NATURAL RUBBER

Sector Policy Paper

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The World Bank
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"We know of no other material which combines so much suppleness with so much elasticity. Also, the manner in which it resists the strongest chemical agents makes it an object worthy of the greatest possible attention."

—P.J. Macquer in a Report to the French Academy, 1768.

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NOTE

When this paper was prepared for publication, it was assumed that the real price of petroleum would rise by approximately 3.2 percent annually over the period 1980–1990. This key assumption, which affects the long-run demand projections for natural rubber, was subsequently revised in early 1982 to an expectation of slightly declining real prices for petroleum through 1985 and a modest increase thereafter. The modified projection implies a less buoyant outlook for natural rubber than that presented in the paper. Although the changed outlook may be expected to extend the time horizon somewhat for natural rubber development, the general conclusions of the paper, nevertheless, remain unchanged.

NATURAL RUBBER
Sector Policy Paper
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This paper was initially written for presentation to the Executive Directors of The World Bank. It was prepared by Theodore J. Goering with the assistance of Teck Yew Pee, C. Barlow, and Brian Gray. Emmanuel D'Silva edited the paper for publication.

Summary

This sector policy paper examines recent developments in the global rubber market that form the basis for establishing World Bank policies in lending for natural rubber production. Building on a comprehensive study of the world rubber economy, prepared jointly by the Bank and the Food and Agriculture Organization of the United Nations (FAO) in 1978, the paper takes note of several subsequent developments that are likely to affect the demand and supply for natural rubber.

These developments include further sharp increases in the price of crude oil and lower projected growth rates for total consumption of elastomers, sharply reduced rates of investment in synthetic rubber capacity in the developed countries, successful negotiation of an International Natural Rubber Agreement, lagging rates of replanting for natural rubber, growing scarcities of rural labor in several producing countries, and a slowdown in the growth of natural rubber production among smallholders. On the basis of these factors, the paper concludes that market prospects for natural rubber are attractive and that increased investment in the sector is warranted.

Several issues are identified that relate to the major question of whether the natural rubber industry can respond adequately to emerging market opportunities. The cost competitiveness of natural rubber *vis-à-vis* synthetic rubber is expected to improve as prices of crude oil rise in real terms (petroleum-based inputs are of greater importance in the production of synthetic rubber than in natural rubber production). In the short run, the supply of natural rubber is expected to increase relatively little in response to projected strong prices. Over the longer term, the stock of rubber trees, as well as production, will be determined in part by the relative profitability of rubber as contrasted with other crops. While other tree crops, such as oil palm, cocoa, or coconut, appear to have been more profitable in recent years than natural rubber, price developments in the future are expected to move in favor of rubber. Moreover, the areas in which these alternative tree crops can be successfully grown are limited by soil, climate, and topography. The adaptability of rubber to wider agroclimatic conditions and its suitability as a smallholder crop add to its development potential.

The paper takes note of the threefold increase in natural rubber yields in the past fifty years and points to several areas of research that promise gains in productivity in the future, as well as to possible labor savings in this relatively labor-intensive industry. Wide differences in yields exist, however, between experimental stations and best commercial practices, between estates and smallholdings, and among various producing countries.

The need for additional research is therefore noted, particularly on technologies suitable to the typical production system, using few inputs, that is employed by smallholders. Extension services have generally not been adequate to introduce improved technologies to large numbers of smallholders, whose rubber yields invariably lag behind those of estates. The suggestion is made that it may be appropriate, in some circumstances, to establish centralized management and group-farming systems so as to deal more effectively with this problem of technology transfer.

As much as half of the world's area devoted to smallholder rubber production appears to be in need of replanting or rehabilitation. Among major rubber producers, only in Thailand is the rate of replanting adequate to maintain the planted areas. Declining real prices for natural rubber over much of the past two years, attractive investments in alternative tree crops, and emerging shortages of rural labor in some countries have contributed to the lagging development of the natural rubber industry.

Improved processing and marketing systems are means to increase producer prices and production incentives in the medium term. Because future demand for particular types of natural rubber (traditional sheet rubber or the newer technically specified rubbers)[1] is difficult to predict, the paper advocates the construction of new processing facilities that permit flexibility in the type of rubber to be produced. While the use of technically specified rubber is expected to increase, demand for sheet rubbers will remain strong among major importers. The growing global market for radial tires emphasizes the need to improve the quality of sheet that smallholders produce.

[1]Natural rubber is graded according to specific standards for plasticity and color, as well as content of dirt, ash, volatile matter, and nitrogen. The size of the rubber block and its packaging are also specified.

Reflecting the optimistic assessment of market prospects for natural rubber over the forseeable future,[2] measures are recommended that would not only increase production from existing plantings (improved marketing and producer incentives, chemical stimulation of yield of overaged plantings), but would also raise the production potential of the planted area (through expanded replanting) and of new planting.

It is recommended that the Bank take an active role in assisting the future development of the natural rubber industry. A major recommendation is that the Bank assist producing countries to build toward an annual replanting program by 1985 of at least 170,000 hectares. Such a program would be more than 50 percent greater than the current rate, but would be well below the level needed to maintain the existing planted area (about 210,000 hectares). The Bank's support for Indonesia's nucleus estate and smallholder program will also be expanded as rapidly as possible and the Bank will explore complementary approaches to smallholder development in that country that may be less demanding of scarce technical and administrative personnel.

A larger role also is warranted for the private sector in providing managerial help and services needed for the distribution of inputs. In developing new areas for rubber, greater involvement by the private sector, perhaps through the International Finance Corporation (IFC), may be possible.

The paper recommends that rubber research be strengthened and that efforts be made to facilitate the international exchange of research results and improved planting materials.

The restructuring of land holdings, centralized management, and group-farming systems may be appropriate means of extending improved technologies and other support services to smallholders.

In government financing of smallholder rubber development programs, particularly those involving new planting and replanting, grant funding (derived from taxes on production or exports) is preferred over the administratively cumbersome system of credit financing now used in some countries.

[2]Approximately ten years.

Chapter 1: Introduction

The purpose of this paper is to examine recent developments worldwide that affect the production and use of natural rubber and to use them as a basis for formulating policies to guide the World Bank's lending for the production of natural rubber in the next few years. The analysis in this paper builds heavily on other studies, both inside as well as outside the Bank. In particular, the paper relies on the comprehensive study of the rubber industry prepared jointly by the World Bank and the Food and Agricultural Organization of the United Nations (FAO).[3] Several background papers were prepared, in addition, by the Bank's staff and outside consultants.

The World Bank/FAO study focused largely on the impact of the fourfold increase in the world prices of crude oil on the rubber industry in the 1973-77 period. The study concluded that the sharp increase in oil prices had significantly improved the competitive position of natural rubber (NR) against synthetic rubber (SR) and had established a solid base for accelerating investment in the NR industry. The study emphasized the existence of a gap between production technologies for NR and the practices that are actually used in the industry and stressed the need for measures that would accelerate the adoption of improved techniques by rubber producers.

In terms of the Bank's operations, the study recommended that consideration be given to support measures that would: (i) speed up current replanting and rehabilitation of rubber plantings in Indonesia, Nigeria, and Sri Lanka; (ii) explore the feasibility of accelerating investment in newly planted rubber in Brazil, India, the Philippines, and countries in the Western Africa region; and (iii) determine the feasibility of increasing the use of chemical stimulants to improve yields, a measure that promises gains in production in the short term.

While these recommendations remain generally valid, developments that have occurred since the Bank/FAO study was prepared in 1978 provide a further impetus to the recommendations made regarding lending by the Bank for NR production. These developments include:

[3]Enzo R. Grilli, Barbara Bennet Agostini, and Maria J.'t Hooft Welvaars, "The World Rubber Economy: Structure, Changes, Prospects." World Bank Staff Occasional Papers, Number 30 (Baltimore: The Johns Hopkins University Press, 1980). The study was first done in 1978 and was revised and published in 1980.

- A large increase in the cost of crude oil. Between 1978 and 1980, the world price of oil rose by 120 percent in nominal terms and 74 percent in real terms; this was in addition to the 400 percent increase during the period 1973-77. The 1978 study, while comparing the profitability of investing in NR and SR in the future, assumed that the real price of oil would remain constant through the mid-1980s. But the Bank, however, currently projects that the price of crude oil will increase, in real terms, at an annual rate of 3.2 percent during the period 1980–90.
- A downward adjustment by the Bank in the projected growth in demand for all elastomers[4] (from more than 5 percent per year in 1977–90 to 4.8 percent in 1980–2000) and a slower growth, from 4 percent to 3.6 percent, in the annual production of both NR and SR during the period 1976–90.
- Near cessation of investment in the production capacity of SR in most developed market economies and reduction in the rates of investment in the centrally planned economies.
- An increase in NR prices averaging, between 1978 and 1980, 47 percent in nominal terms and about 27 percent in real terms.
- An adjustment in the Bank's projected prices for NR in 1990 from about $0.88/kilogram to $1.15. (These prices are expressed in 1977 dollars for ribbed smoked sheets of the highest grade (RSS 1) and is inclusive of cost, insurance, and freight in New York.) The comparable price estimated for NR in 1980 was $1.05 (1977 dollars).
- The recent successful negotiation among rubber producers and consumers of the International Natural Rubber Agreement (INRA).
- Shifts in the type of rubber utilized by industry. This shift has occurred, in part, as a result of the continuing trends worldwide in favor of radial tires for passenger cars. These tires demand large quantities of NR, although this demand is offset to some extent by their longer useful life.
- A steady economic growth and a structural transformation in the rural economies of several rubber-producing countries, particularly Malaysia. These factors have resulted in scarcities of rural labor and have slowed, or caused

[4]The term "elastomer" implies both natural and synthetic rubbers.

stagnation in, the production of rubber by smallholders.

- In several countries, rubber has been replanted at rates that are significantly below targets. The replanting does not even maintain the present levels of the tapped area.
- Technological improvements being incorporated by the NR industry at a faster pace than by smallholders in the field.

The Rubber Industry in Perspective

The implications of these developments for the Bank's operations can be understood more clearly if some perspective of the rubber industry is provided. About 70 percent of the 12.7 million metric tons of rubber produced in 1979 was SR[5] while the remainder was NR.[6] Since the beginning of commercial production of SR in the mid-1940s, improvements in the processing technology, low-cost feedstocks, and economies of scale have steadily reduced the cost of producing SR and have eroded NR's share of the rubber market. Recent evidence suggests that NR's share has stabilized and may be expanding slightly on a global basis. About 60 percent of SR production occurs in the United States, Japan, and the European Economic Community; much of this capacity is integrated backward to petrochemical feedstock supplies and forward to the manufac-

[5]Numerous types of SR are produced. The general-purpose rubbers, in addition to NR, include styrene butadiene (SBR), poly butadiene (BR), and polyisophrene (IR). Among the specialty rubbers are ethylene-propylene (EPM-EPDM), polychlorophene (CR), nitrile (NBR), and butyl rubber (IIR). The three general-purpose synthetics account for about 80 percent of total SR usage, with SBR alone making up more than 60 percent of SR consumption.

[6]At present, virtually all commercial production of natural rubber comes from the rubber tree *(Hevea brasiliensis)*. The guayule shrub *(Parthenium argentatum)* produces a similar material; in 1910, it accounted for 10 percent of the world's natural rubber production. A particular attraction of guayule is its ability to produce a crop in areas that have low, erratic rainfall, wide variations in the annual temperature, and soils of limited fertility. These factors make this plant technically more suitable over a much wider geographical area than the hevea. But because guayule rubber yields (500–600 kg/ha/year) under the best (irrigated) conditions are less than a third of those realized in hevea plantings under good management (1,800–2,000 kg/ha/year on estates in Malaysia), guayule generally is much less attractive economically than hevea. While the genetic potential of guayule may warrant additional research on this crop, this paper assumes that guayule rubber will not account for a significant portion of world NR output in the foreseeable future.

ture of tires. It is widely believed that reductions in the costs of SR production stemming from improvements in the processing technology and economies of scale have largely run their course.

