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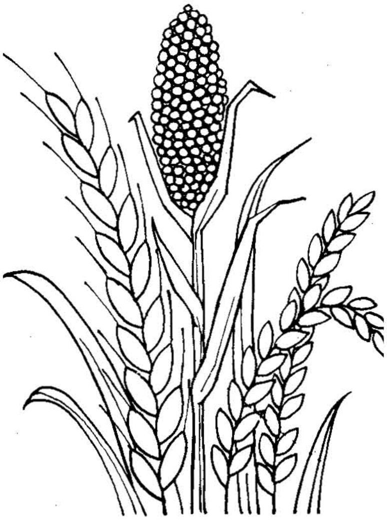

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PERENNIAL CROP SUPPLY RESPONSE: THE CASE OF INDIAN NATURAL RUBBER

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Rubber plantations in India were started by the British. The perennial nature of the crop and its varied economic uses made these plantations economically viable. It is a labour-intensive industry. The history of the growth of this industry shows that more than the favourable geographical environment, the presence of cheap labour was the greatest attraction in developing the industry. The operations involved in planting, culturing, tapping the latex and vulcanizing it are all labour-intensive operations.

The increasing use of synthetic rubber and its competition with natural rubber reveals the pattern of international trade with all its present day problems of the struggle between the rich and the poor nations. In the context of the policy of higher agricultural tariff to be pursued by the developed countries for the next decade and the intentions of the Multinational Corporations to come in a big way in primary products like coffee, tea and may be rubber and the questions of buffer stock operations in these, this is a vital industry which an under-developed country cannot afford to overlook. India's share in world production of rubber in 1975 was 37 per cent.

Rubber is produced in India in plantations classified as Holdings (50 acres or less) and Estates (more than 50 acres). The rubber tree becomes tappable when it attains a particular girth at the height at which tapping out is to be opened. This girth is normally attained by the seventh year of planting.[1]

In this paper we propose to concentrate on estimating the short-run response to price—the harvesting decision, and the long-run response to price—the planting decision.

SHORT-TERM RESPONSE: THE TAPPING DECISION

Fitting of supply functions to perennial crops or tree crops particularly in under-developed countries is now fairly well-known. We do not know of any effort in this direction in India even though some studies for other primary producing countries are available. The motivation for this type of study is provided by the fact that if supply elasticities of these products are available then for some of the problems of Public Finance and income stabilisation these can be taken as datum (Bateman, 1†).

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[1] For an early history of rubber and its agronomic characteristics, reference may be made to B. N. Sastri (Ed.): The Wealth of India (A Dictionary of Indian Raw Materials and Industrial Products), Raw Materials—Vol. V, H-K (look under *Hevea*), 1959.

† Figures in brackets denote references cited at the end of the paper.

As the long-run elasticities of these crops involve taking into consideration past prices or expected prices, these studies use the distributed lag model techniques of econometrics. Thus a review of literature in this field would fall into two categories. First, the development of the econometric technique in dealing with the distributed lag problem. Secondly, a review of the studies which have fitted supply functions to some of these crops. Of the latter, one gets an excellent review in Bateman (1) while of the former, one well-known survey is that of Griliches (6).

In the case of rubber the studies of Bauer (2, 3), Wharton (12), Chan (5) and Stern (11) are well-known. All these studies pertain to Malaya and they use only a limited range of methods available.

The attempt in this paper is to fit supply functions for rubber with Indian data. We have patterned our study on Gwyer's (7) study of Tanzanian sisal. Even though production of sisal resembles the production of tea more than that of rubber, yet since Gwyer uses a wide range of methods and his study is more recent we follow his method.

We have tried to estimate the short-term response to price in terms of the effect on output of a price change in the short-run. This does not involve lagged variables. Even though the Durbin-Watson statistic exhibits the presence of serial correlation, yet as R^2 is quite high and the price coefficients attain significance at .05 level, *i.e.*, their standard errors are low in most of the equations some reliance can be placed on these price elasticities calculated from these price coefficients. In the short-term the intensity of tapping can be varied and therefore it is interesting to see how responsive the tapping decision is to price.

