1979

An econometric study of Thai rubber industry and the world rubber market

Preecha Sakarindr
Iowa State University

7916212

SAKARINDR, PREECHA

AN ECONOMETRIC STUDY OF THAI RUBBER INDUSTRY AND THE WORLD RUBBER MARKET.

IOWA STATE UNIVERSITY, PH.D., 1979

An econometric study of Thai rubber industry

and the world rubber market

by

Preecha Sakarindr

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major: Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1979

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ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my major professor, Dr. James A. Stephenson who not only suggested the topic and discussed the preliminary study in this field but also dedicated an unusually large amount of time to read, correct and offer many useful comments. He also helped me in arranging this program of study to be approved by Dr. Earl O. Heady, Director of the Iowa State University project in conjunction with the Division of Agricultural Economics under contract with AID, and Dr. Somnuk Sriplung, Chief of the Division of Agricultural Economics, Ministry of Agriculture and Co-operatives, Thailand. I would like to thank Dr. Earl O. Heady and Dr. Somnuk Sriplung who provided facilities that made this project possible. I also would like to thank Professor Dr. Dennis R. Starleaf for his excellent guidance on the formulation and execution of my graduate plan of study. Certainly, I wish to express my appreciation to the Rockefeller Foundation which financed my four years of graduate work at Iowa State University under an agreement with Professor Dr. Adul Vichienchareorn. I also owe a debt of deep gratitude to Mr. Wayne Ellingson and my wife, Phantipar, who helped me in reading, correcting some of my mistakes in English, and commenting on the manuscript. There are many people, both ISU staff and Thai who have been involved in this research study to varying degrees, and I would like to acknowledge their help without indicting them for what appears here.

Needless to say, only I am responsible for the content of this dissertation.

CHAPTER I. INTRODUCTION

Rubber and Economy of Thailand, A Brief History

The rubber boom which rapidly swept through the Malayan states in the late 18th century was curiously slow in moving to the southern provinces of Thailand, although the northern tier of Malayan states was under Thai sovereignty. The most important factor that has been responsible for the slow transmission of "the rubber boom" into Thailand proper was the absence of direct government encouragement of foreign plantation development. Another reason is that it was believed that Thailand was not well-suited to rubber production. Therefore, the diffusion of smallholder[1] rubber into the southern border occurred only slowly and gradually during the early 19th century, but later there was one, apparently successful, government program to introduce rubber to Thai Buddhist villages in small plantations by Phya Ratsadanupradit, governor of Trang province, in 1901. Later, the rubber industry expanded by a multiplication of small holder units along each of three racial lines. The Thai and Malay peasants and the Chinese laborers typically cleared jungle lands to plant unselected rubber seeds in response to the high prices in the first decade of the century and on a large scale when prices rose as the Stevenson Plan restricted production in the 1920's. Usually, the periods of immaturity were about 6-8 years for plantation rubber. When the plantings of the mid-twenties were maturing in the early 1930's, the

[1]Smallholder means planters who hold under 250 rai of land (2.5 rai = 1 acre).

world price had fallen so low that tapping ceased on many producing plantations. In 1935 and 1936, prices rose resulting in Thailand's production, as measured by experts, jumping to 4% of world production.

Similar waves of new plantings occurred before the outbreak of World War II and during the Korean War. The post war growth of rubber production transformed the South into a booming and market-oriented, cash economy.

This relative prosperity continued until prices started to decline in the 1960's, and combined with falling yields on old trees, created concern about the future viability of rubber in the South. Fortunately, in 1969 rubber prices rose sharply as a result of Vietnam War and apparently brought out the full potential of those planting. Also there was an increase in late 1973 due to an increase in crude oil price, and kept going up steadily. As the OPEC (the Organization of Petroliam Export Countries) raised their crude oil prices by almost 400 per cent, it caused a big increase in the cost of production of synthetic rubber that formerly was an advantageous substitute for natural rubber for over two decades.

Statistically, high rubber prices stimulate a great short run term rubber production, since smallholders have had relatively large stands of older varieties and of older trees which are suitable for what Wharton[1] calls "selective slaughter tapping". On the other hand, when the price

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[1] C. R. Wharton Jr., "Malayan Rubber Supply Conditions", ADC Reprint (Nov. 1964):146.

had slumped so low that tapping ceased in many producing plantations, especially for large plantations of hired tappers, except for smallholdings in the remote areas that have no alternative sources of income who have to make intensive tapping for raising their income up to subsistence level. However, statistical data for planted area is quite uncertain because of the poor reliability of the data. The best source of detailed statistical information is the 1963 Agricultural Census[1] but this merely confirms the production estimates based upon the small rubber growers with holding under 250 rai. In fact, only 9 per cent of its holdings are over 140 rai, while the national average of rubber holding for Thailand equals 17 rai but this is the combined area of fragmented plots of rubber, rice, perhaps coconuts and other crops. However, the small average size of holdings provides a stability which is a cushion against adversity and a constraint against price change. Generally, the farmers do not know the precise number of days they tap or the number of sheets they produce for a period of more than several weeks. They decide to tap or not to tape from day to day depending on the weather, the price, and alternative activities.

Furthermore, a family may have more or less rubber than it can tap with its own labor, some balance is provided by share-tapping within the village. Those with surplus rubber trees let others tap for them on a 50-50 sharing basis. There are some migratory tappers temporarily living in the village and engaged in this activity as well. Tapping is a

[1]National Statistical Office, Agricultural Census of Thailand in 1963 (Bangkok, Thailand: National Statistical Office, 1966).

family enterprise and women and children are particularly active in mid-morning when it is time to collect the latex in pails and carry it to shed with a set of cast iron mangles used to press the latex into sheets for sale. Usually, they sell irregularly to the village dealers, the middle level dealers who purchase rubber at the village level and resell to the exporters.

In terms of export earning of the country, during most of the last two decades, rubber[1] has been Thai's second most important foreign exchange earner, even briefly surpassing rice which is the dominant crop of the country. The contribution of rubber alone fluctuated between 12-35 percent of the value of agricultural export earnings as in Table 1. The Thai rubber industry ranks third amongst the world's natural rubber producers, it produces 10 percent of the world's supply of natural rubber, employs more than 500,000 workers and generates about 2,000 million Baht[2] in foreign exchange earning yearly. The southern region contains about 95 percent of the rubber growers with an estimated 8.58 million rai of total planted area[3] and 92 percent of the rubber production comes from smallholder enterprises. The value of

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[1]Natural rubber is rubber collected from cultivated rubber trees, exclusively Hevea brasiliensis trees. Hence, in this study the word rubber will be used to denote natural and cultivated rubber only.

[2]U.S. $1.00 = 20 Baht.

[3]FAO, "Survey of Rubber Growing Areas an Agricultural Economic Study" in <u>Rubber Development Project (Phase II) in Thailand</u> (Hat Yai, Thailand: FAO, 1973), p. 9.

Table 1. Value of rubber and agricultural exports, GNP and their percentages

Year	Value of Rubber	Value of Agriculture	GNP	Val of Rub % Val of Agr	Val of Rub % GNP
1955	1,801.9	6,321.7	39,334.0	28.50	4.58
1956	1,526.4	6,321.7	40,928.9	24.14	3.73
1957	1,410.0	6,448.2	45,195.3	21.73	3.12
1958	1,326.6	5,759.6	47,021.1	23.03	2.82
1959	2,336.1	6,635.0	50,309.4	35.21	4.64
1960	2,579.3	7,647.8	55,978.9	33.73	4.61
1961	2,130.0	8,803.2	58,942.5	24.19	3.61
1962	2,110.7	8,612.7	63,694.6	24.51	3.31
1963	1,903.2	8,263.3	69,081.9	23.03	2.75
1964	2,059.9	10,591.6	73,602.2	19.45	2.80
1965	1,998.9	10,751.5	79,454.8	18.59	2.52
1966	1,860.7	11,782.7	89,130.4	15.79	2.09
1967	1,573.8	11,095.3	94,170.9	14.18	1.67
1968	1,815.9	10,591.8	102,710.9	17.14	1.77
1969	2,663.3	11,107.4	112,421.1	23.98	2.37
1970	2,249.7	11,109.0	136,318.0	20.25	1.65
1971	1,906.0	12,614.6	143,938.0	15.11	1.32
1972	1,862.3	15,415.5	161,744.0	12.08	1.15

rubber production is about half of the agricultural gross domestic product in the south, and the postwar growth of rubber production transformed the South into a booming and market-oriented, cash economy. However, prices decreases combined with falling yields on old trees created concern about the future viability of rubber and the economy of people in the South.

Policy Implications for Rubber Industry in Thailand

Like other rubber producing countries, the future of the natural rubber industry of the country depends upon whether it can survive technological competition with the synthetic rubber industry. As recently as a decade ago, most of the planters felt that natural rubber was fated to eventual extinction as a significant commodity of the country. However, in the last few years, the demonstration of the feasibility of massive replantings of old rubber with high yielding varieties as the experimental work of the Rubber Research Center of Thailand at Hat Yai[1] has given a new look for the rubber industry of the country.

Fortunately in Thailand these advances in the technology of rubber production are available to the smallholder. There are no significant economies of scale derived from large plantation operations which might keep the smallholders backward. However, there is a great gap between today's typical production pattern and the advanced methods now

[1] C. Pattanakul, S. Sookmark and S. J. C. Langlois. Present Situation of Selection at the Rubber Research Centre Thailand. Rubber Research Centre, Hat Yai, Thailand, Document No. 84, 1975, pp. 3-16.

feasible and large plantations have the resources to realize these potential advances much more readily than the smallholders. This places a great burden on the government to assist in the transition if it desires to preserve the smallholding character of the industry.

Until 1955, the Thai Rubber Plantation Aid Fund Act received cabinet approval, but it was not enacted until five years later, and the first authorized replantings occurred in 1962. This Replantings Act depends upon an export tax to create a special fund for replanting grants. The rate of actual replanting started slowly, as by early 1970, only about 7% of the mature area has been replanted and replantings equalled under 20% of the area which matured since the Fund Act had become operative. This rate is far below the normal 3% rate per year necessary for sustained coverage of rubber area at the time of the Act. Most plantings during this period were probably outside of the Fund. The replanting grants-in-aid to growers are made in installments of cash and kind. The value of the grant, 2800 Baht per rai, equals the replanting cost[1] but makes no contribution to the loss of income caused by removing the old trees. Therefore, the slow pace of replanting indicates that the smallholder typically will not replant in the absence of even greater government effort, even though the internal rate of return is about 17% or benetif-cost ratio of 1.5 at 12% interest rate at the cost of labor is 10 Baht per day, over a 30 year

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[1]Laurence D. Stifel, "Rubber and the Economy of Southern Siam". A paper presented at a meeting of the Siam Society on September 24, 1970, p. 16.

cycle of replanting.[1] However, the benefits to the South and to the economy as a whole may exceed those perceived by the smallholder and the government may wish further to encourage him to replant because of smallholder survival and the national benefit in the future. Also, the government has tried to stimulate the domestic consumption of rubber by promoting an investment on rubber products factories.

Therefore, this study attempts to identify the major factors that influence the volume of natural rubber produced, consumption and export of the country, and to measure the relationships between these factors and production, consumption, and export respectively. It also attempts to identify the major factors that influnece the Bangkok price of natural rubber and measure the relationships between these factors and price. Later, these relationships and other information are utilized to forecast production, consumption, export, and Bangkok price of natural rubber for the period of 1955-1972.

The World Natural Rubber Economy: A Description

Natural rubber is an important source of foreign exchange earnings and government revenues for developing countries such as Malaysia, Indonesia, Thailand, Sri Lanka and also some countries in Latin America. Presently, the Malaysian rubber industry ranks first amongst the world's natural rubber producers; in 1972 it produced about 44.11% of the world's supply of natural rubber, followed by Indonesia, Thailand

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[1]Laurence D. Stifel, ibid., p. 19.

and Sri Lanka which produced about 27.78, 10.53 and 4.71 per cent, respectively. As shown in Table 2, most natural rubber is produced in the developing countries and marketed in the highly industrialized economies of the world such as the United States, the United Kingdom, West Germany, France etc. However, in recent years consumption of natural rubber has been increasing drastically in countries of the Soviet Bloc, Japan and the Republic of China.

The total consumption of natural rubber has increasing average about 5 per cent every year since 1956 to 1972 and the international rubber study group (IRSG) has predicted that the demand for consumption of natural rubber will be as high as 4.1 million metric tons by 1980.[1]

Natural rubber is a raw material for the manufacturing of tires and tire products, beltings, hoses, gloves, foot wear and hundreds of other industrial and consumer goods.[2] The largest consumer of natural rubber is the tire manufacturing industry which consumes about 70 per cent of the world's supply of natural rubber.

However, a crucial turning point for natural rubber occurred shortly before the World War II. The world market had a shortage of natural rubber, and the isoprene derivatives and other synthetic substitutes for natural rubber were produced in the United States and Western Europe countries scale as an effort to alleviate the shortage of natural rubber. During 1956-66 most developed countries

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[1]International Rubber Study Group, Twenty-Third Assembly, Bangkok, Thailand, Oct. 16-20, 1972.

[2]FAO, Commodity Review 1968 (Rome: FAO, 1968).

Table 2. The quantity of natural rubber exported and imported, 1955-1972

Year	EXPORTS					IMPORTS			
	Malaysia	Indo-nesia	Thai-land	Sri Lanka	Others	U.S.A.	U.K.	France	Germany
1955	691.3	721.1	130.2	97.4	205.0	626.9	269.6	138.7	152.8
1956	678.6	668.7	135.5	86.8	222.4	568.0	176.0	133.8	130.4
1957	699.7	666.5	135.0	94.0	239.3	542.9	215.4	138.6	135.7
1958	725.3	649.6	139.6	90.4	274.7	457.7	147.7	135.0	132.2
1959	806.7	692.2	173.0	93.5	269.5	566.4	169.1	122.3	146.2
1960	775.3	586.5	169.9	106.4	274.4	404.7	139.7	131.6	153.1
1961	805.5	677.2	184.6	89.5	285.6	391.2	155.5	125.3	135.9
1962	792.2	660.2	193.9	101.8	276.9	419.6	153.7	121.8	142.8
1963	866.8	560.9	186.8	95.0	283.0	367.5	157.6	125.6	152.1
1964	886.9	627.4	216.6	115.3	278.8	419.4	186.4	126.5	165.6
1965	919.2	708.5	211.4	123.6	234.8	416.3	191.2	119.9	169.7
1966	965.5	679.9	202.1	124.9	269.7	389.3	180.8	128.8	161.4
1967	990.3	651.6	209.2	135.6	336.4	418.4	183.5	131.7	142.9
1968	1114.3	770.9	251.8	144.7	317.9	508.0	193.6	125.9	172.5
1969	1291.9	857.4	274.8	141.6	315.2	572.2	197.4	160.3	193.9
1970	1304.1	790.2	279.2	154.1	257.5	543.2	193.3	161.3	203.2
1971	1356.1	789.3	317.3	137.8	244.5	599.0	188.3	154.4	196.0
1972	1331.2	733.9	324.4	138.3	282.1	592.6	170.9	159.8	186.4

U.S.S.R.	Japan	China	Italy	Canada	Aus-tralia	Spain	Others	S.D.
125.0	90.5	48.3	56.1	46.4	47.4	14.3	399.0	-70.0
114.5	111.1	75.5	57.6	43.3	37.1	18.8	394.0	-70.1
120.5	130.5	56.8	59.0	42.6	34.0	27.1	447.1	-115.7
236.0	129.4	97.3	55.1	37.4	34.8	23.6	466.3	-72.8
225.0	160.2	110.5	57.0	46.0	38.4	21.9	452.2	-80.3
177.4	172.5	121.8	68.8	35.3	37.3	22.4	520.6	-72.7
340.2	185.7	83.8	79.7	32.0	28.7	22.7	534.3	-72.6
345.7	193.0	108.5	79.8	37.8	35.0	33.7	521.1	-167.5
282.0	187.9	109.3	87.9	35.9	38.0	33.3	582.8	-167.4
162.3	214.9	144.3	89.2	43.0	41.0	34.1	495.8	2.5
248.1	207.3	139.8	83.2	45.4	40.2	36.2	495.5	4.7
283.1	229.1	172.5	86.0	49.7	35.2	42.5	521.7	-38.0
253.1	243.0	159.8	100.6	44.6	38.7	40.2	506.0	60.6
325.9	257.7	211.8	99.1	46.9	42.7	51.2	552.2	12.1
295.0	280.9	275.0	108.0	50.1	42.6	54.9	599.7	50.9
316.5	292.2	181.8	127.8	52.1	39.5	67.3	636.4	-29.5
246.1	315.9	165.3	134.0	52.7	40.0	79.0	656.7	7.6
231.1	292.0	187.5	128.0	60.7	45.4	86.6	683.5	-14.6

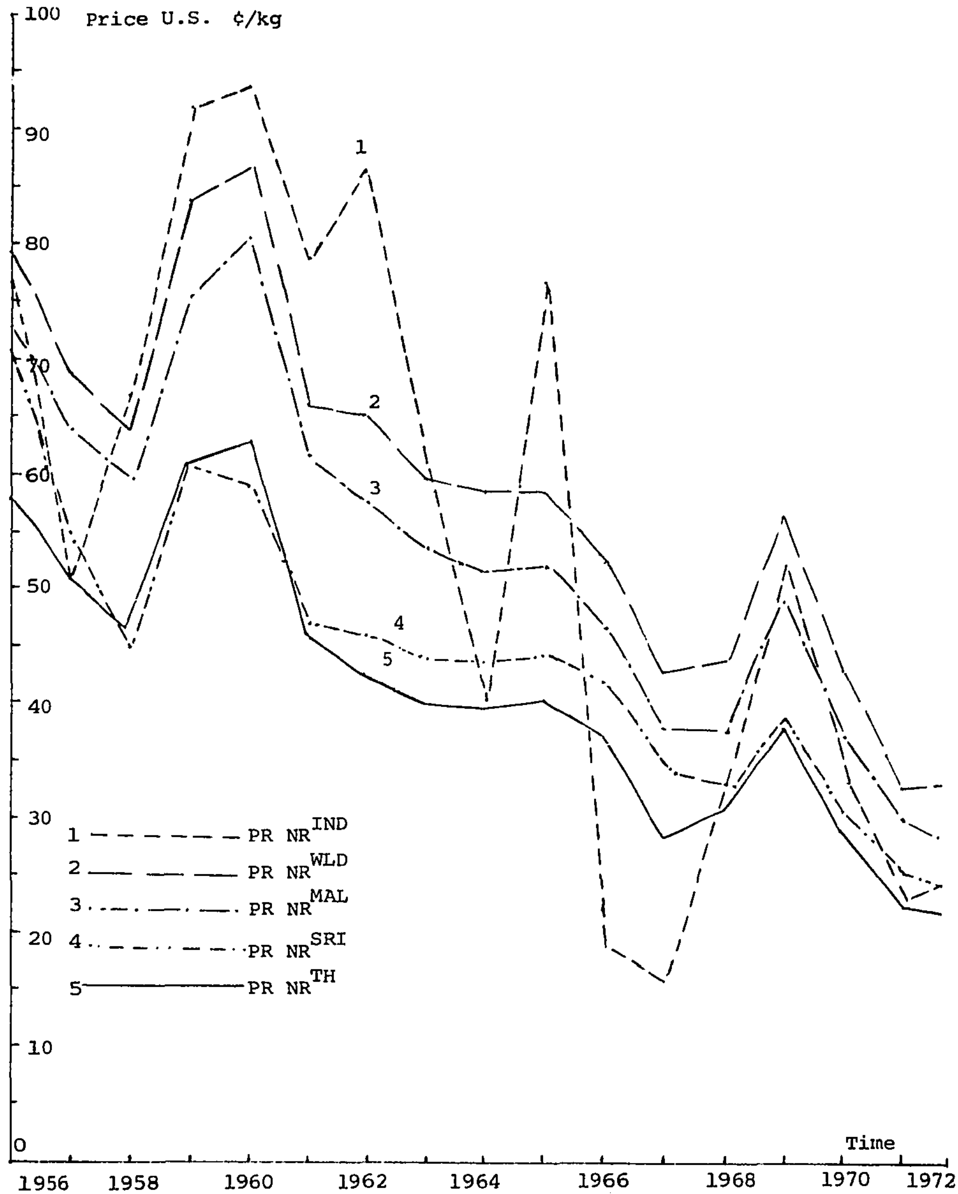

Figure 1. The deflated annual average prices of RSS #1, 1955-1972

increased their product of synthetic rubber at a high rate, and this can be produced almost as cheaply as natural rubber. For many purposes, synthetic rubbers are better than the real thing and there is every reason to believe that they will come into wider use and raise the question for the future of the natural rubber industry as to whether it can survive the technological competition with the synthetic rubber industry. However, in recent years the demonstration of the feasibility of massive replantings of old rubber with high yielding varieties such as PR 107 and GT 1 which are the most promising in Indonesia, the PRIM 700 series which is very promising in Malaysia and KRS 1 to 6, KRS 13 and the latest KRS 200 series in Thailand[1] which give an average yield increase from 60 kilograms per rai in 1939 to 180 today and an estimated 240 by 1980. At present, good Malaysian estates are realizing yields of 270 kilograms per rai per year and experimental trials indicate the capability of reaching 550 or about 10 times the prewar average. Moreover, the development of new packaging, marketing techniques and cost-reducing methods have created a sense of optimism that natural rubber can survive in the long run, if it takes full advantage of new technology such as dramatic and significant measures to improve quality standards in packaging, marketing with consistent properties, and facilitating natural-synthetic blends to reduce cost. The latter is the block rubber or Crumb[2] rubber process which is being vigorously promoted

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[1]C. Pattanakul, S. Sookmark and S. J. C. Langlois, 1975, op. cit., pp. 3-4.

[2]Crumb rubber is natural rubber which has been broken into particles, by one of several then pressed into small bales and wrapped in polythyline bags for shipment.

in Malaysia.

As mentioned before, synthetic rubber is a general term referring to the wide variety of man-made rubbers, e.g. Cis-polyisoprene, Cis-polybutadiene and Ethylene-propylene, which increasingly include blends with one another, with plastics and with natural rubber. As the world consumption of all rubber products has grown rapidly since the end of the World War II, natural rubber's share has declined from about 75% to 40% of total consumption. The world market for rubber thus consists of multiple markets with discrete supply and demand schedules which are unstable because of the rapid change in technology. Nevertheless, the market can be divided into three broad zones.[1]

In the first zone of the market, natural rubber was technically superior prior to 1960 and the competition between natural and synthetic rubbers did not exist. The second zone was occupied by natural rubber and general purpose synthetic rubbers which were technically substitutable and which competed on the basis of price. In the third zone various specialty synthetics were technically superior and did not compete with either natural or general purpose synthetic rubber.

However, in the late 1950's the relative security of natural rubber in the first zone of the market was undermined by the commercial development of a new group of synthetic, isoprene rubber, with its properties almost identical to natural rubber. It can be completely substituted for natural rubber in almost all of the uses in this

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[1]T. R. McHale, "The Competition between Synthetic and Natural Rubber", The Malayan Economic Review 6, No. 1 (1961):24.

first zone.

In the second zone, the general purpose synthetic, SBR, is the most important and the cheapest synthetic. It could compete with the original general purpose natural rubber in many applications. However, SBR is somewhat inferior to natural rubber in some properties, such as resiliency and heat dissipation and less suitable for such products as heavy duty tires. On the other hand, the list price of SBR remained constant from 1953-1965 and slightly increased later. The high and fluctuating price of natural rubber encouraged shifting to SBR where technically feasible and where this switch is easily reversible.

The future demand and price of natural rubber will depend upon the interaction of many factors, such as the level of world industrial activity and the supply of natural rubber placed on the market. Nevertheless, the most important consideration in the long run will be the relative costs of production of natural and the synthetic rubbers.

Therefore, this study will try to identify the major factors that influence the volume of natural rubber imported (demanded) and exported (supplied) of those countries as mentioned before and to measure the relationships between these factors with the imports and exports. Also, the study tries to identify the major factors that influence the world (New York) price and the domestic prices in producing countries of natural rubber and to measure the relationships between these factors and prices. Finally, these relationships and other information are utilized to forecast the imports (demanded) and exports (supplied) of those countries and some related endogenous variables in the model for the period of 1955-1972.

Literature Review

Quantitative studies of the response of Thai rubber production to price changes are rare, and are roughly calculated from rubber growing areas, using photo interpretation of aerial photos taken from September 1960 to the end of spring 1967[1]. These showed that many of the areas were stimulated by high prices. An examination of rubber smallholders' behavior and decision-making in Thailand, Speirs[2] found that the smallholders claim to produce the same weight of rubber sheet irrespective of low or high prices, and thus their income fluctuates proportionally with the market price for rubber. It is, therefore, quite rational for rubber smallholders to place much more emphasis on growing another cash crop during periods of low rubber prices to maintain the same cash income. Other studies used the multiple regression single equation models of J. R. Behrman, in his "Econometric model simulations of the world rubber market 1950-1980", Department of Economics, University of Pennsylvania, 1969, by using annual data, 1949-1963, and assuming that the short run supply of natural rubber is a linear function of the deflated price of natural rubber and the tappable area in rubber. These found a coefficient for the rubber price

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[1]FAO, "Survey of Rubber Growing Areas an Agricultural Economic Study", Rubber Development Project (Phase II) in Thailand, (Hat Yai, Thailand: FAO, 1973), pp. 7-8.

[2]A. J. Speirs, "Towards an Understanding of Rubber Smallholders in Thailand", Rubber Development Project, Hat Yai, Thailand 1973, p. 23.

variable of 0.567 and a price elasticity of supply of 0.409.