Among NR producers, three countries account for about 80 percent of the world's output: Malaysia (43 percent), Indonesia (24 percent), and Thailand (12 percent). Another 12 percent is produced by India, Liberia, Nigeria, and Sri Lanka, while the balance is accounted for by small producers in West Africa and Latin America.[7] Of the 6.9 million hectares under rubber worldwide in 1978, more than three-quarters was cultivated by smallholders, while the balance was produced in the estates (see Annex 1).[8] While data on the smallholdings are frequently deficient, this group of rubber producers may constitute some 1.5 million production units, and the NR industry, in total, may directly support as many as 12 million people. In Thailand, virtually all of the rubber is grown in smallholdings; in Indonesia, the proportion is about 80 percent; in Malaysia, 65 percent; and in Sri Lanka, more than 50 percent. Since the yields on estates are higher per hectare than among smallholders, the proportion of rubber produced on estates is greater than these percentges would indicate. The gross value of NR produced exceeds $4.5 billion annually and almost all of the output is traded. Malaysia accounts for about 50 percent of the world's exports, Indonesia more than 25 percent, Thailand more than 10 percent, and Sri Lanka about 5 percent.

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[7]As the original home of the rubber tree, Brazil deserves special mention. Rubber from wild groves of *Hevea brasiliensis* was first exploited there more than a century ago. Largely because of South American leaf blight disease, production of natural rubber in Brazil has declined rapidly to less than 1 percent of the world total today. Brazilian development programs for natural rubber, initiated in 1972, have steadily extended the planted area in recent years to about 75,000 hectares at present. Yields remain low by international standards, but progress is reported in dealing with the leaf blight problem. Continued new planting at a rate of 20,000 hectares to 25,000 hectares annually is planned over the next decade. Realization of these targets, say Brazilian authorities, would result in the production of over 100,000 tons of natural rubber by 1990. This would be equivalent to about one-third of the total consumption of elastomers in Brazil today, most of which is synthetic rubber.

[8]A smallholding is defined in Indonesia as a production unit of less than 25 hectares, in India of less than 20 hectares, and in Sri Lanka of less than 4 hectares. But this term usually refers to individual holdings of less than 40 hectares, although the majority are of less than 5 hectares.

Some 50 percent of the total consumption of elastomers goes into tires and another 15 percent is accounted for by other automotive uses. The choice of the type of rubber that is to be utilized in manufacturing various products is determined largely by technical factors (performance needs of the end product), economic considerations (costs of producing the rubber), and market-related considerations (availability of raw materials, stability of prices, services by suppliers, and so forth). While there is a significant degree of substitutability between NR and SR, NR is the preferred elastomer in uses where resistance to building up of heat, resistance to cracking, tensility, and adhesion to metal surfaces are important requirements. Thus, NR is better suited for use in tires of airplanes and other heavy equipment, radial tires for automobiles, latex products, and adhesives. A general view is that NR is *technically* suited for as much as 70 percent of the total market for elastomers, although some of the nontechnical factors noted earlier—relative prices and dependability of supplies in particular—may reduce the potential share of NR to less than 50 percent. These figures can be compared with the 30 percent market share that NR now holds.

Producers of natural rubber are essentially price takers in the world elastomer market where prices are largely determined by the costs of producing the more important synthetic rubbers. Because of the considerable range of substitutability with SR, the demand for NR reacts strongly and positively to changes in the price of synthetic rubber. The demand for NR is also moderately responsive to changes in income in importing countries (income elasticities range between 0.6 and 0.8), although this degree of response continues to fall. The considerable volatility in the prices of NR reflects, in part, the relatively low response of NR supplies to changes in price in the short term (elasticities of supply are in the order of 0.1 to 0.2).

The International Natural Rubber Agreement (INRA) is intended to stabilize world prices in a range of about $0.70 to $1.25 (current dollars) per kilogram through the operation of a buffer stock of as much as 550,000 tons. The *reference price,* which relates to a mix of commonly traded rubbers priced free on board in Malaysia/Singapore, has initially been set at $2.10 in Malaysian ringgits, or Singapore dollars, per kilogram (about 90 US cents). But this price is to be revised automatically on the basis of trends in the market, or as a result of net changes in the buffer stock. A *market indicator price,* which is 15 percent above (or below) the reference price, is termed the upper (or lower) *intervention price* and represents the price above (or below) which the buffer stock manager *may* sell (or buy) rubber to encourage price stability. When the market indicator price moves 20 percent above (or below) the reference price, the manager *must* sell (or buy) rubber for purposes of stabilization.

To become fully operational, the Agreement must be ratified by governments of countries that account for at least 80 percent of the net exports and imports.[9] The normal buffer stock of 400,000 tons and a contingency stock of 150,000 tons are to be built up as market conditions permit and are to be financed by contributions from members that are based on the voting rights determined by the relative importance of members in the world market for natural rubber. The basic objective of the Agreement is to reduce the magnitude of fluctuations in prices in the short term, while permitting the orderly evolution of price movements in the longer term. The market prices for NR in 1980 exceeded the reference price by more than 50 percent. Since that time, prices for NR have fallen moderately and sizable supplies have been purchased under the terms of the Agreement.

[9]The Agreement was ratified in April 1982.

Chapter 2: The World Bank's Lending for Natural Rubber

In the period fiscal 1971–80, the World Bank[10] assisted in the financing of twenty-three projects that had components related to rubber development (see Annex 6). The total cost of these projects was $1.53 billion (in current dollars) and the costs of the rubber components amounted to $1.06 billion. The Bank's lending for rubber showed a sharp upward trend during this period, reflecting, in particular, the growth of operations in Indonesia. Sizable amounts of funds were also lent to Cameroon, Malaysia, and Thailand between 1976–80. Typically, the Bank provided about 50 percent of the total cost of the project. About 70 percent of this lending went to countries in the East Asia region, followed by Western Africa (16 percent) and, to a lesser extent, South Asia (7 percent). The components of projects that were financed included the rehabilitation of established rubber, new planting and replanting, improved extension, rubber processing, and research.

The performance of these projects has been mixed. Among the older projects for which disbursements have been completed, or are nearing completion, the major objectives that were set when the projects were designed have been achieved. In the case of some of the more recent projects, particularly those in Western Africa, implementation has been hindered by higher-than-expected costs of developing land as well as the high costs of labor. The replanting program in Thailand, however, is making good progress and could well be emulated elsewhere in terms of its approach, organizational structure, and government support. In Malaysia, the Bank's support for the development of rubber has been limited in recent years by the competition for the use of land from oil palm by smallholders (making the transfer of technology for such small farms difficult) and by scarcity of labor in some areas. The larger projects in Indonesia are newer, and thus complete results are not yet available. However, the slow disbursement of funds in some projects reflects a scarcity of qualified staff for implementing projects; this problem is being tackled in the case of the Bank-supported rubber project in Indonesia. The Indonesian government's

[10]References to The World Bank also include the International Development Association. The fiscal year of the two institutions runs from July 1 to June 30. A billion equals 1,000 million.

efforts to assist the rubber sector also appears to have been hampered by the excessive diffusion of responsibilities among various government agencies.

The World Bank's experience in these projects has demonstrated the importance of:

- Adequate financial incentives to replant and to adopt improved technologies;
- Good distribution systems to provide improved planting materials and other inputs;
- Strong support from the government and well-focused programs for replanting rubber;
- Adequate measures to meet the farmers' subsistence needs during the phase when the rubber plants are immature;
- Effective maintenance and good weed control during this phase; and
- Good arrangements for the collection and marketing of rubber.

A fundamental difficulty that has been experienced in some Bank-supported projects is the reluctance of smallholders to use the full range of inputs available, especially during the period when the rubber is immature; this use is required to obtain satisfactory yields.

Chapter 3: Issues Related to the Future Development of Rubber

The outlook for world demand for rubber has been outlined in detail in *The World Rubber Economy*.[11] During the next fifteen years, the demand for rubber will continue to be shaped largely by the growth in the world's automotive industry, which accounts for about 65 percent of the total use of elastomers. In the developed market economies, where motorization has already reached high levels and the conservation of energy is an important government objective—these factors have an impact on the mode of transportation, size of vehicles, and so forth—the growth in the production and use of motor vehicles in the future is likely to be slower than in the past. Among most centrally planned economies, the impact of higher prices for energy and conservation measures may be considerably less, since, at present, fewer vehicles are owned and used and the demand for motorized transport continues to be strong. Among the poorer developing countries, public transportation will continue to be stressed, thus restraining the growth of the automotive sector.

The demand for nontire rubber is expected to continue to grow, however, in all major consuming areas in rough parallel to the growth in real income or in industrial production. Taking all of these factors together, the Bank estimates that the demand for all elastomers will grow annually by about 4.8 percent in the period 1980–2000, or to about 33.5 million metric tons by the end of this century. The average of 4.8 percent is based on a growth of 6.7 percent in the developing countries, 4 percent in the developed market economies, and 5.5 percent in the centrally planned economies.

A key issue that will arise in the future is the share of the total rubber market between NR and SR. As noted earlier, factors other than the cost of production are important in this regard, although the cost of producing synthetic rubber is likely to be a dominant determinant of market shares over the longer term. A basic thesis of this paper is that the steady increases over the years in the real costs of crude oil and natural gas have improved NR's competitiveness even further from the position outlined in

[11] See especially pp. 76–91 of this Bank/FAO study.

the Bank/FAO study.[12] The increases in petroleum prices that have been projected can be expected to enhance further the competitiveness of NR against SR. The key factor that underlines this assessment is that the petroleum-based inputs, such as chemical feedstocks and energy, are much more important in the cost structure of SR than in NR. The Bank/FAO study indicates that as much as 70 percent of the cost of producing SR consists of petroleum-based feedstocks and energy inputs, such as steam and electricity; the prices of these items are closely related to the prices of oil and gas. In contrast, petroleum-based energy inputs account for only about 15 percent of the total cost of producing NR from existing trees.

The effect of increases in the costs of petroleum products is perhaps best seen in the case of styrene butadiene (SBR), the cheapest and the most widely used of the synthetic rubbers. The most important determinant of the profitability of investment in SBR capacity is the price of crude oil. In 1973, that part of the cost of feedstocks and utilities that was related directly to crude oil prices represented about 16 percent of the total supply price of SBR (at a 10 percent discount rate).[13] By 1977, this proportion had risen to about 30 percent. Given the increase of 74 percent in the real costs of crude oil during 1978–80, this proportion is significantly higher today. Roughly calculated, each increase of 3 percent in the price of crude oil requires a 1 percent increase in the price of SBR to maintain its profitability. In other words, an increase of $1/barrel in the real price of crude raises the cost of producing SBR by about 2 US cents/kg. The future competitive position of SR *vis-à-vis* NR in the United States may deteriorate even more rapidly than, say, in Western Europe, as the lifting of US price controls on petroleum products leads to relatively more rapid increases in the cost of producing SR for US producers.

The relationships among crude oil, NR, and SR can also be explained in physical terms. It has been estimated that a half

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[12]The 1978 study had assumed that the price of crude oil, in real terms, would remain constant during the mid-1980s. But the Bank has currently projected that the real price would actually increase at an annual rate of 3.2 percent during the period 1980–90.

[13]The unit costs of production are assumed to approximate the concept of "full supply price" in the Bank/FAO study, that is, the unit of value which, if received over the lifetime of the plant, would equate the present value of all expenditures to the present value of all receipts, both discounted at the opportunity cost of capital.

ton of crude oil is required to produce 1 ton of NR. In contrast, 3.5 tons of crude oil are required to produce 1 ton of SBR and 5.5 tons of crude for 1 ton of polyisophrene.[14]

In NR production, the cost of labor may represent up to 55 percent of the total cost; the cost of tapping accounts for about half of all labor charges. The importance of labor in NR production can be seen from the data available from Malaysia that indicate that between 1970–74, the cost of producing rubber on estates rose by an estimated 44 percent, largely due to an increase of 45 percent in rural wages. The implications from this data for the future development of NR are clear: In a tight rural labor market, the strategy should stress technologies that save labor; in particular, emphasis should be placed on measures that could reduce the use of labor in tapping. In rubber-producing countries such as Malaysia, which have growing scarcities of rural labor, production may not expand unless there is a breakthrough in tapping technology, or unless the prices of NR rise more rapidly than the increases in the cost of labor.

