INDONESIAN NATURAL RUBBER: AN ECONOMETRIC ANALYSIS OF ITS EXPORT SUPPLY AND FOREIGN IMPORT DEMAND

By

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ABSTRACT

INDONESIAN NATURAL RUBBER: AN ECONOMETRIC ANALYSIS OF ITS EXPORT SUPPLY AND FOREIGN IMPORT DEMAND

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This study is concerned with a quantitative examination of the Indonesian natural rubber. The main objective of the study is to analyze the nature of the supply of and demand for Indonesian natural rubber.

To meet the above objective a simultaneous equation model was developed consisting of fifteen behavioral equations and six definitional identities which are hypothesized to describe the annual structure of the Indonesian natural rubber and its place in the world market for the period 1970 through 1990. The Micro-TSP computer software package was used to carry out the analysis in this study. The data used were primarily taken from several sources.

The study found that production and export supply of Indonesian natural rubber, demand for rubber both in the U.S. and outside the U.S. markets, and foreign import demand for Indonesian natural rubber were perfectly price inelastic. Moreover, level of production -- which depends mainly on the extent of the mature tree area and yield -- primarily determines for the export supply, and yield is influenced by the price of natural rubber in both the world and domestic market price. Furthermore, demand for natural rubber is influenced mainly by the automobile industry.

The major policy implication of the above findings is that dependence on one commodity as a source of export earning is subject to risk. In other words, diversification of export crop promotion must be continued.

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I. INTRODUCTION

The agricultural sector remains the most important section of the Indonesian economy, with the vast majority of Indonesian still depending on agriculture and agro-industries for their livelihood. In fact, throughout the country, agriculture plays a part in most aspects of life, from supporting the rural areas to feeding the urban population.

Indonesian agriculture covers a wide array of crops, products and techniques, ranging from small-scale sugar production to the new palm oil estate; from food crops for own consumption to commercial crops for export to the world's market; and from local fishermen to commercial fishing operation.

Seven primary agricultural commodities (i.e., natural rubber, palm oil, tobacco, tea, coffee, pepper and shrimp) accounted for an average of 36 % of export earnings over the period 1974 - 1989. Natural rubber is one of Indonesia's most important commercial crops, ranking third in value of export (after petroleum and timber) and accounted for an average of 46 % of export earnings from primary agricultural commodities over the same period. While data clearly show that rubber is Indonesia's most important agricultural product, such heavy dependence on a single commodity, which is subject to fluctuation in world rubber's price, has contributed to instability in both the balance of payments and the internal economy.

1.1. Problem Statement

A major goal of agricultural policy in Indonesia is to increase foreign exchange earnings through increasing exports of key agricultural commodities, especially estate crops[1]. As the most important agricultural export commodity in Indonesia, natural

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[1] Estate crops are tree crops that produce commodities traded commercially, including rubber, palm oil, tea, coffee, and pepper.

rubber is critical to the success of the country's export promotion policy. However, fluctuation in the price of natural rubber introduces considerable uncertainty in the level of export earnings from rubber. In addition, increasing use of synthetic rubber has undermined world prices and threatened the viability of the government's efforts to expand foreign exchange earning through increasing natural rubber exports. Thus, a better understanding of factors influencing the historical supply and demand for Indonesian rubber is needed to assure the success of Indonesia's rubber export promotion initiative.

To assess the prospects for a rubber-based export expansion strategy, this study first analyzes the historical determinants of the supply of and demand for Indonesian natural rubber and then assesses the future prospects for increasing supply and demand. Since the United States is the major country importer of Indonesian natural rubber, the study focuses on the United States' import demand for natural rubber and the variables that determine it.

1.2. Specific Objectives

The general objective of this study is to analyze the nature of the supply of and demand for Indonesian natural rubber. If prospects for increasing the demand for Indonesian natural rubbers are sufficiently strong, government should implement policies to increase natural rubber production by encouraging producers to expand the area planted, accelerate replanting with high-yielding tree varieties, and adopt more efficient management practices. Otherwise, diversification should be considered.

The specific objectives of the study are to, first, describe the structure of natural rubber production, including trends in production and export supply both in Indonesia and in the other producing countries, and to provide information decision makers need to better understand the historical evolution of the sector.

The second objective is to describe the trends in natural rubber exports, especially Indonesian natural rubber, including changes in world market shares; develop a model to estimate the relative importance of factors affecting demand for natural rubber; and project the future demand for natural rubber.

The third objective is to review Indonesian policies and programs designed to increase production and productivity, to asses their effectiveness, and to propose policies needed to stimulate rubber production and export earnings.

1.3. Hypotheses

This study proposes the following hypotheses:

a. Fluctuations in the world market price of natural rubber have influenced the supply (production) of Indonesian natural rubber, the quantity of exports, and Indonesian rubber export earnings.

b. The price of natural rubber has influenced consuming countries demand for natural rubber. In addition, fluctuations in the price of petroleum oil have had an impact on the production of synthetic rubber that has, in turn, influenced the quantity of natural rubber demanded by the consuming countries, and thereby influenced the level of fluctuation in the natural rubber price.

1.4. Thesis Organization

The paper consists of seven chapters. Chapter One describes the importance of the study; and presents the problem statements, objectives, and hypotheses to be tested. Chapter Two briefly reviews Indonesia's physical features, population characteristics, development experience, and the economy, giving attention to both the structures of the economy and the structure of agriculture.

Chapter Three provides an overview of Indonesia's role in the world rubber economy. This chapter reviews the world natural and synthetic rubber economy, with emphasis on the historical trends in production, prices, and demand, and factors that have affected these trends. In addition, this chapter describes the structure of the rubber sub-sector in Indonesia.

Chapter Four reviews the literature that provides the theoretical framework used in this study, including related studies, model specification of the supply and demand, and the nature of the data used in this study.

Chapter Five presents and discusses the statistical results that explain factors determining the export supply of and foreign demand for Indonesian natural rubber, and evaluates the general model.

Chapter Six provides the supply and demand forecasts. Finally, Chapter Seven presents the conclusion of this study, including a summary, policy implications, limitations, and recommendations for future research.

II. THE INDONESIAN ECONOMY: AN OVERVIEW

This chapter consists of five sections. Section one briefly reviews physical features of Indonesia; section two describes the population characteristics; section three reviews Indonesian's development experiences; section four describes the performance of the economy over the period of 1975 - 1990, beginning with trends in gross domestic product and its share by sector, export, and import. Section five reviews the structure of Indonesian agriculture, including the role of the agricultural sector in the Indonesian economy, the importance of the estate sub-sector, and past and current agricultural policies.

2.1. Physical Features

Indonesia is the largest archipelago in the world, located in Southeast Asia between Asia and Australia and between the Pacific and the Indonesian Ocean. It consists of five major islands and about 30 smaller groups. Although, there are 13,667 islands, only about 6,000 are inhabited. The total land area is about 1.9 million km^2 while the sea area is about four times the land area (7.9 million km^2). The country is divided into 27 provinces.

The overall average temperature is 25^{o}C with variation between 21^{o}C and 33^{o}C. Average annual rainfall ranges from over 2,000 mm in the coastal to over 3,000 mm in the mountainous regions. Overall, Indonesia has a tropical climate with a dry and a rainy season. For most areas, the dry season occurs in June and ends in September, while the rainy season goes from December to March. These seasons occur after passing the transition period in April - May and October - November (CBS, 1990).

2.2. Population Characteristics

In 1990 Indonesia had a population of 179.3 million; making it the fourth most populous country in the world. In recent years, the population growth rate has decreased from 2.32 % in the period of 1971 - 1980 to 1.97% in the period of 1981 - 1990 (CBS, 1990).

Population density varies by major island. In 1990, population density was highest in Java (814 per km^2), followed by Bali (500 per km^2), Nusa Tenggara (97 per km^2), and Sumatra (77 per km^2). Indonesia had an average population density of 62 per km^2 in 1971, which increased to 93 per km^2 in 1990 (CBS, 1990).

2.3. Development Experience

Since the late 1960s, the Indonesian economy has been guided by a series of five-year development plans (REPELITA) which have attained an almost sacred position, extending into every sector of society. Each five-year development plan (PELITA) has had a different emphasis. For example, on the economic front, PELITA IV stressed the need for greater growth in non-oil exports and a rapid expansion of the manufacturing industry. In contrast, PELITA V, the most recent phase of the first long-term (25 years) development period, emphasized rapid economic growth that contributes to a dynamic and stable society by assuring the equitable distribution of the gains of developments (Presidential Speech, 1990).

2.4. Performance of the Economy

Indonesia has experienced relatively rapid income growth, with the rate of real gross domestic product (GDP) averaging 7.64 % from 1985 to 1989. Table 1 shows the GDP (current market price) in selected years for each sector.

The agricultural sector still accounts for the largest, although a declining, share of contribution to the GDP (Table 2). In 1974, the agricultural sector accounted for 32.7% of the GDP, followed by mining and quarrying (22.2%), and trade and commerce (16.6%). By 1989, the contribution of the agricultural sector had declined to 23.4%, and the other key sectors, in order of importance, were manufacturing industries (18.4%), trade and commerce (17.0%), and mining and quarrying (13.1%).

The break-down of the sectoral contribution to GDP clearly shows that the economy is experiencing structural change, as indicated by the declining importance of agricultural sector, compared to manufacturing, trade and commerce (Table 2).

Table 1. Indonesian GDP at current market price, selected years (million rupiah)

Sectors	1974	1979	1984	1989
Agriculture:	3,497	8,996	20,617	38,998.4
Farm food crops	2,096	NA	12,939	24,187
Smallholder estate crops	386	NA	2,739	4,784
Large estate crops	191	NA	393	1,257
Livestock	223	NA	2,018	4,075
Forestry	422	NA	955	1,733
Fishery	179	NA	1,373	2,963
Manufacturing Industries	890	2,421	11,330	30,573
Trade and commerce	1,775	3,450	13,973	28,314
Mining and Quarrying	2,374	6,980	15,986	21,730
Public and other services	1,159	6,162	12,499	21,186
Transport and communication	442	1,422	4,960	9,085
Construction	406	1,790	4,823	8,884
Banking and Finance	113	655	2,692	6,551
Electricity, gas and water	52	149	655	1,008
TOTAL GDP	10,708	32,025	87,535	166,330

Sources: CBS. Statistical Year Book of Indonesia, selected years
Exchange rate (Rp/$): 1974: 415; 1979: 623; 1984: 1026; and 1989: 1770
NA : data not available

Table 2. Sectoral contribution to gross domestic product at current market price, Indonesia, selected years (percentage)

Sectors	1974	1979	1984	1989
Agriculture:	32.7	28.1	23.7	23.4
Farm food crops	19.6	NA	14.8	14.5
Smallholder estate crops	3.6	NA	3.1	2.9
Large estate crops	1.8	NA	0.4	0.8
Livestock	2.1	NA	2.3	2.4
Forestry	3.9	NA	1.1	1.0
Fishery	1.7	NA	1.6	1.8
Manufacturing Industries	8.3	7.6	12.9	18.4
Trade and commerce	16.6	10.8	15.9	17.0
Mining and Quarrying	22.2	21.8	18.3	13.1
Public and other services	10.8	19.2	14.3	12.7
Transport and communication	4.1	4.4	5.7	5.5
Construction	3.8	5.6	5.5	5.5
Banking and Finance	1.0	2.0	3.1	3.9
Electricity, gas and water	0.5	0.5	0.7	0.6

Sources: CBS. Statistical Year Book of Indonesia, selected years

NA : data not available

Another indicator of the relative importance of a sector to economic growth is its contribution to employment. The agricultural sector has an important role in the economic growth of the country, since it continues to account for a relative high percentage of employment. In 1989, the agricultural sector's share of the total employment equaled 55.6%, followed by services (15.9%), trade and commerce (14.6%), and manufacturing industries (8.8%).

In 1989, Indonesian imports consisted mainly of raw materials and auxiliary goods (72.8%), followed by capital (23.0%), and consumer goods (4.2%). On the other hand, Indonesian export commodities can be categorized into two main groups, i.e., firstly, petroleum and petroleum products, and, secondly, agricultural commodities. During the 1970s and early 1980s petroleum exports accounted for some 70% of export earnings, but fell to less than 40% by 1989. Over the 15-year period considered, the agricultural export share ranged from 9.6 - 13.8 percent (Table 3). Although numerous commodities exported, only about eight of them are really important (Table 4). Among agricultural exports, natural rubber is the second most important export after timber (Table 3).

Table 3. Major source of export earning, Indonesia, selected years (million US dollar)

Sources	1974	1979	1984	1989
Agriculture:				
Rubber	479.2 (6.5)	936.8 (6.0)	948.6 (4.1)	1,007.6 (4.5)
Coffee	98.1 (1.3)	614.5 (3.9)	567.9 (2.6)	491.1 (2.2)
Shrimp	NA	200.5 (1.3)	195.6 (0.9)	533.9 (2.4)
Others	273.7 (3.7)	394.3 (2.6)	390.6 (1.8)	572.5 (2.7)
Total	851.0 (11.5)	2,146.1 (13.8)	2,102.7 (9.6)	2,605.1 (11.8)
Timber	733.0 (9.9)	1,812.0 (11.6)	1,043.0 (4.8)	2,352.0 (10.6)
Others non-oil	631.0 (8.5)	1,468.0 (9.4)	2,724.3 (12.4)	8,522.9 (38.5)
Total Non-Oil	2,215.0 (29.8	5,426.0 (34.8)	5,870.0 (26.8)	13,480 (60.8)
Petroleum & its Product	5,211.0 (70.2)	10,164.0 (65.2)	16,019.0 (73.2)	8,679 (39.2)
Total Export Earning	7,426.0 (100)	15,590.0 (100)	21,888.0 (100)	22,159 (100)

Source: CBS, Statistical Year Book of Indonesia, selected years
( ) = the share value as a percentage of total exports earning
NA = data not available

Table 4. Export of major agricultural commodities, Indonesia, selected years (million U.S. dollar)

Commodity	1974	1979	1984	1989
Rubber	479.2 (56)	936.8 (44)	948.6 (45)	1,007.6 (39)
Shrimp	NA	200.5 (9)	195.6 (9)	533.9 (20)
Coffee	98.1 (12)	614.5 (29)	567.9 (27)	491.1 (19)
Palm Oil	157.3 (18)	204.4 (10)	63.3 (3)	244.6 (9)
Tea	46.3 (5)	83.4 (4)	226.3 (11)	163.1 (6)
White Pepper	7.8 (1)	26.1 (1)	22.8 (1)	68.8 (3)
Tobacco	35.5 (4)	56.5 (3)	32.9 (1.8)	47.2 (2)
Black Pepper	16.5 (2)	20.5 (0.8)	41.4 (2)	40.0 (1.7)
Quinine	10.3 (1)	3.4 (0.2)	3.9 (0.2)	8.7 (0.3)
Total	851.0 (100)	2,146.1 (100)	2,102.7 (100)	2,605.1 (100)

Source: CBS, Statistical year book of Indonesia, selected years
NA = data not available
( ) = the share value as a percentage of total agricultural export earning

2.5. Structure of Agriculture

Land utilization in Indonesia is differentiated by its main use, such as land for house compounds and surroundings, agriculture, and forestry. Only about one-third (70.2 million hectares) of Indonesia's total land area is in productive use, of which 28.9 % is in wooded land, followed by shifting cultivation (18.9%), estates (18.9%), and irrigated-land, 11.7%, (CBS, 1990).

Food crops contribute the largest share to the agricultural GDP, followed by smallholder estate crops. However, in term of export earning, timber and natural rubber play a more important role than food crops.

Indonesia's agriculture, especially the food crops sub-sector is dominated by small-scale and traditional farm households who cultivate less than 1 hectare of land. Similarly, natural rubber is also mainly produced by smallholders who cultivate an average of less than 2 hectares per household, and generally live far away from the major transportation routes, markets, and processing centers. Rubber production, both by small holders and on estates, is highly labor intensive, although varying degree of mechanization is used in field and on-site processing (Barlow, 1982).

Generally, agricultural development policies are designed to provide food security for the population, create employment opportunities, provide access to factors of production (such as land and capital), support growth of the non-agricultural sector through supplying raw material for industry and developing market for domestic production, and to generate foreign exchange by exporting agricultural production.

Those goals have guided policies since the first PELITA and will continue in the future, but with greater emphasis on development of the agricultural and industrial sectors in order to insure balanced growth between those sectors in term of either value added or labor force opportunity (MOA, 1990).

III. INDONESIA IN THE WORLD RUBBER ECONOMY

This chapter briefly reviews the world rubber economy, both for synthetic and natural rubber, starting with the history of rubber development and followed by a review of world production, world price, and the world demand for natural rubber. The natural rubber sub-section in Indonesia is then described.

3.1. The World Rubber Economy

The world rubber economy grew rapidly from the end of World War II until 1973 (Grilli, 1980). During this period, technological evolution resulted great structural changes in the world rubber economy. Synthetic rubber was developed to meet wartime needs, and continued to be produced and developed in increasing quantities. As a result, synthetic rubber has gained a dominant position in the world market, disturbing the near monopoly position of the natural rubber that originally was based on its unique characteristics.

Today, synthetic rubber is a close substitute for natural rubber, although there is no single type of synthetic rubber that has all the characteristics of natural rubber (Dissanayake, 1969). However, by combining various kinds of synthetic rubbers, it is possible to produce synthetic rubbers with properties which are almost identical to those of natural rubbers.

3.1.1. Synthetic Rubber

The evolution of synthetic rubber was primarily a European development, although scientists from many countries contributed to expanding the body of knowledge about natural rubber which was required before they could synthesize it. Michael

Farraday (1826) provided the first clue about the composition of natural rubber and assigned it the empirical formula, $C_{10}H_{16}$ (Herbert and Bissio, 1985).

However, the foundations of the synthetic rubber technology were laid by C.H.G. Williams (1860), who discovered that natural rubber was a polymer of a simple hydrocarbon (Polhamus, 1962). Williams succeeded in isolating the hydrocarbon, C_5H_8, which he named isoprene, synthesized the isoprene, and from isoprene he created a "white, spongy, elastic mass" by action of oxygen.

In 1879, Bouchardat discovered that treating pure isoprene with hydrochloric acid produced an elastic, rubber-like solid (Polhamus, 1962). Furthermore, W. Tilden (1880) showed that polyisoprene synthetic elastomer reacted with sulfur in the same way as natural rubber to form a tough, elastic, insoluble products (Allen, 1972; Herbert and Bissio, 1985).

Since the early 20th century, synthetic rubber has become an increasingly significant factor in the world rubber economy. Synthetic rubber production is concentrated in a few countries (Grilli, 1980). Although the United States has been the dominant producer since World War II, its market share is declining. On the other hand, Japan has become an important producer of this commodity since the 1970s, and its market share has increased over time. Similarly, China and the USSR's market share expanded over the same period (Table 5).

Table 5. Average annual production of synthetic rubber and the market share of each producing country, 1960 - 1990 (Million metric tons).

Producer	1960-1969	1970-1979	1980-1989	1990
USA	1,815.1 (50.3)	2,442.5 (32.5)	2,138.6 (23.7)	2,114.0 (21.1)
EEC	868.8 (20.9)	1,535.8 (20.3)	1664.0 (18.4)	1,899.0 (18.9)
USSR & CHINA	558.7 (15.2)	1,543.0 (19.9)	2,341.1 (25.9)	2,681.0 (26.8)
Others	488.6 (12.8)	1,188.7 (15.5)	1,750.5 (19.4)	1,890.0 (18.9)
JAPAN	195.1 (4.6)	896.0 (11.8)	1,134.8 (12.5)	1,426.0 (14.3)
World	3,720.0 (100)	7,606.0 (100)	9,029.0 (100)	10,010.0 (100)

Source: World Rubber Statistic Handbook, IRSG, 1990
( ) = Average percent share of world total

While six important kinds of synthetic rubber dominate the world market and compete with natural rubber, several additional kinds of synthetic rubber are available on the world market. The most important type of synthetic rubber is styrene-butadiene rubber (SBR), formed by the co-polymerization of butadiene and styrene. Although it does not have the same unit structure as the natural rubber hydrocarbon, SBR is a general purpose rubber, much like natural rubber (Polhamus, 1962). Other types of synthetic rubber include special purposes' rubbers, and stereo regular rubber (Allen, 1972)

3.1.2. Natural Rubber

3.1.2.1. History

Natural rubber is an elastic solid obtained from latex, a white, milky emulsion occurring in the roots, stems, branches, and fruits of a variety of trees (Herbert and Bissio, 1985). However, Hevea braziliensis is the most preferred tree species for producing latex (Courtenay, 1980). The basic structural unit of the natural rubber hydrocarbon is the isoprene molecule. Natural rubber has the desirable properties of extensibility, stretch-ability, and toughness. Christopher Columbus reported the first use of rubber on his second voyage to the New World during 1493-1496, when he saw Indians in Haiti playing a game with balls made from the gum of a tree. Somewhat later, in 1615, historical records mention the use of rubber for making crude footwear and bottles (Polhamus, 1962). Natural rubber was scientifically described by C. M. de la Condamine and Francois Fresneau of France, following an expedition to South America in 1736. The name "rubber" was given by the English chemist Joseph Priestley in 1770 because he found that it could be used to rub out pencil marks (Britannica Encyclopedia, 1990; Morton, 1987).

Before the beginning of the twentieth century, rubber was obtained from hundreds of different plants in tropical region of the America, Africa, and Asia. During this early period, the entire supply of rubber available in the world market was extracted from these wild plants[2]. After the discovery of vulcanization in 1839 by Charles Goodyear and the following rapid increase in demand for article of rubber, cultivation of rubber producing plants was widely promoted (Polhamus, 1962).

The cultivation of rubber trees began in 1876 when the seeds of the Hevea tree were taken from Brazil and germinated in the Botanical Garden at Kew, England

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[2]Four groups of tropical plants that produce rubber are: Euphorbiaceae (Hevea, Manihot, Sapium, Euphorbia, etc.), Moraceae (Ficus and Castilla), Apocyraceae (Funtumia), and Asclepiadaceae (Cryptostegia).

(Polhamus, 1962). Subsequently, British agriculturists brought some of the germinated seeds to Sri Lanka and Malaysia for replanting on plantation and the Dutch developed plantation in Indonesia (World Book Encyclopedia, 1990).

The production of natural rubber involves several processes, including tapping, coagulating, milling, drying and balling. Figure 1 shows the stages in natural rubber processing (Source: Barlow, 1978).

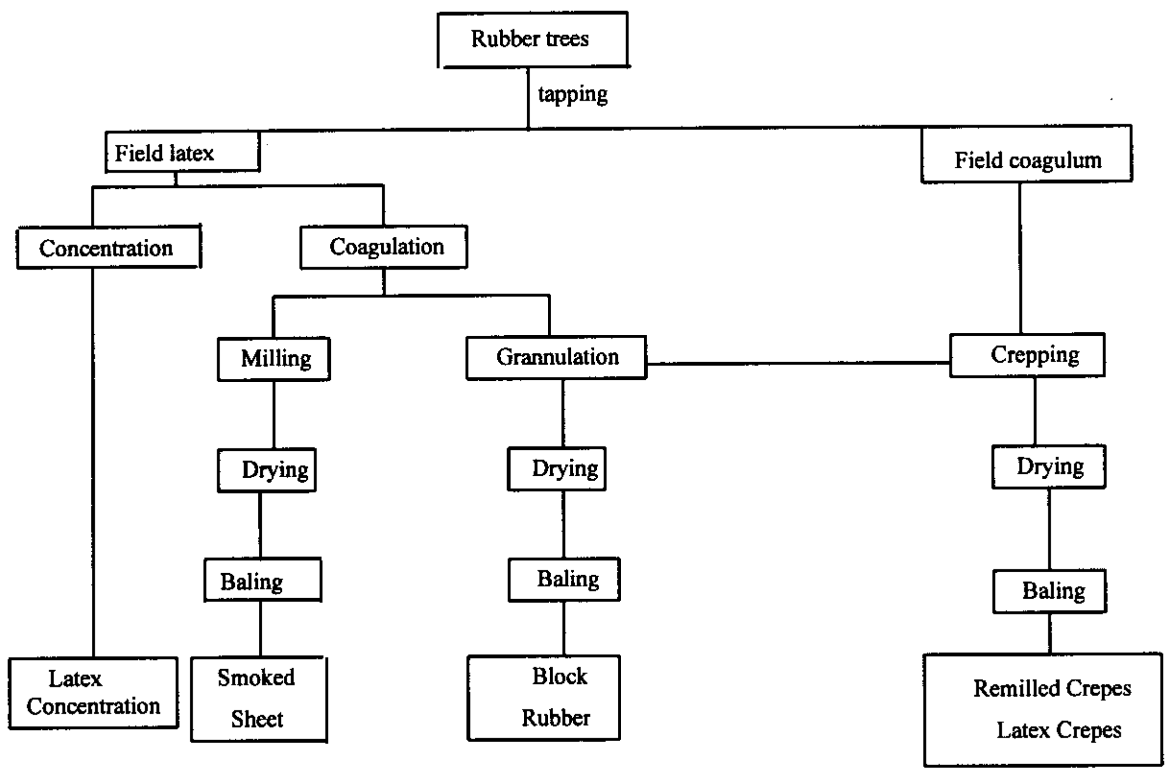

Figure 1. The stages in natural rubber processing.

Table 6. The usage of the natural rubber in products

Product	Percent
Tire and tire products	70 - 72
Mechanical goods	9 - 10
Latex products	7 - 8
Footwear	4 - 5
Engineering products	3 - 4
Adhesive	1 - 2
Others	2 - 3

Source: Adopted from Subramanian in Morton (1987)

Natural rubber is used mainly for tires and tubes, with about 65% of the world's natural rubber production consumed by the tire industry. The balance is used in a wide variety of consumer and producer goods ranging from medical insulation products, carpet-backing and shoes to automotive parts, industrial belt and hoses (World Bank, 1992). Subramanian in Morton (1987) estimated the approximate usage of the natural rubber, by product type, as shown in the above table (Table 6).

3.1.2.2. The Production of Natural Rubber

Rubber trees require five to seven years from planting to the first tapping. After reaching tapable age, the tree of Hevea brasiliensis has a potentially productive life of 30 years, with the peak production at around 12 - 13 years after first tapping, after which the latex yield slowly decreases (Herbert and Bissio, 1985). When the tree reaches 36 years of age, it must be replanted since after this time the latex yield declines rapidly.

In the 1980s, world production of the natural and synthetic rubber grew steadily, with both reaching their peak in 1989, when the total world rubber supply reached 15.39

million metric tons (CRB, 1991). However, natural rubber alone equaled 5.11 million metric tons (mmt), equal to about only 33% of world rubber production.

The oil crisis of the 1970s and a deep economic recession in industrialized countries represented in exogenous shocks that directly and indirectly affected the world rubber economy. The resulting sharp increases in the real prices of oil changed the cost structures of both synthetic and natural rubbers (Grilli, 1980). This crisis directly impacted the synthetic rubber industry because it depends very heavily on oil for petrochemical feed-stocks and for energy inputs such as steam and electricity, whose costs are very closely related to the price of oil and gas. On the other hand, the oil crisis indirectly affected the natural rubber industry, due to an acceleration of world inflation, changes in consumer expectation, and falling demand for rubber-based products.

