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A Study of the Natural Rubber Industry, with Special Reference to Thailand

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A STUDY OF THE NATURAL RUBBER INDUSTRY, WITH SPECIAL REFERENCE TO THAILAND

by

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Suratana Vayagool

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ABSTRACT

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The relative share of natural rubber in the world's total rubber consumption had been decreasing from 75 percent in 1948-1949 to 44.4 percent in 1965. Since the production of natural rubber has been rising over the same period, some predictions have been made indicating that there will be a surplus of production over consumption of natural rubber in the near future.

In the world output of natural rubber industry, Thailand ranks third, being surpassed only by Malaysia and Indonesia. Of all the exports of Thailand, rubber ranks second in value and is exceeded only by rice. Almost all of the rubber plantations are less than 8 acres in size and the prewar stock will give a low yield.

The purpose of this study is to evaluate such predictions. An attempt is also made to show that the rising relative share of synthetic rubber in the world's total rubber consumption has been primarily due to the inability of the producers of natural rubber to increase supply in pace with the increasing demand for rubber and with the technological advances in the synthetic rubber industry.

The study revealed that the United States and Western Europe can be expected to continue to exercise a great influence in the future rubber market as the industrial consumers absorb nearly 50 percent of the world's total rubber consumption. In addition, the United States is expected to play a vital role as the major producer of synthetic rubber, which appears to be a critically important factor in determining the future prospects regarding the demand for natural rubber.

It is concluded that the techniques of replanting and new planting or both, using the best available high yielding clones would enable natural rubber producers to reduce the cost of production enough to meet the keen price competition from synthetic rubber. In the face of the threatening competition from synthetic rubber, the success of the natural rubber industry may be measured by the extent of realization of effective and unremitting efforts by the natural rubber industry.

The future of the natural rubber industry in Thailand, then, depends first on how fast production could be stepped up; secondly how fast the cost of production could be reduced by replanting with high yielding clone; and thirdly on the world price of natural rubber.

The projection of natural rubber production during the year 1970 indicates that all rubber produced will be sold. Synthetic rubber will be used to meet excess demand for new rubber during this period. But some surplus of the natural rubber will occur during the year 1975. The future of the natural rubber industry depends to a large degree on lowered costs of production with replanting and planting with high yielding trees, and improving the quality and marketing.

In conclusion, the planting scheme now being undertaken in the natural rubber producing countries, will be of advantage not only at the present but also in the future.

(166 pages)

CHAPTER I

INTRODUCTION

Origin and the Nature of the Problem

One of the most important raw materials in the world, rubber, is important because of the large number of final products--Industrial, transportational, medical, and household--which are made out of rubber. It is indispensable in a modern economy, both in time of war and in time of peace. The importance of this commodity as a raw material has made it an object of imitation and synthetization. The wild fluctuations in its price have accelerated efforts to discover substitutes.

The production of synthetic rubber took place for the first time in Germany during World War I. This production, however, was terminated at the end of the war, indicating that the cost of production as to quality was not competitive with natural rubber. World War II once again stimulated the production of synthetic rubber when the rubber consuming countries were deprived of supplies. However, the end of World War II did not bring an end to the production of synthetic rubber. The Korean Conflict and subsequent crises have caused increases in the consumption of synthetic rubber. The share of synthetic rubber in the world's total rubber consumption has risen from 25 percent in 1948-1949 to 55.6 percent in 1965.

The producers of natural rubber have watched their relative share decline from about 75 percent in 1948-1949 to 44.4 percent in 1965.

This decline is a concern not only because of the importance of rubber as a raw material for so many products; but because rubber is one of the most important, if not the most important, source of foreign currency which the natural rubber producing countries need in developing their economies.

Of all the exports of Thailand, rubber ranks second in value and is exceeded only by rice. In the world output of natural rubber, Thailand stands third, being surpassed by Malaysia and Indonesia. Thailand's rubber industry, which centers in the south, consists of some 1,800,000 acres of plantation, producing annually some 200,000 long tons of rubber worth at present approximately $100,000,000. This is roughly 10 percent by weight of the total world natural rubber supply and 9 percent by value.

Only 5 percent of the rubber plantations in Thailand exceed 8 acres in size, and only half a dozen are in the 400-acre range. In general, the big producers are more efficient than the small producers. Almost all rubber trees are of the prewar stock, irregularly planted, uneven in growth, and scarred in tapping. Many have been badly tilted by the winds, and many more are badly overgrown with fungi and parasites. Although the plantations are owned by relatively small producers, they have not developed any type of cooperative arrangement for marketing their production. This leaves them at the mercy of the numerous layers of middlemen who function as buyers and sellers for the rubber industry.

Because of the above problems, rehabilitation of the rubber industry has now become a matter of serious concern to the Thai government. Beginning in 1960, it undertook a replanting scheme modeled upon the one

now being successfully completed in Malaysia. The government levies a tax upon all rubber exports and uses the proceed-about $6,000,000 per year--to subsidize producers who are willing to cut down old rubber trees and plant the new high-yielding varieties. At the same time, the Thai government has also taken other steps to promote and improve the production of rubber.

Purpose and Scope

The purpose of this thesis is to study the natural rubber industry with special reference to Thailand. The competitive potential of synthetic rubber is also analyzed because synthetic rubber has been and will remain in strong competition with natural rubber.

Chapters II and II will deal with the development and characteristics of the natural rubber industry. Fluctuations in price, output, volume of trade, and export earning of natural rubber in both the short-term and long-term period will be analyzed. In view of adverse economic repercussions of marked fluctuations of natural rubber prices and export income on the primary producing countries, the various stabilization schemes will be considered.

Chapter IV is concerned with the role of the rubber industry in Thailand and the relative importance of rubber to its future foreign exchange. The balance of payments and economic development will also be studied. The chapter also considers the various steps taken by the Thai government to promote and improve the production of natural rubber in competition with synthetic rubber.

Chapters V and VI discuss the problems and the future of the natural rubber industry. The recent discovery of stereo synthetic rubber, the

replanting of high-yield trees, and chemical stimulation are evaluated. In brief, the various economic policies affecting both the primary natural rubber-producing countries and the western industrial countries and their consequences are discussed and analyzed.

CHAPTER II

A HISTORICAL SKETCH OF THE NATURAL RUBBER INDUSTRY

General Background

Little more than a century ago, the name "rubber" was a curiosity. Today, it is vital to our existence. Unlike iron, copper, and cotton, which have been important commodities for centuries, the development of the rubber industry with the consequent demand for the raw material has all taken place within the last century. The great growth, however, has been in the past 60 years, the period during which the automobile has come into so much prominence.

The first reference to this substance was mentioned in Dr. Priestley's book, Theory and Practice of Perspective, printed in 1770, in which he stated that there was "a substance excellently adapted for erasing black-lead pencil marks from paper."[1] Because this substance came from the land of the Indian, from that time it appears to have taken the name of India rubber.[2]

The history of rubber is unique. No other major commodity in world trade has experienced such dramatic and rapid shifts in sources, factor composition, and magnitudes of supply. Few have undergone such

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[1]H. Stuart Hotchkiss, "The Evaluation of the World Rubber Situation," Harvard Business Review, II(1923-1924), 130-131.

[2]Harvey S. Firestone, Jr., The Romance and Drama of the Rubber Industry (Akron, Ohio: The Firestone Tire and Rubber Company, 1936), p. 24.

significant changes in levels, technical characteristics, and industrial derivation of demand. Shifts in world supply and demand for rubber are invariably related to technical developments in producing, processing, or utilizing rubber. The historic influence of technology and the development of rubber industry to the present are an indication of the technical and economic forces now shaping the industry's future.

The Physical and Chemical Material

The term "rubber" is used as a generic term encompassing not only the "natural" product of the Heavea Braziliensis tree and other vegetative sources, but also the ever-increasing variety of synthetic polymers which gave properties similar in greater or lesser degree to natural rubber. While the term "elastomer" is a far more appropriate generic term from a technical point of view, it has rarely been used outside of the industry, and not universally within it.[3] In this study, therefore, "rubber" will be used in its wider meaning to encompass both the natural product and synthetic materials commonly identified as "synthetic rubber."

Natural rubber

Chemically described, natural rubber is a high molecular weight, terpene hydrocarbon polymer. The basic moecule (or monomer) of rubber, called isoprene, is a deceptively simple-appearing combination of five atoms of carbon and eight of hydrogen. In rubber's natural or polymer

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[3] L. R. G. Treloar, The Physics of Rubber Elasticity (London: Oxford University Press, 1949), pp. 1-2.

state, isoprene molecules are repetitively linked together in symmetrical linear chains approximately 750,000 molecules in length. The extent, the strength, and the symmetry of molecule chain linkages, rather than the basic molecular composition, are primarily responsible for rubber's physical properties. Until recent years, neither the molecular structure nor the resulting properties of natural rubber could be duplicated in any synthesis.[4]

Emulsion found in the roots, stumps, branches, and fruits of a wide variety of plants contain rubber. Moyle listed 554 plants as known rubber producers of some significance in 1942.[5] Included were numerous species of the Hevea, several species of the Castilloa of the Mulberry family, many Euphorbiaceous plants in South and Central America, the Fucus elastica of Asia, the Funtomia and Landolphis members of the Apocymaceae genera in Africa, the Panthenium (Guayule) bush of Mexico, the Milk Weed (Asclepiadacea) and the Golden Rod of North America, as well as the Russian dandelion, Kok-sagyz.[6] All these plants and many others have been used or seriously considered as rubber sources, although their yields and their relative proportions of rubber to extraneous matter range widely. For reason of high yield, low impurities,

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[4]Ibid., pp. 3-4; and P. W. Allen and G. F. Bloomfield, "Natural Rubber Hydrocarbon," and B. L. Archer and Others, "Structure, Composition and Bio-Chemistry of Hevea Latex," in L. Bateman, The Chemistry and Physic of Rubber-like Substance (London: Maclaren & Sons LTD., 1963), pp. 1-8 and 43-45.

[5]Alton Moyle, Bibliography and Collected Abstracts on Rubber Producing Plants (College Station, Texas: Texas Experimental Station, 1942), p. 8.

[6]Loven G. Polhamus, Rubber: Botany, Production, and Utilization (London: Leonard Hill (Books) Limited, 1962), pp. 31-61.

and other factors discussed below, Hevea Braziliensis is now under cultivation on some 11,210,000 acres of land[7] and account for almost all of the natural rubber coming on the market.[8]

Synthetic rubber

Unlike natural rubber, "synthetic rubber" has no specific chemical or technical connotation. In common usage it usually encompasses a group of high molecular weight polymers which have physical properties similar to natural rubber. For economic rather than technical reasons, nearly all synthetic rubber is now manufactured from petroleum-derived chemical intermediaries. Alternative sources of the chemical "building blocks" required for the synthesizing of various synthetic rubbers, however, are numerous. Potatoes, coal, tar, and molasses, for example, are adequate technical substitutes and all have been used at various times.

The varieties and sub-varieties of synthetic rubbers have undergone substantial changes over the past two decades and the total number of technically differentiated types has continued to expand. Until 1960, much of the technical differentiations could be subsumed in three broad categories of synthetics which dominated the supply picture. These were: (1) co-polymerized styrene and budadiene, a general purpose synthetic which is usually considered the main technical substitute for natural rubber; (2) the co-polymer of isobutylene and budadiene called

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[7]Ibid., pp. 31-32. Asia 10,508,000 acres, America 50,000 acres, Africa 622,000 acres, and Oceania 30,000 acres.

[8]Jean Le Bras, Introduction to Rubber (London: Maclaren and Sons LTD., 1963), p. 9.

Bytyl or IIR; and (3) the polymer of chloroprene called Neoprene or CR.[9]

From 1961, a new family of synthetic called "stereo-regular" has emerged on the scene.[10] Within this new family, three major types of rubber are of greatest current interest: cis 1, 4 polyisoprene, referred to as IR; cis 1,4 polybudadiene, called BR; and ethylene-propylene, or EPR. These stereo-regular rubbers are significantly different from other earlier synthetics from both chemical structural and physical property point of view.[11] Their emergence has introduced a completely new economic and technical dimension to the world rubber picture, as will be discussed in Chapter VI.

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[9]In addition to the three major synthetic rubbers, a number of more specialized synthetics should be mentioned. These include Buna-N, a co-polymer of budadiene and acrylonitrile; Thiokol a polysulphide co-polymer made from ethylene dichloride and sodium tetrasulphides; Vnylite made from either vnylchloride or vnylacetate or a combination of these; Bulylite, a polymer of butylene dichloride; the polyurethanes, semi-poltmers that have other molecular group configurations in addition to polymer grouping, and a number of other synthesized products which are more adequately labelled plastics. See M. E. Lerner, "Rubber," in Encyclopaedia Americana, 1965, 23:745-745f.

[10]During the Second World War, most of these synthetics found highly specialized use as replacement for natural rubber, particularly under circumstances where cost was only a minor consideration. In the post-war period, where cost as well as technical qualities have been important determinants of their uses, they have maintained, and in many circumstances expanded their level of use but on a more limited range of applications.

Natural and Synthetic Rubber Terminology

Origin Trade Names	Government Classification	ASTM Terminology
Buna-N	GR-A or Nitrile	NBR
Buna-S	GR-S	SBR
Butyl	GR-I	IIR
Hevea (natural)	-	NR
Neoprene	GR-M	CR
Thiokol	GR-P	Polysulfide

[11]Charles F. Phillips, Jr., Competition in the Synthetic Rubber Industry (Chapel Hill, North Carolina: The University of North Carolina Press, 1963), pp. 13-15 and Encyclopaedia Britannica, "Rubber," 1965, 19:610.

Technological Change and Development of the Rubber Industry

Shifts in the world supply of and demand for rubber have been invariably related to technical developments in producing, processing, and utilizing rubber. In broad outline, we can identify six phases in the development of rubber industry. Each of these phases is characterized by a particular technological change or a combination of developments. In historic sequence, these phases are:

1. The discovery of rubber-bearing plants and the uses for rubber.
2. The development or rubber processing technology; solvents, masticators, and the solution spreader.
3. A technological base for a large-scale industrial use of rubber and vulcanization.
4. Systematic plantation-grown rubber in South and Southeast Asia and the paralleling development of mass-produced automobiles.
5. World War II and the development of synthetic substitutes for natural rubber.
6. Cold polymerization, new compounding material, synthetic natural rubber, and the movement of synthetic from substituting to supplanting.

The discovery of rubber-bearing plants and the uses for rubber

Although the widespread use and development of natural rubber is comparatively modern, rubber was known in very early times.[12] There is

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[12] D. W. Huke, Introduction to Natural and Synthetic Rubbers (London: Hutchinson Scientific & Technical, 1961), pp. 13-16; Jean Le Bras, op.cit.,

some evidence, for example, that rubber was used for playing ball in Ethiopia, and from there the game spread to Egypt. The use of rubber never became widespread in Europe, however, until the nineteenth century, and this may be connected with the distribution of rubber-bearing plants.

Natural rubber is a product of many trees and plants, but it can only be obtained easily and in large enough quantities to make its use worth while from a few types of trees. These trees were not very common in the Old World, but they occurred much more frequently in the New. It is not very surprising, therefore, that rubber has been known and used by the natives of South America for a very long time.

Columbus is usually given credit for having been the first modern European to see natural rubber, and it is said that he brought back rubber play balls which he obtained from the natives of Haiti on his second voyages in 1493-1496. The ball game had, in fact, been known to the Indians for centuries, as revealed by Aztec wall paintings from the 6th Century.

It was only in 1615, however, that certain useful applications of rubber were revealed by Juan de Torquemada in the book Monarquia Indiana, where an account is given of the manufacture of the substance known to the natives of Mexico as "Ulei" for the purpose of waterproofing articles of clothing.

However, the interest later to be shown in Europe in this substance and its many practical applications, and the part it was destined to play

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pp. 7-9; T. R. Dawson, "Chronology of Rubber History," in P. S. Schidrowitz and T. R. Dawson (eds.), History of the Rubber Industry (London: Institution of the Rubber Industry, 1952), pp. ix-xxiii; Hubert L. Terry, India Rubber and Its Manufacture (London: Archibald Constable & Co. Ltd., 1907), pp. 1-63.

in the economy, was only aroused much later by two French scientists, Charles de la Condamine and Francis Fresneau.

La Condamine, the naturalist and mathematician, had been sent in 1736 to South America by the Paris Academy of Sciences to measure a meridian in the neighborhood of the equator. He and his colleagues collected samples of rubber from several species of the Hevea tree and sent them to the Paris Academy for study. He also reported the various uses made of the substance by the natives, and observed that the same tree was to be found growing on the banks of the Amazon River. The material was known to the Maina Indians as "caoutchouc," a word derived from caa (wood) and o-chu (to flow or weep).

Fresneau, an engineer employed by King Louis XV of France at Guiana, spent fourteen years looking for the source of natural rubber. Fresneau described the rubber tree in detail, and gave an account of his efforts to discover where the tree was growing and how to obtain the rubber from it. He made another very important contribution to the knowledge of the properties of rubber and thereby assisted in the birth of the rubber industry.

In 1762 the name Hevea Guianensis was given to the tree described by Fresneau. It was then quickly realized that rubber trees were not exclusively American plants and that others capable of producing the same material existed in Africa and Asia.

Before attracting the attention of European science, both the use and knowledge of rubber was largely limited to the localized areas within which wild rubber-producing plants were found. Practical uses included crude foot coverings and water-proofing for rain caps. But little trade and no evidence of organized production in the America before the eighteenth

century was known. The consumption of rubber in Europe, limited by the lack of knowledge and of interest, was undoubtedly measurable in pounds per year until the latter part of the eighteenth century.

The initial movement of rubber into international trade channels stemmed from the European discovery in the latter decades of the eighteenth century of an increasing number of practical uses for this unique material. Among the first applications of rubber were those in medicine (syringes, small tubes, and surgical probes). In all such early uses of rubber, the shape of the manufactured product was dependent on the original shape or form of rubber as it came out of the jungle. While such limitation severely limited the range of products that could be made, demand grew slowly but steadily as a result of rubber's physical properties which could not be duplicated by another material.

The development of rubber processing technology

With the discovery of a solvent for rubber before the turn into the nineteenth century the way was opened for rubber manufacturing. In conjunction with the development of a rubber solution spreader, the ability to dissolve rubber and apply it to fabrics opened a whole new range of applications for rubber as a raw material. At about the same time a mechanical rubber masticator was developed which not only permitted the continuous reworking of rubber into a plastic state without destroying its ultimate physical qualities, but also established the technical base by which other material could be "compounded" with

rubber.[13]

The new technological base for working rubber, and the increasing variety of products which could be made, generated an increasing demand for rubber as an industrial material. Shoes, waterproof garments (including the famous Mackintosh raincoat), and a growing number of commonly used rubber products began to enter the market in significant quantities. Whereas the demand for rubber in the late eighteenth century probably never exceeded several thousand pounds a year, by 1820 consumption in Europe and the United States was at the rate of 100 tons annually.[14] By the late 1830's international trade in rubber was sufficiently important to warrant the development of secondary rubber markets in both New York and London (see Table 1).

Despite the growth in demand resulting from new processing and fabricating techniques, rubber still presented both the fabricators and the end users with serious problems. On hot days, it became sticky and adhesive as well as malodorous. Direct sunlight resulted in rapid deterioration. And when rubber was exposed to low temperature it became stiff and non-elastic. Users soon discovered that rubber retained its most useful and desirable physical properties within narrow temperature ranges, a severe limitation on its use in either hot or cold weather. While the demand for rubber continued to grow, consumers of the increasing

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[13]French chemists Louis Antoine Prosper Herissant and Pierre Joseph Macquer found "turpentine and ether" could be used as solvents in 1763 and later in 1819 Charles Mackintosh used "naphtha" as a solvent. Thomas Hancock's 1819 machine for a modern internal mixer was called the "pickle."

[14]No pre-1825 rubber trade statistics are available.

Table 1. Rubber consumption in the United States and England and rubber supply from producing centers before 1900. The figures are average for each decade except for odd years (in tons)

	Import		Export						
Year	U.S.A.	U.K.	Brazil	Gold Coast	Nigeria	Sierra leone	Belgiam Congo	Ceylon	Far East
1830		23	150						
1840		307	400						
1850		385	1,500						
1860	750	2,152	2,700						
1870	4,296	7,656	6,600						
1878						223			
1880	8,109	8,479	5,928	0.5		450	135		
1884						750			
1888				392					
1890	15,336	13,200	1,500			450	200		
1895	18,646	17,078	27,355	1,796	2,322	625	670		
1898				2,672	2,054	275	2,150	4	
1900	22,026	25,664	23,918		1,271	123	5,511		821

Source: M. J. Dijkman, Hevea: Thirty Years of Research in the Far East (Coral Gables, Florida: University of Miami Press, 1951), p. 6.

number of rubber goods, particularly in the United States, were losing enthusiasm for products that were usable only under certain temperature conditions.[15]

Technological base for a large-scale industrial use of rubber

The basis for the modern rubber manufacturing industry was established in 1839 when Charles Goodyear discovered a means of permanently altering the physical properties of rubber by heating it in combination with sulphur.[16] The process, called vulcanization, transformed rubber into a far more useful material. It became far stronger and durable; it maintained its elasticity and pliability within a wide-temperature range; and it lost its odor and surface adhesiveness. The discovery of the vulcanization process stands out as one of the major developments in nineteenth century technology. It also marks the beginning of a stage of rapid and sustained growth for the rubber industry that continued with only minor interruption for the rest of the century.

Demand for raw material as a result of this rapid proliferation of new rubber products and expansion of manufacturing activities grew tremendously in both the United States and Europe. By the end of the

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[15]A number of American rubber goods manufacturing companies established in the first decades of the 19th Century went into bankruptcy largely as a result of consumers' reactions to their products under "hot" and "cold" weather conditions.

[16]Although some chemists were on the track of vulcanization prior to 1839, including Frederic Ludersdorff (German), J. van Geuns (Dutch) and Nathaniel Hayward (American) it remained for Goodyear to make it a reality. But Hancock secured the English patent right to it in 1843. See Lerner, op. cit., p. 740.

century, annual world consumption of raw rubber had increased over five hundred-fold over 1820 levels to a rate of approximately 50,000 tons (see Table 2).

Stimulated by, and coincidental with the high price,[17] the search for new supplies of wild rubber in the late decades of the century marked the beginning of the systematic study of the bio-genesis, physiology, and ecology of rubber-bearing plants and the first attempts to cultivate several of them on a systematic basis.

Economically, the most noteworthy characteristic of "wild" rubber production was the intensive use of labor. Direct labor inputs in locating, tapping, and coagulating wild rubber comprised all but a small proportion of total production costs in most areas. This labor-intensive characteristic provided the economic base for substantial rubber output from several low yielding rubber plants in Africa and Asia during the late nineteenth century when an acute physical shortage of labor rather than the lack of wild rubber-bearing trees was the most important limitation on Brazil's capacity to produce increasing supplies of rubber.[18] In the case of Africa and Asia where the labor was relatively

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[17]The average declared value of United Kingdom imports in Sir Andrew McFadyean, The History of Rubber Regulation 1934-1943 (London: George Allen & Unwin, Ltd., 1944), pp. 19-21, showed the following prices per pound:

1830	1s.3d.	1870	2s.0d.	1900	2s.6d.	1903	2s.6d.	1914	2s.3d.
1840	1s.3d.	1880	2s.6d.	1902	2s.3d.	1910	5s.3d.	1916	2s.9d.
1850	1s.6d.	1890	2s.3d.	1904	2s.9d.	1911	5s.6d.	1918	2s.3d.
1860	2s.0d.	1895	2s.0d.	1906	3s.0d.	1912	4s.9d.	1920	1s.9d.

[18]C. E. Akers, The Rubber Industry in Brazil and the Orient (London: Methuen & Co., 1914), p. 1.