The quantitative studies of the response of Indonesian rubber to price change by means of a graphical analysis in their investigation on smallholders' rubber production in South Sumatra by Soeleartaatmadja[1] concluded that the smallholders in that area were not price responsive. In using monthly time series data of 1961 of one of the counties in South Sumatra, a negative relationship between rubber prices and quantities of rubber produce was found. However, using annual time series data of 1957-1963 for all the provinces of South Sumatra, he found a positive relationship between those variables, suggesting the responsiveness of producers to rubber price.

Using simple regression models and the annual time series data, 1951-1960 J. R. Behrman also found in his study a short run supply response of Indonesian smallholders, estates, and the whole country to be a positively significant coefficient for the current price. However, their supply was highly price inelastic at 0.333, 0.054 and 0.473 respectively.

Using the time series data of 1950-1966 for the farm model, Teken[2] found that the supply of Indonesian estates responsed positively to the world rubber price with the price elasticity of supply being 0.0156, indicating that for all practical purposes this supply schedule is perfectly inelastic. Also, for Indonesian smallholders, he found

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[1]Referred by I. B. Teken, "Supply of and Demand for Indonesian Rubber" (Unpublished Ph.D. thesis, Purdue University, Jan. 1971), p. 35.

[2]I. B. Teken, op. cit., pp. 70-73.

a positive coefficient for the domestic price of rubber but the price elasticity of rubber production was about 0.14, indicating an inelastic production response.

In observing the post-war period price of rubber that mainly fluctuated by the world demand, Ronald Ma[1] did not find a close connection between the rubber price and the production of Malayan rubber industry. The proportionate annual changes in smallholders' production tend to move in the same direction with the rubber price, and the elasticity of supply of the Malayan smallholders' rubber varies from 0.1 to 0.3[2] in most years. Indeed the output of the smallholders is basically more responsive to price changes than the output of the estates. They also react to a falling price by growing other crops or work for wages on estates or do both to maintain their income.

To study the supply response of Malayan rubber estate, Chan,[3] using simple regression models and annual time series data, found a negative coefficient for the current price, but a positive coefficient for seven years lag of the price variable indicating that the producers response to price by planting and/or replanting rather than on intensive

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[1]Ronald Ma, "Company Profits and Prices in the Rubber Industry in Malaya, 1947-58". The Malayan Economic Review 4, No. 2 (1959):32.

[2]These price elasticities of supply are not from a regression but merely from the relative changes of the annual price, taken from two consecutive observations at a time.

[3]F. K. W. Chan, "A Preliminary Study of the Supply Response of Malayan Rubber Estates between 1948-1959", The Malayan Economic Review 7, No. 2 (1962):83-84.

tapping. Using a three years' moving average for prices taken with seven years lag, he found a positive coefficient and high coefficient of determination. Incorporating the export duty payable by the rubber producers in identifying the price to which the producers are supposed to react in making their production plan, he also found an insignificant change in the coefficient of determination.

To study the Malayan smallholders rubber behavior, Wharton[1] used simple regression models and the monthly time series data during periods of rising and falling prices, and he concluded that the Malayan rubber smallholders were price responsive, even though their supply was highly inelastic ranging around 0.2 to 0.4.

By applying multiple regression and quarterly time series data on Malayan rubber production, Stern[2] found the estates production had a negative price elasticity in current deflated prices, but it was insignificantly different from zero. In the sector of smallholders rubber production, he found a positive coefficient of the average deflated rubber prices with an elasticity of supply price of 0.20. He also found that private inventory did not have an important role upon the elasticity of the supply of the country while the ratio of estate inventory over sales has an important role.

Using multiple regression single equation model and annual time

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[1] C. R. Wharton Jr, "Malayan Rubber Supply Conditions". ADC Reprint (Nov. 1964):146.

[2] R. M. Stern, "Malayan Rubber Production, Inventory Holdings and the Elasticity of Export Supply", The Southern Economic Journal 31, No. 4 (April 1965):319-321.

series data, J. R. Behrman, in his study on Malayan rubber production, found that the Malayan estates were not at all influenced by variations in current deflated prices. He got a significant negative coefficient of prices of -3.659 and a negative price elasticity, -0.09, which was not significantly different from zero. On the other hand, he found a positive coefficient for deflated prices at 10.202 and 6.6589 for Malaysian peninsula and smallholders respectively, suggesting a responsiveness of producers. The price elasticities were found to be 0.141 and 0.229 respectively, indicating an inelastic supply behavior.

Most studies related to the world natural market are of the historical type. Even though these studies have contributed to the understanding of the natural rubber market, they do not provide quantitative information about the economic relationships among the important market variables. There are few quantitative studies which have a direct bearing upon this study, such as the first study by Horowitz[1] in his econometric study of supply and demand in the synthetic rubber industry. Using quarterly data for 1948-60, he found the elasticity of supply of natural rubber entering the U.S. market with respect to the ratio of current prices of synthetic rubber over natural rubber to be -0.4461 which indicates that supply is relatively inelastic. The price elasticity of supply of synthetic rubber, on the other hand, was found to be 1.4914 which indicates that the supply of synthetic rubber is rather elastic. But the long run price elasticity of demand for

[1]Ira Horowitz, "An Econometric Analysis of Supply and Demand in the Synthetic Rubber Industry", International Economic Review 4 (September 1963):325-345.

synthetic rubber was -0.8408, indicating that demand for synthetic rubber is relatively inelastic. Furthermore, he found that natural rubber and synthetic rubber have a complementary relationship rather than being substitutes. Also he concluded that even though natural rubber prices might stabilize and decline, rubber manufacturers will continue to turn to synthetic rubber, for the reasons of the stability of the price of synthetic rubber and the prospect that eventually it may surpass the natural product in the technical qualities that the synthetic rubber offers.

Secondly, the demand for natural rubber was studied by the FAO,[1] based on assumptions about future growth of population and income and using time series data for the period of 1954-1963. They found the elasticity of demand for all rubber with respect to income and these elasticities were then used to project the total rubber consumption to 1975 for each country. Consumption of natural rubber was projected to 1975 by estimating its proportion in projected total rubber consumption. On the assumption that natural rubber's share would be 20 per cent of all new rubber consumption in 1975, the U.S. consumption of natural rubber was projected to have a range of 528,000 to 580,000 tons depending on whether low or high income growth rates are assumed.

Thirdly, the study made by the United Nations Conference on Trade

[1]FAO, Food and Agricultural Organization, Agricultural Commodities Project for 1975 Vol. I (Washington D.C.: United Nations, 1970), pp. 316-325.

and Development (UNCTAD)[1] was concentrated on constructing a world model, trying to explain the New York price of the ribbed-smoked sheet No. 1 (RSS #1) in terms of the total world consumption of elastomers (synthetic and natural rubber), the world supply of natural rubber and the ratio of natural rubber consumption to the total world elastomer consumption lagged one year. The total world consumption of natural rubber was expressed as a function of the total world elastomer consumption, the ratio of natural rubber consumption to total elastomer consumption lagged one year and the New York RSS #1 price. Using annual time series data for period of 1954-1966, UNCTAD found that an increase of one thousand tons in total elastomer consumption was associated with an increase of 280 tons in natural rubber consumption. The regressions showed that a decrease in the ratio of natural rubber to total elastomer consumption of one percent was associated with a decrease of about 19 thousand tons in natural rubber consumption in the following year. A one cent per pound decrease in RSS #1 price was associated with 14 thousand ton increase in natural rubber consumption.

The last study, made by Ayob and Prato,[2] was to identify the major

[1]United Nations, "A Provisional Model of the World Rubber Market", in Review of Problems and Policies for Specific Commodities Facing Competition from Synthetics and Substitutes (Geneva: UNCTAD, 1968), pp. 316-325.

[2]Ahmad Mahdzan Ayob and Anthony Prato, "An Econometric Analysis of the United States Import Demand and Prices of Natural Rubber", Department of Agricultural Economic, University of Florida, Gainesville, August 1971, pp. 20-23.

factors that influence the volume of the U.S. demand for natural rubber and the New York price of RSS #1. Using a simultaneous equations model with annual time series data for the period of 1947-1969, they found that the U.S. import demand for natural rubber had a statistically insignificant relationship with the New York price of RSS #1. Furthermore, the price of RSS #1 was positive and significantly related to the one year lagged RSS #1 price, the index of automobile production. The quantity consumed of reclaimed rubber in the U.S. was found to be negative and significantly associated with the ratio of synthetic rubber consumption to total consumption of new rubbers, the ratio of commercial inventories of natural rubber at the beginning of the year to consumption of natural rubber in the previous year, and releases of natural rubber from U.S. government strategic stock pile. In the other equation, the demand for import of natural rubber was positively related to the production of trucks and buses and the zero-one dummy variable to the account for war years, 1 in 1950, 1951 and 1952 and 0 otherwise. It was also negatively related to the ratio of synthetic rubber consumption to total consumption of new rubber and releases of natural rubber from the U.S. government strategic stockpile.

CHAPTER II. THEORETICAL APPROACH

Introduction

First of all, the traditional theories of supply and demand are presented and then a specification of the economic models of Thai rubber industry are made, comprising tapping area, rubber production, export supply of Thai rubber, domestic consumption of rubber, domestic price in Bangkok, the world (New York) rubber price, the world supply of natural rubber, and the world consumption of elastomer. Finally, the economic model of the world rubber market is specified, comprising the export supply of the rubber producing countries such as Indonesia, Malaysia, Sri Lanka, Thailand and the rest of the world, and the import demand of the highly industrialized economics of the world such as the United States, the United Kingdom, Japan, West Germany, the Soviet Union, Italy, Canada, Republic of China, Australia, Spain, and the rest of the world.

Theory of Demand and Supply

Theoretically, the demand function for final goods is derived by maximizing the consumers' utility function, subject to their budget constraints. The individual consumer's demand function for a particular commodity is a function of the price of that commodity, the prices of other commodities that are substitutes as well as complements, the income and the tastes and preference of the individual consumer. The demand schedule will be a negatively sloping function of its price. An increase of a substitutable commodity's price will cause the demand schedule of the other to shift to the right and vice versa for the complementary goods, assuming other things remaining unchanged. The effect of the consumer's income on the demand is such that an increase in income will shift the demand curve to the right if it is a normal good, other things unchanged. Conceptually, the effect of tastes and preferences will shift the demand schedule to the right for favor and vice versa.

However, in the case of the demand is a derived demand. Rubber input is purchased for the sake of the contribution it makes to production. Hence, the demand schedule for inputs are derived from the firm's profit function, under assumption of profit maximization of the firm, given the demand schedule for the output. The demand schedule for an input is the firm's marginal revenue product curve,[1] at a diminishing marginal productivity of input. Therefore, the demand for input is a negatively sloping function with respect to its price. An increase of output price or the price of a substitute will shift the input schedule to the right, other things remaining unchanged.

For a multi-product and multi-input firm, the supply schedule of production is derived in such a way that the firm's profit is maximized, subject to its implicit production function, and in a competitive market

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[1] C. E. Ferguson, Microeconomic Theory, Third Edition, (Homewood, Illinois: Richard D. Irwin, Inc., 1972), pp. 396-414.

the following conditions must hold:[1]

1. The value of the marginal productivities of an input with respect to every output must be equal to its price.
2. The marginal rate of technical substitution for every pair of inputs, holding the levels of all outputs and all other inputs constant, must be equal to the ratio of their prices.
3. The marginal rate of product transformation for every pair of outputs, holding the levels of other outputs and all inputs constant, must be equal to the ratio of their prices.

The above mentioned conditions imply that the level of production of any given product will theoretically depend upon the price of the product in question, the price of other products competing for the same inputs and the price of inputs. Since the above conditions are derived from a certain set of output and input prices for a given production function which depends on technology, then the level of production of a product will implicitly depend on technology. Also other non-economic factors such as rainfall, temperature, etc., will influence the production level.

The supply of a product is a positively sloping function of the price of the product. An increase in price of competing products will shift the demand for the product to the right and vice versa,

[1] J. M. Henderson and R. E. Quandt, Microeconomic Theory, A Mathematical Approach (New York: McGraw-Hill Book Company, 1971), pp. 63-98.

while an increase in the price of inputs will cause the supply to decrease.

The Economic Models

Thai rubber industry model

The objective of this modeling process is to produce a structure, quantitative in character, which may be regarded as an approximate analog to the system which determines the values of variables that contribute to the understanding of the domestic rubber market. The main variables whose behavior is to be modeled are yearly quantity of rubber produced, yearly quantity exported, yearly rubber consumed by domestic factories, yearly average price of natural rubber in the world market, and the average domestic price. A systematic analysis of the critical elements of the rubber market is facilitated by the application of the familiar model from the field of industrial organization which traces a causal sequence from market structure to market performance.

The operation of the market suggests that the processes which determine these variables are interdependent. The domestic consumption constitutes only a small fraction of total demand, but in recent years the amount of consumption has gone up rapidly under the government promotion program of investment for rubber product industries, i.e., tires industry. However, the exports contribute a sizeable fraction of total demand in domestic market. These demands are assumed to be competitive.[1] The domestic supply is essentially varied from time to time with the level of domestic price, and among other things the world rubber price that influences demand for export and domestic price is determined from the world demand for consumption of elastomer and the world supply of natural rubber. Under these conditions, competitive market theory suggests not only that prices influence demand and supply but also the factor's demand and supply affect the price. In such a setting, prices and the various quantity demanded and supplied are jointly dependent. The competitive models are used to set a norm against which empirically observed performance in the rubber industry can be evaluated as are done by Baldwin,[2] and Wharton.[3]

The general form of the two Thai rubber industry models is that of a set of 8 stochastic simultaneous equations. The models are different in the specification of the domestic price functions. In Model I, domestic price is hypothesized to be a function of the world rubber price, but in Model II, domestic price is hypothesized to be a function of the main economic variables that effect the rubber price. The unknown parameters in each model are estimated by standard

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[1] Laurence D. Stifel, "Imperfect Competition in a Vertical Market Network: The Case of Rubber in Thailand", American Journal of Agricultural Economics 57, No. 4 (November 1975):638.

[2] William Baldwin, "Structure and Performance in Vertical Market Network: Some Policy Implications for the Thai Rice Trade", Thai Economic Journal 2 (1972):62-102.

[3] Clifton Wharton Jr., "Marketing, Merchandising and Money Lending: A Note on Middleman Monopsony in Malaya", Malayan Economic Review 6, No. 2 (1962):24-44.

statistical techniques of two stage least squares. Each of the equations is intended to model one of the component forces at work in the rubber market, at least approximately. Most of the equations are stochastic, so error terms are introduced as random variables. These error terms may regard as reflecting the effects of omitted variables, improper functional form, measurement errors, etc. However, regardless of interpretation, their use provides a bridge over the difficulty that fully deterministic models, which reproduce and predict human behavior perfectly, can not be constructed except in the most trivial cases.

The following discussion concerns the component equations in Thai rubber industry models. Error terms are omitted, though they will be taken up in the section where empirical estimates are presented. For the present time, the relationships among the observed variables are presented and explained. The formulation, or specification, presented here is a description of the form finally adopted.

Tapped area   Tapped area can be changed by both physical effects (age, yield, natural hazards) and economic effects (price). One major change in the mature acreage in tapping is the new mature acreage from new planting and replanted (it takes about seven to eight years for a rubber tree to come into production after it is planted) and the old mature acreage going out of production because of replanting and abandonment. The yield per acre in tapping, especially a one year lag of yield, plays a big role in advance for planters to decide whether to tap or not in the following year. This is due to the fact that in the old stands of rubber, many of the trees are dry. They yield little latex with declining rate, and the owner stops to tap only those which the experience indicates are worth the effort at the prevailing price. The previous yield will tell the planters whether or not they should prepare for tapping in the next year. The last factor that affects the tapped area is the current domestic price. Many of the rubber fields are abandoned to weeds during periods of low rubber prices, but during times of high rubber prices the abandoned mature trees may be tapped again. Moreover, a one year lag of price has a strong influence on the current tapping area. The previous year's price gives an impression to the planters that they should increase or decrease the tapped area for the next year on the basis of the current prices. Intuitively, if the current price is high he will plan to increase tapping area for next year and vice versa.

Therefore, tapped area is hypothesized to be a linear function of the current and a one year lag of deflated domestic price in Bangkok, a one year lag of yield, the eight year lag of planted area, and a random disturbance.

The production (supply) of natural rubber To estimate the supply response of the natural rubber in Thailand, a distinction should be made between the short-run and the long-run supply response. According to the definition, the short-run is the period of time in which productive capacity can not be changed drastically, while the long-run is a sufficiently long period of time to allow the productive capacity to be changed considerably. In the case of rubber industry for the short-run, producers are unable to increase the number of mature trees that are capable of being tapped. The long-run is a sufficiently long period to allow new trees to become tappable.

The production of natural rubber in Thailand is hypothesized to be a linear function of the deflated domestic price of natural rubber, the tappable area in rubber, a time trend and a random disturbance. The domestic price of natural rubber is included to test the hypothesis that producers respond to market incentives in the short-run by altering their rate of tapping trees (daily, alternate daily, etc.), intensity of tapping (size and number of cuts) and the use of stimulants. The tapped area, which is treated as an endogenous variable, is included to represent the combination of short-run and long-run capacities, i.e., the tapped area is set to capture the fluctuation in tapping due to the effects of those variables in tapped area function.

A time trend variable is included to capture the technological change, such as adoption of higher yielding clones, applying fertilizers, etc.

Briefly, the production of rubber in Thailand is hypothesized to be a function of the domestic price of rubber, the tapped area which is hypothesized to be jointly dependent, while the trend variable is entered as exogenous variable and a random disturbance.

The export demand of Thai rubber   Thailand is the world's third largest natural rubber producer and exporter. In 1972, Thailand accounted for approximately 10 per cent of the world exports of natural rubber. Most of the rubber production in Thailand is exported, and only about 5 per cent of the production is utilized domestically by manufacturing industries that use rubber as a raw material. It is reasonable to assume that the world rubber demand appears to Thai exporters as a nearly horizontal demand curve. The level of Thailand's exports over a year has a very small effect on the foreign price. In other words, export demand is almost infinitely elastic at the world price.

The specification of the export demand equation is intended to portray arbitrary behavior. That is, the exporter is presumed to be motivated by opportunities to earn profits by purchasing in a lower price in the domestic market and selling with a higher price in the foreign market. Alternatively, the process may be conceptualized in terms of derived demand. The equation finally adopted relates yearly exports to the average world rubber price of RSS #1 and the yearly average Bangkok wholesale price of RSS #1 separately as in Model I and the difference of these two prices is used in Model II. Moreover, only a small fraction of rubber produced in the country is used domestically and there is also a limitation on the storage facilities, so it is expected that physical production will exhibit a strong influence on the export supply. The higher the production is, the higher the quantity demanded for export tends to be. Finally, a one year lag of change in stocks[1] is the quantity of ending stocks less than the beginning stocks of the previous year. This amount of rubber is only a small fraction of the rubber production, so its effect on the export is assumed to be small. Therefore, the rubber production and the change stocks of rubber in the country will be included in this export function.

The exporters' demand or supply of rubber from Thailand, the world rubber price, the domestic price of rubber, and the Thai rubber production are hypothesized to be interdependent or jointly determined. This means that the exporters' demand or supply from Thailand will influence the prices of rubber in the markets and domestic production and vice versa. The one year lag of change in stocks of natural rubber is entered as an exogenous variable and a random disturbance.

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[1]PROD NR + BEGINNING STKS = EXPS NR + CONS NR + ENDING STKS

ENDING STKS - BEGINNING STKS = PROD NR - EXPS NR - CONS NR

= CHANGE STOCKS.

Domestic consumption of rubber in Thailand The specification of the domestic consumption demand equation is based on the theory of derived demand. Since the rubber is being used as an input into a manufacturing process, we think of the demand for the input as being "derived" from the demand for the products. That is, the demand schedule for rubber is just the firm's marginal revenue product.[1] Theoretically, the change in prices of inputs or outputs will affect the revenue of firm, and then demand theory would suggest a relationship between quantity of rubber demanded, price of rubber, prices of other inputs used in the manufacturing process, and price of the manufactured product.

The domestic rubber consumption and the Bangkok price of RSS #1 are regarded as jointly dependent variables. This means that the rubber consumption demand in the country will influence the domestic price of rubber in the market. On the other hand, the domestic price of rubber in the domestic market will influence the consumption demand in the domestic market. Though the Bangkok price is not the price paid to planters, it is believed that the variation in price paid will follow the Bangkok price sufficiently closely so that the Bangkok price should be a good proxy.

The limitation on the technology and economic constraint makes synthetic rubber a complement to natural rubber in many rubber

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[1]C. E. Ferguson, op. cit., p. 296.

manufacturing processes of producing rubber products. Therefore, the import of synthetic rubber is necessary for Thailand. It is used as an input together with natural rubber for some rubber products, such as tires, hoses, etc. However, since the impact of synthetic imported on natural rubber consumption takes time, a one year lag of the quantity of synthetic rubber being imported is hypothesized to influnece the domestic consumption of natural rubber instead of its price which was quite stable during the period of study.

A short run derived demand relationship normally would be influenced by the level of factors which are fixed in the short run, such as the variation in the capacity of rubber product industry. In Thailand's experience, this can be changed over a period of time. Therefore, the number of rubber product factories is used as a proxy for the capacity of domestic rubber consumption. Due to the fact that not all factories are of equal capacity, this variable must be regarded as a distinctly second best alternative. However, it appears to be the best of those variables.

To summarize the above discussion, it is then hypothesized that the quantity of domestic consumption is a function of the domestic price of rubber, a one year lag of synthetic rubber imported, the number of rubber products factories, and a random disturbance. The quantity of domestic consumption and the domestic price are hypothesized to be jointly dependent variables, while the lagged import of synthetic rubber and the number of factories are entered as exogenous variables.

The world rubber price of RSS #1   This equation is intended to determine and explain the world rubber price (New York price) of RSS #1. Its specification is very similar to what has been called a world demand equation in other agricultural commodity demands studies where recursiveness is apparent in the determination of production, demand and price.[1] Since the amount of rubber available for distribution can be possible almost over a year, it is reasonable to think of yearly average price being determined as that value on the market demand curve which will equate the total demand to the total supply. In this study we have specified an equation which relates the world rubber price (New York price) to the world demand for consumption of elastomer (synthetic and natural rubber), the ratio of world consumption of synthetic rubber to elastomer lagged one year, the total quantity of commercial stock of natural rubber in the world market lagged one year, the world supply of natural rubber, a one year lag of the world rubber price, and a random disturbance. The world rubber price, the quantity of world consumption of elastomer, and the total supply of natural rubber are hypothesized to be jointly dependent variables, while the ratio of consumption, commercial stock of rubber and the lagged price are entered as predetermined variables.

The quantity of elastomer consumed reflects the effect of demand on the price of natural rubber. According to the basic theory on demand, the higher the demand is, the higher the price consumers are willing to pay. The quantity of elastomer consumption is used instead

[1] Kenneth W. Mienken, "The Demand and Price Structure for Wheat", U.S. Department of Agriculture Technical Bulletin, 1136, Nov. 1955.

of natural rubber alone due to the fact that the natural rubber and synthetic rubber have complementary relationship rather than being substitutes.[1] It is hypothesized that increases in the consumption of elastomer will push up the price of natural rubber in the world market.

A one year lag for the ratio of synthetic rubber to elastomer consumption is based on the assumption that the price adjustments resulting from the complementary of synthetic rubber with an increasing rate, take about one year. On the other hand, price adjustments resulting from the technological improvement on rubber products manufacturing process will press down the price of natural rubber within a year.

The commercial stock of natural rubber in both consuming and producing countries lagged one year reflects the influence of natural rubber inventories on the price of natural rubber. This largely reflects speculative behavior or might be regarded as a reservation demand (or supply) on the part of the stock holder. It expresses their willingness to sell into consumption channels principally as a function of the rewards from selling; i.e., the price. It is hypothesized that the higher the beginning stocks relative to consumption in the preceding year, the lower the price manufacturers are willing to pay for imports of natural rubber.

The total quantity of supply (export) of natural rubber from producing countries is directly related to its price. As a basic

[1]Ira Horowitz, op. cit., pp. 325-345.

theory of supply curve, the higher the price is, the higher the quantity of that product that will be supplied. This function might be considered as a supply relationship. It is hypothesized that an increase in the rubber price will result in an increase in supply of rubber from producing countries.

For lagged price, it is assumed that the bargaining price that occurs in the market is affected by the lagged price. In fact, sometimes the rubber is sold in the form of "paper rubber". This means that they make an agreement on the quantity of rubber to be sold in the future without any rubber on hand but this quantity will be shipped at a specified time in the future at the market price or at a specified future price. Therefore, the handling price may be regarded as an expectation price based on the price when the contract is being signed. So the lagged price will affect the current price through the expectations of the rubber dealers.

In this world rubber price function, the world rubber price, the quantity of elastomer consumed, and the quantity supplied of natural rubber are hypothesized to be jointly dependent variables, while the ratio of synthetic to elastomer consumption lagged, the quantity of commercial stocks lagged, and the price lagged are entered as exogenous variables.

<u>The world consumption of elastomer</u> This equation is formulated to explain the demand for consumption of elastomer (synthetic and natural rubber). Natural rubber and synthetic rubber have a complementary

relationship rather than being substitutes, and the degree of complementarity is varied with the technological change in the manufacturing process. Therefore, studying elastomer consumption is quite valuable. The consumption of elastomer is hypothesized to be a function of the current and lagged world rubber prices, lagged elastomer consumption, a time trend, and a random disturbance.

