the double-log form performed better than the semi-log. Therefore, in the absence of any theoretical constraint the estimation was focused on double-log forms.

Results of the hectarage response model estimation are presented in Table 5.1. The results indicated that the estimated coefficients possessed the expected signs listed in Chapter 4. The R^2 of 0.99 for all four models indicated that most of the variation in the palm oil hectarage could be explained by the variation in the independent variables. The F-statistics at 1107.39, 934.83, 273623.22, and 216623.66 for models A, B, C, and D, respectively, were greater than the critical F-value at a one percent level of significance. Thus, the F-tests rejected the overall joint hypotheses that the explanatory variable coefficients are not statistically different from zero. The Durbin-Watson statistics indicated that at the 5 percent level, model A and B were inconclusive; however, models C and D rejected the null hypotheses that serial correlation is present.

To correct for serial correlation, the Cochran-Orcutt iterative procedure (Appendix six) was performed on Shazam (1993). Results of the estimation with auto-correlation corrections are presented in Table 5.2. The results for the corrected models indicated high R^2 and F-ratios. All coefficient estimates were significant at 95 percent and their signs were as expected. Except for the coefficient of coconut oil price variables (LMPC23), all other coefficients were positive.

Table 5.1. Coefficients of Supply Response Model for Indonesian Palm Oil

Variable[1] and statistics	Model A	Model B	Model C	ModelD
Intercept	-0.263	-0.557	-	-
	(0.255)[2]	(0.366)		
Independent variable:				
LMHA23	0.750**	0.819**	0.715**	0.715**
	(0.079)	(0.100)	(0.072)	(0.076)
LMPP23	0.341**	0.336**	0.347**	0.347**
	(0.119)	(0.118)	(0.119)	(0.122)
LMPC23	-0.119*	-0.127*	-0.118*	-0.118
	(0.068)	(0.068)	(0.068)	(0.069)
LMMP23	0.311**	0.274**	0.335**	0.335**
	(0.071)	(0.078)	(0.067)	(0.069)
LMIMP23	-0.370**	-0.361**	-0.407**	-0.408**
	(0.1416)	(0.141)	(0.137)	(0.1423)
GI	-	-0.069	-	-0.001
		(0.062)		(0.044)
Statistics:				
R^2	0.99	0.99	0.99	0.99
F ratio	1107.395	934.830	273623.218	216623.655
DW test			0.951	0.950

[1] LMHA23 = log two period (2, 3)moving average of palm oil hectarage, LMPP23 = log two period (2,3) moving average of palm oil price, LMPC23 = log two period (2,3) moving average of coconut price, LMMP23 = log two period (2,3) moving average of Malaysian palm oil production, LMIMP23 = log two period (2,3) moving average of interaction between ratio of Malaysian to total Malaysian and Indonesia multiply by palm oil price. The dependent variable is the log of palm oil hectarage (logHA).

[2] parentheses represent standard errors.

* indicates that the coefficient is significant at the 10 % significant level.

** indicates that the coefficient is significant at the 5 % significant level.

Table 5.2. Coefficients of Supply Response Model for Indonesian Palm Oil (adjusted for autocorrelation)

Variable[1] and statistics	Coefficient	Standard Error
Independent variable:		
LMHA23	0.751**	0.077
LMPP23	0.358**	0.121
LMPC23	-0.132**	0.639
LMMP23	0.293**	0.069
LMIMP23	-0.376**	0.132
Statistics:		
R^2 = 0.99		
F-ratio = 273673		

[1]LHA23 = log two period (2, 3)moving average of palm oil hectarage, LMPP23 = log two period (2,3) moving average of palm oil price, LMPC23 = log two period (2,3) moving average of coconut price, LMMP23 = log two period (2,3) moving average of Malaysian palm oil production, LMIMP23 = log two period (2,3) moving average of interaction between ratio of Malaysian to total Malaysian and Indonesia multiply by palm oil price. The dependent variable is log palm oil hectarage (logHA).

** indicates that the coefficient is significant at the 5 % significant level.

One useful aspect of the double log model is that the coefficients of the independent variables can be shown to be the elasticities of hectarage changes with respect to changes in the independent variables. The double-log model also restricts these elasticities to be constant across the whole range of independent variable values.