The competitive position of NR against SR seems likely to continue to improve as the prices of petroleum products rise in real terms. The extent of that increase, however, is conjectural. If the Bank's currently projected real increase of crude oil prices of 3.2 percent a year is realized throughout the 1980–90 decade—to a price of about $27.40/barrel in 1977 dollars, or $82/barrel in 1990 dollars—the cost of producing SBR by the end of the period would be some 10 percent to 12 percent greater in real terms than in 1980. The future costs of producing NR are influenced to a large extent by the success of putting into widespread practice the reservoir of yield-augmenting, labor-saving technologies that are now available. Given these technologies, the possibilties of limiting the increases in the cost, in real terms, of producing NR appear to be much better than in the case of SR, where the gains from improvements in production technology and economies of scale have largely been exhausted.

In a world elastomer market dominated by SR, the potential market for NR will be determined largely by the growth in the capacity for production of SR. This capacity grew at about 9 percent annually in the 1960s but slowed to 5.6 percent during 1970–78. Among the developed market economies, the capacity

[14]See "Rubber Trends" in Economist Intelligence Unit, No. 70 (London: The Economist, June 1976).

of SR grew by only 1.6 percent a year during 1976–80. The growth in the capacity of other SR-producing countries—most by centrally planned economies, which account for about 40 percent of the total production—was somewhat more rapid. Among developed countries, increases in the costs of capital, uncertainty over the future costs of feedstocks, and concerns over the impact of producing rubber on the environment appear to be important factors that constrain new investment. In these countries, no significant increase in SR capacity is likely to be made in the next three to five years. The investment in SR capacity elsewhere may be expected to move in parallel with the growth of the elastomer market in those countries. The production of synthetic rubber in the oil-exporting Middle Eastern countries is not expected to begin, on a significant scale, until the mid-1980s.

The projections that have been made regarding the global supply of SR are highly speculative. If the supply were to increase annually by 3.2 percent,[15] and if the demand for elastomers were to expand by 4.8 percent, as projected by the Bank, the potential market for NR in the year 2000 would approach 16.8 million tons. This is equivalent to the NR market expanding by more than 7 percent each year, a rate that clearly exceeds the estimates of increase in supply over the medium term. Nevertheless, other scenarios could be suggested. If, for example, SR production were to expand annually by 5 percent, the potential market for NR would grow by 4.3 percent annually.[16] While these figures are merely illustrative, they clearly suggest, nevertheless, that growth rates for SR production lower than those of the past two decades would open large new markets for NR.

The output of NR can be estimated somewhat more closely on the basis of the area currently planted to rubber, the trends in the yields of the plant, and the technology that is available for production. However, the uncertain response of producers, particularly smallholders, to changes in NR prices adds a speculative element to these figures. The Bank projects the output of NR to grow at an annual rate of 3.6 percent during the period 1977–90; this figure is heavily influenced by the

[15]Consistent with growth in SR capacity of about 2 percent a year in the developed market economies and 5 percent elsewhere.

[16]This assumes the same annual growth in the demand for elastomers of 4.8 percent.

growth of 3.4 percent a year projected for Malaysia. The evidence from Malaysia, however, suggests that rubber production in that country is now growing at a rate that is considerably slower than 3.4 percent and may, in fact, be nearing a plateau among smallholders.[17] In Malaysia, the growth in output during the decade, 1981–90, of something less than 3.4 percent would not be surprising. Unofficial estimates made recently by the Bank suggest that the production of rubber may expand annually by about 5 percent in Thailand and by 1.1 percent in Indonesia through the year 1990.[18] In such a case, to achieve the 3.6 percent annual growth rate, overall—even with expansion by 3.4 percent a year in Malaysia—would require an expansion in the production of over 6 percent annually among the remaining smaller producing countries that account for the balance (about 21 percent) of the world's NR output. A growth in production of 6 percent among these countries is unlikely. If this assessment of market opportunities proves correct, it is clear that a shortfall of NR will emerge through 1990.

Economics of Rubber and Alternative Tree Crops

The extent of future investments in rubber, either in replanting or new planting, will be determined, in large part, by the perceptions of landowners as to the relative profitability of rubber and alternative crops. The most likely alternatives to rubber among tree crops are oil palm and coconut intercropped with cocoa. But even among these tree crops, differences in the requirements of soil and climate sharply limit the range of substitution in any particular area. NR, in contrast, is adaptable to a wider range of soil and climatic conditions and is

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[17]There are several factors affecting the development of Malaysia's rubber smallholders. The production is slowing as some farmers change over to other crops or take up off-farm employment. An important disincentive to proper maintenance and continued tapping is the high level of taxation. Despite some recent downward adjustment, taxes are equivalent to about half of the net return from rubber for a typical smallholder family. For other tree crops, taxes are lower in the case of oil palm or almost nonexistent as in the case of cocoa. Nearly half of all rubber smallholdings are less than 0.8 hectares in size, a factor that discourages replanting because low-income owners cannot afford to forego the income derived from the overaged planting. Among the measures that can be taken to assist Malaysia's smallholders are: (i) fiscal adjustments to increase the farmgate price of rubber; (ii) an increase in the grant for replanting, particularly for smallholders with holdings of 1.2 hectares or less; and (iii) efforts to enlarge uneconomic holdings.

[18]These estimates are preliminary in nature.

suitable to various systems of production and harvesting. Rubber has the potential to produce acceptable returns from soils of limited fertility in areas of sloping topography—that is, areas that would not generally support sustained cropping of annual food crops. Rubber, generally, performs better than oil palm and coconut on this sort of land, which is increasingly becoming typical of the new land that will have to be brought into production in response to expansion of the rural populations.

Rubber is particularly well suited among tree crops to cultivation by smallholders. The tapping of rubber generally provides year-round employment, but the system, nevertheless, can be adapted to meet the seasonal labor demands of other crops. The processing of rubber on the farm is simple, and the relatively high value-to-weight relationship for finished rubber permits it to bear the high cost of transportation that is typical in new agricultural areas. After simple processing, the rate of deterioration of rubber is much lower than, for example, that of oil palm fruits. Oil palm and coconut intercropped with cocoa, in contrast, are much more demanding in terms of soils, climate, and topography. To process the oil palm efficiently also requires carefully regulated harvesting systems, reliable supplies of fresh fruit bunches, and a relatively large investment in processing facilities. For oil palm to be processed efficiently, a planting area of no less than about 4,000 hectares is required.

These considerations suggest that other tree crops can substitute for natural rubber fully only over a relatively narrow range of climate, soils, and production/processing systems. This point deserves emphasis. In the limited circumstances in which all the three major tree crops (oil palm, coconut or cocoa, and rubber) can be grown, a benefit-cost analysis now tends to favor coconut/cocoa and oil palm over rubber (see Annex 1). In many areas that have less favorable soils and climate, rubber is likely to be the best performer in economic terms; this is probably true, for example, in large areas of Indonesia.

The relative attractiveness of future investment in alternative tree crops will depend, in part, on prices for their products. The Bank's projections through 1990 suggest that prices for rubber, in real terms, will continue to rise *vis-à-vis* prices for products of the other major tree crops. If the prices for petroleum continue to rise, in real terms, beyond 1990, the prices for natural rubber can also be expected to increase. A meaningful analysis of economic returns to investment in alternative tree crops

—wherever they all can be grown—can be done only on the basis of specific locations; their results cannot be used to generalize across other countries.

Research, Extension, and the Productivity Gap

Research in NR has had a relatively short but illustrious history. Rubber yields, under good commercial practice, have increased more than threefold over the past fifty years. These gains in productivity have been sufficiently widespread to allow NR to withstand market pressures exerted by SR prices that have fallen fairly steadily over much of the past three decades. High-yielding materials are now available for commercial planting that are capable of yielding 3,000 kilograms per hectare under optimum growing conditions; this figure compares very favorably with the current yields in the world, averaging about 550 kilograms per planted hectare. There are in operation eleven national rubber research institutes and six research stations maintained by plantation interests in the private sector. More than three-fourths of all expenditures in NR research are incurred in Malaysia, mostly by the Rubber Research Institute (RRIM). But some important research is also undertaken by private estate groups in that country.

The most notable among the research activities in recent years include:

- *The development of advanced planting materials.* The use of budded stumps or planting materials in polybags has reduced the immature period of rubber by approximately twelve months; it is now about five years under best practice.
- *Chemical stimulation of yields.* The application of special chemicals to the bark of mature trees increases yields from particular tapping systems or maintains yields with reduced tapping intensities. Both approaches have been found to result, generally, in higher net returns per unit area. The stimulation of yields, which is now commonly recommended by national research and extension systems, offers the possibility of significant increases in yields if the stimulation is accompanied by proper tapping, weeding, and fertilization.
- *New tapping techniques.* Some of the tapping systems that are being developed are quite novel; they offer prospects of tapping the tree at an earlier age and of requiring less

labor. Because the cost of tapping is the largest single element in the total cost of production, these systems are particularly promising in areas that are short of labor. However, additional research is necessary to determine longer-term effects of these techniques on production, incidence of diseases, and so forth.

- *Rubber processing.* The development of technically specified NRs and group-processing centers offers opportunities to upgrade the low-quality rubber that is frequently produced by smallholders. Upgrading provides consumers a standardized, high-quality product that is more comparable to the uniform product offered by SR producers. Growing emphasis by consumers on clean, high-quality NRs makes it important to continue efforts at improving rubber processing.
- *Intercropping of immature plantings.* Work in Indonesia, Malaysia, Sri Lanka, and Thailand has confirmed that in satisfactory terrains and with good cultural practices, food crops or cash crops can be intercropped with rubber to provide the food or cash that is required to subsist during the period the rubber plant is immature. The intercropping can be carried out during the first one year to three years after tree planting, without adversely affecting the rubber plant. An important consideration, of course, is the availability of ready markets for surplus food or cash crops.

Despite these advances in rubber research, the gaps continue to be large between the results at experimental stations and those on the commercial fields and between the productivity on the estates and among the smallholders. These differences may well be widening. In Malaysia, where production techniques are the most advanced among NR producers, the average yields on estates are, perhaps, only 65 percent of the yields that can be realized from commercially proven planting materials and good cultural practices. In Indonesia, the average yields are about half as large as those in neighboring Malaysia. Among many rubber-producing countries, the average yields among smallholders are, perhaps, 40 percent of the levels that can be attained with improved planting materials and good management. The growing of rubber by smallholders is somewhat unique among agricultural production systems in developing countries in the sense that yields are invariably lower than those realized in large-scale operations, such as the estates. A major reason for such a gap is the extensive use of unimproved planting materials by smallholders.

An example may illustrate some of the reasons for the gap between actual and recommended practice. In Malaysia, the RRIM recommends the use of chemical stimulants on a commercial scale for all trees that are at least fifteen years of age. While this recommendation has normally been practiced on most estates in Malaysia since 1970, fewer than 2 percent of the 361,000 hectares of smallholder trees in this age group were so treated in 1977. The poor response from smallholders is explained, in part, by their frequent inability to pay for the additional inputs, such as fertilizer, that are required to make the use of stimulants successful. The aversion of many smallholders to taking risk may also explain their reluctance to adopt improved technologies. Again, the evidence from Malaysia suggests that the most rapidly adopted technologies are those that require little or no cash or provide incremental returns that are two times to three times greater than the cost of these technologies. There are some types of technologies that need only limited cash and these include improved planting material, more vigorous root stocks (of particular importance in lands of limited fertility), and improved planting and tapping practices. Technologies that require significant cash outlays include the use of stimulants, fertilizers, and herbicides.

