MONTHLY REGIONAL SUPPLY FUNCTIONS OF NATURAL RUBBER

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INTRODUCTION

THE supply characteristics of the natural rubber industry are the focus of this paper. It specifically elaborates on the short-run factors, and these are in turn utilized in the estimation of monthly supply functions for the main producing countries. In Section I, the production characteristics are explored. A short-run monthly supply relationship is then postulated and estimated for the period 1972–76 in Section II. The results indicate a positive response to price in the inelastic range.

I. NATURAL RUBBER PRODUCTION

Rubber cultivation is confined to the humid tropics. It is not exacting as is rice in its soil requirements,[1] though it does demand a heavy and well-distributed rainfall of about 100 inches a year and a high temperature of 80–90°F [2]. The producing regions are concentrated geographically, lying in a tropical belt within 20°N and 10°S. The Southeast Asian region of Malaysia, Thailand, Indonesia, and Sri Lanka produce about 85 per cent of the world's rubber. Other Asian countries[2] produce another 4 per cent, and the rest is contributed by African and Latin American countries like Brazil, Nigeria, and Liberia. The producing units vary in size, ranging from small 5-acre holdings to larger than 1,000-acre estates. About 63 per cent of world production come from smallholdings (less than 100 acres) and the rest from estates (more than 100 acres).[3]

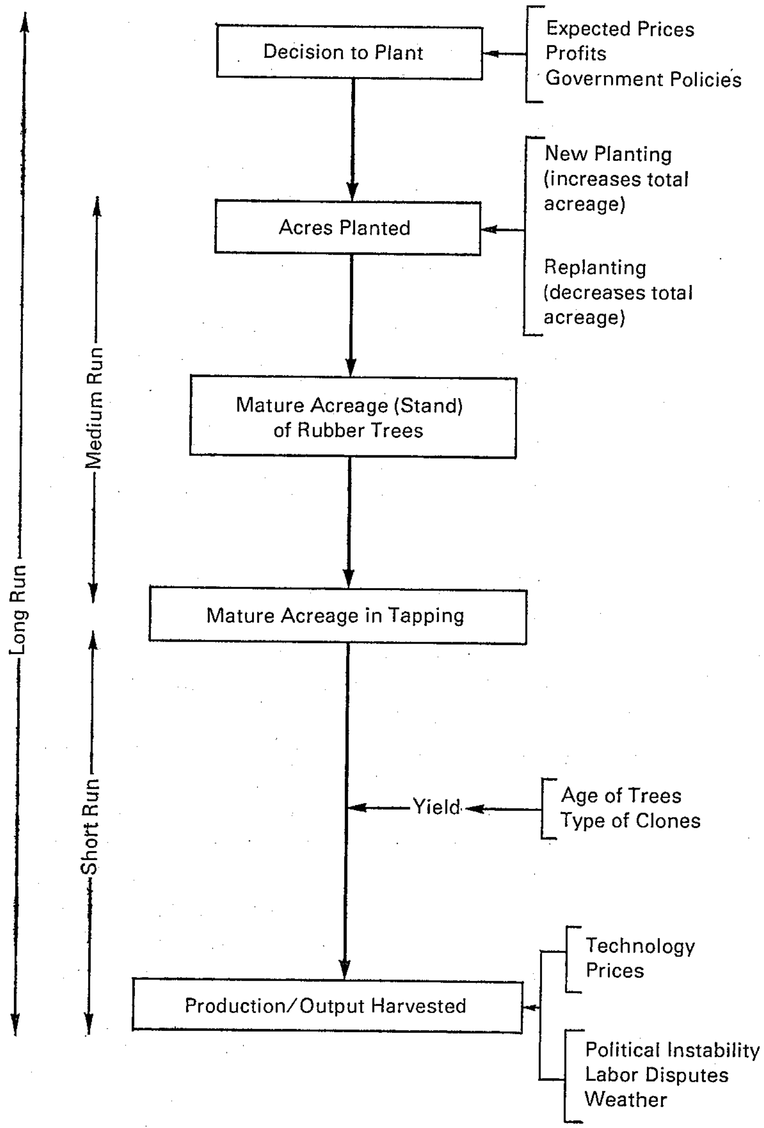
Once the *Hevea* trees have attained maturity, latex production is continuous until they die. Latex is an end product that is not reused in the metabolism of the plant. Unlike most agricultural tree crops, rubber shows no variegated sequence of poor and good crops. The flow of latex is relatively even within the