Both the current and the lagged prices directly affect the demand schedule for consumption of elastomer in the opposite direction. It is hypothesized that the higher the prices are, the lower the manufacturers' consumption of elastomer. However, most manufacturers have planned in advance to acquire the raw materials, so lagged price is assumed to play a stronger effect than the current price.

Lagged consumption of elastomer reflects the capacity and behavior of rubber consuming industries which usually can not be changed drastically in the short period of only one year.

A time trend is added to capture industry growth and also reflects technological change that makes available more elastomer to be consumed.

Moreover, the quantity of elastomer consumption and price of natural rubber are hypothesized to be jointly dependent variables. The price lagged, the consumption lagged, and the time trend are hypothesized to be exogenous variables.

<u>The world supply of natural rubber</u> The supply of natural rubber from all producing countries is the total supply of natural rubber in the world market. The price of rubber in the world market will

influence the supply schedule. A rightward shift of the export supply schedule will shift the total world supply to the right, which causes a decrease in the price of rubber in the world market, other things remaining unchanged.

All countries' export supplies of natural rubber are treated as a function of the world rubber price, its supply lagged, a time trend, and a random disturbance.

According to the basic theory of supply, its price will affect the quantity of supply directly along the supply schedule curve. That is, the higher the price is, the higher the supply that producers are willing to produce.

The lagged supply of rubber reflects the capacity of the producers to produce. In particular, the new rubber tree will take about 7-8 years before it can be tapped, so a drastic increase in the rubber supply (production) is impossible in the short run. Thus the supply lagged will exhibit a big role in explaining the current supply of natural rubber.

A time trend is included to capture the technological improvement for booting the product, especially in the short run, such as the methods of tapping, stimulants, fertilizers etc.

<u>The domestic price of natural rubber, RSS #1</u> There are two versions of domestic price of rubber which have been formulated to explain the price of rubber in the domestic market (the Bangkok price). In fact, the Bangkok price is not the price paid by factories, but it is

believed that fluctuations in the price paid follow the Bangkok price closely so that the Bangkok price should be a good proxy.

In Model I, the domestic price of rubber is constructed to determine the Bangkok price of RSS #1 from those domestic economic variables that strongly affect the pattern of rubber price in the domestic rubber market. It is specified to relate the quantity of production, the exporters' demand, a one year lag of change in stocks of rubber, the import of synthetic rubber lagged one year, and a random disturbance. The price of rubber, the quantity of rubber produced, and the quantity of the exporters' demand are hypothesized to be jointly dependent, while the lagged change in stocks and the lagged import of synthetic rubber are included as exogenous variables.

The quantity of rubber produced is assumed to have a strong influence on domestic price in the opposite direction, i.e., the more rubber that is produced, the lower the price that the buyers are willing to pay. It is hypothesized that an increase in production will depress the current price.

The quantity of export demand directly affects the market price in the same direction. This means that increasing exporters' demand along the demand schedule or shifting demand curve to the right will result in pushing the market price up, other things remaining unchanged. So it is hypothesized that an increase in exporters' demand will raise the current price.

The change in stocks lagged one year reflects the effect of natural rubber inventories in the current year market of rubber. Commercially, the quantity of change in stocks of rubber results from the expectation of the dealers, and the change in stocks will go up when the dealers expect the price to increase and vice versa. So this change in stock is hypothesized to affect the price in both directions depending on the expectations of the dealers.

The quantity of synthetic rubber imported is included as an explanatory variable. It is expected that RSS #1 price is directly affected by the amount of synthetic rubber imported because of complementary and substitution effects.

In Model II, the domestic price of rubber is assumed to be directly influneced by the world rubber price instead of the Singapore or Malayan prices. This is due to the fact that in the past two decades (except during war years), the rubber market is mostly dominated by the highly industrialized import countries, especially, the U.S. which is the largest single import of natural rubber. In 1950 and 1970, the U.S. imported about 50 and 20 percent of the total amount of world import respectively. Also the U.S. is the world's largest producer of synthetic rubber and reclaimed rubber which can be used as a complement or substitute of natural rubber. The New York rubber market is accepted as the world center of rubber trading among the highly industrialized rubber consuming countries and the New York price of natural rubber is announced every day at noon as a buying price for consuming countries in the western hemosphere. The Singapore or

Malaysia prices of natural rubber are known in those producing countries as a selling price which is announced two times daily in the morning and afternoon. However, looking at the world rubber market after the World War II, isoprene derivatives and other synthetic substitutes for natural rubber can be produced almost as cheaply as natural rubber can be bought in the countries which make most use of this commodity. For many purposes the substitutes are better than the real thing, including the technological advantages in the manufacturing process. Therefore, since World War II, the output of synthetic substitutes for rubber has increased drastically with almost stable prices, while the prices of natural rubber have fluctuated with a downward trend. Also the world consumption of natural rubber has slowly increased at a diminishing rate. This indicates that the role of natural rubber has been weakening, while synthetic rubber has been increasing its role in the world rubber industry. Certainly, consuming countries will have more effect on the bargaining price than the producing countries and it is quite reasonable to regard the Bangkok price as a function of the New York price in explaining the domestic price of rubber. This domestic price is also assumed to help equate the demand and supply of rubber in the domestic market. Moreover, the Bangkok price and New York price are hypothesized to fluctuate in the same fashion and also be jointly dependent variables.

Market clearing conditions The last equation in the model, is simply one which requires that the sum of the components of supply equal to the sum of the components of demand as follows:

$$\text{PROD NR}_t + \text{BEGINNING STKS}_t \equiv \text{CONS NR}_t + \text{EXPS NR}_t + \text{ENDING STKS}_t$$

Production, consumption and exports are treated as endogenous variables; the beginning stock and the ending stock are treated as pre-determined variables. Besides expressing an accounting requirement, this equation embodies an important part of the economic logic of the model. On the one hand it expresses the inescapable requirement that any explanation of the quantity demanded and its component parts must take into account the available supply. On the other hand, the process of reconciling supply with demand is the process which determines price, i.e., price is that value at which the total demand is equal to the total supply. Moreover, in the process of forecasting, this equation must hold for the consistency of those variables to be predicted.

The world rubber market model

The world rubber market model has been constructed to determine the nature of production and export supply of natural rubber in each producing country and their relationships in the world market. The determinants of the production and export supply functions in other major producing countries, such as Indonesia, Malaysia and Sri Lanka, were constructed in the same fashion of the production and the export supply functions of Thailand respectively, under the assumption that all of these producing countries are developing nations and are located in the same area of the tropical zone. Therefore, the determinants of production are almost the same, except for the production function of Indonesia, a one year lag of the price of rice is added due to the fact that rice is always in shortage and expensive. According to Thomas,[1] the smallholders' decision is based on the price relationship between rubber and rice, e.g., when there was a result of shortage and high price of rice in 1961, there was a tendency for smallholders to turn to more intensive cultivation of rice. Also, a one year lag of production in Indonesia is included to reflect the capacity of the production in the current year.

In the case of Malaysia, a one year lag of palm oil price is added due to the fact that there was a major switch of rubber plantations into palm oil plantations which give more income than the rubber. The lagged palm oil price is hypothesized to affect the supply of rubber in the opposite way. Also production lagged is introduced into the production function due to incomplete available data on planted area or tapped area in Malaysia. However, this lagged production can reflect the capacity of production in the following year which is so short a period that the production of rubber can not be changed swiftly. On the other hand, the production of the current year depends on the capacity of production in the previous year.

[1]Kenneth D. Thomas, "Shifting Cultivation and Smallholder Rubber Production in a South Sumatran Village," The Malayan Economic Review Vol. 10, No. 1 (April 1965):103.

According to the export supply functions of Malaysia and Indonesia, only minor modifications are made to suit the economic conditions in each country, e.g., the quantity of stocks lagged one year is used instead of change in stocks for the export supply of Malaysia in showing an effect of natural rubber that is left over from the previous year as part of supply in the following year. In the export supply from Indonesia, the change in stocks lagged is dropped due to the lack of stock information. On the import demand side, which includes all the major rubber consuming countries[1] and the rest of the world, the demand functions for each country have been constructed in the same fashion due to the fact that these major consuming countries are developed countries with highly industrialized economy of the world such as the United States, Japan, the United Kingdom, France, West Germany, etc. where the demand for natural rubber are derived demand primarily for use in rubber products. Therefore, the determinants of import demand for each country are mostly the same. However, the United States which is the largest user of natural rubber and has one of the most complicated demand situations for imports of natural rubber, is thought to be appropriate as an example in discussing the details of the major factors that influence the quantity imported, the relationship of those determinants with import demand, and in forecasting import demand and the price of natural rubber.

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[1]The country that consumes natural rubber at least 100,000 metric tons per year.

United States import demand   United States import demand of natural rubber is hypothesized to depend linearly upon the world rubber price in both current and previous years, the U.S. consumption ratio of synthetic rubber to elastomer lagged one year in the U.S., the quantity of automobiles produced in the U.S., the U.S. government releases of strategic stockpiles, the quantity of reclaimed rubber produced in the U.S. lagged one year, and a random disturbance. The import demand functions of other countries are presented in the same fashion as that of the U.S., that is, the import demand of rubber in each country depends linearly upon its determinants which are slightly different from the determinants in the U.S. as a result of the differences in the industrial activities of each country.

Since the demand schedule for rubber is the firm's marginal revenue product curve when using this particular input, theoretically the price of rubber product must also be a shifter of the demand schedule for the input. However, rubber is widely used in the automobile industry for the manufacture of tires and tubes (about 70 percent of rubber is used in this kind of industry), and the value of tires and tubes, in comparison with the total value of the automobile itself, is very small. This suggests that an increase in the price of the tires and tubes may not necessarily lead to an increase in the price of the automobile and vice versa. Hence, it is unlikely that the price of tires and tubes will act as a shifter of the demand schedule for rubber. Instead, the automobile industry that needs tires, tubes and some rubber products is hypothesized to be an important shifter of the demand for rubber. The higher the activities in the automobile industry[1] are, the larger will be the demand for rubber, and vice versa.

The current price and the one year lag of price of natural rubber will affect the import demand of rubber through the revenue and marginal revenue product curve. Static demand theory would suggest a relationship between the quantity to be demanded, its price, the prices of the other inputs used in the manufacturing process, and the price of the manufactured product. This rubber price is hypothesized to affect the import quantity along the demand schedule curve. That is, the higher the price is, the lower will be the import demand for rubber and vice versa. The expectations of the importers and exporters about the price at that moment will lead to an agreement in advance trade or the "paper sell", that is, if they think that the price at that moment is low and expect it to increase, the amount of advance trade will be low and vice versa. Then the effect of this lagged price on the import demand is hypothesized to be either positive or negative.

Since World War II, the synthetic rubber industry has severely affected the natural rubber industry. The growing competition from synthetic rubber results in a pressure on the prices of natural rubber in the long-run, while the price of synthetic rubber is almost stable. The synthetic rubber price was controlled by the U.S. government for a period of time after the World War II, and so it fluctuated very little through out period of study. Therefore, the synthetic price was not taken into consideration and was not added into the models as a

[1]The number of passenger cars and trucks produced is used as a measurement of the automobile industry.

decision variable in the substitution of synthetic for natural rubber. This substitution will likely be based on technological considerations. A one year lag for the ratio of synthetic rubber consumption to the total elastomer consumption is used to capture the adjustments on the import demand resulting from synthetic substitution or the technological change in manufacturing process that take about one year. Therefore, it is hypothesized that an increase in this consumption ratio lagged will depress the amount of the demand to be imported and vice versa.

Another main factor that affects the demand schedule for rubber can be identified as changes in stockpiles due to the speculation, war threats, etc. The U.S. government releases of natural rubber from its strategic stockpile has an influence on the decisions of rubber manufacturers regarding demand for import[1] and also affects on the price of RSS #1, because rubber from the stockpile is usually sold at a rather low price. It is hypothesized that stockpile sales will affect the supply of rubber in the world market. In other words, stockpile sales are hypothesized as an exogenous source of supply that reduces the import demand.

The United States is one of the largest producers of reclaimed[2]

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[1]FAO, Commodity Review 1968, Rome, p. 420.

[2]Reclaimed rubber is obtained by extracting the rubber content of scrap or worn out rubber products after treatment to eliminate the fiber content and to devulcanize the rubber atom by removing their sulphur content. Reclaimed rubber has an important and proper place in manufacturing certain rubber products, particularly where the maximum tensile strength is not needed, but resistance to abrasion is required.

rubber among those rubber consuming countries. The quantity of reclaimed rubber produced has increased drastically since the World War II. It is considered to be a low quality of rubber, because usually it is a mixture of natural rubber. Then it is expected to be both a complement and substitute of natural rubber; however, the effect of substitution is regarded as the stronger effect. It is hypothesized that an increase in reclaimed rubber production in the previous year will result in a reduction of the import demand of natural rubber in the following year.

Summarizing the above discussion, it is then hypothesized that the quantity of rubber imported to the U.S. is a function of the price of rubber in the world market, the consumption ratio lag of synthetic rubber to elastomer, the quantity of automobiles produced in the U.S., U.S. government releases of strategic stocks of rubber, the quantity of reclaimed rubber produced in the U.S. lagged, and a random disturbance. Quantity imported in the U.S. and the price of rubber in the world market are hypothesized to be jointly dependent variables, while the consumption ratio lagged, automobile production, stockpile releases, and the quantity of reclaimed rubber produced are considered exogenous variables.

CHAPTER III. THE ECONOMETRIC MODELS AND ESTIMATIONS

The Econometric Models

From the economic considerations in the economic model of the previous chapter, the functional relationships of the variables can be formulated in the statistical forms which are compatible with empirical analysis and statistical testing. In this analysis each equation is specified to be linear both in the variables and parameters to obtain computational simplicity. Although the total function is curvilinear, it is reasonable to assume that segments covered by the range of the observed data can be approximated by a linear function. The variables entered in the functional relationships of the models are classified into two groups, one as endogenous variables that are determined within the system of equations, another as exogenous variables that are determined outside the system and they also influence the endogenous variables. The length of the available time series data requires that the model be simply constructed but still able to explain the relationships of the variables in the model.

The Thai rubber industry models and the world rubber market model are restated in the statistical forms as follows:

Thai rubber industry models

Thai rubber industry Model I:

$$\text{TAP AREA}_t^{TH} = \alpha_{10} + \alpha_{11}\text{PR NR}_t^{TH} + \alpha_{12}\text{PR NR}_{t-1}^{TH} + \alpha_{13}\text{YLD NR}_{t-1} + \alpha_{14}\text{PLNT AREA}_{t-8} + U_1 \qquad \text{(I.1)}$$

$$PROD\ NR_t^{TH} = \alpha_{20} + \alpha_{21}PR\ NR_t^{TH} + \alpha_{22}TAP\ AREA_t^{TH} + \alpha_{23}TIME + U_2 \quad (I.2)$$

$$EXP\ NR_t^{TH} = \alpha_{30} + \alpha_{31}PR\ NR_t^{WLD} + \alpha_{32}PR\ NR_t^{TH} + \alpha_{33}PROD\ NR_t^{TH}$$

$$+ \alpha_{34}CH\text{-}STKS_{t-1} + U_3 \quad (I.3)$$

$$CONS\ NR_t^{TH} = \alpha_{40} + \alpha_{41}PR\ NR_t^{TH} + \alpha_{42}IMP\ SR_{t-1} + \alpha_{43}NO.FACTY + U_4 \quad (I.4)$$

$$PR\ NR_t^{TH} = \alpha_{50} + \alpha_{51}PROD\ NR_t^{TH} + \alpha_{52}EXP\ NR_t^{TH} + \alpha_{53}CH\text{-}STKS_{t-1}$$

$$+ \alpha_{54}IMP\ SR_{t-1} + U_5 \quad (I.5)$$

$$PR\ NR_t^{WLD} = \alpha_{60} + \alpha_{61}CONS\ ELAST_t^{WLD} + \alpha_{62}SUP\ NR_t^{WLD} + \alpha_{63}RA\text{-}CONST_{t-1}^{WLD}$$

$$+ \alpha_{64}CSTKS_{t-1}^{WLD} + \alpha_{65}PR\ NR_{t-1}^{WLD} + U_6 \quad (I.6)$$

$$CONS\ ELAST_t^{WLD} = \alpha_{70} + \alpha_{71}PR\ NR_t^{WLD} + \alpha_{72}PR\ NR_{t-1}^{WLD} + \alpha_{73}TIME$$

$$+ \alpha_{74}CONS\ ELAST_{t-1}^{WLD} + U_7 \quad (I.7)$$

$$SUP\ NR_t^{WLD} = \alpha_{80} + \alpha_{81}PR\ NR_t^{WLD} + \alpha_{82}TIME + \alpha_{83}SUP\ NR_{t-1}^{WLD} + U_8 \quad (I.8)$$

$$PROD\ NR_t^{TH} + BEGINNING\ STKS_t \equiv EXP\ NR_t^{TH} + CONS\ NR_t^{TH} + ENDING\ STKS_t \quad (I.9)$$

Thai rubber industry Model II:

$$TAP\ AREA_t^{TH} = \alpha_{10} + \alpha_{12}PR\ NR_t^{TH} + \alpha_{13}PR\ NR_{t-1}^{TH} + \alpha_{14}YLD\ NR_{t-1}$$

$$+ \alpha_{15}PLNT\ AREA_{t-8} + U_1 \quad (II.1)$$

$$PROD\ NR_t^{TH} = \alpha_{20} + \alpha_{21}PR\ NR_t^{TH} + \alpha_{22}TAP\ AREA_t^{TH} + \alpha_{23}TIME + U_2 \quad (II.2)$$

$$EXP\ NR_t^{TH} = \alpha_{30} + \alpha_{31}(PR\ NR^{WLD} - PR\ NR^{TH})_t + \alpha_{32}PROD\ NR_t^{TH}$$

$$+ \alpha_{33}CH\text{-}STKS_{t-1} + U_3 \quad (II.3)$$

$$CONS\ NR_t^{TH} = \alpha_{40} + \alpha_{41}PR\ NR_t^{TH} + \alpha_{42}IMP\ SR_{t-1} + \alpha_{43}NO.FACTY + U_4 \quad (II.4)$$

$$PR\ NR_t^{TH} = \alpha_{50} + \alpha_{51}PR\ NR_t^{WLD} + U_5 \quad (II.5)$$

$$PR\ NR_t^{WLD} = \alpha_{60} + \alpha_{61}CONS\ ELAST_t^{WLD} + \alpha_{62}SUP\ NR_t^{WLD}$$

$$+ \alpha_{63}RA\text{-}CONS_{t-1}^{WLD} + \alpha_{64}CSTKS_{t-1}^{WLD} + \alpha_{65}PR\ NR_{t-1}^{WLD} + U_6 \quad (II.6)$$

$$CONS\ ELAST_t^{WLD} = \alpha_{70} + \alpha_{71}PR\ NR_t^{WLD} + \alpha_{72}PR\ NR_{t-1}^{WLD} + \alpha_{73}TIME$$

$$+ \alpha_{74}CONS\ ELAST_{t-1}^{WLD} + U_7 \quad (II.7)$$

$$SUP\ NR_t^{WLD} = \alpha_{80} + \alpha_{81}PR\ NR_t^{WLD} + \alpha_{82}TIME + \alpha_{83}SUP\ NR_{t-1}^{WLD} + U_8 \quad (II.8)$$

$$PROD\ NR_t^{TH} + BEGINNING\ STKS_t \equiv EXP\ NR_t^{TH} + CONS\ NR_t^{TH} + ENDING\ STKS_t \quad (II.9)$$

List of Variables in Thai Rubber Industry Models

Endogenous Variables:

$CONS\ ELAST_t^{WLD}$: The total quantity of world consumption of elastomers (synthetic and natural rubber), measured in 1,000 metric tons of dry-content weight of latex

$CONS\ NR_t^{TH}$: The quantity of rubber consumed in Thailand, measured in 1,000 metric tons of the dry-content weight of latex

$EXP\ NR_t^{TH}$: The quantity of rubber exported by Thailand, measured in 1,000 metric tons of dry-content weight of latex

$PR\ NR_t^{WLD}$: The price of rubber in the world market expressed in U.S. cent per kilogram, represented by the New York F.O.B. price of RSS #1, deflated by the indices of the U.S. energy prices[1]

$PR\ NR_t^{TH}$: The domestic wholesale price of rubber in Bangkok, Thailand, expressed in U.S. cents per kilogram, represented by the Bangkok price of RSS #1, deflated by the indices of the U.S. energy prices

$PROD\ NR_t^{TH}$: The quantity of rubber produced in Thailand, measured in 1,000 metric tons of the dry-content weight of latex

$SUP\ NR_t^{WLD}$: The total quantity of world supply of rubber, (export of rubber from all producing countries), measure in 1,000 metric tons of dry-content weight of latex

$TAP\ AREA_t^{TH}$: The tappable area of rubber trees in Thailand, mostly more than seven years old, measured in rai (2½ rais = 1 acre)

Exogenous Variables:

$CH\text{-}STKS_{t-1}$: The quantity change of rubber stock in Thailand, lagged one year, measured in 1,000 metric tons of dry-content weight of latex

$CSTKS_{t-1}^{WLD}$: The total quantity of commercial stocks of rubber, lagged one year, measured in 1,000 metric tons of dry-content weight of latex

$IMP\ SR_{t-1}$: The quantity of synthetic rubber imported by Thailand, lagged one year, measured in 1,000 metric tons

NO FCTRY: The total number of factories that produce the rubber products

$PLNT\ AREA_{t-8}$: The total planted area of rubber trees in Thailand, lagged eight years, measured in 1,000 rai

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[1]Index of the U.S. energy prices 1967 = 100.

$PR\ NR^{WLD}_{t-1}$: The price of rubber in the world market, lagged one year, expressed in U.S. cents kilogram, represented by the New York f.o.b. price of RSS #1, deflated by the indices of the U.S. energy prices

$PR\ NR^{TH}_{t-1}$: The domestic wholesale price of rubber in Bangkok, lagged one year, expressed in U.S. cents per kilogram, represent by the Bangkok price of RSS #1, deflated by the indices of the U.S. energy prices

$RA\text{-}CONS^{WLD}_{t-1}$: The ratio of world consumption of synthetic rubber to elastomers, lagged one year, measured in percentage

TIME: The trend, denoted consecutively by the number 1 to 17 for the year 1956 to 1972

$YLD\ NR_{t-1}$: The average yield of rubber produced, lagged one year, measured in kilogram per rai per year

U: The random disturbance

The world rubber market Model III

Producing Country Equations:

$$PROD\ NR^{IND}_{t} = \alpha_{10} + \alpha_{11}\ PR\ NR^{IND}_{t} + \alpha_{12}\ PR\ RICE^{IND}_{t-1} + \alpha_{13}\ PROD\ NR^{IND}_{t-1} + \alpha_{14}\ DUM^{IND} + \alpha_{15}\ TIME + U_{1} \qquad (III.1)$$

$$EXP\ NR^{IND}_{t} = \alpha_{20} + \alpha_{21}\ PR\ NR^{WLD}_{t} + \alpha_{22}\ PROD\ NR^{IND}_{t} + U_{2} \qquad (III.2)$$

$$PROD\ NR^{MAL}_{t} = \alpha_{30} + \alpha_{31}\ PR\ NR^{MAL}_{t} + \alpha_{32}\ PR\ PALM^{MAL}_{t-1} + \alpha_{33}\ TIME + \alpha_{34}\ PROD\ NR^{MAL}_{t-1} + U_{3} \qquad (III.3)$$

$$EXP\ NR^{MAL}_{t} = \alpha_{40} + \alpha_{41}\ PR\ NR^{WLD}_{t} + \alpha_{42}\ PROD\ NR^{MAL}_{t} + \alpha_{43}\ CSTKS\ NR^{MAL}_{t-1} + U_{4} \qquad (III.4)$$

$$PROD\ NR_t^{SRI} = \alpha_{50} + \alpha_{51}\ PR\ NR_t^{SRI} + \alpha_{52}\ PR\ TEA\ {}^{SRI}_{t-1} + \alpha_{53}\ TIME + \alpha_{54}\ PROD\ NR_{t-1}^{SRI} + U_5 \qquad (III.5)$$

$$EXP\ NR_t^{SRI} = \alpha_{60} + \alpha_{61}\ (PR\ NR^{WLD} - PR\ NR^{SRI})_t + \alpha_{62}\ PROD\ NR_t^{SRI} + U_6 \qquad (III.6)$$

$$PROD\ NR_t^{TH} = \alpha_{70} + \alpha_{71}\ PR\ NR_t^{TH} + \alpha_{72}\ TAP\ AREA_t^{TH} + \alpha_{73}\ TIME + U_7 \qquad (III.7)$$

$$EXP\ NR_t^{TH} = \alpha_{80} + \alpha_{81}\ PR\ NR_t^{WLD} + \alpha_{82}\ PROD\ NR_t^{TH} + \alpha_{83}\ CH\text{-}STKS_{t-1} + U_8 \qquad (III.8)$$

$$EXP\ NR_t^{ROW} = \alpha_{90} + \alpha_{91}\ PR\ NR_t^{WLD} + \alpha_{92}\ PR\ NR_{t-1}^{WLD} + \alpha_{93}\ DUM^{ROW} + \alpha_{94}\ TIME + U_9 \qquad (III.9)$$