The nine major natural rubber producing countries are Sri Lanka, India, Indonesia, Malaysia, Philippines, Thailand, Liberia, Brazil, and China. Malaysia, the largest producer country, accounts for approximately one-third of the total world production (1,415 mmt). After Malaysia, the other most important producer countries are Indonesia (1,256 mmt, 25%), Thailand (1,178 mmt, 23 %), and Sri Lanka (111 mmt, 2%), as shown in Figure 2.

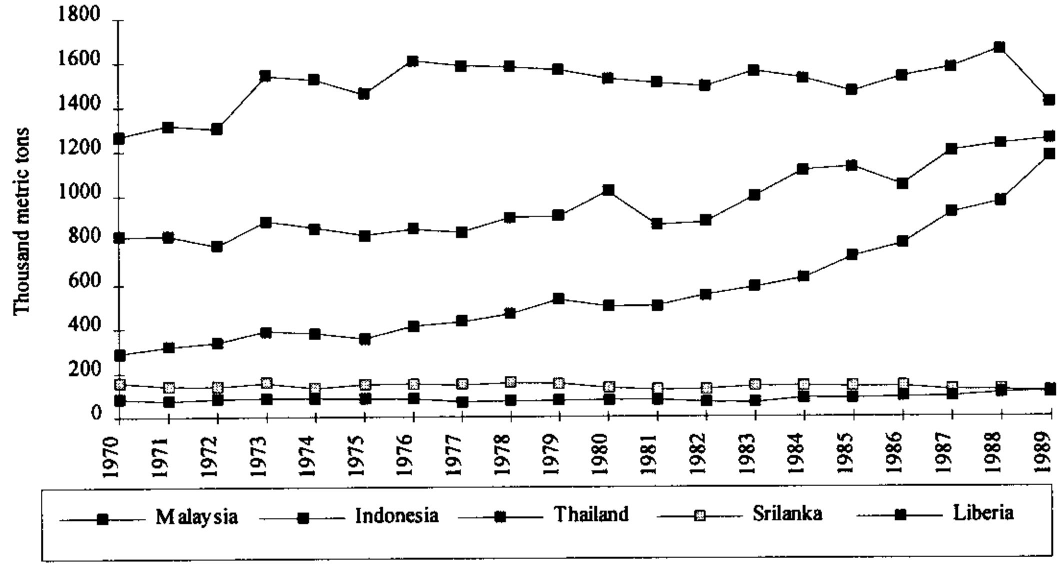

Figure 2. Natural rubber production, in major producer countries, 1970-1989.

According FAO (Production Year Book), during the period 1969 - 1989 production rose in all major countries except for Sri Lanka, which has experienced a decreasing trend in total production (1.2%). Malaysia reached its highest production level in 1979; and then faced a slightly decreasing trend until 1989. During the same period, Indonesia experienced a consistent increasing trend (2.7% per year). Similarly, Thailand experienced not only an increasing trend in total production, but also increased its share of world production. Finally, the other producing countries experienced a slight decrease in share of the world production (Table 7).

Table 7. The Production of Natural Rubber, major producing countries, selected years, (100 metric tons).

Country	1969	1974	1979	1984	1989
Malaysia	11,994 (42)	14,850 (44)	16,170 (42)	15,290 (36)	14,190 (29)
Indonesia	7,880 (27)	8,550 (25)	9,470 (25)	11,150 (26)	12,600 (26)
Thailand	2,818 (10)	3,790 (11)	5,400 (14)	6,290 (15)	9,360 (19)
Sri Lanka	1,508 (5)	1,320 (4)	1,530 (4)	1,420 (3)	1,110 (2)
Others	4,673 (16)	5,600 (16)	6,100 (15)	8,230 (20)	11,390 (24)
World	28,873	34,110	38,670	42,380	48,650

Sources: FAO, Production Year Book, selected years

Note: ( ) = Share of world production in %

Components of a country's level of production are total area under matures trees and yield per hectare (Dissanayake, 1969). Yield per hectare depends on the frequency of tapping, the number of trees tapped, the variety composition of trees, the age of the trees, and the application of stimulants (Polhamus, 1962).

Yields in each country vary widely, depending on the type of enterprises (i.e., smallholder vs. estate). For example, although Indonesia has a large area of rubber plantations, production per hectare for rubber smallholders averages only about 544 kg, while in Malaysia yields can reach 1,200 kg.

3.1.2.3. Price of Natural Rubber

Compared to synthetic rubber, the price of natural rubber is more unstable--experiencing wide fluctuations during certain periods. For example, from 1952 - 1962, the annual average price for natural rubber (Rubber Smoked Sheet I) in New York ranged from $0.23 to $0.39 per pound (FAO, 1964); while for the period of 1969 - 1990, the price ranged from $1.70 per pound (figure 3). This fluctuation greatly affects export earning from rubber for the exporting countries (CRB, 1991).

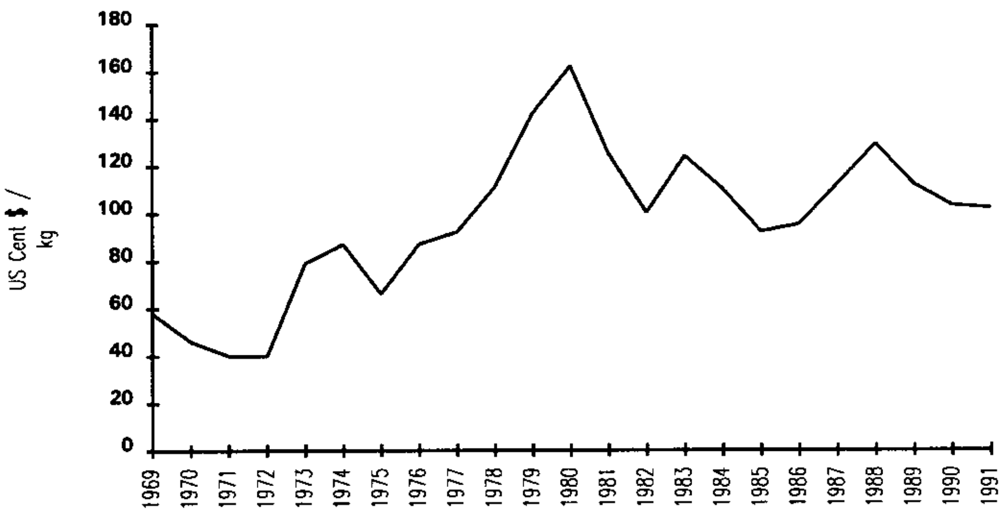

Figure 3. Average spot crude rubber prices, New York, 1969 - 1991.

Many factors contribute to the fluctuation in the natural rubber price, other than actual imbalances in supply and demand. For examples, political instability, reports that a certain country is about to enter the market on a large scale, forecasts of fluctuation in vehicle production, announcements of planned expansion in synthetic rubber capacity, floods in natural rubber producing countries, international monetary problems, speculations, etc., greatly influence the natural rubber price (Allen, 1972).

Grilli (1980) found that the short run demand for natural rubber is relatively insensitive to price changes, with the price elasticity ranging from - 0.2 to - 0.3. However, demand is quite sensitive to the changes in the economic activity, with the income elasticity of natural rubber demand ranging from - 0.6 to - 0.8. Furthermore, Grilli found that in the short run the natural rubber supply is also relatively insensitive to price changes, with a supply elasticity of 0.1 to 0.2.

However, in 1973 and 1979, the price of natural rubber increased due to the rise in the petroleum price during that period. Analysis by the World Bank (1990) found that increasing petroleum prices led to an increase in the natural rubber price in the short run, but had a negative impact in the long run. The increasing short run price was due to the expectation that increasing petroleum prices would cause an increase in the price of synthetic rubber, and would also lead to higher inflation rates.

3.1.2.4. The Demands for natural rubber

Annual consumption has generally increased over the past forty years, but the rate of increase has varied considerably from period-to-period. From 1970 - 1974, world consumption of natural rubber averaged 3.2 million metric tons, with an average rate of increasing of 4.15%. Over the period 1975 - 1979, annual average consumption increased to 3.6 million metric tons, but the average rate of increase decreased to 2.04%. However, from 1980 - 1984 annual average consumption increased slightly to 3.9 million metric tons. Finally, during the period of 1985 - 1989, annual average consumption rose greatly to 4.8 million metric tons, and the annual average rate of increase during this period was 4.34% (Table 8).

Most natural rubber is consumed in the developed countries. In the period 1970 - 1989, the United States consumed the highest portion (17 - 20%) of natural rubber, following by the Western Europe (1 - 17%) and Japan (9 - 12%). However, during 1980 - 1984 consumption in Western Europe decreased and it began to increase rapidly in Japan. In 1982, Japan's consumption surpassed that of Western Europe, and remained higher through 1985 - 1989 (Figure 4).

Table 8. The world's consumption of Natural Rubber in the major consumer (thousand tons)

Year	USA	Western Europe	Japan	World
1970-74	851.34 (20)	540.30 (17)	307.40 (9)	3,247
1975-79	733.14 (20)	510.58 (14)	330.40 (9)	3,644
1980-84	644.14 (17)	467.2 (12)	466.20 (12)	3,867
1985-89	804.24 (17)	507.26 (11)	584.50 (12)	4,785

Source: CRB, Commodity Year Book, Selected Years

( ) = percentage of world consumption

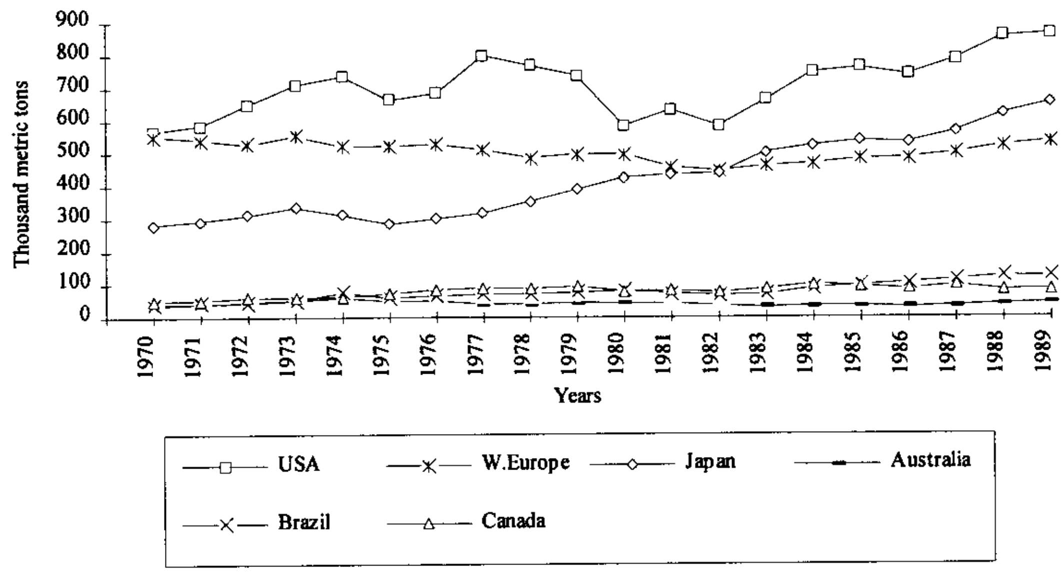

Figure 4. The world's natural rubber consumption

3.2. The Natural Rubber Sub-section in Indonesia

In Indonesia, rubber is produced by two distinct types of enterprises, i.e., estates and smallholders. Furthermore, estate enterprises may be differentiated into two kinds of estates, depending on the ownership of the plantation, i.e., private estate and government estate enterprises.

In Indonesia about 81% of the total rubber area is planted by smallholders; while the rest (19 %) is cultivated on both private and government estates. However, although only 19% of the rubber area is planted under estates, they account for about 30% of the total annual production.

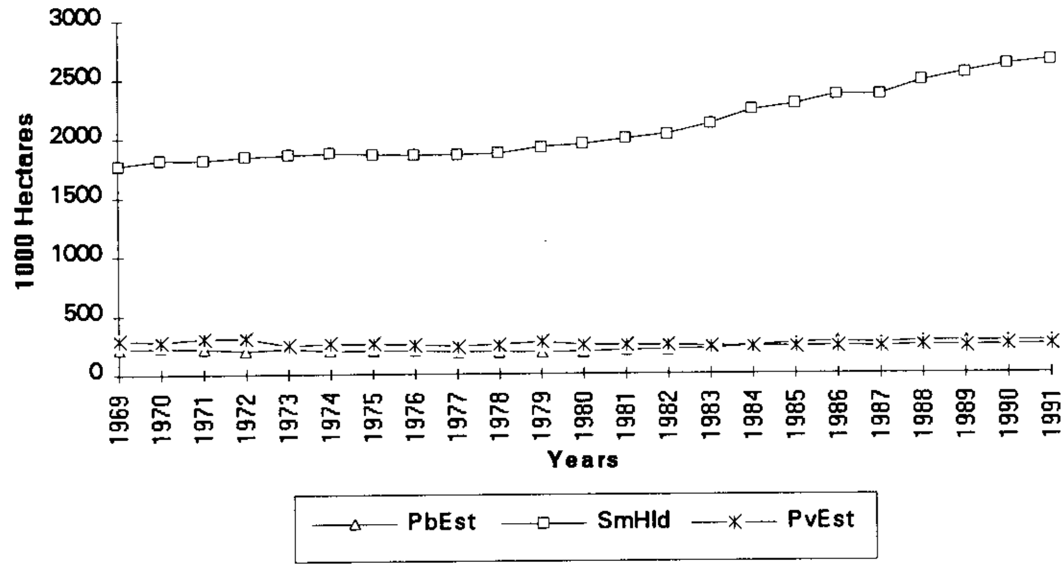

Figure 5. Area planted of natural rubber by types of enterprises, Indonesia, 1969-1991.

Natural rubber is planted throughout the country. However, the majority it is planted in the two large islands of Sumatra and Kalimantan (Figure 6). In 1990, Sumatra had about 2,000 hectares, equal to about 75 % of the total area of rubber planted in Indonesia; and Kalimantan had about 7,000 hectares (22 %). While rubber is also planted in the other islands, including Java, Sulawesi, Bali, Maluku, and Irian Jaya, their share of the total area is less than 5 % (DGE, 1991). In Sumatra and Kalimantan, rubber trees are extensively planted in the provinces of Jambi, Riau, North and South Sumatra, and West Kalimantan, which all have a high annual rainfall over 2,500 mm (Barlow & Muharminto, 1982).

3.2.1. Estate Enterprises

Estates are large commercial agricultural enterprises, operated by hired managers and workers. Estate enterprises employ relatively modern production technique, and require a high initial capital investment. In addition, these enterprises maintain a close relationship with research organizations, especially the Rubber Research Center. Their size of operation ranges between a few hundreds to several thousand hectares, depending on the condition specified in their land license[3].

Two types of estate enterprises are found in Indonesia, based on the source of capital. The government-owned estates are managed much more efficiently than the private-owned estates. However, some of the private estates, especially the larger ones, also have access to the latest technology and scientific inputs, as do the government-owned estates. On the other hands, many private-owned estates face numerous problems, especially in management, processing, and obtaining access to credit.

Most of the estate enterprises are located in Sumatra, especially in North Sumatra and West Java. In West Java, more than 70 % of the natural rubber is cultivated by private-owned estates. While there are many private-owned estates in West Java, the total area planted under this enterprise system is much lesser than that in North Sumatra, because the sizes of private-owned estates are relative smaller in West Java than that in North Sumatra.

In terms of production per hectare, government estates produce higher yields than the other types of enterprises. In 1990, the yield in the government-owned estate averaged 1,208 kg/ha, compared to only 1,022 kg/ha on private estate (DGE, 1991).

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[3]The land license authorizes the enterprises to cultivate a certain area of the land in the indicated commodity. This license is given for a specific period of time (25 - 30 years), depending on the type of commodity being cultivated, and must be renewed.

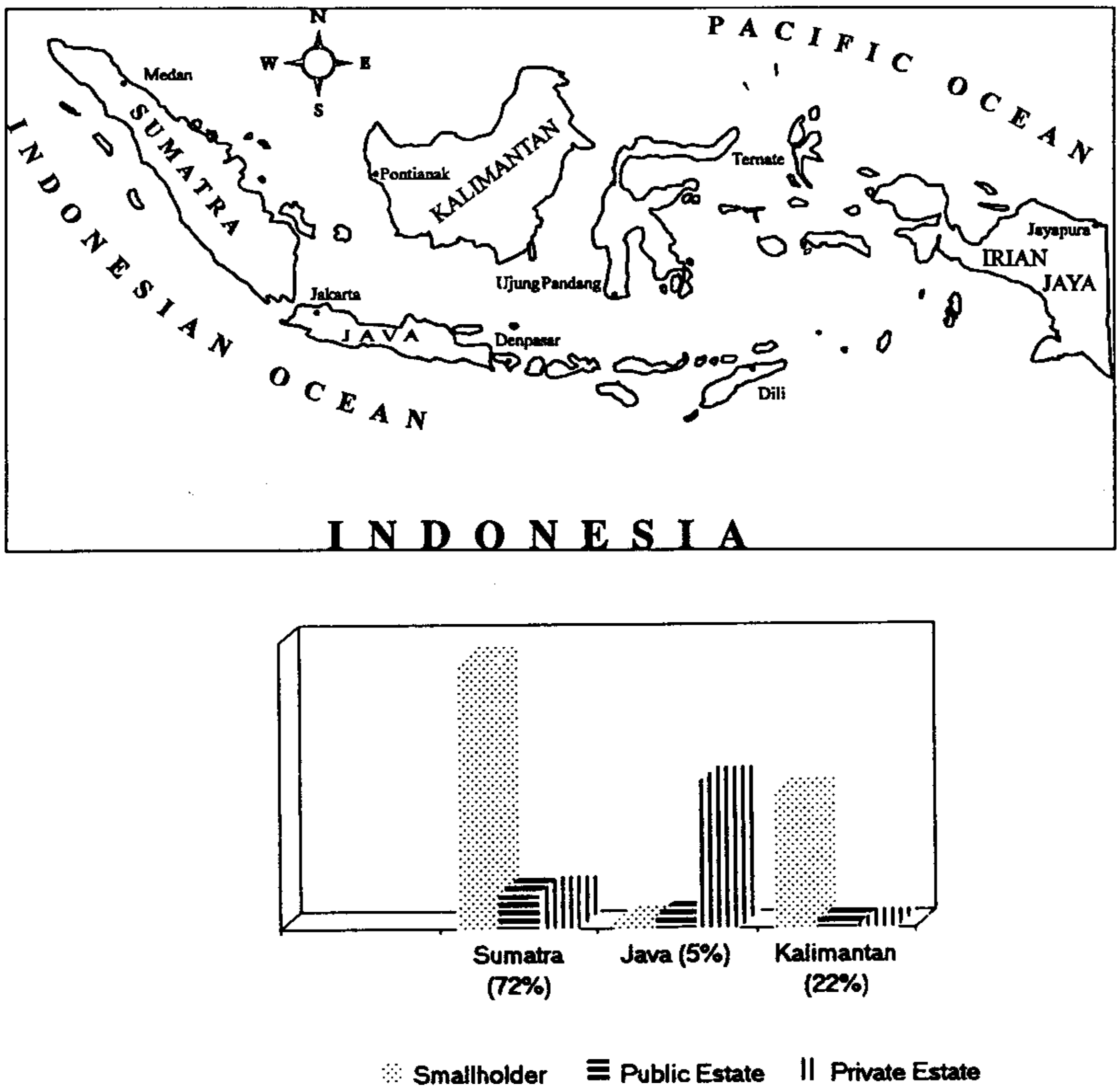

Figure 6. The Distribution of Cultivated Natural Rubber Location

3.2.2. Smallholding Enterprises

The smallholding sub-sector is made up of small family-operated production units that employ traditional techniques, have low yield, and average two hectares or less per family. The smallholder sector is divided into two sub-sectors, government-assisted schemes and unassisted smallholders. The unassisted smallholders account for the largest share (85%) of the area of this sub-sector.

Barlow (1982) noted that smallholder rubber producers are generally located far away from the major transportation routes, markets, and processing centers. They are basically subsistence farmers, whose main farming enterprises are rice and other food crops, followed by rubber and other cash crops. In order to improve these farmers' income, the government of Indonesia has launched programs to improve estate crops' productivity. These programs can be categorized into two types of approaches, namely the Nucleus Estate and Smallholders (NES, or Perkebunan Inti Rakyat) approach and the Project Management Unit (PMU, or Unit Pelaksana Proyek) approach.

Under the NES approach, government-owned estates (PTPs) act as catalysts to promote and assist the development of the surrounding smallholders. The PTPs are contracted by the Government to establish and maintain both the nucleus and the surrounding smallholders. This program is integrated with the transmigration program, which is a government effort to move people from the overpopulated island, like Java, to the less populated outer islands. Under this program, smallholders are given two planted hectares of tree crops, and another two hectare of land for food crops and housing.

Government has also assigned the nucleus estate to buy all the production from the members of the NES at a price determined by the quality of the raw production and based on the export price for that quality of output. To determine the price that farmers receive, the Directorate General of Estates has established a formula that is reviewed every six months. This formula uses the current export price (fob Jakarta, in domestic currency) received every two week from the Joint Marketing Board (Kantor Pemasaran Bersama, KPB), which is responsible for selling rubber on the world market.

The second approach, PMU, is implemented under the Smallholders' Rubber Development Project (SRDP) and Project for the Rehabilitation and Extension of Export Crops (PRPTE). These two projects mainly assist existing smallholders to replant or establish new-planting. Unlike in the NES, smallholders under PRPTE and SRDP are free to make their own arrangements for marketing their product. In 1990, the average yield for smallholders in both assisted and unassisted smallholders averaged only about 586 kg/ha.

Although Indonesia is well known as a major producer of natural rubber, domestic marketing facilities are a major weakness in the process and distribution system (Spillane, 1989). The marketing chain for natural rubber is long and many middlemen are found at each level in each production region. The survey on production and marketing of smallholder natural rubber in Jambi, West Kalimantan, and East Kalimantan provinces (1973) found that the shortest marketing channel of natural rubber was in West and East Kalimantan, while the longest was in Jambi (Mubyarto, 1991). The shortest chanels begin with the village and kecamatan middlemen and continue to the processor or exporter. In contrast, the longest channels start with the village middlemen, and include marga middlemen, kecamatan middlemen, commission agency (Kopuik), and processor or exporter.

Collier and Suhud (1972) found that the marketing channels for smallholder natural rubber vary, depending on the type of natural rubber produced. In West Java, the marketing channel begins with the village smoke house, while in South Sumatera where there is more variation in the types of natural rubber products, marketing channels vary even more. These marketing channel continued to be prevalent ten years later (Sumodiningrat and Anggito, 1987). Natural rubber farmers still prefer to sell their product to middlemen. The result of the census showed that 65.64% of the farmers sold their product to middlemen, 7.85% to the village market, 0.87% to the processor, 0.52% to the village unit cooperation (KUD), 0.05% to the nearest estate, and 3.01% to others.

The marketing structure for smallholder natural rubber found by Collier and Suhud (1972), especially in Java and Sumatra, is summarized in figure 7.

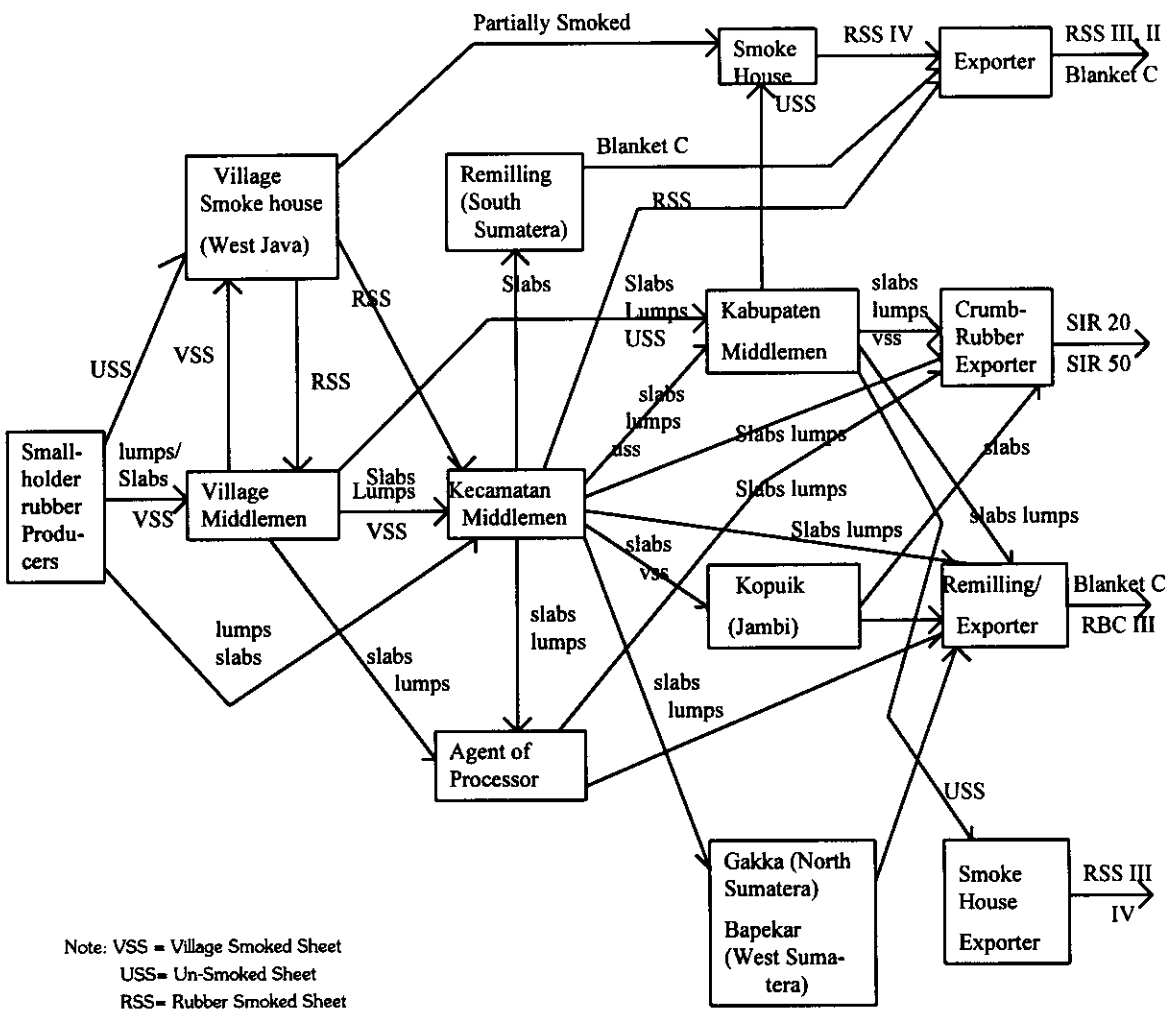

Figure 7. The Marketing Channel of smallholder natural rubber in West Java and Sumatera.