1 Soil favored for rubber cultivation is lotosol (tropical red earth, lateric earth, etc.), the main zonal soil of the tropics [18].

2 These include Brunei, Burma, China, Papua New Guinea, Philippines, Singapore, Portuguese Timor, Vietnam, and Kampuchea, and African and South American countries produce about 7 per cent.

3 Estate production is organized commercially and is capital-intensive, while smallholder rubber production is largely family-oriented and competes with other crops (e.g., paddy farming) for inputs [2, p. 29].

Fig. 1. Natural Rubber Supply Characteristics



year except for the "wintering" period when the *Hevea* trees shed their leaves and grow new ones. The yields decline while the latex is drawn into the new foliage, but production does not cease [8].

Three separate economic forces influence current output. The first of these are long-run in nature, associated with acreage decisions made years prior to "harvesting" (see Figure 1). Secondly and of lesser importance, are the medium-run factors associated with yield. The last group of factors, from the point of view of this paper, are decisions which can influence current yields over the short run.

Long-run increases or decreases in output result from changes in mature acreage. These changes arise from (i) new plantings or refraining from new planting, and (ii) replanting with higher-yielding varieties which increase yields per unit area tapped. Rubber acreage, like that of other tree crops, is slow to come to maturity with a gestation period of five to seven years and depends upon price expectations formed several years before planting begins. High past prices relative to other crops would encourage plantings while a lower one would discourage additions to total production capacity. In addition to rubber price incentives, a large portion of more recent replantings is the direct result of the individual producing countries' financial incentives (subsidies) for replanting.[4]

For purposes of this study which utilizes a monthly model of the rubber market, acreage is assumed to remain constant, i.e., the short-run acreage response was assumed to be zero. The annual acreage data for Malaysia supports this assumption. The change in rubber acreage for the entire period under consideration, 1972–76, was less than 1 per cent [9]. The assumption of constant acreage implies that net additions to acreage (through new planting and replanting) approximately equals net removals (through the abandonment of old unproductive trees).

Medium-run factors influencing output relate to the maintenance and care of rubber trees during the intervening period between planting and "harvesting." Factors such as the control of diseases and pests,[5] weeding, thinning, and the application of fertilizers during the immaturity period, all tend to affect yield during the subsequent maturity period.[6] A typical yield profile for rubber is shown in Figure 2. Since these factors do not influence current harvest decisions, they are assumed not to influence variations in monthly yields.