The global research effort in NR has not been adequate to meet the needs of all producers; it has concentrated in Malaysia and the production problems outside of that country have, in general, not been looked into systematically. Research has tended to be directed more to the needs of estates than of smallholders; this is indicated by the limited amount of work done on intercropping, on weeding and pest control with the use of inputs, and on the development of clones that respond well to the high-intensity or periodic tapping systems practiced by many smallholders. The important areas in which research is needed are:

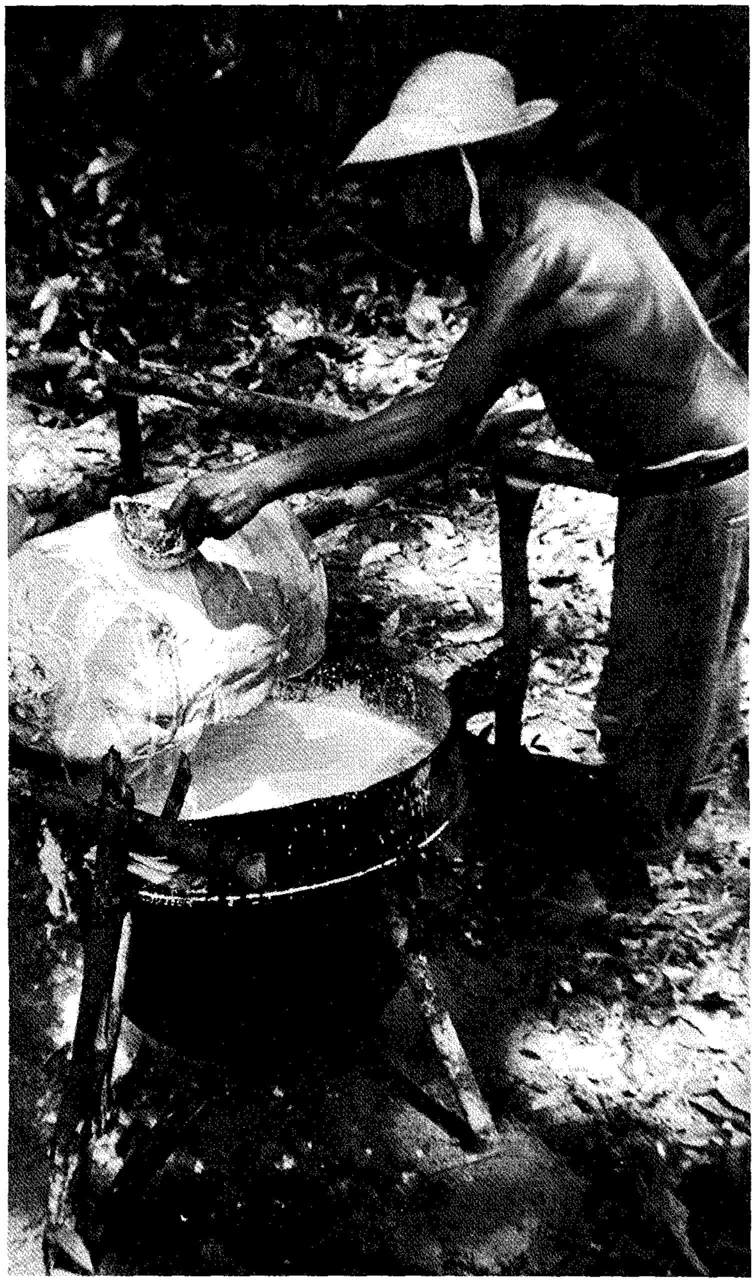
- *Plant breeding.* A majority of national programs for rubber breeding is restricted by a narrow genetic base. To improve the yields and the resistance to diseases requires systematic expansion of this resource base and a clearer understanding of the hereditability of the factors that endow planting materials with desirable economic characteristics. Effective selection of improved planting materials requires consideration of both genetic and economic factors.

NATURAL RUBBER—in pictures

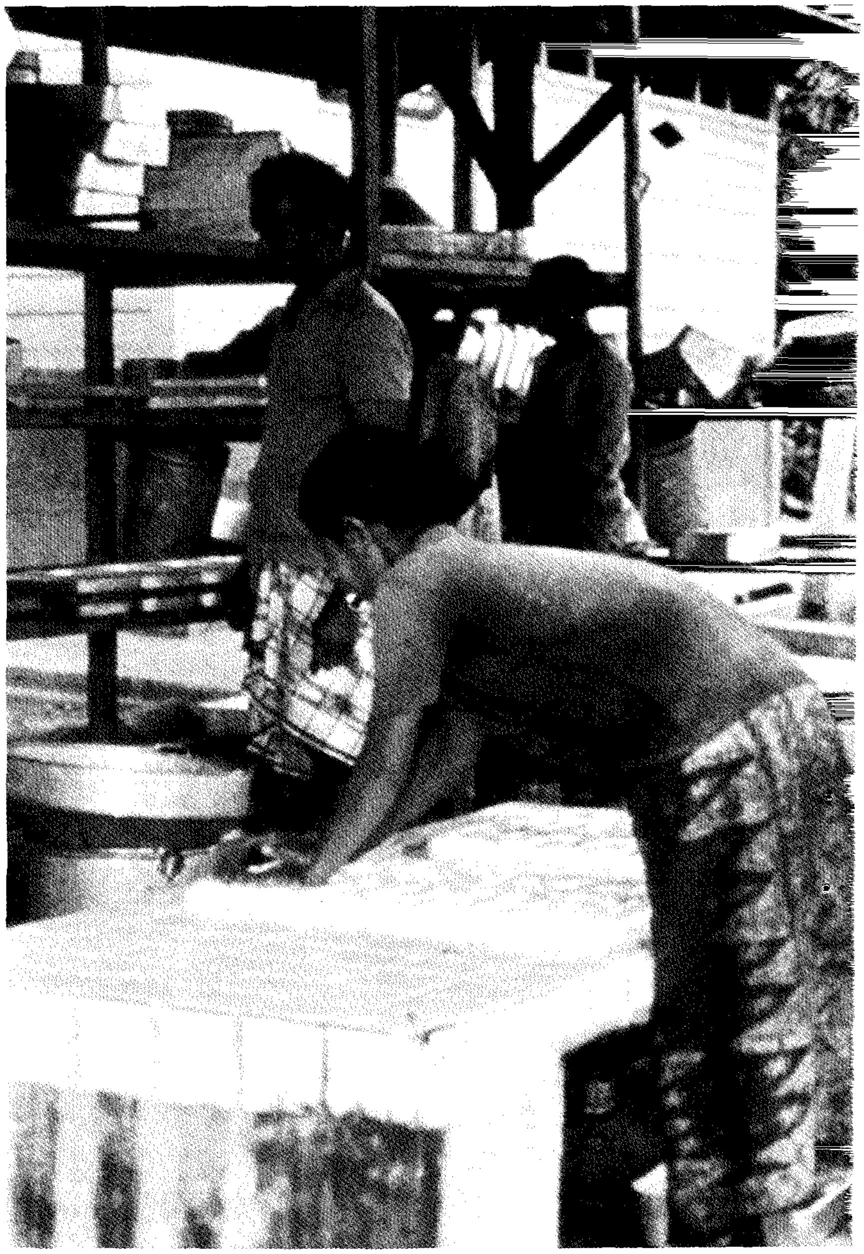
A *seringueiro*, or rubber gatherer, is a study of concentration as he taps a weathered rubber tree for latex. He makes a spiral cut as opposed to the crude fishscale wound left by those who bled this tree for its milky sap many years before in the Amazon. Brazil today produces less than 1 percent of the world's natural rubber. ❶

Soil-filled polyethylene bags are placed in orderly rows in North Sumatra, Indonesia. Bud-grafted tree stumps put into these bags will eventually be transplanted to another field where they will produce rubber in five years. 2

Root stock for rubber trees is dipped in fungicide before planting at a rubber estate in Niete, Cameroon. The World Bank provided a credit of $16 million to plant 5,800 hectares of rubber at this estate. 3



A rubber gatherer coagulates latex into a rubber ball over fire. Trees growing wild in the Amazon jungle provide bulk of the natural rubber Brazil produces annually. ❹



At a smallholders' development center in Malaysia, rubber farmers process their rubber into sheets of dry rubber. There is need for additional research on technologies suitable to the typical production system employed by smallholders.

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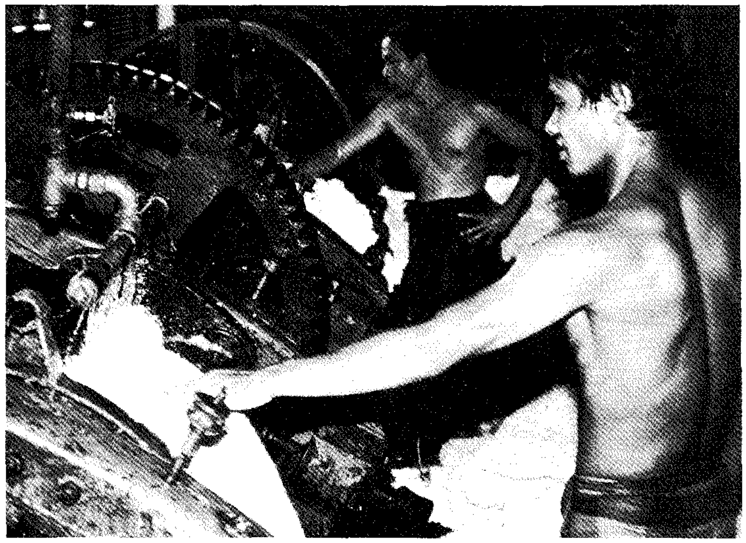


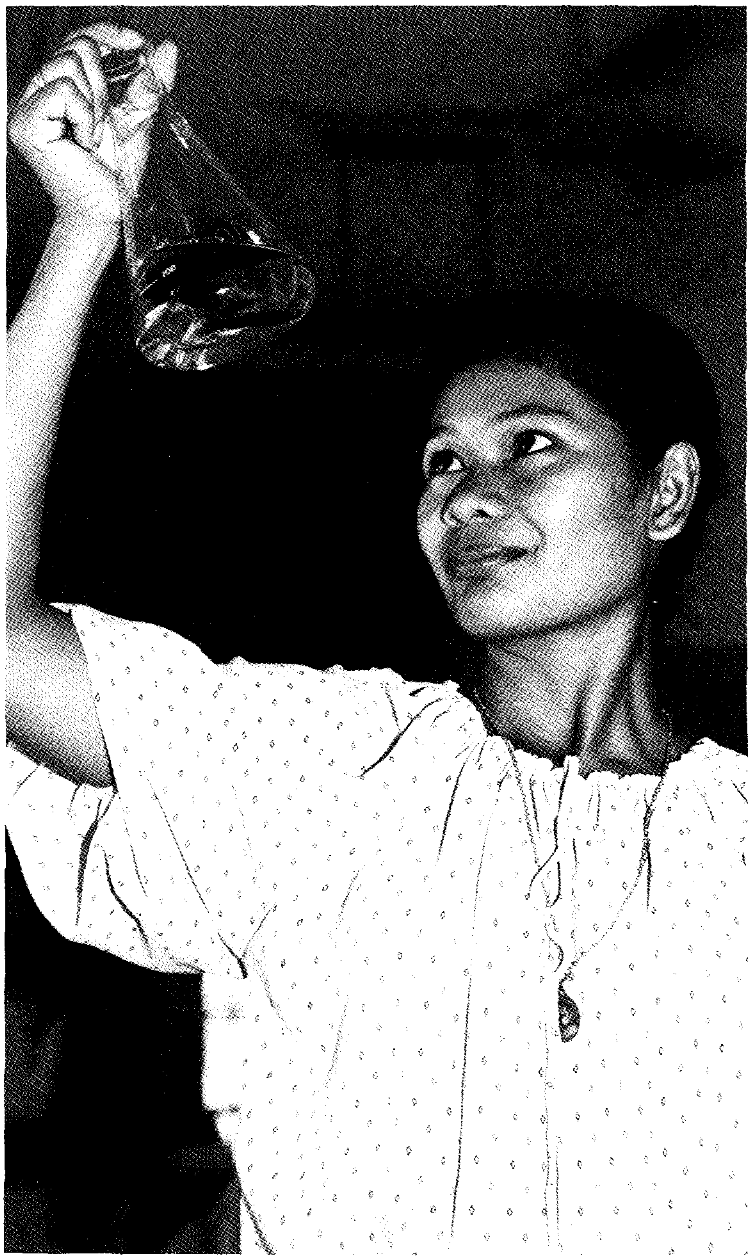
Latex being processed at a rubber estate in southern Thailand. Thailand is the world's third largest rubber producer after Malaysia and Indonesia. The World Bank has provided $50 million to assist rubber replantings in the country. 6

Rubber sheets hung on a trolley to be dried and smoked; they are compressed into bales for export. The growing global market for radial tires and other rubber products emphasizes the need to improve the quality of sheet that smallholders produce. 7

Rubber sheets made of natural rubber are inspected at a privately run rubber estate in Indonesia. A bigger role is warranted for the private sector, particularly in providing managerial services needed tor distribution of inputs.