Discussion of the Results

Model C of a supply response model for Indonesian palm oil with correction for auto-correlation performed better statistically and indicated meaningful results. A supply response model for Indonesian palm oil estimates (Table 5.2) shows that supply price elasticities are inelastic. These findings are consistent with previous findings that supply price elasticities of perennial crops are inelastic because perennial crops do not respond immediately (Nerlove, 1956; Suryana, 1986).

The two-year moving average of hectarage (LMHA23) was statistically significant at 95 percent. The positive relationship was as expected, and indicated that past levels of hectarage influence growers' desire to expand hectarage for palm oil. This result is consistent with the trend in the expansion of hectarage. Although data indicate that there are differences in the rate of hectarage expansion among smallholder, government and private owners, estimation to include the differences were statistically not significant.

The two-year moving average of palm oil price (LMPP23) was positive and statistically significant at 95 percent level. The elasticities estimated were found to be 0.358, which was inelastic. This result means that a one percent change in the price of palm oil will

only change hectarage by 0.358 percent. This inelastic own-price result reflects the perennial nature of crop and the extent to which growers allow prices to influence in the decision. In other words, it takes several years for a price signal to effect hectarage.

The two-year moving average of coconut price (LMPC23) was negative and statistically significant at 95 percent level. This result means that coconut is considered a substitute crop for palm oil in Indonesia. Previously, coconut production has dominated vegetable oil production in Indonesia. Most of vegetable oil produced has been for cooking oil. Production of coconut oil has remained constant at around 700 thousand tons since the early 1970's, whereas production of palm oil has increased dramatically, more than 20 times, from around 200 thousand tons in the early 1970's to 4,300 thousand tons in 1995 (USDA, 1996).

The two-year moving average of Malaysian production (LMMP23) was positive and statistically significant at 95 percent level. The positive coefficient indicated that Indonesia growers' decision on hectarage are similar to those of Malaysian gowers. The combined palm oil production of Indonesia and Malaysia is almost 80 percent of world production. This may indicate that Indonesian growers see the same opportunity in the expansion of palm oil production.

The two-year moving average of interaction of Malaysia production over the total of Indonesia and Malaysia, multiplied by palm oil prices (LMIMPP23) was negative and statistically significant at 95 percent level. Since the coefficient price elasticities of palm oil were expected to be positive, the negative sign in the interaction effect may indicate opposite direction in proportion of Malaysia production over total Indonesia and Malaysia and

Indonesian growers' decisions on hectarage. This result also may indicate that Indonesian growers recognize that as the share of palm oil revenue going to Malaysian producers declines, Indonesian producers will increase their hectarage because of the increased market present.

With respect to nutritional and health factors, no good approximations were developed. Since the importance of these factors is expected to be significant in the future, this may be a good area for future research.

CHAPTER VI

CONCLUSIONS

Policy Implications

The hectarage supply response model developed in this study attempts to explain variations in hectarage in Indonesia by considering factors that are suspected to influence Indonesian palm oil grower's decisions on hectarage. First, Indonesian palm oil growers' decision are influenced by changes in palm oil sales and competition from other domestically produced crops. This factor is represented by hectarage of palm oil and the price of palm oil. Government incentive toward expansion of palm oil production could be interpreted by two situations: (1) The dramatic increase in the hectarage owned by smallholders and private-land owners and in turn total hectarage, a trend which began around 1979/1980, and (2) The price of palm oil, which beginning in 1990 was not controlled by government so that its fluctuations followed world palm oil prices. Results from the supply response estimation indicate that previous changes in hectarage and prices of both palm oil and coconut oil were significant factors in growers' decisions. The positive coefficients for hectarage and price of palm oil indicate that growers' decision to increase/decrease hectarage reflects previous changes in hectarage and price of palm oil. Thus, policies designed to expand palm oil hectarage should focus on allowing international price signals to influence growers' decisions.

Second, the international demand for and supplies of palm oil and its substitutes affect

Indonesian palm oil growers. International factors in this study addressed the influence of Malaysian palm oil production on Indonesian grower's decision.