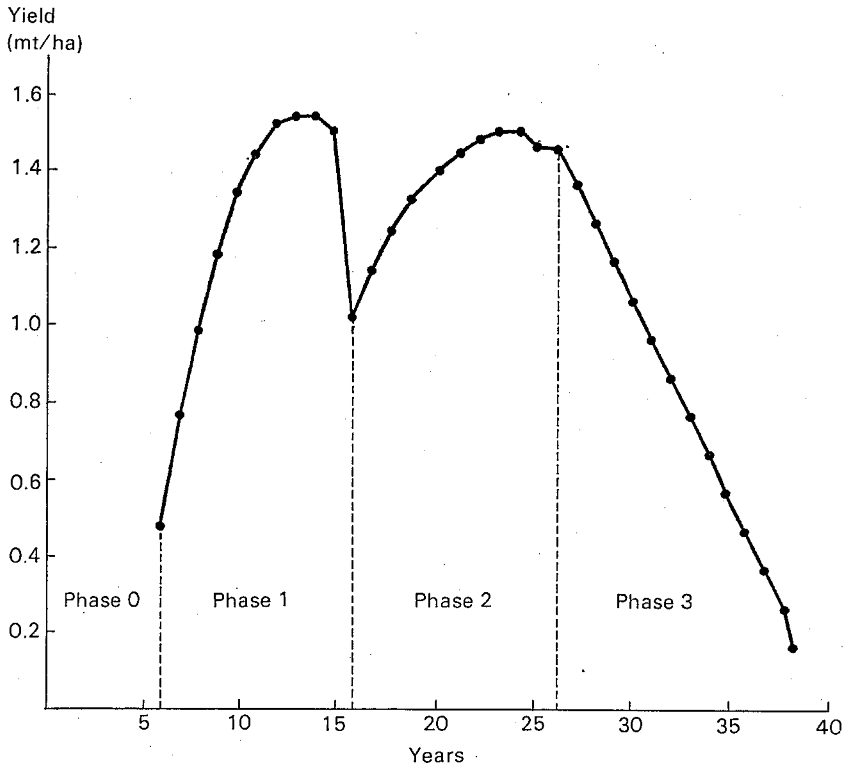
The remaining influences on rubber production are very short-run in nature and directly affect current yields. The producer, especially the smallholder, might deviate from the normal alternate, the third or fourth day tapping system.

[4] Government policies also affect new plantings through the opening of new land development schemes. This is demonstrated by the Federal Land Development Authority's schemes in Malaysia.

[5] Diseases peculiar to rubber trees are generally classified as above and below ground diseases. Root diseases cause major damage in the South and Southeast Asian region and are the only ones that may kill the tree directly. They are transmitted mainly by root contact of previous stumps and fallen timber. Classification of diseases is by the characteristic white, red, or brown color of their rhizomorphs (strands or sheet of fungus). Above the ground, phytophtora diseases affect the tapping panel, stem, shoots, leaves, and seeds, caused by fungi entering through fresh tapping cuts during the wet season and infected seed pods. The most serious effect of the phytophtora is the abnormal leaf fall which tends to have detrimental long-term effects on the yield of mature trees. In comparison, pests cause less damage as the latex is an effective deterrent to most creatures attempting to feed on the rubber tree [12, July 1974] [13, pp. 75–76].

[6] During this period, the application of nitrogen, potassium, and phosphate fertilizers is common in Malaysia and Indonesia [10, p. 15] [11, p. 356]. Also included in this category are practices such as branch induction (to increase leaf area from induced branches) and the replacement of plants that die (about 10–15 per cent) in the original plantings [3, p. 134] [12, January 1974, pp. 18–20].

Fig. 2. Expected Rubber Yield



Source: [6].

Tapping is done by making an incision in the bark of the rubber tree to drain out the milk-like liquid called latex, which is raw natural rubber. The producer might engage in heavy daily tapping, known as slaughter tapping in the short run at the expense of long-term production. This practice is generally associated with smallholders who have predominantly old stocks of trees. Such actions are likely to retard later growth, consume bark faster than the normal rate of renewal, and increase susceptibility to brown bast disease [1, pp. 1–10]. Slaughter tapping is usually not associated with estates where managerial decisions affect long-run output (due to capital stock considerations) but with smallholders who follow price movements. This difference tends to reflect the profit motivations of the two groups of producers [2]. The latter would be responsive to short-run profits, while the former to longer-run considerations. Estates might be subsidiaries of fabricators and may engage in long-term contracts (although it is the exception rather than the rule). The ratio of high fixed costs to variable costs is also offered as an explanatoin for the nature of estate behavior [2, p. 140]. Another short-run influence on yields is the application of the stimulant ethephon (or two-chloroethyl phosphoic acid) on the tapping panel. It tends to increase yields by about 100 per cent or more within one to two weeks [3, p.142], and its continued use results in yield increase of 30–60 per cent over a seven-year period [15].