IV. THEORETICAL FRAMEWORK

This chapter reviews the literature that provides the theoretical framework used in the analysis. First, related study are reviewed, followed by the model specification for estimating the supply of, and the demand for Indonesian natural rubber. Finally, the data needed for this study, including the sources and its limitations, are discussed.

4.1. Related Study

While several studies have examined aspects of natural rubber, there exist few quantitative studies of the response of Indonesian rubber to price changes. On the other hand, there exist numerous studies of Malaysian natural rubbers. Some of these studies used simply regression models, where price was treated as an independent variable and quantity of natural rubber produced as a dependent variable. Other studies used multiple regression, single-equation models. These models were estimated from either annual, quarterly, or monthly time series data.

By using simple regression models and annual time series data (1948 - 1959) to study the supply response of Malaysian natural rubber estate, Chan (1963) found that output was a function of world price. He used both monthly and annual data, and his models were generally directed to obtain parameters which apply to the harvest or tapping response to the price changes. His basic model used the relation of the output to the price of natural rubber, the composition of the tree stand, mature tree acreage, and trend variable. The model separates for estates and smallholders. The use of annual data provided an imperfect estimates of the short-run period. In the estate, the coefficients derived from this data were statistically insignificant, while the price coefficient in the smallholder's equation suggested an elasticity of 0.12.

Using simple regression models, but monthly time series data, Wharton (1964) also studied the Malaysian smallholders natural rubber sector. He extended Chans' analysis by including total world demand and concluded that the smallholders were price responsive.

Another Malaysian study of natural rubber production, using multiple regression single-equation model and quarterly time series data for the period of 1953 - 1960, was carried out by Stern (1965). He also separated the analysis into estates and smallholders. For the estates, he used current price deflated by estate wages for tapper and field workers, ratio of the estates inventory to the estate sale, and time trend as independent variables of the output. On the other hand, for the smallholders, he related output to a deflated current price, a deflated current price of rice, and trend variable. His results indicated that estate production was not influenced by variations in current deflated prices. Moreover, he found that the price elasticity was negative, although, not significantly different from zero. However, Stern found that the ratio of estate inventory over sales together with the time trend were the important determinants of estate output. In terms of smallholders, he found that the current price (deflated) was significant at the 1% level and suggested a short-run price elasticity of about 0.20.

Horowitz (1963), in Reutens (1974), used a simultaneously equation model in his econometric analysis of supply and demand in the synthetic rubber industry. Using monthly time series data, he found that natural and synthetic rubber exhibited a complementary relationship, rather than being substitutes. In addition, he found that the elasticity of supply of natural rubber entering the U.S. market, with respect to the ratio of current price of synthetic rubber over current price of natural rubber, was 0.47.

Pasaribus (1963) used annual time series data in a simultaneous equation model to analyze competition between natural and synthetic rubber in the world market. He found that the supply schedule of natural rubber in the world market has a positive slope and that price of natural rubber has a positive relationship with the price of synthetic rubber.

In 1974, Reutens' study of the international rubber economy found that both world natural rubber demand and supply are highly price inelastic with the price elasticity coefficient of -0.0044 and 0.0517, respectively. The study also found that the world natural rubber import demand depends on automobile production in all consuming countries and the indices of industrial production in both the U.S. and non-U.S. countries. In addition, commercial stock of natural rubber held in the U.S. and in other consuming countries were seen to influence world demand to the extent that large quantities of stock held will reduce natural rubber import demand. However, this effect is slightly greater from stock held in the U.S. than that in the other consuming countries.

Most studies of Indonesian natural rubber have employed qualitative techniques to examine ways to increase production and raise farmers' incomes. In 1972, Collier and Suhud analyzed smallholders natural rubber production and marketing. After describing the existing marketing and production situation in Sumatra and West Java, they proposed recommendations as to what should be done to improve the industry. This study identified the importance of improving the quality of rubber produced by the farmers, since better quality rubber (at the farm-level) would enable the processor to produce a higher grade of rubber and reduce processing costs. As a results, the processor would be able to give farmers a premium price for good quality rubber, which would encourage the farmer to produce better quality rubber. To achieve this objective, they recommend that the government provides free improved planting materials to the farmers, establish small-scale processing centers near the producing areas, and provide credit for replanting to enable farmers to improve their agronomic technique, etc.

Since the early 1970s, several policies for improving the rubber sub-sector have been proposed, including changes in fiscal policies, restructuring agricultural research, and launching some projects. In response to these suggestions, the official cess was removed in 1976, which reduced the total tax on rubber exports from 17 % to 10 % of the f.o.b. price. In addition, the 1978 devaluation of the rupiah by 15 % against U.S. dollars also benefited natural rubber farmers substantially (Barlow, 1982).

Since 1975, agricultural research has been restructured by including rubber as one of four priority commodities, establishing new natural rubber research stations, and by designating one research station to specialize on the research for smallholders problems, and another to specialize on estate problems.

4.2. Theory of Demand and Supply

Price theory deals with four important functions: the demand function, the cost function, the production function, and the supply function . This section reviews two functions related to this study--the demand function and the supply function. First, the demand function for a commodity shows the relation between the various quantities of the commodity that might be bought and the determinants of those quantities (Watson, 1981). Moreover, the determinants are the price of the commodity, the income of the buyers, their tastes, and the prices of closely related commodities. In this case, the individual consumer's demand function for a certain commodity is a function of: the price of the commodity in question, the price of other commodities taken by the consumer (either substitutes or complements), and income, tastes, and preferences of individual consumers.

Furthermore, the market demand function for a finished commodity is defined in terms of the alternative quantities of a commodity that all consumers in a particular market are willing and able to buy, as price varies and as all other factors are held constant (Tomek & Robinson, 1990). From the demand of all the individual consumers in a market for that commodity, with the horizontal summation of all the consumers' demand schedule, the market demand for the commodity can be derived (Nicholson, 1989).

The second is the supply function, which shows the relationship between different quantities sold and the determinants of the quantities (Watson, 1981). In the multi-factor-multi-product case, the supply schedule of a commodity is derived from the firm's profit function, subject to its implicit production function. In this case, firms or producers attempt to maximize their profit by equating marginal cost and marginal revenue in choosing their level of output (Tomek & Robinson, 1990 ; Nicholson, 1990). Hence, the production level of a certain commodity will depend, theoretically, on the price of the commodity in question, the price of the commodity competing for the same inputs, and the price of inputs.

4.3. Model Specification

Econometric modeling may be classified into five stages (Hallam, 1990). The first stage involves specification of the model. This stage includes selection of the variables to be considered, defining the variables in terms of available series of statistical observations, and specifying the mathematical and statistical form of the relationships hypothesized to exist between variables. The second stage involves collecting and manipulating the relevant data. The third stage includes the estimating of the parameters of the hypothesized relationship between variables. The next stage includes validating the model, where the estimated model is tested and evaluated. In this stage, the result of validation and evaluation will show the accuracy of a model. The final stage involves applying the model.

This section briefly discuss on the specification of the model of the supply of and demand for natural rubber.

4.3.1. Overview

The price of natural rubber in the world market is hypothesized to be determined by the total world supply of, and demand for natural rubber. The world supply of natural rubber comes from the export supply of Indonesian natural rubber, and the export supply of natural rubber from other producing countries. Hence, Indonesia's export supply is also influenced by the price of natural rubber in the world market.

In all exporting countries, almost all natural rubber produced is exported; so, the quantity exported is assumed to equal total production. In other words, world supply determined the quantity available for export. Furthermore, since the export supply of the Indonesian natural rubber is the total natural rubber produced from both estate and smallholders in Indonesia, it is hypothesized that the price of natural rubber in the world is interrelated with the natural rubber production from both estate and smallholders in the country.

The natural rubber demand is equal to the total demand for natural rubber in the world market because the natural rubber from all exporting countries is assumed to be a homogenous product. The world market itself consists of the U.S. market, and non-U.S. market (i.e. outside the U.S. market). The demand for Indonesian natural rubber and other producing countries are derived from the total world demand for natural rubber.

4.3.2. Supply of Natural Rubber

In order to develop a meaningful estimation of the supply of natural rubber industry, it is necessary to distinguish between the short run and long run. The short run refers to that period of time during which the inputs of one or more productive factors of a particular firm are fixed. The changes in the output must be accomplished only by changing the quantity of variable factor inputs (DeSerpa, 1988).

The fixed productive factors for an individual natural rubber firm are the stand of mature tapable trees. So, for the natural rubber firm, the short run is the period of time in which the firm is unable to change the number of mature trees capable of being tapped. On the other hand, the long run is a sufficiently long period to allow new trees to come into tapping.

In the short run, the production of rubber will depend on the yield per hectare in tapping and the mature tree area in tapping. For any given mature area in tapping, the yield per hectare will depend on the frequency of tapping, the intensity of tapping, the number of trees tapped, the age of the trees, soil quality, weather, condition of the trees, and the use of stimulants.

In summary, factors that affect the production of natural rubber at any given time are the frequency of tapping, intensity of tapping, number of trees tapped, variety composition of stand, age composition of stand, density of stand, soil quality, weather, and use of stimulants.

4.3.2.1. Natural Rubber Export Supply from Indonesia

Since two types of enterprises are found in Indonesia, total natural rubber output is equal to the total production of those enterprises, which is a function of yield and area under mature trees. With respect to the area, farmers in both types of enterprises are generally slow to change in the short-term. Theoritically, the area planted in particular year is influenced by the price that prevails in that year, but new planting takes about six to seven years before producing latex. In the preliminary test, this study has tried to relate the mature tree area with the lagged price for several years. However, it did not provide a satisfaction result. Beside that, the lack of data also accounted for this unsatisfaction result. In addition, there is also a strong tendency for an individual enterprise to base its present area on his past year's area. Hence, based on the above information, the equations for the area of the mature trees this year, both under estate and under smallholders, may be formulated as :

MTAE = f(C, MTAE(-1), TREND) (1)

MTASM = f(C, MTASM(-1), TREND) (2)

where:

MTAE = area of mature trees under estates, measured in 1,000 hectares;

C = the constant term;

MTAE(-1) = area of mature trees under estates in the previous year, measured in 1,000 hectares;

MTASM = area of mature trees under smallholders, measured in 1,000 hectares;

MTASM(-1)= area of mature trees under smallholders in the previous year, measured in 1,000 hectares;

TREND = the time trend;

Moreover, estate enterprises, which are operated using business principles, are price responsive in their decision making. In the short term, the influence of the price of natural rubber on their decision will be reflected in the changes of the following factors : frequency of tapping, intensity of tapping, number of trees tapped, and the use of stimulants. Since many estates export their products by themselves, their production will respond to the price of the natural rubber in the world market. Therefore, the current yield of natural rubber from the estate enterprises is hypothesized to be a function of the price in the world market and the time trend. This relationship can be formulated as :

YLDE = f(C, PRDLTD, TREND) (3)

where:

YLDE = yield (ton/hectare) of natural rubber in estates;

PRDLTD = the price of natural rubber in the world market, US $/ton, represented by Jakarta fob price of RSS 1, deflated by CPI U.S. (1985=100);

TREND = the time trend;

On the other hand, smallholders are family operated enterprises consisting of small, traditionally managed units which produce low yields. Except for the government-assisted smallholders, most smallholder natural rubber production is part of a shifting cultivation cycle. Barlow and Muharminto (1982) found that available family labor is divided among several activities. During the period when fields (ladang) were cultivated, most family labor was used to cultivate rice and other non-natural rubber areas. In addition, Thomas (1965) observed that tapping tends to compete for the farmer's and his household's labor, and the farmers tap their rubber whenever they are not working in the ladang, regardless of the market price. From the above discussion, it can be hypothesized that the current yield of natural rubber from smallholders is influenced by the price of rice in the previous year.

Moreover, although smallholder farmers do not export their product by themselves, as estates do, they still respond to price changes. In this case, the price that they know is the domestic rubber price. Ideally, the farm-level natural rubber price is the appropriate price to which the smallholders will respond. However, since natural rubber is an export commodity, its farm-level price is still related to the export price, in this case the fob price in Jakarta, the capital city. Therefore, the current yield of smallholder natural rubber can be hypothesized to be a function of the domestic price of natural rubber, the price of rice lagged by one year, and the time trend. This relationship can be formulated as:

$$YLDSM = f(C, JKPRRPD, RICEPD) \qquad (4)$$

where :

YLDSM = yield (ton/hectare) of natural rubber for smallholders;

C = the constant term;

JKPRRPD = the domestic price of natural rubber, Rp.1,000/ton, represented by Jakarta fob price of RSS 1, deflated by CPI Indonesia (1985=100);

RICEPD = average annual domestic price of rice lagged by one year, represented by the un-weighted average prices of rice in Palembang, Jambi, and Banjarmasin, Rp/kg, deflated by Indonesian CPI (1985=100);

The relation between yield, area of the mature trees, and production supply is described by the following identities:

PRDE = MTAE * YLDE (5)

PRDSM = MTASM * YLDSM (6)

where :

PRDE = the quantity of natural rubber produced by estates in Indonesia, measured in 1,000 mt of the dry-content weight of latex;

PRDSM = the quantity of natural rubber produced by smallholders in Indonesia, measured in 1,000 mt of the dry-content weight of latex;

Then, the total annual production of Indonesian natural rubber (INAPRD) is the summation of the annual production from both estates and smallholders, formulated as:

INAPRD = PRDE + PRDSM (7)

Finally, based on economic theory, the export supply would be a function of the price. Since most production is exported, the physical quantity of export supply is highly influenced by the total level of production. Therefore, the export supply of natural rubber from Indonesia can be formulated as:

QEINR = f(c, INAPRD, PRDLTD) (8)

where :

QEINR = the quantity of Indonesian's export supply of natural rubber, measured in 1,000 mt of the dry-content weight of latex;

INAPRD = the total annual production of Indonesian natural rubber, measured in 1,000 mt of the dry-content weight of latex;

PRDLTD = the price of natural rubber in the world market, U.S. \$/ton, represented by Jakarta fob price of RSS 1, deflated by CPI U.S. (1985=100);

4.3.2.2. Natural Rubber Export Supply from Other Countries

Indonesia exports most of its natural rubber production; as do other producing countries. Exports from countries other than Indonesia are the second source of the world's natural rubber supply. Thus, the world market price of natural rubber is also influenced by these exports. While the same factors determine the supply of natural rubber in other producing countries, as for Indonesia, such a comprehensive treatment is not carried out for several reasons. First, the main interest for this study is to determine the impact of the world market price of natural rubber on Indonesian production. Also, it is impossible to obtain the appropriate time series data for all of the other producing countries.

Therefore, for simplicity, the export supply of natural rubber from other producing countries is hypothesized to be a function of the world market price of natural rubber, the total quantity produced from all other countries, and the time trend. The export supply from other countries is formulated as:

$$QEONR = f(C, ONRPRD, PRDLTD, TREND) \qquad (9)$$

where :

QEONR = the quantity of other producing countries' export supply of natural rubber, measured in 1,000 mt of the dry-content weight of latex;

C = The constant term;

ONRPRD = the natural rubber produced by producing countries other than Indonesia, measured in 1,000 mt of the dry-content weight of latex;

PRDLTD = the price of natural rubber in the world market, U.S. \$/ton, represented by Jakarta fob price of RSS 1, deflated by CPI U.S. (1985=100);

TREND = the time trend

4.3.3. Demand for natural rubber

The consumption of natural rubber is still dominated by the United States, followed by Japan which surpassed the total consumption of Western Europe countries in 1982 (CRB, 1992). Similar to the demand model built by Reutens (1972) and taking into account the recent demand situation, this study separate the world market into the U.S. and non-U.S. market.

4.3.3.1. Demand for natural rubber in the U.S. market.

Applying the economic theory discussed above, the import demand for natural rubber is influenced by the price of natural rubber, the price of synthetic rubber, the level of natural rubber usage, the level of natural rubber stock held by the country in the beginning of the year, the consumption of synthetic rubber, and the real income of the country. With respect to the price of natural rubber, a negative relationship between consumption and price is expected to exist. Moreover, a negative relationship is also expected to be found between import demand and beginning stocks.

Natural rubber is mostly used in the automobile industry, especially to produce tires and automotive parts. Since the automobile industry is influenced by the national income, national income indirectly influences the level of rubber consumed through the automobile production. In addition, natural rubber is used in many other industries. To take into account natural rubber consumption by these industries, the index of industrial production is used as a proxy to account for movement in industrial production. Moreover, although both natural and synthetic rubber have distinct qualities, they are substitutes for many product applications. Thus, the main determinants of the choice are their relative price and availability. Hence, synthetic rubber consumption should be included in the demand equation. However, synthetic rubber consumption is not included as a single independent variable, but is incorporated it in total rubber consumption to get the ratio of natural to total rubber consumption. Then, this ratio becomes one dependent variable considered in the equation. Furthermore, it is hypothesized that the relative price of natural and synthetic rubber influences the ratio of natural rubber to total rubber consumption. Thus, an increase in the ratio implies that natural rubber consumption will decrease, because the higher the ratio, the higher the price of natural rubber. The U.S. natural rubber consumption is formulated as:

RUNC = f(C, RATPR, TREND); (10)

AUTUSP = f(C, DICD); (11)

USTRC = f(C, AUTUSP, IDXPUS, TREND); (12)

where :

RUNC	= the ratio of the U.S. natural rubber to total rubber consumption; where total rubber consumption includes of natural rubber and synthetic rubber consumption;
C	= the constant term;
RATPR	= the ratio of natural rubber to synthetic rubber prices in the world market;
TREND	= the time trend;
AUTUSP	= the production of U.S. automobiles (passenger cars and commercial vehicles), measured in 100,000 vehicles;
DICD	= the U.S. real disposable income;
USTRC	= the U.S. total rubber consumption (natural + synthetic rubber), measured in 1,000 mt of the dry-content weight of latex;
IDXPUS	= the index of annual industrial production for the U.S.;

Finally, total U.S. import demand for natural rubber theoretically will depend on the level of natural rubber consumption and the beginning stock of natural rubber. This relationship can be formulated as:

USINR = f(C, USNRC, BUSTOCK) (13)

where :

USINR	= the quantity of U.S. import demand for natural rubber, measured in 1,000 mt of the dry-content weight of latex;
C	= the constant term;

USNRC = the quantity of U.S. natural rubber consumption, measured in thousands metric tons of the dry-content weight of latex, (USNRC = RUNC * USTRC);

BUSTOCK= the U.S. beginning stock of natural rubber, measured in thousands metric tons of the dry-content weight of latex

4.3.3.2. Non-U.S. Import Demand for Natural Rubber.

The non-U.S. market demand for natural rubber was treated similarly to the U.S. market demand. It is influenced by the price of natural rubber, the price of synthetic rubber, the level of natural rubber consumption, the level of the beginning stock, the level of synthetic rubber consumption, and average real income. This relationship is formulated as:

RONC = f(C, RATPR, TREND); (14)

AUTOP = f(C, GPOCD); (15)

OTRC = f(C, AUTOP, TREND); (16)

OINR = f(C, ONRC, BOSTOCK); (17)

where :

RONC = the ratio of the non-U.S. natural rubber to total rubber consumption; where total rubber consumption includes natural rubber and synthetic rubber consumption;

C = the constant term;

RATPR = the ratio of natural rubber to synthetic rubber prices in the world market;

TREND = the time trend;

AUTOP = the production of non-U.S. automobiles (passenger cars and commercial vehicles), measured in 100,000 vehicles;

POCD = the averaged non-U.S. real disposable income, deflated by the U.S. CPI;

OTRC = the non-U.S. total rubber consumption (natural + synthetic rubber), measured in 1,000 mt of the dry-content weight of latex;

OINR = the quantity of the non-U.S. import demand for natural rubber, measured in 1,000 mt of the dry-content weight of latex;

ONRC = the quantity of the non-U.S. natural rubber consumption, measured in 1,000 mt of the dry-content weight of latex, (ONRC = RONC * OTRC);

BOSTOCK = the non-U.S. beginning stock of natural rubber, measured in 1,000 mt of the dry-content weight of latex;

4.3.4. The Price of Natural Rubber and Its Stocks

Factors that affect the price changes of natural rubber in the short-term are: changes in the level of stock and inflation ratio, while in the long-term trend is determined by the trend of synthetic rubber price (Grilli, 1979).

Three kinds of stocks are found in the natural rubber commodity, that are stocks kept by producer, traders, and users. Beside that, government also held stocks for security reasons, although it has been exhausted since 1978 (IRSG, 1990). This study used the total stocks' data published by International Rubber Study Group. The price relationship could be formulated as:

$$PRDLTD = f(C, SBRPTD, WSTK) \qquad (18)$$

where:

PRDLTD = the price of natural rubber in the world market, U.S. $/ton, represented by Jakarta fob price of RSS 1, deflated by CPI U.S. (1985=100);

C = constant term;

SBRPTD = the U.S. price of synthetic rubber, U.S. $/ton, represented by the price of SBR, deflated by CPI U.S. (1985=100);

WSTK = stock of natural rubber ('000 mt).

The relationship between total stocks, total supply, and total demand is assumed to be as:

$$WSTK = WSTK(-1) + TSUPLY + GSTK - TDEMAN \qquad (19)$$

where:

WSTK = ending stock of natural rubber ('000 mt);

TSUPLY = total supply of natural rubber ('000 mt);

GSTK = government stockpile sale ('000 mt);

TDEMAN = total demand for natural rubber ('000 mt).

Finally, this model uses two price time-series for natural rubber. World market prices are represented by the world market export price (fob Jakarta) in U.S. $/ton (PRDLT). Domestic prices are represented in Indonesian Rp.1,000/ton JKPRRP). The relationship between these prices is :

$$JKPRRP = PRDLT * XRINA \qquad (20)$$

where :

XRINA = Indonesian exchange rate (Rp/US $).

4.3.5. Foreign Demand for Indonesian Natural Rubber

Finally, the foreign demand for Indonesian natural rubber is equal to total world demand, minus the export supply from other countries.

4.4. The Nature of the Data

This study uses data from several sources. Indonesian data were taken from time series compiled by Directorate General of Estates Crops and Central Bureau of Statistics. In addition, the study uses selected data compiled by International Rubber Study Group (IRSG), Food and Agricultural Organization (FAO), Commodity Research Bureau, and the IMF (International Financial Statistics).

Using different sources of the data presents some problems, since no single source provides data for all of the variables included in this study.

V. STATISTICAL RESULTS AND EVALUATION OF THE GENERAL MODEL

This chapter presents the results of the statistical analysis of the model. First, the overall results of the estimated coefficients of the model and an evaluation of the general model are presented. This is followed by a discussion that focuses on the supply of and demand for Indonesian natural rubber.

5.1. Overall Results

The following results include both the selected equations (originally specified in Section 4.3.) that passed the statistical and economic tests and some additional specifications not originally discussed.

All equations are estimated using annual data from 1970 to 1990. These analyses were carried out using the Micro-TSP computer software package. To incorporate the general inflation rate, the consumer price index (CPI) is used as a price deflator, instead of as a separate variable.

All the estimated equations and the selected diagnostics, such as the standard error of the estimates, t-statistic values, 2-tail significance, R^2 , adjusted R^2 , F-statistics, and Durbin-Watson statistics, are presented in the following tables. The variables' definitions are presented in the Appendix I.

5.1.1. Natural Rubber Export Supply from Indonesia

The general model of Indonesia's natural rubber export supply consists of five single equations and three identity products. The single equations include equations for the mature tree area and yield under both estate and smallholder enterprises, and the equation for the quantity of Indonesian export supply. The identity products represent the annual production from both estates and smallholders enterprises, and the total annual production of Indonesian natural rubber.

5.1.1.1 Estimated Mature Tree Area

The results of the mature tree area regression equation are presented in Table 9 (for estates) and Table 10 (for smallholders). As mentioned in the previous chapter, farmers in both types of enterprises are generally slow to change their production practices and they tend to base their present area on their past year's area. These results confirm a strong relationship between the present area and the previous year's area as indicated by the high t-statistic value, especially for smallholder enterprises.

In addition, zero-one dummy variables for 1971 and 1984 are used to capture the abrupt shift in the natural rubber mature tree area, for the respective years, in both types of enterprises. The shifts represent the farmers' reaction to Government programs that rehabilitated the non-productive trees and expanded the area in new plantings.

Table 9. Selected results for the mature trees area under estates equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT	D-Watson
TAE					0.76	0.67	11.12	2.06
	130.88	59.04	2.22	0.0415				
TAE(-1)	0.50	0.21	2.38	0.0301				
REND	1.80	0.78	2.32	0.0336				
V71	30.55	14.86	2.05	0.0566				
V84	28.00	15.65	1.79	0.0925				

Source: Constructed by the author.

The coefficient of determination (R^2) of 0.76 implies that the independent variables in this equation explained 76 percent of the variation in the dependent variable. The adjusted R^2 of 0.67 indicates that after taking into account the number of independent variables included, the model explained 67 percent adequate for the time series data used (21 observations).

The equation for mature tree area under estates is tested by evaluating the significancy of the t-statistics corresponding to each included independent variable. A t-statistic, the most common statistical procedure to evaluate estimated parameters is used to test the null hypothesis that an independent variable's coefficient does not explain anything in the regression (Tomek and Robison, 1990). If a variable has a t-statistic value (i.e. ratio of the coefficient to its standard error) greater than one, it is retained in the equation (Tomek and Robinson, 1990). A t-statistic that is larger than one means there is at least a two-thirds likelihood that the true value of the coefficient is not zero; while if the t-statistic is greater than two, it is at least 95 percent likely that the coefficient is not zero (Hall, et. al., 1990).

Using the above information, it is found that all the regression coefficients in the mature tree area under estate equation, except for the coefficient of dummy variable DV84, are significant at the 5 percent level of significance. However, the t-statistic for the coefficient of DV84 is greater than one (1.79), indicating that at least there is a two-thirds probability of this variable has an influence on the dependent variable.

The F-statistic is used to test the hypothesis that none of the independent variables help to explain the variation of the dependent variable about its mean (Pindyck and Rubinfeld, 1981). In other words, the F-statistic tests the joint hypothesis that all coefficient of independent variables, except the intercept, are zero. If the value of the F-statistic is greater than its critical value level, it means that at least one of the coefficient is probably not equal to zero. In the mature tree area under estate equation, the F-statistic of 11.12 exceeds the critical value at the 1% ($F_{0.99(4,21)}$= 4.37) level of significance.

This implies that the joint hypothesis that all variable coefficients are zero can be rejected with a margin of error of less than one percent.

The Durbin-Watson (D-Watson) statistic, calculated from the residuals of an ordinary least square regression, is used to test for first-order auto-correlation (Kennedy, 1989). A D-Watson statistic of much larger than two implies that there is positive auto-correlation; where as a D-Watson is much less than two indicates negative auto-correlation. Moreover, if the D-Watson statistic is around 2, the hypothesis of no auto-correlation will be accepted. If auto-correlation exists, the equation should be re-specified or should be corrected. However, when there is a lagged dependent variable in the equation, the D-Watson test is not likely to be valid. Since the equation of the mature tree area under estates has a lagged of the dependent variable, the D-Watson statistics is not applicable in this equation. However, the Durbin h-test can be used to evaluate this type of equation, as specified below:

$$h = (1 - DW/2) * [\, T/ (1 - T * S_e^2)]^{1/2}$$

where:

h	= Durbin h-statistics;
DW	= Durbin-Watson statistics;
T	= the number of observation;
S_e	= standard error of the coefficient of lagged endogenous variable.