Consuming Country Equations:

$$IMP\ NR_t^{AUS} = \beta_{10} + \beta_{11}\ PR\ NR_t^{WLD} + \beta_{12}\ PR\ NR_{t-1}^{WLD} + \beta_{13}\ CSTKS_{t-1}^{AUS} + \beta_{14}\ CONS\ RR_{t-1}^{AUS} + \beta_{15}\ DUM^{AUS} + \beta_{16}\ IMP\ NR_{t-1}^{AUS} + U_{10} \qquad (III.10)$$

$$IMP\ NR_t^{CA} = \beta_{20} + \beta_{21}\ PR\ NR_t^{WLD} + \beta_{22}\ PR\ NR_{t-1}^{WLD} + \beta_{23}\ RA\text{-}CONS_{t-1}^{CA}$$

$$+ \beta_{24}\ PROD\ RR_{t-1}^{CA} + \beta_{25}\ PROD\ AUTO_t^{CA} + U_{11} \qquad (III.11)$$

$$IMP\ NR_t^{FR} = \beta_{30} + \beta_{31}\ PR\ NR_t^{WLD} + \beta_{32}\ PR\ NR_{t-1}^{WLD} + \beta_{33}\ RA\text{-}CONS_{t-1}^{FR}$$

$$+ \beta_{34}\ PROD\ AUTO_t^{FR} + \beta_{35}\ PROD\ SR_t^{FR} + \beta_{36}\ DUM^{FR}$$

$$+ U_{12} \qquad (III.12)$$

$$IMP\ NR_t^{ITLY} = \beta_{40} + \beta_{41}\ PR\ NR_t^{WLD} + \beta_{42}\ PR\ NR_{t-1}^{WLD} + \beta_{43}\ PROD\ AUTO_t^{ITLY}$$

$$+ \beta_{44}\ IMP\ SR_{t-1}^{ITLY} + \beta_{45}\ GDP_t^{ITLY} + U_{13} \qquad (III.13)$$

$$IMP\ NR_t^{JAP} = \beta_{50} + \beta_{51}\ PR\ NR_t^{WLD} + \beta_{52}\ PR\ NR_{t-1}^{WLD} + \beta_{53}\ RA\text{-}CONS_{t-1}^{JAP}$$

$$+ \beta_{54}\ CSTKS\ NR_{t-1}^{JAP} + \beta_{55}\ PROD\ AUTO_t^{JAP}$$

$$+ \beta_{56}\ IMP\ NR_{t-1}^{JAP} + U_{14} \qquad (III.14)$$

$$IMP\ NR_t^{CH} = \beta_{60} + \beta_{61}\ PR\ NR_t^{WLD} + \beta_{62}\ PR\ NR_{t-1}^{WLD} + \beta_{63}\ CONS\ SR_{t-1}^{CH}$$

$$+ \beta_{64}\ IMP\ NR_{t-1}^{CH} + \beta_{65}\ DUM^{CH} + U_{15} \qquad (III.15)$$

$$IMP\ NR_t^{ROW} = \beta_{70} + \beta_{71}\ PR\ NR_t^{WLD} + \beta_{72}\ PR\ NR_{t-1}^{WLD} + \beta_{73}\ IMP\ NR_{t-1}^{ROW}$$

$$+ U_{16} \qquad (III.16)$$

$$\text{IMP NR}_t^{SP} = \beta_{80} + \beta_{81}\,\text{PR NR}_t^{WLD} + \beta_{82}\,\text{PR NR}_{t-1}^{WLD} + \beta_{83}\,\text{PROD SR}_{t-1}^{SP} + \beta_{84}\,\text{PROD AUTO}_t^{SP} + U_{17} \qquad \text{(III.17)}$$

$$\text{IMP NR}_t^{UK} = \beta_{90} + \beta_{91}\,\text{PR NR}_t^{WLD} + \beta_{92}\,\text{PR NR}_{t-1}^{WLD} + \beta_{93}\,\text{CSTKS NR}_{t-1}^{UK} + \beta_{94}\,\text{GRS NR}_{t-1}^{UK} + \beta_{95}\,\text{PROD SR}_{t-1}^{UK} + \beta_{96}\,\text{PROD RR}_{t-1}^{UK} + U_{18} \qquad \text{(III.18)}$$

$$\text{IMP NR}_t^{US} = \beta_{10,0} + \beta_{10,1}\,\text{PR NR}_t^{WLD} + \beta_{10,2}\,\text{PR NR}_{t-1}^{WLD} + \beta_{10,3}\,\text{RA-CONS}_{t-1}^{US} + \beta_{10,4}\,\text{PROD AUTO}_t^{US} + \beta_{10,5}\,\text{GRS NR}_{t-1}^{US} + \beta_{10,6}\,\text{PROD RR}_{t-1}^{US} + U_{19} \qquad \text{(III.19)}$$

$$\text{IMP NR}_t^{USSR} = \beta_{11,0} + \beta_{11,1}\,\text{PR NR}_t^{WLD} + \beta_{11,2}\,\text{PR NR}_{t-1}^{WLD} + \beta_{11,3}\,\text{RA-CONS}_{t-1}^{USSR} + \beta_{11,4}\,\text{IMP SR}_{t-1}^{USSR} + \beta_{11,5}\,\text{IMP SR}_{t-1}^{USSR} + \beta_{11,6}\,\text{DUM}^{USSR} + U_{20} \qquad \text{(III.20)}$$

$$\text{IMP NR}_t^{W.GER} = \beta_{12,0} + \beta_{12,1}\,\text{PR NR}_t^{WLD} + \beta_{12,2}\,\text{PR NR}_{t-1}^{WLD}$$

$$+ \beta_{12,3}\,\text{RA-CONS}_{t-1}^{W.GER.} + \beta_{12,4}\,\text{PROD AUTO}_t^{W.GER}$$

$$+ \beta_{12,5}\,\text{CSTKS}_{t-1}^{W.GER} + \beta_{12,6}\,\text{PROD RR}_{t-1}^{W.GER}$$

$$+ \beta_{12.7}\,\text{CONS(SR+RR)}_{t-1}^{W.GER} + U_{21} \qquad \text{(III.21)}$$

$$\text{PR NR}_t^{WLD} = \beta_{13,0} + \beta_{13,1}\,\text{CONS ELAST}_t^{WLD} + \beta_{13,2}\,\text{RA-CONS}_{t-1}^{WLD}$$

$$+ \beta_{13,3}\,\text{CSTKS NR}_{t-1}^{WLD} + \beta_{13,4}\,\text{PR NR}_{t-1}^{WLD} + U_{22}$$

$$\text{(III.22)}$$

$$\text{CONS ELAST}_t^{WLD} = \beta_{14,0} + \beta_{14,1}\,\text{PR NR}_t^{WLD} + \beta_{14,2}\,\text{PR NR}_{t-1}^{WLD}$$

$$+ \beta_{14,3}\,\text{CONS ELAST}_{t-1}^{WLD} + \beta_{14,4}\,\text{TIME} + U_{23}$$

$$\text{(III.23)}$$

$$\text{PR NR}_t^{IND} = \beta_{15,0} + \beta_{15,1}\,\text{PR NR}_t^{WLD} + U_{24} \qquad \text{(III.24)}$$

$$\text{PR NR}_t^{MAL} = \beta_{16,0} + \beta_{16,1}\,\text{PR NR}_t^{WLD} + U_{25} \qquad \text{(III.25)}$$

$$\text{PR NR}_t^{SRI} = \beta_{17,0} + \beta_{17,1}\,\text{PR NR}_t^{WLD} + U_{26} \qquad \text{(III.26)}$$

$$\text{PR NR}_t^{TH} = \beta_{18,0} + \beta_{18,1}\,\text{PR NR}_t^{WLD} + U_{27} \qquad \text{(III.27)}$$

$$\sum_{i=1}^{5} \text{EXP}_i\,\text{NR}_t \equiv \sum_{i=1}^{12} \text{IMP}_i\,\text{NR}_t + \text{SD}_t \qquad \text{(III.28)}$$

List of Variables in World Rubber
Market Model

Endogenous Variables:

$CONS\ ELAST_t^{WLD}$: The total quantity of world consumption of elastomers (synthetic and natural rubber), measured in 1,000 metric tons of dry-content weight of latex

$EXP\ NR_t^{IND}$: The quantity of rubber exported by Indonesia measured in 1,000 metric tons of the dry content weight of latex

$EXP\ NR_t^{MAL}$: The quantity of rubber exported by Malaysia, measured in 1,000 metric tons of the dry content weight of latex

$EXP\ NR_t^{ROW}$: The quantity of rubber exported by other countries besides Indonesia, Malaysia, Sri Lanka and Thailand, measured in 1,000 metric tons of the dry content weight of latex

$EXP\ NR_t^{TH}$: The quantity of rubber exported by Thailand, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{AUS}$: The quantity of rubber imported by Australia, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{CA}$: The quantity of rubber imported by Canada, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{FR}$: The quantity of rubber imported by France, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{ITLY}$: The quantity of rubber imported by Italy, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{JAP}$: The quantity of rubber imported by Japan, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{CH}$: The quantity of rubber imported by the Republic of China, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{ROW}$: The quantity of rubber imported by other countries besides Australia, China, ...USA, etc., measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{SP}$: The quantity of rubber imported by Spain, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{UK}$: The quantity of rubber imported by the United Kingdom, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{US}$: The quantity of rubber imported by the United States, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{USSR}$: The quantity of rubber imported by the Soviet Union, measured in 1,000 metric tons of the dry content weight of latex

$IMP\ NR_t^{W.GER}$: The quantity of rubber imported by West Germany, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ NR_t^{IND}$: The total quantity of rubber produced in Indonesia, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ NR_t^{MAL}$: The total quantity of rubber produced in Malaysia, measured in 1,000 metric tons of dry content weight of latex

$PROD\ NR_t^{SRI}$: The total quantity of rubber produced in Sri Lanka, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ NR_t^{TH}$: The total quantity of rubber produced in Thailand, measured in 1,000 metric tons of the dry content weight of latex

$PR\ NR_t^{IND}$: The domestic price of rubber in Indonesia, expressed in U.S. cents per kilogram, represented by the Djakata f.o.b. price of RSS #1, deflated by the indices of the U.S. energy prices

$PR\ NR_t^{MAL}$: The domestic price of rubber in Malaysia, expressed in U.S. cents per kilogram, represented by the buyers' midday prices, f.o.b. in bales of RSS #1 in Kuala Lumper, deflated by the indices of the U.S. energy prices

$PR\ NR_t^{SRI}$: The domestic price of rubber in Colombo, Sri Lanka, expressed in U.S. cents per kilogram, represented by the Colombo prices of RSS #1 excluding export duties, deflated by the indices of the U.S. energy prices

$PR\ NR_t^{TH}$: The domestic price of rubber in Bangkok, Thailand, expressed in U.S. cents per kilogram, represented by the Bangkok wholesale price of RSS #1, deflated by the indices of the U.S. energy prices

$PR\ NR_t^{WLD}$: The average import prices for U.S. or New York quotations refer to sellers' asking prices for delivery of RSS #1, expressed in U.S. cents per kilogram, deflated by the indices of the U.S. energy prices

$SUP\ NR_t^{WLD}$: The total quantity of world supply of rubber (export of rubber from all producing countries), measured in 1,000 metric tons of the dry-content weight of latex

Exogenous Variables:

$CH\text{-}STKS_{t-1}^{SRI}$: The difference of rubber stocks at the ending from the beginning stocks of the year in Sri Lanka, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$CH\text{-}STKS_t^{TH}$: The difference of rubber stocks at the ending from the beginning stocks of the year in Thailand, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$C\text{-}TKS_{t-1}^{AUS}$: The quantity of commercial stocks of rubber in Australia, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$CSTKS_{t-1}^{JAP}$: The quantity of commercial stocks of rubber in Japan, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$CSTKS_{t}^{MAL}$: The quantity of commercial stocks of rubber in Malaysia, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$CSTKS_{t-1}^{UK}$: The quantity of commercial stocks of rubber in the United Kingdom, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$CSTKS_{t-1}^{W.GER}$: The quantity of commercial stocks of the synthetic and reclaimed rubber in West Germany, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$CSTKS_{t-1}^{WLD}$: The total quantity of commercial stocks of rubber, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

DUM^{IND}: Dummy variable for Indonesia, 1960, 1963 = 1, 1969 = 1, otherwise 0

DUM^{CH}: Dummy variable for the Republic of China, 1968-9 = 1, otherwise 0

DUM^{ROW}: Dummy variable for other export countries 1967-9 = 1, otherwise 0

DUM^{OT}: Dummy variable for other import countries, 1964-5 = 1, otherwise 0

DUM^{UK} DUM^{US}: Dummy variable for the United Kingdom, and the United States, 1956-7 and 1959 = 1, otherwise 0

DUM^{USSR}: Dummy variable for the Soviet Unions, 1960, 1964 = -1 and 1961-2 = 1, otherwise 0

$EXP\ NR_{t-1}^{IND}$: The quantity of rubber exported by Indonesia, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$EXP\ NR_{t-1}^{TH}$: The quantity of rubber exported by Thailand, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$GRS\ NR_{t-1}^{UK}$: The quantity of rubber released by the Government of the United Kingdom, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

GRS NR^{US}_{t-1}: The quantity of rubber released by the Government of the United States, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

IMP NR^{AUS}_{t-1}: The quantity of rubber imported by Australia, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

IMP NR^{CH}_{t-1}: The quantity of rubber imported by the Republic of China, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

IMP NR^{ITLY}_{t-1}: The quantity of rubber imported by Italy, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

IMP NR^{ROW}_{t-1}: The quantity of rubber imported by other countries, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

IMP NR^{SP}_{t-1}: The quantity of rubber imported by Spain, lagged one year, measured in 1,000 metric tons of dry content weight of latex

IMP NR^{USSR}_{t-1}: The quantity of rubber imported by the Soviet Unions, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

IMP SR^{USSR}_{t-1}: The quantity of synthetic rubber imported by the Soviet Unions, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

PR NR^{WLD}_{t-1}: The New York price of RSS #1, lagged one year, expressed in U.S. cents per kilogram, deflated by the indices of the U.S. energy prices

PR $RICE^{IND}_{t-1}$: The domestic price of rice, lagged one year, represented by the unweighted average price of rice in Djakarta, Djambi and Banjarmasin, measured in Rupiahs per 10 liters, deflated by the indices cost of living in Indonesia, 1967 = 100

PR $PALM^{MAL}_{t-1}$: The domestic price of palm oil in Malaysia, lagged one year, measured in Malaysia cents per kilogram, deflated by the indices of GDP, 1967 = 100

$PR\ TEA^{SRI}_{t-1}$: The domestic price of tea in Colombo, lagged one year, measured in Rupers per kilogram, deflated by the indices of the U.S. energy prices

$PROD\ AUTO^{FR}_{t}$: The amount of France automobiles production, consisting of passenger cars and commercial vehicles, measured in 1,000 vehicles

$PROD\ AUTO^{ITLY}_{t}$: The amount of Italy automobiles production, consisting of passenger cars and commercial vehicles, measured in 1,000 vehicles

$PROD\ AUTO^{JAP}_{t}$: The amount of Japan automobiles production consisting of passenger cars and commercial vehicles, measured in 1,000 vehicles

$PROD\ AUTO^{SP}_{t}$: The amount of Spain automobiles production, consisting of passenger cars and commercial vehicles, measured in 1,000 vehicles

$PROD\ AUTO^{US}_{t}$: The amount of U.S. automobiles production, consisting of passenger cars and commercial vehicles, measured in 1,000 vehicles

$PROD\ AUTO^{W.GER}_{t}$: The amount of West Germany automobiles production, consisting of passenger cars and commercial vehicles, measured in 1,000 vehicles

$PROD\ NR^{IND}_{t-1}$: The quantity of rubber produced by Indonesia, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ NR^{MAL}_{t-1}$: The quantity of rubber produced by Malaysia, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ NR^{SRI}_{t-1}$: The quantity of rubber produced by Sri Lanka, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ NR^{TH}_{t-1}$: The quantity of rubber produced by Thailand, lagged one year, measured in 1,000 metric tons of the dry content weight of latex

$PROD\ RR^{UK}_{t-1}$: The quantity of reclaimed rubber produced by the United Kingdom, lagged one year, measured in 1,000 metric tons

$PROD\ RR^{US}_{t-1}$: The quantity of reclaimed rubber produced by the United States, lagged one year, measured in 1,000 metric tons

$PROD\ RR^{W\ GER}_{t-1}$: The quantity of reclaimed rubber produced by West Germany, lagged one year, measured in 1,000 metric tons

$PROD\ SR^{FR}_{t-1}$: The quantity of synthetic rubber produced by France, lagged one year, measured in 1,000 metric tons

$PROD\ SR^{JAP}_{t-1}$: The quantity of synthetic rubber produced by Japan, lagged one year, measured in 1,000 metric tons

$PROD\ SR^{SP}_{t-1}$: The quantity of synthetic rubber produced by Spain, lagged one year, measured in 1,000 metric tons

$RA\text{-}CONS^{AUS}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of Australia

$RA\text{-}CONS^{CH}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of the Republic of China

$RA\text{-}CONS^{FR}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of France

$RA\text{-}CONS^{JAP}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of Japan

$RA\text{-}CONS^{UK}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of the United Kingdom

$RA\text{-}CONS^{US}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of the United States

$RA\text{-}CONS^{W\ GER}_{t-1}$: The ratio of synthetic rubber consumption to the total elastomer consumption, lagged one year, of West Germany

$RA\text{-}CONS^{WLD}_{t-1}$: The ratio of world consumption of synthetic rubber to elastomers, lagged one year, measured in percentage

SD: Statistical discrepancy

TIME: The trend, denoted consecutively by the number 1 to 17 for the year 1956-1972

Identification

Identification is the problem that we have to look at prior to the estimation of the structural parameters, because it will tell us whether the structural parameters can be obtained from the given knowledge of its reduced form. A unique estimate of the structural parameters may be obtained only if the equations in the model are identified or over identified. From the previous system of linear equation models, it may be expressed in a general form as follows,

$$BY_t + \Gamma X_t = U_t \qquad t = 1,2,\ldots,n$$

where B and Γ are the coefficient matrices of the endogenous and exogenous variables in the system respectively, and Y and X are the matrices of endogenous and exogenous variables respectively.

In both Thai rubber industry models, B is an 8 by 8 matrix of β_{ij} coefficients, Y is the 9 by 1 element vector of endogenous variables, Γ is the 8 by 13 matrix of the γ_{ik} coefficients, X is the 13 by 1 element vector of the predetermined variables, and U is the 8 by 1 element vector of the disturbance terms. When the elements of B, Γ and the probability distribution of U's take on specific numerical values, then it has a structure within the model. If the specification of the model is correct, the presumption is that some specific structure has generated the observations under study, so the econometric work is to estimate the values of these structural parameters. However, prior to the estimation of the structural parameters, the equations of the model must be shown to be identified. When there is a unique set, more than one set, or no set of estimates of the structural parameters can be derived from the estimates of the reduced form parameters, commonly the equation is said to be just identified, over-identified or under-identified, respectively. That is, in the case of under-identification it is impossible to obtain the estimates of some or all parameters, in the case of just-identification, all parameters can be obtained uniquely, while in the case of over-identification, all parameters can be determined.

For instance, consider the specified equation of the above linear structural model, $BY_t + \Gamma X_t = U_t$, and rewriting the model as

$$Y_t = -B^{-1}\Gamma X_t + B^{-1}U_t$$

or

$$Y_t = \Pi X_t + V_t$$

where

$\Pi = -B^{-1}\Gamma$, assume B^{-1} exists

$V_t = B^{-1}U_t$ are the reduced form disturbances,

let

G^{Δ}: the number of endogenous variables included in the particular equation of interest;

$G^{\Delta\Delta}$: the number of endogenous variables excluded in the particular equation of interest;

G: the total number of endogenous variables in the system;

$G = G^{\Delta} + G^{\Delta\Delta}$;

K^*: the number of exogenous variables included in the particular equation of interest;

K^{**}: the number of exogenous variables excluded in the particular equation of interest;

K: the total number of exogenous variables in the system, and

$K =$ $K^{*} + K^{**}$.

In obtaining the reduced form of the model above, where the jointly dependent variables Y_t are expressed as a function of the predetermined variable X_t, the matrices of structural coefficients are computed, and the matrix of reduced form coefficients, Π, can be calculated.

The reduced form of the above equation can be written as

$$\begin{pmatrix} Y_{\Delta} \\ Y_{\Delta\Delta} \end{pmatrix}_t = \begin{pmatrix} \Pi_{\Delta,*} & \Pi_{\Delta,**} \\ \Pi_{\Delta\Delta,*} & \Pi_{\Delta\Delta,**} \end{pmatrix} \begin{pmatrix} X_{*} \\ X_{**} \end{pmatrix}_t + V_t$$

because $B\Pi = -\Gamma$, and for the particular ith equation

$$\therefore \; (\beta_{\Delta},\, 0)_i \begin{pmatrix} \Pi_{\Delta,*} & \Pi_{\Delta,**} \\ \Pi_{\Delta\Delta,*} & \Pi_{\Delta\Delta,**} \end{pmatrix}_i = -(\gamma_{*},\, 0)_i$$

where

β_{Δ}: nonzero coefficients of endogenous variables included in the specified equation

γ_{*}: nonzero coefficient of exogenous variables included in the specified equation

$\Pi_{\Delta,*}$: the reduced form coefficient, associated with endogenous and exogenous variables respectively included in the specified equation

Note, for other partitions of Π, defined in the same fashion, then

$$\beta_\Delta \cdot \Pi_{\Delta,*} = -\gamma_*$$

$$\beta_\Delta \cdot \Pi_{\Delta,**} = 0$$

and from the above two equations, the parameters β_Δ and γ_* can be solved under the necessary and sufficient condition for identification, which is called the rank condition,[1]

$$\rho(\Pi_{\Delta,*}, \Pi_{\Delta,**}) = \rho(\Pi_{\Delta,**}) = G^\Delta-1 \qquad i = 1,2,\ldots,n$$

where ρ denotes "the rank of", and n is the number of equations in the system. That is, there must be at least one nonvanishing determinant of order $G^\Delta-1$ of the reduced form coefficient matrix that corresponds to the included joint determined variables and excluded predetermined variables to guarantee that the equation is identifiable. On the other hand, the necessary condition or the order condition for identifiability is that for any specified equation the number of predetermined variables excluded from that equation must be at least one less than the number of joint determined variables included in the equation. This order condition can be specified in three cases as follows: if,

$K^{**} = G^\Delta-1$ is called just identified

$K^{**}>G^\Delta-1$ is called over identified

$K^{**}<G^\Delta-1$ is called less identified

[1] Henry Theil, Principles of Econometrics (New York: John Wiley and Sons Inc., 1971), pp. 491-493.

In the Thai Rubber Industry Models and the World Rubber Market Model, all equations are tested and found to be all over-identified, so that the structural parameters can be estimated.

Forecasting with Stochastic Models

The objective of forecasting in time series analysis is to estimate the value of a random variable in a future period based on the relationships obtained from sample observations in the past period. Generally, we are dealing with a forecast that is qualified,[1] by assuming that exogenous events must simultaneously have occurred or be given, so it is called the conditional forecast.

The general linear models that are mentioned previously represent the relationships between a set of random endogenous variable, Y, which are the economic variables we wish to explain and forecast and a set of independent variables, X, which are the economic variables that are determined outside the model or known (given) constants. For a model with G endogenous variables and K exogenous variables, the general linear representation of a simultaneous equations econometric system in the matrix form be as:

$$BY + \Gamma X = U$$

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[1]Laurence R. Klein, An Essay on the Theory of Economic Prediction (Chicago: Markham Publishing Co., 1971), p. 13.

where

Y is an endogenous vector of $1 \times G$

X is an exogenous vector of $1 \times K$

U is the stochastic vector $G \times 1$

B is the structural parameter matrix of $G \times G$, associated with the endogenous variables

Γ is the structural parameter matrix of $G \times K$, associated with the exogenous variables.

Given the data on the endogenous variables, Y and the exogenous variables, X, estimated values of the structural parameter B and Γ can be obtained by using some standard statistical inference procedures. Forecasting the effects of changes in the variables that are considered exogenous to the system or particular policy actions may be done by rewriting the structural model as follows:

$$Y = B^{-1}\Gamma X + B^{-1}U$$
$$= \Pi X + V$$

where

$$\Pi = -B^{-1}\Gamma$$
$$V = B^{-1}U$$

This is called the reduced form of the structural model, and is the form of the model used for forecasting purposes. It expresses each of the endogenous variables in terms of all the exogenous variables. The forecasting with econometric models can be done under unchanged structure or changed structure. The former assumes that the structural parameters will remain unchanged for the forecast period.

Hence, to forecast the effect of a change in one of the exogenous variables it is necessary only to obtain the estimates of the reduced form parameters. Forecasting underchanged stru ture poses a more difficult problem in that there is at least one of the structural parameters that will be different in the forecast period than in the estimation period. In this case it is necessary first to have the estimates of structural parameters for the sample period. When the matrices of structural coefficients are obtained, and the hypothesized change in the structural parameter is made, then the matrix of reduced form coefficient, $\hat{\Pi}$ can be calculated. This is called the derived reduced from. To obtain the predictions of each of the jointly dependent variables is to multiply $\hat{\Pi}$ by X, the matrix of predetermined variables. The predictive capability of the entire structural model can be evaluated by comparing these predicted values with the actual values and the accuracy of the forecast could be measured by the U-statistic, where

$$U = \frac{\sqrt{\sum_t (\text{Predicted}_t - \text{Actual}_t)^2}}{\sqrt{\sum_t \text{Predicted}_t^2} \cdot \sqrt{\sum_t \text{Actual}_t^2}}$$

This statistic is used as a measure of an accuracy of the forecast, and is approximately the average percent error of forecast.