II. SPECIFICATION OF THE SHORT-RUN SUPPLY EQUATION

A short-run relationship is postulated whereby current supply S_t is related to lagged output prices P and a time trend T, in an attempt to capture the intensity of harvest discussed in Section I.

$$S_t = S(P, T, X_i) \ . \qquad (1)$$

The influence of weather on rubber is minimal unlike its effect on annuals. The weather in the tropics where rubber is grown is generally uniform, but occasional droughts and prolonged rainfall would tend to reduce output; the former through severe wintering, and the latter due to interference with tapping. The rainfall and wintering effect on output is postulated to be picked up by dummy variables for seasonal adjustments X_i, where $i=2$ to 12 indicating ith month.

Prices of alternative crops are not included because they represent longer-run considerations compared with the resource fixity of the short-run analysis. Moreover, many crops (palm oil, cocoa, cardamon, etc.) compete for the resources employed in rubber production in different parts of the world. Absent in this formulation are input prices since in this model intensity of harvest requires few inputs of which labor is the most important.

The trend term in turn primarily would reflect the technological factors that affect yield. Both the effect of yield[7] and the varietal effect[8] which increases the intercept of the yield function[9] are jointly embedded in the time trend. It could also account for the effect of mature trees becoming economically productive for the first time, i.e., additions to mature acreage in countries where replanting with higher-yielding, lower-immaturity-period trees have played a major role in the last two decades.

The production equation in the linear form is estimated for each of the major producing countries, i.e., Malaysia, Indonesia, Thailand, and Sri Lanka, and the rest of the world which includes Vietnam, Kampuchea, India, Burma, Philippines, other Asian and Oceanian countries (e.g., Timor), Liberia, Nigeria, Ghana, Zaire, Cameroon, Central African Empire, Ivory Coast, Brazil, and other Latin American countries such as Ecuador and Mexico. The production data are taken from the *Rubber Statistical Bulletin* [7] published monthly by International Rubber Study Group. All of them are in metric tons of dry rubber content of latex. Prices in the supply equation are the London spot price in

7 As indicated in Figure 2, two yield spurts are associated with the yield profile of rubber trees after which yields decline with age.

8 The higher-yielding clones of the R.R.I.M. series (developed by the Rubber Research Institute of Malaysia) can be expected to produce about 100 per cent higher yields than the older varieties of 1929–30 [3, p. 115].

9 Planting density (spacing of trees) has shown to affect yields in the first years of production but later the effect diminishes, and yields tend to converge with time [18, p. 72].

£/mt deflated by the individual countries' consumer price indices obtained from the *Monthly Bulletin of Statistics* published by the United Nations [16].

III. RESULTS

Results of the estimated behavioral equations for the period January 1972 to December 1976, are as follows.

Malaysia:

$$\begin{aligned}S_t = &\ \underset{(22.688)}{124{,}565} - \underset{(-8.657)}{44{,}240X_2} - \underset{(-11.605)}{59{,}319X_3} - \underset{(-13.627)}{69{,}713X_4} - \underset{(-8.780)}{45{,}099X_5}\\ &- \underset{(-6.787)}{34{,}829X_6} - \underset{(-3.468)}{17{,}783X_7} - \underset{(-4.130)}{21{,}183X_8} - \underset{(-5.3695)}{27{,}636X_9} - \underset{(-4.3541)}{22{,}471X_{10}}\\ &- \underset{(-5.100)}{26{,}283X_{11}} - \underset{(-2.0841)}{10{,}744X_{12}} + \underset{(5.909)}{18.79P_{t-1}} + \underset{(4.3144)}{274.99T}\,, \end{aligned} \qquad (2)$$

$R^2=0.90,\ F(13,\ 46)=33.23,\ D.W.=1.54$.