A metal plate is used to mark a rubber tree for tapping in Sumatra, Indonesia. The marks enable the tapper to always cut the tree's bark in the same direction. The World Bank is expanding support for Indonesia's nucleus estate and smallholder program. 9

A tractor-pulled fog maker leaves a cloudy cover of oil-based fungicide to protect rubber trees from South American leaf blight near Belem, Brazil. Progress is reported in dealing with this problem that had caused rapid decline in rubber production in the past. 10



Testing the quality of latex in a laboratory in Thailand. The growing demand by consumers for clean, high-quality natural rubber makes it necessary to continue efforts at upgrading the low-quality rubber that is frequently produced by smallholders.

- *Disease control.* While the most important progress is likely to come through breeding and the development of resistant clones, improvements in agronomic practices and new chemical-control and biological-control techniques will also play a part in reducing losses in production arising from diseases. Improved, cost-effective means are needed, in particular, to control the South American leaf blight that has been a major constraint to a rapid expansion of rubber production in Brazil.
- *Propagation techniques.* Much of the variability in the planting material can be attributed to the heterogeneity of the seedling rootstocks. By developing improved rootstocks or, alternatively, by propagating the best clones using tissue-culture techniques, the need for seedling material could be dispensed with and the yields could increase substantially.
- *Exploitation systems.* Until recently, the availability and cost of labor have not been major constraints to the expansion of natural rubber production. Now, with increases in real wages and expectations of higher standards of living in major rubber-producing countries, there is a need to focus on measures that will increase the productivity of labor. Research into new methods of tapping that require less labor is taking place. By making greater use of chemical stimulants to promote the flow of latex, these methods would help to expand the output per worker. However, the technical problems are complex. So far, no fully satisfactory alternatives to long-established, conventional tapping methods have been developed to the stage at which large-scale application on a commercial basis can be recommended.

It would be useful to strengthen the national research programs and to expand efforts to facilitate the international exchange of scientists, research results, and planting materials. Over the medium term to longer term, the effectiveness of the NR research effort will determine the industry's ability to meet future requirements of the market. An internationally funded tree-crops research effort, covering rubber, oil palm, cocoa, and coconut, may also merit consideration.

The extension services that are provided to smallholders are typically understaffed and ineffective. In Indonesia, in 1978, there were fewer than 900 extension workers in the field and 70 extension specialists for estate crops. Only about 25 percent of these specialists dealt with rubber; many of these were preoccupied with administrative tasks. In Indonesia and elsewhere, the task of disseminating information of improved technologies has proved to be very difficult among individual rubber smallholders outside of the centrally managed development projects such as those in Malaysia.[19] For individual smallholders, new approaches to extension are required that economize on scarce technical staff. The Training and Visit System may be useful, although there is little experience, to date, with this approach in tree-crop agriculture.[20] One approach that has been tried with considerable success in some producing countries has been to establish smallholders around nucleus estates. These estates provide extension services, sometimes jointly with processing and marketing facilities, on a contractual basis.

Providing adequate extension services to smallholders in groups has been much easier. In Malaysia, evidence from development projects suggests that smallholders are prepared to sacrifice some of their freedoms in operating their individual farms for the enhanced security of, and higher incomes from, FELDA-types of projects. In Malaysia, independent smallholders obtain rubber yields of between 800 kilograms and 1,000 kilograms per hectare per year. In contrast, smallholders in centrally managed development projects, such as the FELDA schemes, typically produce between 1,400 kilograms and 1,600 kilograms, while the production on the estates averages well over 1,600 kilograms per hectare. Apart from FELDA, more than thirty-five group-farming schemes are now operating in Malaysia's smallholder sector, where lagging productivity and growing off-farm employment opportunities are rapidly making the individual rubber smallholding an anachronism. The continuing gap in the yields of the smallholders and estates requires rethinking on the appropriate

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[19]In Malaysia, the Federal Land Development Authority (FELDA) is responsible for developing new lands for rubber, oil palm, and, occasionally, other crops in smallholder settlement under centralized management. Since its establishment in 1958, FELDA has developed more than 500,000 hectares.

[20]The Training and Visit system aims at increasing incomes, mainly of smallholder farmers, through the use of simple techniques of better crop husbandry. These techniques often call for little or no increase in cash inputs. See Daniel Benor and James Q. Harrison, *Agricultural Extension: The Training and Visit System* (Washington: World Bank, 1977).

approach that should be followed to develop rubber. In some circumstances, centralized management systems, in which smallholders continue to retain their identity as production units, appear to have an advantage. Such a system has the potential to accelerate the dissemination of technology by spreading risk and providing the economies of scale in the areas of credit, technical assistance, managerial skills, and modern inputs. These benefits are available readily to estate type of operations. The precise organization for these production systems must be, of course, determined on a country-by-country basis.

Replanting and Rehabilitation

The productive life of a rubber tree is usually assumed to be twenty-five years to thirty years, with replacement at thirty years to thirty-five years.[21] Assuming the economic life of a tree to be just over thirty years, some 3 percent of the total rubber area must be replanted annually to maintain the planted area. Globally, this would mean that about 210,000 hectares would have to be replanted each year, some 60,000 hectares in Malaysia, nearly 70,000 hectares in Indonesia, and about 48,000 hectares in Thailand. The actual replantings in organized programs in these countries appear to have totaled no more than about 85,000 hectares annually in recent years. There may have been planting in additional areas of unknown size each year, usually with unselected seedlings that have genetic potential to produce no more than about 800 kilograms of rubber per hectare. In any case, the total replanting, at present, probably does not exceed 110,000 hectares a year.

At present, only Thailand is replanting at a rate that is required to maintain its stock of rubber trees. The organized replanting on smallholdings in Indonesia totals less than 15,000 hectares annually. Today, nearly 3 million hectares of smallholder rubber—more than half of the world's total smallholder area—appear to be in need of replanting or

[21]These are approximations. In economic terms, the optimum replacement age is that number of years that maximizes the net present value from a planting at an appropriate discount rate and with a particular configuration of output prices, production costs, technology, and annual yields over the production life of the tree. In general, higher product prices lead to an older optimum replacement age. Rapid changes in technology, as reflected in an upward shift of the yield curve, substantially reduce the optimum replacement age.

rehabilitation in these three countries alone. In Indonesia, as many as 1.8 million hectares of unimproved rubber, as yet, have felt little or no effect from the government's extension service. In Thailand, some 700,000 hectares of unimproved rubber are growing in remote areas. In Malaysia, at least 400,000 hectares of old seedling rubber, almost all of the area cultivated by smallholders, remain to be replanted.

Several reasons can be cited for this slow development of the NR industry in recent years. Over much of the past twenty years, the prices for NR have declined, in real terms, thereby reducing the incentives to invest in the industry by governments, smallholders, or estates.[22] Smallholders, in particular, are reluctant to replant because they cannot afford to forego the decline in income when an old, but producing, rubber tree is felled. Onerous export taxes on rubber have further reduced incentives, and inadequate marketing systems have resulted in farmgate prices being low relative to world prices.[23] The government's extension services have not effectively reached many smallholders with information on new, productive technologies. Frequently, improved planting materials have not been made readily available to smallholders for replanting. In some cases, smallholders and, particularly estates, diverted their rubber areas to other crops that proved to be financially attractive. In some countries, employment outside the farm is frequently more attractive financially than income from old, low-yielding rubber.

It was noted earlier that during the next decade NR supplies are likely to fall short of the opportunities in the market place (see page 19). Supplies beyond that time will depend on the efforts that are made at replanting in the near future. The appropriate size of the replanting program must reflect both the opportunities in the market as well as the feasibility of implementing specified replanting programs in particular countries. The market for NR could grow in excess of 4 percent a year in the longer term. Roughly estimated, this growth in

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[22]The price for rubber declined from about $1.65/kg in 1960–64 to $0.92/kg in 1975–79. These prices are in 1977 dollars. However, these prices rose significantly in 1980.

[23]Largely reflecting differences in marketing costs, Indonesia's smallholders realize 35 percent to 40 percent of the rubber price (f.o.b.) as compared with 70 percent for Malaysia's smallholders.

demand for NR could be met from replanting on about 170,000 hectares each year.[24] To achieve this target by 1985 would require a more vigorous development effort than the one undertaken so far in most countries. The underlying annual planting targets necessary for specific countries are considered feasible.[25]

An increased rate of replanting is likely to be a sound approach in most producing countries. However, since the price for NR is expected to remain strong, replacement of trees can be delayed and rehabilitation of existing plantings can be taken up in some areas that have productive but underutilized plantings. By offering incentives, tapping can recommence in these areas; this can be done by establishing group processing facilities, improving access to markets, reducing taxes, or providing financial assistance to clear the undergrowth and to purchase chemical stimulants and fertilizers. These measures may be appropriate to increase rubber production quickly and economically. However, where the productive potential is low—that is to say, the yields are less than about 500 kilograms per hectare—the opportunities for rehabilitating existing trees economically are likely to be limited.

The negative cash flow during the initial period of five years to seven years when the tree is immature can be troublesome for replanting or new planting programs. Cash crops or food crops can be planted during this period to offer additional security to the smallholder. But there are risks, too. Removal of the canopy of old trees could result in soil erosion and serious weed infestation and may reduce the yield potential of the new rubber plantings.

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[24]Replanting on some 170,000 hectares yearly is equivalent to about 2.5 percent of the current planted area. Assume, somewhat optimistically, that the replanted rubber has average yields over the tappable years of the planted tree of up to twice the present average yield worldwide—that is, an increase to something exceeding 1,000 kg/ha. (The average yields in Thailand, which has an ambitious replanting program, are not expected to exceed 800 kg/ha by the year 2000.) Thus, gross growth of rubber output would be about 5 percent a year. Losing one percentage point annually from the felling of old trees would result in a net increase in natural rubber production of about 4 percent a year.

[25]This would include about 50,000 hectares in Thailand, at least 30,000 hectares in Malaysia, 45,000 to 50,000 hectares in Indonesia, up to 25,000 hectares of new planting in Brazil, 7,000 hectares in Nigeria, and the balance (some 12,000 hectares) divided among other producing countries. Further analysis on a country-by-country basis is required to confirm these figures.

Moreover, intercropping is not generally suitable in the jungle areas where new rubber trees have been planted; stumps could exist in between the rows of rubber plants. The objective of the cropping system should be to maximize the present value of net returns for each unit of land over the lifetime of the planting. With intercropping, realization of this objective requires a higher level of management than in monoculture cropping of rubber.

Rubber Processing and Marketing

Because the tire industry accounts for about half of the world's elastomer consumption, the demands of the industry, as reflected in the prices paid, largely determine the type of NR that needs to be produced. The introduction of technically specified natural rubbers (TSNR) in the mid-1960s was motivated, in large part, by the need to be competitive with SR—that is to say, to supply the tire industry with an NR product that was of uniform quality, one that could be made available in several specific grades to meet the particular needs of the industry and in a convenient physical form that could facilitate blending with the SRs. After a rapid growth in the late 1960s and in the early 1970s, the production of TSNR has leveled off in recent years. The general enthusiasm for the product now is somewhat less than it was fifteen years ago. Among the major NR producers, Indonesia is now the leader, with about 65 percent of its output consisting of TSNR. In Malaysia, the TSNRs account for only about 35 percent of the total production while, among the smaller producers, the Ivory Coast requires all its production be made into TSNR.