Table 2. Total and types of rubber production by specific years, 1836-1866 (in thousand long tons)

Year	Wild rubber	Plantation rubber	Synthetic rubber	Total world production	
1825	0.1			0.1	Boots, shoes, waterproof garment and mechanical
1830	0.2			0.2	
1835	0.1			0.1	
1840	0.4			0.4	
1845	0.6			0.6	
1850	1.5			1.5	
1855	2.2			2.2	
1860	2.7			2.7	
1865	3.5			3.5	
1870	6.6	0.5		7.1	
1875	8.0	0.8		8.8	
1880	9.7	0.5		10.2	Bicycle
1885	12.0	0.8		12.8	
1890	17.9	0.5		18.4	
1895	26.1	0.5		26.6	
1900	43.3	0.8		44.1	
1905	62.1	0.1		62.1	
1910	82.0	11.0		93.0	Automobile and tires
1915	50.0	115.6		166.6	
1920	37.0	319.6		353.6	
1925	42.0	482.9		524.9	
1930	20.2	805.9		826.1	
1935	17.7	854.9		872.6	
1840	26.0	1,391.5	42.4	1,459.9	
1945	47.1	202.9	866.1	1,116.1	
1950	26.9	1,833.1	534.6	2,394.6	
1955	26.0	1,891.5	1,085.3	3,002.8	
1960	29.7	1,972.8	1,892.5	3,895.0	
1965	38.5	2,292.2	3,015.0	5,343.0	
1966	32.5	2,375.5	3,318.0	5,726.0	

Source: 1825-1900 from G. L. Wallace, "Statistical and Economic Outline," in P. Schidrowitz and T. R. Dawson (eds.), History of the Rubber Industry (London: Institution of the Rubber Industry, 1952), p. 86.
1905 from H. Stuart Hotchkiss, "The Evolution of the World Rubber Situation," Harvard Economic Review, II(1923-1924), p. 130.
1910-1935 from George Rae, "Statistics of Rubber Industry," Journal of the Royal Statistic Society, Part II(1938), p. 345.
1940-1966 from Rubber Statistical Bulletin, several issues.

plentiful and cheap it became economically feasible to utilize higher physical labor inputs in securing a given weight of rubber from many low-yielding rubber plants. The wild fig (Ficus elastic) and the Urceola elastica vines in Asia, the Clitandra vines found throughout most of tropical Africa, and after 1883 the Funtumia elastica (Kickseia) were examples of relatively poor yields which became commerical sources of rubber in the 1890's. The economic advantages of low cost labor[19] appeared to have been so substantial that shipments of African and Asian wild rubber to world markets expanded rapidly after 1880. By 1900 Africa alone was producing more than a third of world supplies, as Table 2 indicates.

Plantation rubber in Southeast Asia and the parallel development of the mass-produced automobile

Rapidly increasing demand in the face of the short-run upward inelasticity of wild rubber supplies had already led to record price levels when new technical developments in both the supply and the demand side of the industry formed the basis of the fourth phase of rubber's history. On the demand side, the first factor was the development in the initial decades of the twentieth century of the automobile industry, primarily in the United States, with its needs for rubber tires, gaskets, tubing, and other items. The derived demand for rubber stemming from the expansion of the automobile industry for overshadowed anything that had ever been known in the industry before. Automobile manufactures

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[19] Ibid., p. 25.

which had used practically no rubber in the 1880's and only a few tons in 1900, consumed 5,110 tons, representing 70 to 80 percent of all rubber produced in the world, by 1910.

Rubber has always been a minor material in an automobile (usually amounting to less than 4 to 5 percent of the total weight and rarely exceeding the same percentage of total cost.[20] The absolute quantity of rubber consumed in the industry grew large because the production of cars grew large. To appreciate the relationship of the automobile industry to the increasing demand for rubber in the first four decades of the twentiety century, Table 3 provides a record of the production of motor vehicles in the United States from 1900 to 1940 and estimated demand for rubber derived from the industry alone. The derived 1915 demand for rubber in the American automobile alone was greater than the total aggregate supply for rubber in the world in 1900.

The rapid escalation of derived demand for rubber stemming from the growth of the automobile industry began at a time when high prices and severe shortages had already led to world-wide searches for new sources of rubber. Only the development of a substantial plantation industry in South and Southeast Asia enabled supply to expand rapidly enough to fill demand. Demand devels exceeded 100,000 tons by 1912; 200,000 by 1916; 300,000 by 1919; and 1,000,000 tons by 1930. According

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[20]In addition to tires there are numerous other uses for rubber in the modern automobile. In the average American passenger car, this adds up to 175 pounds or more per car, including tires, for 1967 models. Fred Olmsted, "Rubber in the 1967 Automobile," Rubber Age, XCVIII(1966), p. 68. The first models at the turn of the century used less, but 60 pounds is perhaps the lowest amount ever used in the standard automobile, and the amount tends to increase steadily over the years. The 1942 models used approximately 171 pounds of rubber. W. S. Woytinsky and S. E. Woytinsky, World Population and Production (New York: 20th Century Fund, 1953), p. 1168.

Table 3. Derived demand for rubber from the United States automobile industry

Year	Automobiles manufactured, in thousands	Estimated derived demand for rubber, in short tons
1900	4	120
1905	25	750
1910	187	5,110
1915	970	48,500
1920	2,227	220,000
1925	4,266	596,000
1930	3,356	568,000
1935	3,947	673,000
1940	4,472	760,000

Source: T. R. McHale, "Changing Technology and Shifts in the Supply and Demand for Rubber an Analytical History," Malayan Economic Review, IX(1964), p. 41.

to Jean Le Bras's comment:

> This shortage of raw material and the resulting increase in the market value of rubber were, of necessity, a considerable hindrance to the rubber industry. However, by a strange coincidence, just as the development of the motor car increased demands, still further plantation rubber began to appear on the market.[21]

The emergence of cultivated Hevea Braziliensis as the dominant source of rubber, and the geographic shift of the supply locus from South America and Africa to South and Southeast Asia, was preceded by several decades of botanical trial and errors in cultivating rubber-

[21] Bras, op. cit., p. 14.

producing plants in many parts of the tropical world. Although introduced as a cultivated plant into South and Southeast Asia on an experimental basis in 1870, large-scale planting of Hevea were not attempted until the twentieth century.[22]

By the end of the first decade of the twentieth century, organized production of plantation rubber in South and Southeast Asia had clearly demonstrated economic advantages over the traditional methods of collecting rubber from wild plants: at about the same time the botanic superiority of Hevea Braziliensis as a cultivated rubber producer was also becoming widely apparent.[23] Once it began, the shift in supply source from wild rubber-bearing plants to the systematic cultivation and tapping of Hevea Braziliensis proceeded rapidly. The emergence of South and Southeast Asia Hevea plantation rubber to dominance in the world supply picture can be seen in Table 2.

The shift from wild to plantation rubber involved a dramatic shift in the geographic locus of production. It also involved fundamental changes in the nature of factor input, factor proportions, and the organization characteristics of the productive proceeses. The shift from labor-intensive to capital intensive production was of particular significance. While land in South and Southeast Asia was relatively plentiful, the cost of clearing, planting, and cultivating land, establishing labor lines and engaging managerial skill over six or seven unproductive years, had to be capitalized. The production of rubber

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[22] Ibid., pp. 19-35.

[23] Polhamus, op. cit., pp. 28-29 and 62-90.

per tree during the early plantation period began at several hundred pounds and rapidly exceeded 1,000 pounds per years. Consequently labor inputs in the tapping, collecting, and coagulating of rubber is very low compared to wild rubber cost where the average individual tapper rarely had an output in excess of 100 pounds per year.[24]

World-rubber price had remained around 60 cents per pound in the decade 1895-1904 as plantation cultivation of Hevea expanded slowly but steadily in South and Southeast Asia. In 1905-1906 record high prices had substantial impact on world rubber supplies. A rubber planting boom, financed in large part by London speculators and later joined by Amsterdam speculators, was under way. Rapidly increasing demand for rubber as a result of growing needs in the American auto industry, and the inability of wild rubber production to meet the requirements sent rubber prices skyrocketing to more than $2 a pound in the United States in 1910 and 1911. The impact of the spectacular price rise on rubber planting in South and Southeast Asia is indicated in Table 4.

Consumers of rubber in the United States, Germany, Russia, and the United Kingdom were all faced with the fact that rubber's technical value in use stemmed from a unique set of properties possessed by no other known material. Elasticity, resiliency, extensibility, and capacity to absorb shock were the most important of these general properties, but highly specific ones like inertness, impermeability to water and numerous other liquids and gases, high fictional resistance when dry,

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[24] T. R. McHale, "Changing Technology and Shifts in the Supply and Demand for Rubber, an Analytical History," Malayan Economic Review, IX(1964), p. 33.

Table 4. Estimated new and cumulative total acreage planted to rubber in South and Southeast Asia, 1904-1951

Year	Annual planting acres	Total acres
1904 and earlier	-	50,000
1905	100,000	150,000
1906	200,000	350,000
1907	200,000	550,000
1908	200,000	750,000
1909	300,000	1,050,000
1910	400,000	1,450,000
1911	400,000	1,850,000
1912	400,000	2,250,000
1913	250,000	2,500,000
1914	250,000	2,750,000
1915	250,000	3,000,000

Source: Statistics Relating to the Rubber Industry issued by the Rubber Growers Association, Inc., London, 1928, p. 7.

non-conductivity to electricity, and low conductivity to heat were of particular value for some uses. Functional analysis, nevertheless, suggested that some qualities were neither needed nor desirable in many uses; furthermore, alternative synthetic materials were known that would be able to fill many of specific functions of natural rubber adequately, particularly if costs were not considered.

While the development and expansion of synthetic rubber production facilities included a number of synthetic rubbers which were usually

described as general purpose rubbers, budadiene-styrene co-polymers, now referred to as SBR, were considered the most important substitutes. Of all the available synthetics, they possessed the greatest balance of functional qualities sought in the widest range of applications. SBR rubbers were superior to natural rubber in only a few minor ways but, for most heavy volume use, they provided an adequate substitutes for natural rubber.[25]

Not only was the South and Southeast Asian rubber supply potential far greater than anything known, but it was also technically, organizationally, and economically different from the wide rubber supply complexes of South America or Africa. Systematic planting, cultivation, and tapping tied up large amounts of capital and labor over long periods of time. Direct labor inputs in the tapping and processing, on the other hand, were reduced from a dominent cost input to a minor cost input on a typical plantation. The increasing level of fixed costs involved in rubber production and the decreasing level of variable costs in the form of direct labor inputs meant that rubber supplies were becoming far more inelastic than they had been when wild rubber, with its low capital commitment and highly variable direct labor input, dominated the scene.[26]

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[25] R. F. Dunbrook, "Historical Review," in G. S. Whitby and Other (eds.), Synthetic Rubber (New York: John Wiley and Sons, Inc., 1954), pp. 32-55; Phillips, op. cit., pp. 10-15; Huke, op. cit., pp. 27-65.

[26] The emergence of the smallholder changed this to some degree.

World War II and the development of synthetic substitutes for natural rubber

The fifth phase in the history of rubber began during the Second World War. With the world's largest consumers of rubber effectively cut off from the major Southeast Asian producers, alternative sources of natural rubber supplies or alternative material that could replace natural rubber had to be found without delay. The seven years gap between planting Hevea and its initial tappability, the limited prospects of any dramatic increase in wild rubber supplies, and unpromising prospects for semi-tropical or temperate vegetative sources forced all major consumers to seek a solution to their problem in development of "synthetic" substitutes rather than in new vegetative sources of natural rubber.

Working with synthetics during the war led to the identification of limited areas where synthetics possessed technical advantages over natural rubber. In the immediate postwar period, however, when free choice between natural and synthetic rubber became possible, the heavy demand for natural rubber reflected its technical and cost advantages in all large volume usages.

While the so-called speciality synthetics, like CR, IIR, and NBR appeared capable of holding and expanding a relatively low volume technical market, the future of general-purpose SBR was clearly in doubt in the early postwar year--particularly in the United States. Wartime research and development had led to a number of substantial improvements in processing and fabricating SBR, but it still appeared unable to compete, even at a significantly lower cost, with natural

Table 5. Production of synthetic rubber in U.S.A. (in thousand long tons)

Year	SBR (GR-S)	CR (Neoprene)	IIR (Butyl)	NBR (Nitrile)	Total
1940	-	2.5	-	0.1	-
1941	.2	5.4	0	2.5	-
1942	3.7	9.0	-	9.7	-
1943	182.3	33.6	1.4	14.5	231.8
1944	670.3	58.1	18.9	16.8	764.1
1945	719.4	45.7	47.4	7.9	820.4
1946	613.4	47.8	73.1	5.7	740
1947	407.8	31.5	62.8	6.6	508.7
1948	393.9	34.8	52.6	7.0	488.3
1949	295.2	35.2	52.2	11.1	393.7
1950	358.2	50.1	55.8	12.0	476.1
1951	696.8	58.9	74.1	15.3	845.1
1952	637.2	65.7	79.4	16.2	798.5
1953	669.2	80.5	78.5	20.2	848.4
1954	474.2	69.2	58.1	21.4	622.9
1955	791.2	91.4	55.3	32.6	970.5
1956	871.2	99.4	75.0	34.0	1,079.6
1957	907.5	110.7	67.0	33.0	1,118.2
1958	872.6	97.8	52.2	32.0	1,054.6
1959	1,130.7	124.8	81.0	43.2	1,379.7
1960	1,166.2	134.4	98.0	37.9	1,436.5

Source: Rubber Statistical Bulletin, Vol. 6, No. 1, Oct., 1951; and Vol. 15, No. 1, Oct., 1960.

Table 6. Production of synthetic rubber in Germany (Metric tons)

Year	Buna-S types	Buna-N	Numbered Bunas	Total
1937	2,110	400	637	3,147
1938	3,994	640	848	5,482
1940	37,137	1,898	1,431	40,466
1941	65,889	2,631	1,955	70.475
1942	94,166	2,824	2,721	98,711
1943	110,569	3,656	3,388	117,613
1944	97,493	3,172	2,590	103,255

Source: R. F. Dunbrook, "Historical Review," in G. S. Whitby and Others, Synthetic Rubber (New York: John Wiley & Sons, Inc., 1954), p. 53.

rubber in any large volume. Fear that most of the synthetic rubber industry established during the war in the United States would face imminent economic collapse in the postwar years prompted legislation (the Rubber Act of 1948, Public Law 469 of the 80th Congress) designed to ensure survival of the industry. The law, which was to be administered by the Department of Commerce, required rubber manufacturers to use a certain percentage of synthetics in various rubber goods in order to keep aggregate demand up to a specified level. With the technical development, however, the legislation proved unnecessary and the law had no impact on the industry.

Cold polymerization, new compounding materials, and the stereo-regular synthetics

Polymer research has resulted in a continuous flow of new synthetic rubber type. Three major technical developments came into the picture of Amiercan synthetic rubber.[27] The first discovery technique was the low temperature polymerization of styrene and budadiene in replacing a high temperature polymerization process which had been used during the war because it permitted maximum output in the shortest time. The discovery of a relatively quick "cold" polymerization process in the immediate postwar years led to the production of a SBR with greatly improved abrasion and aging resistance both substantially superior to natural rubber without a major increase in production cost. Cold SBR soon demonstrated advantages over natural rubber in automobile tire treads, and rapidly gained a major place in this important market.

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[27]McHale, op. cit., p. 37-39.

The second important technical change in the industry was the development of "oil extension: a technique which permits the incorporation of substantial quantities of low cost mineral oil additives to the various polymers and at the same time improving physical performance characteristics.

The third development was the discovery of the key role played in rubber compounds by the particle size of carbon black fillers. The carbon black permitted more effective heat dissipation within the rubber compound.[28] This latter technique was of interest to the fabricators of all types of rubber, including natural. It was of particular importance to SBR users since internal heat build-up was SBR's major problem in tires.

These three discoveries provided synthetic SBR with a capacity not only to survive but also to carve out a substantial share of the total rubber market in the United States on both a technical and a cost basis during the 1950's. SBR accounted for the largest absolute contribution to this growth pattern. It indicated similar trends in the United Kingdom, Germany, and France--and in the world.[29] The rapid growth of synthetic rubber exports from the United States to world markets is indicated in Table 7.

Despite the rapid absolute and relative growth in demand for synthetics during the 1950's, natural rubber still held technical advantages

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[28]Carbon black is a key reinforcing filler in making the rubber compound increasing the tearing resistance of rubber, natural and especially for SBR. See Bateman, op. cit., pp. 316-327 and G. S. Whitby (ed.), Synthetic Rubber (New York: John Wiley & Sons, Inc., 1954), pp. 384-413.

[29]Ibid., p. 37.

Table 7. Exports of synthetic rubber from the United States in long tons, 1950-1960

Year	SBR	IIR	NBR	CR	Total
1950	900	31	1,895	4,826	7,652
1951	483	216	1,725	6,825	9,249
1952	9,467	126	2,695	9,813	22,101
1953	7,692	237	3,245	11,494	22,668
1954	11,069	2,831	4,155	12,062	30,117
1955	60,704	9,895	4,593	18,098	93,290
1956	112,366	8,699	6,194	21,909	149,168
1957	158,030	8,835	6,377	30,206	203,448
1958	142,069	13,793	6,718	31,337	193,917
1959	220,493	21,811	8,374	39,790	290,468
1960	257,028	29,646	7,699	47,581	341,954

Source: Rubber Statistical Bulletins, XV(Jan. 1961), XVIII(Jan. 1964).

in several important uses where its stereo-regular polymer chains gave it properties that could not be duplicated by any synthetics. This advantage lasted until 1955 when the discovery of the means of regulating the positioning of polymer molecules moved to be as economically significant as it was technically impressive. The commercial production of this new general category of synthetic was first announced in 1959.[30] This synthetic, referred to as the stereo-regular, changed the entire competitive picture in the rubber industry. The development of stereo-regular has almost breached the last significant technical strong hold of natural rubber.

[30] Phillip, op. cit., p. 13-14.

Three stereo-regular rubbers are now being produced in significant quantities in the United States and Europe.[31] If the cis 1,4 polyisoprene is from a chemical stand point a synthetic "natural" rubber, in physical porperties it approximates natural rubber. Another stereo synthetic, cis 1, 4 polybudadiene, is chemically dissimilar to natural rubber but looms as a major economic and technical threat in the automative tire field because of substantially superior physical wear advantages over natural rubber in almost all important functional uses. A third stereo synthetic, ethylene-propylene rubber or EPR, is potentially the most inexpensive general-purpose rubber on the horizon and has attracted wide-ranging attention despite its newness and the fact that it is still not available in large commercial quantities.

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[31]Richard A. Arnold, "The World Stereo Homopolymer Rubbers," 54, 1966, pp. 59-63.

CHAPTER III

ECONOMIC STRUCTURE OF THE NATURAL RUBBER INDUSTRY

Natural rubber is grown only in developing countries and consumed almost exclusively elsewhere. In 1959-1961 less than 5 percent of total output was consumed in countries where rubber is grown, 73 percent was exported to developed and 21 percent to centrally planned countries.[1] Most of the natural rubber produced is from Southeast Asia. It can be seen in Table 8 that for most of these countries natural rubber is a major foreign exchange earner, and for some of them a very important source of national income and therefore furnishes one of the major opportunities for employment and economic development. On the whole it can be said that for most countries in Southeast Asia natural rubber is one of the main pillars of the economy.

As Table 8 indicates, over two thirds of the total export earnings were attained through the exports of natural rubber in the Federation of Malaya, Indonesia and South Vietnam. In the other two nations which owe sizeable proportions of their exports to rubber, the percentages were about 16 percent. Therefore, Mrs. M. J. 't Hooft Welvaars, of Amsterdam University, described the role of natural rubber in developing countries as:

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[1] F.A.O. Commodity Review-Special Supplement, Trade in Agricultural Commodities in the United Nations Development Decade, Vol. 1 (CCp 64/6), 1964, p. II - 101.

Table 8. Relative importance of natural rubber exports to the economy in 1965

Country	Net export volume (in thousand long tons)[1]	Percentage of total export in natural rubber[2]	Rubber export as percent of GNP[3]
Malaya	860.7	42.1	17.0
Indonesia	705.7	35.0[4]	
Thailand	213.1	15.5	2.5
Ceylon	116.4	15.6	3.9
South Vietnam	60.0	71.4	1.3

Source: 1. International Rubber Statistical Bulletin.
2. International Financial Statistic.
3. U.N. Yearbook of National Account Statistic.
4. Britannica Book of the Year 1967, p. 411.

(a) providing a livelihood for many people, (b) being a major foreign exchange earner for producing countries. To this can be added that at present (c) natural rubber provides a considerable part of government revenue in the producing countries by paying export taxes (and/or other taxes).[2]

To the developed countries, Jean Le Bras indicated that:

There are more than 1,000 rubber factories in the United States, employing some 250,000 workers. The most important city is Akron, Ohio, principal rubber manufacturing center . . . . The Canadian industry is closely linked to that of the United States and possesses some 80 factories and employs more than 25,000 workers, its principle center being Toronto. In Europe, the British rubber industry is the oldest and most important. Official Statistics show that there are more than 200 enterprises operating over 300 factories and other establishments scattered throughout the United Kingdom. The smallest

[2]United Nations Conference on Trade and Development (hereafter referred to UNCTAD), The International Organization of Commodity Trade Case Study of Natural Rubber, TD/B/AC. 2/4, 4 January, 1966, p. 11.

> enterprises employs more than about 25 persons, the largest being staffed by over 4,000 . . . . In Western Germany, there are about 200 factories employing about 72,000 workers . . . . In France, there are now some 400 factories employing 50,000 workers, these figures being indicative of the continued importance of small scale manufacture . . . . Mention may also be made of other countries, such as Japan, Italy and Russia.[3]

Demand and Supply

The greatest portion of total natural rubber exports are consumed annually by the United States, the Western Europe countries, and Japan. Only in recent years have the centrally planned countries increased consumption in natural rubber. An insignificant portion of natural rubber production has been consumed within the rubber producing countries (see Tables 9 and 10).

The change in the demand condition affecting world trade in natural rubber during the past five decades has had enormous economic repercussions on the major producing countries in the region. The heavy reliance on rubber demand from the developed nations thus has

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[3]Le Bras, op. cit., pp. 91-93. The names of major important rubber manufacturing firms in various countries are:

U.S.A. - Goodyear Tire and Rubber Co.
- The B.F. Goodrich Co.
- The Firestone Tire and Rubber Co.
- The United States Tire and Rubber Co.
- The General Tire and Rubber Co.

U.K. - Dunlop Rubber Company

Western Germany - Continental Gummi - Werke A.G.
- the Phoenix Gummi - Werke A.G.

France - Rattier and Guibal
- Michelin Tyre Factory
- the Bergougnan Factory
- the Dunlop Factory

Table 9. World consumption of rubber and percentage shares of natural rubber, average 1959-1961 (in million long tons)

	Natural	Synthetic	Total	Percent of natural
Developed countries	1.43	1.68	3.11	46
Developing countries	0.22	0.08	0.30	73
Centrally planned countries	0.49	0.48	0.97	50
World	2.14	2.24	4.38	49

Source: F.A.O. Commodity Review--Special Supplement, Trade in Agriculture Commodities in the United Nations Development Decade, Vol. 1 (CCP 64/6), 1964. p. II-103.

Table 10. Natural rubber imports in centrally planned economics; also as a percentage of world national rubber consumption (in thousand long tons)

Year	Eastern Europe (incl. USSR)	China	Total	Percentage of world natural rubber consumption
1954	50	62	112	6
1955	91	48	139	7
1956	198	76	274	15
1957	227	57	284	15
1958	354	97	451	22
1959	331	109	440	21
1960	317	120	437	21
1961	485	83	568	27
1962	433	107	540	25
1963	421	108	529	24
1964	292	142	434	20
1965	-	-	520	22
1966	-	-	600	24

Source: 1954-1964 UNCTAD, The International Organization of Commodity Trade Case Study of Natural Rubber, TD/B/AC. 2/4, 4 January, 1966, p. 17.
1965-1966 R.M.R. Carey, "1965--A Year of Continued Growth for Natural Rubber," Rubber Development, 19, 1966, p. 50.

been an important factor in causing economic instability in these producing countries. More specifically, a minor change in general economic activities of the developed nations has sharply affected price levels of rubber, and also has often reacted directly on the quantities of rubber exported. Variations in price and the quantity of rubber exported have frequently moved in the same direction, which indicated that demand factors have played an important role in the interantional rubber market (see Table 11).

Table 11. Production, consumption, and price of natural rubber in selected years, 1900-1966

Year	Production (in thousand long tons)	Consumption (in thousand long tons)	Price (in cent per lbs.)
1900	44.1	52.6	99.5
1905	62.1	70.2	126.5
1910	93.0	99.4	206.6
1915	166.6	155.6	65.7
1920	353.6	294.3	35.9
1925	524.9	553.6	73.0
1930	826.1	708.9	10.24
1935	872.6	939.0	12.32
1940	1,372.5	1,110.0	20.10
1945	147.5	262.5	22.50
1946	750.0	1,722.5	22.50
1948	1,452.5	1,470.0	21.9
1950	1,777.5	1,722.5	41.3
1952	1,682.5	1,470.0	38.6
1954	1,810.0	1,780.0	23.4
1956	1,893.0	1,878.0	34.5
1958	1,943.0	2,013.0	28.2
1960	1,990.0	2,065.0	38.5
1962	2,130.0	2,220.0	28.5
1964	2,240.0	2,260.0	25.2
1966	2,408.0	2,470.0	23.6

Source: Derived from Appendix, Tables 35, 36, 38, 39, and 41.