Indonesia:

$$\begin{aligned}S_t = &\ \underset{(12.478)}{55{,}702} - \underset{(-1.7719)}{6{,}176.2X_2} + \underset{(0.0639)}{223.11X_3} + \underset{(0.3394)}{1{,}185.7X_4} + \underset{(0.9078)}{3{,}185.5X_5}\\ &+ \underset{(0.7848)}{2{,}747.5X_6} + \underset{(0.3832)}{1{,}340.1X_7} + \underset{(0.8277)}{2{,}895.2X_8} - \underset{(-1.5236)}{2{,}522.3X_9} - \underset{(-0.1013)}{356.07X_{10}}\\ &+ \underset{(0.1413)}{496.75X_{11}} - \underset{(-0.3530)}{1{,}241.7X_{12}} + \underset{(4.5158)}{13.82P_{t-1}} + \underset{(2.0233)}{95.43T}\,, \end{aligned} \qquad (3)$$

$R^2=0.39,\ F(13,\ 46)=2.35,\ D.W.=2.21$.

Thailand:

$$\begin{aligned}S_t = &\ \underset{(4.5266)}{3{,}188} + \underset{(0.3030)}{1{,}370.51X_2} + \underset{(0.2857)}{1{,}875.69X_3} - \underset{(-2.1197)}{13{,}862.3X_4} - \underset{(-0.3192)}{2{,}085.6X_5}\\ &+ \underset{(0.3030)}{1{,}979.32X_6} - \underset{(-1.6489)}{10{,}772.2X_7} - \underset{(-0.0695)}{2{,}413.2X_8} - \underset{(-2.0055)}{13{,}110.7X_9}\\ &+ \underset{(0.2972)}{1{,}942.4X_{10}} - \underset{(-0.4450)}{2{,}909.3X_{11}} + \underset{(0.3623)}{2{,}369.7X_{12}} + \underset{(0.09887)}{0.3904P_{t-2}}\\ &+ \underset{(0.574)}{43.668T}\,, \end{aligned} \qquad (4)$$

$R^2=0.32,\ F(13,\ 45)=1.69,\ D.W.=2.44$.

Sri Lanka:

$$\begin{aligned}S_t = &\ \underset{(3.6082)}{9{,}191.7} - \underset{(-0.4344)}{1{,}059.6X_2} + \underset{(0.6475)}{1{,}582.0X_3} + \underset{(0.5310)}{1{,}292.6X_4} + \underset{(0.4983)}{1{,}211.6X_5}\\ &+ \underset{(0.0060)}{14.70X_6} + \underset{(1.0344)}{2{,}512.3X_7} + \underset{(0.4037)}{980.94X_8} + \underset{(0.7925)}{1{,}927.58X_9} + \underset{(1.008)}{2{,}451.1X_{10}}\\ &+ \underset{(1.9916)}{4{,}842.4X_{11}} + \underset{(0.6192)}{1{,}506.4X_{12}} + \underset{(0.3978)}{0.5779P_{t-2}} + \underset{(0.6905)}{20.1109T}\,, \end{aligned} \qquad (5)$$

$R^2=0.18,\ F(13,\ 45)=0.80,\ D.W.=1.99$.

The rest of the world:

$$S_t = 36{,}886 - 11{,}163.8X_2 - 7{,}699.3X_3 - 8{,}236.2X_4 - 6{,}798.1X_5$$
$$(17.4518)\ (-5.5524)\ (-3.8260)\ (-4.1053)\ (-3.3915)$$
$$-5{,}373.0X_6 - 7{,}219.0X_7 - 6{,}186.4X_8 - 4{,}540.8X_9 - 2{,}124.3X_{10}$$
$$(-2.6815)\ (-3.6038)\ (-3.0875)\ (-2.2643)\ (-1.05982)$$
$$-2{,}648.6X_{11} - 1{,}681.58X_{12} + 1.8041P_{t-2} + 165.99T\,, \qquad (6)$$
$$(-1.3205)\ (0.8380)\ (1.5244)\ (6.9437)$$
$$R^2 = 0.90,\ F(13, 45) = 12.26,\ D.W. = 1.82.$$

The figures in parentheses are t-values of the estimated coefficients. Several linear specifications were estimated for the supply equations. Ordinary least squares method was employed in estimating the equations.[10] As the estimation results did not differ significantly due to the length of the lag on prices, only the best-fitted equation for each country is reported.