The slowing of growth in production of TSNR appears to reflect a combination of factors related to demand for the product and the relative costs of producing TSNRs as compared with conventional rubbers. Largely because the control of quality at the point of production has been inadequate, the TSNRs have not always come up to expectations in the manufacture of tires. The major manufacturers continue to buy both rubber sheet and TSNR block rubber in proportions determined by relative prices and requirements of the products. No sharp change in these proportions is evident yet, and none can be predicted. The price differential, which was expected to favor the TSNRs, has varied widely, in fact, over much of the past ten years. While the best grades of TSNR now sell at a premium over comparable grades of ribbed smoked sheets

(RSS 1), lower grades of the TSNRs sell at a slight discount against comparable sheet rubber (RSS 3).

With price premia being so variable, the costs of production become an important factor in determining the types of NR that are economical for use. Compared with sheet rubber, TSNR plants require relatively large volumes of daily throughput to be commercially viable—at least five tons a day and up to one hundred tons. Organizing the supply of raw material in such volume is difficult, particularly among smallholders. Consequently, there is considerable excess capacity in many TSNR plants in both Malaysia and Indonesia. Studies in Malaysia indicate that the costs of production vary widely between old and new TSNR plants—reflecting, of course, the scale of operations—as well as between TSNR plants and those plants producing ribbed smoked sheet or air-dried sheet. The Malaysian data suggest that total costs per kilogram of processing TSNR on estates may be as much as 60 percent higher than the costs of processing NR into ribbed smoked sheet. In the case of smallholders, these cost comparisons of TSNR production were even more unfavorable *vis-à-vis* the traditional sheet rubbers.

The appropriate strategy in the development of processing facilities in these circumstances is one that facilitates a flexibility in the choice of output. The tire industry is increasingly laying emphasis on cleanliness of NR that is supplied. Ideally, producers should be encouraged to sell latex of high quality to central-processing facilities for processing into those NR products that provide the highest net returns. Where the collection of latex from producers is not possible because of inadequate transportation, for example, the preferred alternative is to construct processing facilities that offer flexibility in producing block rubber or high-grade sheet, depending on conditions in the market. The demand for latex, for which uses are fairly narrowly defined, is expected to grow in parallel with general economic expansion in importing countries. The rates of growth of consumption of block or sheet are less predictable. One approach is to construct a factory in which the capacity for sheet or block can be expanded later in response to market conditions. Investment cost and labor factors must be kept in mind, though. Industry sources suggest that the capital cost per unit of output of a plant producing sheet rubber may be greater than the one producing block rubber. On the other hand, the operating costs of block plants are substantially higher, though they require fewer workers than do sheet plants of the same capacity.

In many circumstances, upgrading the quality of air-dried or smoked sheet is among the most effective means to improve the producers' income from rubber in the short-term and the medium-term. Among smallholders, upgrading generally requires access to group processing facilities that can be constructed for less than $5,000 per unit and can be dispersed throughout the rubber-producing areas. These units should be linked to a marketing system that collects the sheet on a regular basis and then grades and prices the products objectively. These processing facilities also provide a convenient focus around which to organize an extension effort in rubber production. Another approach that appears to respond well to the requirements of users is to market technically specified sheet rubbers in standardized polyethylene-wrapped packages.

Organization and Financing for Development

The sound development of the NR industry in a particular country requires a strong commitment by the government. Adequate funds and proper organization are also needed to support research, planning, and direct investment. The most successful models that can be followed by rubber-producing countries appear to be those in which:

- Research is carried out largely by a national research institute, complemented by research groups in the private sector.
- Policymaking for the industry is the responsibility of a central, semiautonomous rubber development authority that is overseen by a government ministry.
- Implementation of national policy is vested largely in a single organization. Such an organization must have the authority to command the resources that are necessary for the task and to delegate responsibility to state-level or provincial-level units that are in direct contact with smallholders and estates.

It is essential that the field-level units have adequate numbers of qualified technical staff who maintain close links with rubber and who are capable of providing training in production and processing technology. Efficient marketing systems frequently involve entities in both the public sector and private sector.

In replanting and new planting of rubber trees, providing production inputs and planting materials in time has proven to be difficult in some countries. But some exceptions do exist. In Thailand, for example, the replanting program has achieved its targets partly because improved planting materials are made readily available through a system in which smallholders and their families are taught the techniques required to propagate these materials. Other production inputs are distributed through a system in which private stockists are involved at the field level. In addition, replanting incentives are maintained by periodically adjusting the replanting grant from government to compensate for increases in the costs of replanting.

A generally successful way by which the costs of rubber research and of administering the programs of replanting and new planting trees has been financed has been through collection of revenues generated by taxes on production or export of rubber. However, care is required to ensure that the taxes that are levied on the rubber industry are equitable *vis-à-vis* producers of other agricultural commodities and that they do not destroy the incentives to produce rubber.

Programs to replant rubber and to plant new trees require relatively small amounts of credit per beneficiary. But these credits need to be extended annually for as many as ten years. The repayment can begin only after the trees begin to produce rubber; if the repayment is linked to the smallholders' ability to pay as determined by the yields, it may extend to over fifteen years. The collection of repayments when individual smallholders market their produce can be difficult because of the producers' isolated locations and the opportunity they may have to sell their output through numerous local rubber traders. The high overhead costs per participant in supervising and collecting credit suggest that, in many circumstances, the credit schemes for replanting or new planting by smallholders are not likely to be cost effective in providing the required resources for investment.

Chapter 4: Policy Recommendations and the Role of The World Bank

The prospects for natural rubber probably are even brighter than indicated in the World Bank/FAO study of 1978 referred to earlier (see page 8). These enhanced prospects stem, in large part, from the increase of 74 percent in the real costs of crude oil between 1978 and 1980, as well as increases in the costs of other related inputs used in the manufacture of SR; these costs are likely to increase steadily over the next decade. A key issue that arises is whether the NR industry can capitalize on the attractive opportunities that seem likely in the market over the next decade and beyond. Although improved technologies are available for the production and processing of NR, and although some other techniques that offer promise are under development, efforts to extend these innovations to smallholders have not been adequate. As a result, the smallholder sector of the industry is producing far below its potential. There are growing shortages of rubber labor in the rural areas of several important rubber-producing countries and in the rubber estates of nearly all of them. These shortages have resulted in rubber going untapped, in holdings not being properly maintained, and in overaged rubber trees not being replaced. The situation in the estates is somewhat better. There is some evidence that private sector estates are now assessing NR prospects more favorably and reconsidering their earlier decisions to shift out of rubber to alternative tree crops.

An active role for the World Bank is warranted in the future development of the natural rubber industry. The Bank's support of this sector has been important in transferring financial resources and in introducing technical and institutional innovations among rubber-producing countries. The technical standards of Bank-supported projects are high and the monetary benefits to participants and the economic gains to borrowing countries are substantial. The Bank's support for the development of NR will be expanded to meet the needs of the producing countries and the opportunities in the market place. The technologies available to the industry are promising. In addition, there is a considerable backlog of needed replanting and there are large numbers of smallholders who have yet to benefit meaningfully from the Bank's or governments' assistance. However, a more specific lending program for natural rubber can be defined only within the context of the Bank's overall lending operations and after uncertainties regarding the future availability of financial resources to the Bank are resolved.

Two types of measures can be recommended here: those that help to increase production or improve the quality of rubber from existing plantings and those of a longer-term character that affect production by altering the productive potential of tappable trees. Both are important and both have the potential to increase substantially the supply of NR. Prompt actions are required—even in the case of long-term measures—since decisions that are taken on replanting and new planting in the early 1980s will not significantly affect production before the early 1990s.

Measures that the Bank will take to increase production during the next two years to five years include:

- Encouraging rubber-producing countries to implement tax policies for rubber growers that are equitable with other agricultural producers—policies that increase incentives to expand production.
- Exploring the opportunities to develop projects that include stimulation of yields and fertilization and proper cultural practices in existing rubber areas—in particular, focusing on overaged plantings and poorly managed smallholder areas planted to high-yielding materials.
- Supporting NR development projects that focus on improved marketing, particularly for smallholders, to increase the quality, prices, and production incentives of rubber.

The major opportunities to expand the financial support for the development of NR are likely to be in activities that offer the prospect of increasing rubber production over the longer term. In this regard, the Bank will:

- Support expanded programs of rubber replanting, particularly in the major rubber-producing countries where existing replanting programs lag behind the levels needed to meet the future opportunities in the market place. A major effort is likely to be needed in Indonesia. The Bank will assist producing countries to build toward an annual total replanting area of at least 170,000 hectares by 1985; this figure is more than 50 percent larger than the current replanting rates, but it is still below the level of about 210,000 hectares that is needed to maintain the existing planted area.

- Seek to tailor the programs for rehabilitation, replanting, and new planting more carefully to meet the circumstances of individual countries. The programs will take into account the size of the replanting task, the availability of financial resources and qualified personnel, and the objectives of sound land use, economic efficiency, and equitable distribution of rural incomes. In several countries of Western Africa and in Malaysia, increasingly serious shortages of labor will require projects to incorporate labor-saving technologies in rubber production and processing.
- Explore opportunities, in replanting projects, to intercrop with annual food crops or cash crops during the immature phase of rubber; this will be done in circumstances in which managerial skills are adequate and in which soils, topography, and market conditions permit.
- Expand its support for Indonesia's nucleus estate and smallholder program as rapidly as the availability of local technical and administrative staff will permit; it will also examine opportunities for other complementary approaches to smallholder development. The government's efforts in Indonesia, even with the support of the Bank, can provide effective assistance to smallholders on no more than about 40,000 hectares a year. Therefore, basic changes in local institutions may be required to expand the replanting effort.

  The changes could include: (a) organizational restructuring in order to focus more directly on the development of rubber and to avoid competition and duplication of effort among various government agencies; (b) greater reliance on fiscal measures, rather than on the administratively cumbersome credit system, to finance rubber programs for participating smallholders; (c) expansion of programs to train technical and managerial staff; and (d) changes in approach to smallholder replanting that will place less demand on the scarce administrative and technical staff than is the case in most rubber smallholder programs now operating in Indonesia.[26] Such approaches must be technically sound, provide for adequate service by extension

[26]A pilot-scale effort to explore possible merits of such an approach is included in the Bank-supported Indonesian Smallholder Rubber Development I Project approved by the Bank's Executive Directors in fiscal 1980.

personnel, and be tailored to assist participants in activities that are critical to the success of the planting programs.

- Consider new management and extension systems to increase the effectiveness of transferring technology to smallholders in other countries where the task of replanting is smaller compared with the capital and the trained staff that are available. In some circumstances, a stronger, centralized management and group farming systems may be the most effective means by which improved technologies can be introduced and the reluctance of smallholders to take risk can be overcome. Experiments with new approaches are warranted. Malaysia's experience with FELDA and other centrally managed schemes, for example, may offer some useful lessons. It may be essential to avoid giving assistance to individual smallholders on uneconomic-sized farms to ensure that the participants are not locked into financially unrewarding agriculture. In such circumstances, the Bank will encourage and assist in the restructuring of land holdings and management systems.
- Examine the technical and economic possibilities of expanding production of rubber in newer areas—for example, China, parts of Latin America, particularly Brazil, and other parts of South Asia and East Asia. There is some evidence to suggest that natural rubber can be produced successfully in latitudes as much as 20 degrees north or south of the equator.
- Explore opportunities for expanding investment by the private sector in the development of natural rubber—perhaps through the assistance of the International Finance Corporation, an affiliate of the Bank that works closely with the private sector enterprises in developing countries. The Bank will support efforts to enlarge the roles for private estates in providing managerial and technical services to smallholders.
- Support national research efforts in rubber and encourage the international exchange of scientists, research results, and planting material.