However, the heavy dependence on the demand for natural rubber in developed countries has not been the only cause of instability in these rubber producing nations. This vulnerable position has been accentuated by the low elasticity and flexibility of natural rubber supply. The students of the rubber industry are generally agreed that short-run supply of the natural rubber industry is price inelastic:

> While production is responsive to prices, the extent to which it can be increased at any one time is limited by the number of trees which can be tapped. It must be remembered that it takes seven years from the time of planting for a rubber tree to come into tapping . . . . Supply does not therefore, due to it relative short-term inelasticity, fully or rapidly adjust itself to major changes in demand and in consequence this is a major cause of price instability.[4]

P. T. Bauer adds:

> The vulnerable position of the industry was accentuated by the low elasticity of supply of important groups of producers.[5]

When rubber demand has declined in the past, the majority of estate producers have maintained output at a fairly constant level until the price of rubber declined below direct costs. These direct costs are estimated at approximately one-third to two-fifths of total costs. But many small holders have virtually no direct costs and they can be expected not only to maintain their current production, but they may even increase output in order to compensate for lost income due to the

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[4]P. E. Adams, Memorandum on the Fluctuations in the Price of Natural Rubber (Kuala Lumper, Malaysia: Government Printer, 1958), pp. 2-3.

[5]P. T. Bauer, The Rubber Industry: A Study in Competition and Monopoly (Cambridge: Harvard University Press, 1948), p. 28.

price declines.[6] Owing to the characteristic of the demand for and supply of natural rubber, prices have exhibited abrupt and violent fluctuations.[7]

Consumption by Regions

The world consumption of new rubber, including both natural and synthetic, has been continuously rising, despite the years of sharp depression and political and economic uncertainties. Table 12 presents the average regional share of the world's total consumption of new rubber in each decade since the turn of this century for the United States and Western Europe. The information in Tables 2, 35 and 36 are considered together. It can be seen that the average consumption figures in each decade shown in Table 12 for the United States, Western Europe, and the world as a whole, have been higher than the peak consumption in any year during the preceding decade. Tables 35 and 36 not only indicate the rapid growth in the consumption of new rubber which has taken place in this century, but also clearly present the importance of the United States and Western Europe as a rubber consumer. In the present decade the United States' share of rubber consumption has decreased. However, it is still the major rubber consuming country.

Table 13 shows the average consumption of natural rubber by regional share of the world consumption, for the United States and Western Europe.

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[6]You, Man He, "A Study of the Natural Rubber Industry with Special Emphasis on Its Future Prospects," (Unpublished Ph.D. Dissertation, Eugene, Oregon: University of Oregon, 1963), p. 7.

[7]Wharton, Clifton R. "Rubber Supply Condition: Some Policy Implication," in T. H. Silcock and E. K. Fisk (eds.), The Political Economy of Independence Malaya: A Case Study in Development (Berkeley and Los Angeles, California: University of California Press, 1963), pp. 133-134.

Table 12. Average consumption and regional share of new rubber consumption since 1900 (in thousand long tons)

Period	U.S.A.		Western Europe		World total
	Average	Percentage	Average	Percentage	
1901-1910	29	41	31	47	70
1911-1920	117	63	53	29	185
1921-1930	354	64	131	24	548
1931-1940	485	52	-	-	941
1941-1950	865	59	328	22	1,464
1915-1960	1,403	47	801	25	2,962
1961-1966	1,866	39	1,362	28	4,844

Source: Calculated by using Table 35 for 1900-1937 and thereafter, Rubber Statistical Bulletins several issues.

Table 13. Average consumption and regional share of natural rubber consumption since 1900 (in thousand long tons)

Period	U.S.A.		Western Europe		World total
	Average	Percentage	Average	Percentage	
1901-1910	29	41	33	47	70
1911-1920	117	63	53	29	185
1921-1930	354	64	131	24	548
1931-1940	485	52	-	-	941
1941-1950	448	47	254	27	952
1951-1960	531	29	642	35	1,825
1961-1966	483	21.1	661	29	2,278

Source: Calculated by using Table 35 for 1900-1937 and thereafter, Rubber Statistical Bulletin several issues.

There has been a growth in the consumption of natural rubber in each decade in both the United States and Western Europe. Yet, although average consumption increased, it did not expand enough to surpass the peak of the preceeding decade. This is an interesting contrast to the case of new rubber which was examined in Table 12.

In the period 1951-1960 and 1961-1966, the United States and Western Europe together consumed 64 and 50 percent of the world's total consumption of natural rubber respectively. This drastic decline from the approximate 90 percent average in the first three decades was primarily due to the large change in the use of synthetic rubber, particularly in the United States. Before the synthetic industry was successfully developed, the United States alone absorbed 63 percent and 64 percent of the total world consumption in the decades 1911-1920 and 1921-1930 respectively. The effects of the increase use of synthetic rubber for widely diversified products in the decade 1951-1960 and 1961-1966, on the United States' dependence on natural rubber were great.[8] The share of the United States in the total world consumption of natural rubber was diminished to 21 percent in the period 1961-1966, the all-time low. In the present decade, the annual consumption of natural rubber in the United States was approximately 500,000 tons less than that of Western Europe.

Clearly, less reliance on foreign sources for natural rubber by the United States is a result of the successful development of synthetic

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[8]UNCTAD, Report of the International Rubber, Study Group Working Party on the Prospects for Natural Rubber, TD/B/C. 1/20, 28 June, 1966, Appendix 1, pp. 1-7.

rubber. For example, in 1966 the United States met its consumption requirement for new rubber by using 549,700 tons of natural rubber, equivalent to 24.7 percent, and 1,672,000 tons of synthetic rubber (see Table 36).

In contrast with the United States, the share of Western Europe in the consumption of natural rubber has been increasing, as shown in Table 13. However, the moderate increase is not enough to offset the sharp decline in consumption of natural rubber by the United States. Relatively heavy Western Europe dependence on foreign sources of natural rubber can be seen in the consumption pattern shown in Table 36. In 1966, 50 percent of the total new rubber consumption was supplied by natural rubber.

The drastic decline in the consumption of natural rubber in the United States has resulted in attempts by the rubber producing countries to increase their sales elsewhere and various methods such as more efficient production to lower costs, increase in its quality and uniformity, make available new forms of rubber, and to expand its uses.[9]

In this connection, a brief mention is made below with respect to consumption of natural rubber in the centrally planned countries; the Soviet Union, Eastern Europe, and Communist China.

Table 14 shows estimated natural rubber imports and estimated synthetic rubber domestic production in Soviet Union and Eastern Europe. The sudden low percentage use of natural rubber in U.S.S.R. and Eastern Europe in 1964 is probably due to U.S.S.R. drawing down inventories during

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[9]Stephen T. Semegen, "Natural Rubber: Progress at the Mid-Decade," Rubber World, 154(1966), p. 75.

Table 14. Estimated imports of natural rubber and domestic production of Soviet Union and Eastern Europe (in thousand long tons)

Year	N.R. imports	S.R. production	Total consumption	Percentage of N.R.
1961	485	478	963	50
1962	433	604	1,037	42
1963	421	754	1,175	36
1964	292	933	1,225	24

Source: UNCTAD, The International Organization of Commodity Trade Case Study of Natural Rubber, TD/B/AC. 2/4, 4 January, 1966, p. 18.

that year.[10] Imports to the U.S.S.R. in 1965-1966 has to have been resumed at a higher level than that of the proceding year (see Table 10).

The figures in Table 10 and 14 show that the centrally planned countries have shown a steady growth in the consumption of both natural and synthetic rubber in the last decade. In 1964, the centrally planned countries consumed about 434,000 tons of natural rubber. This is equivalent to 35 percent of their requirements. In addition, they consumed 933,000 tons of synthetic rubber.

At present of the natural rubber consuming countries Japan ranks second, exceeded only by the United States. Table 15 shows the fast and steady growth in consumption of both natural and synthetic rubber. Note that the share of natural rubber declined from 73 percent in 1960 to 54 percent in 1965. In 1965 Japan consumed about 365,000 tons of natural and synthetic rubber. This was 7 percent of world rubber

[10] UNCTAD-TD/B/AC. 2/4, op. cit., p. 18.

Table 15. Consumption of natural and synthetic rubber in Japan (in thousand long tons)

Year	N.R.	S.R.	Total	Percentage of N.R.
1960	165.7	61.3	227	73.0
1961	176.0	84.0	260	68.0
1962	190.0	104.0	294	64.5
1963	192.4	125.6	318	60.5
1964	202.8	159.2	362	56.0
1965	198.3	166.7	365	54.3

Source: UNCTD, Report of the International Rubber Study Group Working Party on the Prospects for Natural Rubber, TD/B/C. 1/20, 28 June, 1966, p. 17-18.

consumption (see Table 15 combined with Table 36).

Consumption by Uses

Crude rubber is a remarkably versatile raw material and therefore finds application in the fabrication of a wide variety of goods. K. E. Knorr has classified the use of rubber by its special properties as:

> In many articles--tubes, hose, boots, waterproof clothing, bathing utensils, contraceptives--rubber is used because of its impermeability to liquids and gases and its singular plasticity. In the electrical field, rubber is applied primarily because of its remarkable resistance to electrical currents. Its elasticity is utilized in the field of mechanical rubber goods. In combination with other qualities, rubber's abrasion-resistance allows the making of satisfactory tires, soles, and conveyor belts. The fabrication of rubber-containing sanitary goods utilizes the ease with which the material can be cleaned with water and antiseptics. Imperviousness to many chemicals makes rubber indispensable

in the modern laboratory.[11]

Concerning the importance of rubber, P. W. Barker, a rubber specialist with the U. S. Department of Commerce has pointed out that:

> Rubber is the one of the most useful substances in the world today. Remove it entirely from our lives and civilization would be plunged into another Dark Age; gone would be the modern system of communication and transportation . . . whole branches of the arts . . . and a bewildered world we would inhabit.[12]

World consumption of rubber takes many forms. Countries not only differ in the amount, but also in the nature of the goods they produce. The extremely rapid development of the pneumatic tire, which accounted for more than 70 percent of total consumption around 1940, made its mark almost everywhere, and, as a result, production methods became relatively standardized.[13] Jean Le Bras has classified the major types of goods with reference to the four localizations of the industry.[14]

First, there is the heavy finished products industry, corresponding to application in cars, bicycles and aircraft. It manufactures pneumatic tires, inner tubes, solid tires, etc., using mass-production methods in extensive factories. It has been established where a large labor force is readily available.

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[11] K. E. Knorr, World Rubber and Its Regulation (California: Stanford University Press, 1945), pp. 44-45.

[12] P. W. Barker, Rubber Industry of the United States 1839-1939 Trade Promotion Series, No. 197 (Washington, D. C. Department of Commerce, 1939), p. 30.

[13] Le Bras, op. cit., p. 93.

[14] Ibid., pp. 93-96.

The second group consists of the footwear industry, including the manufacture of soles and heels, and the clothing industry. These are frequently associated with the textile industry.

The third group includes the ancillary industries, covering the production of all rubber articles likely to be used in engineering or for machine tools, such as hose, belting, conveyor belts, brake lining, coating for metals, and also the cables and insulating material for electrical equipment. Their location usually tends to reflect the influence of concentration of the engineering or electrical manufacturing industries.

In addition, there are many other types of goods--medical, surgical, and dental goods, furnishing materials, sports goods, glues and adhesives, printing accessories, and ebonite goods. Factors which determine where it shall be produced are the location of the consumer, and very frequently the availability of skilled labor of the different types required for the heavy section of the industry.

Table 16 shows that in the United States, until 1941, 100 percent of new rubber required in the production of transportation goods was provided by natural rubber. However, abundant supplies of synthetic rubber caused abrupt changes in the relative distribution of natural and synthetic rubber in transportation products, as well as in non transportation goods.

The use of natural rubber in transportation, almost entirely in tires and tubes for automobile, farm tractors, trucks, buses, airplanes, and bicycles, declined from 100 percent in 1941 to 14.7 percent in 1945.[15]

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[15]"The Rubber World Outlook for '67," Rubber World, 155, (January,

Table 16. Consumption of rubber in transportation and non-transportation and percentage of natural rubber to the total consumption (in thousand long tons)

	U.S.A.				U.K.				France			
Year	Transp.	%	Non-transp.	%	Transp.	%	Non-transp.	%	Transp.	%	Non-transp..	%
1935	378.5	100	113.2	99.8								
1937	424.0	100	120.1	99.6								
1939	442.7	100	151.1	98.7								
1941	525.0	100	256.3	97.5								
1943	348.8	66.5	139.7	61.5								
1945	590.2	14.7	208.8	8.9								
1947	830.6	53.3	291.6	41.1								
1949	659.5	58.0	329.4	58.3					64.6	95.0	39.9	85.1
1950	818.2	58.4	440.3	55.1	128.7	100	93.8	97.0	65.4	95.4	41.9	89.3
1951	812.0	38.1	401.0	36.1	135.8	100	102.3	96.3				
1952	842.0	35.9	419.0	36.0	108.1	99.8	94.1	94.8				
1953	858.0	41.7	480.0	40.7	115.9	99.6	95.6	95.3				
1954	777.0	49.6	456.0	46.1	133.6	97.9	119.4	95.0				
1955	960.0	42.7	570.0	39.5	147.9	92.5	120.7	92.5				
1956	897.0	40.6	539.0	36.7	126.2	78.4	113.6	89.9				
1957	926.0	37.0	538.0	36.4	128.0	66.5	116.5	87.3				
1958	861.0	35.1	496.0	36.9	126.6	63.0	119.3	86.0				
1959	1,024.0	34.7	603.0	33.8	142.3	59.1	120.0	83.3	115.5	66.5	84.2	67.3
1960	995.0	32.5	563.0	27.5	155.6	53.3	135.4	71.5	124.1	60.8	94.1	55.3

Source: Calculated from data in Man He You, "A Study of the Natural Rubber Industry with Special Emphasis on Its Future Prospects" (Unpublished Ph.D. Dissertation, Eugene, Oregon: University of Oregon, 1963), pp. 192-197.

This was caused by the United States being cut off from Southeast Asia rubber sources during World War II. Renewed supply of natural rubber from Southeast Asia after 1945 increased the proportion of natural rubber absorbed in transportation products to 58 percent in 1950. This rise did not last long. After the Korean Conflict, the sufficient supply of synthetic rubber offered various advantages in both prices and quality as compared to natural rubber (see the detail in Chapter V). The consumption of natural rubber in transportation declined to the low level of 32 percent in 1960. The most recent report from the General Tire Company reveals that synthetic rubber in America's transportation continued its growth in usage as it reached approximately 76 percent of total 1966 volume of raw material.[16]

As in the United States, the predominant position held by natural rubber in transporation products has been seriously affected by the recent emergence of synthetic rubber industries in both the United Kingdom and France. Table 16 shows that the percentage use of natural rubber declined from 100 percent in 1951 to 53 percent in 1960 in the United Kingdom. In the case of France, the percentage declined from 95 percent in 1950 to 61 percent in 1960.

A similar trend in the decline of the percentage use of natural rubber in transportation goods is also apparent in non-transportation goods. In the United States, the proportion of natural rubber used in non-transportation products has been not only continuously falling, but is also lower than the proportion of natural rubber used in

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[16] Ibid., p. 51

transportation goods. For example: in 1960, 28 percent of total new rubber consumption for non-transportation goods was supplied by natural rubber, while 32 percent was natural rubber in transportation products.

In the United Kingdom no sharp change in the distribution of new rubber consumption in non-transportation products has occurred in the past decade. However, quite a change is evident in case of France.

Production

Plantation rubber production is very well developed in Southeast Asia because of well-distributed rainfall, temperatures between seventy and ninety degrees Fahrenheit, and abundant cheap labor.[17] In addition to these factors, four others are cited by Sir Andrew Mc Fadyean in explaining the development of rubber plantations in this area: (1) All of the early experimental work on rubber planting was carried out here; (2) the countries in which the plantation industry was begun had stable governments with good administrators since they were either British or Dutch colonies; (3) there was ample land suitable for planting; and (4) there was no great transportational difficulties, all the territories having easy access to the sea from coast lines long in proportion to the areas behind them.[18]

As Table 2 indicates, in 1910 almost all of the world production of raw rubber, 93,000 tons, came from wild rubber trees. The plantation rubber-growing industry, at this early stage of its development, produced

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[17]Phillips, op. cit., p. 147.

[18]Andrew Mc Fadyean, The History of Rubber Regulation 1934-1943 (London: George Allen & Unwin, Ltd., 1944), p. 10.

only 11,000 tons, or about 12 percent of the year's supply.[19] By 1966 the world production of raw rubber increased to about 5,726,000 tons, of which 2,408,000 long tons was natural rubber from plantation and about 3,318,000 long tons was synthetic.

Since 1914 plantation rubber has maintained its leadership over wild rubber, contributing about 99 percent of the total natural rubber output of the world in 1966. In this case, plantation rubber was developed not only to increase the supply of rubber, but also for technological advantages. Wild rubber was non-uniform and dirty, and could not meet the basic technological requirements for all kinds of expansion of the rubber industry during the early 1900's.[20] Another reason for the rapid development of plantation of rubber is the greater regularity of supply and lower price. As Lennox A. Mills wrote:

> By 1914 the output of estate rubber exceeded that of jungle rubber, since systematized production with settled labor conditions proved the more economical and reliable. Malayan estates could deliver rubber in New York for less than its cost to collect and ship wild rubber from the Amazon. Moreover they could assure a regular supply while the collectors of wild rubber could not.[21]

The rise in demand for rubber due to improved technology and new uses resulted in greater efforts to improve and develop new sources of rubber supply (see Chapter II). In 1962, 10.5 million acres were planted

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[19] G. S. Whitby and others (eds.), Synthetic Rubber (New York: John Wiley & Sons, Inc., 1954), p. 1.

[20] S. M. Caldwell, "Scientific Contributions to the Rubber Industry," Rubber World, 145, (April, 1957), p. 58.

[21] L. A. Mills, Malaya: A Political and Economic Appraisal (Minneapolis, Minnesota: University of Minnesota Press, 1958), p. 22.

with natural rubber trees.[22] On a world wide basis rubber is exported by Malaya, Indonesia, Thailand, Ceylon, and many other Asian countries, as well as some countries in Africa and Latin America. The States of Malaya, Indonesia, Thailand, and Ceylon together have provided about 80 percent of the world's rubber production since 1948.

Table 17 indicates the ranking of the more important rubber producing countries in Asia. Table 18 shows the relative importance of estates and small holdings in various countries.

Throughout the first quarter of the century, the bulk of all rubber produced was supplied by the estates.[23] Gradually, however, the samll holders have strengthened their position. Today, small holdings supply nearly two-trhids of the total output in Indonesia, more than two-fifths in Malaya, and almost the entire output of rubber in Thailand.[24] Although the distinction between estate producers and native small holders is arbitrary, a distinction between the two types of production is useful for economic analysis of flexibility of supplies, discussed in Chapter V. Mrs. M. J. 'tHooft Welvaars' case study for UNCTAD presented the significant difference between estates and small holdings as follows:

> Perhaps it may be said that those countries producing natural rubber largely on estate are better fitted in the race for higher productivity than the countries producing mainly on smallholdings, unless the latter's governments are very active of applying research and possess--or provided with--the financial means to carry their smallholders over

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[22]Polhamus, op. cit., pp. 31-32.

[23]Percy W. Bidwell, Raw Material: A Study of American Policy (New York: Harper & Brothers, 1958), p. 264.

[24]Phillips, op. cit., pp. 147-148.

Table 17. Production of natural rubber in the principle producing countries (in thousand long tons)

Year	Malaya	Indonesia	Thailand	Ceylon	Vietnam	Rest of Asia	Africa	Latin America	World Total
1956	626.0	686.7	134.6	95.4	69.1	138.0	113.5	29.7	1,893
1957	637.5	684.5	134.0	98.2	68.6	135.9	116.3	30.0	1,905
1958	662.9	685.2	138.4	100.2	70.5	136.2	123.3	26.3	1,943
1959	697.8	693.5	171.3	91.7	74.2	144.6	141.8	28.1	2,043
1960	708.4	610.5	168.2	97.3	75.4	154.2	147.0	29.0	1,990
1961	736.7	671.4	183.2	96.0	77.9	158.4	142.0	29.4	2,095
1962	751.6	670.8	192.3	102.4	74.0	159.8	150.8	28.3	2,130
1963	788.5	573.1	186.8	103.1	70.7	166.8	151.8	27.2	2,068
1964	825.3	638.4	218.2	109.8	73.3	181.3	158.8	34.9	2,240
1965	860.7	705.7	213.1	116.4	60.0	182.8	153.5	35.8	2.328
1966	928.5	700.0	210.0	128.9	50.7	187.4	170.0	32.5	2,408

Source: Commodity Yearbook 1967, p. 282.

Table 18. Structure of natural rubber industry, percentage acreage of smallholdings

Country	Estates	Smallholdings (less than 100 acres)
States of Malaya and Singapore	47%	53%
Sarawak	3	97
Sabak	37	63
Brunei	11	89
Indonesia	28	72
Ceylon	47	53
Thailand	10	90
Vietnam	71	29
Cambodia	90	10
India	32	68
Burma	53	47
Total Asia and Oceania	36	64
Brazil	42	58
Congo	73	27
Liberia	50	50
Nigeria	12	88
Cameroon	98	2
Total Africa	47	53
Total World	37	63

Source: UNCTAD, TD/B/AC. 2/4, op. cit., p. 29.

a replanting period.[25]

Production of Synthetic Rubber

At the end of World War II, only four countries had any substantial synthetic rubber production capacity--Canada, Germany, Russia, and the United States. The competition between natural and synthetic rubber did not become serious until 1940 when the United States embarked on a synthetic rubber program to counter the threat of being cut off from the rubber source in Asia. The Japanese conquest of nearly all the producing areas in Asia resulted in a rapid acceleration of the synthetic rubber program. American advance technology and mass production techniques fostered the infant synthetic rubber industry to a high level of production in less than five years.[26] After 1945, the future of synthetic rubber remained uncertain. Few countries other than the United States showed interest in building the new industry. In the past few years, however, capacity outside the United States had rapidly expanded.

Table 19 showed the production of synthetic rubber in various countries from 1940-1966. The bulk of synthetic rubber at present produced is accounted for by SBR, which is well ahead, followed by butyle, neoprene, stereo-rubbers (polyisoprene and polybutadiene) and nitrile.[27] At the same time, we find that production is on the increase in many

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[25]UNCTAD-TD/B/AC. 2/4, op. cit., p. 30.

[26]A completed study of U.S. syntehtic rubber industry during the World War II, see Frank A. Howard, Buna Rubber: the Birth of an Industry (New York: D. Van Nostrand Company, Inc., 1947).

[27]Phillips, op. cit., pp. 68-82.

Table 19. World production of synthetic rubber 1940-1966 (in thousand long tons)

Year	U.S.A.	Canada	Germany	U.K.	Italy	Japan	France	World Total
1940	2.6		39.8					42.4
1942	22.4		98.1					77.5
1944	764.1	34.8	101.6					120.2
1946	740.0	51.0	15.6					350.0
1948	488.3	40.5	3.4					900.5
1950	476.1	58.4	-					534.6
1952	798.5	74.3	4.9					877.8
1953	848.4	80.9	6.3					935.6
1954	622.9	86.6	7.0					716.4
1955	970.5	103.9	10.9					1,085.3
1956	1,086.0	120.7	10.7					1,211.0
1957	1,118.0	132.1	11.6	0.8				1,263.0
1958	1,055.0	135.0	22.7	11.3	20.0			1,243.0
1959	1,380.0	100.7	48.1	57.0	47.0	1.2	5.9	1,633.0
1960	1,436.0	159.7	79.8	90.0	70.0	18.8	17.2	1,880.0
1961	1,404.0	164.5	85.6	106.0	82.0	50.0	40.0	1,975.0
1962	1,574.0	168.3	88.2	117.0	86.0	68.0	63.0	2,240.0
1963	1,608.0	178.7	106.5	125.0	94.0	90.0	97.0	2,438.0
1964	1,765.0	197.5	135.7	153.0	110.0	120.0	128.0	2,803.0
1965	1,814.0	203.0	161.4	171.7	118.0	158.8	146.0	3,015.0
1966	1,969.0	200.0	170.9					3,318.0

Source: Rubber Statistical Bulletins, several issues.

countries. Germany, Russia, Canada, and the United States are the pioneer countries. The new countries, who made a determined entry into their branch of the synthetics industry, have recently been joined by Great Britain, Italy, Holland, France, Japan, Australia, and Brazil. In addition, projects have been announced in several other countries, namely, Poland, India, Israel, Mexico, Argentina, South Africa, Belgium, Rumania, and Red China.[28]

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[28]Le Bras, op. cit., p. 70.

CHAPTER IV

THE NATURAL RUBBER INDUSTRY IN THAILAND

Structure of the Economy

A country with an area of approximately 200,000 square miles, entirely under the tropical monsoon climate, and a population of about 32 million people, Thailand is relatively small and underdeveloped.[1] Known resources are limited to agriculture and rubber-planting areas, tin deposits, and some high-value teak forests. Basic mineral and power resources, as far as they are known, are particularly poor.[2] Relatively better endowed with hydro electric power potentials, the first hydro-power dam, part of the Yanhee Multi-Purpose Project,[3] was completed in 1964. In terms of absolute number, the population of 32 million, increasing at a rate about three percent per annum, is sizable. Per capita income, however, was only about $125 dollars in 1965 (see Table 20).