(i) Malaysia: The results for Malaysia were the best of the producing countries. The price variable was significant, with the expected sign for prices lagged one to three months, indicating the important role of prices in the production process. The time trend variable was also significant, reflecting technological improvements which increased yields during the estimation period. All the seasonal variables were significant, showing marked seasonality in production throughout the year.

(ii) Indonesia: The results for Indonesia were not as impressive as those of Malaysia. The price variable was again significant with the expected sign. The time trend variable was only significant at the 5 per cent level. This factor, together with the nonsignificance of dummy variables from March to December, could have contributed to the low level of R^2, which was only about 0.4.

(iii) Thailand: For Thailand, the price coefficient was unstable, turning out to be negative in one instance. The positive price coefficient was however not significant. Employing longer price lags did not improve the results. With the exception of the April and September dummy variables, the others including the time trend variable were not significant. The coefficient of determination, therefore, was only in the range of 0.32.

(iv) Sri Lanka: Although the price variable for Sri Lanka had the expected sign, it was not significant for the various lagged prices tried. R^2 for the estimated equations were in the range of 0.16 to 0.18 as the dummy variables for seasonal adjustments and the time trend variable also proved not to be significant.

(v) The rest of the world: For this category, the results turned out to be relatively better than the three earlier countries. Although it had a positive sign, the price variable was not significant for the various trials with lagged prices. Since eight seasonal adjustment variables and the time trend variable

10 Ordinary least squares method was employed as the postulated model was recursive in nature. For the details, see [14].

TABLE I

SHORT-RUN PRICE ELASTICITIES OF SUPPLY

Country	Price Elasticity
Malaysia	0.24
Indonesia	0.31
Thailand	0.02
Sri Lanka	0.10
Rest of the world	0.07

TABLE II

PRICE ELASTICITIES FOR ESTATES AND SMALLHOLDINGS

Period	Elasticity	
	Estates	Smallholdings
Rising Price:		
June 1949–Feb. 1951	−0.04	0.13
Feb. 1954–Sept. 1956	0.04	0.37
June 1958–May 1960	0.07	0.20
Falling price:		
Mar. 1951–Jan. 1954	−0.02	0.23
Oct. 1955–May 1958	−0.02	0.22

Source: [17].

were significant, the coefficient of determination improved to 0.77 when compared with the earlier cases.[11]

IV. MONTHLY SUPPLY ELASTICITIES

Table I presents the estimated price elasticities of supply for the main producing countries. Generally the results indicate that there is some output response to price. The response for Indonesia is somewhat higher than Malaysia though in the inelastic range. For the other categories there is only a slight response. Such results generally conform to other monthly studies that have been done for Malaysia. Wharton [17] conducted the first monthly analysis for both the estates and smallholdings. His results for the period 1948–61 are reported in Table II. More recently Chow [5] conducted his monthly study for 1956–74, and his results produced price elasticities of 0.29 for smallholdings and 0.028 for estates, and 0.15 for both sectors which is slightly lower than the one obtained in this study.

V. CONCLUSION

The focus of this paper has been on the very short-run factors affecting rubber production. The monthly time frame was employed as it is the shortest time

[11] Malaysian price was used as the proxy for the price variable for the rest of the world.

period for which data is available. Over such a time period, the decisions affecting the producer are the frequency or intensity of tapping and the use or otherwise of stimulants. It was found that price response for the major producing countries is positive and small as would be expected for the very short run. The response was highest for Indonesia, and this could be attributed to the organization structure of the production units as the proportion of small-holdings are greater than that of Malaysia. Smallholdings tend to have greater flexibility than estates in adjusting production to price changes in the short run. Future research should aim at integrating the medium- and long-term supply behavior [4] with those of the short term conducted in this paper.

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