The Statistical Analysis

Thai rubber industry

As mentioned in Section 3.1, two econometric models were set up to study the Thai rubber industry, both are models of 8 simultaneous equations, linear in both the parameters and the variables, and all of the stochastic equations in both models are over-identified. Direct estimation of each of the equations in the models with the Ordinary Least Squares (OLS) will yield biased and inconsistent estimates of the parameters,[1] and as a result of over-identification, the Indirect Least Squares (ILS) is also not appropriate.[2] The instrumental variables estimation method is applicable and the method of Two-stage Least Squares (2 SLS) is used to estimate the parameters in the equations in the models for the sake of simplicity and limitation on the computers' program. Annual data for the sample period, 1955-1972, is used.

The world rubber market model

The econometric model of the world rubber market was constructed to study the behavior of demand and supply relationships in the world rubber market. This model consists of 26 behavioral equations and one identity, linear in both the parameters and the variables. The instrumental variables estimation method was used to estimate the

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[1] J. Johnston, Econometric Methods, 2nd Edition, (New York: McGraw-Hill Book Company, 1972), pp. 238-240.

[2] A. S. Goldberger, Econometric Theory, (New York: John Wiley & Sons, Inc., 1964), p. 327.

structural parameters in each equation of the model, using annual data for the sample period of 1955-1972. Due to the small number of time series observations, the direct application of Two-stage Least Squares procedures can not be used. An alternative that could be used would be to estimate the first stage regressions by either factor analysis or principal components.[1] Unfortunately, there was not any available, and so instead the stepwise regression, which was available, was used to select the variables used in estimating the first stage regressions.

In both the Thai and the world rubber models, the t-test is used to test the significance of individual regression coefficients at a certain probability levels by assuming that the error terms are normally distributed. However for the small sample properties of the estimators, the application of t-test is technically incorrect.[2] In spite of this, the standard errors are computed for each of the estimated coefficients for the reliability of the estimates.

The Durbin-Watson (D-W) statistic is used to test for serial correlation in the unexplained residuals. The Durbin-Watson test is inappropriate for testing serial correlation in the equations containing one or more lagged endogenous variables as the explanatory variables. Durbin[3] has developed a test of serial correlation which can be applied

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[1] J. Johnston, op. cit., pp. 327, 392-395.

[2] C. F. Christ, Econometric Models and Methods (New York: Wiley & Sons, Inc., 1958), pp. 515-516.

[3] J. Durbin, "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors are Lagged Dependent Variables", Econometrica 38 (May 1970):410-420.

in such cases. Finally, the values of multiple correlation coefficient (R^2) are presented. The elasticity, the standard error of the regression coefficient, and Sy.x are computed for each structural equation.

The random disturbance term is assumed as follows: (1) to be random real variables, (2) to be independent from any predetermined variables, (3) to be homoscedastic over time, (4) to have an expected value of zero, (5) to not be serially correlated over time and, (6) to be normally distributed.

CHAPTER IV. STATISTICAL RESULTS AND DISCUSSION

The results of the statistical analysis are presented in an overall picture of the estimated coefficients of the models and the results of reduced form simulation of models. Then the discussion of equation specifications for both Thai rubber and the world rubber models will be given in detail later.

Discussion of the Equations in the Models

The discussion of the results of the statistical analysis, presented in the previous section, will focus only on those functions that are concerned with Thai rubber industry (Model II) and the world rubber market such as the supply (production) behavior function, export, domestic consumption, the domestic price of rubber (Bangkok wholesale price), the world rubber price of RSS #1 (New York price) and U.S. imports.

An overall view of the statistical results presented in the previous section shows that most of the variables entered in the equations of the models have coefficients with the expected signs. The R^2 of those equations are quite high, ranging from 0.88 to 0.994 and finally the results of the simulation of all three models for each of the jointly dependent variables had the U-statistics are in the accepted range.

Table 3. Thai rubber industry Model I

$$TAP\ AREA_t = -4453.4834 - 9.4205\ PR\ NR_t^{TH} + 16.5980\ PR\ NR_{t-1}^{TH} + 61.6538\ YLD\ NR_{t-1} + 1.1675\ PLNT\ AREA_{t-8}$$

Std error	1388.5664	12.9142	8.6547	17.4399	0.1572
t-value	(-3.207)	(-0.729)	(1.918)	(3.535)	(7.429)
elasticity	-	0.1052	0.1982	0.9766	1.1301
Sy.x = 223.384			$R^2 = 0.968$		D-W = 1.800

$$PROD\ NR_t^{TH} = 2.7871 + 0.6154\ PR\ NR_t^{TH} + 0.0339\ TAP\ AREA_t + 6.3414\ TIME$$

Std error	28.9239	0.3996	0.0059	1.4337
t-value	(0.096)	(1.540)	(5.762)	(4.423)
elasticity	-	0.1173	0.5787	0.2919
Sy.x = 8.373			$R^2 = 0.985$	D-W = 1.744

$$EXP\ NR_t^{TH} = -53.1260 + 0.9126\ PR\ NR_t^{WLD} - 0.5060\ PR\ NR_t^{TH} + 1.0633\ PROD\ NR_t^{TH} + 0.5273\ CH\text{-}STKS_{t-1}$$

Std error	19.8812	0.7919	1.0613	0.0470	0.2409
t-value	(-2.672)	(1.152)	(-0.477)	(22.602)	(-2.188)
elasticity	-	0.2556	- 0.0991	1.0924	+ 0.0023
Sy.x = 5.060			$R^2 = 0.994$		D-W = 2.529

Table 3 (Continued)

$$CONS\ NR_t^{TH} = 3.7637 - 0.0951\ PR\ NR_t^{TH} + 1.0928\ IMP\ SR_{t-1} + 0.0414\ NO\ FACTY_t$$

Std error	2.5809	0.0325	0.4720	0.9184
t-value	(1.458)	(-2.927)	(2.315)	(2.243)
elasticity	-	0.7950	0.1941	0.8418
Sy.x =	0.888		$R^2 = 0.962$	D-W = 1.372

$$PR\ NR_t^{TH} = 87.7141 - 0.8711\ PROD\ NR_t^{TH} + 0.6650\ EXP\ NR_t^{TH} + 0.6197\ CH\text{-}STKS_{t-1} + 3.2732\ IMP\ SR_{t-1}$$

Std error	8.6840	0.2082	0.2056	0.1933	2.2732
t-value	(10.101)	(-4.184)	(3.235)	(3.205)	(1.444)
elasticity	-	04.5712	3.3968	-0.0138	0.0717
Sy.x =	4.585		$R^2 = 0.898$	D-W = 1.758	

Table 3 (Continued)

$$PR\ NR_t^{WLD} = 82.4887 + 0.044\ CONS\ ELAST_t^{WLD} + 0.0213\ SUP\ NR_t^{WLD} - 1.3925\ RA\text{-}CONS_{t-1}^{WLD}$$

Std error	40.4936	0.0052	0.0177	0.5621
t-value	(2.037)	(0.853)	(1.204)	(-2.477)
elasticity	-	0.4346	0.7343	-1.2922
Sy.x = 6.400		R^2 = 0.891		D-W = 1.930

<u>Continued</u>

$$PR\ NR_t^{WLD} \quad + 0.0372\ CSTKS_{t-1}^{WLD} + 0.2219\ PR\ NR_{t-1}^{WLD}$$

Std error	0.0272	0.2161
t-value	(-2.688)	(1.027)
elasticity	-0.5087	0.2353
Sy.x		

$$CONS\ ELAST_t^{WLD} = 1050.2459 + 5.2106\ PR\ NR_t^{WLD} - 11.7551\ PR\ NR_{t-1}^{WLD} + 112.4349\ TIME + 0.7540\ CONS\ ELAST_{t-1}^{WLD}$$

Std error	933.2795	8.2127	7.6399	€6.1326	0.1447
t-value	(1.125)	(0.634)	(-1.539)	(1.170)	(5.210)
elasticity	-	0.0527	0.1262	-	0.7018
Sy.x = 231.911		R^2 = 0.992		D-W = 2.703	

Table 3 (Continued)

$$SUP\ NR_t^{WLD} = 252.2628 + 8.4838\ PR\ NR_t^{WLD} + 60.8216\ TIME + 0.3504\ SUP\ NR_{t-1}^{WLD}$$

Std error	445.7701	3.9577	10.9384	0.1176
t-value	(0.566)	(2.144)	(5.560)	(2.979)
elasticity	-	0.2460	0.2978	0.3325

Sy.x = 99.322 R^2 = 0.925 D-W = 0.945

Table 4. Thai rubber industry Model II

$$TAP\ AREA_t = -4469.2910 - 8.9783\ PR\ NR_t^{TH} + 16.4903\ PR\ NR_{t-1}^{TH} + 61.4576\ YLD\ NR_{t-1} + 1.1713\ PLNT\ AREA_{t-8}$$

Std error	1382.4602	12.3971	8.6097	17.3651	0.1541
t-value	(-3.233)	(-0.724)	(1.915)	(3.539)	(7.602)
elasticity	-	-0.1002	0.1970	0.9734	1.1347
Sy.x =	223.372		R^2 = 0.968		D-W = 1.806

$$PROD\ NR_t^{TH} = 4.9245 + 0.5912\ PR\ NR_t^{TH} + 0.0335\ TAP\ AREA_t + 6.3591\ TIME$$

Std error	28.2557	0.3885	0.0059	1.4201
t-value	(0.174)	(1.522)	(5.715)	(4.478)
elasticity	-	0.1127	0.5719	0.2917
Sy.x =	8.371		R^2 = 0.985	D-W = 1.733

$$EXP\ NR_t^{TH} = -43.6186 + 1.7184\ (PR\ NR^{WLD} - PR\ NR^{TH})_t + 1.0311\ PROD\ NR_t^{TH} + 0.4647\ CH\text{-}STKS_{t-1}$$

Std error	16.3495	0.5414	0.0344	0.2329
t-value	(-2.668)	(3.174)	(30.002)	(-1.996)
elasticity	-	0.1449	1.0593	0.0020
Sy.x =	5.143	R^2 = 0.994		D-W = 2.558

Table 4 (Continued)

$$CONS\ NR_t^{TH} = 4.0661 - 0.0995\ PR\ NR_t^{TH} + 1.0950\ IMP\ SR_{t-1} + 0.0401\ NO\ FACTY_t$$

Std error	2.5464	0.0319	0.4717	0.0184
t-value	(1.597)	(-3.115)	(2.322)	(2.187)
elasticity	-	-0.8318	0.1945	0.8096

Sy.x = 0.887 $R^2 = 0.962$ D-W = 1.407

$$PR\ NR_t^{TH} = -4.0600 + 0.7675\ PR\ NR_t^{WLD}$$

Std error	1.324	0.0216
t-value	(-3.066)	(35.504)
elasticity	-	1.0980

Sy.x = 1.393 $R^2 = 0.988$ D-W = 1.074

Table 4 (Continued)

$$PR\ NR_{t}^{WLD} = 79.3265 + 0.0038\ CONS\ ELAST_{t}^{WLD} + 0.0232\ SUP\ NR_{t}^{WLD} - 1.3462\ RA\text{-}CONS_{t-1}^{WLD}$$

Std error	40.2998	0.0050	0.0176	0.5487
t-value	(1.968	(0.756)	(1.323)	(-2.453)
elasticity	-	0.3754	0.7998	-1.2493

Sy.x = 6.394 $R^2 = 0.892$ D-W = 1.915

Continued

$$PR\ NR_{t}^{WLD} + 0.0714\ CSTKS_{t-1}^{WLD} + 0.2179\ PR\ NR_{t-1}^{WLD}$$

Std error	0.0264	0.2149
t-value	(-2.709)	(1.014)
elasticity	0.4962	0.2304

Sy.x

$$CONS\ ELAST_{t}^{WLD} = 1032.5891 + 5.4476\ PR\ NR_{t}^{WLD} - 11.8008\ PR\ NR_{t-1}^{WLD} + 112.6115\ TIME + 0.7549\ CONS\ ELAST_{t-1}^{WLD}$$

Std error	923.3999	8.0094	7.6316	66.1161	0.1446
t-value	(1.118)	(0.680)	(-1.546)	(1.703)	(5.221)
elasticity	-	0.5515	1.2666	0.1995	0.7026

Sy-x = 231.902 $R^2 = 0.992$ D-W = 2.703

Table 4 (Continued)

$$SUP\ NR_t^{WLD} = 254.3239 + 8.4646\ PR\ NR_t^{N.Y.} + 60.7870\ TIME + 0.3501\ SUP\ NR_{t-1}^{WLD}$$

Std error	433.3156	3.8350	10.7970	0.1167
t-value	(0.587)	(2.209)	(5.630)	(3.001)
elasticity	-	0.2341	0.2977	0.3322

Sy.x = 99.320 R^2 = 0.925 D-W = 0.944

Table 5. The world rubber market model (statistical results of export country behavior equations)

INDONESIA

$$PROD\ NR_t^{IND} = 401.689 + 0.215\ PR\ NR_t^{IND} - 9.008\ PR\ PRICE_{t-1}^{IND} + 0.376\ PROD\ NR_{t-1}^{IND} + 103.229\ DUM^{IND} + 5.017\ TIME$$

	Constant	$PR\ NR_t^{IND}$	$PR\ PRICE_{t-1}^{IND}$	$PROD\ NR_{t-1}^{IND}$	DUM^{IND}	TIME
Std error	97.001	0.542	22.761	0.121	17.590	2.572
t-value	(4.141)	(0.396)	(-0.396)	(3.114)	(5.869)	(1.951)
elasticity	-	0.0124	-0.01205	0.3749	-	0.0698

Sy.x = 28.609 R^2 = 0.905 D-W = 2.519

$$EXP\ NR_t^{IND} = -74.416 + 0.450\ PR\ NR_t^{WLD} + 1.030\ PROD\ NR_t^{IND}$$

	Constant	$PR\ NR_t^{WLD}$	$PROD\ NR_t^{IND}$
Std error	90.541	0.464	0.098
t-value	(-0.822)	(0.975)	(10.463)
elasticity	-	0.0385	1.0717

Sy.x = 23.222 R^2 = 0.919 D-W = 2.753

Table 5 (Continued)

MALAYSIA

$$PROD\ NR_t^{MAL} = 92.571 + 1.811\ PR\ NR_t^{MAL} - 1.194\ PR\ PALM_{t-1}^{MAL} + 18.972\ TIME + 0.707\ PROD\ NR_{t-1}^{MAL}$$

Std error	254.325	1.841	1.896	8.171	0.155
t-value	(0.364)	(0.984)	(-0.630)	(2.322)	(4.577)
elasticity	-	0.0999	-0.1028	0.1994	0.6805

Sy.x = 40.757 $R^2 = 0.975$ D-W = 1.975

$$EXP\ NR_t^{MAL} = -137.760 + 0.603\ PR\ NR_t^{WLD} + 1.072\ PROD\ NR_t^{MAL} + 0.382\ CSTKS\ NR_{t-1}^{MAL}$$

Std error	67.211	0.523	0.037	0.186
t-value	(-2.050)	(1.153)	(28.895)	(2.051)
elasticity	-	0.0372	1.0631	0.0432

Sy.x = 17.430 $R^2 = 0.995$ D-W = 2.668

SRI LANKA

$$PROD\ NR_t^{SRI} = 51.573 + 0.458\ PR\ NR_t^{SRI} - 10.413\ PR\ TEA_{t-1}^{SRI} + 1.982\ TIME + 0.660\ PROD\ NR_{t-1}^{SRI}$$

Std error	44.647	0.446	7.907	1.347	0.201
t-value	(1.155)	(1.027)	(-1.317)	(1.471)	(3.292)
elasticity	-	0.1658	-0.4096	-	0.6449

Sy.x = 7.176 $R^2 = 0.928$ D-W = 1.799

Table 5 (Continued)

SRI LANKA (Continued)

$$EXP\ NR_t^{SRI} = -11.330 + 0.385\ (PR\ NR^{WLD} - PR\ NR^{SRI})_t + 1.015\ PROD\ NR_t^{SRI}$$

Std error	19.029	0.465	0.116
t-value	(-0.595)	(0.827)	(8.716)
elasticity	-	.0005	1.0478

Sy.x = 8.465 R^2 = 0.880 D-W = 2.750

THAILAND

$$PROD\ NR_t^{TH} = -0.055 + 0.678\ PR\ NR_t^{TH} + 0.034\ TAP\ AREA_t^{TH} + 6.534\ TIME$$

Std error	31.051	0.443	0.034	1.589
t-value	-0.021	(1.520)	(5.476)	(4.113)
elasticity	-	0.1292	0.5805	0.3007

Sy.x = 8.807 R^2 = 0.983 D-W = 1.964

$$EXP\ NR_t^{TH} = -44.196 + 0.465\ PR\ NR_t^{WLD} + 1.049\ PROD\ NR_t^{TH} + 0.371\ CH\text{-}STKS_{t-1}$$

Std error	41.851	0.372	0.095	0.487
t-value	(-1.056)	(1.249)	(11.097)	(-0.762)
elasticity	-	0.1302	1.0777	0.0016

Sy.x = 9.803 R^2 = 0.977 D-W = 2.388

Table 5 (Continued)

<u>THE REST OF THE WORLD</u>

$$EXP\ NR_t^{ROW} = 244.504 + 1.232\ PR\ NR_t^{WLD} - 1.056\ PR\ NR_{t-1}^{WLD} + 55.770\ DUM^{ROW} + 2.314\ TIME$$

Std error	91.388	0.837	0.715	16.355	3.107
t-value	2.675	(1.472)	(-1.478)	(3.410)	(0.745)
elasticity	-	0.2661	0.2418	-	0.0844

Sy.x = 22.063 R^2 = 0.595 D-W = 1.372

Table 6. The world rubber market model (statistical results of import country behavior equations)

AUSTRALIA

$$IMP\ NR_t^{AUS} = 28.5396 + 0.0416\ PR\ NR_t^{WLD} - 0.2134\ PR\ NR_{t-1}^{WLD} - 1.4914\ CSTKS_{t-1}^{AUS} + 0.4754\ CONS\ RR_{t-1}^{AUS}$$

Std error	5.9594	0.0580	0.0521	0.6546	0.3539
t-value	(4.789)	(0.745)	(-4.095)	(-2.2781)	(1.3430)
elasticity	-	0.0646	-0.3513	0.1803	0.1240

Sy.x = 1.564 R^2 = 0.902 D-W = 2.294

Continued

$$IMP\ NR_t^{AUS} + 6.8684\ DUM^{AUS} + 0.6030\ IMP\ NR_{t-1}^{AUS}$$

Std error	2.3750	0.1516
t-value	(2.8920)	(3.977)
elasticity	-	0.6056
Sy.x		

Table 6 (Continued)

CANADA

$IMP\ NR_t^{CA}$ =	73.3762 +	$0.0227\ PR\ NR_t^{WLD}$ -	$0.1873\ PR\ NR_{t-1}^{WLD}$ -	$0.4799\ RA\text{-}CON_{t-1}^{CA}$ -	$0.8937\ PROD\ RR_{t-1}^{CA}$
Std error	25.2337	0.1392	0.1265	0.2382	0.5643
t-value	(2.908)	(0.163)	(-1.481)	(-2.015)	(-1.584)
elasticity	-	0.0303	-0.2647	-0.6993	-0.1757

Sy.x = 3.685 R^2 = 0.829 D-W = 3.100

Continued

$IMP\ NR_t^{CA}$	$+\ 0.0259\ PROD\ AUTO_t^{CA}$
Std error	0.0082
t-value	(3.173)
elasticity	0.4580
Sy.x	

Table 6 (Continued)

FRANCE

$$IMP\ NR_t^{FR} = 115.9215 - 0.2302\ PR\ NR_t^{WLD} + 0.3802\ PR\ NR_{t-1}^{WLD} - 0.9127\ RA\text{-}CONS_{t-1}^{FR} + 0.0228\ PROD\ AUTO_t^{FR}$$

Std error	24.1418	0.2654	0.1782	0.1940	0.0082
t-value	(4.802)	(-0.867)	(2.133)	(-4.705)	(2.777)
elasticity	-	-0.1007	0.1763	-0.3075	0.3064

Sy.x = 5.224 $R^2 = 0.9172$ D-W = 2.269

Continued

$$IMP\ NR_t^{FR} \quad + 0.0677\ PROD\ SR_{t-1}^{FR} + 25.0019\ DUM^{FR}$$

Std error	0.0603	7.0728
t-value	(1.123)	(3.535)
elasticity	0.0587	-

Sy.x

Table 6 (Continued)

ITALY

$$IMP\ NR_{t}^{ITLY} = -27.3107 + 0.0769\ PR\ NR_{t}^{WLD} + 0.4488\ PR\ NR_{t-1}^{WLD} + 0.0181\ PROD\ AUTO_{t}^{ITLY}$$

Std error	24.9607	0.2002	0.1490	0.0089
t-value	(-1.094)	(0.384)	(3.013)	(2.027)
elasticity	-	0.0516	0.3193	0.2310

Sy.x = 4.815 $R^2 = 0.975$ D-W = 1.940

Continued

$$IMP\ NR_{t}^{ITLY} \quad + 0.4083\ IMP\ NR_{t-1}^{ITLY} + 0.7816\ GDP_{t}^{ITLY}$$

Std error	0.2244	0.4268
t-value	(1.820)	(1.832)
elasticity	0.3887	0.3186

Sy.x

Table 6 (Continued)

JAPAN

$$IMP\ NR_t^{JAP} = 70.8620 + 0.3119\ PR\ NR_t^{WLD} - 0.0365\ PR\ NR_{t-1}^{WLD} + 1.0035\ RA\text{-}CONS_{t-1}^{JAP} - 0.7883\ CSTKS\ NR_{t-1}^{JAP}$$

	Constant	$PR\ NR_t^{WLD}$	$PR\ NR_{t-1}^{WLD}$	$RA\text{-}CONS_{t-1}^{JAP}$	$CSTKS\ NR_{t-1}^{JAP}$
Std error	48.0605	0.5165	0.3421	1.1658	0.7682
t-value	(1.474)	(0.604)	(-0.107)	(0.861)	(-1.026)
elasticity	-	0.0872	-0.0108	0.1742	0.1125

Sy.x = 11.1515 $R^2 = 0.980$ D-W = 2.382

Continued

$$IMP\ NR_t^{JAP} \quad + 0.0186\ PROD\ AUTO_t^{JAP} + 0.3347\ IMP\ NR_{t-1}^{JAP}$$

	$PROD\ AUTO_t^{JAP}$	$IMP\ NR_{t-1}^{JAP}$
Std error	0.0076	0.3890
t-value	(2.445)	(0.860)
elasticity	0.2109	0.3160

Sy.x

Table 6 (Continued)

REP OF CHINA

$$IMP\ NR_t^{CH} = 104.1913 + 0.6797\ PR\ NR_t^{WLD} - 0.9804\ PR\ NR_{t-1}^{WLD} + 0.6043\ CONS\ SR_{t-1}^{CH}$$

Std error	44.6587	0.7207	0.6371	0.5743
t-value	(2.333)	(0.943)	(-1.539)	(1.052)
elasticity	-	0.2850	-43.5912	0.0948

Sy.x = 18.136 R^2 = 0.926 D-W = 2.727

Continued

$$IMP\ NR_t^{CH} \quad + 0.3381\ IMP\ NR_{t-1}^{CH} + 48.0825\ DUM^{CH}$$

Std error	0.1500	12.8296
t-value	(2.254)	(3.748)
elasticity	0.3185	-

Sy.x

REST OF THE WORLD

$$IMP\ NR_t^{ROW} = 179.4478 - 0.4841\ PR\ NR_t^{WLD} - 0.3180\ PR\ NR_{t-1}^{WLD} + 0.7799\ IMP\ NR_{t-1}^{ROW}$$

Std error	176.3864	1.2542	1.1137	0.2282
t-value	(1.017)	(-0.386)	(-0.286)	(3.417)
elasticity	-	-0.0538	-0.0375	0.7547

Sy.x = 40.246 R^2 = 0.784 D-W = 2.326

Table 6 (Continued)

SPAIN

$$IMP\ NR_t^{SP} = 57.1098 - 0.3090\ PR\ NR_t^{WLD} - 0.1379\ PR\ NR_{t-1}^{WLD} + 0.6765\ PROD\ SR_{t-1}^{SP} + 0.0178\ PROD\ AUTO_t^{SP}$$

Std error	13.0852	0.1352	0.1056	0.1232	0.0169
t-value	(4.364)	(-2.286)	(-1.306)	(5.489)	(1.053)
elasticity	-	0.4474	0.2117	0.1538	0.1097

Sy.x = 3.389 $R^2 = 0.980$ D-W = 2.361

UNITED KINGDOM

$$IMP\ NR_t^{UK} = 330.9570 + 0.3060\ PR\ NR_t^{WLD} + 0.3780\ PR\ NR_{t-1}^{WLD} - 3.0811\ CSTKS\ NR_{t-1}^{UK}$$

Std error	67.4021	0.6001	0.3310	0.8283
t-value	(4.910)	(0.510)	(1.142)	(-3.720)
elasticity	-	0.1027	0.1345	-0.4865

Sy.x = 11.049 $R^2 = 0.816$ D-W = 1.857

Continued

$$IMP\ NR_t^{UK} - 1.3036\ GRS\ NR_{t-1}^{UK} - 0.0488\ PROD\ SR_{t-1}^{UK} - 2.4514\ PROD\ RR_{t-1}^{UK}$$

Std error	0.2683	0.0948	0.6391
t-value	(-4.858)	(-0.515)	(-3.838)
elasticity	0.0431	-0.0380	0.5450

Sy.x

Table 6 (Continued)