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[1] Office of the Prime Minister, Thailand Official Yearbook 1964 (Bangkok: Government House Printing Office, 1965), pp. 1-10, 327-374.

[2] United Nations, Economic Survey for Asia and the Far East, 1947-1955 (Bangkok).

[3] The first project to undertake storage and regulation of river waters in Thailand on a large scale includes a 150 meter high dam and a reservoir of over 5 billion cubic meter capacity. Beside providing 560,000 kilowatts of electric power, it will benefit irrigation and flood control in the Central Plain.

Table 20. Gross national product of Thailand (in thousand dollars)[a]

Product	1951	%	1955	%	1960	%	1965	%
Agriculture, total	14,139.1	50.1	828,405	42.0	1,084,440	38.9	1,314.690	32.8
Agricultural corps	10,873.3	38.5	598.760	30.4	749,270	26.9	866,070	22.1
Livestock	1,208.4	4.3	105,610	5.3	195,990	7.0	207,635	5.2
Fisheries	615.4	2.2	41,440	2.1	48,930	1.8	111,840	2.8
Forestry	1,439.0	5.1	82,595	4.2	90,250	3.2	109,145	2.7
Mining and quarrying	537.4	1.9	30,775	1.6	38,265	1.4	83,800	2.1
Manufacturing	2,900.6	10.3	232,370	11.8	294,100	10.5	484,215	12.1
Construction	810.4	2.9	79,300	14.0	100,515	3.6	191,955	4.8
Electricity and water supply	31.2	0.1	4,210	0.2	11,355	0.4	28,845	0.7
Transportation and communication	883.4	3.1	100,700	5.1	197,425	7.1	299,865	7.5
Wholesales and retail trade	5,084.6	18.0	386,865	19.6	483,010	17.3	746,435	18.6
Banking, insurance, and real estate	100.4	0.4	27,370	1.4	63,780	2.3	146,730	3.7
Ownership of dwellings	1,048.9	3.7	59,555	3.0	127,845	4.6	169,700	4.2
Public administration and defense	783.7	2.8	93,985	4.8	135,330	4.8	196,100	4.9
Service	1,890.2	6.7	128,850	6.5	254,730	9.1	346,925	8.6
GNP. at market price	28,209.9	100.0	1,972,385	100.0	2,790,795	100.0	4,009,260	100.0
				Per Capita Income				
Population (in million)	20.3		22.9		27.1		32.0	
Per capita GNP. at market price - dollars	62.4		76.4		102.8		125.2	

Source: Calculated from Office of the National Economic Development Board (hereafter referred to as ONEDB), National Income of Thailand (Bangkok, Thailand: Several issues).

[a]Conversion at exchange rate for convenience and hereafter, $ 1 = 20 baht.

Agriculture and other primary producing activities dominate the entire economy. The proportion of the occupied population engaged in agriculture was 82 percent in the census year of 1961.[4] About 33 percent of the G.N.P. in 1965 was directly attributed to agriculture, forestry, and fishing. No doubt the contribution of agriculture to the national income would be much greater if related activities--the processing, transport, commerce, finance, of agricultural products--were included.

The postwar growth of the economy has resulted in significant structural changes. The most outstanding feature of the changing production pattern has been the marked decline in the relative importance of the dominant agricultural sector. From 50 percent of the G.N.P. in 1951 the share of agriculture fell to 33 percent in 1965. At the same time the combined contribution to the G.N.P. of manufacturing, construction, transportation and communication, and public utilities rose sharply from 16 percent of the G.N.P. in 1951 to 22 percent in 1960 and 25 percent in 1965.

The trend towards diversification of the Thai economy is reflected not only in the different growth rates between the dominant agricultural sector and the industrial and service sectors, but in a widening variety of production within the agricultural sector itself. As may be seen in Table 21 the combined value of the "other crops" which include corn, sugar cane, cassava, kenaf, coconut, tobacco, cotton, and livestock has risen considerably faster than rice in the postwar period.

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[4] Office of the Prime Minister, op. cit., p. 330.

Table 21. Percentage shares of the value of major types of agricultural production in Thailand

	1938-39	1948-50	1953-55	1958	1961	1963	1965
Rice	62.6	55.5	42.1	40.0	39.8	46.2	43.4
Rubber	8.9	8.8	11.4	8.8	9.1	8.0	7.6
Other Crops	28.5	35.7	46.5	51.2	51.1	43.2	46.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: For 1938-1950: J. S. Gould, Preliminary Estimates of the Gross Geographical Product and Domestic Income of Thailand (Bangkok: National Economic Council, 1953), pp. 11-12.
For 1953-1965: ONEDB, National Income of Thailand (Bangkok: several issues)

The share of the "other crops" in recent years has amounted to about half of the total value of all agricultural production whereas the share of rice since the early 1950's has declined from about one half to just more than one-third. But the rubber has generally constituted an annual share in agricultural sector of about eight to nine percent yearly.

Development of Rubber Plantations

Rubber (Hevea Brasiliensis), according to the records available, was introduced into Thailand from Malaya on two occasions. The first one was taken to Trang (southern region) around 1900-1901 by the late Phya Rasda-nu Pradit, then the Governor of Trang. The second was conveyed some ten years later by Luang Rajmaitree, a prominent resident of Chantaburee (eastern region).[5] From these two importations rubber

[5]Pan Maleewan," Future of Rubber Plantation Owners in Thailand," Agriculture XXXII(1959), pp. 281-283. Ceylon began planting in 1889, Malaya in 1895, and Indonesia in 1896. Virginia Thompson, Thailand: The New Siam (New York: the Macmillan Company, 1941), p. 479); Dijkman, op. cit., p. 6.

plantations began their first exports in 1911 when 100 tons were shipped out. At the same time Malaya exported 10,000 tons; Indonesia 2,300 tons; Ceylon 3,200 tons; and Indo-China 2,000 tons. Since then rubber plantations in Thailand increased consistently and in 1950 Thailand was able to export as much as 112,200 long tons, thus ranking fourth among the producer countries.

In 1955 Thailand's rubber export increased to 130,200 long tons, and was exceded only by Malaya and Indonesia. Thailand's 1955 planting acreage was recorded to be above 912,400 acres, against 419,200 acres in 1940. In 1964 the planting area had increased to about 1,400,000 acres, of which 1,108,800 acres were tappable and the production was about 218,200,000 tons (see Table 22). Domestic consumption, however, was very low. The most recent consumption (1964) was estimated to be about 2,000 tons a year.[6]

The rubber planted areas are in the fourteen provinces of the Southern region and four provinces of the Eastern region. But the principle planted areas, amounting to more than 90 percent of the total rubber planted areas are in the Southern region. The four provinces, planting over 100,000 acres each, are Narathiwat, Songkhla, Yala and Pattan. These are deep south provinces bordering with Malaya and Trang. The center of the planting region has been along the branch railroad between Thungsong, Kantang, and Hadyai, where the town of Trang and Hadyai are the rubber centers. Acceptable climatic conditions,

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[6]Boonchu Disayavanich, The Development of Rubber Plantation in Thailand (Unpublished M.A. Thesis, Thamasat University, 1964), p. 117.

Table 22. Rubber plantation areas in Thailand (in thousand acres)

Year	Rubber area[a]	Tapped area	Production (in long tons)
1920	60,000	-	400
1929	150,000	35,200	4,300
1934	366,000	200,000	17,700
1940	419,200	299,200	-
1950	800,000	680,000	112,200
1955	912,400	727,600	130,200
1960	1,203,600	960,000	168,200
1962	1,256,000	1,038,800	192,300
1964	1,400,000	1,108,800	218,200
1966	-	-	210,000

Source: For 1920-1950, James C. Ingram, Economic Change in Thailand Since 1850. (Stanford, California: Stanford University Press, 1955), p. 102.
For 1955-1966, ONEDB, Annual Report on Economic Condition of Thailand, several issues.

[a]Rai is an area measure in Thailand, equal to 1,600 square meters or about 0.4 acre (hereafter referred to this rate to convert rai to acres).

unused land, and easy railway access favored this development in the southern peninsula. Smaller acreages are found along the lower slopes of rainy hills in Chanthaburi, Rayong, and Trat on the southeast coast of the mainland.[7]

[7]Department of Agriculture, Ministry of Agriculture, "Para Rubber," Bangkok, 1965, pp. 1-3. (Mimeographed)

Rubber-growing in Thailand followed a different pattern of development from that in other countries of South Asia. Plantations have never been large. Most plantings are of only a few acres each. K. P. Landon wrote in the late 1930's that most of the small planters had 2,000 to 3,000 trees, and that only a few estates have as many as 10,000 trees.[8] The planting and production are controlled by Chinese and native Thai, not by Europeans as in Malaya.[9]

Production of rubber in Thailand has responded roughly to price changes. Production was first undertaken during the automobile boom at the beginning of this century when the price of the world rubber market rose to over $1.00 during the period 1904-1912 (see Figure 1). The acreage was increased extremely slowly in this period. By 1920 only about 60,000 acres were planted. After that year world rubber prices collapsed (the rubber price at New York moved down from 36 cents per pound in 1920 to as low as 3.4 cents per pound in 1932), and growers ceased to plant trees and abandoned gardens not old enough to be tapped. However, interest revived for a short period from about 1921, reaching its peak in 1925 when the British Government and Rubber Growers' Association in Malaya and Indonesia controlled production and exports in Malaya, Indonesia, and Ceylon. From 1925, prices started to fall again rapidly reaching the lowest point in 1931 because of the world economic crisis. Because the controls imposed were only regional in nature, they were only

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[8] K. P. Landon, Siam in Transition (Chicago, Illinois: University of Chicago Press, 1939), pp. 70-73. There are average about 125 rubber trees per acre.

[9] Robert L. Pendleton, Thailand: Aspects of Landscape and Life (New York: Duell, Sloan and Pearce, 1963), p. 202.

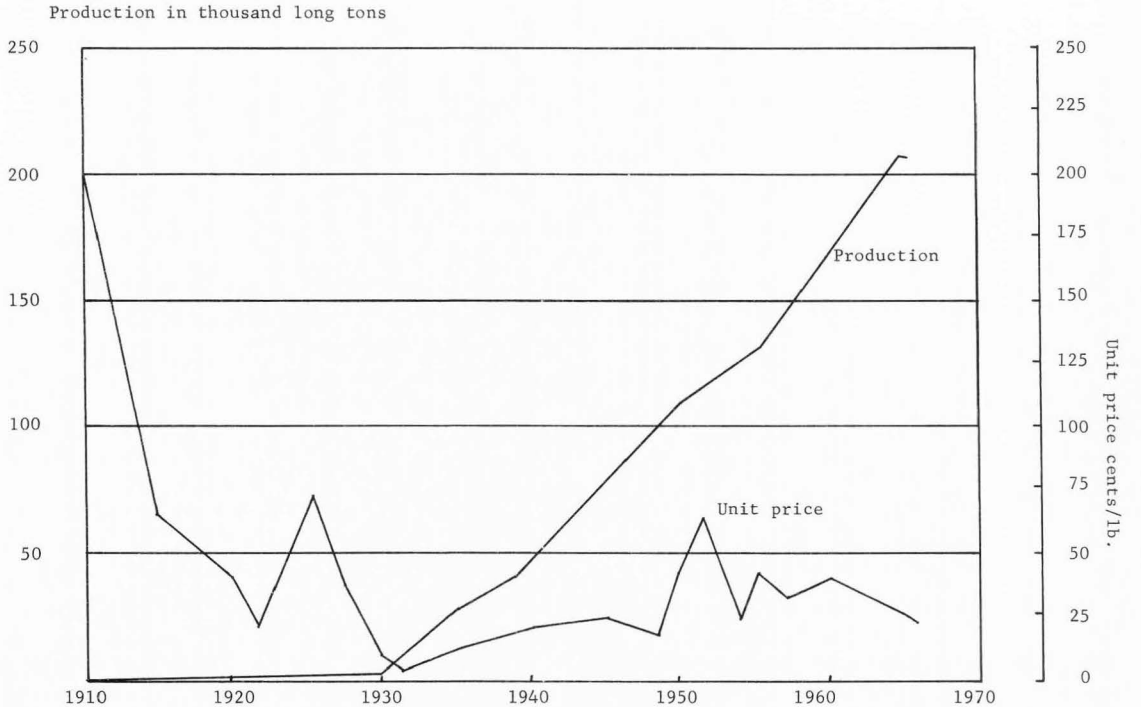

Figure 1. Thailand's rubber production and price, 1910-1966. Plotted from Tables 38, 39 and 41.

effective until 1925. In March 1934 Thailand joined the International Rubber Regulation Agreement which was in force from 1934-1943.[10]

The high demand following World War II brought an unprecedented rubber boom in Southern Thailand.[11] Prices rose rapidly. As a consequence of the United States stockpiling and excess buying during the Korean Crisis, sheet rubber production rose from 64,900 tons in 1947 to 112,200 tons in 1950. The market value at Bangkok of Thai rubber in 1947 was $156,750,000; in 1950, $696,150,000; in 1951, $1,073,800.[12] Then, in 1953, at the end of the Korean Crisis, prices fell drastically from 61 cents a pound in 1951 to 24 cents a pound. It has recovered somewhat since, but Thai growers have been very badly affected. Recent increases in production reflect the coming into tappable maturity of trees planted shortly after World War II.[13] Both exports and prices rose sharply in 1959 and 1960 due to the increase in demand of developed countries and planned countries. The value of rubber exports in this period rose 23

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[10]McFadyean, op. cit., pp. 22-47 and Knorr, op. cit., pp. 90-124. The IRRA, the first comprehensive and compulsory scheme for the strict control of rubber supplies to the world market, was a treaty between the five signatory governments. The producing countries covered were British Malaya, Ceylon, India, Burma, North Borneo, and Sarawak; the Netherland Indies; Thailand; and French Indo-China. Together these countries furnished 89 percent of the world rubber's exports in 1934. The agreement came into force from June 1, 1934 to December 31, 1938 and then it was renewed extending to 1943. However, on April 30, 1944, the agreement was finally terminated.

[11]Ingram, op. cit., p. 105.

[12]Division of Agriculture Economics, Ministry of Agriculture, A Statistical Review of Thai Agriculture 1954 (Bangkok, Thailand, 1956), p. 82.

[13]Pendleton, op. cit., p. 202.

percent, bringing a 30 percent rise in income.[14] The year 1960 was the first time that rubber export exceeded rice earned $128,950,000, thus exceeding rice which was $128,500,000 and had always been Thailand's most important export items (see Table 25).

Rubber Holding

Native planters control most of the rubber acreage. Table 23 shows that the average acreage holding was only 8.5 acres in 1950. Ninety-six percent of the number of holdings in 1950 were under 19 acres, and 67 percent of the acreage in rubber was in these small holdings. Only 8 percent of the total area was in plantations of 99 acres or over, and these 241 holdings averaged only 266 acres. Large-scale plantation cultivation is not important in Thailand.

Rubber acreage expansion in recent years has come principally from small holdings under the Thai or Chinese. The smaller plantings are generally owned by Thai, especially those of Malay descent. Larger plantings, including genuine plantations, are primarily Chinese-owned and operated. Table 24 shows the ownership of rubber holdings, based on nationality.

It is estimated that roughly about half the total rubber area is owned by persons of Chinese ancestry, but there are no official statistics on this point.[15] Of holdings under 20 acres, the Chinese-owned holdings averaged nearly 10 acres, compared to only 5.6 acres for those owned by

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[14] U. S. Department of Commerce, World Trade Information Service: Economic Development in the Far East and Oceania, 1959. Part, No. 60-67, Washington, 1960.

[15] Ingram, op. cit., p. 103.

Table 23. Rubber holdings in Thailand, 1944 and 1945

	1944	1950
	Number of holdings	
250 rai (98.75 acres) and over	213	241
50 - 250 rai (19.75-98.75 acres)	1,915	3,426
Less than 50 rai (19.75 acres)	72,817	87,780
Total	75,000	91,447
	Area in holding (in acres)	
250 rai (98.75 acres) and over	65,965	61,620
50 - 250 rai (19.75-98.75 acres)	71,100	198,290
Less than 50 rai (19.75 acres)	298,225	518,820
Total	435,290	779,730
	Average size of holding (in acres)	
250 rai (98.75 acres) and over	309.7	266.2
50 - 250 rai (19.75-98.75 acres)	35.9	57.7
Less than 50 rai (19.75 acres)	4.0	5.9
Over-all average	5.8	8.5

Source: Ingram, op. cit., p. 102.

Table 24. Ownership of rubber holdings in 1949

	Holding, under 20 acres		Holdings, 20 acres or over	
Nationality of owner	Number	Area	Number	Area
Thai	77,845	423,402	1,716	107,174
Chinese	5,752	57,220	1,858	130,655
Other	151	60.4	67	8,147

Source: Ingram, op. cit., p. 103.

Thai, For the most part the Thai rubber grower is a very small operator.

Not much capital was needed to develop and operate a small holding in the past. So, Western capital and enterpreneurship have not played an important part in the Thai rubber industry. In the late 1920's American and other Western interests considered developing the Southern region of Thailand. But because of unfavorable local conditions and the refusal of the Thai government to encourage an increase in the numbers of foreigners in the economy, the American attempts in this region were soon abandoned.[16] In 1949 only 67 plantation-type holdings, averaging 90 acres apiece, were owned by foreigners other than Chinese. Foreigners of non-Chinese descent, including Europeans, controlled only one percent of the total rubber acreage in Thailand.

Processing and Marketing

Small holders usually sell their rubber in the form of raw rubber sheets and the buyers do the smoking on a large scale. The larger owners operate their own smokehouses, and they may also have equipment for washing, congealing, and rolling the rubber on a large scale. The rubber merchants of all levels (local, city center, exporting center) who buy raw and smoke sheets also sort, grade, pack, and export it. Some of the larger plantations, including a government rubber plantation, operate crepe-rubber rolling factories, and some export crepe-rubber directly. Most smoked sheets, however, are exported by rubber merchants, nearly all of whom are Chinese.[17]

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[16]Pendleton, op. cit., pp. 203-204.

[17]Ingram, op. cit., p. 104.

Thai rubber has a reputation for a rather poor quality. This is the result of the low price, or classifying it as bearing a low grade price. It is frequently said that the fault lay with the Chinese merchants who do not grade or sort it properly. This part of the problem, in fact, comes from the small holding-type of rubber industry. The growers have different standards, poor facilities and tools, and inadequate quality grading. No doubt this is part of the problem. The establishment of standards has also been hindered by the processing methods of the small holders. They need to learn to clean and prepare the rolled sheets properly.

Williard A. Hanna has explained some basic characteristics of Thai rubber processing and marketing:

> The tappers are also mainly Thai--whether owners, tappers, or share-tappers who tend the Thai-Chinese estates. As a rule, the tappers are also the processors. /Marketing, however, is the function of middlemen, of whom, in Thailand, there are layers upon layers. . . ./ Instead of using formic acid to coagulate the latex, they use sulphuric acid, which is cheaper but less suitable and results in a rubber that is deficient in elasticity. They squeeze the liquid out of the coagulate and dry it in the sun, but they rarely go to the pains to produce the neatly waffled evenly smoked, brown sheet for which the buyers pay premium prices.
>
> Once the rubber is ready for market, they sell it to a collector, who smokes it and sells it to shopkeeper, who sells it to a journeyman, who sells it to a dealer--none of whom neglects to charge a commission.[18]

In 1950, the rubber industry furnished employment for about 150,000 individuals and their dependent families. There are over 91,000 planters,

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[18] Williard, A. Hanna, "Peninsular Thailand: Rubber of Haadyai and the Tin of Phuket," American University Field Staff, Southeast Asia Series, Vol. 13, No. 25 (October, 1965), pp. 2-3.

50,000-60,000 tappers, and an indeterminate number of factory workers, merchants, and others directly dependent upon the industry for their livelihood.[19] A recent estimate of people who worked on rubber plantations excluding marketing, was made by Boonchu Disayavanich, of the Ministry of Agriculture:

> From this rough calculation, we can estimate that the rubber industry employs 990,632 people. This is equivalent to 4.52 percent of the population or 6.06 percent of the people occupied in agriculture.[20]

Export of Natural Rubber

Rubber is a relative newcomer, having become a major export only since the second half of the 1930's. The growth of Thailand's rubber production and exports, however, has been quite rapid. It was increased at the rate of about 8 percent per year between 1934-1935 and 1955-1957, and 7 percent per year between 1960-1964. In consequence, the contribution of rubber to the total export earnings of Thailand has increased from 2 percent during the interwar period 1925-1929, to 13 percent before the outbreak of World War II, and to as high as 30 percent in 1959-1960. Rubber has therefore far outranked both tin and teak, and as mentioned overtook rice in 1960.

Since 1961 the percentage share of rubber has declined steadily from 21 percent of total exports to 13 percent in 1966. During 1961-1966, the world natural rubber price was shaken by the United States and Britain releasing their rubber stockpiles and by the strong competition

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[19] Ingram, op. cit., p. 104.

[20] Disayavanich, op. cit., p. 21.

of synthetic rubber. The average rubber price at Bangkok declined from $582 per ton in 1961 to $442 per ton in 1966 (see Table 25). At the same time, Thailand's Government Replanting Scheme of 1960 has started effecting the decreasing volume of production, beginning in 1964. In any event, the growth of rubber exports has significantly affected Thailand's balance of payments situation, especially in the postwar period.

Statistics released by the Department of Customs showed that in 1965, Thailand exported a total of 213,100 metric tons of rubber to twenty-six countries.[21] Most of the export went to the Asian countries. Japan and Singapore and Malaysia were the leading buyers who imported 54,178 and 46,217 metric tons, respectively. They were followed by the United Kingdom, the Federal Republic of Germany, Italy, and France (see Table 27).

Traditionally, the United States was the most important Thailand rubber importing country. From 1950-1957, the United States bought more than 90 percent of Thailand rubber.[22] Since then the United States' share was decreased steadily, because of her own production of synthetic rubber. In 1965, the United States imported only 7,028 metric tons of Thai rubber--3.3 percent of total rubber exports.

Since 1962 Japan has become the principal Thailand rubber customer, replacing the United States.

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[21] Bangkok Bank Monthly Review, November 1965, p. 228.

[22] Somporn Devsitha, Economics and Trade Perspective (Bangkok, Thailand: Progress Printing Office, 1962), p. 44.

Table 25. Quantity and value of principal exports of Thailand from 1957-1966[a]

Type of exports	1957	1958	1958	1960	1961	1962	1963	1964	1965	1966
Rice										
Quantity	1,570.2	1,183.0	1,091.7	1,202.8	1,576.0	1,271.0	1,417.7	1,896.3	1,895.2	1,505.3
Value	181.1	148.4	128.8	128.5	179.9	162.0	171.2	219.5	216.7	199.9
Rubber										
Quantity	134.8	138.4	171.3	168.2	183.2	192.3	186.9	218.2	213.1	210.0
Value	70.3	66.3	116.8	129.0	106.5	105.6	95.2	103.0	100.0	92.8
Tin										
Quantity	18.4	9.1	13.7	17.1	18.1	19.8	22.0	22.3	20.5	18.9
Value	26.1	12.8	21.7	26.8	30.9	34.8	37.1	48.1	58.3	65.8
Maize										
Quantity	64.3	162.9	236.8	514.7	567.2	472.4	744.0	1,115.0	804.4	1,226.7
Value	3.7	9.7	12.5	27.6	29.9	25.1	41.4	67.3	48.5	76.5
Teak										
Quantity	75.7	72.6	73.3	100.9	64.5	39.8	32.2	40.5	45.2	49.5
Value	13.1	12.0	12.2	17.8	12.6	8.5	6.9	8.9	10.1	12.2
Tapioca products										
Quantity	8.8	151.6	194.6	269.7	443.4	400.8	427.4	738.9	719.4	722.4
Value	6.9	9.6	11.2	14.4	22.3	21.2	22.0	32.7	33.8	34.2
Jute and Kenaf										
Quantity	14.6	27.6	37.3	61.8	143.4	237.9	125.8	162.1	317.0	485.5
Value	2.3	3.5	4.4	11.5	31.3	29.0	12.9	24.8	55.1	82.6
Others - Value	73.0	60.7	70.4	82.2	86.6	51.0	92.3	112.7	124.7	157.4
Total - Value	377.0	322.3	378.0	430.7	499.9	476.5	488.8	617.0	647.1	721.4

Source: Monthly Economic Report of the Bank of Thailand, Vol. 7, No. 4 (April, 1967), pp. 44-45.

[a]Quality in thousand metric tons except teak in cubic metres and value in million dollars.