The equation of mature tree area under estates has a Durbin h-statistics of 0.53. Since this value is less than the critical value of the normal distribution at the 5% level (1.645), the hypothesis of no serial correlation can not be rejected.

Table 10. Selected results of the mature trees area under smallholders equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
TASM					0.99	0.98	615.90	2.12
	23.66	41.76	0.57	0.5780				
TASM(-1)	0.997	0.03	34.11	0.0000				
V84	386.82	38.45	10.06	0.0000				

Source: constructed by the author.

The equation for mature tree area under smallholder enterprises has an R^2 of 0.99. This value indicates a strong statistical fit for the regression. The adjusted R^2 of 0.98 shows that the independent variables used in this equation explain 98 percent of the variation in the dependent variable. T-statistics of greater than 2 for coefficient of the lagged mature tree area and dummy variable for 1984 show that these variables are significant at less than the 5% level of significance.

The F-statistic for this equation is 615.91. This value is far above the critical value of 5.78 at the 1% level of significance. The D-Watson for this equation is 2.12, indicating that auto-correlation is not presence in this equation.

5.1.1.2. Estimated Averaged Annual Yield of Natural Rubber

The yield of natural rubber is influenced by several factors, including the frequency of tapping, intensity of tapping, number of trees tapped, and the use of stimulant. However, producers vary those factors depending on the price of the natural rubber, especially in the estate enterprises that operate using business principles.

A dummy variables, equal to one for the years from 1981 to 1983 and zeros otherwise (DV2), is used to capture the unusual situation that characterized natural rubber prices over the period of the analysis. In addition, a zero-one dummy variable is also used for 1986 to capture the change in the value of Indonesian currency, resulting from a devaluation of the rupiah against the U.S. dollar. Finally, a trend variable is used to account for changes in natural rubber technology. The estimated coefficients for the variables included in the estate enterprises yield equation are presented in Table 11.

The equation for yield under estates has a coefficient of determination (R^2) of 0.89 and an adjusted R^2 of 0.87. The t-statistic of the coefficients corresponding to all independent variables are significant at the 5% level of significance. The F-statistic of 33.15 is significant at the 1% level because it exceeds the critical values of $F_{0.99(4,21)}=$ 2.84. A D-Watson statistic of 2.01 indicates thaty there is no auto-correlation in the equation.

Table 11. Selected results of the yield under estates equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
YLDE					0.89	0.87	33.15	2.01
C	0.6685	0.0510	13.11	0.0000				
PRDLTD	0.0078	0.0036	2.18	0.0442				
TREND	0.0139	0.0018	7.77	0.0000				
DV2	0.1743	0.0277	6.30	0.0000				
DV86	0.1329	0.0469	2.84	0.0119				

Source: Constructed by the author.

The following table (Table 12) presents selected result of the smallholder enterprises yield equation. Variations in the yield of natural rubber produced by smallholder enterprises are explained by the domestic price of natural rubber, domestic price of rice in the previous year, and the dummy variable for 1984 (DV1), which is equal to one for the years after 1984 and zero otherwise. This dummy variable is used to capture changes in the new mature tree area. Even though the area of mature trees is increasing, initially production is still low. The low production is due to the biological characteristics of natural rubber trees. During the early tapping period, output is relatively low; but production increases gradually over time. Hence, the coefficient of the dummy variable has a negative sign.

The signs of the variables are as expected. For example, the sign of the deflated natural rubber price variable is positive. This implies that the higher the price, the more intensive the farmers would tap their trees, and -- as the result -- would produce more natural rubber .

Table 12. Selected results of the yield under smallholder equation.

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
YLDSM					0.70	0.65	13.19	1.06
C	0.506	0.064	7.96	0.0000				
JKPRRPD	0.007	0.002	2.91	0.0098				
RICEPD	-0.024	0.016	-1.44	0.1681				
DV1	-0.062	0.011	-5.45	0.0000				

Source: Constructed by the Author

The coefficient of determination (R^2) for this equation is 0.70. This implies that the independent variables in the smallholder yield equation explain 70% of the variation in the dependent variable. The t-statistic corresponding to the coefficient of the domestic natural rubber price and the dummy variable are significant at the 5% level. While the t-statistic corresponding to the lagged price of rice is not significant at the 5% level, its t-statistic is greater than one. This indicates that there is at least a 67 percent probability that the previous year's price of rice affects the yield of natural rubber under smallholder enterprises.

The equation for the yield of smallholder enterprises has an F-statistic of 13.19. This exceeds the critical value of 4.88 at the 1% level of significance. The equation's D-Watson statistic of 1.06 falls in the inconclusive region.

5.1.1.3. Estimated Indonesian Export Supply of Natural Rubber

Selected results of the equation for Indonesian natural rubber export supply are presented in the Table 13. The export supply of Indonesian natural rubber depends on Indonesia's total production, both from estates and smallholders, and the export price in the world market deflated by the U.S. consumer price index. The total production of Indonesian natural rubber was an identity, specified as:

$$PRDE = YLDE * MTAE$$

$$PRDSM = YLDSM * MTASM$$

$$INAPRD = PRDE + PRDSM$$

Table 13. Selected result on the Indonesian' export supply equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
QEINR					0.98	0.98	451.77	1.82
C	78.38	38.72	2.02	0.0580				
INAPRD	0.81	0.03	27.76	0.0000				
PRDLTD	3.51	1.56	2.25	0.0372				

Source: Constructed by the Author

The R^2 of the Indonesian export supply equation is 0.98, while its adjusted R^2 is also 0.98. All the coefficients of the independent variables are significant at the less than 5% level. The F-statistic of 451.77 is highly significant at the 1% level. The equation's D-Watson statistic is 1.82, which indicates that there is no auto-correlation in the equation.

5.1.2. Estimated Export Supply from Other Producing Countries

The export supply from producing countries other than Indonesia is explained by the total production from those countries, the price of natural rubber in the world market represented by the deflated Jakarta fob price, and the time trend. As indicated in the previous chapter, a comprehensive treatment of this export supply function is not carried out. The result of the statistic analysis is presented in the Table 14.

Both coefficients of the explanatory variables have the expected sign. The positive sign for the natural rubber price coefficient denotes that the higher the price the greater the quantity of natural rubber exported from countries other than Indonesia, all other things remaining unchanged. The positive sign of the coefficient for production is also compatible with ***a priori*** reasoning, since almost all natural rubber production is exported.

Table 14. Selected result on the export supply from other producing countries' Equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
QEONR					0.98	0.98	343.48	2.14
C	291.57	128.41	2.27	0.0365				
ONRPRD	0.75	0.06	13.07	0.0000				
PRDLTD	6.36	3.39	1.87	0.0786				
TREND	-13.98	4.84	-2.89	0.0102				

Source: Constructed by the Author

The equation for natural rubber export from other producing countries has both an R^2 and an adjusted R^2 of 0.98. The t-statistic of the coefficient corresponding to both natural rubber production and the trend is greater than two, implying that they are significant at the 5% level. However, the t-statistic of the coefficient corresponding to the price of natural rubber is greater than one. This indicates a 67 percent probability that the price of natural rubber affects the production level of natural rubber in other producing countries. The F-statistic of this equation is significant at 1% level, while a D-Watson statistic of 2.14 shows that auto-correlation is not present.

5.1.3. Demand for Natural Rubber in the U.S. market

The demand for natural rubber in the U.S. market is postulated to be the function of the natural rubber price, synthetic rubber price, the number of automobiles produced in the country, the level of industrial production in the country, and the level of natural rubber consumed in the country.

To determine the level of natural rubber demanded by the U.S., three prior estimated equations were selected and one identity was used. These are the estimated equation for the ratio of the U.S. natural rubber consumption to total rubber consumption, the estimated equation for automobile production in the U.S., and the estimated equation for the total, natural and synthetic, rubber consumption.

5.1.3.1. Estimated ratio of the US natural rubber to total rubber consumption

The results of the regression equation of the ratio of the U.S. natural rubber to total rubber consumption are presented in Table 15. Variations in the consumption ratio are explained by the ratio of the natural to synthetic rubber price (RATPR), trend , and the dummy variable of one for year 1985 and zero otherwise (DV85). The signs of all variables are as expected. For instance, the negative sign of the coefficient on the RATPR variable support the economic theory that changes in relative price would affect the proportion in which synthetic and natural rubbers are used. Keeping all other factors constant, an increase in relative price of natural rubber to that of synthetic rubber would reduce the consumption of natural rubber.

Table 15. Selected results on the ratio of the U.S. natural to total rubber consumption equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
RUNC					0.93	0.92	56.77	1.74
C	0.21	0.02	12.00	0.0000				
RATPR	-0.01	0.01	-1.15	0.2689				
TREND	0.0046	0.0008	5.34	0.0001				
DV85	0.023	0.008	3.32	0.0044				
AR(1)	0.52	0.22	2.30	0.0351				

Source: Constructed by the Author.

The R^2 of 0.93 for this equation is high, indicating a good statistical fit. The equation also has a high adjusted R^2 of 0.92, suggesting the number of independent variables is adequate for the length of time series data used (21 observation).

The t-statistics corresponding to the coefficient of the trend, the dummy variable and AR(1) are significant at the 5% level. However, the t-statistic corresponding to the coefficient of ratio price of natural to that of synthetic rubber variable is not significant at the 5% level. But, since it is greater than one, this variable is retained in the equation.

The F-statistic of 56.77 for the consumption share of natural rubber equation is significant at the 1% level because it exceeds the critical values of 4.88. After adding the variable for correcting the first order auto-correlation, the D-Watson statistics is 1.74 indicating that no auto-correlation is present in the equation.

5.1.3.2. Estimated the U.S. Automobile Production

The level of U.S. automobile production is explained by the disposable income of the country, deflated by its consumer price index, and the trend. Automobile production consists of commercial vehicles and passenger cars and is tied to the level of the income of the country. As expected, the estimated equation indicates that the income variable has high positive t-statistics value, indicating when the income of the country increase, automobile production increases.

Table 16. Selected results on the U.S.' automobile production equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
AUTUSP					0.71	0.68	21.86	1.03
C	-30992	6292	-4.93	0.0001				
DICD	4.65	0.70	6.61	0.0000				
TREND	-707,6	111.8	-6.33	0.0000				

Source: Constructed by the Author.

The equation for automobile production in the U.S. has an R^2 0f 0.71 and the adjusted R^2 of 0.68. The t-statistics for the coefficients corresponding to all independent variables are significant at the 1% level. Moreover, the F-statistic for this equation is 21.86, which surpassed the critical value at the 1% ($F_{0.99(2,21)}$= 5.78) level of significance. The D-Watson statistic of 1.03 falls in the inconclusive region.

5.1.3.3. Estimated the U.S. Total Rubber (natural + synthetic) consumption

The total rubber consumption is equal to the total consumption of natural and synthetic rubber. Since natural and synthetic rubber can be interchanged in many end uses, the consumption for all rubber became the important factor for the demand model of natural rubber. More than half of the total supply of all (natural and synthetic) rubbers is used in the manufacturing of tires.

Variation in total rubber consumption is explained by total automobile production, the index of the industrial production, and the trend (Table 17). The trend variable is used to capture changes in technology, especially in the manufacturing of tires which affects the choice of rubber inputs.

Table 17. Selected results on the U.S. total rubber consumption equation

	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
VARIABLES	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
USTRC					0.78	0.72	14.00	2.18
C	842.34	523.61	1.61	0.1272				
AUTUSP	0.08	0.03	2.86	0.0114				
IDXPUS	22.11	11.29	1.96	0.0680				
TREND	-67.14	31.05	-2.16	0.0461				
AR(1)	0.47	0.20	2.39	0.0297				

Source: Constructed by the Author.

The R^2 of the equation for total U.S. rubber consumption is 0.78, while the adjusted R^2 is 0.72. The t-statistics for the coefficients corresponding to total automobile production, the trend, and the AR(1) are significant at the 5% level. The t-statistic for the coefficient of industrial production index is not significant at the 5% level of significance. However, since it is greater than one (1.96), this variable is maintained in the equation.

The F-statistic for this equation is 14.00 which exceeds the critical value of 4.37 at the 1% level of significance. The D-Watson statistic of 2.19 shows that auto-correlation is not present in the equation. Total natural rubber consumption in the U.S. is obtained from the product of identity, that is, the ratio of natural rubber consumption multiplied by total U.S. rubber consumption (USNRC = RUNC * USTRC).

5.1.3.4. Estimated the U.S. Import Demand for Natural Rubber

The U.S. import demand for natural rubber is explained by total natural rubber consumption and the trend. In specifying the model, it was postulated that the beginning stock would also influence a country's import level. However, because the stock variable gave the incorrect sign, is was dropped from the estimated equation (Table 18).

The R^2 of 0.92 for the equation of the U.S. import demand is high, as is the adjusted R^2 which is 0.91. These statistical results indicate that the equation has a good statistical fit and the number of independent variables is adequate for the length of time series data used. The t-statistic for coefficients corresponding to all independent variables are significant at less than the 5% level.

The F-statistic of 110.19 exceeds the critical value of 4.04 at the 1% level of significance. A D-Watson statistic of 1.84 indicates that auto-correlation is not present in this equation.

Table 18. Selected results on the U.S. import demand equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
USINR					0.92	0.91	110.19	1.84
C	108.97	51.51	2.12	0.0486				
USNRC	0.76	0.08	9.14	0.0000				
TREND	4.05	1.20	3.38	0.0034				

Source: Constructed by the Author.

5.1.4. Demand for Natural Rubber in Market Other than U.S.

The remaining demand for natural rubber come from markets outside the U.S. The demand for non-U.S. demand for rubber is estimated using procedures similar to those used to estimate U.S. demand, as presented below.

5.1.4.1. Estimated Equation for Ratio of the Natural Rubber to the total Rubber Consumption

The variation in the ratio of natural rubber to total rubber consumption is explained by the ratio price of natural to synthetic rubber and the dummy variable which is one for year 1982 and zero otherwise (Table 19). As expected, the coefficient of the price ratio has a negative sign. The coefficient of determination (R^2) of 0.91 indicates that the independent variables in this equation explain a very high proportion (91 percent) of the variations in the dependent variable, with the assumption that the theoretical specification is true.

Table 19. Selected results on the ratio of natural to total rubber consumption equation in the other consuming countries.

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
RONC					0.91	0.89	55.45	1.45
C	0.35	0.01	35.14	0.0000				
RATPR	-0.014	0.009	-1.54	0.1417				
DV82	0.035	0.006	5.76	0.0000				
AR(1)	0.75	0.06	12.62	0.0000				

Source: Constructed by the Author.

In addition, the adjusted R^2 of 0.89 indicates that the number of independent variables is sufficient for the time series data used in this equation. Moreover, the F-statistic of 55.45 is highly significant at the 1% level. Finally, a D-Watson statistic of 1.45 falls in the inconclusive region.

5.1.4.2. Estimated Other Countries Automobile Production

The results of the estimated equation for automobile production in countries other than U.S. is presented in Table 20. As in the U.S., the automobile production in non-U.S. countries is also tied to the income level of the countries, which in this study is measured as the average gross domestic production per capita deflated by the U.S. CPI. The positive sign of this variable is consistant with prior expectation.

The equation for total automobile production in countries other than the U.S. has a very high R^2 and adjusted R^2, which are 0.98 and 0.97, respectively. The t-statistics for the coefficients corresponding to all independent variables in the equation are significant at less than the 5% level.

Table 20. Selected results on the other countries automobile production equation

	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
VARIABLES	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
AUTOP					0.98	0.97	452.35	1.69
C	-58201	16597	-3.51	0.0025				
GPOCD	13.48	2.38	5.65	0.0000				
AR(1)	0.82	0.07	11.68	0.0000				

Source: Constructed by the Author.

Furthermore, this equation was estimated assuming first order serial auto-correlation. The coefficient for the correction for this auto-correlation [AR(1)] is also significant at less than the 1% level.

Moreover, the F-statistic of 452.35 suggests that the equation is highly significant, even at the 1% level of significance. A D-Watson statistic of 1.69 is greater than the upper bound of the 5% critical value for the true distribution of D-Watson statistics (Judge et.all., 1988; Greene, 1990), indicating no auto-correlation presence in the equation after correction by AR(1).

5.1.4.3. Estimated non-U.S. Total Rubber Consumption

Variations in the total rubber consumption is explained by the total automobile production and dummy variable, which is one for year 1982 and zero otherwise (Table 21). This dummy variable was used to capture the unusual economic situation (i.e. world recession) in the other countries (non-U.S.).

Table 21. Selected results on the non-U.S. consuming countries' total rubber consumption equation.

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
OTRC					0.98	0.98	367.93	2.25
C	4508	1747	1.64	0.1192				
AUTOP	0.22	0.06	3.89	0.0012				
DV82	-1180	191	-6.17	0.0000				
AR(1)	0.91	0.07	12.97	0.0000				

Source: Constructed by the Author.

The equation for total rubber consumption in countries other than the U.S. has a very high R^2 and adjusted R^2 of 0.98. The t-statistic of all coefficients are highly significant at a less than 1% level of confidence. Furthermore, the F-statistic for this equation is 367.93. This F-statistic exceeds the critical value of 5.78 at the 1% level of confidence. Finally, the D-Watson statistic equals 2.25, after correcting for the first-order auto-correlation is.

Moreover, the consumption of natural rubber in countries other than U.S. is the results of the identity defined as: ONRC = RONC * OTRC

5.1.4.4. Estimated Other Countries Import Demand for Natural Rubber

The import demand for natural rubber in countries other than the U.S. is explained by their total natural rubber consumption and the time trend (Table 22). Since the consuming countries are developed countries that do not produce natural rubber, it is clear that the more the countries consumed, the higher the amount of natural rubber imported. This phenomenon is consistant with the negative sign of the coefficient for the natural rubber consumption in other countries (ONRC).

The coefficient of determination (R^2) of 0.98 for the equation of other countries' import demand is very high. This equation also has the very high adjusted R^2 of 0.97. These statistical properties suggest that the equation has a good statistical fit, and the number of the independent variables are sufficient for the time series data used in this equation. Moreover, the t-statistics of all independent variables are highly significant at less than the 1% level. In addition, the F-statistic of 470.29 is highly significant at the 1% level, since it exceeds its critical value of $F_{0.99(2,21)} = 5.78$. Finally, the D-Watson statistic of 1.36 falls in the inconclusive region.

Table 22. Selected results on the other countries import demand equation

VARIABLES	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
OINR					0.98	0.98	470.29	1.36
C	437.59	134.59	3.26	0.0043				
ONRC	0.76	0.06	12.31	0.0000				
TREND	-21.52	6.04	-3.56	0.0022				

Source: Constructed by the Author.

5.1.5. Estimated Price of Natural Rubber Equation

The variation of deflated natural rubber's price is explained by the deflated price of synthetic rubber, the total stock of natural rubber, and two dummy variables (DV73 and DV74). These dummy variables were included in the price equation to capture the short-term impact of the oil crisis.

As expected, the coefficient of total stock has a negative sign. It means that low levels of stocks would put upward pressure on the price. Moreover, the coefficient of the synthetic rubber's price is positive as expected. Theoretically, when the price of a substitute commodity is high, the commodity in question would also be high because the demand for this commodity would increase in response to the high price of the substitute commodity.

The R^2 of 0.82 for the deflated price equation is sufficiently high to indicate the goodness of fit for this equation. The adjusted R^2 of 0.79 is also high enough to verify that the number of independent variables is sufficient for the time series data used in this equation. Moreover, the t-statistics of all independent variables are highly significant at less than 1% level.

Table 23. Selected results on the deflated world natural rubber price equation

	RESULTS OF INDIVIDUAL VARIABLES				RESULTS OF THE REGRESSION			
VARIABLES	COEFF.	STD. ERROR	T-STAT	2-TAIL SIG.	R^2	ADJ. R^2	F-STAT.	D-WATSON
PRDLTD					0.83	0.79	19.30	1.81
C	17.68	6.63	2.67	0.0169				
SBRPTD	0.98	0.13	7.36	0.0000				
WSTK	-0.01	0.004	-3.22	0.0054				
DV73	6.70	1.49	4.51	0.0004				
DV74	6.11	1.49	4.09	0.0008				

Source: Constructed by the Author.

Furthermore, the F-statistic of 19.30 is significant at the 1% level, since it exceeds the critical values of 4.37. Finally, the D-Watson statistic of 1.81 suggests that there is no presence of auto-correlation in this equation.

5.2. Evaluation of the Estimated General Model

In the evaluation of the estimated general model, a number of criteria was applied in this study, such as statistical evaluation (i.e., R^2, adjusted R^2, t-statistic, F-statistic, and D-Watson statistic), and the accuracy of the model's forecasting ability (i.e., analysis of turning point errors (TPE), percentage changes of mean square errors (MSEP), root mean square percentage errors, and Theil's U-statistic). This section briefly discusses all of those evaluations.

5.2.1.Statistic evaluation

This study reported both the R^2 and the adjusted R^2. The higher the R^2 or the adjusted R^2 the closer the functional linear relationship between the dependent and the independent variables. The values of R^2 varied from 0.70 in equation (4) to 0.99 in equation (2). The R^2, the coefficient of determination, measures the proportion of the variation in the dependent variable that is accounted for linearly, by variation in the independent variable. In other words, the R^2 measures the goodness of fit the regression.

Because the R^2 will increase as additional independent variables are added, this study also reported the adjusted R^2 which is a better statistic for empirical analysis. In multiple regression, the adjusted R^2 will fall, if one deletes an independent variable that has a t-statistic greater than one (Greene, 1990). The values of adjusted R^2 found in this study vary from 0.65 in the equation (4) to 0.98 in the equation (2), (6), and (7).

By considering the adjusted R^2 in the evaluation of the general model, it can be said that the model is satisfactory because in all cases, except equation (1), (4), and (8), more than 70% of the total variation in each equation was explain by the respective independent variables.

In terms of the t-statistics, most of the coefficient had a t-statistic greater than two; therefore, these were significant at the 5% level of significance. While the rest of the variables had t-statistic less than 2, they were above one. Hence, they still offered at least two-thirds confidence that they influenced the corresponding dependent variables.

With respects to the F-statistic, the values of the F-statistics vary from 11.12 in the equation (1) to 470.29 in the equation (12). All F-statistics are significant at the 1% level of significance. Hence, it means that the joint hypothesis that all parameter coefficients in respective regression are zero can be rejected with a margin of error of either less than 5% or less than 1% level of significance. The D-Watson statistics, which vary from 1.02 to 2.24, either indicate no presence of serial auto-correlation between variables or fall in the region where no conclusion can be drawn as to whether serial auto-correlation is presence. Based on the statistical evaluation above, it can be concluded that the general model is statistically satisfactory.

5.2.2. Accuracy of Forecasts Evaluation

One of the objectives of this study in building the econometric model was to make forecasts of supply and demand for Indonesian natural rubber. In order to forecast, first, one has to evaluate the ability of the model to forecast. This section evaluates the forecasting accuracy of the model by using several criteria, including the analysis of turning point errors, percentage changes of mean squared errors, root mean squared percentage errors, and Theil's U-statistic. The results of these evaluation are presented in the Table 24. Moreover, Figures 8 to 22 in the Appendix 1 show the actual and forecast values for the sample period.

In the analysis of turning point errors, Tomek and Robison (1990) mention that specific definitions or conventions should be adopted. This study follows the conventions used by Tomek and Robison. Their convention assumes that one step-ahead forecasts are being evaluated and uses the current predicted value ***relative to the previous actual value***. Following this, turning point errors occur when the sign in the second column is different from the sign in the first column of the table for TPE evaluation. The tables for evaluation of turning point error (TPE) on each variable are presented in the Appendix IV and summarized in Table 24.

The table shows that, out of 21 valid observations, the number of turning point errors varies from 2 for the QEONR equation to 9 for the PRDLTD equation. The PRDLTD equation is the equation for the deflated price of natural rubber.

Table 24. Summary of Quantitative Measures of the Accuracy Model's Ability to Forecast

Variable	Valid observations	TPE	MSEP	RMSPE	U-statistic
MTAE	21	5	0.0018	0.0005	0.0001
MTASM	21	5	0.0008	0.0287	0.0056
YLDE	21	4	0.0023	0.0478	0.0102
YLDSM	21	6	0.0062	0.0801	0.0165
QEINR	21	8	0.0089	0.0990	0.0214
QEONR	21	2	0.0003	0.0179	0.0037
RUNC	21	7	0.0010	0.0317	0.0068
AUTUSP	21	7	0.0075	0.0877	0.0181
UTRC	21	3	0.0024	0.0499	0.0108
USINR	21	3	0.0036	0.0615	0.0131
RONC	21	8	0.0009	0.0311	0.0065
AUTOP	21	4	0.0011	0.0342	0.0068
OTRC	21	4	0.0010	0.0330	0.0071
OINR	21	7	0.0025	0.0498	0.0110
PRDLTD	21	9	0.1210	0.3931	0.0717

Source: Constructed by the Author

As mentioned by Colleman and Thigpen (1991), the mean square error (MSE) will depend on the units in which the variable is measured. Hence, the percentage changes of mean squared error (MSEP) is more useful in comparing forecasting accuracy for variables measured in different units. Thus, this study applied the MSEP, instead of directly using its MSE because the variables used in this model have different units. The MSEP measures MSE in term of percentage changes and it can be calculated as:

$$MSEP = 1/n \Sigma [\{(P_t - A_{t-1})/A_{t-1}\} - \{(A_t - A_{t-1})/A_{t-1}\}]$$

where:

P_t = Predicted values of the dependent variables

A_t = Actual values of the dependent variables

n = number of observations.

The results of the MSEP are presented in the Table 24. The highest MSEP is for the PRDLTD equation (12%), while the lowest is for the QEONR equation (0.03%). In general, the lower the MSEP, the better the ability of the model to forecast. In fact, this study found that in all cases, except for the equation for PRDLTD, the MSEP statistics are less than 5%. By this criterion, the model is satisfactory.

The next criterion used to evaluate the general model is the root mean squared percentage error (RMSPE). This statistic measures the deviation of the forecasted variable from its actual time path, but in percentage terms. Hence, the smaller the value of RMSPE, the better the fit and the higher the accuracy of the model for forecasting. The results of this evaluation show that almost all dependent variables have RMSPE statistic which are less than 5%, except for the YLDSM, QEINR, AUTUSP, and USINR equations which have RMSPE statistic which are less then 10% and the PRDLTD equation which has the highest RMSPE statistic (30%).

Finally, the last evaluation uses the Theil's U-statistic. This statistic is related to both the RMSPE and the MSE. Theil's inequality statistic is defined as,

$$U = \frac{[1/n \sum_t (P_t - A_t)^2]^{1/2}}{[1/n\sum_t(A_t)^2]^{1/2}}$$

where P_t, A_t, and n are defined as above. The value of U-statistic will lie between 0 and 1, of which U = 0 represents a perfect fit, while a large value suggests a poor forecasting performance.