UNITED STATES

$$IMP\ NR_{t}^{US} = 994.8585 - 1.6965\ PR\ NR_{t}^{WLD} - 0.7911\ PR\ NR_{t-1}^{WLD} - 5.3509\ RA\text{-}CONS_{t-1}^{US}$$

Std error	258.1619	0.9109	0.9423	2.9072
t-value	(3.854)	(-1.862)	(-0.840)	(-1.841)
elasticity	-	-0.2089	-0.1033	-0.7940

$Sy.x$ = 25.218 $R^2 = 0.948$ D-W = 1.857

Continued

$$IMP\ NR_{t}^{US} + 0.0232\ PROD\ AUTO_{t}^{US} - 1.1120\ GRS\ NR_{t-1}^{US} - 0.5041\ PROD\ RR_{t-1}^{US}$$

Std error	0.0082	0.2449	0.2449
t-value	(2.822)	(-4.541)	(-2.059)
elasticity	0.4208	-0.1302	-0.2772)

Sy.x

Table 6 (Continued)

SOVIET UNION

$$IMP\ NR_t^{USSR} = -4.6047 + 0.1125\ PR\ NR_t^{WLD} + 1.4538\ PR\ NR_{t-1}^{WLD} + 1.6322\ RA\text{-}CONS_{t-1}^{USSR}$$

Std error	68.2101	0.9090	0.8388	1.7076
t-value	(-0.068)	(0.124)	(1.732)	(0.956)
elasticity	-	0.0267	0.3694	0.0729

Sy.x = 27.6802 R^2 = 0.905 D-W = 2.302

Continued

$$IMP\ NR_t^{USSR}\ 1.3120\ IMP\ SR_{t-1}^{USSR} + 0.4074\ IMP\ NR_{t-1}^{USSR} + 60.2098\ DUM^{USSR}$$

Std error	0.8269	0.1022	10.2480
t-value	(1.587)	(3.987)	(5.875)
elasticity	0.1190	0.3874	-

Sy.x

Table 6 (Continued)

WEST GERMANY

$$IMP\ NR_t^{W.GER} = 105.7140 + 0.2575\ PR\ NR_t^{WLD} - 0.1559\ PR\ NR_{t-1}^{WLD} - 0.9381\ RA\text{-}CONS_{t-1}^{W.GER}$$

Std error	30.0465	0.2877	0.3238	0.6257
t-value	(3.518)	(0.895)	(-0.481)	(-1.499)
elasticity	-	0.095335	-0.061199	-0.271704

Sy.x = 5.945 $R^2 = 0.9466$ D-W = 1.8018

Continued

$$IMP\ NR_t^{W.GER} + 0.0327\ PROD\ AUTO_t^{W.GER} - 0.7400\ CSTKS_{t-1}^{W.GER} - 0.4315\ PROD\ RR_{t-1}^{W.GER} + 2.2766\ CONS\ (SR+RR)_{t-1}^{W.GER}$$

Std error	0.0089	1.028	0.3535	2.5570
t-value	(3.659)	(-0.720)	(-1.221)	(0.890)
elasticity	0.536463	-0.072667	-0.101133	2.276599

Sy.x

Table 7. The world rubber market model (statistical result of world price and consumption)

$$PR\ NR_t^{WLD} = 121.5414 + 0.0067\ CONS\ ELAST_t^{WID} - 1.4998\ RA\text{-}CONS_{t-1}^{WLD} - 0.0674\ CSTKS\ NR_{t-1}^{WLD}$$

Std error	31.1769	0.0048	0.6104	0.0294
t-value	(3.898)	(1.380)	(-2.457)	(-2.290)
elasticity	-	0.6619	1.3918	0.4684

Sy.x = 6.670 $R^2 = 0.870$ D-W = 1.650

<u>Continued</u>

$$PR\ NR_t^{WLD} \quad + 0.1416\ PR\ NR_{t-1}^{WLD}$$

Std error	0.2191
t-value	(0.646)
elasticity	0.1501
Sy.x	

$$CONS\ ELAST_t^{WLD} = 633.2150 + 6.7128\ PR\ NR_t^{WLD} - 3.5581\ PR\ NR_{t-1}^{WLD} + 0.5212\ CONS\ ELAST_{t-1}^{WLD} + 213.5052\ TIME$$

Std error	1486.5371	13.1490	11.6240	0.2213	101.6062
t-value	(0.426)	(0.511)	(-0.306)	(2.356)	(2.101)
elasticity	-	0.0679	0.0382	0.4851	0.3649

Sy.x = 355.021 $R^2 = 0.980$ D-W = 1.899

Table 7 (Continued)

PRICE RELATIONSHIPS:

INDONESIA

$$PR\ NR_t^{IND} = -30.8717 + 1.4489\ PR\ NR_t^{WLD}$$

Std error	13.6907	0.2236
t-value	(-2.255)	(6.479)
elasticity	-	1.5604

Sy.x = 14.263 $R^2 = 0.737$ D-W = 1.973

MALAYSIA

$$PR\ NR_t^{MAL} = -3.9128 \div 0.9669\ PR\ NR_t^{WLD}$$

Std error	2.1912	0.0358
t-value	(-1.786)	(27.015)
elasticity	-	1.073

Sy.x = 2.283 $R^2 = 0.980$ D-W = 1.974

Table 7 (Continued)

SRI LANKA

$$PR\ NR_t^{SRI} = 0.2867 + 0.7396\ PR\ NR_t^{WLD}$$

Std error	4.3243	0.0706
t-value	(0.066)	(10.472)
elasticity	-	0.9934

Sy.x = 4.505 $R^2 = 0.880$ D-W = 1.470

THAILAND

$$PR\ NR_t^{TH} = -4.0848 + 0.7679\ PR\ NR_t^{WLD}$$

Std error	2.1492	0.0351
t-value	(-1.901)	(21.875)
elasticity	-	1.0987

Sy.x = 2.239 $R^2 = 0.970$ D-W = 1.847

Table 8. Actual and forecast values of endogenous variables from reduced form analysis of Thai rubber industry Model I

Year		$TAP\ AREA_t$	$PROD\ NR_t^{TH}$	$EXP\ NR_t^{TH}$	$CONS\ NR_t^{TH}$	$PR\ NR_t^{TH}$	$PR\ NR_t^{WLD}$	$SUP\ NR_t^{WLD}$	$CONS\ ELAST_t^{WLD}$
1956	F[a]	2455.777	135.357	134.835	0.520	59.173	80.872	1659.471	2810.465
	A[b]	2495.000	136.700	135.700	1.000	58.660	80.140	1654.300	3012.500
1957	F	2368.139	136.004	128.580	0.734	54.760	71.099	1616.942	3087.425
	A	2495.000	142.000	135.000	1.000	51.580	69.290	1697.500	3160.000
1958	F	2417.637	141.577	135.481	1.564	50.775	66.492	1653.797	3414.608
	A	2480.000	149.600	139.600	1.000	47.170	64.930	1737.900	3260.000
1959	F	2552.604	152.602	152.951	2.328	50.930	71.150	1768.276	3677.966
	A	2473.000	161.000	173.000	1.000	61.230	84.550	1862.000	3752.500
1960	F	3058.589	177.669	168.995	1.601	53.406	73.610	1543.407	3943.934
	A	2871.000	171.800	169.900	1.000	63.080	87.530	1742.600	3930.000
1961	F	3288.624	187.808	185.249	2.255	46.863	67.954	1864.451	4126.698
	A	3449.000	186.100	184.600	1.55	46.580	66.920	1857.900	6112.500
1962	F	3349.570	195.054	190.602	2.698	44.965	64.844	1939.248	4601.802
	A	3449.000	195.400	193.900	1.500	43.130	65.110	1831.100	4467.500
1963	F	3472.132	204.690	200.835	3.176	43.547	64.046	1983.919	4999.025
	A	3400.000	198.300	186.800	5.000	40.430	60.110	1805.700	4670.000
1964	F	3552.189	212.040	212.798	3.461	40.763	63.295	2029.479	5319.005
	A	3622.000	210.600	216.600	5.000	40.110	59.390	1908.400	5825.000

[a]F - *forecast values of endogenous variable.*

[b]A - actual values of endogenous variable.

Table 8 (Continued)

Year		$TAP\ AREA_t$	$PROD\ NR_t^{TH}$	$EXP\ NR_t^{TH}$	$CONS\ NR_t^{TH}$	$PR\ NR_t^{TH}$	$PR\ NR_t^{WLD}$	$SUP\ NR_t^{WLD}$	$CONS\ ELAST_t^{WLD}$
1965	F	3852.448	225.152	204.198	4.470	35.172	45.595	1976.070	6218.532
	A	3677.000	217.400	211.400	5.000	40.870	59.310	1986.100	6187.000
1966	F	4094.456	237.891	226.106	5.537	32.197	46.183	2069.076	6607.921
		3635.000	218.100	202.100	5.000	37.790	53.250	2040.400	6677.000
1967	F	4144.753	234.749	236.218	6.623	28.630	42.685	2119.231	7142.823
	A	3845.000	219.300	209.200	6.000	28.880	43.880	2115.800	6805.000
1968	F	3779.376	238.986	226.911	7.167	30.774	43.209	2210.890	7464.644
	A	3845.000	258.200	251.800	7.000	31.110	44.230	2348.200	7650.000
1969	F	4439.972	268.132	255.587	8.971	31.335	43.706	2357.269	8212.685
	A	4642.000	285.100	274.800	8.000	38.640	57.230	2607.700	8267.501
1970	F	5201.848	296.097	284.314	9.950	24.376	37.073	2452.642	8603.335
	A	5072.000	289.000	279.200	9.000	29.980	43.550	2505.800	8617.501
1971	F	5348.364	306.949	288.265	12.309	23.611	29.200	2410.999	9099.447
	A	5766.000	318.000	307.300	12.500	22.871	33.640	2527.700	9237.501
1972	F	5939.553	332.567	315.782	13.160	22.272	30.272	2488.585	9801.441
	A	5842.000	337.000	324.400	13.700	21.750	33.900	2485.600	9840.001
U^c		0.026	0.024	0.032	0.070	0.056	0.061	0.027	0.015

^{c}U - the U-statistic.

Table 9. Actual and forecast values of endogenous variables from reduced form analysis of Thai rubber industry Model II

Year		$TAP\ AREA_t$	$PROD\ NR_t^{TH}$	$EXP\ NR_t^{TH}$	$CONS\ NR_t^{TH}$	$PR\ NR_t^{WLD}$	$PR\ NR_t^{TH}$	$CONS\ ELAST_t^{WLD}$	$SUP\ NR_t^{WLD}$
1956	F[a]	2449.441	136.362	137.405	6.449	83.365	59.964	2824.511	1680.947
	A[b]	2495.000	136.700	135.700	1.000	80.140	58.660	3012.500	1654.300
1957	F	2388.600	136.331	133.347	0.973	73.846	52.654	3101.441	1640.726
	A	2495.000	142.000	135.000	1.000	69.290	51.580	3160.000	1697.500
1958	F	2430.447	142.169	140.449	1.734	69.563	49.364	3430.120	1680.378
	A	2480.000	149.600	139.600	1.000	64.930	47.170	3260.000	1737.900
1959	F	2532.854	154.237	156.241	2.125	74.469	53.132	3696.413	1796.832
	A	2473.000	161.000	173.000	1.000	84.550	61.230	3752.500	1862.000
1960	F	2977.008	181.140	178.529	0.734	86.462	62.343	4014.664	2002.563
	A	2871.000	171.800	169.900	1.000	87.530	63.080	3930.000	1742.600
1961	F	3248.274	190.112	188.436	1.874	71.897	51.157	4146.769	1898.281
	A	3449.000	186.100	184.600	1.500	66.920	46.580	4112.500	1857.900
1962	F	3315.304	197.516	194.569	2.339	69.180	49.070	4625.584	1976.426
	A	3449.000	195.400	193.900	1.500	65.110	43.130	4467.500	1831.100
1963	F	3428.142	207.462	204.604	2.718	68.630	48.648	5024.583	2023.179
	A	3400.000	198.300	186.800	5.000	60.110	40.430	4670.000	1805.700
1964	F	3485.585	251.535	215.740	2.775	68.103	48.243	5346.216	2070.616
	A	3622.000	210.600	216.600	5.000	59.390	40.110	5825.000	1908.400

[a]F - forecast values of endogenous variable.

[b]A - actual values of endogenous variable.

Table 9 (Continued)

Year		$TAP\ AREA_t$	$PROD\ NR_t^{TH}$	$EXP\ NR_t^{TH}$	$CONS\ NR_t^{TH}$	$PR\ NR_t^{WLD}$	$PR\ NR_t^{TH}$	$CONS\ ELAST_t^{WLD}$	$SUP\ NR_t^{WLD}$
1965	F	3923.051	224.331	205.750	5.332	40.703	27.200	6190.073	1585.432
	A	3677.000	217.400	211.400	5.000	59.310	40.870	6187.000	1986.100
1966	F	4059.929	240.435	232.404	5.251	51.920	35.814	6638.047	2118.354
	A	3635.000	218.100	202.100	5.000	53.250	37.790	6677.000	2040.400
1967	F	4098.362	246.678	242.241	6.227	48.784	33.406	7175.041	2171.608
	A	3845.000	219.300	209.200	6.000	43.880	28.880	6805.000	2115.800
1968	F	3748.989	241.539	234.068	6.892	49.623	34.050	7499.435	2265.883
	A	3845.000	258.200	251.800	7.000	44.230	31.110	7650.000	2348.200
1969	F	4405.186	270.699	262.377	8.657	50.703	34.880	8251.775	2417.151
	A	4642.000	285.100	274.800	8.000	57.230	38.640	8267.501	2607.700
1970	F	5146.375	299.536	291.065	9.424	44.705	30.273	8644.507	2517.749
	A	5072.000	289.000	279.200	9.000	43.550	29.980	8617.501	2505.800
1971	F	5342.407	309.069	297.132	12.284	37.014	24.367	9140.908	2478.024
	A	5766.000	318.000	307.300	12.500	33.640	22.870	9237.501	2527.700
1972	F	5915.351	335.535	323.759	12.895	38.394	25.427	9846.087	2558.159
	A	5842.000	337.000	324.400	13.700	33.900	21.750	9840.001	2485.600
U[c]		0.025	0.025	0.032	0.074	0.056	0.063	0.015	0.036

[c]U - the U-statistic.

Table 10. *Actual and forecast values of endogenous variables from reduced form analysis of the world rubber market model*

Year		PROD NR_t^{IND}	EXP NR_t^{IND}	PROD NR_t^{MAL}	EXP NR_t^{MAL}	PROD NR_t^{SRI}	EXP NR_t^{SRI}	PROD NR_t^{TH}	EXP NR_t^{TH}	EXP NR_t^{ROW}
1956	F[a]	698.208	682.557	687.096	695.940	92.306	90.625	138.040	139.563	252.295
	A[b]	686.670	668.700	686.560	678.600	95.400	86.800	136.700	135.700	222.400
1957	F	682.119	662.477	677.180	677.766	89.068	86.563	140.533	138.380	260.337
	A	684.520	666.500	698.390	699.700	98.200	94.000	142.000	135.000	239.300
1958	F	683.821	661.901	694.476	694.856	101.461	98.625	143.873	141.711	267.760
	A	685.200	649.600	722.020	725.300	100.200	90.400	149.600	139.600	274.800
1959	F	689.099	669.436	748.810	760.471	104.983	102.664	152.587	154.114	280.398
	A	704.620	692.200	772.080	806.700	93.200	93.500	161.000	173.000	269.500
1960	F	603.642	584.884	813.059	808.723	100.780	99.167	176.649	174.737	271.447
	A	620.250	586.500	785.400	775.300	98.900	106.400	171.800	169.900	274.400
1961	F	678.048	655.837	824.183	817.418	103.407	100.574	196.285	194.625	255.118
	A	682.180	677.200	814.690	805.500	97.500	89.500	186.100	184.600	285.600
1962	F	698.300	675.470	856.732	851.134	104.757	101.673	201.407	198.397	275.781
	A	681.240	660.200	818.350	792.200	104.100	101.800	195.400	193.900	276.900
1963	F	597.473	571.343	383.222	889.516	109.469	106.394	205.958	202.883	279.329
	A	581.960	561.000	865.120	866.850	104.800	95.000	198.300	186.800	283.000
1964	F	673.932	649.904	934.468	938.045	115.621	112.597	219.818	219.623	286.400
	A	648.370	627.400	870.730	887.000	111.600	115.300	210.600	216.600	278.800

[a]F - forecast values of endogenous variable.

[b]A - actual values of endogenous variable.

Table 10 (Continued)

Year		PROD NR_t^{IND}	EXP NR_t^{IND}	PROD NR_t^{MAL}	EXP NR_t^{MAL}	PROD NR_t^{SRI}	EXP NR_t^{SRI}	PROD NR_t^{TH}	EXP NR_t^{TH}	EXP NR_t^{ROW}
1965	F	702.541	673.190	926.286	922.289	116.103	111.716	221.102	208.116	216.857
	A	716.470	708.500	916.940	919.200	118.300	123.600	217.400	211.400	234.800
1966	F	735.727	707.301	965.707	963.575	123.391	119.098	226.126	217.761	274.832
	A	736.680	679.900	972.840	965.500	131.000	124.900	218.100	202.100	269.700
1967	F	745.942	716.558	1032.440	1038.165	134.890	130.490	238.345	232.977	335.872
	A	700.830	651.600	990.450	990.300	143.400	135.600	219.300	209.200	336.400
1968	F	734.996	705.343	1066.538	1086.980	148.612	144.431	244.945	237.356	292.469
	A	793.910	770.900	1100.280	1114.300	148.700	144.700	258.200	251.800	317.900
1969	F	876.728	850.962	1173.667	1192.207	148.120	143.850	278.158	270.082	293.420
	A	880.430	857.400	1268.010	1292.000	150.800	141.600	285.100	274.800	315.200
1970	F	811.734	780.702	1298.352	1318.082	151.708	146.758	295.491	285.910	272.965
	A	815.160	790.100	1269.200	1304.100	159.200	154.100	289.000	279.200	257.500
1971	F	797.530	763.987	1290.995	1327.051	155.381	150.024	323.220	312.271	284.046
	A	819.310	789.300	1518.520	1356.000	141.400	137.800	318.000	307.300	244.500
1972	F	804.697	771.963	1345.930	1391.089	146.060	140.696	333.023	322.190	298.444
	A	773.660	733.900	1304.150	1331.200	140.400	138.300	337.000	324.400	282.100
U[c]		0.015	0.021	0.019	0.021	0.026	0.031	0.018	0.024	0.034

[c]U - the U-statistic.

Table 10 (Continued)

Year		IMP NR_t^{AUS}	IMP NR_t^{CA}	IMP NR_t^{FR}	IMP NR_t^{ITLY}	IMP NR_t^{JAP}	IMP NR_t^{CH}	IMP NR_t^{SP}	IMP NR_t^{UK}	IMP NR_t^{US}
1956	F[a]	36.607	42.826	140.140	63.644	122.695	84.684	18.527	189.246	525.859
	A[b]	37.100	43.300	133.800	57.600	111.100	75.500	18.000	176.000	568.000
1957	F	34.656	41.280	132.889	56.794	132.484	54.708	23.141	200.667	564.407
	A	34.000	42.600	138.600	59.000	130.500	56.800	27.100	215.400	542.900
1958	F	36.110	41.024	127.293	54.899	137.535	103.629	26.552	140.803	461.699
	A	34.800	37.400	135.000	55.100	129.400	97.300	23.600	147.700	457.700
1959	F	38.497	40.500	126.565	54.237	142.540	125.291	25.875	187.919	560.329
	A	38.400	46.000	122.300	57.000	160.200	110.500	21.900	169.100	566.400
1960	F	36.488	37.129	130.567	68.880	167.780	118.491	20.843	208.196	503.278
	A	37.300	35.300	131.600	68.800	172.500	121.800	22.400	139.700	404.700
1961	F	28.994	33.336	124.780	77.769	180.622	69.097	24.778	81.345	338.478
	A	28.700	32.000	125.300	79.700	185.700	83.800	22.700	155.500	391.200
1962	F	35.133	38.128	124.706	78.035	186.786	121.412	28.936	177.812	464.982
	A	35.000	37.800	121.800	79.800	193.000	108.500	33.700	153.700	419.600
1963	F	38.574	39.944	127.123	85.225	197.047	122.884	29.818	166.531	372.404
	A	38.000	35.900	125.600	87.900	187.900	109.300	33.300	157.600	367.500
1964	F	39.906	40.761	121.802	86.037	212.317	127.614	31.514	171.391	412.142
	A	41.000	43.000	126.500	89.200	214.900	144.300	34.100	186.400	419.400

Table 10 (Continued)

Year		IMP NR_t^{AUS}	IMP NR_t^{CA}	IMP NR_t^{FR}	IMP NR_t^{ITLY}	IMP NR_t^{JAP}	IMP NR_t^{CH}	IMP NR_t^{SP}	IMP NR_t^{UK}	IMP NR_t^{US}
1965	F	39.735	46.145	123.291	89.615	218.915	147.461	36.724	169.931	460.438
	A	40.200	45.400	119.900	83.200	207.300	139.800	36.200	191.200	416.300
1966	F	37.555	46.795	132.015	92.892	223.080	147.421	38.760	180.301	415.907
	A	35.200	49.700	128.800	86.000	229.100	172.500	42.500	180.800	389.300
1967	F	38.256	47.235	128.866	97.309	238.993	165.533	41.801	188.753	352.100
	A	38.700	44.600	131.700	100.600	243.000	159.800	40.200	183.500	418.400
1968	F	39.884	48.858	127.257	103.925	263.017	221.611	50.382	197.132	472.972
	A	42.700	46.900	125.900	99.100	257.700	211.800	51.200	193.600	508.000
1969	F	43.697	53.173	162.986	105.945	280.888	241.317	61.878	192.903	551.869
	A	42.600	50.100	160.300	108.000	280.900	275.000	54.900	197.400	572.200
1970	F	39.766	46.505	154.519	124.344	290.413	199.886	69.167	186.500	432.971
	A	39.500	52.100	161.300	127.800	292.200	181.800	67.300	193.300	543.200
1971	F	41.583	56.025	157.718	129.089	297.667	181.676	75.119	191.297	593.828
	A	40.000	52.700	154.400	134.000	315.900	165.300	79.000	188.300	599.000
1972	F	45.143	58.030	160.049	132.215	298.815	188.215	83.807	177.864	617.304
	A	45.400	60.700	159.800	128.000	292.000	187.500	86.600	170.900	592.600
U^C		0.014	0.033	0.014	0.021	0.019	0.049	0.036	0.075	0.042

Table 10 (Continued)

Year	$IMP\ NR_t^{USSR}$	$IMP\ NR_t^{W.GER}$	$IMP\ NR_t^{ROW}$	$CONS\ ELAST_t^{WLD}$	$PR\ NR_t^{IND}$	$PR\ NR_t^{MAL}$	$PR\ NR_t^{WLD}$	$PR\ NR_t^{SRI}$	$PR\ NR_t^{TH}$
1956 F	152.518	130.253	413.358	2823.406	90.367	76.996	83.670	62.203	60.174
A	114.500	130.400	390.000	3012.500	77.120	73.520	80.140	71.280	58.660
1957 F	106.811	133.213	424.543	3067.600	79.120	69.490	75.908	56.459	54.213
A	120.500	135.700	447.100	3160.000	51.830	64.600	69.290	54.090	51.580
1958 F	213.614	136.549	471.929	3361.971	71.652	64.507	70.755	52.645	50.255
A	236.000	132.200	466.300	3260.000	67.730	60.550	64.930	45.440	47.170
1959 F	256.830	144.321	486.005	3674.261	78.38	68.997	75.398	56.081	53.820
A	255.000	146.200	452.200	3752.500	92.600	76.780	84.550	61.280	61.230
1960 F	177.493	153.087	465.031	4126.042	89.499	76.417	83.071	61.760	59.714
A	177.400	153.100	520.600	3930.000	94.110	81.040	87.530	59.630	63.080
1961 F	290.760	141.036	523.577	4336.985	71.273	64.254	70.494	52.452	50.054
A	340.200	135.900	534.300	4112.500	79.560	62.130	62.990	47.840	46.580
1962 F	358.757	147.683	542.123	4700.467	67.343	61.631	67.781	50.445	47.971
A	345.700	142.800	521.100	4467.500	87.440	58.260	65.110	46.850	43.130
1963 F	262.360	162.080	532.712	5101.526	66.460	61.042	67.172	49.994	47.503
A	280.000	152.100	582.800	4670.000	61.430	54.200	60.110	44.550	40.430
1964 F	165.301	165.494	582.626	5435.476	65.845	60.631	66.747	49.680	47.176
A	162.300	165.600	495.800	5825.000	40.530	52.220	59.390	44.180	40.110

Table 10 (Continued)

Year		IMP NR_t^{USSR}	IMP $NR_t^{W.GER}$	IMP NR_t^{ROW}	CONS $ELAST_t^{WLD}$	PR NR_t^{IND}	PR NR_t^{MAL}	PR NR_t^{WLD}	PR NR_t^{SRI}	PR NR_t^{TH}
1965	F	241.282	161.947	521.606	6161.498	46.029	47.407	53.072	39.560	36.674
	A	248.100	169.700	495.500	6187.000	77.530	52.840	59.310	44.290	40.870
1966	F	287.925	166.294	521.435	6562.834	45.802	47.255	52.915	39.444	36.553
	A	283.100	161.400	521.700	6677.000	19.070	47.840	53.250	42.130	37.790
1967	F	267.800	142.898	545.205	7034.439	41.753	44.553	50.120	37.376	34.407
	A	253.100	142.900	506.000	6805.000	16.740	38.830	43.880	35.600	28.880
1968	F	312.497	168.399	535.853	7348.837	41.938	44.677	50.248	37.471	34.506
	A	325.900	172.500	552.200	7650.000	33.620	38.440	44.230	33.060	31.110
1969	F	270.409	193.017	572.160	7995.933	40.771	43.898	49.442	36.874	33.887
	A	295.000	193.900	599.700	8267.501	52.780	49.370	57.230	38.160	38.640
1970	F	340.727	196.723	608.620	8435.625	30.137	36.801	42.104	31.444	28.251
	A	316.500	203.200	636.400	8617.501	33.950	37.910	43.550	31.640	29.980
1971	F	265.546	198.733	643.827	8849.220	23.457	32.344	37.494	28.032	24.710
	A	246.100	196.000	656.700	9237.501	23.070	30.670	33.640	25.660	22.870
1972	F	227.005	194.940	662.223	9429.839	25.362	33.615	38.808	29.005	25.720
	A	231.100	186.400	683.500	9846.001	25.120	27.960	33.900	24.030	21.750
U^C		0.041	0.015	0.032	0.020	0.138	0.045	0.045	0.049	0.050

Tapping area

Tapping area of rubber in Thailand is hypothesized to be a function of the domestic price of rubber in both current price and a one year lag of domestic price, the yield of rubber lagged one year, and the total planted area of rubber lagged eight years. The results of the statistical analysis for the equation of the tapping area are as follows:

$$TAP\ AREA_t = -4469.2910 - 8.9783\ PR\ NR_t^{TH} + 16.4903\ PR\ NR_{t-1}^{TH}$$

Std error	1382.4602	12.3971	8.6097
t-value	(3.233)	(0.724)	(1.915)
elasticity	-	-0.1002	0.1970

continued

$$TAP\ AREA_t \quad + 61.4576\ YLD\ NR_{t-1} + 1.1713\ PLNT\ AREA_{t-8}$$

Std error	17.3651	0.1514
t-value	(3.539)	(7.602)
elasticity	0.9734	1.1347

TAP AREA is the tapped area, $PR\ NR^{TH}$ is the domestic price of rubber, YLD NR is the rubber yield, and PLNT AREA is the planted area of rubber.