Table 26. Annual volume and value of Thailand's rubber exports (in selected periods)

Period	Volume (metric tons)	Unit value ($ / ton)	Value (million dollars)	Percentage and total commodity exports
1925-29	9.780	283	2.4	2.3
1935-39	38,580	264	10.2	12.9
1948-49	93,392	307	23.6	10.9
1950-51	111,490	738	83.0	26.0
1952-55	115,714	462	53.9	17.0
1956	134,600	454	73.9	22.0
1957	134,833	521	70.3	18.6
1958	138,400	479	66.3	20.6
1959	171,300	682	116.8	30.9
1960	168,200	767	129.0	29.4
1961	183,200	582	106.5	21.3
1962	192,300	549	105.6	22.1
1963	186,887	509	95.2	19.7
1964	218,200	472	103.0	16.7
1965	213,100	468	100.0	15.5
1966	210,000	442	92.8	12.9

Source: For 1925-29 to 1935-39, Ingram, op. cit., p. 95.
For 1948-49 to 1956, International Financial Statistics, International Monetary Fund, Washington, D.C., several issues.
For 1957-1966, Monthly Economic Report of the Bank of Thailand Vol. 7, No. 4 (April, 1967), pp. 44-45.

Table 27. Principle rubber importing countries from Thailand (in metric tons)

Year	U.S.A.	Japan	U.K.	Singapore and Malaysia	West Germany	Italy	France	Czechos-lovakia	U.S.S.R.	Others	Total
1957	119,978	57	927	11,342	2,348	41	-	-	-	143	134,833
1958	92,723	368	10,780	20,863	6,225	20	382	204		6,835	138,400
1959	108,308	16,578	4,277	36,159	4,338	117	-	457	2,845	1,325	171,300
1960	59,075	40,717	5,007	35,261	14,280	613	189	3,455	7,606	1,997	168,200
1961	45,690	44,926	19,535	30,142	20,659	4,050	4,068	3,038	6,942	4,151	183,200
1961	41,150	50,742	28,371	27,515	19,225	5,144	2,190	989	7,401	9,573	192,300
1963	33,352	62,478	23,951	17,308	22,501	10,464	2,747	2,837	3,353	7,896	186,887
1964	13,944	80,815	38,136	27,103	23,235	11,948	7,438	3,455	-	12,126	218,200
1965	7,028	54,178	36,293	46,217	25,671	11,778	9,415	2,154	1,006	19,360	213,100

Source: Monthly Economic Report of the Bank of Thailand, Vol. 7, No. 4 (April, 1967), pp. 34-35.

Centrally planned countries have recently shown increasing interest in the natural rubber market. When Thailand cancelled its prohibition of exporting rubber to the Communist Bloc on September 22, 1957,[23] Czechoslovakia and U.S.S.R. became important customers. In 1965 they imported 2,154 and 1,000 metric tons, respectively.

One important cause of the rapid growth of Thailand rubber production and exports has been the strong world demand for rubber. Since the turn of the century aggregate rubber consumption has generally doubled every decade, increasing at the rate of 7.5 percent per year. Although there has been some slowing down in growth since the end of the Korean Conflict, the rate of growth remains as high as 6 percent per year, which exceeds the rate of increase in both GNP and industrial production of the more highly industrialized countries.[24]

Due to the rapid rate of increase as outlined before, Thailand has not only participated in the rubber boom but has increased its share in total world exports of natural rubber from 3.2 percent during that late thirties, to 6.6 percent in 1948, to 7.3 percent during 1955-1957 and 9.0 percent during 1960-1965 (see Table 28). In the process, Thailand has moved from the fifth place to become the third largest rubber exporting country of the world since 1954, after Malaya and Indonesia.

The significant rate of growth of Thai rubber production and export over the past two or three decades may not, perhaps, continue after the

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[23] ONEDB, Economic Condition of Thailand 1957 (Bangkok, 1958), p. 54.

[24] International Bank for Reconstruction and Development, The Prospects for Rubber, (Unpublished, Washington, D.C., September 11, 1959), quoted

Table 28. Trend in the share of Thailand's export of natural rubber in total world exports (in thousand long tons)

	1934-1938	1948	1955-1957	1961-1966
Thailand	32.1	95.9	132.2	200.6
World total	995.0	1,457.5	1,817.5	2,221.5
Percentage share of Thailand	3.2	6.6	7.3	9.0

Source: Calculation from Tables 38, 39, and 40.

mid-1960's. A slowing down has already taken place during the mid 1950's, although it rose quickly again in 1959-1960. This sudden increase in the volume of rubber export in 1959 and 1960 may partly be explained in terms of the ready response of smallholders to the high price of rubber during these two years. But the coming into maturity of rubber trees planted during the Korean boom[25] also contributed to the recent increase in the volume of rubber export. The increase is likely to be sustained when, after a certain time lag, the current program for planting of the new high-yielding varieties bears fruit. The estimated increase of 2 percent per year from the mid-1950's to the mid-1960's was too low. In general, the present natural rubber has lost its price premium in relation to synthetic. Thailand should concentrate

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by Snoh Unakul, International Trade and Economic Development of Thailand, (Unpublished Ph.D. Dissertation (Columbia University, 1961), p. 92.

[25]The rubber tree will take 6-7 years to become tappable and 12 years to become fully productive. See Dijkman, op. cit., pp. 115-117, and UNCTAD, TD/B/AC. 2/4, op. cit., p. 29.

on improving quality and yield and thus lowering its cost of rubber production. If and when the time comes, the cost of production will be the most crucial factor determining the volume of exports of natural rubber, and the high cost producer will be driven out of the market. The relative importance of rubber and its future foreign exchange contributions to the total export earning of Thailand thus depends on how effectively the government of Thailand responds to the changing rubber market condition in the coming decade.

Role of the Government

Perhaps as a result of the absence of an extensive middle class there is little valid public opinion. The Thai knows little and cares less for international politics and is only very slightly interested in questions of internal politics, which are, for him, mostly a matter of personalities. The people merely wish to be left alone to grow their rice, catch their fish, and have an occasional festival at their local Buddhist temple. So, the long-term economic development is initiated and pushed principally by government policy. Thai tradition believes that government will provide every means or will do everything for the people.[26]

But, rubber may be a special case which was pioneered by the people, especially by those of Chinese descent. The rubber areas were expanded rapidly, responding roughly to the price rise during the

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[26]W. D. Reeve, Public Administration in Siam (London: Royal Institute of International Affairs, 1951), pp. 8-9, and F. W. Riggs, "Modern Thai Administration," Ecology of Public Administration (London: Asia Publishing House, 1961), pp. 87-91.

automobile boom in the early part of this century and World War II. Rubber trees are well suited to Thai soils and climates. Moreover it is fit for the small holding and family operations. Rubber trees need no good soil and can be grown even in sloping mountain areas. The cultivation of rubber was considerably more profitable than rice cultivation,[27] because after the tree gives latex it needs little care. The tree will give latex at least twenty-five years.

Jmae C. Ingram explained how the Thai government came to involve the rubber industry:

> Rubber was produced in Thailand for several years without license, tax, or other interference by the government. The growers and tapper were independent entrepreneurs and, unlike tin producers, they needed no license from the government to begin operations. Not until the mid-1930's did the government place an export tax on rubber. The export duty was set at 7 percent ad valorem, and this rate is still in force (in 1955). The government has encouraged the cultivation of rubber by allowing land to be taken from the state for a nominal fee, and by taxing rubber production lightly. A permit must be obtained to plant new rubber but since World War II this has been granted without difficulty.[28]

During the Voluntary Restriction of 1920-1921 and the Stevenson Restriction Scheme of 1922-1928 in regulating rubber supply for improving price, Thailand was not a member of the cartel. But the high price maintained by the cartel induced Thai rubber growers to plant more rubber, although the acreage figures given before were not accurate enough to enable us to compare the acreage increase of the 1920's with that of the 1930's. During the latter decade, however, Thailand was

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[27] Ingram, op. cit., p. 105.

[28] Ibid.

a member of the cartel and new planting was supposed to be rigidly controlled.[29]

The International Rubber Regulation Agreement of 1934-1943 was formed in 1933. The member governments felt that it was necessary for Thailand to become a member of the agreement because of the long common border with Malaya which facilitated smuggling and reduced the effectiveness of the agreement. Therefore, Thailand was given exceptionally favorable terms in order to induce her to become a member.

K. E. Knorr explained the position of Thailand under the cartel as follows:

> Thailand was guaranteed a minimum percentage of her basic quota amounting to 50, 75, 85, 90, and 100 percent for the five control years from 1934 to 1938. Despite this liberal concession, the Thai parliament refused to ratify the agreement, insisting on an increase in its basic quota from 15,000 to 40,000 tons and complete freedom of action. These demands were not granted immediately, and the restriction scheme was started without Thailand's participation. Yet her position was so strong, both on account of her expanding production capacity and a geographic location eminently suitable as a smuggling base, that the country's basic quota was increased as demanded for the years from 1935 to 1938, and Thailand permitted /sic/ to extend its rubber plantations by a total of 31,000 acres.[30]

Again the result was that the quotas allotted to Thailand did not necessitate much curtailment of output; indeed, in most years she was not able to produce her full quota.[31]

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[29] McFadyean, op. cit., pp. 24-47, and Knorr, op. cit., pp. 88-107.

[30] Ibid., p. 114.

[31] Ibid., p. 248.

Since World War II there has been no restriction on rubber production. The government has encouraged production through its land policy and through technical assistance to growers, while at the same time it has derived revenue from the industry by taxing exports.

Although Thailand is one of the leading producers, yet her problems are not identical with those of most of her neighbors. Most of the plantations are in the form of smallholdings, while most of the rubber-bearing areas in other producing territories are under the efficient management of various estate concerns. The smallholders work their trees on a hand-to-mouth basis. They do not care much about the quantity of the rubber produced and sometimes lack knowledge and use poor techniques. Virginia Thomson once said that the price received by Thai rubber is always lower than that for Malayan rubber because Thailand lacks scientific methods.[32]

Another problem about rubber trees which was reported by American University Field Staff was that:

> The rubber trees, for instance, are almost prewar stock, irregularly planted, uneven in growth, and scarred in tapping. Many have been badly tilted by the winds, and many more are badly overgrown with fungi and parasites. The undergrowth is rarely cleared; fertilizers, if used at all, are applied parsimoniously.[33]

Although, the above view is rather over stated, such as that most rubber trees are of prewar stock, nevertheless, it is not without reason and casts light on Thai problems.

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[32]Virginia Thomson, Thailand: The New Siam (New York: the Macmillan Company, 1941), p. 480.

[33]Hanna, op. cit., p. 3.

Beside all these problems, certain special difficulties have arisen from the strong competition with synthetic rubber. Synthetic rubber production and consumption have gone far ahead of natural rubber since 1962-1963. Thailand, however, still looks bright for the future of natural rubber as Sir Harry Melville, the President of the British Science Research Council says:

> Natural rubber can compete with synthetic rubber provided natural rubber is sold at competitive price . . . . Natural rubber has certain unique qualities which synthetic rubber can never hope to replace.[34]

Anyhow, the Thai government is well aware of the world natural rubber situation and her own natural rubber industry. She is convinced that rubber is one of the principal foreign exchange earners, employment, government income, and National income as a whole. Practically, all the tasks involved in the improvement of the industry rest heavily on the government. The following are various steps which offer projects in improving the Thai rubber industry.[35]

Varietal and quality improvement

1. Indigenous varietal selection of rubber. Almost all Heavea plantations in Thailand grow by using seedlings resulting from natural crosses of native varieties. Thus a wide range of variations occurred. The object of this investigation is to survey and select high yield

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[34]Malayan Strait Time, September 17, 1965, quoted in Ratana Petchara Chantara, Future Situation of Natural Rubber and Development in Rubber Plantation, Rubber Division, Department of Agriculture, Ministry of Agriculture, Thailand, June 15, 1966, p. 8. (Mimeographed)

[35]This part is heavily based on Department of Agriculture, Ministry of Agriculture, Thailand, Para Rubber Improvement Project, 1965, pp. 1-3. (Mimeographed)

varieties for further planting and distribution.

2. Selection of rubber through the improved varieties. During World War II several good varieties of rubber have been introduced into Thailand under government support. The planting of good varieties now total approximately 24,710 acres (10,000 hectares). The productivity of the new plantations were better than those of natives, but many varieties introduced are not of a pure line. The purpose of the investigation is to select superior lines among these varieties for further propagation studies.

3. Varietal improvement through hybridization. The objective of varietal improvement is to search for a high yielding plant. However, owing to past experiences it was found that many of the high yield plants usually carry many inferior characters, such as formation of trunk, susceptible to insects and diseases, etc. The purpose of this study is to hybridize plants of superior character, study and collecting the good desirable characters for better planting.

4. Regional testing of rubber varieties. Selected varieties of Hevea may fit and grow well in certain locations but may not do so in others. Regional trials for varieties in different locations will assist in finding out proper varieties to be recommended and extended to planters.

5. Quality improvement of rubber. Thailand ranks third in exporting rubber, but 55 percent of the products are of low grade. This does not mean the raw latex is of low quality; it is mostly due to the lack of proper technique in processing. For example, many private firms still use coconut shells in collecting latex instead of porcelain cups or other equivalents. Filtering is still practiced in a primitive way,

and there is lack of curing and procession. Since the Thai government has already gathered all information needed through previous investigations, the main purpose of this project is to extend correct methods for processing, not only be recommendation but also including training, demonstration, and investigation of other better methods for processing.

The varietal and quality improvement mainly was worked through the government branches in the Ministry of Agriculture. But the principal works are assigned to the Rubber Division, Department of Agriculture and Rubber Organization. The Rubber Division has branches and stations scattered over the rubber areas in the Eastern and Southern regions--altogether, twenty-seven offices and stations. The Rubber Organization has the head office and rubber plantation at the center of the Southern region between Surat Thani and Nakorn Si Thammarat.[36]

Improvement on cultural practice

The Office of Rubber Replanting Aid Fund has assisted private rubber planters since 1961. Those who request aid have to eliminate their own poor native rubber trees and replant with new approved high yield varieties. This requires at least seven years before the new trees start to give products which will affect the annual income of owners. The Thailand replanting scheme will be discussed in detail in Chapter VI. The objective of this research is to investigate artificial means to stimulate the production of old plants, and to prolong their productive lives in order to overcome the losses during the period of

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[36] Disayavanich, op. cit., pp. 166-176; and Public Administration Department, Manual of the Organization of Thailand (Bangkok, Thailand: Mongkol Karnpim, 1961), pp. 220-221.

Rubber Organization was established under the Rubber Organization Act 1961. After it has long experience and success in operating and demonstrating rubber plantation business. At the same time it lends services in rubber field to the government and the people at large.

waiting for the new plantations to start yielding their products.

Soil fertility improvement

Generally, the rubber tree can grow in any type of soil of ordinary fertility. Like any other crops, if fertility of soil could be improved, its yielding ability would increase remarkedly. Many institutes have found fertilizer formulars and grades for the rubber trees under their conditions. It is therefore the purpose of this research to find out the proper fertilization for the rubber plantation under Thailand's environmental conditions.

Pests and siseas control

Abnormal leaf fall is a common and often destructive disease on rubber plants. In Thailand, the reduction in yields due to this disease has been observed in many areas in the Southern region. Although young rubber trees seem to be more susceptible to the disease, particularly in winter, mature trees have often shown a high level of infection. In Malaya, the fungi Oidium heveae and/or Cloesoporium alborubrum are the causal agents.

CHAPTER V

COMPETITIVE POSITION OF NATURAL AND SYNTHETIC RUBBER

Natural rubber long had a monopoly position in the rubber market. Today over fifty percent of the annual production of rubber is in the form of synthetic rubber and this proportion may be higher in the future. It is perhaps trite, but nevertheless true, that the natural rubber industry is "fighting for its life." Because of this, raw rubber has been and continues to be the leading product and export commodity of many underdeveloped countries. Their economic welfare, therefore, is largely tied to this commodity. The leaders of natural rubber producing countries are confident that the competitive challenge offered by synthetic can be met.

Ratana Petchara-Chantara, Director of Thailand's Rubber Division, Department of Agriculture, in his report, "The Future of Natural Rubber," reported: "The future of the natural rubber industry is still bright but the planters have to take an important step with high-yield replanting."[1]

B. C. Sekhar, Director of the Malayan Rubber Research Institute said:

> Synthetic rubber science has been stretched to the limit. The limit has probably been reached in the search

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[1]Ratana Petchara Chantara, Future of Natural Rubber Situation and Rubber Plantation Development (Bangkok: Department of Agriculture, 1966), p. 18.

> by scientists for a synthetic that would fully rival natural rubber. Even though synthetic is slightly better in resilience, it does not have the inherent strength of natural rubber. When the scientists tried to increase the strength of synthetic, they found its resilience had decreased.[2]

In viewing the present position of the natural rubber industry, it is necessary to make a careful study of the factors deciding the competitiveness of natural rubber and synthetic rubber. Those factors would seem to be:

1. The structure of the rubber market and the availability of natural and synthetic rubber.
2. Technical advantages and disadvantages.
3. The relative price of natural and synthetic rubber.
4. The relative production of natural and synthetic rubber.

Structure of the Rubber Market

A very important aspect would seem to be that synthetic rubber plants are usually not independent firms, but belong either to one of the giant rubber-using companies, or to the equally giant petrochemical concerns that produce the raw material for synthetic rubber. Those rubber manufacturers which own a synthetic rubber plant will not easily switch to natural rubber. As Charles F. Phillips stated:

> In terms of production capacity the synthetic rubber industry is an oligopoly. The four firm concentration ratio for the general purpose rubber[3] producers is 62 percent,

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[2] Ibid., p. 5. Mr. Sekhar lecturing at Penang City Hall and was reported by Malayan Straits Time, September 29, 1965.

[3] There are two major classifications of synthetic rubber. (1) General purpose rubber (Styrene-Budadiene Rubber: SBR), developed to replace natural rubber in major uses, accounts for nearly 82 percent of

> representing a slight increase over the 1955-1959 period. This overstates, however, the concentration of sales passing through the actual market, since the largest producers are also the most fully integrated. Nearly 51 percent of domestic SBR sales are "captive" representing either intercompany transfers or sales to affiliated or constituent companies.[4]

Although some natural rubber plantations are owned by rubber using companies (usually tire manufacturers), their importance is small.[5]

It is obvious that the existence of captive markets ensures a competitive advantage for existing synthetic producers. The existence of captive markets is repeated in brief by Mrs. M. J. 't Hooft Welvaars:

> It is stated that in 1960 only 25 percent of budadiene sales were true open market sales, 46 percent of sales on the contrary were merely inter-company transfer. . . . Regarding sales of general purpose rubber, captive sales amounted to 55 percent of total U.S. comestic sales in 1960. This percentage was about equally divided between intracompany transfers and sales to affiliated and constituent companies.[6]

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total synthetic production. (2) Special purpose rubber (Butyl: IIR, Neoprene: CR, and Nitrite: NBR), developed to replace natural rubber in certain uses, account for the remaining 18 percent. In recent years a third major type, stereo regular rubber, has been developed. This rubber has the same unit structure as the natural rubber hydrocarbon. Today, stereo regular rubber has some shared in the market. See Chapter II, pp. 26-31 and also Charles F. Phillips, Jr., "The Competitive Potential of Synthetic Rubber," Land Economics, XXXVI(1960), pp. 322-326.

[4]Charles F. Phillips, Jr., "Workable Competition in the Synthetic Rubber Industry," Southern Economic Journal, XXVIII(1961-1962), p. 155 and also see Table 1, p. 156.

[5]Examples are Goodyear ownership of two large estates in Indonesia, Firestone and B. F. Goodrich owning 70,000 and 60,000 acres, respectively, in Liberia, Goodyear plants in Guatemala, etc.

[6]UNCTAD, TD/B/AC. 2/4, op. cit., p. 21.

Another advantage is the time-distance. In the United States, generally, the raw material producer can ship synthetic rubber to the manufacturer almost overnight and in some cases they are immediately adjacent firms. For natural rubber, it takes about six weeks between supplier and factory.

Availability of synthetic rubber will in all probability continue to be excellent. The present overcapacity of synthetic rubber plants is not very likely to be diminished appreciably in the near future.

Technical Advantages and Disadvantages

In an address before the International Institute of Synthetic Rubber Producers' Conference, which was held in Brussels, Belgium, on May 11, 1962, George R. Vila, President of the United States Rubber Company, outlined the factors determining the manufacturer's preference between natural and the various types of synthetic rubber. He selected five factors most important for scoring performance. They are: wear resistance, heat buildup, groove cracking resistance, chipping resistance, and aging resistance.[7]

According to Mr. Vila, natural rubber is still considered pretty good in wear resistance. It is particularly durable at cooler driving temperatures. The cold countries like Sweden prefer natural rubber because of this fundamental advantage. Low heat build up remains the best advantage of natural rubber, and makes it especially valuable for

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[7]George R. Vila, speech delivered before the International Institute of Synthetic Rubber Producers in Brussels, Belgium, on May 11, 1962.

heavy duty tires. Although natural rubber starts to crack sooner than synthetic rubbers, its cracks deteriorate more slowly. Natural rubber's chipping resistance is outstanding and becomes the standard to which all synthetic rubber strives. However, natural rubber is relatively deficient in resistance to aging. Natural rubber has been approached, but never excelled by the synthetics in ease of mixing. It still reigns supreme in building tack (adhesiveness) also, but when natural rubber is cured above 140 degrees centigrade, the problem of polymer deterioration arises.

In order to provide a clearer picture of the comparative technical competition between natural and synthetic rubber, P. C. Ratchaga has divided the general purpose rubber market (the largest sector of rubber market) into three zones:

1. Natural rubber zone
2. Synthetic rubber zone
3. Competitive zone[8]

The natural zone is that portion of the general purpose market in which natural rubber is preferred to synthetic rubber. Synthetic rubber is preferred to natural rubber in the synthetic zone. In these two zones, physical characteristics are the most important factors in deciding which one to be used. There is still some degree of competition in these two zones, especially if the price difference between the two commodities is too large. The competitive zone is the fraction of the market for general purpose rubber where the two commodities are

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[8]P. C. Ratchaga, "The Future of Malay's Natural Rubber," Malayan Economic Review, I(1956), pp. 42-47.

competing with each other and price is the only factor in deciding which one is to be bought.

T. R. McHale made a brief conclusion about these three zones as follows:

> In Zone 3, the ultimate choice between synthetic or natural has revolved around price or cost considerations. If the cost of natural were lower than the cost of synthetic relative to the value of the final product, then natural was selected. As we shall see, recent developments in the synthetic field threaten to virtually eliminate Zone 2, where natural enjoys a technical superiority and to increase Zone 3 where there is competition between the two.[9]

The division into these three zones is made after deducting special purpose rubber from the total rubber market, since nearly all special purpose rubber is now made from synthetic rubber.

Dr. J. N. Street, Director of Laboratories, Firestone Tire and Rubber Company, estimated the respective shares of the three zones as follows: Natural rubber zone, 27 percent of the total general purpose rubber requirements; synthetic rubber zone, 38 percent; competitive zone, 35 percent.[10] All three zones are not "completely black" or "completely white" but all of them involve a certain degree of "grey." Even in the competitive zone the two types of rubber are not absolutely satisfactory substitutes. However, small price differentials are significant and if maintained over a period of time will bring about a large switch over within this area.

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[9]T. R. McHale, "The Competition Between Synthetic and Natural Ru ber," The Malayan Economic Review, VI(1961), p. 24.

[10]J. N. Street, Natural Rubber News, December, 1954, quote in "Ratchaga," op. cit., p. 45.

Ratchaga concluded that if the price of natural rubber were higher than the price of synthetic rubber, only 27 percent of the general purpose market would be captured by natural rubber. But if the price of natural rubber could be lowered to a level below that of synthetic rubber, it is possible that total consumption will be 62 percent (27 + 35 percent) of all total general purpose rubber, assuming, of course, that the supply can be sufficiently increased. In the same way, if the price of synthetic rubber remains lower than that of natural rubber, the total consumption of synthetic rubber can be as high as 73 percent (38 + 35 percent) of total general purpose rubber consumption--if, that is, supply can be sufficiently increased.[11]

Thus, if the producers of natural rubber can reduce their costs so as to enable them to offer their products in the international market at a price lower than a price of synthetic rubber, the future of the natural rubber industry can be bright. There is no reason, of course, to assume that the entire 62 percent will be realized since most synthetic rubber plants in the United States are in the hands of the tire manufacturers.[12] But the argument serves to show that the market for rubber is divided according to the two aspects of competition mentioned above, and how the share of the two rubber industries may be changed by varying the price and cost structure.

The other aspect of competition is the technical advantage of synthetic rubber because of its uniform quality. Because it is a synthetic,

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[11] Ibid., pp. 46-47.

[12] Robert Solo,"The New Threat of Synthetic to Natural Rubber," Southern Economic Journal, XXII(1955-1956), p. 57.

man-made product, its chemical composition is known and can be controlled. Moreover, producers can tailor synthetics to the needs of customers. In contrast, the quality of natural rubber is far from uniform, varying considerably among estates, small holdings, and producing countries. This is one problem that has confronted rubber manufacturers for many years. In a discussion of crude rubber quality problems the Rubber Manufacturers Association reported in 1952:

> The tremendous growth of small holders production compared to European-managed estates has created transport and distribution problems. The emergence of many new middlemen-traders and commercial packers having primary interest in short-term and speculative profits has brought emphasis on quantity rather than quality. Periods of excess demand and the large differentials between grades created incentive to upgrade, mix grades and otherwise engage in unscrupulous practices.[13]

Recently, as a direct result of the emergence of the synthetic rubber industry, attempts have been made to improve this situation, both for exporting and importing nations. Natural rubber quality, including poor pack, moisture in bales and mixture of grades, has been the prominent topic of discussion and consultation. New grade specifications have been adopted and accepted by producing and consuming countries alike. As a further aid, the members of the New York Commodity Exchange adopted a new rubber contract, "Standard Rubber Contract," in 1961.