The third factor is technical advances that are believed to have increased the degree of substitutability of different oils in food and nonfood uses. The major use of palm oil in Indonesia has been for cooking oil, so that the competing oil available has been coconut oil. Coconut oil production has remained stable since the 1960s; on the other hand, palm oil production has increased by more than fifteen times from the 1960's to 1995. Although recent research on palm oil has indicated different types of uses, this factor was not explicitly able to be incorporated in model estimation. However, the price of the coconut oil may explain the phenomenon. The coefficient of the two-period moving average of coconut price was negative, which indicates that the price of coconut oil has a negative effect on palm oil growers' decision on hectarage. In other words, sustained increases in the price of coconut will induce palm oil growers to reduce palm oil hectarage. However, the magnitude of the effect was very small (price elasticity of -0.132), which was expected, since palm oil is a perennial crop. Therefore, a policy for expanding hectarage in the short run would not be effective as a price incentive.

The fourth factor influencing Indonesian palm oil growers' production and marketing decision is government policies. As previously explained, government policy was established in two forms, through incentive in hectarage expansion and through palm oil price policy. However, this variable was found to be statistically insignificant. Implementation through the hectarage variable and price of palm oil may be the reason for this finding.

The last factor that has been proposed to affect Indonesian plam oil growers' decision

is the perennial nature of the palm oil tree, which introduces a multi-year horizon to growers production decisions because initial production from new planting takes place only after several years of maturation. Unfortunately, as with many perennial crops, detailed data on tree age, bearing hectarage and non-bearing hectarage were not available (Dunn and Beilock, 1979; Misra, 1985; Knapp and Konyar; 1991). Therefore, the estimated model is limited in explaining this factor.

Limitations and Suggestions

Limitation of the model's implications are in some part due to the following data limitations. Data on alternatives land uses was very limited. Even though coconut is an alternate land use, other crops or uses may also be available. Data on returns from other opportunities were not available. In addition to other crops, alternatives such as housing may also present competition because of the growing population.

It was not possible to assess nutrition factors directly into the explanatory variable. In this case, the only possible explanatory variables were the prices of palm oil and coconut oil. Health concerns about palm oil were addressed by arguing that palm oil fulfills calorie needs. As indicated in the literature review, palm oil is comparable in nutritious value to other vegetable oils.