All the variables entered in this equation have coefficients with the expected sign, except for the current price which still is a matter of some controversy. Chan[1] indicated that the negative coefficient of

[1] F. K. W. Chan, op. cit., pp. 83-84.

a current rubber supply price was carried out through a replanting scheme rather than through a more intensive tapping or an increase in tapping area. Furthermore, the target income theory might be applied to those peasants who only work as hard as necessary to earn the projected cash target above subsistance. However, intuitively, current price should have a positive effect on tapping area. From the numerical analysis, the magnitude of the standard error of price coefficient and its t-value, indicates a price coefficient not significantly differs from zero. Hence, tapping area is in fact price inelastic. The lagged price was found to have greater influence than current price upon tapped area with a significantly positive sign, suggesting that the planter had planned to tap in advance on the basis of price information which they had at that time, under the limitation of technology and hired labor inputs.[1] J. R. Behrman found that an expected yield is one of the factors that influenced the change in the tappable area decision. As the result of the analysis, lagged yield gave a positively significant effect on tapping area in the following year. However, the lagged yield elasticity of tapping area is 0.9734 which suggests that tappable area is slightly elastic with respect to lagged yield.

According to Lok[2] in his study on the financial evaluation of a simulated rubber replanting scheme for Southern Thailand, the period

[1]A. J. Speirs, op. cit., p. 33.

[2]Siepko H. Lok, A Financial Evaluation of a Simulated Rubber Replanting Scheme for Southern Thailand, Rubber Research Center, Hat Yai, Thailand, 1974, p. 24.

for immaturity of rubber was 6-7 years. Stifel,[1] in his paper on rubber and the economy of southern Siam also found that where there was poor maintenance and even temporary abandonment of the stands, the periods of immaturity were longer than 6-8 years for plantation rubber. The period of immaturity is therefore not exactly fixed but it depends on many factors such as maintenance and soil fertility. Therefore, the eight year lag of planted area exhibited the most effect on tapping area, its coefficient being 1.1713. The elasticity of the 8 year lagged of planted area is 1.1347.

Rubber production in Thailand

Rubber production in Thailand is hypothesized to be a function of the domestic price of rubber in Bangkok, the tapping area, and the time trend that captures the technological progress such as the high yield clones, fertilizer, communication, etc. The result of the statistical analysis for the equation of the rubber production is as follows:

$$PROD\ NR_t^{TH} = 4.9245 + 0.5912\ PR\ NR_t^{TH} + 0.0335\ TAP\ AREA_t + 6.3591\ TIME$$

Std error	28.2557	0.3885	0.005	1.4201
t-value	(0.174)	(1.522)	(5.715)	(4.478)
elasticity		0.1127	0.5719	0.2917

[1] Laurence D. Stifel, "Rubber and the Economy of Southern Siam", A paper presented to a meeting of the Siam Society, Thailand on September,24, 1970, p. 4.

where PROD NR^{TH} is the production of natural rubber, PR NR^{TH} is the domestic price of rubber, TAP AREA is the tapping area, and TIME is the time trend.

All the variables in this function have coefficients with the expected sign and the equation has very high R^2 (0.985). The price coefficient is 0.5912 with a positive sloping supply schedule. However, the price elasticity of this supply schedule is about 0.1127, indicating of an inelastic production response. This means that an increase in rubber prices of 10 percent will be associated with an increase in rubber production only 1.127 percent, other things remain unchanged. There might be limitations in the factor inputs such as labor, capital, technology which are mostly immobile in the rural area. Because of limitations in alternative sources of income for their labor, the hired tappers or smallholders are forced to increase output rather than to decrease it to maintain a constant cash income flow when rubber prices decreased, and when rubber prices increase, they produce less just to maintain their income at a satisfactory level. However, Speirs,[1] in his study of the smallholders in Thailand, found that the target income theory does not appear to hold for smallholders who claim to produce the same weight of rubber sheet irrespective of low or high prices. Thus their income fluctuates proportionally with the market price for rubber. For low rubber prices of the recent past, the smallholders have looked for other sources of cash income to supplement their income from rubber. Usually they have grown rice.

[1] A. J. Speirs, op. cit., pp. 22-23.

Another opinion is that the smallholders' supply naturally is highly price elastic because in the smallholdings' rubber production, almost no purchased inputs are used. There are still productive idle plots and the alternative sources of income are usually available for the smallholders' labor. Therefore, the supply of smallholders have a potential to respond to the price changes almost immediately. For example, tapping of rubber trees may fall off when the prices drop and intensive tapping can be done when the prices go up.

However, the positively sloping supply schedule of the total rubber output from this analysis implies that the multiculture of smallholders still prevail in Thailand, even when the availability of alternative sources of income of the peasants' labor is still limited. Hence the rubber production in Thailand is price responsive with an inelastic supply schedule.

It is also hypothesized that rubber production is influenced by the tapped area. The results show that the tapped area has a coefficient with the expected positive sign of 0.0335 and significantly differs from zero. The elasticity of tapped area is 0.5719 which means that a 10 percent increase in tapped area will induce the rubber production to increase by 5.7 percent, other things remain unchanged. This high response shows that tapping area is the main factor of production and it is quite true for immobility of the other factors.

Finally, the time trend or technological improvement such as tapping methods, replanting with high yield clones, fertilizer, communication, etc., shows a positively significant effect on rubber output.

The coefficient of the trend is 6.3591, indicating of an increase about 6359 tons of rubber produced each year, other things remain unchanged due to the technological improvement relative to the previous year.

Exporters' demand of Thai rubber

The export demand of Thai rubber is hypothesized to be a function of the difference between the world rubber price and the domestic price of rubber, the total production of rubber in Thailand, and the change of rubber stocks at the end of the year. The statistical results of the export demand of Thai rubber are as follows:

$EXP\ NR_t^{TH}$ =	-43.6186	$+ 1.7184\ (PR\ NR^{WLD} - PR\ NR^{TH})_t$	$+ 1.0311\ PROD_t^{TH}$
Std error	16.3495	0.5414	0.0344
t-value	(-2.668)	(3.174)	(30.002)
elasticity		0.1449	1.0593

continued

$EXP\ NR_t^{TH}$	$+ 0.4647\ CH\text{-}STKS_{t-1}$
Std error	0.2329
t-value	(-1.996)
elasticity	0.0020

$EXP\ NR^{TH}$ is export demand, $(PR\ NR^{WLD} - PR\ NR^{TH})$ is the difference in the price of rubber in New York from that in Bangkok, and CH-STKS is a change in stocks.

The coefficients of all variables in the above equation have the expected signs. The coefficient of the price difference of rubber has a positive sign, denoting that the higher the price difference is, the higher the quantity of rubber will be needed for export by exporters, other things remain unchanged. That is, Thai rubber has a positively sloping export supply schedule to the world market, which means that the exporters will try to export more when the price difference is greater. The coefficient of the price difference is 1.7184, indicating that a 10 percent increase in price difference will induce the export quantity to increase by 17 percent, other things remain unchanged.

However, the elasticity of export with respect to the price difference is 0.1449, indicating an inelastic export supply. This result is somewhat surprising but it is quite possible for an imperfectly competitive market[1] in which only four big firms exported up to 78 percent of the total exports in 1972. Theoretically, the logic of using the price difference will have some advantages of the reduction in possible multicollinearity problems and also for saving "scarce" degree of freedom.

Moreover, the other version of export demand function was set up in Model I by fitting the world rubber price and the domestic price as separate regressors. The coefficients of the world rubber price and the domestic rubber prices are + 0.9126 and - 0.5060, respectively, with the expected signs. Although the price of rubber in the world market had the expected positive sign and significantly influenced export supply, the price elasticity of supply is only 0.256 which is practically zero, denoting an inelastic supply. An acceptable explanation of this

[1]Laurence D. Stifel, 1976, op. cit., p. 634.

inelastic supply of primary products such as rubber, was developed by Tan.[1] He argued that the price elasticity of export supply is composed of four components: the price elasticity of production, the price elasticity of domestic consumption, the price elasticity of inventory decumulation, and the price elasticity of the import for re-export purposes. This can be derived as follows:

Given E = quantity exported;

Q = quantity produced;

C = quantity of domestic consumption;

S = quantity of inventory decumulated;

I = quantity imported for re-export,

as E = Q - C + S + I, and let p be the price of rubber, then

$$\frac{\partial E}{\partial P} = \frac{\partial Q}{\partial P} - \frac{\partial C}{\partial P} + \frac{\partial S}{\partial P} + \frac{\partial I}{\partial P}$$

$$\frac{\partial E}{\partial P}\cdot\frac{P}{E} = \frac{\partial Q}{\partial P}\cdot\frac{P}{E}\cdot\frac{Q}{Q} - \frac{\partial C}{\partial P}\cdot\frac{P}{E}\cdot\frac{C}{C} + \frac{\partial S}{\partial P}\cdot\frac{P}{E}\cdot\frac{S}{S} + \frac{\partial I}{\partial P}\cdot\frac{P}{E}\cdot\frac{I}{I}$$

$$= q\cdot\frac{Q}{E} - c\cdot\frac{C}{E} + s\cdot\frac{S}{E} + i\cdot\frac{I}{E} \qquad (1)$$

where

$$\eta = \frac{\partial E}{\partial P}\cdot\frac{P}{E} = \text{price elasticity of export supply}$$

$$q = \frac{\partial Q}{\partial P}\cdot\frac{P}{Q} = \text{price elasticity of production}$$

$$c = \frac{\partial C}{\partial P}\cdot\frac{P}{C} = \text{price elasticity of domestic consumption}$$

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[1]Referred by I. B. Teken, op. cit., pp. 95-96.

$s = \frac{\partial S}{\partial P} \cdot \frac{P}{S}$ = price elasticity of inventory decumulation

$i = \frac{\partial I}{\partial P} \cdot \frac{P}{I}$ = price elasticity of imported for re-exported

If one makes the following assumptions: 1) the rubber price's rate of change in Bangkok and in the world market are the same; 2) Thailand has inadequate storage facilities to hold inventory in case of slumps and decumulate them in times of rising prices;[1] and 3) import for re-export of rubber in Thailand is zero; then the components left in Tan's formula are the price elasticity of production and domestic consumption only. By substituting numerical values of those unknown in Equation (1), the price elasticity of export supply was found to be η[2] = 0.09631 which is not significantly different from zero. That is, a 10 percent increase in price will cause the export to go up by only 1 percent.

The coefficient of rubber production is approximately unity with the expected positive sign and it is highly significant, indicating that the higher the production is, the larger the quantity of Thai rubber to be proportionally exported. The elasticity of export with respect to the production was quite high, suggesting that the quantity of export responded greatly to the total rubber production. This was

[1] Laurence Stifel, 1976, p. 635.

[2] $\eta = 0.1127 \times \frac{217.2705}{211.4881} - 0.8318 \times \frac{4.9529}{211.4881} + 0 + 0$

$= 0.1127 \times 1.02734 - 0.8318 \times 0.02341$

$= 0.11578 - .01947 = .09631 \approx 0.1.$

quite true for Thailand where most of the production was exported with only about 5-6 percent consumed domestically. Because of inadequate storage and financial capital, export was the main channel for Thai rubber marketing.

The coefficient of the one year lag of change-stock[1] of rubber is +0.4647, it is significantly different from zero with the expected sign. However, the elasticity of change-stock due to export is negligible, being only 0.002, showing very little response in export with respect to the one year lagged of change stock. It is quite possible that the absolute quantity of change stock is only a small portion of the total quantity of rubber produced, because the Thai rubber industry has insufficient capital and facility to stock.

Domestic consumption of rubber in Thailand

The domestic rubber consumption in Thailand is hypothesized to be a function of the domestic price of rubber, RSS #1, in Bangkok, the import of synthetic rubber lagged one year, and the number of rubber products factories. The statistical results of the domestic consumption in Thai rubber are as follows:

$$CONS\ NR_t^{TH} = 4.0661 - 0.0995\ PR\ NR_t^{TH} + 1.0950\ IMP\ SR_{t-1} + 0.0401\ NO\ FACTY_t$$

Std error	2.5464	0.0319	0.4717	0.0184
t-value	(1.597)	(-3.115)	(2.322)	(2.187)
elasticity		0.8318	0.1945	0.8097

[1]See page 33.

where CONS NR^{TH} is the quantity of rubber consumed domestically, PR NR^{TH} is the price of rubber RSS #1 in Bangkok, IMP SR is the import quantity of synthetic rubber and NO FACTY is the number of rubber products factories.

All the coefficients have the expected signs. The coefficient of the domestic price of rubber has a negative sign, indicating that the higher domestic price of rubber is, the less the quantity of rubber will be consumed, other things remain unchanged. That is, Thai rubber has a negative sloping demand schedule in the domestic market. The coefficient of the domestic price is -0.0995 and is significantly different from zero which indicates that an increase in the domestic price of rubber by one cent will induce about 100 tons less quantity of rubber to be consumed. The price elasticity of that demand for domestic consumption is -0.8318 which denotes a slightly elastic demand schedule.

The coefficient of the lagged import of synthetic rubber is 1.095 and is significantly different from zero which implies that there is a lag in the response to rubber consumption due to the importation of synthetic rubber. Also the domestic consumption of natural rubber in Thailand had a positive response to the lagged import of synthetic rubber, suggesting that the utilization of natural rubber and synthetic rubber in Thailand have a complementary relationship rather than being substitutes. Horowitz[1] also found that the natural rubber and synthetic

[1] Ira Horowitz, op. cit., p. 334.

rubber used in the U.S. likely were complements. Pasaribu[1] found that positively sloping supply and demand schedules of natural rubber in the world market and also that the price of natural rubber has a positive relationship with the price of synthetic rubber. The elasticity of domestic consumption with respect to the import lagged of synthetic rubber is about 0.1945, suggesting that an increase in 10 percent of synthetic rubber imported in the previous year will increase consumption of natural rubber in the current year by only about 2 percent. It is not as strong a response as the lagged import of synthetic rubber on the consumption of the natural rubber. The reasons might be the limitation in technology and the limitation on the final rubber products' market.

Finally, the coefficient of the number of rubber product factories has an expected positive sign and is about 0.0401, showing that an increase in rubber product factories brings an increase in consumption of natural rubber by 40 metric ton per year. The elasticity of the domestic consumption with respect to the number of factories is 0.8096 which is slightly elastic.

Domestic price of natural rubber in Model I

The domestic price of natural rubber in Thailand is hypothesized to be a function of total rubber production, the quantity to be exported for natural rubber, the change in stocks of rubber lagged in one

[1]Referred by I. B. Teken, op. cit., pp. 88-94.

year and a one year lag for the import of synthetic rubber. The statistical results are as follows:

$PR\ NR_t^{TH}$ =	87.7141	$- 0.8711\ PROD\ NR_t^{TH}$	$+ 0.6650\ EXP\ NR_t^{TH}$
Std error	8.6840	0.2082	0.2056
t-value	(10.101)	(-4.184)	(3.235)
elasticity		-4.5712	3.3968

<u>continued</u>

$PR\ NR_t^{TH}$	$+ 0.6197\ CH\text{-}STKS_{t-1}$	$+ 3.2732\ IMP\ SR_{t-1}$
Std error	0.1933	2.2732
t-value	(3.205)	(1.444)
elasticity	0.0138	0.0717

where $PR\ NR^{TH}$ is the domestic price, $PROD\ NR^{TH}$ is the quantity of rubber produced, $EXP\ NR^{TH}$ is the quantity of rubber exported, CH-STKS is the change in stocks of rubber and IMP SR is the quantity imported of the synthetic rubber.

All the coefficients have the expected signs. The coefficient of the production is -0.8711, the negative sign indicating that an increase in the production of rubber will bring down the price of natural rubber in the domestic market, assuming other things remain unchanged. The elasticity of production with respect to the domestic price is about -4.5712 which indicates a very high elasticity in the domestic price schedule. In the study of Thai rubber market structure, Stifel[1] found that at the exporter level, there is a high degree of

[1] Laurence D. Stifel, 1976, op. cit., pp. 633-634.

market concentration by a few firms clearly established as paramount that tend to dominate most major markets. Their social homogeneity and control of the essential processing capacity appears to represent the classic structural conditions for monopsonistic power. Therefore, the rubber price is changed drastically with respect to the change in the rubber output.

The quantity of natural rubber exported has the coefficient with an expected positive sign and significantly different from zero, showing that an increase in exporters' demand for export will push up the domestic price of natural rubber.

The elasticity of domestic price with respect to the quantity of exports is 3.3968, denoting an elastic response in export quantity. This means that an increase in the quantity of export by 10 percent will result in an increase of the domestic price about 34 percent, assuming other things remain unchanged.

The coefficient of the change in stocks of rubber lagged is -0.6197 which is an expected negative sign significantly different from zero. This means that an increase in the left-over of rubber stock in the previous year will push down the domestic price of natural rubber in the current year. However, the elasticity of the change in stocks lagged is only 0.0138, indicating an inelastic response of domestic price to change in stocks lagged. This is due to the fact that the amount of the change stock of rubber in Thai rubber industry is a very small proportion of the quantity of rubber produced or exported, so the response of domestic prices to change in stocks lagged is quite negligible.

The coefficient of a one year lag of import of synthetic rubber is 3.2732 and is significantly different from zero. An expected positive sign of the coefficient of lagged import of synthetic rubber will help in confirming the complementary nature of synthetic rubber with natural rubber in Thailand. This means that the more the imports of synthetic rubber are, the more natural rubber in the country will be consumed. Therefore, the domestic price of rubber will tend to increase as a one year lag of the import of synthetic rubber increase. However, the elasticity of domestic price with respect to the lagged import of synthetic rubber is about 0.0717 which denotes an inelastic response. It is quite possible that there are limited uses of the synthetic rubber as the fixed ratios to the natural rubber for producing of general rubber products. Therefore, the response of the domestic price of natural rubber to the lagged import of synthetic rubber is negligible.

Domestic price of natural rubber in Model II

The domestic price of rubber in Thailand is hypothesized to be a function of the rubber price in the world market. The result of the statistical analysis for the domestic price of rubber is as follows:

$$PR\ NR_t^{TH} = -4.0600 + 0.7675\ PR\ NR_t^{WLD}$$

Std error	1.324	0.0216
t-value	(-3.066)	(35.504)
elasticity		1.098

where $PR\ NR^{TH}$ is the domestic price of rubber and $PR\ NR^{WLD}$ is the rubber price in the world market.

The coefficient of the world price has an expected positive sign of about 0.7675 which is significantly different from zero. That is, the domestic price responds positively to the world rubber price. The elasticity of domestic price with respect to the world rubber price is 1.098 which denotes an elastic response of the domestic price to the world rubber price. In practice, the rubber price in the producing countries is announced in the late morning from Singapore, then after studying the daily demand and supply of rubber in the consuming countries the demand prices of rubber in New York and London markets will be announced at noon and finally, the closing price of rubber will be announced in the late afternoon from Singapore. To study rubber market structure in Thailand, Stifel[1] hypothesized the Thai rubber price as a function of Singapore rubber price, the Singapore Thai exchange rate, and the index of freight rates. Using monthly data for the period of 1969-1972 for RSS #3, he also found a highly significant relationship between Thai rubber price and Singapore price.

<u>The world rubber price of RSS #1</u>

The world rubber price is hypothesized to be a function of the world supply of natural rubber, a one year lag of the ratio of consumption of the synthetic rubber to the consumption of elastomer, the commercial stock of natural rubber in the world market lagged one year,

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[1]Laurence D. Stifel, 1976, op. cit., p. 638.

the total consumption of elastomer, and the world rubber price lagged. The statistical analysis for the equation of the world rubber price is as follows:

$PR\ NR_t^{WLD}$ =	79.3265	+ 0.023 $SUP\ NR_t^{WLD}$	- 1.3462 $RA\text{-}CONS_{t-1}^{WLD}$	- 0.0714 $CSTKS_{t-1}^{WLD}$
Std error	40.2998	0.0176	0.5487	0.0264
t-value	(1.968)	(1.323)	(-2.453)	(-2.709)
elasticity		0.7998	-1.2493	0.4962

continued

$PR\ NR_t^{WLD}$	+ 0.2179 $PR\ NR_{t-1}^{WLD}$	+ 0.0038 $CONS\ ELAST_t^{WLD}$
Std error	0.2149	0.005
t-value	(1.014)	(0.756)
elasticity	0.2304	0.375

All the variables entered in the equation have coefficients with the expected signs. The coefficient of the supply of natural rubber in the world market has a positive sign, denoting that the higher the price of natural rubber in the world market is, the higher the quantity of natural rubber will be supplied (exported), other things remaining unchange. Therefore, the world supply of natural rubber has a positive sloping export supply schedule in the world market.

Although the supply of natural rubber in the world market has indeed the expected positive sign in an export supply function of the world market, the supply elasticity is about 0.7998 which denotes a slightly inelastic supply schedule. Generally, there is considerable agreement among scholars concerning the inelastic supply of primary products, especially natural rubber.

The coefficient of the lag of the consumption ratio of synthetic rubber to elastomer has an expected negative sign, and it is significantly different from zero. This variable tends to reflect the effect of synthetic substitution (or technological improvement on manufacturing processes for rubber products) upon the demand for natural rubber. Therefore, an increase in the consumption ratio will depress the price of natural rubber. The above coefficient indicates that the greater technological improvement is, the lower the price of natural rubber in the world market. Due to the fact that the advantages of synthetic rubber to natural rubber were large, e.g., the price of synthetic rubber has remained relatively low and stable, a shorter period in the processes of production, etc.

The elasticity of the world rubber price with respect to the consumption ratio of synthetic rubber to elastomer is -1.2493, denoting an elastic response of the rubber price to technological improvement, i.e., a 10 percent increase in the manufacturing processes will decrease the natural rubber price by about 12.5 percent.

The lagged commercial stock of the natural rubber in the world market reflects the effect of natural rubber inventories on the price of natural rubber. It is hypothesized that the higher the beginning inventories in the preceding year, the lower the price manufacturers are willing to pay for imports of natural rubber. The coefficient of this commercial stock lagged is -0.0714 with the expected negative sign and is significantly different from zero. The magnitude of the coefficient indicates that each 1000 tons decrease of the commercial stock at the beginning of the year will result in about 0.07 U.S. cents increase in price of rubber in the world market, other things remaining unchanged. The elasticity coefficient of lagged commercial stock is 0.4962 which shows an inelastic of the world rubber price with respect to the lagged commercial stock. This might be the result of a decrease in the world tension and the existence of a strong synthetic rubber industry that causes commercial stock to have less influence on the world market.

The coefficient of lagged price has a positively expected sign about 0.2179 and is significantly different from zero which implies that there is a lag in the response to the current price for decision-making by the rubber traders. In practice, in world rubber trading price expectations of future trading have a strong influence on the quantity of rubber to be sold; it is called the "paper rubber sales"[1] in which the rubber dealers buy and sell the rubber in advance without having it on hand. The quantity and the time that natural rubber has to be shipped are fixed for a specific time in the future at a specified price for that moment which is the expected price for traders. Therefore, the lagged price should have an influence on the current or future price. However, the elasticity of the lagged is only 0.2304, indicating

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[1]Joan Wilson, The Singapore Rubber Market (Singapore: Eastern University Press, 1958), p. 50.

an inelastic response of the current price to the lagged price. Due to the fact that "the paper sales" are not on a large scale compared to the total amount of rubber sales, a one year lag of price gives only a very rought figure for making a decision on the current price or future price.