> The new contract basic grade is No. 1 International Ribbed Smoked Sheets. Rubber inferior to this grade is deliverable at discounts for half-grade but not as low as No. 2 International Ribbed Smoked Sheets.[14]

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[13]W. J. Sears and C. C. Miller (eds.), Natural Rubber Buying (New York: The Rubber Manufacturers Association, Inc., 1953), p. 10.

[14]Rubber Age, March, 1961, p. 1050.

In 1965, Dr. Lim Swee Aun, the Malaysian Minister of Commerce and Industry, announced that Malaysian producers are shortly to market natural rubber to a guaranteed technical specification, Standard Malayan Rubber (SMR), in convenient plastic-covered bales.[15] The SMR has qualifications roughly as followed:

> The specification for SMR is broadly similar to that proposed by the International Organization. There will be three basic grades, SMR 5, SMR 20, and SMR 50. These will be graded according to purity as measured by the content of particulate dirt and other injurious contaminants, rather than by visual appearance as at present . . . . Minimum levels of dirt content are 0.05, 0.20, and 0.50 percent, respectively, for the three grades.

The greatest advantage synthetic rubbers have over natural rubber, however, is the vast amount of research and technical assistance that goes into the production and use of synthetic rubber. According to Dr. L. Bateman, Chairman of the Malayan Rubber Fund Board, in an address in Tokyo in May 1964, the annual research expenditure on synthetic rubber in the United States alone amounted to $124 million, where total research expenditure for natural rubber over the world only added to $6 million.[16] Any improvement either in composition or in production processes is mainly sought for in the field of synthetic rubber, and thus stimulates its use, while extension of these developments to the natural rubber field is hindered by lack of funds, and perhaps by lack of coordination of research.

At present the manufacture of rubber articles is still labor intensive; changes to a capital intensive production process might considerably

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[15] Rubber Development, XVIII(1965), p. 21.

[16] UNCTAD, TD/B/AC, 2/4, op. cit., p. 23.

lower costs. Experiments in this direction are pushed through by synthetic rubber producers, who have made special solution polymers for this purpose. If a stage were reached where this process is possible for certain synthetic rubber, while it would still be impossible for natural rubber, its labor cost saving aspects might lead to substitution away from natural rubber to synthetic rubber, even if the latter were more expensive raw material.[17]

This aspect should not be neglected, especially as the main conclusion from previous paragraphs would seem to be that in certain fields of usage natural has no definite technical advantage over synthetic. It would only be bought at a price lower than that of synthetic rubber, owing to its shortcoming, both in constant availability and technical specifications.

The Relative Price of Natural and Synthetic Rubber

If there were no quality difference between natural and synthetic rubber, it would be perfectly justifiable to say that the price competition between the two commodities was already over and had been won by synthetic rubber. This would be justifiable since the price of natural rubber, except in 1949, has been always higher than the price of synthetic rubber. A trade journal for the rubber industry recently stated:

> In the past, natural rubber has normally commanded a fairly substantial premium over general

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[17] Ibid.

> purpose synthetic rubber, because of its superior over-all qualities, but a new situation is now developing as a result of the evolution of stereo-specific rubbers . . . It is now quite clear that, more than ever in the past, the natural rubber industry has to face competition from man-made rubber on the basis of price, rather than quality.[18]

The truth of this statement can be questioned, but its implementation raises many complex problems.

In the past, natural rubber price have borne little relationship to production costs. The supply curve of natural rubber is relatively inelastic in the short run, largely due to the seven to ten years waiting-period between planting and tapping. In the short run, therefore, production costs will have little effect upon the "free" market price of natural rubber. But because demand conditions are subject to continuous change, price show wide fluctuations over a period of years, or even from one month to another. Dr. C. R. Wharton, Jr. Malayan economist, made a brief view about demand, supply, and price of natural rubber that:

> The threat of economic instability is certainly not due exclusively to supply characteristics alone. Demand factors are equally important shifts in demand due to exogenous factors such as wars, threats of war, stock piling decisions, development of sbustitutes and their prices. . . . The short run in elasticity of supply of rubber should not be neglected in the formulation of policies designed to cope with the threat and reality of instability. Given an inelasticity in supply, any shifts in demand merely aggrevate the fluctuations in price and the resulting instability. Second, the long-run inelasticity of supply which has very serious economic implications for resource allocation and mobility should be taken into consideration.[19]

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[18] Rubber Age, January, 1962, p. 676.

[19] Wharton, op. cit., p. 162.

The following are brief factors that influence natural rubber prices, primarily from the demand side.

1. Economic conditions in consuming countries. General economic conditions in consuming countries raise or depress price of imported crude rubber. Undoubtedly, this is the most significant factor affecting the long-run price of natural rubber.

2. Political disturbance within the rubber producing countries. Prices are particularly sensitive to political disturbances that block or threaten supply. The good example is the price of natural rubber rising from 27.8 cents per pound (second quarter of 1950) to 73 cents (first quarter of 1951) after the attack on Korea.

3. Bilateral barter agreement. The supply of crude rubber is further effected in any particular year by the number of trade agreements arranged between producing countries and buyers. In 1959, to illustrate, Ceylon exchanged 30,000 tons of rubber with Red China for 250,000 tons of rice. It was not until the following year, therefore, this rubber producing country re-entered the rubber market and then only for a short period of time.

4. Centrally planned countries purchases. In the past few years, buying by the Communist Bloc has had important effects upon crude rubber prices. In 1961, Russia purchased an estimated $76 million worth of Malayan rubber, compared with about $50 million the preceeding year.[20] Chinese purchases, too, have become significant. As these purchases are unpredictable, they add to market fluctuation.

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[20]Phillip, op. cit., p. 165.

5. Stockpile programs. In recent years the world rubber market has been strongly influenced by the specific government policy relating to the strategic stockpiling program in the United Kingdom and the United States. This policy is still a controversy between rubber producing countries and both consumers.

These five factors are significant in explaining variations in natural rubber prices. Some are common to all raw materials; others are particular to the rubber market. Over a longer period, it is expected that the stability of synthetic rubber prices will reduce fluctuations in the price of natural rubber (see Table 29).

Table 29 shows the average spot price of R.S.S. 1 type of natural rubber in New York and the average price of three major synthetic rubbers. The prices of synthetic rubbers are overstated because the quotations do not show the discounts which are almost the rule, bringing the price down by one or two cents. Synthetic rubber prices are moreover quoted on delivery, whereas the natural rubber price is the New York c.i.f. price to which further transport costs must be added.

The situation in 1949, when the price of natural rubber was actually lower than the price of synthetic rubber, indicates that at that time price competition was still in progress and almost won by the natural rubber industry. Tire manufacturers, who were required to consume a certain amount of synthetic rubber, demanded that the synthetic rubber plants be abandoned and suggested that the stockpiling plan alone be trusted to provide security.[21] But before some real actions were taken,

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[21]Robert Solo, "The Sale of Synthetic Rubber Plants," Journal of Industrial Economic, II(1953), p. 37.

Table 29. Price of rubber, 1946-1965 (cents per pound)

Year	Natural rubber average N. Y.	Synthetic rubber		
		SBR	Butyle	Neoprene
1946	22.5	18.5	18.0	27.5
1947	20.8	18.5	18.5	29.4
1948	21.9	18.5	18.5	32.0
1949	17.6	18.5	18.5	32.0
1950	41.3	19.0	18.7	34.0
1951	60.9	25.0	20.8	38.0
1952	38.6	23.5	20.8	38.0
1953	24.1	23.0	21.3	40.0
1954	23.4	23.0	22.5	41.0
1955	39.0	23.0	23.0	41.0
1956	34.3	23.0	23.0	41.0
1957	31.1	23.0	23.0	41.0
1958	28.2	23.0	23.0	41.0
1959	36.5	23.0	23.0	41.0
1960	38.5	23.0	23.0	41.0
1961	29.6	23.0	23.0	41.0
1962	28.5	23.0	23.0	41.0
1963	26.3	23.0	25.0	41.0
1964	25.2	23.0	25.0	41.0
1965	25.7	23.0	25.0	41.0

Source: For the price of natural rubber, Commodity Yearbook, several issues.
For synthetic rubber, Rubber Statistical Bulletin, several issues.

the Korean Crisis had cuased the price of natural rubber to rise again and the objections of the synthetic rubber consumer faded away.

Now, we can ask whether or not the synthetic rubber industry has been competitive in terms of price since 1949. The fact that the price of natural rubber was higher than the price of synthetic rubber between 1950-1965 does not necessarily mean that the synthetic rubber industry has been competitive relative to the natural rubber industry in terms of price. In order to be able to decide what the situation really is, we have to take the quality difference between natural and synthetic rubber into consideration. A price difference must allow for this quality difference. After such a price difference is deducted from the price of natural rubber, then the above question can be answered correctly.

The Relative Production Cost of Natural and Synthetic Rubber

The possible emergence of the price competition between natural and synthetic rubber makes it imperative to consider their respective production costs, and the possibilities of lowering either in the long run. As with quality, natural rubber costs vary substantially between producing countries. The relative cost involved in producing natural rubber and its synthetic counterpart now becomes the dominant variable in the long run pattern of development.

One line of study shows that an initial capital outlay for the construction of an optimum size plant producing SBR per year is estimated at $10,000,000. An initial capital investment of $250 must be made for

every ton of rubber to be produced each year.[22] On the other hand, McGavack estimated that about $500 per acre is required to bring plantation rubber into maturity, if started from scratch. A production of a little more than a ton of natural rubber per acre per year is calculated. Therefore, the initial capital investment in modern plantation rubber is approximately twice the capital cost which is required to produce a ton of synthetic rubber in the most efficient size plant. However, the life of a plantation is about twice as long as that of modern synthetic rubber plant.[23] Thus, it appears that over a long period of time the relative capital outlay to produce a ton of either natural or synthetic rubber is about the same.

As to the labor cost, plantation labor cost is greater than that of the synthetic rubber industry because a much greater number of laborers is used per unit of production. However, the plantation rubber industry has the offsetting advantages of a much lower rate of wage for hand labor. It seems possible that this advantage will last for a long time to come.

In addition, several recourses to overcome the necessity for this greater employment of hand labor are available to the plantation rubber industry. Replanting with high yielding clones, a new technical development known as stimulation, which requires only small amounts of particular chemicals at infrequent times to increase the yield of rubber trees, and mechanization of some of the production process may outstrip the

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[22] C. H. Chilton, Chemical Engineering, VI(1958), pp. 102-105, as quoted by John McGavack, "The Future of Natural Rubber," Rubber Age, 91, February, 1959, p. 791.

[23] McGavack, Ibid., p. 793.

current disadvantage of employing a greater number of hand laborers.

The strongest basis for Dr. McGavack's belief that production cost of synthetic rubber will always be higher than natural rubber lies in the assumption that all of the raw materials which go into the production of synthetic rubber have to be produced at a relatively high cost. In contrast to the synthetic material, virtually the entire ingredients required in the production of natural rubber are free. More specifically, the carbon dioxide of the air, the mineral substances from the leaf drop of the trees, the tropical soil, containing minerals and water, and sunlight in quantities more than sufficient to polymerize all the rubber are all there for the asking.[24]

The other approach is in terms of cost reducing competition between natural and synthetic rubber.[25] It might bring the price of natural rubber down to the point where it becomes unprofitable to produce synthetic rubber in existing plants, let alone to create new capacity.

Dr. W. E. Cake, in a 1962 article "The Position of Natural and Synthetic Rubber in this Changing World,"[26] estimated the selling price of various types of synthetic rubber that would be necessary:

1. To continue production at all

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[24] Ibid., pp. 795-796.

[25] This part is based on Mrs. 't Hooft Walvaars' study, preparing for UNCTAD. UNCTAD, TD/B/AC. 2/4, op. cit., pp. 25-31.

[26] W. E. Cake, "The Position of Natural and Synthetic Rubber in the Changing World," Revue General de Caoutchouc, 39, 1962, quoted in Petchara Chantara, op. cit., p. 7.

2. To establish new plants.

The selling price required to continue production at all would only have to cover variable costs; it would contain no coverage of fixed costs or research. These variable production costs are lower in the case of integrated concerns, where the raw material is acquired from producers within the same concern. The selling price necessary to continue production at all would be between 12.2 and 15.8 cents per pound for SBR and 14.5 to 18.5 cents per pound for Cis-polybudadiene.

The selling price required to establish new plants, i.e. a price covering all costs and promising a 10 percent return on investment would be 23.8 cents per pound for SBR, in the case of non-integrated production and 26 cents per pound for Cis-polybudadiene, non-integrated.

This required selling price for SBR seems rather high; even if the largest price differential resulting from integration, put at 3.6 cents under (i), would be substracted, the SBR price necessary to obtain a 10 cent return on investment would still be 20.2 cents.

In 1964 a paper for the International Rubber Study Group by Messrs. Buckler and Sykes stated that compound costs of SBR were declining steadily, without however quoting figures.[27]

With respect to Cis-polyisoprene, the synthetic rubber most likely to displace natural rubber from the purely technical point of view, these authors assume that it will continue to remain too expensive in comparison to natural rubber if the price of natural rubber continues to fall. The existence of Cis-polyisoprene would thus be not so much a

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[27] UNCTAD, TD/B/AC. 2/4, op. cit., p. 25.

threat to natural rubber but an insurance against rising natural rubber prices and natural rubber shortages.[28]

A possible cost reduction in the synthetic rubber industry might stem from a lower price of the chemical raw material. The main chemical, budadiene, was quoted in 1956 at around 15 cents a pound and 1961 at 12-3/4 cents a pound. It is estimated that it could drop to 10-1/2 cents a pound.[29]

Considering the heavy amount of research in the synthetic industry, a lowering of costs through innovations seem always possible.

In the natural rubber industry an impressive process of cost reduction is underway. The information from the papers presented by Dr. L. C. Bateman,[30] to the International Rubber Study Group meetings in Washington and Tokyo, in 1962 and 1964, revealed the following:

The reduction of production costs of natural rubber would seem possible in three ways:

(1) Rejuvenation programs, as newer trees have been developed with a far higher yield,

(2) More systematic manuring and yield-stimulation,

(3) Exploitation of fundamental research.

The last point, though of very great importance, is as yet difficult to express by figures. The possible results of replanting or new planting can be judged from the following figures:

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[28] Ibid., p. 26.

[29] Ibid.

[30] L. C. Bateman, "The Competitive Prospects of Natural Rubber over the Next Ten Years--The Supply of Natural Rubber," The Future of Natural and Synthetic Rubbers, Proceedings of a Symposium organized by the International Rubber Study Group in Washington, D.C., May 20 to June 1, 1962; and UNCTAD, op. cit., p. 26.

Unselected stock	400 lbs./acre per year
Pedigree clones (of the 1920's)	800 lbs./acre per year
Pedigree clones (of the 1930's)	1,100 lbs./acre per year
Pedigree clones (of the 1940's)	1,500-1,600 lbs./acre per year
New pedigree clone, recently in exploitation	2,000 lbs./acre per year
Avery new pedigree clone, R.R.I.M. 600 still in the experimental stage	3,000 lbs./acre per year

As the discussion was already mentioned, at a selling price of SBR would be between 12.2 and 15.8 cents a pound, the synthetic factories will still be in business. If the natural rubber wants to gain ground on SBR, natural rubber should not cost more than 15 cents a pound. As a result of a steady increase in productivity, this does not seem an impossible cost price for natural rubber to reach.

The following statements are quoted from Mr. 't Hooft Welvaars, whose compilations show various researches in the development of reducing natural rubber cost:

> A report by Mr. Phillip F. Adam, the Secretary-General of the International Rubber Study Group, states that in order to induce a change from SBR to natural rubber usage a price of below 16-2/3 cents a pound would seem to be required.
>
> Mr. Bateman, in 1962, thought it prudent to aim at a natural rubber price of 18 cents a pound, which in his opinion would leave the natural rubber industry entirely viable.
>
> In May 1965 Mr. R. Ormsby, in a paper entitled "Potentials in Rubber--A Consumer's Review," mentioned that for Malayan estates New York cif cost has been
>
> | | | |
> |---|---|---|
> | at the 1961 average output | 690 lbs./acre, | 20.5 cents |
> | at the 1964 average output | 800 lbs./acre, | 17.5 cents |
> | at the 1970 estimated output | 1,200 lbs./acre, | 12.0 cents[31] |

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[31] Ibid., pp. 30-31.

On this basis, Mr. Ormsby is of the opinion that natural rubber producers will be in an excellent position to compete cost-wise with synthetic producers.

On smallholdings real production costs, in the sense of the real effort to produce one pound of rubber, are doubtlessly higher than on estates. This does not mean however that smallholders will stop production when the natural rubber price would only be sufficient to cover the cost of fairly efficient estates. This would depend on the speed with which the price declined and on the alternative means of livelihood. Some natural rubber from smallholders would doubtlessly still be forthcoming at a price considerably lower than the present one.

An economic mission from the International Bank for Reconstruction and Development in the Federation of Malaya in 1955 reported as follows:

> Cost data from a representative cross-section of rubber estates indicate that the production of high-yielding rubber on well-managed estates could continue to compete profitably with synthetic rubber even if prices of the latter were to fall well below present levels. Smallholdings on high-yielding rubber cultivated mainly with family labor or on a crop-sharing basis would be even less vulnerable to lower synthetic rubber prices. And it seems clear that high-yielding rubber tree, once they reach bearing age, promise a return greater than that of any other crop for which the vast majority of smallholding would be suitable.[32]

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[32] International Bank for Reconstruction and Development, The Economic Development of Malaya (Baltimore, Maryland: The John Hopkins Press, 1955), p. 48.

CHAPTER VI

THE PRESENT AND FUTURE SITUATION OF THE NATURAL RUBBER INDUSTRY

General View of Natural Rubber Producers

The natural rubber producing countries have long realized the seriousness of the problem they have faced, for the exportation of rubber is one of their most important sources of exchange. This is true for Malaysia, Indonesia, South Vietnam, Ceylon, and Thailand. Improvements that would lead to reduction in cost had been known since the period before World War II,[1] but the war prevented the producers from introducing them, and at that time the need to take some cost-reducing measures was not so pressing.

At present, the most widely adopted method to reduce production cost of natural rubber is the replanting of plantations with high yielding trees. In almost every country some kind of replanting program has been designed and carried out. In almost all of them the governments are active in taking part in the execution of the plan. But the degree to which the programs have been carried out are different in different countries. Therefore, a discussion of the individual countries is preferable to a discussion covering the countries as a whole.

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[1] S. Moos, "Natural versus Synthetic Rubber," Oxford, Institute of Statistic: Bulletin, V(1943), pp. 51-55.

The Federation of Malaysia has proved the most successful in replanting her rubber plantation. She has been engaged in replanting schemes since 1955. With the large subsidy from the government, over 150,000 acres are currently being replanted per year, or about 4 percent of the total land used for rubber production. At this rate, Malaya expects to have completely high-yield acreage not later than 1973, capable of producing an annual output of 1.2 million tons.[2] Today more than 2,560,000 acres or about 60.7 percent of the total rubber planted area has high yielding trees, as shown in Table 30.

For Malaya today, the most important problem is time. The price of natural rubber should remain fairly high and stable so that she can complete the replanting scheme without too many difficulties. This is understandable since some of the funds used to finance the replanting scheme have been obtained from export taxes.[3] The replanting scheme has begun to show results at the present time. Until 1959, Indonesia had been the world's leading producer of natural rubber. Since the war, Malaya has forged vigorously ahead with the planting of new high-yielding stock and is now well established as the leading producer.[4]

Indonesia, the second largest producer of natural rubber, is still very far behind Malaya in replanting her plantations though she

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[2]The Wall Street Journal, January 11, 1961, p. 1; and Rubber Age, May, 1961, p. 313.

[3]Lim Chong Yah, "The Malayan Replanting Taxes," Malayan Economic Review, VI(1961), pp. 43-52.

[4]D. D. Humphrey, "Indonesia's National Plan for Economic Development," Asian Survey, II(1962), p. 13.

Table 30. Composition of rubber acreage in Malaya, 1966 (in 1,000 acres)

	Total	Mature		Immature
		Prewar	Postwar	
Estate	1,910	600	825	485
Smallholding	2,310	1,059	414	837
Total	4,220	1,659	1,239	1,322

Source: United Nations Conference on Trade and Development, TD/B/AC. 2/4, 4 January, 1966, pp. 27-28.

has 4.4 million acres of rubber trees under cultivation.[5] A replanting program is also underway in Indonesia,[6] but no substantial increase in rubber exports from the country can be expected for the next few years. Because of the unfavorable political climate in the country (War of Independence, 1945-1950, Local and Army Rebellions, 1956-1962, Communist's failure Coup d'tat, 1965) discouraged the owners of the plantation from replanting their acreage. Moreover, foreign estate owners, such as British and United States interest, have faced two major problems, the exchange problem and the possibility of nationalization.[7] It remains to be seen what the Indonesian government will do to increase the speed of such a replanting plan now the political situation is more stable.

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[5]Phillip, op. cit., p. 150.

[6]Indonesia has been in a replanting plan since 1956. This replanting plan, designed for the ten-year period from 1956 to 1965, called for the replanting of 26,000 hectares per annum. U.N. Economic Survey of Asia and the Far East, Bangkok, 1961, p. 111.

[7]Phillip, op. cit., p. 152.

The present condition of the rubber plantations of Indonesia is still best described by Humphrey:

> In rubber, as in other sectors, Indonesia has been living off of her capital since the trees have a productive life of 35 years, Indonesia still harvests from prewar planting. Owing to neglect of replanting 30% of estate trees are now over 35 years old and additional 25% are over 30 years. Smallholders acreage which amount to more than 70% of the total, though it accounts for about 60% of production, is in a still worse condition owing to the over-age trees.[8]

The task of a replanting scheme in this country is much heavier than in Malaya. Immature trees which will come into production during the next year consist of no more than 12 percent of the estate area and 3 percent of the smallholder area.[9] A recent report revealed that if their affairs are straightened out in the next few years we might expect some improvement, perhaps another 50,000 tons or so a year.[10]

Thailand has the potential of becoming an important rubber producing country. At the end of 1959, only 11.2 percent of the total rubber plants were classified as high-yielding trees.[11] The replanting program is slow when compared with Malaya and Ceylon. A 1960 report by F.A.O. called the attention of the Thai government to this fact:

> The planting of rubber can no longer be looked upon, like in the past, as something that will take place of its own accord, without government help, advice, or control, according to the whim and will of a multitude of private individuals. The mere planting of new acres is not enough, they must be planted with the best available materials and according to up to date techniques. Thailand can continue to ignore the hundreds of thousands of acres

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[8] Humphrey, op. cit., p. 13.

[9] Ibid.

[10] H. C. Bugbee, "Natural Rubber's Place in the World Picture," Rubber World, XV(1966), p. 95.

> of low yielding rubber which are gradually, but surely becoming uneconomic and are yearly increasing in number.[12]

Thailand's Rubber Replanting Act was drawn up in 1955, but little concrete action was taken by the government until the Rubber Plantation Aid Fund Act was passed on August 25, 1960. According to prediction of the World Bank, the potentiality for expanding the productivity capacity by means of development of unused land in Southern Thailand suitable for rubber trees was regarded sufficient to increase the rubber area twofold, with the possibility of tripling if these were terracing of the usable hill country.[13] (The development of the Thailand replanting program will be discussed later in this chapter.)

The government of Ceylon followed the policy established by the Malayan government. Ceylon is now farther than Indonesia in her planting scheme. But a new planting policy prohibits cultivation of new rubber without permission of the Minister of Agriculture and Lands. The present Government subsidized rubber replanting scheme is the third five years program to be put in effect (the first and the second five years program was from 1953 to 1958 and 1959 to 1963, respectively). It is hoped that Ceylon's total of 668,000 acres of rubber plants will have been completely replanted by the end of 1968 and the output of rubber

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[12] F. A. O., Expanded Technical Assistance Programme, Rome, 1960, No. 1253 is cited in the Far Eastern Economic Review, July 27, 1961, p. 182.