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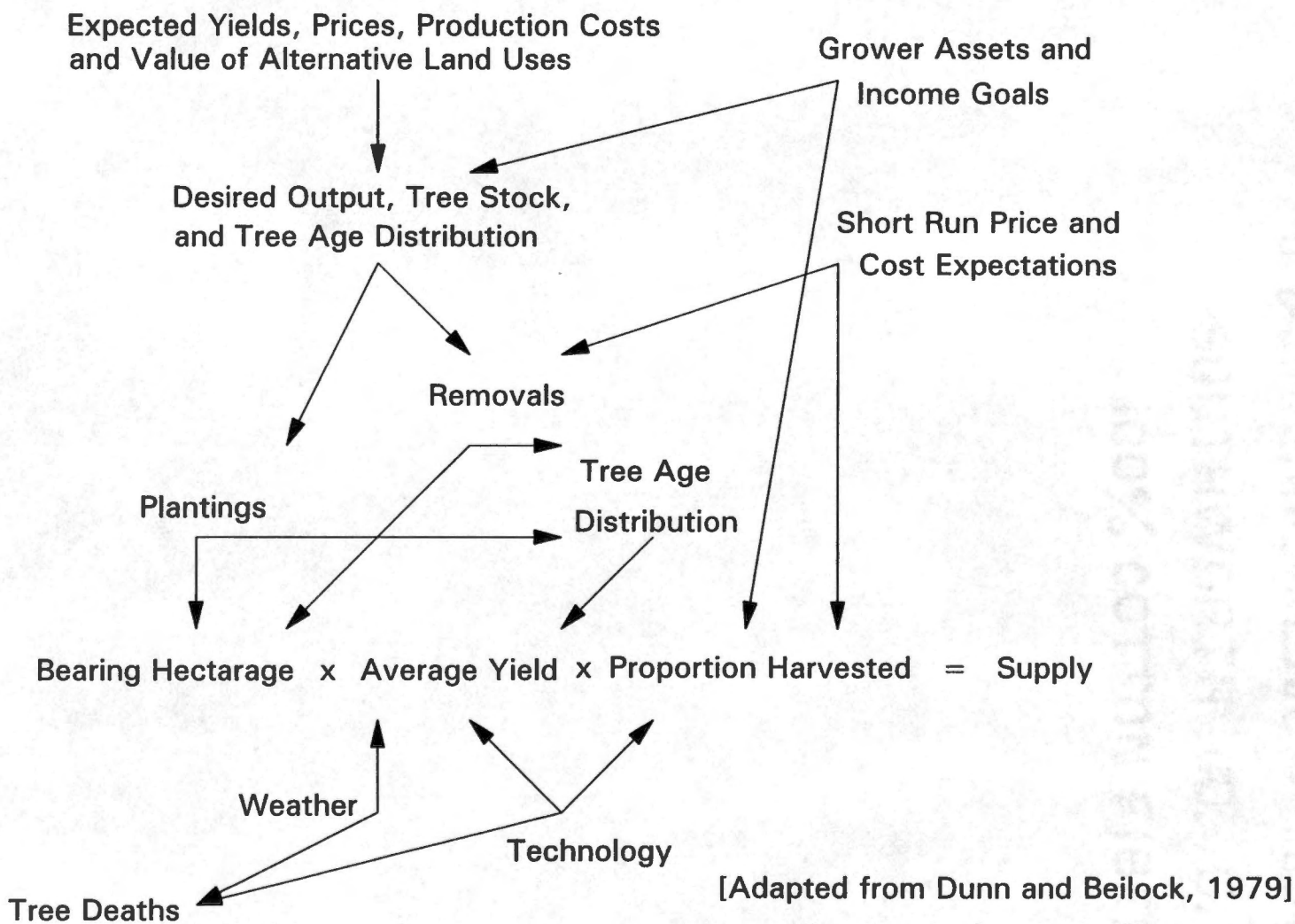
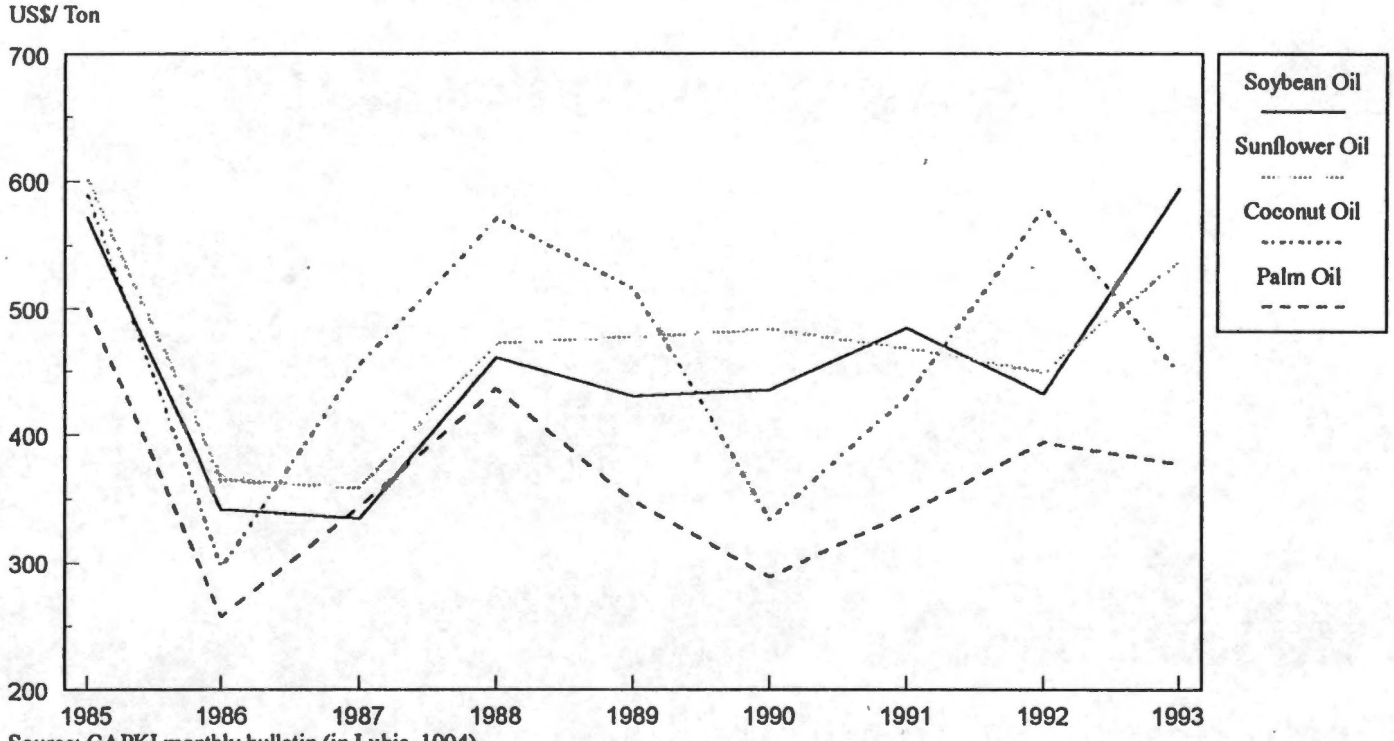
APPENDICES