From Table 24, it can be seen that the Theil's U-statistics for almost all endogenous variables are less than 5%. Only the PRDLTD variable has a U-statistics of 7%. The variable, the deflated natural rubber price (PRDLTD), gives consistent results under all evaluation criteria, such as TPE, MSEP, RMSPE, and Theil's U-statistic. This is least accurate variable in tracking the actual value. However, in general, the model has reasonalbe results from all evaluation criteria use and is suitable to be used in forecasting.

5.3. Supply of and Foreign Demand for Indonesian Natural Rubber

5.3.1. Export Supply of Indonesian Natural Rubber

Indonesia's export supply of natural rubber is, hypothesized to be a function of Indonesia's total production and the price of natural rubber in the world market. The statistical results presented in Table 13 shows that all the coefficients have the expected signs. The coefficient of the deflated price of natural rubber has a positive sign, indicating that the higher the price of natural rubber in the world market, the higher the quantity of natural rubber exported. Hence, Indonesia's export supply schedule of natural rubber in the world market is positively sloping.

. Although the sign is positive, the price elasticity of supply is almost zero (0.04), suggesting that Indonesia has a perfectly inelastic export supply schedule. Beside that, the coefficient of the total production of Indonesian natural rubber in the Indonesian export supply equation is 0.81 and is highly significant. This coefficient indicates that for every ten tons of increase in production, about 8.1 ton will be exported, other things remain unchanged. The magnitude of this coefficient shows that the physical production of natural rubber is the most important determinant of Indonesia's export supply.

Underlying the export supply of the Indonesian natural rubber are the estates and smallholders equations for both mature trees and yields, which are discussed below.

5.1.3.1. The Mature Tree Area

The mature tree area under both enterprises depend on the area of mature tree in the previous year. However, for estate enterprises the coefficient of this variable is 0.50. This implies that forecastes the area in mature trees, which is the result of new planting and replanting, varies greatly from year-to-year. On the other hand, smallholders enterprises have a coefficient of 0.99 for the same variable. It denotes that in this sector the area in mature treesis fairly stable. This result confirms the real situation that small farmers rarely change their area and seldom replant.

In addition, a positive trend is found in the estate enterprises and it is significantly different from zero. This indicates that the area of mature tree under estate enterprises increase over time, although the activities of new-planting and re-planting does occur. Moreover, the dummy variable in both equations is introduced to capture the reaction on the government program in both rehabilitation and new-planting of the natural rubber area.

5.1.3.2. The Yield of Natural Rubber

For both type of enterprises, the yield of natural rubber is influenced by its price. The empirical results show that both enterprises have a positively sloping supply schedule. However, when the price elasticity of yield is calculated at mean prices and yields, it gives a price elasticity of 0.08 for estates and 0.14 for the smallholders. The price used for analyzing yields for estates is the world price, while for smallholders the domestic price is used. These price elasticities for yield show that yield is price inelastic. Furthermore, smallholders' respond to a greater extent to change in price than do estate. This feature reflects the fact that the estate industry's responsiveness to rising market is limited by existing production capacity. In contrast, smallholder enterprises are slightly more responsive to price changes because they have some flexibility in controlling the flow of rubber output in the short run--they can tap their trees more intensively when the price of natural rubber increases. In other words, farmers in Indonesia are price responsive with an inelastic supply schedule.

In addition, the yield on estate enterprises is also influenced by the effect of technology, represented by the time trend. In the smallholder enterprises, the price of rice in the previous year also influenced the yield of natural rubber negatively, although its cross-price elasticity (-0.18) is only significantly different from zero at less than the 20% level of significance. Hence, a 10 % increase in the domestic price of rice in a certain year will be associated with a 1.8 % decrease in natural rubber yield from smallholder in the subsequent year.

5.3.2. Foreign Demand for Indonesian Natural Rubber

The foreign demand for Indonesian natural rubber is considered to be the difference between the total world market demand for natural rubber; minus the export supply of natural rubber from countries other than Indonesia and government stockpile sales. However, goverment stockpile has been exhausted since 1978.

5.3.2.1. Demand for Natural Rubber in the World Market

The demand for natural rubber in the world market consists of two main equations: (1) the demand for natural rubber in the U.S. market and (2) the demand for natural rubber in the countries other than the U.S. market. The demand for natural rubber in each market is influenced by the price of natural and synthetic rubber, the automobile production, the level of income, and technology which is represented by the time trend.

In the U.S. market, the import demand for natural rubber is determined by the level of consumption and the effect of technology, i.e. radialization of the tires. It is clear that the higher the level of consumption, the more the U.S. imports natural rubber. The level of consumption itself depends on the production of automobile, because natural rubber is mainly used by the tire industry and for other automobile parts. In addition, the production of automobile is influenced by the level of income. Hence, the level of income also indirectly determines the import demand for natural rubber. This situation is in line with the World Bank's (1992) projections of the natural rubber demand which states that one of the major determinant of natural rubber demand would be the income of the country.

The price ratio of natural to synthetic rubber determines the relative share of consumption for these commodities. As expected, this coefficient, for both markets, has a negative sign. The price elasticity for the ratio of natural rubber consumption at the mean value are -0.03 and -0.02 for the U.S. market and non-U.S. market, respectively. These results suggests that a change in relative prices has only a marginal influences on a firms' decision to use one type of rubber over another.

5.3.2.2. Export Supply of Natural Rubber from Other Countries

Export supply of natural rubber from other producing countries is hypothesized to be a function of the total production, the price of natural rubber in the world market, the time trend, and a random disturbance. Both coefficients of the independent variables have the expected sign. The coefficient for the price variable has a positive sign, indicating that the higher the price of natural rubber in the world market, the greater the quantity of natural rubber that will be exported, other variables remaining unchanged. Hence, the export supply schedule is positively sloping with respect to price, in line with theory.

The price elasticity of export supply at the mean value of price and quantities is 0.03, meaning that other producing countries also have a perfectly inelastic export supply schedule. This supports the reasoning that other country's supply of natural rubber is likely to be price inelastic. Exporters can not rapidly respond to an increase in price, since they only can gain a greater supply from an increase in production.

5.3.2.3. Derivation of Foreign Demand for Indonesian Natural Rubber

Foreign demand for Indonesian natural rubber can be derived as: total world demand, which is the U.S. demand and non-U.S. demand, less the export supply from other producing countries. This derivation is used to evaluate the opportunity for Indonesia to export natural rubber and is done outside the model.

Using the behavioral equations of the U.S. import demand, non-U.S. import demand, and other producing countries export supply, the foreign demand for Indonesian natural rubber can be derived. The foreign demand for Indonesian natural rubber has a negatively sloping demand schedule with a price elasticity at the mean value of price and quantity of about -0.18. This shows a very inelastic demand schedule, which means that a 10 percent decrease in the world market price of natural rubber will be associated with a 1.8 percent increase in the quantity of Indonesian natural rubber demanded, other things remaining unchanged.

In summary, these results show that the foreign demand for Indonesian natural rubber is influenced by the consumption of natural rubber both in the U.S. and in the non-U.S., and the upward trend as rightward shifters, and the production from other producing countries as a leftward shifter.

VI. EXPORT SUPPLY AND IMPORT DEMAND FORECASTS

6.1. Forecast of Exogenous Variables

After developing a general model that performs satisfactorily against actual values, the next step is to derive forecasts. In generating the forecast value for endogenous variables, all exogenous variables included in the general model must have values for the entire forecast period.

Several ways were used to obtain forecast value of exogenous variables. First of all, some of the forecast value of exogenous variables were taken from World Bank projection, such as the level of income. Secondly, some were generated by using a double exponential smoothing method, especially for those variables which indicate a trend, such as the consumer price index, the industrial production index, and the exchange rate. Next, some values were estimated using a combination of regression against time and forecasting, based on the result of that regression. This method assumed that the conditions which exist in the period of observation will continue to exist in the forecast period. This technique was used for forecasting the price of rice and other countries production of natural rubber. The actual and forecast value for all the exogenous variables are presented in the Appendix V.

6.2. Forecast of Endogenous

After entering all forecast values of exogenous variables, the general model was solved for a period beyond the observation time (1991 - 1995) to forecast the dependent variable values. The forecasts of the endogenous variables, together with their actual values used in this model, are presented in Appendix VI. In addition, the actual and forecast values for all endogenous variables are presented graphically in Figures 23 - 29 (Appendix VII).

Figure 23 and 24 show that the area in mature trees increases in both the estate and smallholder enterprises. This result indicates that the effect of Indonesia's efforts to expand the area of natural rubber continues through 1995. The yield of natural rubber under estates increases slightly, as does the yield for smallholders (Figure 25 and Figure 26, respectively).

Indonesia's total production increases substantially, after sharping decreasing in 1991 (Figure 27). While Indonesia's export supply is projected to decrease in 1991, it increases slightly until the end of forecast period (1995), as shown in Figure 28. This result is in line with natural rubber production condition in the country, which increase due to increasing yields in both the estate and smallholder sectors. Similarly, other producing countries' export supply also increases (Figure 29). This result is in line with the production situation in other producing countries, which is characterized by a positively trend.

Turning to the demand side, the U.S. as a major consumer of natural rubber is projected to face an increase in import demand for natural rubber at the end of the forecasting period. This follows the forecast of automobiles production that starts to increase in the end period of forecast. The actual and forecast values of U.S. automobiles production and import demand for natural rubber are presented in Figure 30 and 32, respectively. An increase in import demand is also projected for consuming countries other than the U.S. Figure 33 - 35 show the actual and forecast value of automobiles production, total rubber consumption and import demand for natural rubber in the non-U.S. countries, respectively.

Finally, a deflated natural rubber price is also forecast (Figure 36). After reaching the highest level in 1979 and 1980 (the period of oil boom), the deflated price of natural rubber continued to decrease, after peaking in 1983 and 1988. The decrease in deflated price is forecast to continue until late 1992, and then begins to recover in 1993. Then, the model projected the deflated price to increase slowly until the end of forecast period.

The increasing in the projected price of natural rubber is in response to the increase in the projected price of synthetic rubber.

VII. SUMMARY AND CONCLUSION

This chapter begins with a summary of the study and is followed by a discussion of conclusions and policy implications. In the final section some suggestions regarding future research are presented.

7.1. Summary

The main purpose of the study is to analyze the nature of the supply of and demand for Indonesian natural rubber, to develop a model to estimate the relative importance of factors affecting the demand for natural rubber, and to project the future demand for natural rubber.

Chapter Two reviews the physical features of Indonesia, its population characteristics, its development experiences since the late 1960s, the performance of economy, and the structure of agriculture.

Chapter Three describes the world rubber economy, including the development history of both synthetic and natural rubber, production and price of natural rubber, and the natural rubber sub-sector in Indonesia.

Chapter Four reviews the literature related to the theoretical framework used in the analysis. This part discusses related studies, followed by the theory of supply and demand, the specification of the model, and the nature of the data used.

Chapter Five presents the results of the econometric model and statistical tests used to evaluate the model. The simultaneous equations model used consisted of fifteen behavioral equations and six definitional identities. The fifteen behavioral equations represent the following relationships: (1) the mature tree area under estates, (2) the mature tree area under smallholders, (3) the yield from estate, (4) the yield from smallholders, (5) the annual export supply from Indonesia, (6) the annual export supply from other producing countries, (7) the ratio of natural to total rubber consumption in the U.S., (8) the annual automobiles production in the U.S., (9) the annual total rubber consumption in the U.S., (10) the annual import demand for natural rubber in the U.S., (11) the ratio of natural to total rubber consumption in the non-U.S., (12) the annual automobiles production in the non-U.S., (13) the annual total rubber consumption in the non-U.S., (14) the annual import demand for natural rubber in the non-U.S., and (15) the deflated price in the world market. The seven definitional identities represent the following relationships: (1) the total production under estates, (2) the total production under smallholders, (3) the total production of Indonesia, (4) the annual consumption of natural rubber in the U.S., (5) the annual consumption of natural rubber in the non-U.S., (6) the annual world ending stock of natural rubber, and (7) the price relationship of domestic price in Indonesia. Moreover, the foreign demand for Indonesian natural rubber was derived from the total demand in the world market, minus the export supply from producing countries other than Indonesia.

Natural rubber production in Indonesia, both from estate and smallholders, is perfectly inelastic, with the price elasticity of 0.08 and 0.14, respectively. In addition, Indonesian exports face a perfectly inelastic supply schedule with an elasticity of 0.04. Similarly, the other producing countries' exports also face an inelastic export supply schedule with an elasticity of 0.03; and the price elasticity of the foreign demand for Indonesian natural rubber was - 0.18. The cross-price elasticity between natural rubber production from smallholding and rice production was found to be - 0.18. The demand for natural rubber in both the U.S. and outside the U.S. was found to be perfectly inelastic, with respect to the price of natural rubber in the world market.

All equations of the model are linear in the actual values. The structure of the model is presented in Appendix I. Appendix II presents the definition of all variables used in this study. Appendix III presents the results of forecast simulation during the sample period, while Appendix IV provides the evaluation of turning point errors for all endogenous variables. Overall, the statistical evaluation indicates that the model generates reasonable results and that it is suitable for use in forecasting.

Chapter Six provides the results from forecasting all endogenous variables, while Appendix VI and VII display the actual and forecast value of the endogenous variables in tabular form and graphically.

7.2. Conclusion and Policy Implication

This study has tried to analyze the supply and demand for Indonesian natural rubber. The analysis was carried out by developing an econometric model of Indonesia's natural rubber sector including its export supply and foreign import demand. The results of this study can provide information decision makers need to be understand the factors that affect the natural rubber industry.

This study found that several factors influence natural rubber industry. On the supply side, the level of production dominates export supply. Moreover, total production depends mainly on the mature tree area and yield. The mature tree area in both the estate and smallholder sectors were found to be based on the previous year, while the yield is influenced by the price of natural rubber both in the world market (estate) and in the domestic economy (smallholder). Furthermore, although smallholders are more price responsive than the estates, both sectors have an inelastic price elasticity for yield. Indonesia has a perfectly inelastic export supply, as does the demand for Indonesian natural rubber. An inelastic export supply also characterized other producing countries. On the demand side, the U.S. is found to have an increase trend, while countries outside the U.S. experiences a decreasing trend. World demand for natural rubber is influenced mainly by the automobile industry, since most natural rubber is used in tire the industry.

Finally, the world natural rubber price tends to decrease over the middle of the five-year forecast period and start to recover slightly after that.

The major policy implication of the study is that since Indonesia faces an inelastic supply schedule, strong dependence on one commodity as a source of export earning is subject to risk. Hence, the Indonesian government must continue to promote export crop diversification. Regarding the existing natural rubber area, government should introduce policies that encourage smallholders to improve their management, since this sector account for over 81 percent of total rubber area, while smallholder's yields are still very low.

7.3. Future Research

Due to the short length and the non-availability of some time series data, this study was unable to incorporate some variables that might be relevant to the analysis. For example, in analyzing the production of natural rubber, data on the age composition of trees, variety composition of stands, and the weather would likely improve the accuracy of the production estimates.

Although data constraints reduced the explanatory power of the model developed, the model estimated provided acceptable results that served to identfy important policy implications. These insights can be used to guide future expansion of the export sector in general, and the natural rubber subsector.

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APPENDIX I

STRUCTURE OF THE SUPPLY AND DEMAND MODEL

1. MTAEF = 130.8863 + .5028949*MTAEF(-1) + 1.803133*TREND + 30.54525*DV71 + 28.00278*DV84
2. MTASMF = 23.6624 + .9973946*MTASMF(-1) + 386.8182*DV84
3. YLDEF = .6685144 + 7.876938D-03*PRDLTDF + 1.390076D-02*TREND + .1742974*DV2 + .1329026*DV86
4. YLDSMF = .5059488 + 7.325873D-03*JKPRRPDF-2.350978D-02*RICEPD - 6.161896D-02*DV1
5. PRDEF = MTAEF*YLDEF
6. PRDSMF = MTASMF*YLDSMF
7. INAPRDF = PRDEF + PRDSMF
8. QEINRF = 78.37957 + .8115278*INAPRDF + 3.507032*PRDLTDF
9. QEONRF = 291.5683 + .7517098*ONRPRD + 6.358194*PRDLTDF - 13.98339*TREND
10. RUNCF = .2107013 - 1.347473D-02*RATPRF + 4.600662D-03*TREND + 2.530873D-02*DV85 + [AR(1)=.5166443]
11. AUTUSPF = -30992.13 + 4.647693*DICD - 707.6437*TREND
12. USTRCF = 842.3429 + 7.941874D-02*AUTUSPF + 22.10627*IDXPUS -67.13697*TREND + [AR(1)=.4681272]
13. USNRCF = RUNCF*USTRCF
14. USINRF = 108.973 + .7563582*USNRCF + 4.051068*TREND
15. RONCF = .3456475 -1.404341D-02*RATPRF + 3.534852D-02*DV82 + [AR(1)=.7481382]
16. AUTOPF = -58201.8 + 13.47674*GPOCD + [AR(1)=.8205574]
17. OTRCF = 4508.47 + .2160485*AUTOPF - 1180.736*DV82 + [AR(1)=.9122145]
18. ONRCF = RONCF*OTRCF
19. OINRF = 437.5894 + .7575838*ONRCF - 21.52131*TREND
20. TSUPLYF = QEINRF + OINRF
21. TDEMANF = USINRF + OINRF
22. PRDLTDF = 17.68435 + .981637*SBRPTD - 1.382172D-02*WSTKF + 6.703473*DV73 + 6.111079*DV74
23. WSTKF = WSTKF(-1) + TSUPLYF + GSTK - TDEMANF
24. PRDLTF = PRDLTDF*CPIUS
25. JKPRRPF = PRDLTF*XRINA/1000
26. JKPRRPDF = JKPRRPF/CPINA
27. RATPRF = PRDLTDF/SBRPTD

APPENDIX II

ALPHABETICAL ORDER AND DESCRIPTION OF THE VARIABLES USED IN THE MODEL

LIST OF VARIABLES

AUTOP = the production of non-U.S. automobiles (passenger cars and commercial vehicles), measured in 100,000 vehicles;

AUTUSP = the production of U.S. automobiles (passenger cars and commercial vehicles), measured in 100,000 vehicles;

C = the constant term;

DICD = the U.S. real disposable income;

GSTK = Government stockpile sale (1,000 mt);

IDXPUS = the index of annual industrial production for the U.S.;

INAPRD = the total annual production of Indonesian natural rubber, measured in 1,000 mt of the dry-content weight of latex;

JKPRRPD = the domestic price of natural rubber, Rp.1,000/ton, represented by Jakarta fob price of RSS 1, deflated by CPI Indonesia (1985=100);

MTAE = area of mature trees under estates, measured in 1,000 hectares;

MTAE(-1) = area of mature trees under estates in the previous year, measured in 1,000 hectares;

MTASM = area of mature trees under smallholders, measured in 1,000 hectares;

MTASM(-1)= area of mature trees under smallholders in the previous year, measured in 1,000 hectares;

OINR = the quantity of the non-U.S. import demand for natural rubber, measured in 1,000 mt of the dry-content weight of latex;

ONRC = the quantity of the non-U.S. natural rubber consumption, measured in 1,000 mt of the dry-content weight of latex, (ONRC = RONC * OTRC);

ONRPRD = the natural rubber produced by producing countries other than Indonesia, measured in 1,000 mt of the dry-content weight of latex;

OTRC = the non-U.S. total rubber consumption (natural + synthetic rubber), measured in 1,000 mt of the dry-content weight of latex;

POCD = the averaged non-U.S. real disposable income, deflated by the U.S. CPI;

PRDE = the quantity of natural rubber produced by estates in Indonesia, measured in 1,000 mt of the dry-content weight of latex;

PRDLTD = the price of natural rubber in the world market, US $/ton, represented by Jakarta fob price of RSS 1, deflated by CPI U.S. (1985=100);

PRDSM	= the quantity of natural rubber produced by smallholders in Indonesia, measured in 1,000 mt of the dry-content weight of latex;
QEINR	= the quantity of Indonesian's export supply of natural rubber, measured in 1,000 mt of the dry-content weight of latex;
QEONR	= the quantity of other producing countries' export supply of natural rubber, measured in 1,000 mt of the dry-content weight of latex;
RATPR	= the ratio of natural rubber to synthetic rubber prices in the world market;
RICEPD	= average annual domestic price of rice lagged by one year, represented by the un-weighted average prices of rice in Palembang, Jambi, and Banjarmasin, Rp/kg, deflated by Indonesian CPI (1985=100);
RONC	= the ratio of the non-U.S. natural rubber to total rubber consumption; where total rubber consumption includes natural rubber and synthetic rubber consumption;
RUNC	= the ratio of the U.S. natural rubber to total rubber consumption; where total rubber consumption includes natural rubber and synthetic rubber consumption;
SBRPTD	= the U.S. price of synthetic rubber, U.S. $/ton, represented by the price of SBR, deflated by CPI U.S. (1985=100);
TREND	= the time trend;
USINR	= the quantity of U.S. import demand for natural rubber, measured in 1,000 mt of the dry-content weight of latex;
USNRC	= the quantity of U.S. natural rubber consumption, measured in thousands metric tons of the dry-content weight of latex, (USNRC = RUNC * USTRC);
USTRC	= the U.S. total rubber consumption (natural + synthetic rubber), measured in 1,000 mt of the dry-content weight of latex;
WSTK	= stock of natural rubber ('000 mt).
YLDE	= yield (ton/hectare) of natural rubber in estates;
YLDSM	= yield (ton/hectare) of natural rubber in smallholders;

APPENDIX III

FIGURES OF ACTUAL AND FITTED VALUE DURING OBSERVATION PERIOD FOR EACH EQUATION

(includes Figures 8 - 22)

Figure 8. Mature Tree Area under Estate Enterprises Equation, Actual and Fitted Value during Sample Period

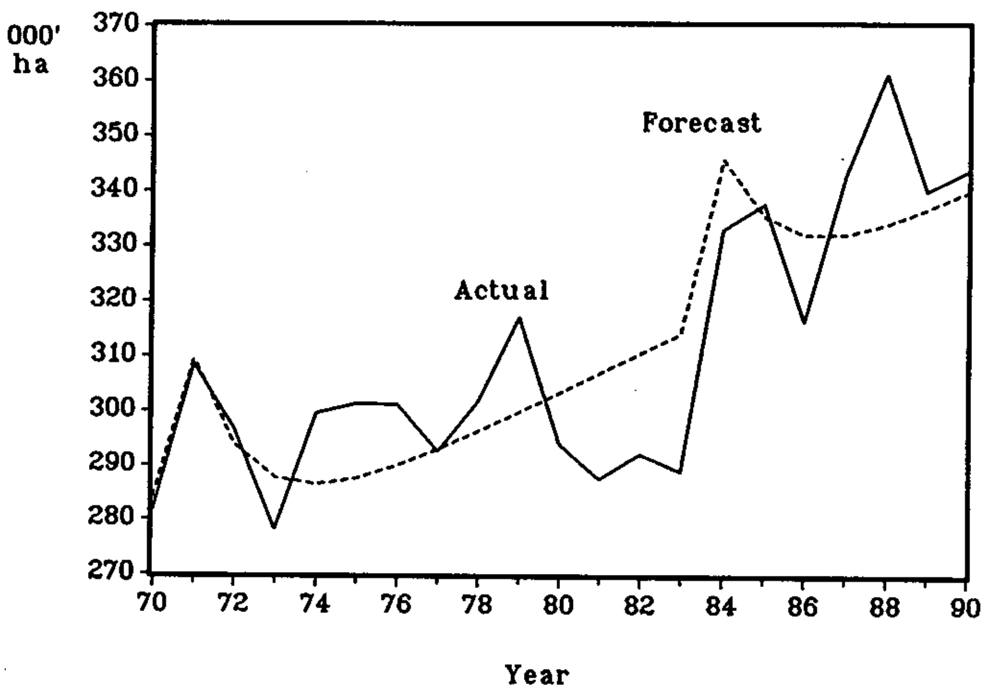


Figure 9. Mature Tree Area under Smallholder Enterprises Equation, Actual anf Fitted Value during Sample Period.