[13] International Bank for Reconstruction and Development, A Public Development Program for Thailand (Baltimore, Maryland: The John Hopkins Press, 1959) p. 71.

will increase to about 160,000 long tons a year.[14]

Elsewhere in South and Southeast Asia, Pakistan has recently entered upon a rubber growing program in Eastern Pakistan, Chittagong, and Sylhet. Their climatic conditions approach those in the Malayan forest. There has not been much progress. In India, where most rubber is produced by smallholders in Kerala Province and yearly averages are low, the government has recently announced a modernization program of planting and tapping.[15] In 1964, there were about 381,000 acres of rubber trees and 6,519 acres were newly registered under the Rubber Act of 1947.[16] Finally, in Indochina, one-third of the cultivated plantations were subjected to war damage. However, Indochina rubber, according to trade reports, is of high quality, clean, and well packed. With the exception of Vietnam, which, despite the war, is still exporting some rubber, the outlook is good.[17] Cambodian estates, according to a Rubber Age report were established by French companies which cover 90 percent of the total rubber area, producing 50,017 long tons in 1966. This represents a spectacular yield of 1,302 pounds per acre, or over 450 pound more than the Malaysian yield. The present rubber tapped area is only 70 percent of the total planted area, whereas the untapped 30 percent represent immature areas planted 5 years ago with high yield

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[14] Far Eastern Economic Review, op. cit., p. 249.

[15] Rubber Age, September 1960, p. 1087.

[16] Rubber Development, XVIII(1965), p. 54.

[17] Bugbee, op. cit., p. 95.

trees.[18]

Africa and Latin America produce about 200,000 long tons a year. But they have many problems to solve. Natural rubber supplies from Africa will continue to increase in the next few years. Two large American rubber manufacturers, Firestone and B. F. Goodrich, own plantations in Liberia, with free technical assistance being offered to native producers, and both new planting and replanting continuing at a rapid rate.[19] In Latin America, the rubber produced is not sufficient for local consumption and still faces the lack of availability of labor. They are unwilling to stay in the areas devoted to rubber production without high wages. Moreover, the inability to control leaf blight was a principal deterrent to plantation rubber.[20] Today, there are six rubber companies (Firestone, Goodyear, Pirelli, Brasiliera de Borracha, Dunlop, and General Tire), involved in rubber plantations in Brazil, after the government decreed support of rubber plantations in 1952. The other, Goodyear, has been establishing rubber plantations in Southwestern Guatemala since 1957.[21] It will be several years before the success of the program is known.

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[18] Rubber Age, April, 1967, p. 139.

[19] Phillip, op. cit., p. 154-155.

[20] D. M. Phelps, Rubber Development in Latin America (Ann Arbor, Michigan: University of Michigan Press, 1957), pp. 169-170.

[21] Phillip, op. cit., pp. 155-156.

Thailand's Rubber Replanting Scheme[22]

It is generally accepted that rubber trees need about seven years after the planting of a rubber grove before the trees are sufficiently mature for tapping. Thereafter its yield increases rapidly after the first tapping until it reaches its peak between the fourteenth and seventeenth year. The maximum yield of latex is attained in about 12 years. At 30 or 35 years, there is declining yield and losses from disease and the economic life of rubber trees. From then on, the tree will not be worth tapping and will eventually produce nothing.[23]

Thus it is clear that a rubber plantation must be periodically renewed. It is generally accepted that the whole stand should be replanted approximately every 30 years. If 3 percent of the trees are replanted each year, the renewal of the planted area will be completed in roughly 31 years. Adding the period before the most recently planted trees can be tapped, the tree will renew its capital in about 40 years. Then, at any one time, 21 percent of the planted area should be immature. The productive trees must carry the acreage of immature rubber as well as the other plantation costs. In this case, if a plantation postpones replanting until many of its trees approach the end of their economic life, the revenue from the latter will not be enough to cover all expenses, since much of the plantation may be planted with immature, non-yielding trees.

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[23] Perey W. Bidwell, Raw Material: A Study of American Policy (New York: Harper & Brothers, 1958), p. 266, note 20.

In Thailand, as discussed before, where almost the entire production of natural rubber is in the hands of the small holders, there are about 1.8 million acres of rubber planted area. From the total rubber planted area, 400,000 acres are immature. Of the remaining 1.4 million acres, it is estimated that 600,000 acres are prewar stock and 800,000 acres are growing too old.[24] In 1958 the IBRD recommended procedures of replanting similar to those followed in Malaya and Ceylon. In addition, the World Bank strongly suggested that the essential element of the rubber program should be to stimulate planting of new rubber areas by smallholders.[25]

After a long delay, the Thai government has finally decided to carry out the rubber promotion program. She has enacted the Rubber Planting Aid Fund, 1960, by imposing a cess tax of 2-5 1/2 cents a pound depending on the grade and export price of the smoked sheets. These exports will be used to finance the dissemination of the high-yielding varieties for new planting.[26]

The principal objective of the project is to collect contributions from rubber exporters at a certain rate and place them in a central fund. Subsidies are then given out of this fund to rubber growers who possess old indigenous rubber trees and are willing to cooperate with the program. The subsidies are used to clear away the old trees and replace them with high yielding clones. By this method, rubber growers

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[24] Petchara Chantara, op. cit., p. 12.

[25] IBRD, op. cit., pp. 69-73.

[26] Swang Kulthongkum, op. cit., p. 31.

will be able to reduce the cost of production in the future and can compete with synthetic rubber in the world market.

The Aid Fund Committee is responsible for executing the program, approving the amount of each subsidy, and providing cash and/or materials (all together not exceeding $250 per acre) for the rubber grower who signs a contract with the organization. Payment will be made in six installments within a period of five years after the rubber growers fulfill the provision of the fund step by step.

The allocation of this fund is as follows: 90 percent for the subsidies, 5 percent for the cost of administration, and the remaining 5 percent for the cost of research.

Since 1961, the beginning of the year of the replanting program until 1964, 77,375 acres have been granted to replant the high yielding clones. Only 56,678 acres have been reported as planted. If the replanting scheme is in progress at the present moment, the completed program should take about 25 years (see Table 31). According to recent information from 1961 to February 1967, about 96,000 acres were granted for replanting with high yielding varieties. The growers have had replanted 72,000 acres, the rest will be in progress in the coming planting season. The total amount of cess tax, $25 million, were collected and $21 million have been appropriated. It is estimated that for the year 1967 22,400 acres have been reported in applying for replanting. The fund, amounting to $5.5 million, will be used for 1967.[27]

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[27]The Rubber Replanting Aid Fund Office, Occupation on Thailand's Soil: Rubber Replanting with High-Yielding Varieties (Bangkok, 1967), p. 4. (mimeographed)

This material was presented in a television program at Bangkok, April 15, 1967. It was a conversation between Dr. Swang Kulthongkum,

Table 31. Thailand's replanting area, 1961-1964

Year	Area granted		Replanting area	
	Unit	Acres	Unit	Acres
1961	1,868	14,840	1,314	9,796
1962	8,312	33,328	7,130	27,857
1963	2,040	12,738	1,635	9,516
1964	4,291	16,469	2,551	9,509
Total	16,511	77,375	12,630	56,678

Source: Rubber Planting Aid Fund News, Vol. 4, No. 1 (January 1966), pp. 3-4.

The following problems have been encountered in connection with this project:

1. Problem of subsidy. The fund for this subsidy came originally from the rubber exporters, and the amount of export cannot be accurately forecast. It depends on the international selling price of rubber, which is always fluctuating. The contribution will thus vary according to the fluctuation of the selling price of rubber. If the subsidy appears to be inadequate in lean years, there is less hope of enough aid from the government budget or other outside sources, and the program will be delayed accordingly. The price of rubber has generally declined, which aggravates the situation.

2. Co-ordination of rubber growers. This is no provision forcing the rubber growers to adopt the official technical methods of improving

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Deputy Undersecretary of the Ministry of Agriculture and Mr. Chup Muniganonta, Director of the Rubber Replanting Aid Fund Office.

their rubber plantations. The method being used is persuasion and not coercion. It is a recognized fact that people tend to resist change.[28]

3. Rubber tree cutting. The rubber growers are reluctant to cut down their old rubber trees and replace them with trees of high-yielding varieties. Most rubber growers have smallholdings and would be unable to survive during the replanting period, 6-7 years. In fact, $250 per acre for replanting is not covered. The government has insisted on the various methods such as rotating the rubber area for replanting and growing the other crops during the waiting period, etc.

4. Lack of skill and technical knowledge. In general, most rubber growers lack skill and technical knowhow. The Department of Agriculture and the Rubber Planting Aid Fund Office have to work closely together in instituting effective training programs.

Outlook for the Future of Natural Rubber

The long run outlook for natural rubber vis-a-vis synthetic rubber is in doubt; the short run outlook is not.[29] In the United States, a ceiling on domestic imports of natural rubber seems to have been established by the growth of the American synthetic rubber industry. A change in domestic consumption patterns, however, does not pose an immediate threat to the continued expansion and prosperity of the natural rubber growing industry. Because the annual consumption of the United States is always around 500,000 tons, it still holds the position of leader of

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[28]Rubber Replanting Aid Fund News, Vol. 3, No. 1, (January, 1965), pp. 5-11.

[29]Phillip, op. cit., p. 167.

the natural rubber consuming countries.

Outside of the United States and Soviet Russia, the use of synthetic rubber, in spite of recent gains, has not attained large volume (see Chapter III). And although the synthetic rubber production capacity of these countries are increasing, world production has not reached a significant level. Many foreign manufacturers of tires and other rubber products, except those affiliated with American companies, still lack chemical engineers who know how to use synthetic rubber.[30] With natural rubber supplies not expected to increase significantly until the 1970's, it seems certain that ample markets will be available for all of the crude rubber that is produced.

For the expansion of natural rubber production due to begin in the 1970's, markets will have to be found largely outside the United States and Canada. The world consumption of rubber has been steadily increasing since the end of World War II. Countries outside the United States raised their consumption of rubber from 328,500 tons in 1945 to an estimated 3,468,300 tons in 1966. Of the latter, nearly 2 million tons were natural rubber and only 1.5 million tons were synthetic. Measured by American standards, foreign per capita consumption is still low. Table 32 shows 1964 usage of rubber in leading consuming countries. Assuming freedom from major internal disturbances and continued growth in national income in these major developed countries, foreign rubber consumption will continue to rise, particularly in the European Common market and Japan; and in the virtually untapped markets of Africa, China,

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[30] Ibid.

Table 32. Rubber consumption per caput in 1964, for various countries (in pounds)

Country	Total rubber consumption per caput	Natural rubber consumption per caput	Synthetic rubber consumption per caput	Natural rubber as percentage of total
United States	22.66	5.64	17.02	25
Canada	15.77	4.51	11.26	30
Australia	14.65	7.63	7.02	52
United Kingdom	13.63	7.19	6.44	53
West Germany	13.09	6.11	6.98	47
France	12.46	5.89	6.57	47
Eastern Europe (incl. U.S.S.R.)	8.66	2.07	6.59	24
Japan	8.38	4.69	3.69	56
Italy	7.65	3.52	4.13	46
Netherlands	7.40	4.01	3.39	54
Brazil	2.02	0.90	1.12	44
China (Mainland)	0.42	0.42	-	100
India	0.35	0.29	0.06	81

Source: United Nations Conference on Trade and Development, TD/B/AC. 2/4, 4 January, 1966, p. 81.

India, and South America. Tremendous growth possibilities still remain for the natural rubber growing industry if it can increase its production efficiency through better land utilization, and maintain a fairly stable price for its product.

Estimate of Natural Rubber Consumption

Projecting current consumption patterns into the future is always a speculative venture. Nevertheless, a review of various studies of future rubber demand may be helpful in assessing the competitive position of natural and synthetic rubbers.

Below are shown F.A.O. projections for 1970,[31] Mrs. 't Hooft Welvaars' estimated for UNCTAD,[32] and International Study Group estimate for UNCTAD.[33]

F.A.O. estimate (1964) for 1970	7.15-8.47 million long tons
Exclude Centrally Planned Countries	5.17-5.83 million long tons
Mrs. 't Hooft Welvaars' estimate (1964) for 1970, excluding Centrally Planned Countries	6.16 million long tons
I.R.S.G. estimate (1965) for 1970	6.60 million long tons
Exclude Centrally Planned Countries.	6.03 million long tons

Estimates for 1970 of the world rubber consumption differ considerably. For convenience in making these estimates, it is useful to eliminate the centrally planned countries, for which data are a matter of conjecture.

According to Mrs. 't Hooft Welvaars' estimate, from 1954-1964, exclusive of centrally planned countries, there was an average yearly growth rate of 6.37 percent. From 1959-1964 the average growth rate was

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[31] F.A.O. (CCP 64/6 I-III), op. cit., p. II, 102-104.

[32] UNCTAD, TD/B/AC. 2/4, op. cit., pp. 36-38.

[33] UNCTAD, TD/B/C. 1/20, op. cit., pp. 1-2.

7.3 percent. In fact, the growth of total demand for rubber is dependent on the absolute level of national income of any one country and on the rate of growth of G.N.P. Thus the faster growth between 1960 and 1964 seemed to result from the persistent boom in the U.S.A. and the European Common Market countries. It should be remembered that for the world as a whole the calculated rate of growth of consumption between 1959-1964 slowed down as compared to the consumption in the centrally planned economies.

World consumption, exclusive of centrally planned countries, has been growing by 6.37 percent from 1954-1964, and by 7.3 percent from 1959-1964. Mrs. Welvaars extrapolated the 1964 consumption figure at an annual growth rate of 6.25 percent a year. This would bring overall consumption in the Free World to 6.16 million long tons in 1970.

The highest F.A.O. estimate of 5.83 million tons would mean an average yearly growth rate of 5.5 percent since 1960, and of 4.5 percent since 1964. The F.A.O. estimate will be assumed to be a reasonably conservative estimate of world demand for rubber in 1970 (excluding centrally planned economies).

In the F.A.C. projection for 1970, eliminating centrally planned economies, the percentage usage of natural rubber is estimated at 37 percent and 41 percent. Thus, the estimated consumption of natural rubber, excluding the centrally planned countries, will be between 2.18 and 2.39 million tons. The F.A.O. 1970 estimate of natural rubber consumption of centrally planned economies varies between 0.31 and 0.69 million tons. Added to the rest of the world, the F.A.O. estimate for 1970 amounts to a total world consumption of natural rubber of between 2.48 to 3.08 million tons.

Mrs. 't Hooft Welvaars' view that the percent usage of natural rubber is 37 percent and 41 percent seems too high. Since 1964 the natural rubber percentage usage for this part of the world was already down to 40 percent. It is more likely that in the near future the natural rubber percentage of the total rubber consumption would lie between 25 percent and 35 percent. She used 35 percent as the natural rubber share in total rubber consumption. A 35 percent usage of natural rubber in 1970 would then amount to 2.16 million long tons of natural rubber. Adding the F.A.O. estimates for the centrally planned economies, total consumption of natural rubber might be between 2.47 and 2.85 million long tons.

The International Rubber Study Group considered the prospects for natural and synthetic rubber consumption up to 1975. The Working Party had the benefit of the views of most of the main consuming countries, and in particular estimates for 1970 and 1975. Table 33 summarizes the group's informed judgment of the probable consumption in 1970 and 1975.[34]

The Working Party had studied the actual world consumption of various countries for the period 1960-1965 and followed with the estimates for 1970 and 1975 of consumption and the natural rubber percentage. It will be seen that world consumption, excluding Eastern Europe and Mainland China, is expected to be of the order of 6,025,000 long tons in 1970 and 7,500,000 long tons in 1975, with Eastern Europe and Mainland China importing a total of 575,000 long tons of natural rubber in

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[34] Ibid., p. 1.

Table 33. Natural and synthetic rubber consumption and percentage consumption of natural rubber in 1970 and 1975 (in long tons)

Country	1970 Consumption (,000) NR	SR	Total	NR %	1975 Consumption (,000) NR	SR	Total	NR %
United States	575	1,820	2,395	24	560	2,240	2,800	20
Western Europe								
United Kingdom	187	238	425	44	180	320	500	36
France	116	216	332	35	127	298	425	30
F.R. of Germany	157	293	450	35	165	360	525	31
Italy	97	158	255	38	109	221	330	33
Netherlands	22	33	55	40	22	48	70	32
Others	205	260	465	44	214	381	595	36
Total Western Europe	784	1,198	1,982	40	817	1,628	2,445	33
Australia	38	57	95	40	40	75	115	35
Brazil	39	71	110	35	42	98	140	30
Canada	44	141	185	24	48	182	230	21
India	84	61	145	58	100	100	200	50
Japan	231	347	578	40	269	545	814	33
Others	297	233	530	50	394	346	740	53
Total Rest of World[a]	733	910	1,643	45	893	1,346	2,239	40
Total World (rounded)[a]	2,100	3,925	6,025	35	2,275	5,225	7,500	30
U.S.S.R.[b]	250	-	250		300	-	300	
Other Eastern Europe[b]	125	-	125		125	-	125	
Mainland China[b]	200	-	200		250	-	250	
Total World	2,675	3,925	6,600		2,950	5,225	8,175	

Source: United Nations Conference on Trade and Development, TD/B/C. 1/20, 28 June, 1966, p. 19.

[a]Excluding Eastern Europe and Mainland China.

[b]Imports of natural rubber.

N.B. Estimates of future consumption must always be subject to a margin of error and the above figures reflect an estimated order of magnitude. The margin of error for 1970 should be less than for 1975. However, due to the inadequacy of the data available the margin of error for Eastern Europe and Mainland China will be very much wider, and the Working Party considered that imports of natural rubber in 1970 and 1975 could be within the following ranges:

	1970	1975
U.S.S.R.	225-275	250-350
Other Eastern Europe	100-150	100-150
Mainland China	175-225	200-300
	500-650	550-800

1970 and 675,000 long tons in 1975.

The estimates of the percentage of natural rubber to total world rubber consumption assume, for the purpose of estimating, that there will be no significant change in the competitive relation between natural and general purpose synthetic rubber. The estimate of natural rubber percentage of the total rubber consumption are 35 percent in 1970 and 30 percent in 1975.

The 35 percent usage of natural rubber in the Free World in 1970 would then amount to 2,100,000 long tons of natural rubber in 1970 and 2,275,000 long tons in 1975. To this should be added the estimate importation of centrally planned economies natural rubber up to 575,000 long tons in 1970 and 675,000 long tons in 1975. The total consumption of natural rubber might then be 2,675,000 long tons in 1970 and 2,950,000 long tons in 1975 (see Table 33).

Estimate of Natural Rubber Production[35]

Table 34 shows the world production of natural rubber during the four years, 1962-1965, and the production of most countries.

According to W. G. G. Kellett, the principal estimates reveal that:

> The estimate for world production of natural rubber for the year 1965 to 1975 inclusive should not be interpreted as indicating the amounts which will actually be produced in these years. They are attempts to measure, ignoring all outside influences including political circumstances, the amounts which could be produced by all those producers--estates and smallholders--who normally produce natural rubber. They do not take into consideration the effects of price on output, particularly smallholders' output, and exclude production from

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[35]This part is heavy based on the study of Mr. W. G. G. Kellett who was invited by the Working Party of I.R.S.G., Ibid., pp. 2-3.

Table 34. Natural rubber actual supply 1962-1965 and potential supply in 1970 and 1975 (in thousand long tons)

Country	Actual				Estimated potential	
	1962	1963	1964	1965	1970	1975
States of Malays						
Estates	439	459	478	481	575-625	700-750
Smallholdings	312	329	347	380	425-475	550-600
Total	751	788	825	861	1,000-1,100	1,250-1,350
Sabah	22	21	23	24	35-40	50-60
Sarawak	44	45	45	40	45	45
Total Malaysia	817	845	893	925	1,080-1,185	1,345-1,455
Indonesia						
Estated	206	205	219		240-250	250-275
Smallholdings	465	368	419		584-495	500-525
Total	671	573	638	690	725-745	750-800
Thailand	192	187	218	213	240-260	280-300
Ceylon	102	103	110	116	135-145	155-165
Vietnam	74	71	73	61	85-95	100-110
Cambodia	41	40	45	48	60-70	70-80
India	31	37	44	49	60-70	75-85
Burma	12	12	12	12	10	10
Other Asia and Oceania	11	12	12	13	20	20
Liberia	45	40	42	48	55-65	70-80
Nigeria	59	63	72	69	95-105	110-120
Cameroon	8	9	9	10	15	20
Congo	37	37	33	20	40-50	60-70
Other Africa	1	2	3	3	10	15
Brazil	21	20	28	29	30	35
Other Latin America	7	7	7	7	10	10
Total Production	2,125	2,075	2,250	2,325	2,675-2,875	3,125-3,375

Source: United Nations Conference on Trade and Development, TD/B/C. 1/20, 28 June, 1966, p. 20.

certain smallholders in Indonesia and Sarawak which has been forthcoming in the past during periods of exceptionally high prices.

The estimates have been constructed where possible by making use of acreages and yield data but in some instance the acreage data is so out-of-date that the assumption which had to be made detract from the value of the estimates. The estimates made all territories in the later years of the period are of course based on certain assumptions regarding future annual rates of planting.[36]

The estimate for natural rubber potential production capacity which presented by the International Rubber Study Group for 1970 and 1975 is shown in Table 33. It gives a range of potential production capacity of 2,675,000-2,875,000 long tons for 1970 and a range of 3,125,000-3,375,000 long tons for 1975.

The Estimated Supply and Demand Position

The summarized estimates for the consumption and potential supply of natural rubber in 1970 and 1975 are shown below.

	(in thousand tons) 1970	1975
Import into Eastern Europe and Mainland China	575	675
Consumption in the rest of the world	2,100	2,275
	2,675	2,950
Potential supply of natural rubber	2,675-2,875	3,125-3,375

It may be noted that the above estimates do not take account of any increase of natural rubber stocks. Assuming normal relationship being maintained between consumption and total stock, the increased consumption of natural rubber between 1965-1975 would require the addition of some 250,000 long tons to world stocks, or in other words, some 25,000 long

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[36] Ibid., pp. 2-3.

tons a year.[37]

Proposed Solutions to the Problem

At various times and in various forums proposals have been made to improve the economic position of those developing countries largely dependent on commodity trade. As discussed before, the fundamental problems facing natural rubber was its long term prospects and not short term price fluctuation. There seemed no doubt that there would be significant surplus capacity for general purpose synthetic rubber throughout the period up to 1975. This would mean a continuation of the downward pressure on both natural and synthetic rubber prices and in consequence the probability of a slow but limited decline in prices.[38] In addition, there was the danger that a significant surplus productive capacity for natural rubber might develop before 1975. In the circumstances under which natural rubber is traded, it is likely to create a much more immediate and severe pressure on prices than in the case of the synthetic surplus capacity. The prospedt would then be for a fall in price, which might well be followed by reductions in the prices of the competing synthetic rubbers. There might, therefore, be a period of severe competition at low prices.

The main proposal made here follows Mrs. 't Hooft Welvaars in her valuable and stimulating paper "International Organization of Commodity

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[37] Ibid., p. 4.

[38] UNCTAD, TD/B/AC. 2/4, op. cit., pp. 39-45.

Trade with respect to Natural Rubber."[39] She recommends:

1. Improving the efficiency of the natural rubber industry by:
   a. Increasing the amount of agronomic and fundamental research which at present goes into improving the quality and yields of the rubber trees. Researchers in the field constantly complain of lack of funds.
   b. Disseminating the result of this research among estates and smallholders, and putting new techniques into effect. This might entail a good network of government-appointed agronomic consultants in rubber gorwing areas. Pilot projects might be needed to overcome the normal peasant conservatism. Financial incentives might also be needed.
   c. Drawing up a co-ordinated replanting program in each country and putting it into effect. One of the most important ways of continuously reducing production costs is steady replanting.
2. Improving the technical qualities of natural rubber in order to increase the demand for natural rubber. Most consumers of natural rubber stress the importance of:
   a. Simplification of the grading system.
   b. Better control of cleanliness and uniformity.
   c. Improved methods of packing and presentation.
3. Stimulating the demand for natural rubber by:

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[39] Ibid., pp. 49-76.

a. Removing obstacles to trade in technically improved natural rubber. An important element would be the elimination or reduction of the wall of import duties in both developed and developing countries for rubber products.

b. Providing natural rubber consumer services in importing countries. These services could take advantage of technical progress in manufacturing industries which might lead to new techniques and new applications.

c. Supplying information which is in the interest of both natural rubber and synthetic rubber producing countries. With sufficient information one might estimate the future cost price of natural rubber. This might act as a check on undue expansion synthetic rubber production.

d. Promoting cooperation between natural rubber and synthetic rubber producers in trying to increase overall demand, through research into finding new uses of rubber.

4. Diversification. If through replanting and new planting rubber trees there was a clear danger of excessive natural rubber production capacity developing then diversifying into other crops would require consideration. Diversification in its broadest sense can also include the development of the industrial sector in a country primarily dependent on its agriculture.

5. During the interim adjustment period, natural rubber producing countries might need:

a. Compensatory finance to provide some temporary assistance to natural rubber producers if the price of natural rubber

would fall significantly.

b. Long-term contracts of a bilateral or multilateral character. These could assure a more stable return for some part of the supply, at least over the period of the contract.