Appendix 1. Schematic of Factors Affecting Supply



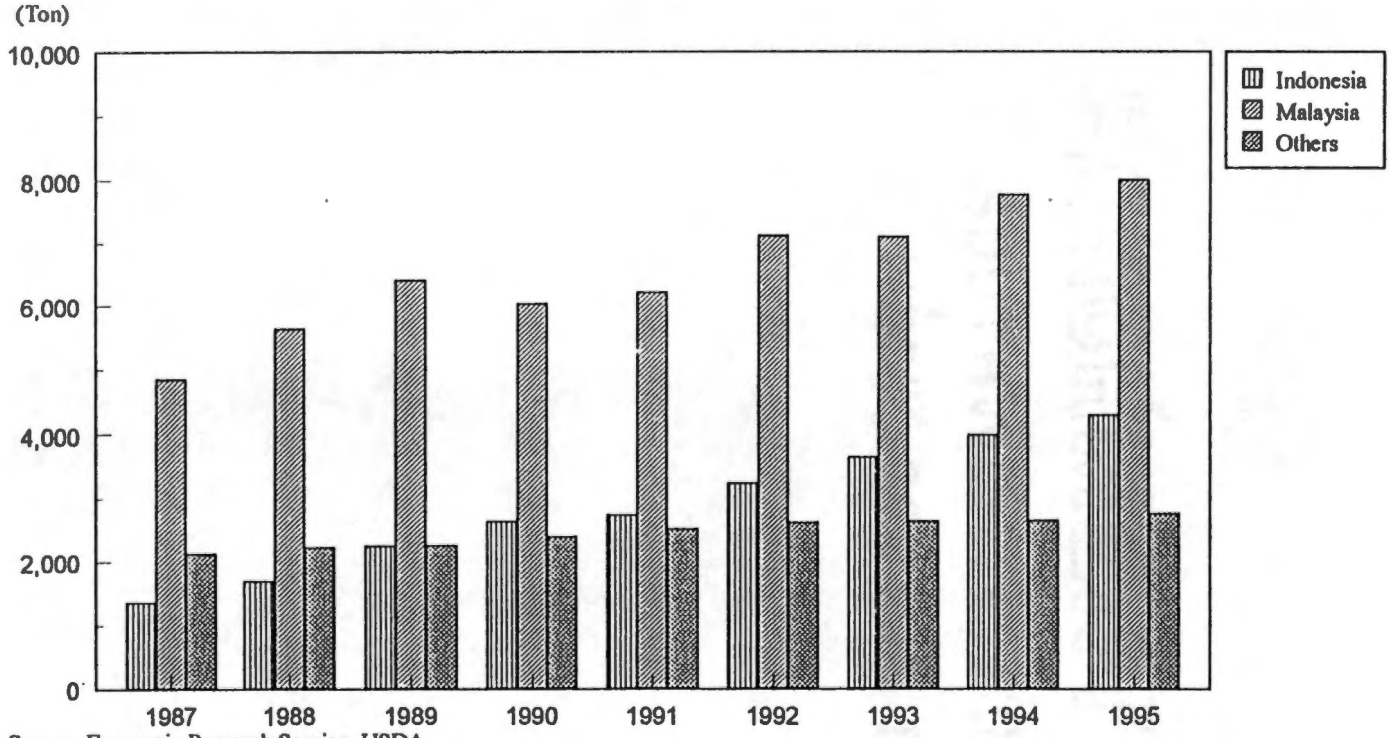
[Adapted from Dunn and Beilock, 1979]