The consumption of elastomer in this price function has a coefficient with an expected positive sign. The standard error of the coefficient strongly suggests that the coefficient is not significantly different from zero, indicating that this demand for elastomer consumption is, in fact, perfectly inelastic rather than positively sloping.

The world supply of natural rubber

The supply of natural rubber is hypothesized to be a function of the world rubber price, supply lagged and a time trend. The result of the statistical analysis is as follows:

$$SUP\ NR_t^{WLD} = 254.3239 + 8.4646\ PR\ NR_t^{WLD} + 60.7870\ TIME + 0.3501\ SUP\ NR_{t-1}^{WLD}$$

Std error	443.3239	3.8350	10.7970	0.1167
t-value	(0.587)	(2.209)	(5.630)	(3.001)
elasticity		0.2341	0.2977	0.3322

All the variables entered in the equation have coefficients with the expected signs. From the above result it can be seen that the world supply of natural rubber has a positively sloping supply schedule with respect to its price. However, the price elasticity of this supply is 0.2341 which is inelastic, i.e., a 10 percent increase in natural rubber price will stimulate the supply to go up by only 2.3 percent. The result of an inelastic supply of rubber has been supported by many research studies such as Teken[1] who found the price elasticity of export supply of Indonesia at the mean values of prices and quantities to be about 0.11. The price elasticity of export supply of Malayan rubber estimated by Stern,[2] was rather close to the export supply elasticity of Thai rubber, about 0.14. Horowitz,[3] in his study of supply and demand of synthetic rubber in the U.S. market, found an inelastic export supply of natural rubber entering the U.S. market with the elasticity, about 0.47.

The coefficient of the trend in the equation is 60.7870 with an expected positive sign and is highly significant difference from zero. This means that each year the export supply from all producing countries other than Thailand is increasing by 60,787 tons, other things remaining constant, due to the technological improvement.

The coefficient of the world supply lagged has an expected positive sign and is significantly different from zero. The elasticity of supply lagged is 0.3322, showing an inelastic supply of natural rubber with respect to a one year lag of supply. That is, a 10 percent increase in the previous year supply of natural rubber will result in only about a 3 percent increase in rubber supply of the current year, other things remaining unchanged.

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[1] I. B. Teken, op. cit., p. 90.

[2] R. M. Stern, op. cit., p. 321.

[3] Ira Horowitz, op. cit., p. 334.

<u>The world elastomer consumption</u>

The world elastomer consumption is hypothesized to be a function of the world rubber price in both the current and lagged price, a time trend, and the elastomer consumption lagged one year. The statistical results of analysis are as follows:

$$\text{CONS ELAST}^{WLD}_{t} = 1032.5891 + 5.4476\ \text{PR NR}^{WLD}_{t} - 11.8008\ \text{PR NR}^{WLD}_{t-1}$$

Std error	923.3999	8.0094	7.6316
t-value	(1.118)	(0.680)	(1.546)
elasticity		0.5515	1.2666

<u>continued</u>

$$\text{CONS ELAST}^{WLD}_{t} + 0.7549\ \text{CONS ELAST}^{WLD}_{t-1} + 112.6115\ \text{TIME}$$

Std error	0.1446	66.1161
t-value	(5.221)	(1.703)
elasticity	0.7026	0.1995

CONS ELAST^{WLD} is the total quantity of the elastomer consumption, PR NR^{WLD} is the price of natural rubber in the world market and TIME is the time trend.

The price of rubber in this equation has a coefficient with the expected positive sign, but the standard error of the coefficient suggests that the coefficient is not significantly different from zero. This indicates that this demand consumption function is, in fact, perfectly inelastic rather than positively sloping; all other variables in the equation have coefficients with the expected signs.

The coefficient of the lagged price has an expected negative sign and is highly significantly different from zero, showing a strong effect of a lagged price on current consumption. This means that it takes one year for consumers to adapt their consumption behavior or change the manufacturing process. Other possibilities are that the consumers likely buy rubber a year in advance due to the market channels of the rubber trade. The calculated lagged price elasticity of the demand for consumption of elastomer is 1.2666, indicating that the consumption demand schedule is quite elastic with respect to the lagged price. A 10 percent decrease in the RSS #1 price will result in an increase in consumption of elastomer in the next year by 12.6 percent.

The coefficient of the lagged consumption of elastomer has an expected positive sign and is significantly different from zero. This means that the quantity of elastomer consumed in the previous year still influences the consumption of elastomer in the current year. The elasticity of lagged consumption is 0.7026, i.e., an increase in last year's consumption of 10 percent will result in an increase of consumption in the current year of 7 percent.

The coefficient of the trend is 112.6115 and is significantly different from zero. This indicates that each year 112,611 tons more quantity of elastomer is being consumed, other things remaining unchanged, due to the technological improvement in the manufacturing processes of final rubber products. However, the elasticity of this technology change is about 0.2 which indicates that total elastomer consumption is inelastic with respect to technological change.

The import demand of natural rubber in the U.S.

The import demand of natural rubber in the U.S. is hypothesized to be a function of the world rubber prices in both current and lagged prices, the ratio of consumption of synthetic rubber to consumption of elastomer in the U.S., the quantity of automobiles produced in the U.S., the U.S. government releases from strategic stockpiles of natural rubber, and the production of reclaimed rubber in the U.S. The results of the statistical analysis of the U.S. import demand of natural rubber are as follows:

$$\text{IMP NR}_t^{US} = 994.8585 - 1.6965\ \text{PR NR}_t^{WLD} - 0.7911\ \text{PR NR}_{t-1}^{WLD} - 5.3509\ \text{RA-CONS}_{t-1}^{US}$$

Std error	258.1619	0.9109	0.9423	2.9072
t-value	(3.854)	(-1.862)	(-0.840)	(-1.841)
elasticity		-0.2089	-0.1033	-0.7940

continued

$$\text{IMP NR}_t^{US} \quad + 0.0232\ \text{PROD AUTO}_t^{US} - 1.1120\ \text{GRS}_{t-1}^{US} - 0.5041\ \text{PROD RR}_{t-1}^{US}$$

Std error	0.0082	0.2449	0.2449
t-value	(2.822)	(-4.541)	(-2.059)
elasticity	-0.420	-0.1302	-0.2772

where IMP NR^{US} is the quantity of rubber imported to the U.S., PR NR^{WLD} is the world rubber price of RSS #1, RA-CONS^{US} is the consumption ratio of synthetic rubber to elastomer in the U.S., PROD AUTO^{US} is the production of automobiles in the U.S., GRS^{US} is the U.S. government releases from strategic stockpiles of rubber, and PROD RR^{US} is the quantity of production of reclaimed rubber in the U.S.

All the coefficients of variables in the equation have their expected signs. The price of rubber in this equation has a coefficient with an expected negative sign about 1.6965. The standard error of the coefficient or the t-value statistic strongly shows that the coefficient is significantly different from zero, indicating that this import demand equation in the U.S. is negatively sloping. A one cent decrease in RSS #1 price was associated with a 1696.5 tons increase in natural rubber imported to the U.S. The calculated price elasticity of import demand for rubber in the U.S. market is 0.2089, which implies that the demand for rubber in the U.S. market is price inelastic. This might be true for the U.S. which is the world's largest producer and consumer of synthetic and reclaimed rubbers which can substitute for natural rubber, and where the demand for natural rubber is just a derived demand. Knorr,[1] in his study of the rubber market before the war and the entrance of synthetic rubber into the market, had the opinion that the short-term price elasticity of demand for rubber in all rubber articles is very slight. Wharton[2] suggested that one would assume the world demand for rubber is price inelastic in the short-run, since this demand is a derived demand for the raw material input which usually constitutes a small proportion of the value of the final product. Hence, the price of natural rubber may increase by an appreciable amount without causing any significant

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[1] K. R. Knorr, World Rubber and its Regulation, (Stanford, Calif.: Stanford University Press, 1945), pp. 71-78.

[2] C. R. Wharton Jr., op. cit., p. 133.

change in the cost of the article concerned. McHale[1] considered rubber as a minor material import in an automobile, less than 4-5 percent of the total weight, and rarely exceeding the same percentage of the total cost. The absolute quantity of rubber demand grew with the increase in car production. Therefore, a price elastic demand for natural rubber in the world market is possible. However, there is considerable disagreement among scholars concerning the price elasticity of demand for rubber. Horowitz,[2] in his study of supply and demand of the synthetic rubber industry in the U.S., expresses the opinion that the demand for natural rubber should be price elastic by assuming that the U.S. demand for natural rubber is infinitely elastic, because in his model, the U.S. demand schedule for natural rubber is hypothesized to be horizontal in the price-quantity plane. Tan[3] also expresses an opinion of the unlikelihood of an inelastic demand for natural rubber in the world market, since rubber is a storable commodity and synthetic rubber can be very well-substituted for natural rubber. FAO[4] also says that natural rubber is characterized by a high price elasticity of demand over most of the price range and there are extensive possibilities of substitution between natural rubber and synthetic elastomers, in some

[1]T. R. McHale, "Changing Technology and Shifts in the Supply and Demand for Rubber, An Analytical History", The Malayan Economic Review 9, No. 2 (October 1964):p. 31.

[2]Ira Horowitz, op. cit., pp. 389, 334-335.

[3]Referred by I. B. Teken, p. 84.

[4]FAO, 1964, op. cit., pp. 10-106.

cases through the replacement of one elastomer by another, and in others, by varying the proportions of different elastomers in mixtures.

The coefficient of lagged price has an expected negative sign which is not significantly different from zero, indicating an inelastic demand of import with respect to the lagged price. Also, the calculated elasticity of the demand for rubber in the U.S. market is 0.1033 which is very inelastic, which shows that the demand for rubber in the U.S. market is not strongly related to the past price.

The coefficient of the consumption ratio of synthetic rubber to elastomer in the U.S. has expected negative signs of 5.3509 which is significantly different from zero. This means that an increase of one unit in the ratio of consumption or technological change is associated with a reduction in natural rubber imports of 5350 tons. Thus, as the synthetic rubber's share of the market increases, natural rubber imports are expected to decrease. Such reductions in natural rubber imports result from the substitution of synthetic rubber for natural rubber. Improving techniques in the synthetic rubber industry will result in an increase in synthetic rubber's share of the market which causes the consumption ratio to increase.

The elasticity of the consumption ratio is -0.794, indicating a slightly inelastic response of the U.S. imports to technological change. This means that a 10 percent increase in technological improvement in the synthetic rubber industry will result in a reduction of import demand by 8 percent.

The coefficient of automobile production is 0.0232 with an expected positive sign and is significantly different from zero. This means that an increase of 1,000 automobiles produced in the U.S. will result in an increase of demand for rubber of about 23.2 tons in natural rubber imports. The elasticity of import with respect to the production of automobiles, computed at the means of the variables, indicates that a 10 percent increase in the production of automobiles is associated with 4.2 percent increase in natural rubber imports, and if there is no major breakthrough in the use of synthetic rubber for heavy duty tires in the near future, natural rubber imports can be expected to increase in order to meet the demand from manufacturers of heavy duty tires.

The negative coefficient of GRS seems to support the claim made by the FAO concerning the detrimental effects of stockpile releases on manufacturers' decisions to import. This coefficient is -1.1120 which indicates that a one thousand tons release of rubber from the government stockpile is associated with a 1,112 tons decrease in natural rubber imports. Certainly, one thousand tons from stockpiles cannot replace 1120 tons of natural rubber imports. Perhaps the deficit in natural rubber import is made up by the domestic production of synthetic rubber. However, the elasticity of stockpile release is 0.13, indicating an inelastic response with respect to these releases of stockpiles which occur irregularly in a small amount compared to the quantity of rubber imported.

CHAPTER V. SUMMARY AND CONCLUSIONS

Summary

As mentioned before, natural rubber is the main source of foreign exchange earnings in Thailand. It is the principle source of income for people in the southern region of the country and the future of the economy of the Southern provinces depends heavily on the rubber prices. Because of downwardly wide fluctuations in the earnings from rubber, the economic problem is whether or not rubber can be relied on, and what an appropriate policy should be.

The objective of this study is focused on the Thai rubber industry and moderately on the world rubber marekt. It is an attempt to investigate the Thai rubber industry in a comprehensive and quantitative nature such as trying to identify the economic variables that influence both the demand and supply sides, the prices of natural rubber in both domestic and world rubber markets, and also to measure the production, imports, exports, consumption, and price relationships for the period of 1955-1972. Another objective is to make conditional simulations of those jointly determined variables in the models. Two models are formulated to explain the Thai rubber industry. Each contains 8 simultaneous equations and one identity in which the production, export, consumption, and prices, are jointly determined. The estimation of these two models were done by the method of two-stage least squares (2SLS). The world rubber market model was constructed to explain the import demand and the export supply of the major consuming and producing countries in the world, respectively, and also the domestic price of each producing country and the world rubber prices. It contains 27 simultaneous equations and one identity in which imports, exports, and the prices of natural rubber are jointly determined. This model was also estimated by the method of two-stage least squares (2SLS). The data used in the estimation were obtained from various issues of United Nations publications, various issues of agricultural statistics from the Division of Agricultural Economics, and the rubber statistics were obtained from the Rubber Research Center, Ministry of Agriculture and Co-operatives in Thailand.

For the Thai rubber industry, the structural parameters estimated from the two models are only slightly different. The price elasticities of tapped area, production, and export supply of rubber from Thailand are 0.1052, 0.1173 and 0.2556, respectively, which for all practical purposes are perfectly inelastic.

Tapped area is significantly influenced by the eight year lag of planted area and is significantly affected by a one year lag of rubber yield. However, tapped area is only slightly influenced by the domestic prices.

There is an increasing trend over time in rubber production and the quantity of rubber produced is directly influenced by the tapped area which is a significant rightward shifter of the rubber supply, while the elasticity of production with respect to tapped area is 0.579, indicates an inelastic effect. The domestic price also exhibited a significant effect on rubber produced. The quantity of rubber exported is strongly affected by physical production that shifted the export supply schedule to the right. The elasticity of export with respect to rubber production is 1.0924 which is slightly elastic. Also, the world rubber price and the price difference of rubber in the world and the domestic markets showed a significant effect on the quantity exported.

The consumption of natural rubber in the country is almost elastic with respect to the domestic price, the price elasticity of consumption being 0.795. The quantity of rubber consumption is also significantly influneced by the number of rubber products factories and the quantity of synthetic rubber imported.

Finally, the domestic price of rubber is found to be highly affected by the quantity of rubber produced and the exporters' demand for export. An increase in the quantity of rubber produced will cause the domestic price to decrease while an increase in export demand will increase the domestic price. An increase in the change in stocks lagged and the import quantity of synthetic rubber lagged are found to have a significant effect on the domestic price. The elasticity of domestic price with respect to production and exports are -4.5712 and 3.3968, respectively, which are highly elastic. However, the elasticity of domestic price with respect to change in stocks and lagged imports of synthetic rubber are negligible. In Model II, the domestic price of rubber is assumed to be a function of the world rubber price, and it is found that the domestic price is strongly influenced by the world rubber price. The elasticity of domestic price with respect to world rubber price is 1.098, which is slightly elastic.

In the world rubber market model, the price elasticities of export supply and import demand from producing and consuming countries are, for all practical purposes, perfectly inelastic or negligible except for Spain, The Republic of China, and the United States which have price elasticities in an inelastic range of 0.45 to 0.21.

The demand for rubber in the U.S. was found to be inelastic with respect to both the current and the lagged prices. The ratio of consumptions lagged that measures the technological progress in rubber manufacturing processes is a significant leftward shifter of the demand for import of natural rubber. Automobile production in the U.S. is a significant rightward shifter of the demand for rubber. An increase in the production of 1,000 automobiles results in an increase in the import demand for rubber of about 23 tons in the U.S. market. The U.S. government releases from rubber stockpiles result in a significant leftward shift in the demand for rubber in the U.S. market. A reduction of 1,000 tons of the U.S. strategic stockpiles of rubber lagged will result in a decrease in import demand for rubber in the U.S. market in the following year by 1,100 tons. Finally, the quantity of reclaimed rubber produced in the U.S. is a significant leftward shifter of the demand for rubber. An increase in the production of reclaimed rubber of 1,000 tons results in a reduction of demand for rubber of about 500 tons in the U.S. market.

The R^2 in the second stage of computation, 2SLS, of the U.S. import demand for rubber is 0.948 which shows a very good fit. The value of the Durbin-Watson statistic is 1.857, showing no autocorrelation in the observed data.

The results of the simulations from the reduced form of all of the rubber models show the predicted values for each endogenous variable in all models are in an acceptable range. This implies that all models were constructed in such a way that they could represent the behavior of the Tahi rubber industry and the world rubber market.

However, the study was limited by the availability of data and the quantity of data available, especially the data of tapped area, the quantity of rubber consumed, and the amount of rubber stocks in the domestic market. These are very rough figures and the reliability is doubtful. Moreover, the length of the time series is so short that there is only a small number of degrees of freedom.

Conclusions and Policy Implications

The results of this study show a price inelastic demand for Thai rubber in the world rubber market. Also, there is an increasing trend of synthetic rubbers that narrow the world natural rubber market. Most of the natural rubber markets in highly industrialized countries in Europe and the U.S. are shown to be shrinking with the exceptions of Japan, The Republic of China and the U.S.S.R. which are expanding markets. The Thai rubber industry has faced serious trouble with the export earnings associated with export quantities for the last decade. The economy in

Southern Thailand has been in recession. Several potential suggestions and extensions can be readily cited, though their implementation will not necessarily be easy. For example, one attempt would be to increase production and export of rubber by replanting the old and low yield rubber trees by the high yield clones. However, the highly priced inelastic production of rubber creates its own obstacles and to do so would require a government subsidy program.

On the other hand, an attempt might be made to shift some of the resources in rubber to other uses. This suggests a diversification of the agricultural economy to decrease its dependency on rubber. This means that other suitable crops should be introduced to replace the old and low yield rubber trees such as palm oil trees, orchards, etc. or even to shift to nonagricultural uses. However, in these conversions of resources from rubber to other uses, consideration needs to be given to which production activities are feasible and which will be consistent with maintaining or increasing export earnings. Also, any alternative activities should increase the marginal returns to resources.

In case of human resources, especially for smallholders, the shift might be obtaining a part-time job in agriculture or nonagricultural work and tapping his own rubber tree only when prices are high enough. For an agriculture which is in a state of change, the development of human resources is of great importance and it will be necessary to the knowledge of farmers by means of agricultural extension services.

Moreover, the government should induce the new technologies in producing the block rubber, latex, etc. and increase the port facilities to handle the big cargo liner and container shipment system to reduce cost of manufacturing processes and shipment. Certainly, the government should promote an investment on rubber products industry to increase the domestic consumption of rubber.

Suggestions for Further Research

There are several potential improvements and extensions that should be worked out for the improvement of these models, and in this section there is a brief discussion of a partial list of ways that models could be improved.

1. The price of synthetic rubber should be taken into consideration. Since the latter part of 1972 when the crude oil price was raised by nearly 300 percent, the price of synthetic rubber which was almost stable for a long period of time rose sharply. A rise in the synthetic rubber price will directly affect the consumption behavior both synthetic and natural rubber. Natural rubber will have more room to compete with synthetic rubber. At present the price of synthetic rubber and natural rubber have gone up considerably with the price of the former increasing faster. Therefore, the price of synthetic rubber should be incorporated into the model.as the price ratio or the nominal price. On the other hand

the quality of synthetic rubber produced should be incorporated.

2. It is possible that having a model specification that is linear in the parameters is too restrictive and improved performance might be gained by using nonlinear specifications.
3. Due to the length and the availability of time series data, this study is unable to incorporate some variables which might be relevant to the demand and supply of rubber in the domestic and the world markets. Also, reliable data is a pressing need and the existing data series should be up-dated and if possible revised, especially tapped area, stocks and domestic demand for consumption.
4. The proxy variables used in the models are probably not good enough to exhibit the effect of their real activities. Automobile production, which is used as a proxy of industrial activity, is probably not strong enough to shift the demand for rubber, since rubber is also extensively used in other industries. The consumption ratio of synthetic rubber to elastomer, which is used as a proxy for technological change in improving the quality of competing synthetic rubbers or improving the industrial process in rubber products, does not probably capture wholly the effect of its real activity.

BIBLIOGRAPHY

Ayob, Ahmad Mahdzan and Anthony Prato. "An Econometric Analysis of United States Import Demand and Prices of Natural Rubber". Department of Agricultural Economics, University of Florida, Gainesville, August 1971.

Baldwin, William L. "Structure and Performance in Vertical Market Network: Some Policy Implications for the Thai Rice Trade". Thai Economic Journal 2 (1972):62-102.

Chan, F. K. W. "A Preliminary Study of the Supply Response of Malayan Rubber Estates between 1948-1959." The Malayan Economic Review 7, No. 2 (1962):79-101.

Christ, C. F. Econometric Models and Methods. New York: John Wiley & Sons, Inc., 1958.

Durbin, J. "Testing for Serial Correlation in Least Squares Regression when Some of the Regressors are Lagged Dependent Variables." Econometrica 38 (May 1970):410-421.

FAO. Agricultural Commodities Projection for 1975. Washington, D.C.: United Nations, 1970.

FAO. Commodity Review 1964. Special Supplement. Rome: FAO, 1964.

FAO. Commodity Review 1968. Rome: FAO, 1968.

FAO. "Survey of Rubber Growing Areas an Agricultural Economic Study" in Rubber Development Project (Phase II) in Thailand. Hat Yai, Thailand: FAO, 1973.

Ferguson, C. E. Microeconomic Theory. Third Edition. Homewood, Illinois: Richard D. Irwin, Inc., 1972.

Goldberger, A. S. Econometric Theory. New York: John Wiley & Sons, Inc., 1964.

Henderson, J. M. and R. E. Quandt. Microeconomic Theory, A Mathematical Approach. New York: McGraw-Hill Book Company, 1971.

Horowitz, Ira. "An Econometric Analysis of Supply and Demand in the Synthetic Rubber Industry." International Economic Review 4 (September 1963):345-395.

International Rubber Study Group. Rubber Statistical Bulletin, Various Issues, London, 1960-1975.

International Rubber Study Group. Twenty-Third Assembly, Bangkok, Thailand, October 16-20, 1972.

Johnston, J. Econometric Methods. 2nd Edition. New York: McGraw-Hill Book Company, 1972.

Klein, Laurence R. An Essay on the Theory of Economic Prediction. Chicago: Markham Publishing Co., 1971.

Knorr, K. R. World Rubber and its Regulation. Stanford, California: Stanford University Press, 1945.

Lok, Siepko H. A Financial Evaluation of a Simulated Rubber Replanting Scheme for Southern Thailand. Rubber Research Center, Hat Yai, Thailand, Document No. 41, July 1974.

Ma, Ronald. "Company Profits and Prices in the Rubber Industry in Malaya 1947-58." The Malayan Economic Review 4, No. 2 (1959):27-39.

McHale, T. R. "Changing Technology and Shifts in the Supply and Demand for Rubber, An Analytical History." The Malayan Economic Review 9, No. 2 (October 1964):24-48.

McHale, T. R. "The Competition between Synthetic and Natural Rubber." The Malayan Economic Review 6, No. 1 (1961):1-26.

Mienken, Kenneth W. "The Demand and Price Structure for Wheat". U.S. Department of Agriculture Technical Bulletin 1136, November 1955.

National Statistical Office. Agricultural Census of Thailand in 1963. Bangkok, Thailand: Author, National Statistical Office, 1966.

National Statistical Office. Thai Statistical Year Book. Bangkok, Thailand: Various Issues, 1956-1975.

Pattanakul, C., S. Sookmark, and S. J. C. Langlois. Present Situation of Selection at the Rubber Research Centre Thailand. Rubber Research Centre, Hat Yai, Thailand, Document No. 84, 1975.

Speirs, A. J. "Towards an Understanding of Rubber Smallholders in Thailand." Rubber Development Project (UNDP-FAO), Hat Yai, Thailand, 1973.

Stern, R. M. "Malayan Rubber Production, Inventory Holdings and the Elasticity of Export Supply." The Southern Economic Journal 31, No. 4 (April 1965):219-321.

Stifel, Laurence D. "Imperfect Competition in a Vertical Market Network: The Case of Rubber in Thailand." American Journal of Agricultural Economics 57, No. 4 (November 1975):631-640.

Stifel, Laurence D. "Rubber and the Economy of Southern Siam". A paper presented at a meeting of the Siam Society on September 24, 1970, Thailand.

Teken, I. B. "Supply of and Demand for Indonesian Rubber." Unpublished Ph.D. Thesis. Purdue University, January, 1971.

Theil, Henry. Principles of Econometrics. New York: John Wiley & Sons, Inc., 1971.

Thomas, Kenneth D. "Shifting Cultivation and Smallholder Rubber Production in a South Sumatran Village." The Malayan Economic Review 10, No. 1 (April 1965):92-115.

United Nations. "A Provisional Model of the World Rubber Market." In Review of Problems and Policies for Specific Commodities Facing Competition from Synthetics and Substitutes. Conference on Trade and Development. Geneva: United Nations, 1968.

U.S. Office of Statistical Standards. Standard Industrial Classification Manual 1967. Washington: U.S. Government Printing Office, 1967.

Wharton, Clifton R., Jr. "Malayan Rubber Supply Conditions." ADC Reprint (November, 1964):132-159.

Wharton, Clifton, R., Jr. "Marketing, Merchandising and Money Lending: A Note on Middlemen Monopsony in Malaya." Malayan Economic Review 6, No. 2 (1962):24-44.

Wilson, Joan. The Singapore Rubber Market. Singapore: Eastern Universities Press, 1958.