ANNEXES

Annex 1

Indicative Estimates of Economic Returns to Investments in Alternative Tree Crops in Malaysia

The foregoing paper stressed that natural rubber tends to be more widely adaptable and less demanding of soil and climatic conditions than do other tree crops such as oil palm, cocoa, and coconuts. In the limited circumstances where all of these major tree crops can be grown, economic factors will be the major determinants of which crop should be planted. As noted in the paper, a meaningful economic analysis of alternatives can be done only within the context of a particular location and specific assumptions regarding soils, climate, and production systems. Based on the results, one cannot readily generalize across countries or regions within a country, but it may be useful to indicate the orders of magnitude of returns to alternative investments under a particular set of assumption regarding costs, prices, and crop yields. This annex refers to the estimates of economic returns to alternative tree crops in the relatively small areas in Malaysia which are considered technically suited for the production of these crops. The analysis, though modified slightly, is based on the data collected from a rural credit project in Malaysia which was supported by the Bank.

This credit project provides funds to the Bank Pertanian Malaysia for purposes of relending to both individual smallholders and smaller, locally-owned estates. Two models for the development of estates were used in this project (rubber and oil palm, each of 10,000 hectares) and three models for the development of smallholders (rubber, oil palm and coconut/cocoa intercrop). No changes were made in the estate model for purposes of this annex, but several adjustments were made in the smallholder models to make them easier to compare among the various alternatives. Specifically, the analysis in this annex assumes new plantings with smallholdings of 2.4 hectares (6 acres) of tree crops. It also includes as capital expenditure the cost of providing housing to the settler at M$3,000 each. The yields and prices for products ex-factory, are identical to those in the credit project and are indicated in Annex 3. Product prices are based on price projections by the Bank. Family labor is shadow priced at M$6 per day. Capital costs for processing facilities were annualized and derived largely from Bank sources. The costs on a per-hectare basis, are estimated to be M$219 for rubber, M$1,900 for oil and kernels, M$1,400 for cocoa, and M$300 for copra. The rubber-processing facility is assumed to be a Standard Malaysian Rubber Factory with a capacity to produce about 900 kilograms of dry rubber on a ten-hour shift.

The estate model is detailed in Annex 2 and the smallholder model is detailed in Annex 3, while results of the economic analysis are indicated in Annex 5. The results suggest that in circumstances in which all of these crops can be grown, economic returns to oil palm, or for coconut intercropped with cocoa, are higher than for rubber. In less favorable soils and climatic conditions, the returns to rubber are likely to be higher than returns to investment in other tree crops. The analysis also suggests (see Footnote 2, Annex 5) that if rubber prices rise by 2 percent annually in real terms after 1990—as it seems plausible in circumstances of rising real petroleum prices—the economic rate of return to investment in smallholder rubber under conditions similar to those assumed here, could exceed 20 percent. The intercropping of coconut with cocoa appears to be slightly more attractive in economic terms than oil palm, but this combination in Malaysia is limited by climate and soils to only a relatively small area.[27] Production of palm oil also is constrained by the need to have a compact planted area of at least 4,000 hectares to warrant investment in processing on a scale that permit a reasonably efficient operation in technical and financial terms.

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[27]Limitations among various tree crops in Malaysia are indicated to some extent by the area planted to each crop. More than half of the tree crop area is in rubber, about a quarter is in oil palm, 15–20 percent in coconut, and the balance in cocoa, increasingly intercropped with coconut. In recent years, the portion of the area under rubber has fallen while the share under oil palm and coconut/cocoa has increased.

Annex 2

Indicative Economic Returns to New Planting of Rubber and Oil Palm on Estates in Malaysia

(in million 1980 Malaysian ringgits)

A. Rubber (10,000 ha)

Year	Total planted area ('000 ha)	Total harvested area ('000 ha)	Incremental costs: Fixed	Incremental costs: Variable	Incremental costs: Total	Incremental benefits	Net incremental benefits
1	1.0	—	3.0	—	3.0	—	(3.0)
2	2.5	—	6.9	—	6.9	—	(6.9)
3	4.5	—	10.8	—	10.8	—	(10.8)
4	2.0	—	15.0	—	15.0	—	(15.0)
5	10.0	—	19.6	—	19.6	—	(19.6)
6	10.0	1.0	14.7	—	14.7	—	(14.7)
7	10.0	1.3	10.2	0.8	11.0	1.5	(9.5)
8	10.0	4.5	9.3	2.0	11.3	4.5	(6.8)
9	10.0	7.0	8.8	4.2	13.0	10.2	(2.8)
10	10.0	10.0	8.5	6.9	15.4	20.6	5.2
11	10.0	10.0	5.9	10.7	16.6	32.8	16.2
12	10.0	10.0	5.5	13.3	18.8	41.2	22.4
13	10.0	10.0	5.0	15.7	20.7	49.2	28.5
14	10.0	10.0	4.6	16.8	21.4	52.8	31.4
15	10.0	10.0	4.6	17.9	22.5	56.4	33.9
16	10.0	10.0	4.6	19.2	23.8	60.4	36.6
17	10.0	10.0	5.2	20.4	25.6	64.6	39.0
18	10.0	10.0	5.0	22.4	27.4	71.6	44.2
19	10.0	10.0	5.0	24.5	29.5	79.2	49.7
20	10.0	10.0	5.0	26.9	31.9	86.9	55.0
21	10.0	10.0	5.0	28.8	33.8	92.7	58.9
22	10.0	10.0	5.2	30.4	35.6	98.0	62.4
23	10.0	10.0	5.2	28.7	33.9	92.9	59.0
24	10.0	10.0	5.2	26.9	32.1	87.4	55.3
25	10.0	10.0	5.1	25.4	30.5	82.5	52.0

Indicative Economic Returns to New Planting of Rubber and Oil Palm on Estates in Malaysia (continued)

(in million 1980 Malaysian ringgits)

B. Oil Palm (10,000 ha)

Year	Total planted area ('000 ha)	Total harvested area ('000 ha)	Incremental costs			Incremental benefits	Net incremental benefits
			Fixed	Variable	Total		
1	1.0	—	3.7	—	3.7	—	(3.7)
2	2.5	—	6.7	—	6.7	—	(6.7)
3	4.5	—	12.2	—	12.2	—	(12.2)
4	7.0	1.0	17.2	0.6	17.8	1.8	(16.0)
5	10.0	2.5	22.6	2.3	24.9	7.4	(17.5)
6	10.0	4.5	15.5	5.3	20.8	16.5	(4.3)
7	10.0	7.0	15.9	9.7	25.6	31.0	5.4
8	10.0	10.0	9.2	15.3	24.5	49.3	24.8
9	10.0	10.0	8.5	20.5	29.0	66.8	37.8
10	10.0	10.0	7.9	22.2	30.1	72.8	42.7
11	10.0	10.0	7.7	22.7	30.4	74.2	43.8
12	10.0	10.0	7.3	22.8	30.1	74.5	44.4
13	10.0	10.0	7.3	22.5	29.8	73.6	43.8
14	10.0	10.0	7.3	22.1	29.4	72.1	42.7
15	10.0	10.0	7.3	21.9	29.2	71.5	42.3
16	10.0	10.0	7.3	21.6	28.9	70.7	41.8
17	10.0	10.0	7.3	21.4	28.7	69.8	41.1
18	10.0	10.0	7.3	21.0	28.3	68.6	40.3
19	10.0	10.0	7.3	20.9	28.2	68.2	40.0
20	10.0	10.0	7.3	20.7	28.0	67.7	39.7
21	10.0	10.0	7.3	20.4	27.7	66.5	38.8
22	10.0	10.0	7.3	19.9	27.2	65.0	37.8
23	10.0	10.0	7.3	19.3	26.2	63.1	36.5
24	10.0	10.0	7.3	18.9	26.2	61.8	35.6
25	10.0	10.0	7.3	18.4	25.7	60.1	34.4

Source: The World Bank.

Indicative Economic Returns to Smallholder Tree Crops in Malaysia

(in Malaysian ringgitts)

C. 6-Acre Coconut/Cocoa Model

	Benefits Stream											
	Coconut crop				Cocoa crop							
Year	Acreage harvested	Yield/ acre[1]	Total yield[2]	Value[3]	Acreage harvested	Yield/ acre[4]	Total yield	Value[5]	Total revenue	Gross value[6]	Total incremental benefits
1										600	600
2										600	600
3										600	600
4					2	94	188	288	288	360	648
5	3	129	387	148	4	232	918	1,404	1,552	180	1,732
6	6	799	4,794	1,831	4	330	1,320	2,020	3,851	180	4,031
7	6	1,335	8,010	3,060	4	442	1,768	2,705	5,765	180	5,945
8	6	1,866	1,960	4,569	4	500	2,000	2,999	7,568	180	7,748
9	6	2,402	14,412	5,505	4	580	2,320	3,550	9,055	180	9,235
10	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
11	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
12	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
13	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
14	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
15	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381

16	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
17	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
18	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
19	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
20	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
21	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
22	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
23	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
24	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381
25	6	2,902	17,412	6,651	4	580	2,320	3,550	10,201	180	10,381

[1]In lbs. of copra/acre.
[2]In lbs. of copra.
[3]At 38.2¢/lb. for copra.
[4]In lbs. of drybeans/acre.
[5]At 153¢/lb.
[6]Proforma value of cashcrops, houselot, etc.

Indicative Economic Returns to Smallholder Tree Crops in Malaysia *(continued)*
(in Malaysian ringgitts)

6-Acre Coconut/Cocoa Model (continued)

	Costs Stream					
Year	Farm inputs[7]	Family labor	Housing	Total incremental costs	Net incremental benefits/ farm	Net incremental benefits/ ha.
1	480	1,353	3,000	4,833	(4,233)	(1,743)
2	496	1,599		2,085	(1,495)	(615)
3	308	864		1,172	(572)	(582)
4	444	903		1,347	(699)	(288)
5	410	675		1,085	647	266
6	530	879		1,409	2,622	1,079
7	688	1,077		1,765	4,180	1,721
8	837	1,239		2,076	5,672	2,335
9	930	1,383		2,313	6,922	2,850
10	969	1,491		2,460	7,921	3,261
11	988	1,515		2,503	8,866	3,650
12	988	1,533		2,503	7,878	3,243
13	988	1,533		2,503	7,878	3,243
14	988	1,533		2,503	7,878	3,243
15	988	1,533		2,503	7,878	3,243
16	988	1,533		2,503	7,878	3,243
17	988	1,533		2,503	7,878	3,243
18	988	1,533		2,503	7,878	3,243
19	988	1,533		2,503	7,878	3,243
20	988	1,533		2,503	7,878	3,243
21	988	1,533		2,503	7,878	3,243
22	988	1,533		2,503	7,878	3,243
23	988	1,533		2,503	7,878	3,243
24	988	1,533		2,503	7,878	3,243
25	988	1,533		2,503	7,878	3,243

[7]Excluding family labor.

Features of the Natural Rubber Industry, 1978

Country	Production ('000 tons)	Area ('000 ha) Estates[1]	Smallholdings[2]	Total	National average of yields (kg/planted ha)	Proportion of area under high-yielding planting material[3] (%)	Area replanted each year ('000 ha)	Annual replanting required to maintain stable area under rubber[4] ('000 ha)
Malaysia	1,606	640	1,360	2,000	803	80	33.0[5]	60.0
Indonesia	880	455	1,875	2,330	378	13	12.0[6]	69.9
Thailand	464	70	1,530	1,600	290	20	50.0	48.0
Sri Lanka	156	106	122	228	684	76	n.a.	6.8
India	133	60	173	233	571	77	n.a.	7.0
Philippines	63	19	n.a.	29	n.a.	80	n.a.	0.9
Liberia	78	77	43	120	650	n.a.	n.a.	3.6
Nigeria	58	32	218	250	232	n.a.	n.a.	7.5
Vietnam	40	100	—	100	400	72	n.a.	3.0
Other	212	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
TOTAL	3,690	1,559	5,331	6,890	n.a.	n.a.	110.0[7]	206.7

Note: "n.a." means "not available".