Appendix 2. Price Comparison of Selected Vegetable Oils



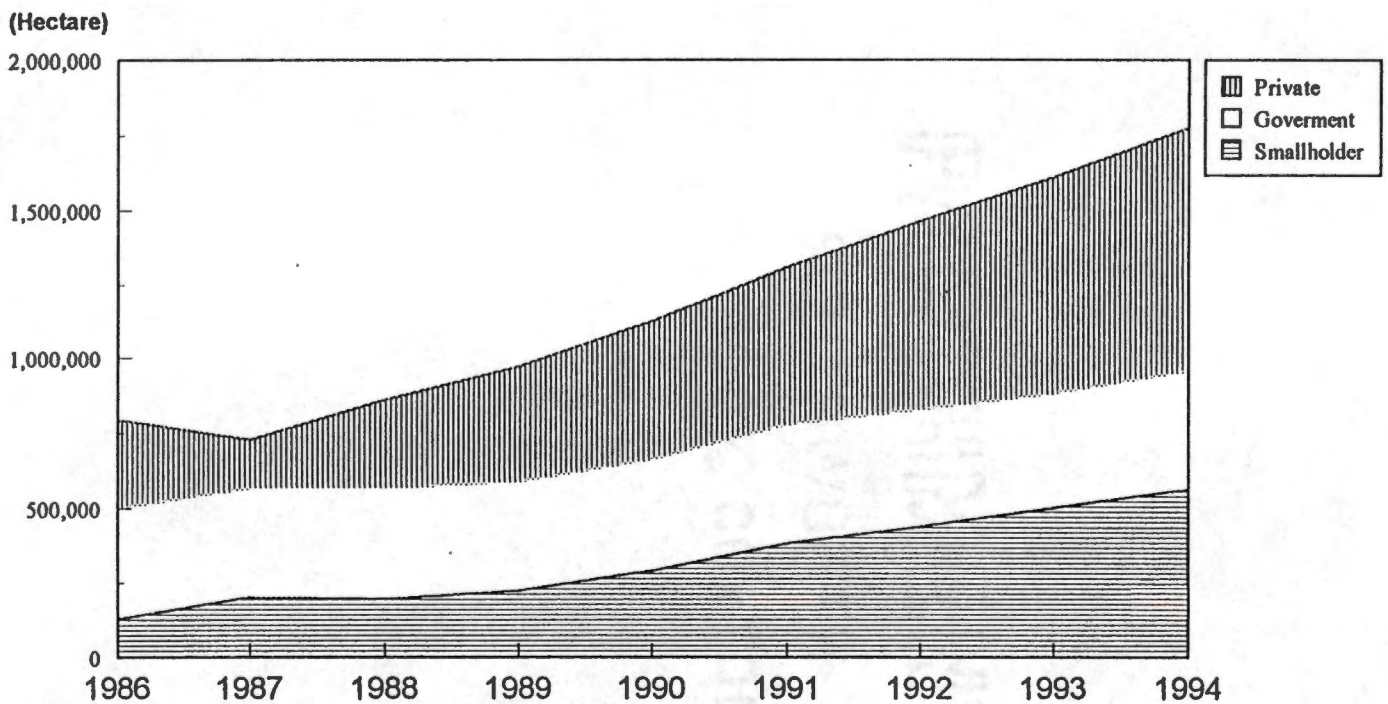
Source: GAPKI monthly bulletin (in Lubis, 1994)

Appendix 3. World PalmOil Production



Source: Economic Research Service. USDA

Appendix 4. Indonesia Palm Oil Ownership Trends



Source: Indonesia Central Bureau of Statistics. Statistik Perkebunan. Various Issues.

Appendix 5. Supply Response model for Indonesian Palm Oil (linear log from)

Variable and statistics	Model A	Model B	Model C	Model D
Intercept	834.57 (26820)	-2477.3 (26510)	-	-
Independent variables:				
LHA1	-0.031 (0.062)	0.024 (0.074)	-0.312 (0.059)	0.024 (0.072)
LPP1	427.91* (216.9)	357.62 (220.1)	431.10** (186.7)	348.71 (193.6)*
LPC1	-42.131 (53.08)	-56.264 (53.34)	-42.255 (51.72)	-55.802 (51.84)
LMP1	0.030 (0.012)	0.029 (0.012)**	0.302 (0.117)**	0.028 (0.012)**
LIMP1	-525.80* (259.4)	-428.62 (265.9)	-527.48 (247.9)**	-424.35 (255.7)
GI	-	-59123 (45400)	-	
Statistics:				
R	0.68	0.70	0.68	0.70
F	8.803	7.862	22.422	19.636
DW				

[1] LHA1 = lag one period palm oil hectarage, LPP1 = lag one period palm oil price, LPC1 = lag one period coconut price, LMP1 = lag one period Malaysian palm oil production, LIMP1 = lag one period interaction proportion of Malaysian palm oil production to total Indonesia and Malaysia multiply by palm oil price, GI = dummy 0-1 variable for government policy. The dependent variable is DHA = changes in the palm oil hectarage.