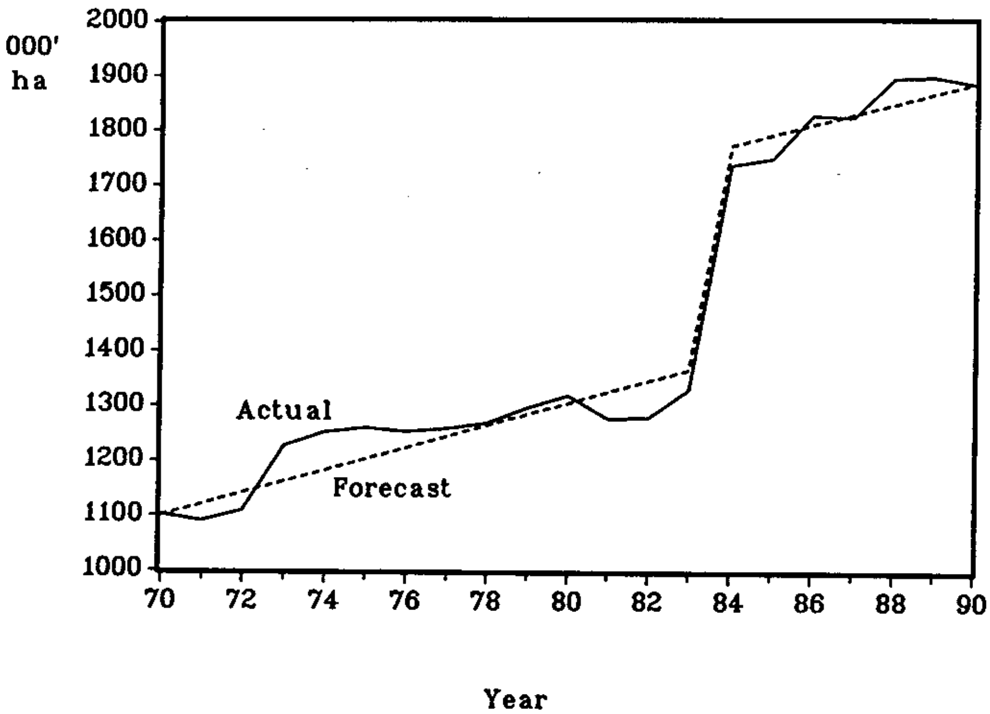


Figure 10. Yield of Natural Rubber under Estate Enterprises Equation, Actual and Fitted Value during Sample Period

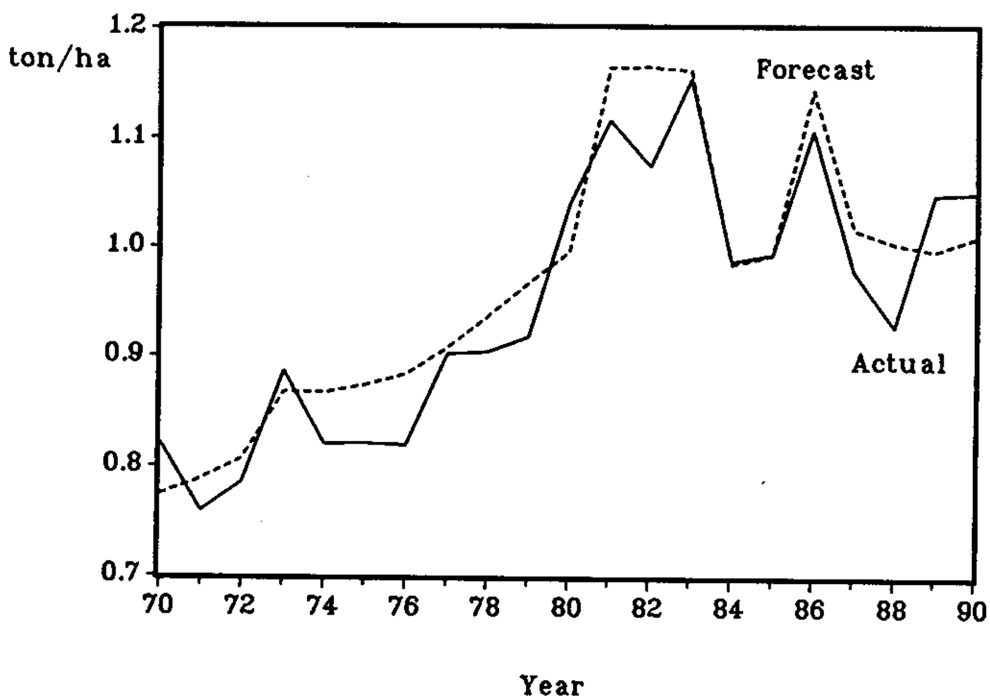


Figure 11. Yield of Natural Rubber under Smallholder Enterprises Equation, Actual and Fitted Value under Sample Period

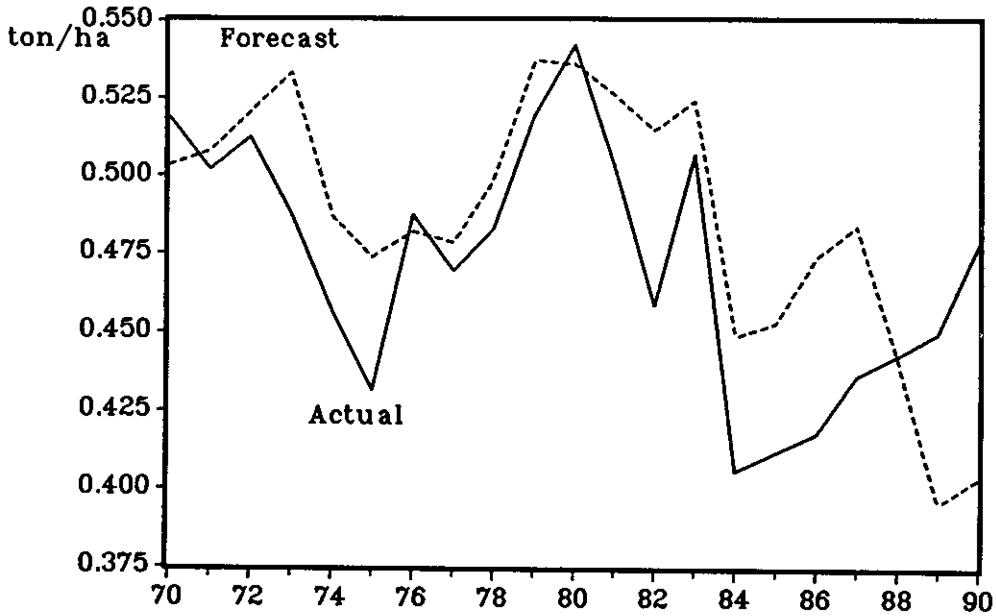


Figure 12. Indonesian Natural Rubber Export Supply Equation, Actual and Fitted Value during Sample Period

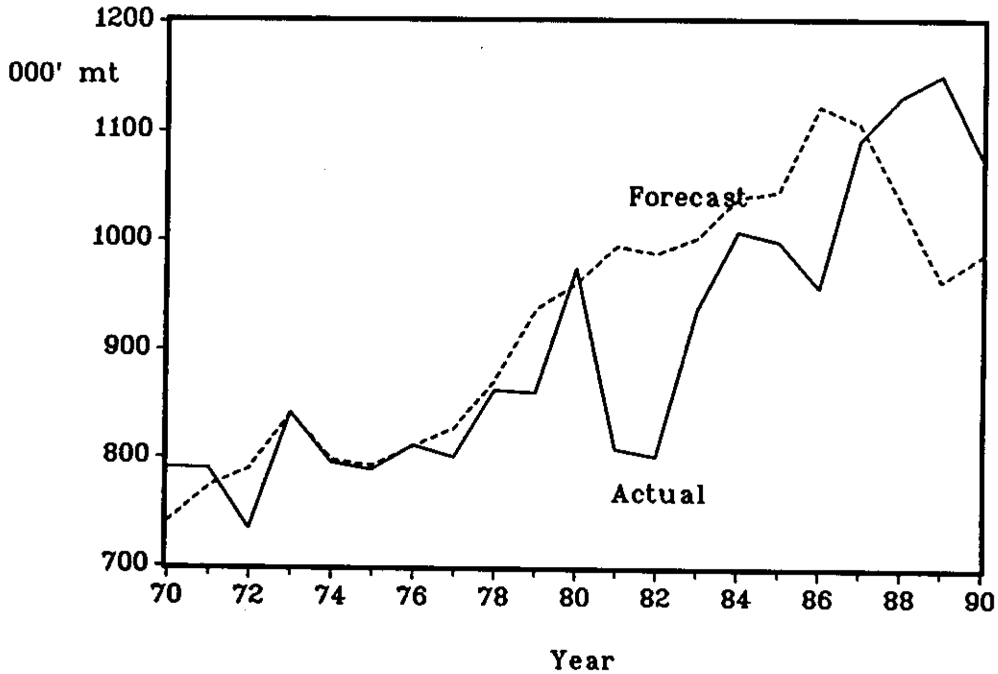


Figure 13. Other Countries Export Supply of Natural Rubber Equation, Actual and Fitted Value during Sample Period

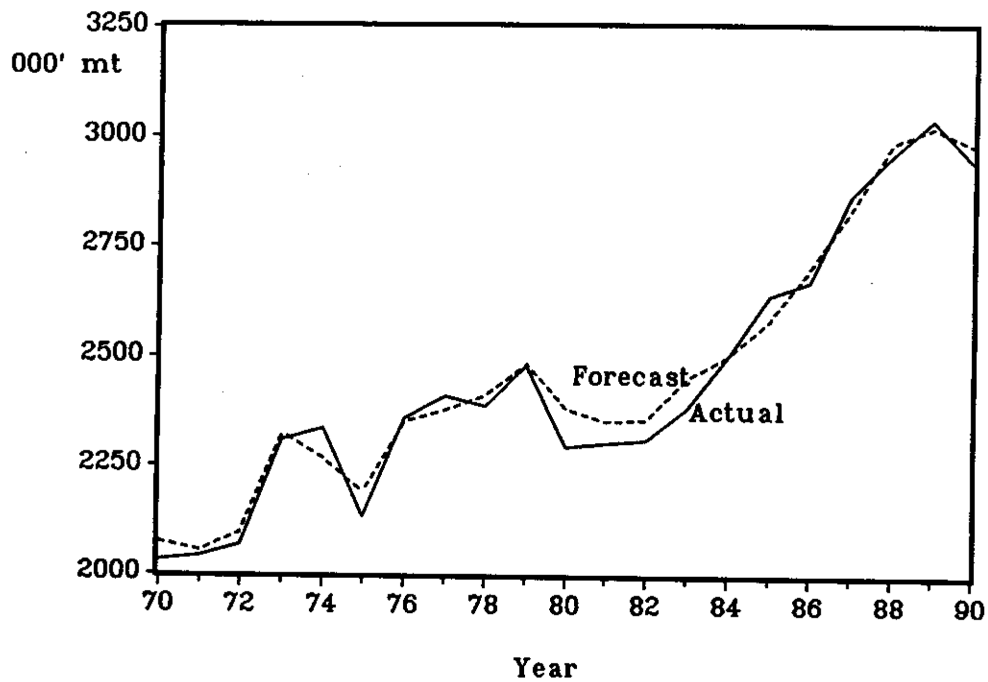


Figure 14. Ratio of Natural Rubber Consumption in the U.S. Equation, Actual and Fitted Value during Sample Period

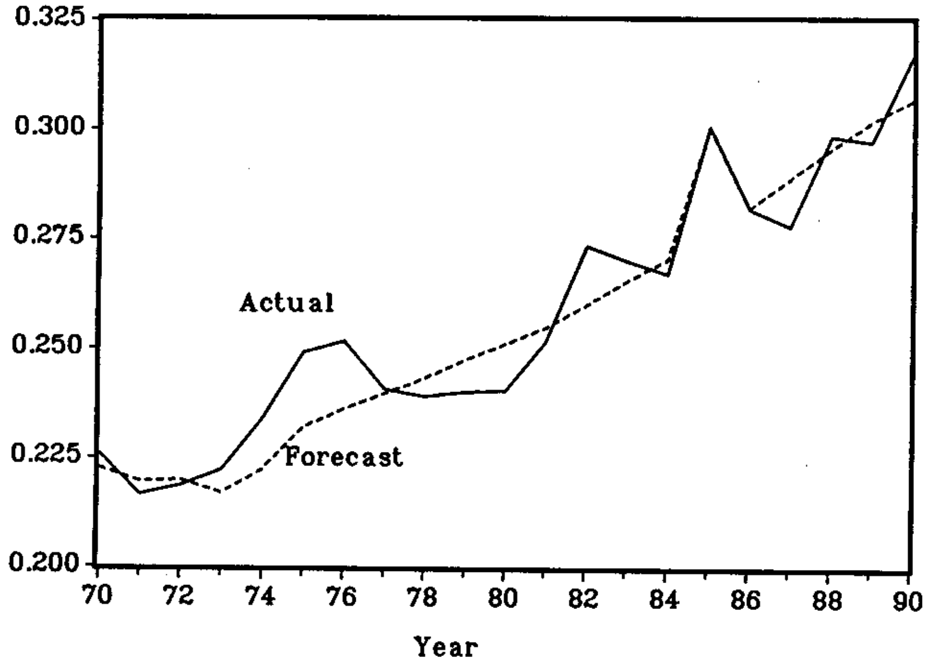


Figure 15. Automobile Production in the U.S. Equation, Actual and Fitted Value for the Sample Period

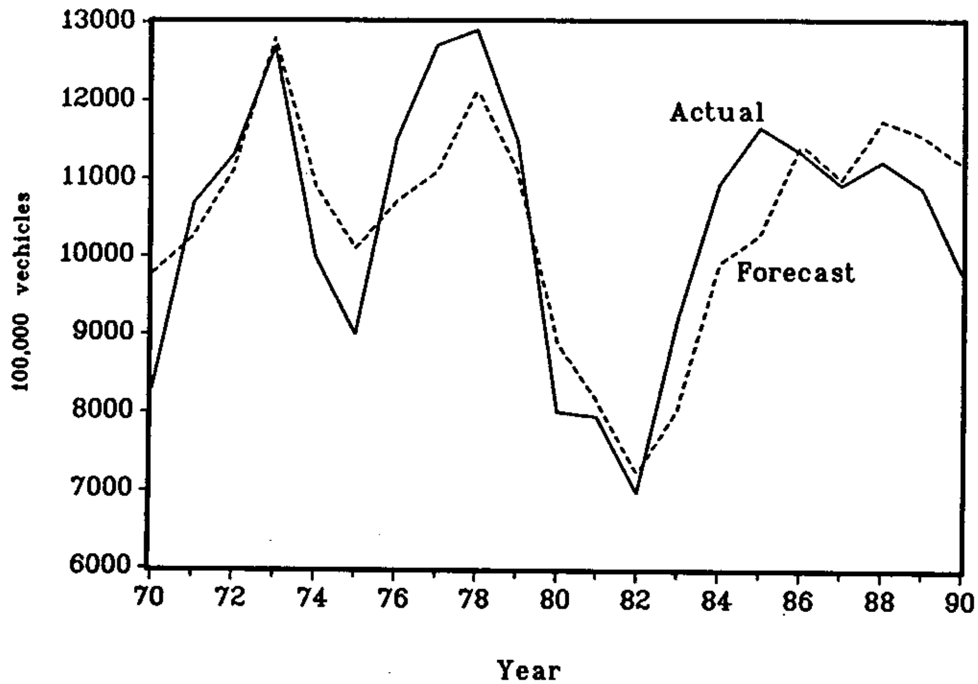


Figure 16. Total Rubber Consumption in the U.S. Equation, Actual and Fitted Values for the Sample Period

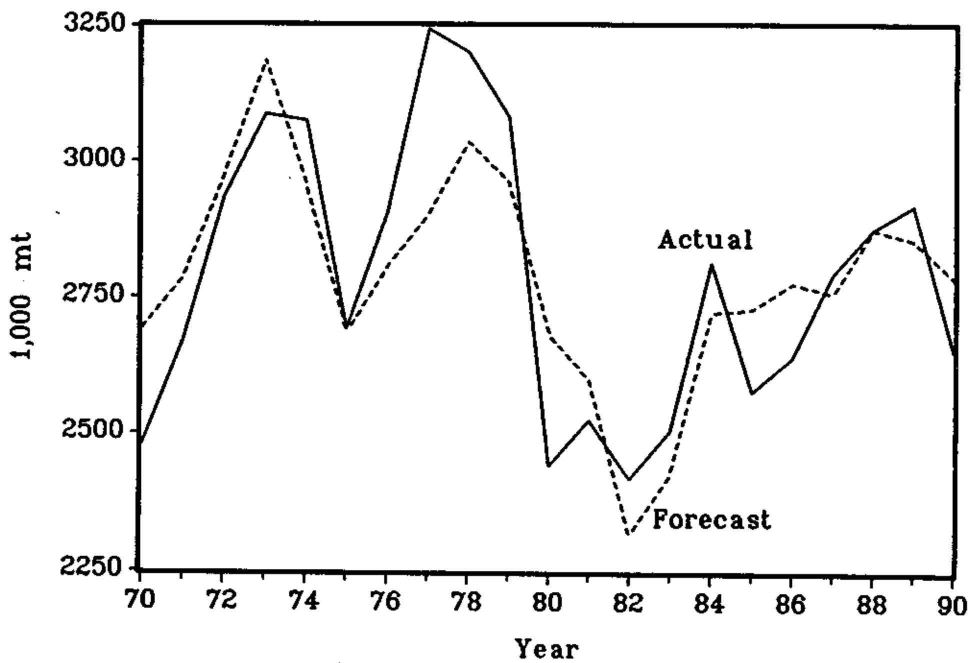


Figure 17.The U.S. Import Demand for Natural Rubber Equation, Actual and Fitted Values for the Sample Period

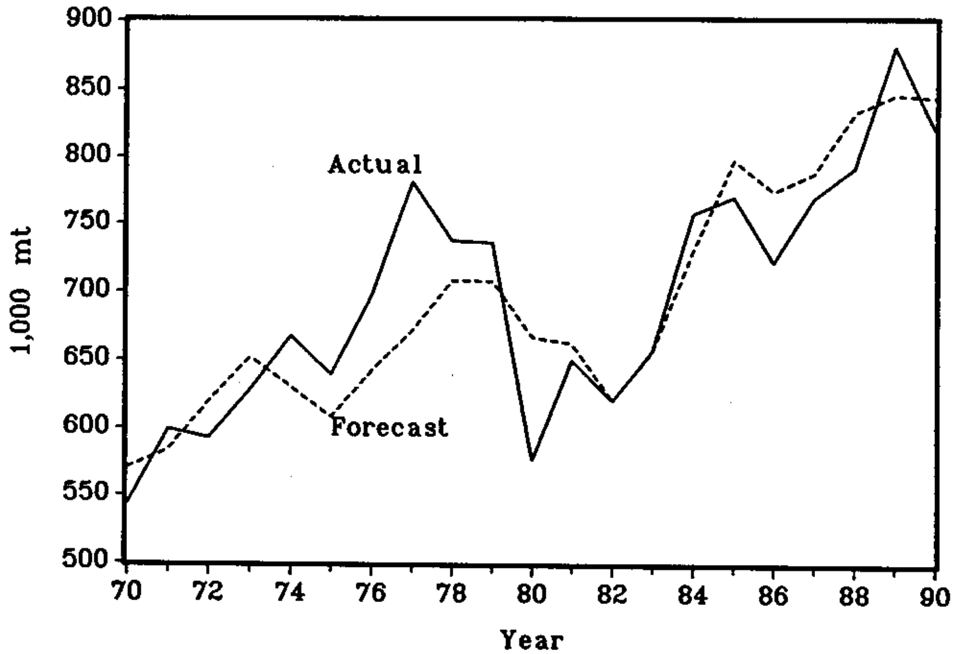


Figure 18. Ratio of Natural Rubber Consumption in the Other Countries Equation, Actual and Fitted Values for Sample Period

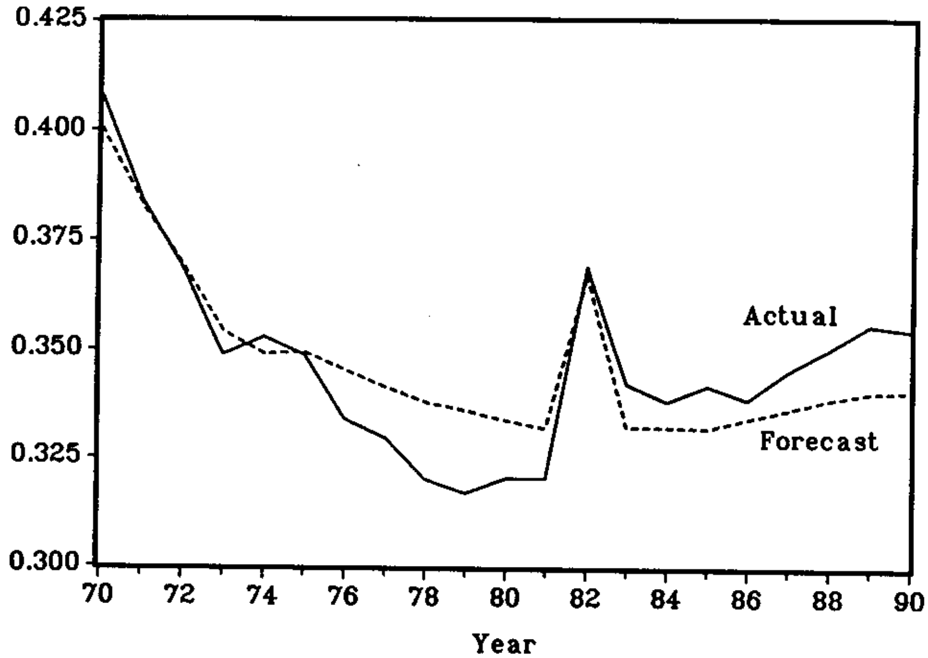


Figure 19. Automobiles Production in Other Countries Equation, Actual and Fitted Values for the Sample Period

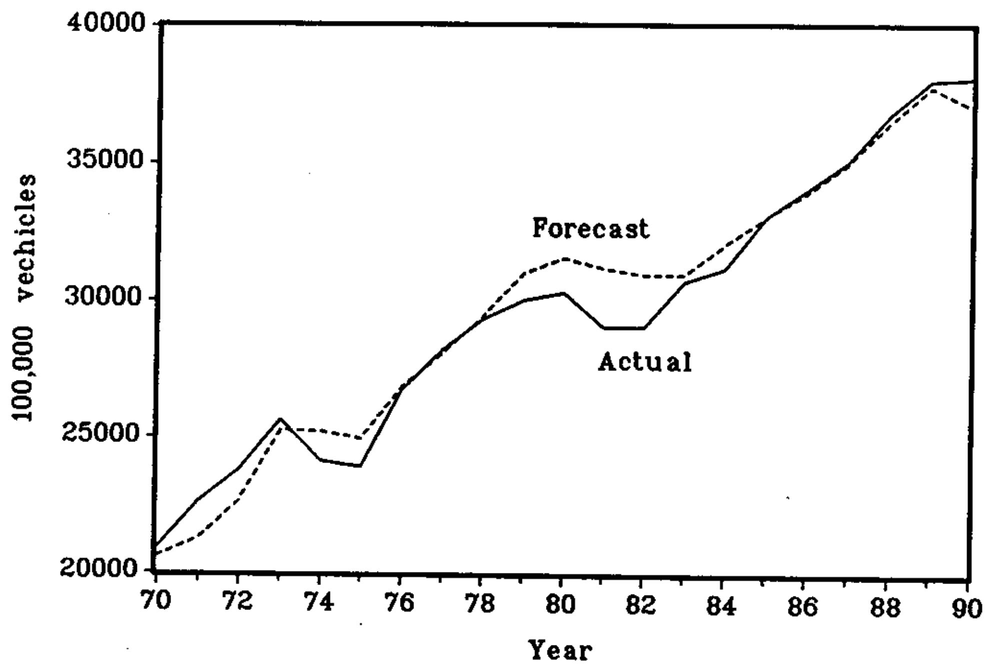


Figure 20. Total Rubber Consumption in Other Countries Equation
Actual and Fitted Values for the Sample Period

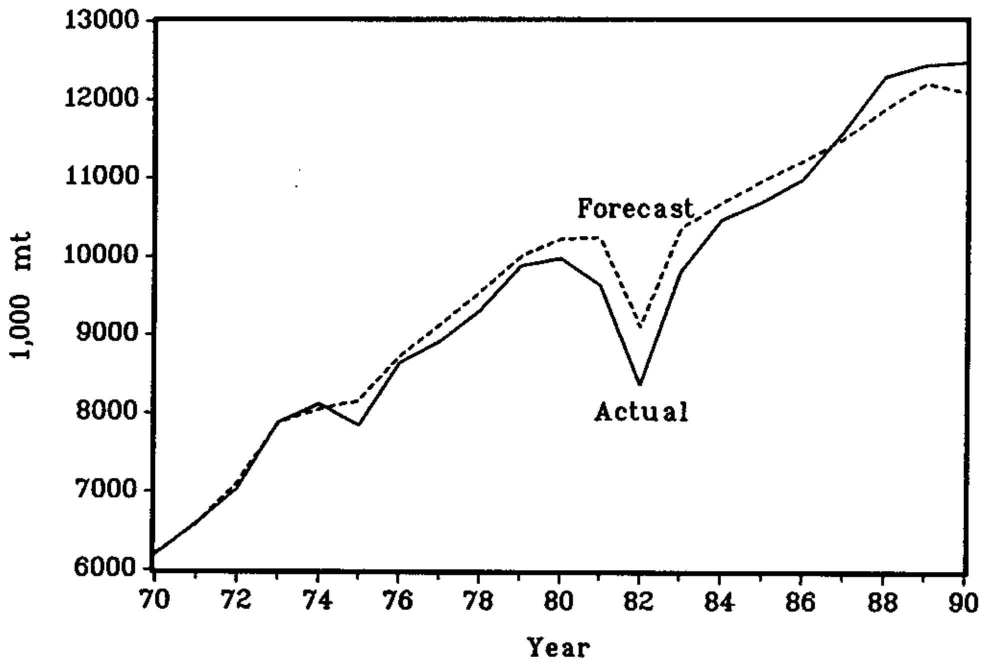


Figure 21 Other Countries Import Demand for Natural Rubber Equation, Actual and Fitted Values for the Sample Period

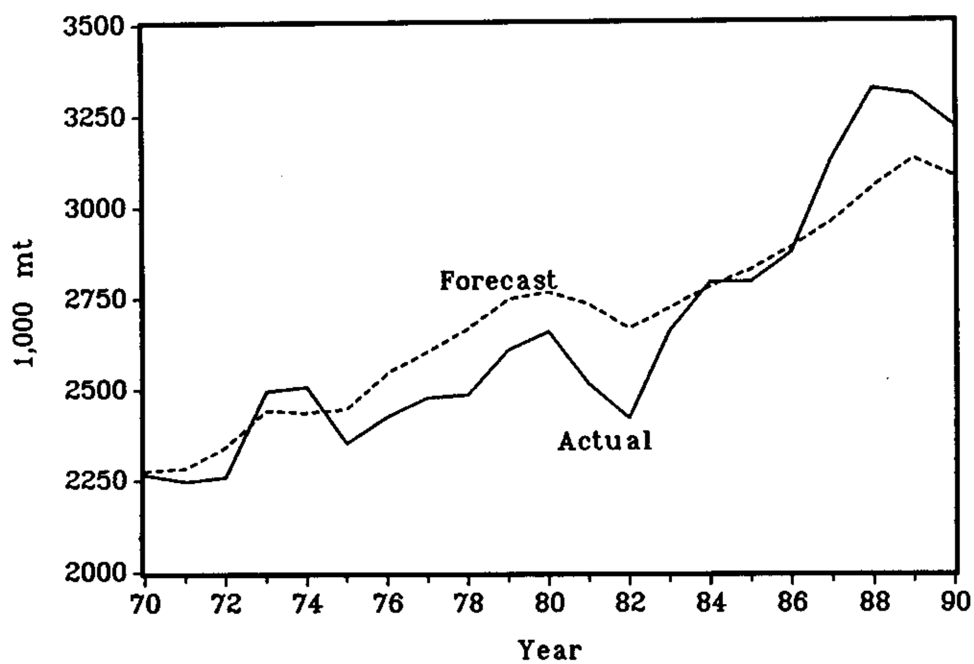
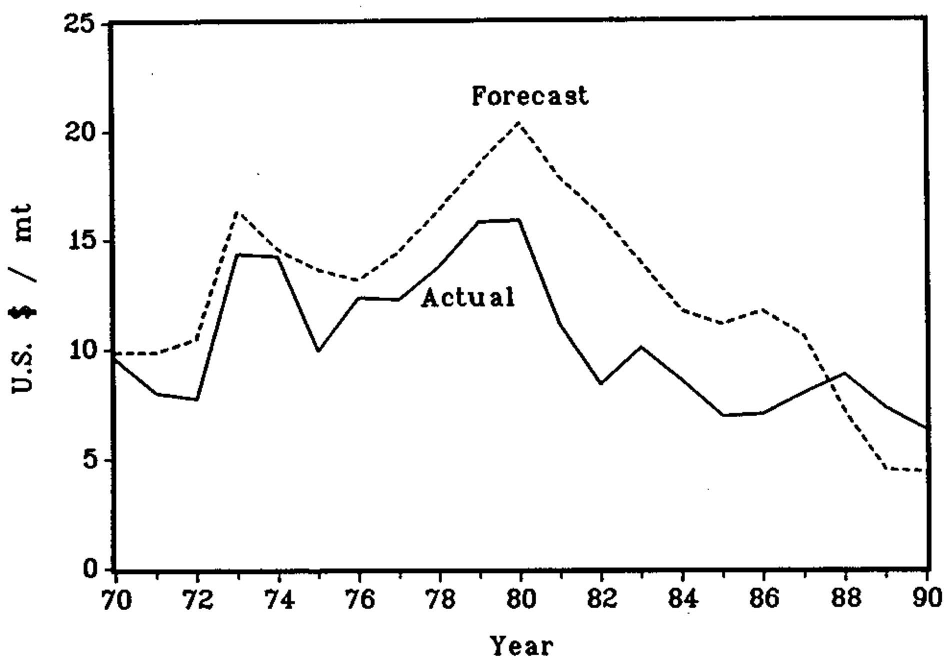