[1]Includes government estates which are important in Indonesia, Sri Lanka and Vietnam.

[2]Includes holdings in land development schemes. Generally refers to individual holdings of less than 40 ha.

[3]In the total planted area.

[4]Assumes an economic life of trees of just over 30 years and 3 percent of the area replanted each year.

[5]Some 45,000 ha of old rubber were replanted, on average, in 1976–78, but only 33,000 ha were planted again to rubber.

[6]This is the target for 1978–79 under government replanting programs. An additional unknown quantity of spontaneous and unassisted replanting, generally of low quality, had been undertaken by smallholders.

[7]Very rough estimate. May well be overstated.

Source: International Rubber Study Group and World Bank.

Summary Analysis of Economic Returns to Alternative Tree Crop Investments in Malaysia

	Rubber	Oil Palm	Coconut/Cocoa
Product Price (ex-factory in 1980 dollars)			
Malaysian ringgit	2.48/kg	1,089/ton	Cocoa: 3.37/kg Copra: 0.84/kg
US dollars	1.13/kg	495/ton	Cocoa: 1.53/kg Copra: 0.38/kg
Smallholder models			
Area planted (ha)	2.4	2.4	2.4 (of which 1.6 inter-cropped with cocoa)
Annual or food crops	------- M$600 per year during tree-crop immaturity; M$180 thereafter -------		
Phasing of tree crop planting	2 years	2 years	2 years
Peak tree crop yield/ha (year)	1,770 kg (16)	19.8 tons ffb (8–14)	Copra: 3,250 kg (10) Cocoa: 1,624 kg (9)
Economic rate of return[1]	18.9[2]	25.3	27.5
Net present value (M$/ha at 12%)[1]	3,626[2]	7,799	8,189

Estate Models			
Area planted (ha)	10,000	10,000	—
Annual or food crops	—	—	—
Phasing of tree crop planting	5 years	5 years	—
Peak tree crop yield/ha (year)	2,900 kg (17)	20 tons ffb (8,9)	—
Economic rate of return	16.1	27.9	—
Net present value (M$/ha at 12%)	2,970	9,126	—

[1]Excludes returns to annual or food crops.

[2]This assumes a constant real price for rubber in the ninth year and beyond. If, alternatively, the rubber prices increase annually by 2 percent beyond the ninth year, the estimated economic return to this crop is 20.1 percent per year and the net present value/ha at 12% is M$4,697.

Source: The World Bank.

The World Bank's Lending for Rubber Production and Processing

Region/Country	Project name	Fiscal year of project approval	Loan/credit amount	Project cost: Total	Project cost: Directly related to rubber production and processing (US$ million)	Percent financed by Bank	Project description
West Africa							
Cameroon	Niete Rubber Estate	1975	16.0	28.5	27.3	56.0	The project is the first phase of a large rubber estate development. It includes land clearing, planting and maintenance of 5,800 ha of rubber; preparation of 1,700 ha for planting in the second phase; construction of housing, health, education and other community facilities; and establishment of research facilities and a company to manage the estate. It is estimated that 3,000 permanent jobs will be provided under the project.
	Second HEVECAM	1980	31.5	95.0	94.6	33.0	The project will finance the preparation of 9,800 ha and planting and maintenance of 13,500 ha of rubber; tapping of 1,500 ha; factory construction and equipment; housing and social facilities; land clearing for food crop production; establishment of facilities for smallholder rubber production; and studies and surveys for further rubber development.

	Second CAMDEV	1977	15.0	39.3	31.3	38.0	The project includes land clearing, planting and maintenance of 7,900 ha of estate rubber; planting of about 1,000 ha of outgrower rubber and palm oil with provision of credit extension and management services to these outgrowers; and development of studies for further expansion. It is estimated that 5,000 jobs will be created for estate workers.
Ivory Coast	Grand Bereby Rubber	1978	8.3	29.1	25.0	28.4	The project is the first phase of a 13,500 ha rubber estate. It involves land clearing and planting of 13,500 ha of rubber; power and water installation; and construction of roads, housing, health education and other facilities.
	Second Grand Bereby Rubber	1978	20.0	60.4	60.4	33.0	The project includes land clearing, planting and maintenance of 6,500 ha of rubber; construction of housing, health, education and other facilities for staff and estate workers; provision of equipment, vehicles, management and technical services; factory construction and equipment; and credit and extension services for an outgrowers pilot project. About 4,500 jobs are expected to become available.

The World Bank's Lending for Rubber Production and Processing (continued)

Region/Country	Project name	Fiscal year of project approval	Loan/ credit amount	Project cost: Total	Project cost: Directly related to rubber production and processing (US$ million)	Percent financed by Bank	Project description
	SAPH Rubber	1978	7.6	19.8	19.7	38.4	The project is designed to finance the planting and maintenance of 3,500 ha of smallholder rubber and a 200 ha of Government owned nucleus industrial estate; the establishment of training for farmers and extension services; and a study to determine the likely rate of smallholding expansion and the impact of this on other cash and food crops. About 8,000 people are expected to benefit from this project by increased per capita income from US$300 to US$590 at full development.
Liberia	Rubber Development	1978	13.0	29.9	29.9	43.5	The project provides financial assistance to farmers for replanting over 16,100 ha of old rubber and rehabilitating 9,500 ha of mature untapped rubber; and provides training to staff and farmers. About 6,350 farmers are expected to participate and about 3,500 jobs will be provided.
Subtotal			111.4	302.0	260.8		

East Asia and Pacific							
Indonesia	Second North Sumatra Estates	1970	17.0	31.7	13.0	54.0	The project involves the rehabilitation of 12,000 ha of rubber and bringing to maturity another 31,400 ha; construction and rehabilitation of rubber factories; rehabilitation of roads and buildings; and technical and management assistance. The project also includes oil palm rehabilitation.
	Fourth Agricultural Estates	1972	11.0	21.9	13.0	50.0	The project finances the planting of 4,000 ha of abandoned rubber land with rubber; management of these and existing areas; construction and rehabilitation of rubber factories; rehabilitation of equipment, roads, housing and other facilities; technical assistance; and oil palm planting and rehabilitation.
	Agricultural Research and Extension	1975	21.5	46.6	7.5	46.1	The project is designed to strengthen national agricultural research programs on rubber and several food crops.
	Transmigration and Rural Development	1977	30.0	56.8	56.8	53.0	The project finances block planting of 7,000 ha of rubber and the establishment of villages with health and education, and other facilities; establishment and staffing of credit, extension and cooperative services; construction and upgrading of roads and distribution of food etc. during the first year of the project. The benefits of this project will accrue to transmigrants.

The World Bank's Lending for Rubber Production and Processing (continued)

Region/Country	Project name	Fiscal year of project approval	Loan/credit amount	Project cost: Total	Project cost: Directly related to rubber production and processing (US$ million)	Percent financed by Bank	Project description
	First Nucleus Estates and Smallholder	1977	65.0	134.0	92.7	49.0	The project finances block planting of 15,000 ha of rubber and maintenance up to three years of 11,500 ha; distribution of food crop inputs to settlers; construction of roads, housing, health and other facilities; provision of credit and extension facilities; and land acquisition for palm oil development. About 28,700 people in the rural target population are expected to benefit through increased incomes, from US$50 to about US$160 at full development.
	Second Nucleus Estates and Smallholder	1978	65.0	100.5	100.5	65.0	The project involves block planting and maintenance for three years of 15,200 ha of smallholder rubber and 3,500 ha of state owned rubber; distribution of food crop inputs; construction of roads, settler housing, health, education and other facilities; provision of credit extension and cooperative facilities; and technical assistance. The number of beneficiaries is estimated at about 11,350 smallholder families or 56,750 people in the rural target population as well as 2,000 families who are expected to find employment on State-owned estates.

	Third Nucleus Estates and Smallholder	1979	99.0	152.5	140.0	65.0	The project is designed to finance: (a) A smallholder development scheme, including planting of 32,000 ha of rubber; construction of roads, housing, educational health and other village facilities; credit, extension and cooperative facilities; and food crop inputs. (b) Expansion of existing rubber estates by 15,790 ha of newplanting; rehabilitation of 2,356 ha of existing plantings; extension and new construction of factories and housing, and other buildings; and (c) Oil palm production and processing.
	Smallholder Rubber Development	1980	45.0	70.5	70.5	63.8	The project includes planting of 38,500 ha of smallholder rubber and maintenance of 46,500 ha; nursery development; construction and upgrading of access roads; construction of housing; studies and pilot programs for future projects and strengthening of the Project Management Unit. About 32,000 families or 160,000 people are expected to benefit from the project.
	North Sumatra Smallholder Development	1973	5.0	10.0	6.3	50.0	The project was designed to provide improved extension; primary processing and marketing facilities, train farmers in improved methods of tree and food crop production; and assist in the financing of inputs for these crops both on new and existing cultivations.
Malaysia	Jengka Triangle II	1970	13.0	25.4	11.5	51.2	This land settlement project includes clearing of about 12,950 ha of forest and planting of 5,500 ha of rubber and 6,800 ha of oil palm.

The World Bank's Lending for Rubber Production and Processing (continued)

Region/Country	Project name	Fiscal year of project approval	Loan/ credit amount	Project cost: Total	Project cost: Directly related to rubber production and processing (US$ million)	Percent financed by Bank	Project description
	Jengka Triangle III	1973	25.0	43.3	18.4	57.7	The project includes the planting of 25,000 ha of rubber and 8,900 ha of other tree crops, and construction of villages and facilities for settlers. The project participants were selected from a large number of unemployed and underemployed people.
	FELDA VI Land Settlement	1973	28.0	92.3	79.0	30.0	The project finances the development of about 25,000 ha of rubber; and settlement of 6,200 families; 4,000 ha of cocoa and a 200 ha experimental cropping area; and the construction of roads, housing, health, education and other community service centers. About 6,200 settler families are expected to benefit from the rubber component.

Thailand	Rubber Replanting	1976	50.0	148.0	148.0	33.8	The project finances replanting of about 16,000 ha of rubber; improvement of nurseries to produce higher quality planting material; maintenance of replantings; increased staff training programs for staff and smallholder in planting, maintenance, tapping and marketing techniques; and technical assistance in planning and implementation.
Subtotal			474.5	933.5	757.2		
South Asia							
Burma	Rubber Rehabilitation	1979	4.5	8.7	8.7	52.0	The project is designed to improve rubber production on Government estates by rehabilitation of all facilities; replacement of 3,375 ha and expansion of 1,125 ha of rubber; introduction of new exploitation techniques; rehabilitation of mills; provision of staff, training and research programs; and technical assistance. About 3,200 man-years of employment is expected to be provided to benefit landless and underemployed families.
India	Kerala Agricultural Development	1977	30.0	69.0	6.3	48.0	The project finances the establishment of 10 rubber factories and strengthening of the rubber board, and rehabilitation of newplanting of other tree crops.

The World Bank's Lending for Rubber Production and Processing (continued)

Region/Country	Project name	Fiscal year of project approval	Loan/ credit amount	Project cost: Total	Project cost: Directly related to rubber production and processing (US$ million)	Percent financed by Bank	Project description
Sri Lanka	Smallholder Rubber Rehabilitation	1980	16.0	28.0	28.0	57.1	The project's major aim is to support the country's smallholder replanting scheme. It finances replanting of 18,800 ha of rubber; strengthening of the implementing agency; services to private processors; and provision of equipment for the Rubber Research Institute; technical assistance for training and administration. About 27,000 smallholders are expected to benefit from this project.
Subtotal			50.5	105.7	34.3		

Latin America and the Caribbean							
Brazil	Agricultural Research	1976	40.0	189.4	12.2	21.0	The main purpose of the project is to assist the Brazilian Research Institute to strengthen its research capabilities on a range of agricultural commodities. It emphasizes the improvement of rubber being harvested from existing trees and development of disease-resistant high-yielding clones.
Subtotal			40.0	189.4	12.2		
Total—All Regions			676.4	1,530.6	1,064.5		

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