[2] parentheses represent standard error.

* represent 10% significant level.

** represent 5% significant level.

Appendix 6. Supply Response Model for Indonesian Palm Oil (linear two period moving average)

Variable and statistics	Model A	Model B
Intercept	-14121 (31260)	
Independent variables:		
MHA2	-0.033 (0.866)	-0.034 (0.085)
MPP2	528.84 (284)*	483.07 (260.3)*
MPC2	-10.630 (72.04)	-13.441 (70.40)
MMP2	0.030 (0.017)*	0.030 (0.017)*
MIMP2	-665.79 (379.5)*	-640.62 (368.2)*
GI	-	-
Statistics:		
R	0.65	0.64
F	7.30	19.82
DW		

[1] MHA2 = two-period (1,2) moving average palm oil hectarage, MPP2 = moving average two-period (1,2) palm oil price, MPC2 = moving average two-period (1,2) coconut price, MMP2 = moving average two-period (1,2) Malaysian palm oil production, MIMP2 = moving average two-period (1,2) interaction proportion of Malaysian palm oil production to total of Indonesia and Malaysia multiplied by palm oil price, GI = dummy 0-1 variable for government policy. The dependent variable is DHA = changes in the palm oil hectarage.

[2] parentheses represent standard error.

* represents 10% significant level.

** represents 5% significant level.

Appendix 7. Supply Response Model for Indonesian Palm Oil (two period lagged moving average)

Variable and statistics	Model C	Model D
Intercept	-61553	
	(29120)**	
Independent variables:		
MHA23	0.482	0.375
	(0.160)**	(0.164)**
MPP23	218.94	80.661
	(255.7)	(268.8)
MPC23	59.41	56.539
	(63.78)	(69.34)
MMP23	-0.036	-0.027
	(0.021)*	(0.225)
MIMP23	-256.09	-230.41
	(351.6)	(382.1)
GI	-186550	-140110
	(67060)**	(68900)**
Statistics:		
R	0.75	0.64
F	9.07	6.67
DW		

[1] MHA23 = moving average two-period (2,3) palm oil hectarage, MPP23 = moving average period palm oil price, MPC23 = moving average two-period (2,3) of coconut price, MMP23 = moving average two-period (2,3) Malaysian palm oil production, MIMP23 = moving average two-period (2,3) interaction proportion of Malaysian palm oil production to total of Indonesia and Malaysia multiplied by palm oil price, GI = dummy 0-1 variable for government policy. The dependent variable is DHA = changes in the palm oil hectarage.

[2] parentheses represent standard error.

* represents 10% significant level.

** represents 5% significant level.

Appendix 8. Cochran-Orchutt Iterative Procedure

Autoregression were performed with Shazam (1993) to re-estimate the models, because of a concern of the presence of serial autocorrelation. The procedure use Cochrane-Orchutt iterative estimation which involves three steps:

(1) Run the regression equation by OLS and retained the estimated residual e_t.

(2) Run the regression of e_t as a function of its one period lag:

$$e_t = \rho\, e_{t-1} + v_t^*$$

The least squares estimate of ρ is:

$$\dot{\rho} = \frac{\sum_{t=2}^{N} e_t\, e_{t-1}}{\sum_{t=2} N\, e_{t-1}^2}$$

$$Y_1^* = \sqrt{1-\dot{\rho}^2}\; Y_1 \;,\; X_1^* = \sqrt{1-\dot{\rho}} X_1$$

$$Y_t^* = Y_t - \dot{\rho}\; Y_t \;,\; X_t^* = \dot{\rho} X_{t-1} \;\; \forall\; t=2,3,\ldots,N$$

(3) Use the coefficient estimate to transform observation Y* and X* as:

The estimate of the Y* and X* can then be obtained from an OLS regression of Y* and X*. Steps (2) and (3) are repeated until successive estimates of ρ differ by less than 0.001.

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