Figure 22. Deflated Price of Natural Rubber Equation, Actual and Fitted Values for the Sample Period



APPENDIX IV

EVALUATING TURNING POINT ERRORS

(includes Tables 25 - 39)

Table 25. Evaluating turning point errors (MTAE)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 15.89	- 13.35
1971	26.89	28.17
1972	- 11.72	- 14.57
1973	- 18.63	- 9.01
1974	21.45	8.31
1975	1.73	- 11.98
1976	- 0.12	- 11.33
1977	- 8.61	- 8.20
1978	9.20	3.72
1979	15.37	- 2.01
1980	- 23.15	- 13.84
1981	- 6.48	12.90
1982	4.59	23.00
1983	- 3.17	22.02
1984	44.14	56.82
1985	4.63	2.37
1986	- 21.40	- 5.63
1987	26.62	15.87
1988	18.29	- 8.88
1989	- 21.28	- 24.44
1990	3.73	0.01

Table 26. Evaluating turning point errors (MTASM)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	22.45	20.85
1971	- 10.68	19.20
1972	17.73	50.62
1973	119.03	53.58
1974	23.77	- 44.81
1975	8.11	- 48.00
1976	- 5.98	- 35.59
1977	5.41	- 9.13
1978	10.71	5.87
1979	27.34	15.53
1980	22.20	8.50
1981	- 41.70	6.56
1982	0.94	68.47
1983	51.51	87.69
1984	407.01	443.10
1985	12.20	55.13
1986	78.49	61.91
1987	- 3.65	2.36
1988	72.64	24.92
1989	1.94	- 28.87
1990	- 12.18	- 12.02

Table 27. Evaluating turning point errors (YLDE)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	0.08	0.03
1971	- 0.06	- 0.03
1972	0.02	0.04
1973	0.10	0.08
1974	- 0.06	- 0.01
1975	0.00	0.05
1976	- 0.00	0.06
1977	0.08	0.08
1978	0.00	0.03
1979	0.01	0.06
1980	0.12	0.07
1981	0.07	0.12
1982	- 0.04	0.04
1983	0.08	0.08
1984	- 0.16	- 0.17
1985	0.00	0.00
1986	0.11	0.15
1987	- 0.12	- 0.09
1988	- 0.05	0.02
1989	0.12	0.06
1990	0.00	- 0.03

Table 28. Evaluating turning point errors (YLDSM)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	0.00	- 0.01
1971	- 0.01	- 0.01
1972	0.01	0.01
1973	- 0.02	0.02
1974	- 0.03	- 0.00
1975	- 0.02	0.01
1976	0.05	0.05
1977	- 0.01	- 0.00
1978	0.01	0.02
1979	0.03	0.05
1980	0.02	0.01
1981	- 0.03	- 0.01
1982	- 0.04	0.01
1983	0.04	0.06
1984	- 0.10	- 0.05
1985	0.00	0.04
1986	0.00	0.06
1987	0.01	0.06
1988	0.00	0.00
1989	0.00	- 0.04
1990	0.02	0.04

Table 29. Evaluating turning point errors (QEINR)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 67.20	- 117.31
1971	- 90.00	- 17.76
1972	- 55.39	- 0.15
1973	107.60	106.80
1974	- 46.79	- 43.86
1975	- 6.40	- 2.66
1976	23.20	22.21
1977	- 11.29	15.85
1978	63.00	71.70
1979	- 2.20	74.71
1980	115.10	101.05
1981	- 167.40	20.26
1982	- 7.29	180.95
1983	136.60	202.67
1984	71.59	102.32
1985	- 8.69	35.97
1986	- 42.20	122.37
1987	134.10	14.36
1988	39.19	- 55.61
1989	19.80	- 167.33
1990	- 74.50	- 162.02

Table 30. Evaluating turning point errors (QEONR)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	57.20	101.27
1971	10.89	23.42
1972	25.40	54.94
1973	242.39	258.48
1974	26.40	- 42.71
1975	- 203.60	- 147.17
1976	226.80	219.01
1977	51.30	18.84
1978	- 23.00	1.60
1979	92.19	97.07
1980	- 185.10	- 98.54
1981	7.40	58.17
1982	7.30	54.36
1983	73.39	141.89
1984	118.39	119.87
1985	138.70	82.06
1986	32.19	61.74
1987	195.89	163.22
1988	90.80	117.87
1989	80.19	63.22
1990	- 95.50	- 58.64

Table 31. Evaluating turning point errors (RUNC)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 0.002	- 0.005
1971	- 0.009	- 0.006
1972	0.002	0.003
1973	0.003	- 0.001
1974	0.011	0.000
1975	0.015	- 0.001
1976	0.002	- 0.012
1977	- 0.011	- 0.011
1978	- 0.001	0.002
1979	0.001	0.008
1980	0.000	0.011
1981	0.011	0.014
1982	0.021	0.008
1983	- 0.003	- 0.007
1984	- 0.003	0.000
1985	0.033	0.033
1986	- 0.018	- 0.018
1987	- 0.004	0.006
1988	0.020	0.017
1989	- 0.004	0.003
1990	0.019	0.009

Table 32. Evaluating turning point errors (AUTUSP)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 1923	- 436
1971	2389	1977
1972	639	453
1973	1371	1486
1974	- 2700	- 1786
1975	- 993	107
1976	2509	1710
1977	1198	- 409
1978	196	- 555
1979	- 1412	- 1804
1980	- 3470	- 2590
1981	- 56	140
1982	- 979	- 740
1983	2230	1076
1984	1719	698
1985	729	- 648
1986	- 318	- 210
1987	- 425	- 356
1988	302	821
1989	- 343	332
1990	- 1089	305

Table 33. Evaluation turning point errors (USTRC)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 145	69
1971	193	309
1972	261	302
1973	153	255
1974	- 11	- 130
1975	- 383	- 391
1976	213	114
1977	338	- 3
1978	- 43	- 208
1979	- 120	- 240
1980	- 639	- 398
1981	84	157
1982	- 107	- 210
1983	86	6
1984	308	216
1985	- 236	- 85
1986	61	198
1987	154	116
1988	82	81
1989	42	- 21
1990	- 268	- 133

Table 34. Evaluating turning point errors (USINR)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 29	- 1
1971	55	40
1972	- 6	20
1973	35	59
1974	39	2
1975	- 27	- 59
1976	57	2
1977	84	- 25
1978	- 44	- 73
1979	- 1	- 29
1980	- 159	- 69
1981	73	85
1982	- 29	- 29
1983	36	36
1984	100	73
1985	12	39
1986	- 48	4
1987	48	66
1988	22	63
1989	89	53
1990	- 60	- 36

Table 35. Evaluating turning point errors (RONC)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 0.011	- 0.018
1971	- 0.023	- 0.024
1972	- 0.015	- 0.014
1973	- 0.019	- 0.014
1974	0.003	0.000
1975	- 0.004	- 0.003
1976	- 0.014	- 0.003
1977	- 0.004	0.007
1978	- 0.009	0.008
1979	- 0.003	0.016
1980	0.003	0.017
1981	- 0.001	0.011
1982	0.048	0.046
1983	- 0.026	- 0.036
1984	- 0.004	- 0.010
1985	0.003	- 0.006
1986	- 0.003	- 0.007
1987	0.006	- 0.002
1988	0.005	- 0.006
1989	0.005	- 0.009
1990	- 0.001	- 0.015

Table 36. Evaluating turning point errors (AUTOP)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	1723	1394
1971	1711	330
1972	1161	19
1973	1829	1457
1974	- 1500	- 423
1975	- 207	813
1976	2791	2924
1977	1502	1375
1978	1104	1224
1979	712	1698
1980	270	1528
1981	- 1244	886
1982	- 21	1885
1983	1670	1915
1984	481	1367
1985	1871	1882
1986	1018	887
1987	1025	954
1988	1698	1424
1989	1243	1026
1990	89	- 940

Table 37. Evaluating turning point errors (OTRC)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	547	566
1971	413	403
1972	425	513
1973	857	851
1974	234	166
1975	- 272	43
1976	791	879
1977	282	495
1978	397	632
1979	569	692
1980	96	346
1981	- 342	266
1982	- 1237	- 537
1983	1443	1998
1984	664	871
1985	227	489
1986	283	512
1987	617	519
1988	691	276
1989	147	- 87
1990	39	- 348

Table 38. Evaluating turning point errors (OINR)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 1.00	8.29
1971	- 18.80	16.94
1972	12.39	94.27
1973	233.90	182.12
1974	12.50	- 59.14
1975	- 155.20	- 60.76
1976	73.79	194.39
1977	52.40	178.72
1978	6.19	188.85
1979	124.30	263.08
1980	50.30	157.16
1981	- 143.60	74.69
1982	- 95.30	151.60
1983	238.30	302.58
1984	135.39	122.04
1985	- 0.09	33.77
1986	79.69	94.59
1987	256.89	85.48
1988	191.30	- 77.05
1989	- 16.09	- 191.50
1990	- 85.20	- 223.60

Table 39. Evaluating turning point errors (PRDLTD)

Year	Forecast - Actual(-1)	Actual - Actual(-1)
1970	- 3.20	- 2.92
1971	- 1.58	0.028
1972	- 0.25	2.47
1973	6.63	8.65
1974	- 0.11	0.18
1975	- 4.34	- 0.61
1976	2.44	3.24
1977	- 0.08	2.09
1978	1.48	4.07
1979	2.05	4.72
1980	0.08	4.56
1981	- 4.76	1.97
1982	- 2.73	5.01
1983	1.68	5.58
1984	- 1.50	1.66
1985	- 1.64	2.54
1986	0.09	4.79
1987	0.95	3.57
1988	0.85	- 0.84
1989	- 1.51	- 4.31
1990	- 0.99	- 2.90

APPENDIX V

LIST OF THE EXOGENOUS VARIABLES USED IN THE MODEL

List of the exogenous variables used in the model

Observations	RICEPD	SBRPTD	DICD	GPOCD	ONRPRD	CPIUS	CPINA	XRINA
1969	3.9465	10.4176	8924.1	5179.9	2140.000	34.08	11.60	326.00
1970	3.1793	10.5989	9074.9	5384.4	2325.000	36.09	13.10	362.83
1971	3.2481	10.2799	9332.6	5516.2	2316.000	37.62	13.60	391.88
1972	3.0007	10.4889	9671.0	5688.1	2386.000	38.87	14.50	415.00
1973	3.4428	11.6021	10183.1	5936.8	2659.000	41.28	19.00	415.00
1974	4.0268	11.3804	9926.0	5978.7	2615.000	45.84	26.80	415.00
1975	4.1377	15.8422	9905.0	5996.8	2538.000	50.03	31.90	415.00
1976	3.3751	15.0148	10188.5	6168.9	2777.000	52.90	38.20	415.00
1977	3.6565	15.3659	10424.5	6286.4	2820.000	56.33	42.40	415.00
1978	3.2878	16.0123	10803.1	6407.4	2868.000	60.63	45.90	442.05
1979	3.2114	17.7252	10728.7	6541.5	2965.000	67.47	53.30	623.06
1980	3.5664	18.3909	10408.1	6595.7	2830.000	76.58	62.90	626.99
1981	3.3490	15.1892	10401.3	6579.6	2832.000	84.48	70.60	631.76
1982	3.4956	14.2452	10352.0	6570.8	2870.000	89.68	77.30	661.42
1983	3.4596	13.1156	10684.6	6579.2	3033.000	92.57	86.40	909.26
1984	3.6036	11.2809	11235.3	6668.8	3139.000	96.56	95.50	1025.94
1985	3.4766	10.6997	11467.6	6747.9	2370.000	100.00	100.00	1110.58
1986	3.2491	13.6083	11870.9	6817.2	3441.000	101.86	105.90	1282.56
1987	3.2751	15.2055	11923.3	6901.2	3647.000	105.67	115.60	1643.85
1988	3.4022	13.5994	12237.6	7015.0	3895.000	109.91	124.90	1685.70
1989	4.2378	11.0806	12349.7	7113.8	3984.000	115.21	133.00	1770.06
1990	3.8673	11.5956	12422.2	7062.0	3948.000	121.43	142.90	1842.81
1991	3.8988	11.3109	12257.4	6870.4	3983.000	127.63	152.00	1971.64
1992	3.8202	10.9613	12380.0	6825.1	4070.512	133.83	161.21	2082.76
1993	3.8488	10.6427	12528.6	6879.1	4316.659	140.03	170.42	2193.88
1994	3.8775	10.3511	12678.9	6948.5	4202.806	146.23	179.63	2305.00
1995	3.9061	10.0832	12985.0	7017.9	4268.953	152.43	188.83	2416.13

APPENDIX VI

ACTUAL AND FORECAST VALUES OF THE ENDOGENOUS VARIABLES USED IN THE MODEL

Actual and forecast values of the endogenous variables used in the model

Year	MTAE	MTAEF	MTASM	MTASMF	YLDE	YLDEF	YLDSM	YLDSMF	PRDE	PRDEF
1969	297.416	297.416	1078.152	1078.152	0.7384	NA	0.5137	NA	219.607	NA
1970	281.518	284.062	1100.603	1099.005	0.8210	0.7738	0.5188	0.5032	231.132	219.803
1971	308.415	309.694	1089.923	1119.804	0.7585	0.7878	0.5019	0.5078	233.919	243.977
1972	296.689	293.842	1107.656	1140.549	0.7845	0.8065	0.5122	0.5206	232.763	236.970
1973	278.055	287.674	1226.692	1161.240	0.8859	0.8670	0.4874	0.5331	246.330	249.405
1974	299.505	286.375	1250.466	1181.877	0.8195	0.8664	0.4567	0.4869	245.432	248.116
1975	301.237	287.525	1258.582	1202.460	0.8204	0.8731	0.4312	0.4736	247.120	251.031
1976	301.113	289.906	1252.596	1222.990	0.8182	0.8832	0.4871	0.4819	246.365	256.047
1977	292.497	292.907	1258.011	1243.466	0.9013	0.9073	0.4693	0.4783	263.639	265.755
1978	301.707	296.219	1268.724	1263.889	0.9034	0.9361	0.4827	0.4985	272.573	277.291
1979	317.077	299.688	1296.068	1284.259	0.9172	0.9668	0.5194	0.5371	290.817	289.738
1980	293.918	303.235	1318.275	1304.575	1.0395	0.9956	0.5420	0.5359	305.532	301.903
1981	287.428	306.823	1276.569	1324.838	1.1165	1.1640	0.5032	0.5260	320.907	357.154
1982	292.022	310.430	1277.514	1345.049	1.0739	1.1643	0.4584	0.5143	313.602	361.439
1983	288.851	314.047	1329.028	1365.207	1.1543	1.1612	0.5068	0.5242	333.425	364.678
1984	333.001	345.672	1736.046	1772.131	0.9861	0.9832	0.4056	0.4486	328.385	339.849
1985	337.634	335.376	1748.254	1791.176	0.9926	0.9922	0.4117	0.4528	335.134	332.752
1986	316.230	332.002	1826.748	1810.172	1.1067	1.1438	0.4178	0.4737	349.981	379.735
1987	342.850	332.108	1823.093	1829.118	0.9776	1.0159	0.4362	0.4836	335.179	337.372
1988	361.150	333.964	1895.738	1848.015	0.9260	1.0025	0.4425	0.4415	334.433	334.787
1989	339.866	336.701	1897.682	1866.863	1.0470	0.9957	0.4496	0.3951	355.837	335.267
1990	343.603	339.880	1885.502	1885.661	1.0487	1.0240	0.4781	0.4257	360.350	348.022
1991	NA	343.283	NA	1904.411	NA	1.0350	NA	0.4247	NA	355.291
1992	NA	346.797	NA	1923.112	NA	1.0472	NA	0.4269	NA	363.151
1993	NA	350.367	NA	1941.764	NA	1.0608	NA	0.4288	NA	371.653
1994	NA	353.965	NA	1960.367	NA	1.0752	NA	0.4321	NA	380.578
1995	NA	357.578	NA	1978.922	NA	1.0900	NA	0.4362	NA	389.745

Actual and forecast values of the endogenous variables used in the model (Continued)

Year	PRDSM	PRDSMF	INAPRD	INAPRDF	QEINR	QEINRF	QEONR	QEONRF	AUTUSP	AUTUSPF
1969	553.826	NA	880.000	NA	857.400	NA	1972.600	NA	10206	10206.000
1970	571.014	553.047	815.000	772.850	790.200	740.061	2029.800	2073.861	8283	9769.934
1971	547.027	568.640	819.000	812.617	789.300	772.382	2040.700	2053.202	10672	10260.000
1972	567.327	593.759	774.000	830.729	733.900	789.198	2066.100	2095.676	11311	11125.130
1973	597.925	619.109	886.000	868.513	841.500	840.615	2308.500	2324.537	12682	12797.570
1974	571.050	575.407	855.000	823.523	794.700	797.663	2335.300	2265.800	9982	10895.010
1975	542.727	569.481	822.000	820.513	788.300	792.002	2131.700	2188.101	8989	10089.760
1976	610.183	589.374	848.000	845.421	811.500	810.537	2358.500	2350.732	11498	10699.740
1977	590.339	594.722	835.000	860.478	800.200	827.296	2409.800	2377.303	12696	11088.950
1978	612.409	630.025	902.000	907.316	863.200	871.939	2386.800	2411.427	12892	12140.920
1979	673.122	689.758	905.000	979.496	861.000	937.994	2479.000	2483.917	11480	11087.490
1980	714.468	699.115	1020.000	1001.018	976.100	962.096	2293.900	2380.485	8010	8889.797
1981	642.331	696.881	868.000	1054.035	808.700	996.322	2301.300	2352.053	7954	8150.550
1982	585.612	691.799	880.000	1053.238	801.400	989.610	2308.600	2355.638	6975	7213.776
1983	673.555	715.623	997.000	1080.301	938.000	1004.004	2382.000	2450.463	9205	8051.950
1984	704.213	794.958	1116.000	1134.807	1009.600	1040.370	2500.400	2501.898	10924	9903.795
1985	719.832	811.073	1130.000	1143.824	1000.900	1045.515	2639.100	2582.448	11653	10275.810
1986	763.152	857.413	1049.000	1237.149	958.700	1123.386	2671.300	2700.879	11335	11442.580
1987	795.172	884.635	1203.000	1222.007	1092.800	1107.126	2867.200	2834.547	10910	10978.480
1988	838.865	815.917	1235.000	1150.703	1132.000	1037.110	2958.000	2984.959	11212	11731.600
1989	853.200	737.514	1256.000	1072.781	1151.800	964.693	3038.200	3021.232	10869	11544.970
1990	901.529	802.695	1262.000	1150.717	1077.300	1034.312	2942.700	2991.740	9780	11174.280
1991	NA	808.707	NA	1163.999	NA	1043.812	NA	3001.747	NA	9700.699
1992	NA	821.020	NA	1184.172	NA	1059.415	NA	3052.156	NA	9562.860
1993	NA	832.669	NA	1204.322	NA	1075.631	NA	3087.649	NA	9545.860
1994	NA	847.147	NA	1227.724	NA	1094.858	NA	3123.815	NA	9536.770
1995	NA	863.116	NA	1252.861	NA	1115.646	NA	3160.260	NA	10251.780

Actual and forecast values of the endogenous variables used in the model (Continued)

Year	RUNC	RUNCF	USTRC	USTRCF	USNRC	USNRCF	USINR	USINRF	RONC	RONCF
1969	0.2282	0.2282	2622.300	2622.300	608.000	608.000	572.200	572.200	0.4191	0.419
1970	0.2258	0.2226	2477.300	2650.531	568.000	589.904	543.200	547.070	0.4079	0.401
1971	0.2163	0.2194	2670.800	2743.696	587.000	602.054	599.000	552.188	0.3840	0.391
1972	0.2184	0.2197	2932.600	2939.983	651.000	645.989	592.600	581.368	0.3688	0.383
1973	0.2221	0.2168	3086.440	3164.432	712.000	685.997	627.700	607.577	0.3488	0.383
1974	0.2338	0.2222	3075.040	2940.489	738.000	653.310	667.200	578.803	0.3528	0.377
1975	0.2489	0.2319	2691.970	2674.072	666.000	620.071	639.400	549.611	0.3487	0.368
1976	0.2515	0.2360	2905.730	2800.654	687.000	660.968	696.600	576.493	0.3340	0.365
1977	0.2405	0.2396	3244.130	2898.268	802.000	694.426	781.200	597.748	0.3296	0.364
1978	0.2389	0.2430	3200.650	3033.779	771.000	737.355	737.000	626.167	0.3200	0.364
1979	0.2399	0.2473	3080.000	2959.243	740.000	731.874	735.700	617.970	0.3168	0.363
1980	0.2402	0.2510	2440.150	2680.612	585.000	672.890	576.400	569.306	0.3203	0.363
1981	0.2514	0.2547	2524.670	2597.123	635.000	661.474	650.000	556.620	0.3203	0.364
1982	0.2732	0.2599	2417.610	2314.310	585.000	601.437	620.300	507.160	0.3690	0.327
1983	0.2700	0.2654	2504.270	2424.386	665.000	643.384	657.000	534.836	0.3422	0.362
1984	0.2669	0.2703	2812.740	2721.027	751.000	735.568	757.600	600.509	0.3381	0.361
1985	0.3007	0.3003	2576.690	2727.685	764.000	819.006	769.700	659.567	0.3419	0.361
1986	0.2818	0.2819	2638.560	2775.339	743.000	782.452	721.000	627.868	0.3386	0.358
1987	0.2778	0.2888	2792.820	2755.359	789.000	795.613	769.100	633.771	0.3451	0.356
1988	0.2985	0.2957	2875.280	2874.046	858.000	849.795	791.800	670.701	0.3502	0.353
1989	0.2971	0.3019	2917.870	2853.989	867.000	861.516	880.900	675.515	0.3558	0.351
1990	0.3167	0.3046	2649.030	2783.942	808.000	847.975	820.100	661.222	0.3546	0.353
1991	NA	0.3094	NA	2621.897	NA	811.335	NA	629.459	NA	0.353
1992	NA	0.3141	NA	2597.930	NA	815.985	NA	628.924	NA	0.353
1993	NA	0.3185	NA	2583.560	NA	822.941	NA	630.134	NA	0.353
1994	NA	0.3228	NA	2569.819	NA	829.642	NA	631.152	NA	0.353
1995	NA	0.3271	NA	2613.585	NA	854.889	NA	646.197	NA	0.354

Actual and forecast values of the endogenous variables used in the model (Continued)

Year	AUTOP	AUTOPF	OTRC	OTRCF	ONRC	ONRCF	OINR	OINRF	PRDLTD	PRDLTDF
1969	19194	19194	5636.000	5636.000	2362.000	2362.000	2267.800	2267.800	12.7641	12.764
1970	20917	20588	6183.000	6196.223	2522.000	2483.151	2266.800	2275.742	9.5594	9.835
1971	22628	21247	6596.000	6576.037	2533.000	2568.464	2248.000	2318.852	7.9745	9.849
1972	23789	22647	7021.000	7093.494	2589.000	2718.166	2260.400	2410.743	7.7180	10.453
1973	25618	25247	7878.000	7848.611	2748.000	3006.653	2494.300	2607.775	14.3532	16.371
1974	24118	25194	8112.000	8018.580	2862.000	3021.106	2506.800	2597.202	14.2343	16.534
1975	23911	24932	7840.000	8127.687	2734.000	2987.566	2351.600	2550.272	9.8941	13.617
1976	26702	26834	8631.000	8686.021	2883.000	3173.113	2425.400	2669.318	12.3346	13.138
1977	28204	28078	8913.000	9089.563	2938.000	3311.845	2477.800	2752.898	12.2493	14.432
1978	29308	29429	9310.000	9504.226	2979.000	3460.423	2484.000	2843.937	13.7308	16.324
1979	30020	31006	9879.000	9956.414	3130.000	3617.754	2608.300	2941.606	15.7848	18.456
1980	30290	31548	9975.000	10176.870	3195.000	3699.259	2658.600	2981.832	15.8658	20.348
1981	29046	31177	9633.000	10192.580	3085.000	3708.777	2515.000	2967.521	11.0973	17.839
1982	29025	30931	8360.000	9046.192	3085.000	2962.396	2419.700	2380.554	8.3631	16.110
1983	30695	30940	9803.000	10308.150	3355.000	3726.953	2658.000	2938.249	10.0465	13.952
1984	31176	32062	10467.000	10620.660	3539.000	3833.501	2793.400	2997.447	8.5439	11.709
1985	33047	33058	10694.000	10899.810	3656.000	3932.038	2793.300	3050.575	6.9000	11.089
1986	34065	33935	10977.000	11147.600	3717.000	3992.232	2873.000	3074.656	6.9949	11.698
1987	35090	35020	11594.000	11434.720	4001.000	4067.428	3129.900	3110.103	7.9496	10.565
1988	36788	36515	12285.000	11804.800	4302.000	4169.540	3321.200	3165.939	8.8027	7.101
1989	38031	37814	12432.000	12128.710	4423.000	4263.226	3305.100	3215.393	7.2910	4.483
1990	38120	37090	12471.000	12015.350	4422.000	4246.277	3219.900	3181.031	6.2999	6.300
1991	NA	34487	NA	11496.020	NA	4059.377	NA	3017.918	NA	5.935
1992	NA	33859	NA	11396.250	NA	4023.355	NA	2969.106	NA	5.716
1993	NA	34580	NA	11582.310	NA	4090.781	NA	2998.667	NA	5.677
1994	NA	35495	NA	11807.110	NA	4173.588	NA	3039.878	NA	5.744
1995	NA	36421	NA	12031.570	NA	4257.156	NA	3081.667	NA	5.855

Actual and forecast values of the endogenous variables used in the model (Continued)

Year	JKPRPD	JKPRPDF
1969	12.2250	NA
1970	9.5554	9.8311
1971	8.6444	10.6767
1972	8.5862	11.6285
1973	12.9415	14.7606
1974	10.1040	10.3168
1975	6.4397	8.8625
1976	7.0887	7.5503
1977	6.7535	7.9572
1978	8.0176	9.5315
1979	12.4495	14.5563
1980	12.1117	15.5329
1981	8.3892	13.4860
1982	6.4174	12.3620
1983	9.7872	13.5919
1984	8.8628	12.1459
1985	7.6630	12.3153
1986	8.6291	14.4311
1987	11.9449	15.8761
1988	13.0578	10.5334
1989	11.1793	6.873597
1990	9.8653	9.865289
1991	NA	9.8255
1992	NA	9.8833
1993	NA	10.2343
1994	NA	10.7789
1995	NA	11.4194

APPENDIX VII

FIGURES OF THE ENDOGENOUS VARIABLES FOR THE OBSERVATION AND FORECAST PERIOD

(includes Figures 23 -36)