CHAPTER VII

SUMMARY AND CONCLUSION

An entirely new factor entered rubber trade after World War II in the shpe of competition from synthetic rubber. The appearance and success of synthetic products have drastically changed the supply and demand conditions of the whole rubber market. On the supply side, more flexibility has been introduced by synthetic rubber's quicker response to demand change; no rubber tree can be tapped earlier than seven years after it has been planted. On the demand side, natural rubber has lost its monopoly position in many uses and growing substitutability has increased the price elasticity of demand. This substitutability will increase sharply with the development of stereo regular rubber, which can replace the natural product in many uses in which the earlier synthetic could not.

Natural rubber prices have been subject to considerable fluctuations. This appears to be due to the fact that it is not usually possible for manufacturers to shift frequently between one kind of rubber or mixture of rubbers to another. They tend to substitute on price grounds only when price differences are expected to last for sometime. However, in the sixties, price certainly became a more prominent factor in the demand for natural rubber than it had ever been before.

The United States has been traditionally the largest consumer of natural rubber; in recent years it has become a leading producer of synthetic rubber and thus threatens to become lost as a market for the

products of the rubber plantations of Asia. Such a tremendous dislocation of the natural rubber market poses especially difficult problems for Thailand and other rubber producing countries which are in large measure dependent upon rubber exports for their domestic economic prosperity.

A study of the natural rubber industry shows that the situation it faces is not so much one of immediate survival as it is a question of its future position in the world market. In fact, natural rubber is a growing industry. The decline of the natural rubber industry has not been an absolute one, but relative. Natural rubber is facing a declining share of the market rather than decreasing output. For example, according to figures issues by the International Rubber Study Group, world production of natural rubber was 1,918,000 long tons in 1955, 1,990,000 long tons in 1960, and 2,408,000 long tons in 1966. But its share in world rubber production was reduced from 63.9 percent to 51.4 and 42.0 percent, respectively.

Since the demand for natural rubber is almost completely dependent on the manufacture of tires and tubes for motor vehicles, and on the absorption of rubber in other manufactured goods, the fluctuations of the natural rubber trade has been very closely associated with changes in industrial activities, particularly the automotive industries. Thus, the primary economic problem has been the transmission of trade cycles from the United States and the other developed countries to rubber producing countries. Under this condition, changes in the United States' and European industrial countries' demand for natural rubber has exercised a vital role in determining the price movement, instead of the opposite being true. This means that in the future a change in the

price of natural rubber will have little impact on the amount of rubber used in automobile production because rubber is only a small fraction of the price of an automobile. Should natural prices at any time have a significant influence on the price of an automobile, synthetic rubber might be substituted for it. IRSG has reported that a rise of some 3.5 cents (3 pence) a pound for natural rubber would provide an incentive for a 5-10 percent substitution of natural rubber by synthetic rubber in automobile tires.[1]

The vulnerable position of the natural rubber industry could have been less severe than it has been if the inherent inflexibility in the structure of natural rubber supply were absent from the industry. Because of relatively stable rubber prices, estate producer can more adequately plan capital investment and develop more comprehensive long range labor policies, which will ensure a more efficient utilization of the labor force. On the other hand the smallholders, to whom no alternative means of livelihood are available, not only continue to tap, but also accelerate tapping in their efforts to maintain a subsistence level of income.

In the competitive market, synthetic rubber has enjoyed several advantages over natural rubber. These are: availability, unique properties, technical improvement, and lower and more stable prices. But in the field of general properties, natural rubber still holds the preference. In the eyes of industrial consumers, the price stability and quality of rubber are important factors to be considered in their choice. Up to

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[1]UNCTAD, TD/B/C. 1/20, op. cit., Appendix I, pp. 3-4.

the present time, these advantages have been offered only by synthetic rubber. Efforts to improve the qualities and lower the cost of production of natural rubber, which have already begun, will be stepped up.

According to estimates made by the IRSG, all natural rubber produced during the years to 1970 will be sold. Synthetic rubber will be used to meet excess demand for new rubber during their period (see pp. 119-126). Obviously, for the past several years, excess demand has been increasing at a faster rate than natural rubber production. However, the outlook for natural rubber still looks good. Projections show that in 1975 some surplus of natural rubber production will occur. But the natural rubber industry's future depends to a large degree on lowered costs of production with replanting and new planting with high-yielding trees, and improving its quality and marketing.

The future of the natural rubber industry is not entirely bleak. Natural rubber has a definite future. Mr. John McGavack wrote:

> It is well established at the present time in the elastomer field that about 30 percent of the production requires natural rubber regardless of cost, and about 30 percent requires the synthetic type. The balance, or 40 percent of the production, can use either depending upon its cost. This percentage holds even if the newer synthetic types which are quite similar to natural rubber are taken into consideration.[2]

P. C. Ratchaga came to a similar conclusion:

> Natural rubber will always find a market, as world demand for new rubber is increasing because of further development of present uses for rubber, discoveries of new uses for rubber and the opening up of new markets for rubber.[3]

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[2] McGavack, op. cit., p. 789.

[3] Ratchaga, op. cit., p. 46.

Thailand's rubber industry depends on the world rubber market situation. Since World War II, the production of natural rubber has increased steadily from 52,000 long tons in 1947 to the peak of 218,000 long tons in 1964. At present the government of Thailand is busy promoting the replanting scheme which has been activated since 1961. Various policies in improving the qualities of rubber and capacity of the tree are being introduced. The government plans to replant with high-yielding varieties up to 400,000 acres within the next seven years before the price of world natural rubber declines. At that time Thailand would produce the same as the present level of production, 200,000-250,000 long tons, so that she can maintain her economy at least at today's standard of employment and income.[4]

In fact, natural rubber must continue to be an important source of foreign exchange. Despite the expansion of industry and other crops, natural rubber is still one of the best hopes of further economic development, since it is a very important source of government revenue and personal income. For the next several decades rubber will be a vital element in Thailand's economic development.

The future of the natural rubber industry of Thailand, then, depends first, on how fast production could be stepped up; secondly how fast the cost of production could be reduced by replanting with high-yielding clones; and thirdly on the world price of natural rubber.

In conclusion, it can be said that the increasing relative share of man-made rubber in the world's total consumption of rubber has been primarily due to the slow increase in the supply of natural rubber

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[4] Petchara Chantara, op. cit., p. 12.

compared to the technological development in the other sector of the rubber industry. The natural rubber industry, therefore, should increase the supply in such a way as to keep pace with the developments in the synthetic rubber industry. The replanting scheme now being undertaken in the natural rubber producing countries will be of advantage not only at present but also in the future.

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APPENDIX

Table 35. World consumption of natural rubber, 1900-1937 (in thousand long tons)

Year	U.S.A.	Western Europe	Others	World total
1900	20.3	26.7	5.6	52.6
1901	23.0	22.6	6.8	52.4
1902	21.2	22.1	7.4	49.7
1903	23.2	25.3	8.2	56.7
1904	26.1	30.6	7.4	64.1
1905	27.0	36.0	7.2	70.2
1906	28.6	37.0	9.0	74.6
1907	28.8	40.4	8.2	77.4
1908	32.4	32.7	9.2	74.3
1909	39.8	37.8	8.6	86.2
1910	42.2	46.5	10.7	99.4
1911	41.7	46.5	10.9	99.1
1912	55.9	50.8	14.0	120.7
1913	52.0	59.9	17.7	129.6
1914	62.3	48.1	6.9	117.3
1915	99.0	35.7	20.9	155.6
1916	117.6	48.5	19.6	185.7
1917	157.4	49.0	9.0	215.4
1918	160.0	50.6	17.2	227.8
1919	215.0	72.5	17.5	305.0
1920	206.0	68.5	19.8	294.3
1921	177.8	67.7	32.1	277.6
1922	301.5	74.5	32.2	408.2
1923	319.4	89.1	37.1	445.6
1924	328.8	93.7	43.8	466.3
1925	388.5	119.0	46.1	553.6
1926	366.2	115.9	59.1	541.2
1927	373.0	145.2	77.4	595.6
1928	437.0	154.2	93.0	684.2
1929	467.4	220.8	114.0	802.2
1930	376.0	234.0	98.9	708.9
1931	355.2	198.3	127.6	681.1
1932	336.7	207.0	148.1	691.8
1933	412.4	245.7	167.0	825.1
1934	462.5	276.4	199.7	938.6
1935	491.5	272.5	175.0	939.0
1936	575.0	282.5	189.0	1,046.5
1937	543.6	342.8	217.7	1,104.1

Source: Compiled from Rubber Statistics, 1900-1937, by P. W. Barker, U. S. Department of Commerce, Trade Promotion Series, No. 181 (Washington, D.C.: Government Printing Office, 1938), pp. 14-17.

Table 36. World consumption of natural rubber, 1938-1966 (in thousand long tons)

Year	U.S.A.	U.K.	Japan	Germany	France	Canada	Brazil	Austra-lia	World Total
1938	437.0								437.0
1939	592.0								592.0
1940-44 (ave)	452.4	104.1	n.q.	16.2	12.3	34.2	7.7	17.0	824.0
1945	105.4	27.3	19.7	1.0	3.6	5.9	7.6	8.5	263.0
1946	277.6	96.6	20.1	1.7	29.8	9.6	13.5	15.6	555.0
1947	562.7	153.6	17.0	8.1	61.2	32.3	14.1	23.0	1,110.0
1948	627.3	193.7	26.4	45.6	86.5	41.6	15.6	26.3	1,423.0
1949	574.5	184.3	35.3	65.9	91.2	38.3	19.1	27.7	1,438.0
1950	720.3	219.7	60.1	78.6	102.6	46.1	23.4	34.2	1,723.0
1951	454.0	234.2	58.6	91.5	119.3	44.4	26.2	35.9	1,515.0
1952	453.8	197.3	68.2	93.5	121.6	33.5	27.7	28.5	1,470.0
1953	553.5	219.6	88.9	106.2	114.8	37.5	31.8	36.0	1,655.0
1954	596.3	244.3	88.9	130.0	127.0	41.6	37.8	45.1	1,780.0
1955	634.8	248.3	87.8	147.6	134.4	44.3	39.2	48.1	1,890.0
1956	562.1	200.2	108.9	134.0	134.6	43.1	36.8	38.4	1,878.0
1957	538.8	186.9	130.3	136.0	135.2	40.8	38.5	33.9	1,900.0
1958	484.5	182.3	128.2	129.3	136.9	37.1	42.3	35.4	2,013.0
1959	555.0	184.3	158.8	144.1	133.5	44.3	44.5	37.8	2,118.0
1960	479.0	179.9	165.7	145.7	127.3	35.2	43.8	36.9	2,065.0
1961	427.3	166.1	176.0	135.8	127.0	31.7	38.7	29.0	2,128.0
1962	462.8	164.2	190.0	145.9	125.1	34.8	40.1	33.3	2,220.0
1963	457.2	168.7	192.4	149.9	125.4	36.0	35.5	36.4	2,233.0
1964	481.5	180.9	202.8	152.7	125.1	40.2	32.2	38.3	2,260.0

Table 36. Continued

Year	U.S.A.	U.K.	Japan	Germany	France	Canada	Brazil	Austra-lia	World Total
1965	514.7	183.8	198.3	155.4	120.6	42.8	26.1	36.3	2,355.0
1966	549.7	183.8	205.0	149.6	121.0	47.0	30.5	35.5	2,470.0

Source: Commodity Yearbook, several issues.

Table 37. World consumption of synthetic rubber, 1940-1966 (in thousand long tons)

Year	United States	West Germany	United Kingdom	France	Canada	World Total
1940-44	152.8	65.6	9.0	4.3	5.7	252
1945	693.6	22.5	63.8	17.4	35.9	865
1946	761.7	11.9	30.1	28.7	29.6	913
1947	559.7	7.9	2.8	12.6	29.2	625
1948	442.1	4.4	2.6	7.4	20.6	480
1949	414.4	2.2	2.4	8.3	18.1	450
1950	538.3	3.4	2.8	7.4	22.6	580
1951	758.3	5.2	3.9	8.6	26.4	813
1952	807.0	9.8	4.9	11.3	33.6	885
1953	784.8	11.5	4.9	12.9	35.9	873
1954	636.7	17.0	9.4	14.4	30.1	740
1955	894.9	25.4	21.3	19.4	40.2	1,063
1956	874.4	36.0	41.1	31.6	48.4	1,135
1957	925.9	47.0	59.2	49.9	47.5	1,260
1958	879.9	54.4	65.0	55.1	46.7	1,248
1959	1,073.0	73.4	80.2	62.2	57.2	1,583
1960	1,079.0	104.4	115.8	90.8	55.9	1,798
1961	1,102.0	120.3	121.3	95.5	62.7	1,920
1962	1,256.0	129.3	132.8	108.3	73.0	2,175
1963	1,307.0	142.9	143.5	123.4	83.7	2,360
1964	1,452.0	174.3	165.7	139.3	90.9	2,748
1965	1,514.0	205.2	179.8	145.2	96.1	2,975
1966	1,672.0	204.0	190.0	163.0	108.0	3,220

Source: Commodity Yearbook, several issues.

Table 38. World natural rubber production (net export) 1910-1937 (in thousand long tons)

Year	Malaya	Indonesia	Ceylon	India	Burma	N. Borneo	Sarawak
1910	6.5	2.4	1.6	0.2		0.1	-
1911	10.8	2.3	3.2	0.4		0.1	-
1912	20.3	3.7	6.7	0.7		0.2	0.1
1913	33.6	6.4	11.4	1.0		0.5	0.2
1914	47.0	10.4	15.8	1.3		0.6	0.3
1915	72.2	20.0	20.8	2.2		1.2	0.6
1916	96.0	33.1	24.4	2.8		1.9	1.0
1917	129.0	44.0	31.9	4.0		2.4	1.7
1918	112.0	42.0	21.1	4.4		2.6	1.5
1919	204.0	85.0	44.8	6.6		3.9	2.2
1920	181.0	80.0	39.0	4.2	2.2	4.1	2.2
1921	151.0	71.0	40.2	3.7	1.7	3.2	2.1
1922	214.0	94.0	47.4	3.2	2.0	3.8	3.8
1923	201.0	117.0	37.1	4.4	2.5	4.2	5.7
1924	183.0	149.0	37.4	4.6	3.7	4.6	6.7
1925	210.0	189.0	45.7	6.3	4.7	5.4	9.1
1926	286.0	204.0	58.8	6.5	4.5	5.8	9.9
1927	242.0	229.0	55.4	7.0	5.9	6.6	11.2
1928	299.0	229.0	58.0	7.2	4.8	7.0	10.6
1929	457.0	255.0	80.3	7.9	5.5	7.4	11.2
1930	443.0	242.0	75.6	6.8	5.2	7.1	10.6
1931	423.0	257.0	62.3	5.4	4.5	6.2	10.4
1932	406.0	211.0	49.3	1.1	3.0	5.4	7.1
1933	445.8	282.3	63.8	1.4	3.4	7.8	11.1
1934	467.4	379.4	79.1	6.5	6.3	11.1	17.6
1935	417.4	282.9	54.3	9.1	4.9	8.9	19.3
1936	353.7	309.6	49.7	8.6	5.9	8.2	21.0
1937	470.0	431.6	70.4	9.8	7.2	13.2	25.9

Source: George Rae, "Statistics of Rubber Industry," Journal of the Royal Statistical Society, Part II, 1938, p. 345.

Table 38. Continued

Thailand	Indo-China	Oceania	Africa	South America	Mexico	World Total
-	0.2	-	20.0	44.0	18.0	93.0
0.1	0.2	-	18.0	43.0	15.0	93.1
0.1	0.3	-	19.0	49.0	12.0	112.1
0.1	0.2	-	16.0	43.0	6.0	118.4
0.1	0.2	-	8.0	38.0	1.0	122.7
0.1	0.4	0.1	8.0	40.0	3.0	166.6
0.1	0.6	0.2	10.0	38.0	2.0	210.1
0.2	0.9	0.2	10.0	41.0	2.0	267.3
0.1	0.5	0.3	7.0	27.0	3.0	221.4
0.3	2.9	0.3	7.0	39.0	2.0	398.0
0.4	3.1	0.4	6.0	30.0	1.0	353.6
0.4	3.6	0.3	4.0	21.0	-	302.2
0.6	4.5	0.1	3.0	24.0	-	400.4
1.5	5.1	0.3	5.6	23.3	1.0	408.7
2.5	6.5	0.4	5.4	25.1	1.5	430.4
4.6	7.4	0.7	7.8	30.2	4.0	524.9
3.5	8.1	1.0	9.5	26.7	4.0	628.3
4.7	8.9	1.3	8.5	30.8	5.0	616.3
4.1	9.1	1.3	7.5	21.6	3.0	662.2
4.3	9.5	0.9	6.3	21.3	1.3	867.9
4.7	9.7	1.2	4.9	14.3	1.0	826.1
3.6	11.0	0.9	3.5	12.2	-	800.0
3.0	13.5	0.8	2.0	6.5	-	708.7
7.0	17.3	1.2	2.3	10.1	-	853.5
17.7	19.6	1.4	3.5	9.1	0.4	1,019.1
28.3	28.7	1.5	5.0	12.2	0.5	872.6
34.6	40.8	1.6	6.1	14.6	1.2	855.6
35.6	43.4	1.6	7.7	16.0	2.7	1,135.1

Table 39. World production of natural rubber, 1938-1966 (in thousand long tons)

Year	Malaya	Indonesia	Thailand	Ceylon	Vietnam	Cambodia
1938	345.3	300.9	41.6	49.3	59.2	
1939	361.6	369.9	41.8	61.6	65.2	
1940	547.2	543.2		90.0	64.0	
1941	600.0	650.0		99.5	75.0	
1942	155.0	200.0		101.5	76.2	
1943	75.0	100.0		105.5	70.4	
1944	25.0	50.0		98.5	60.4	
1945	8.6	10.0		97.5	12.0	
1946	403.7	175.0		94.0	20.0	
1947	646.4	278.0		89.0	38.1	
1948	698.2	432.3		95.0	44.0	
1949	671.5	431.8		89.5	43.0	
1950	694.1	696.5	112.2	113.5	33.4	15.1
1951	605.3	814.4	108.8	105.0	36.7	15.4
1952	584.2	750.5	97.9	96.5	44.9	18.3
1953	574.4	694.6	95.6	98.6	52.4	22.2
1954	586.5	744.4	116.7	93.9	54.1	24.0
1955	638.7	737.1	130.2	93.8	65.3	27.4
1956	626.0	686.7	134.6	95.4	69.1	31.6
1957	637.5	684.5	134.0	98.2	68.6	31.2
1958	662.9	685.2	138.4	100.2	70.5	33.1
1959	697.8	693.5	171.3	91.7	74.2	33.9
1960	708.4	610.5	168.2	97.3	75.4	36.5
1961	736.7	671.4	183.2	96.0	77.9	39.3
1962	751.6	670.8	192.3	102.4	74.0	40.9
1963	788.5	573.1	186.8	103.1	70.7	40.1
1964	825.3	638.4	218.2	109.8	73.3	45.1
1965	860.7	705.7	213.1	116.4	60.0	48.1
1966	928.5	700.0	210.0	128.9	50.7	50.5

Source: Rubber Statistical Bulletin, several issues.

Table 39. Continued

India	Sarawak	Africa	Brazil	Other Latin America	World Total
14.7	27.3	12.0			871.5
16.3	36.4	14.7			989.7
17.5	35.0	16.1	18.6	7.4	1,417.5
17.0	35.0	16.9	16.9	8.9	1,600.0
16.0	10.0	29.6	22.2	13.6	640.0
16.6	5.0	45.0	23.1	18.8	465.0
17.3	-	54.8	29.4	20.5	360.0
16.1	-	53.6	24.1	23.0	250.0
15.8	9.0	46.8	23.7	16.0	837.5
16.4	36.8	38.5	25.9	9.0	1,260.0
15.4	39.7	42.0	20.2	9.0	1,525.0
15.6	39.5	45.0	21.3	6.0	1,490.0
15.6	55.6	55.3	19.4	7.5	1,860.0
17.1	42.4	72.0	20.8	9.0	1,885.0
19.9	31.8	73.5	26.5	9.0	1,790.0
21.1	24.0	77.0	26.3	9.0	1,727.5
21.5	23.4	82.8	21.9	6.0	1,810.0
22.5	39.2	98.8	21.3	6.0	1,918.0
23.4	40.7	113.5	23.7	6.0	1,893.0
23.8	41.0	116.3	24.0	6.0	1,905.0
24.3	38.9	123.3	20.3	6.0	1,943.0
23.4	43.4	141.8	21.1	7.0	2,043.0
24.8	49.7	147.0	22.7	7.0	1,990.0
26.6	47.3	142.0	22.4	7.0	2,095.0
30.6	43.4	150.8	21.3	7.0	2,130.0
36.6	44.6	151.8	20.3	7.0	2,068.0
43.5	44.7	158.8	27.9	7.0	2,240.0
48.6	39.9	153.5	28.8	7.0	2,328.0
51.5	35.0	170.0	25.5	7.0	2,408.0

Table 40. World production of synthetic rubber, 1940-1966 (in thousand long tons)

Year	U.S.A.	Canada	West Germany	U.K.	Italy	Japan	France	World Total
1940	2.6		39.8					42.4
1941	8.1		69.4					77.5
1942	22.4		98.1					120.2
1943	231.7	2.5	115.8					350.0
1944	764.1	34.8	101.6					900.5
1945	820.4	45.7	-					866.1
1946	740.0	51.0	15.6					806.6
1947	508.7	42.4	8.2					559.3
1948	488.3	40.5	3.4					532.2
1949	393.7	46.6	-					440.3
1950	476.1	58.4	-					534.6
1951		62.3	1.0					908.4
1952	798.5	74.3	4.9					877.8
1953	848.4	80.9	6.3					935.6
1954	622.9	86.6	7.0					716.4
1955	970.5	103.9	10.9					1,085.0
1956	1,080.0	120.7	10.7					1,211.0
1957	1,118.0	132.1	11.6	0.8				1,263.0
1958	1,055.0	135.0	22.7	11.3	20.0			1,243.0
1959	1,380.0	100.7	48.1	57.0	47.0	1.2	5.9	1,633.0
1960	1,436.0	159.7	79.8	90.0	70.0	18.8	17.2	1,880.0
1961	1,404.0	164.5	85.6	106.0	82.0	50.0	40.0	1,975.0
1962	1,574.0	168.3	88.2	117.0	86.0	68.0	63.0	2,240.0
1963	1,608.0	178.7	106.5	125.0	94.0	90.0	97.0	2,438.0
1964	1,765.0	197.5	135.7	153.0	110.0	120.0	128.0	2,803.0
1965	1,814.0	203.0	161.4	171.7	118.0	158.8	146.0	3,015.0
1966	1,969.0	200.0	170.9					3,318.0

Source: Rubber Statistical Bulletin, several issues.

Table 41. Yearly average price of crude rubber (ribbed smokes sheet plantation rubber) in New York (in cent per pounds)

Year	Price	Year	Price	Year	Price
1900	99.5	1920	35.9	1940	20.10
1901	88.5	1921	16.5	1941	22.30
1902	80.5	1922	17.3	1942	22.50
1903	96.5	1923	30.7	1943	22.50
1904	112.5	1924	26.4	1944	22.50
1905	126.5	1925	73.0	1945	22.50
1906	125.5	1926	48.7	1946	22.50
1907	103.0	1927	37.8	1947	20.8
1908	98.0	1928	22.3	1948	21.9
1909	167.5	1929	20.48	1949	17.6
1910	206.6	1930	10.24	1950	41.3
1911	141.3	1931	6.12	1951	60.9
1912	121.6	1932	3.43	1952	38.6
1913	82.0	1933	5.90	1953	24.1
1914	65.3	1934	12.94	1954	23.4
1915	65.7	1935	12.32	1955	39.0
1916	72.5	1936	16.43	1956	34.3
1917	72.2	1937	19.37	1957	31.1
1918	60.2	1938	14.68	1958	28.2
1919	48.5	1939	17.66	1959	36.5
				1960	38.5
				1961	29.6
				1962	28.5
				1963	26.3
				1964	25.2
				1965	25.7
				1966	23.6

Source: Commodity Yearbook, several issues.

Table 42. Synthetic rubber prices (in cent per pound)

Year	GR-S	Neoprene	Butyl
1940	-	65	-
1941	-	65	-
1942	50	65	33
1943	26-3/8	44-1/4	19-7/8
1944	18-1/2	27-1/2	15-1/2
1945	18-1/2	27-1/2	15-1/2
1946	18-1/2	27-1/2	18
1947	18-1/2	29-3/8	18-1/2
1948	18-1/2	32	18-1/2
1949	18-1/2	32	18-1/2
1950	19	34	18-11/16
1951	25	38	20-3/4
1952	23-1/2	38	20-3/4
1953	23	40	21-5/16
1954	23	41	22-1/2
1955	23	41	23
1956	23	41	23
1957	23	41	23
1958	23	41	23
1959	23	41	23
1960	23	41	23
1961	23	41	23
1962	23	41	23
1963	23	41	25
1964	23	41	25
1965	23	41	25

Source: Rubber Statistical Bulletin.

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