Figure 23. Mature Tree Area under Estate: Actual and Forecast

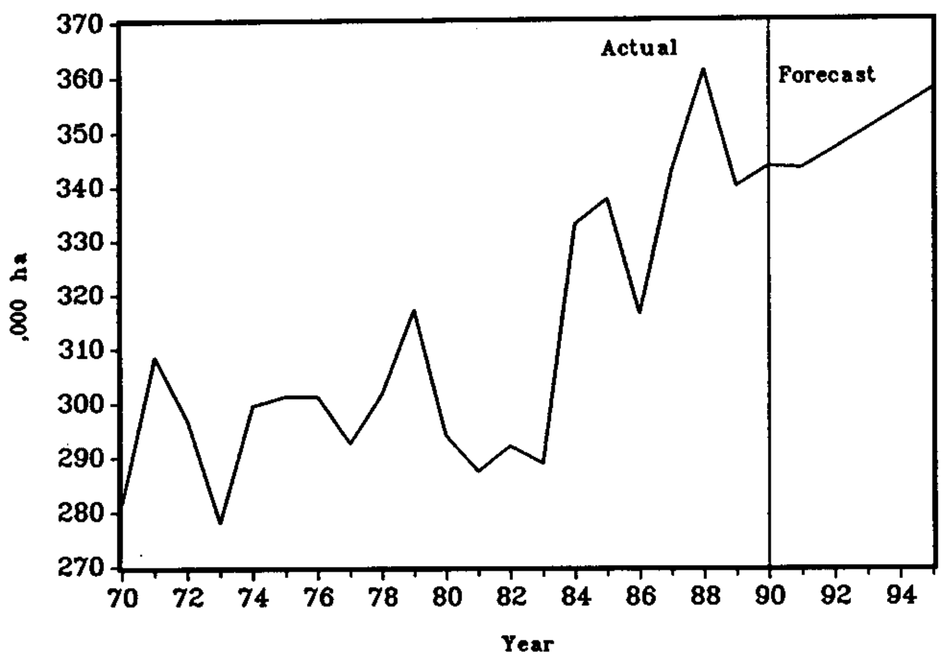


Figure 24. Mature Tree Area under Smallholders: Actual & Forecast

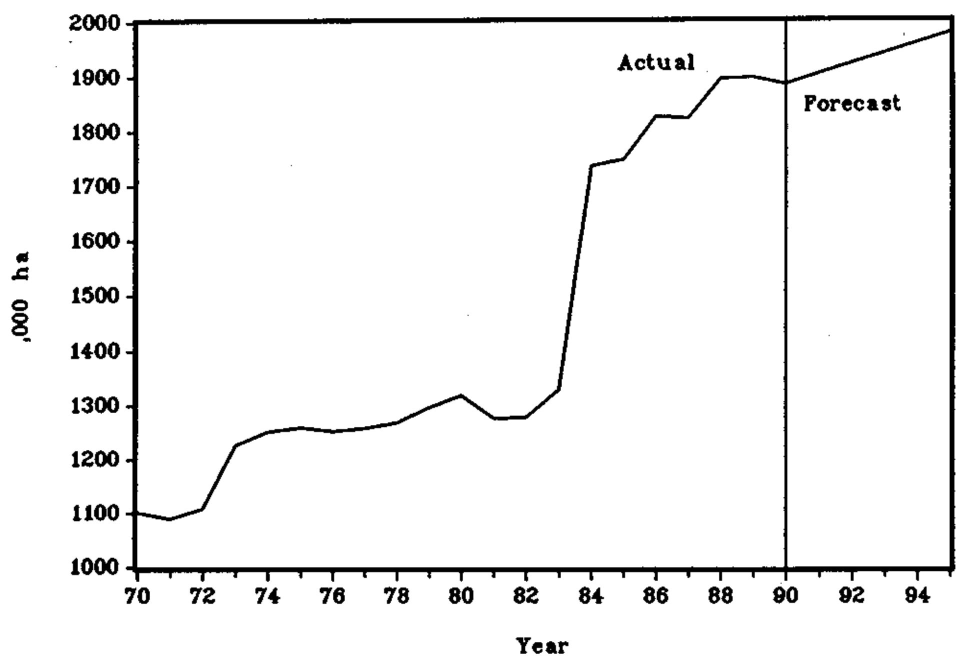


Figure 25. Yield under Estates: Actual and Forecast

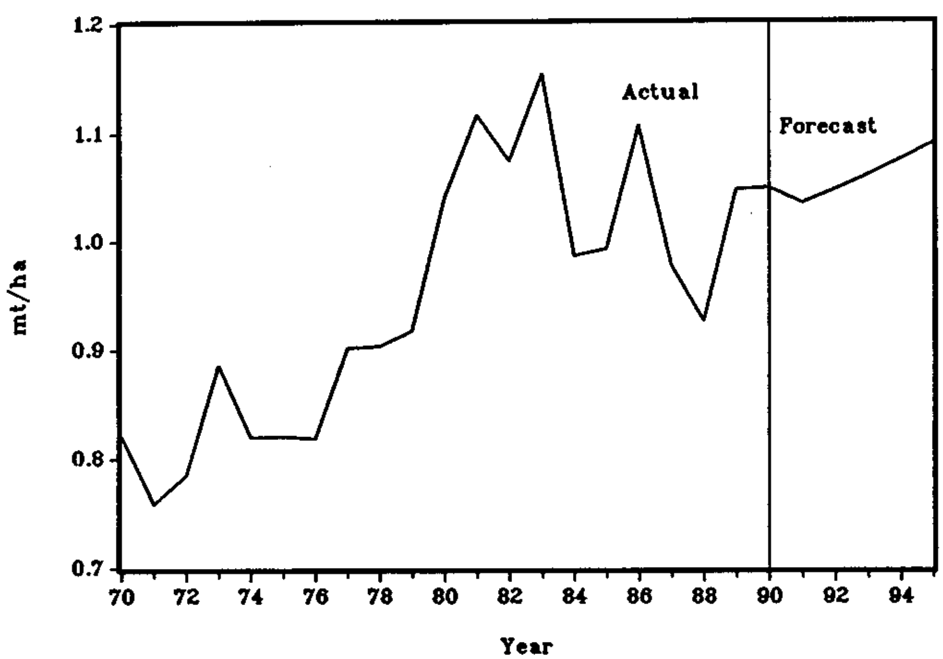


Figure 26. Yield under Smalholders: Actual and Forecast

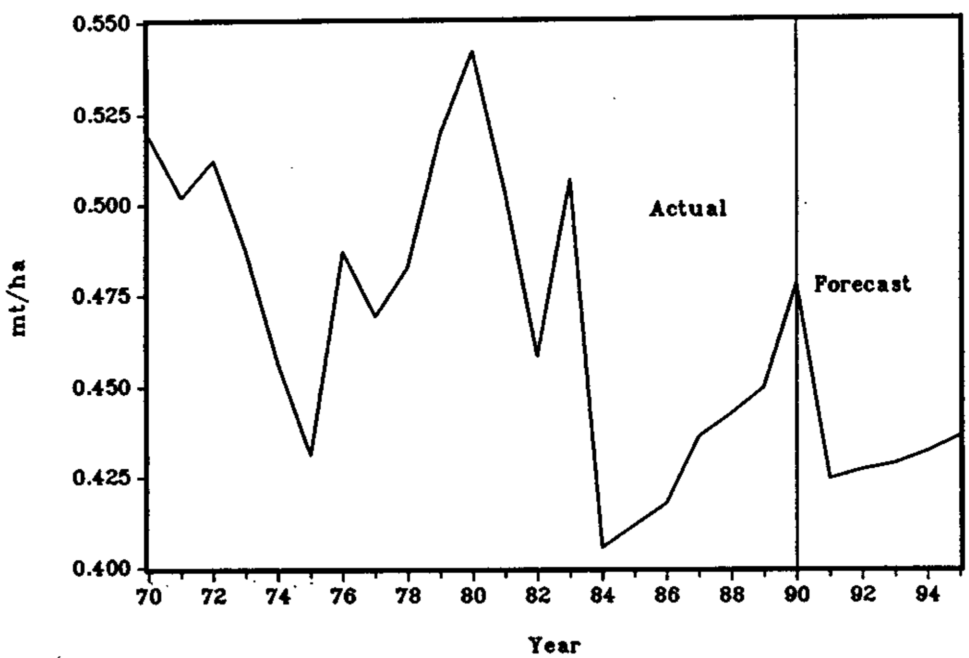


Figure 27. Total Indonesian Production: Actual and Forecast

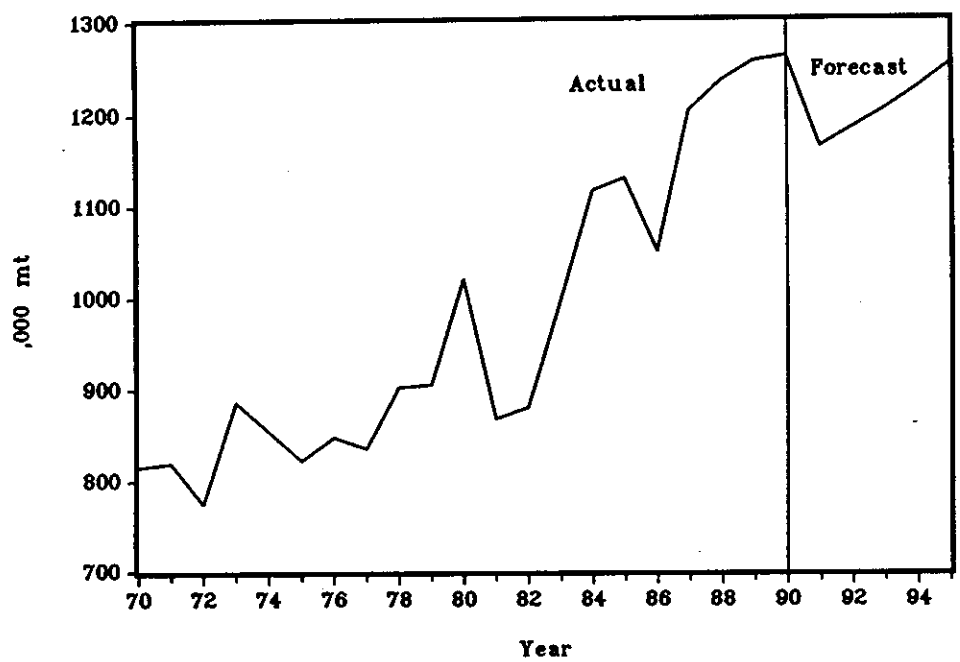


Figure 28. Indonesian Export Supply: Actual and Forecast

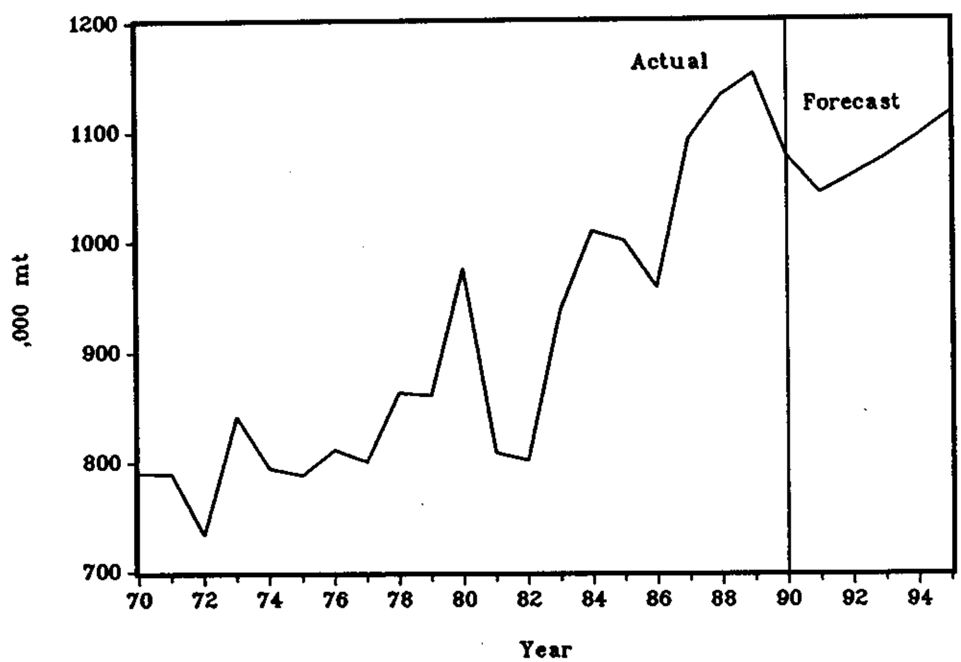


Figure 29. Other Producing Countries Export Supply:
Actual and Forecast

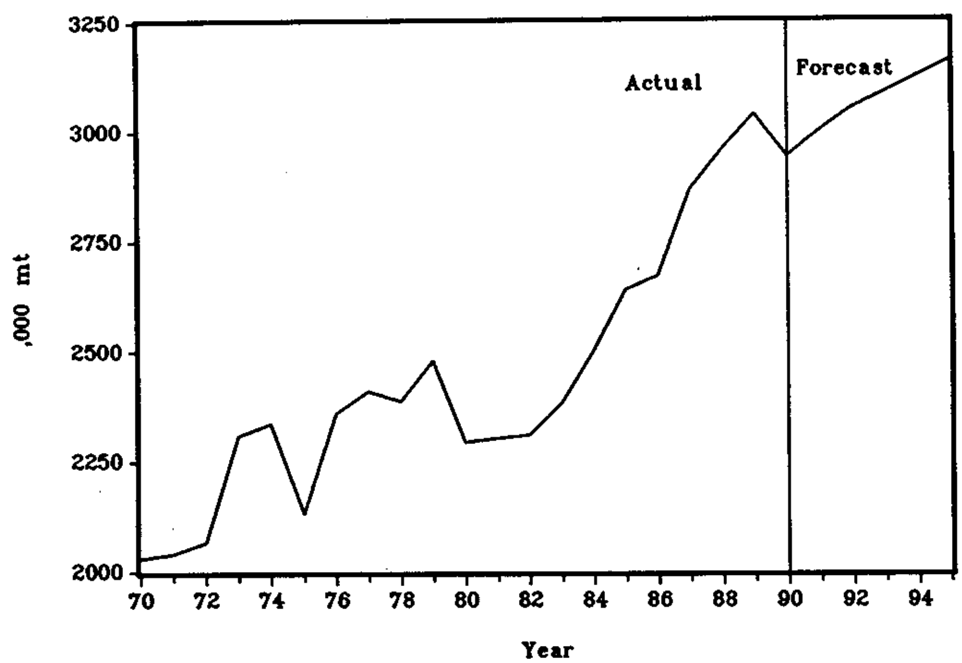


Figure 30. Automobiles Production in the U.S.: Actual & Forecast

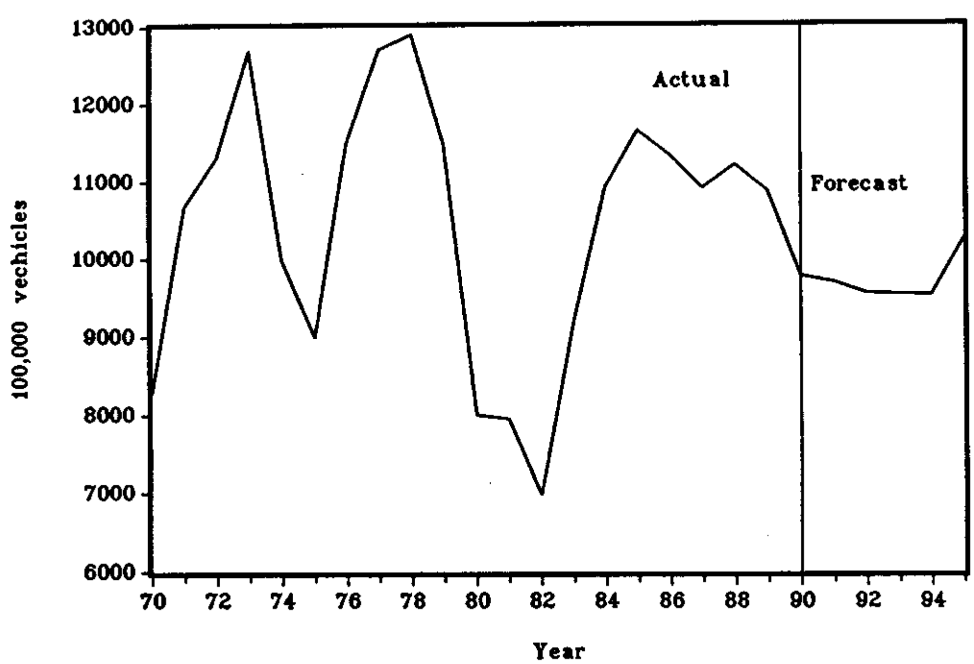


Figure 31. The U.S. Natural Rubber Consumption: Actual & Forecast

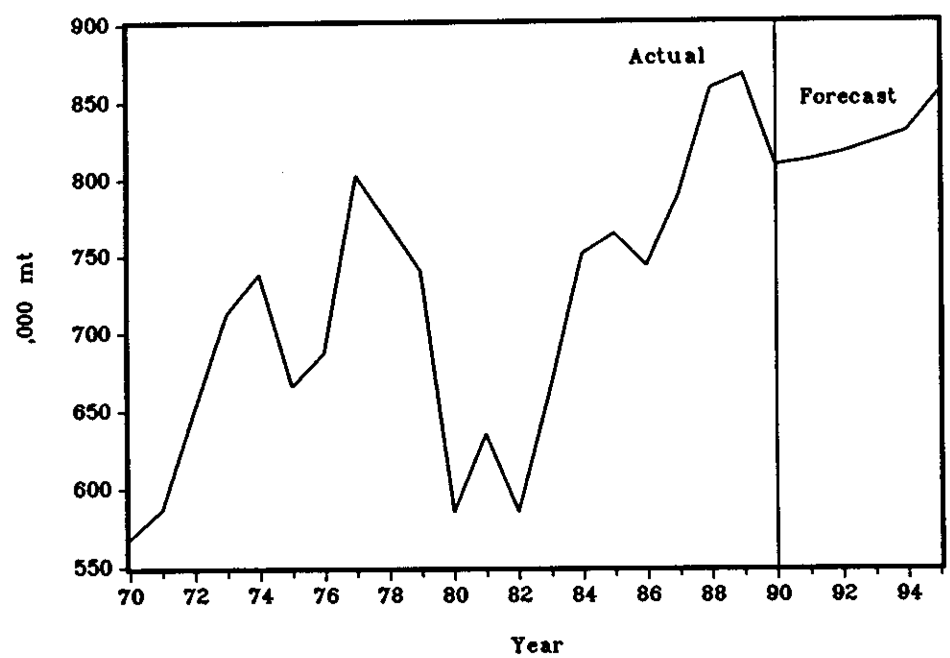


Figure 32. The U.S. Import Demand: Actual and Forecast

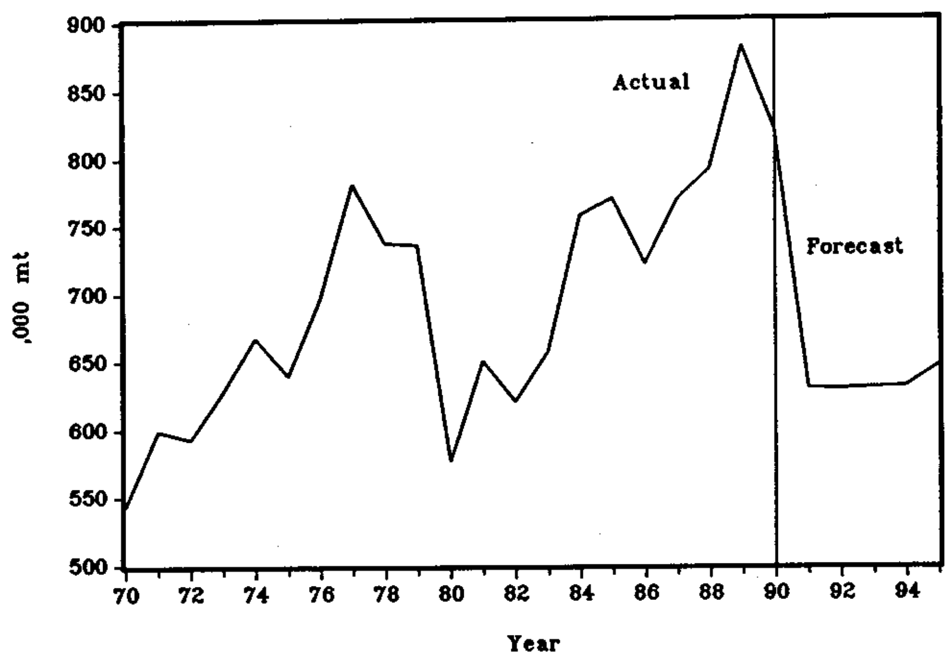


Figure 33. Automobiles Production in non-U.S. Countries: Actual and Forecast

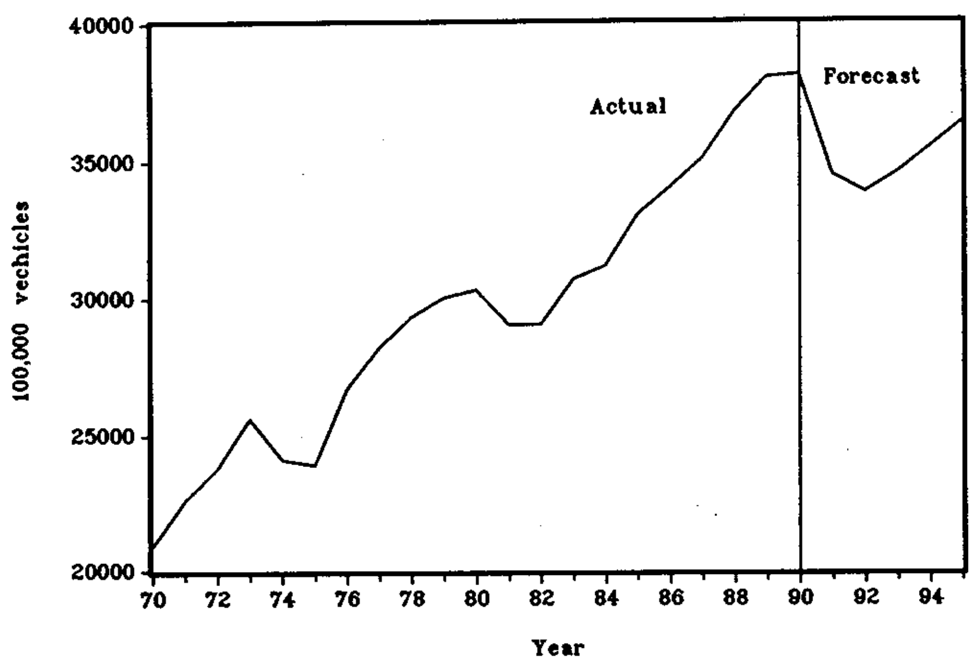


Figure 35. The non-U.S. Import Demand: Actual and Forecast

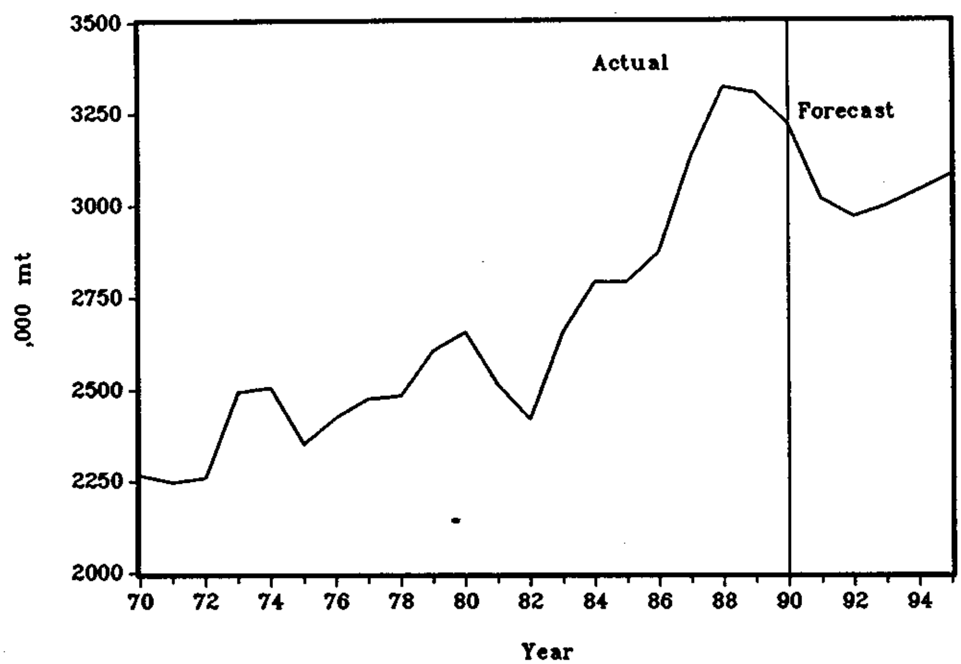


Figure 34. Natural Rubber Consumption in non-U.S. countries: Actual and Forecast

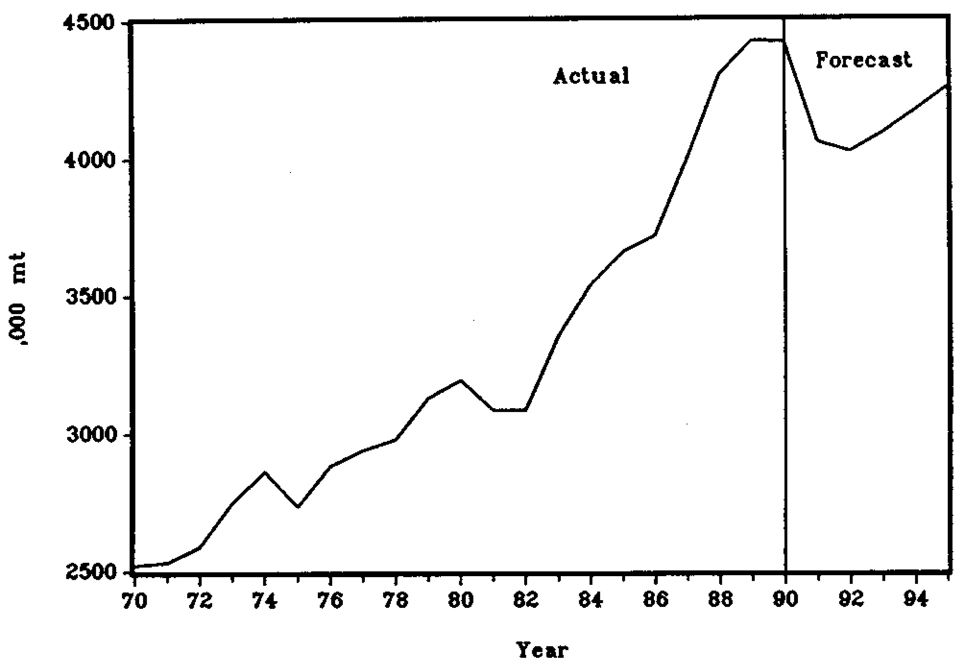


Figure 36. Deflated Natural Rubber Prices in the World Market