Four types of multiple regression were run for estimating the short-term response of output of rubber to price.

SET I

(1948-49 — 1972-73)

I (1)

$$(O/T)_t = \underset{(4.403)}{5.556} + \underset{(0.048)}{0.191\,P_t} + \underset{(0.317)}{0.449t}$$

$$R^2 = 0.885182, \quad \bar{R}^2 = 0.874744, \quad D.W. = 0.775514$$

I (2)

$$(O/T)_t = \underset{(4.445)}{5.717} + \underset{(0.049)}{0.198\,P_t} + \underset{(0.392)}{0.268t} + \underset{(3.197)}{2.545D}$$

$$R^2 = 0.888546, \quad \bar{R}^2 = 0.872624, \quad D.W. = 0.841906$$

(Figures in brackets refer to the standard errors of coefficients.)

where $(O/T)_t$ = production of rubber as a percentage of tappable area or yield per hectare of tappable area in year t,

P_t = average of the maximum and minimum prices per 50 kg. of rubber declared by the Government of India (with adjustments where necessary),

t = trend variable,

D = dummy variable with weight 1, for years of decontrol and 0 for years of price control.

Both the equations exhibit serial correlation as judged by the Durbin-Watson statistic. R^2 is quite high and still higher when the dummy variable is included. The price coefficient is significant in both the equations at .05 level of significance. The intercept term and the trend coefficient in both the equations and the coefficient of the dummy variable in equation (2) are not significant. But it is the price coefficient, which is significant, that interests us. The trend variable and the dummy variable only help in increasing the R^2.

The price elasticity of supply is got by multiplying the price coefficient by the ratio of the mean of P_t and mean of (O/T). Thus the short-run price elasticity of supply as given by equation (1) is 0.726 and that given by equation (2) is 0.752. Both are positive and show that a 10 per cent change in price induces a 7.2 per cent or 7.5 per cent change in output as a percentage of tappable area. This seems plausible as tapping can be varied much in the short-run.

Instead of using the average of maximum and minimum price of all grades, only the average of maximum prices of all grades was taken and this time (O/T) was regressed on this price variable. The results are given in equation (3) below.

(1948-49—1972-73)

$$\text{I (3)} \qquad \begin{array}{lcccccccc} (O/T)_t & = & 5.353 & + & 0.220\,P_t & + & 0.025t & + & 4.351D \\ & & (5.965) & & (0.047) & & (0.394) & & (3.059) \end{array}$$

$$R^2 = 0.903380, \quad \bar{R}^2 = 0.889577, \quad D.W. = 0.6696961$$

Here also the price coefficient is positive, and significant at .05 level of significance. The intercept term, trend and dummy variable, though positive are not significant at .05 level of significance. Yet R^2 improves further though D.W. exhibits serial correlation. The price elasticity works out to 0.814.

In equation (4) production in metric tons was regressed on P_t along with two more new variables, *i.e.*, newly planted area and tappable area.

$$\text{I (4)} \qquad \begin{array}{lcccccccc} O_t & = & -37508.4 & + & 197.27P_t & - & 0.731N_t & + & 0.580T_t \\ & & (4043.077) & & (67.927) & & (0.245) & & (0.103) \end{array}$$

$$R^2 = 0.971881, \quad \bar{R}^2 = 0.967864, \quad D.W. = 0.760605$$

O_t = production in metric tons in year t,

P_t = average of maximum and minimum price of all grades declared by the Government,

N_t = newly planted area in year t,

T_t = tappable area in year t.

All the variables are significant at .05 level of significance. The price coefficient and coefficient of T_t are positive. The intercept term is negative. But in all other equations the intercept term is positive, so in this case the presence of the variables N_t and T_t probably leads to negativity of the intercept term. The negative sign of N_t shows that output in the short-run is negatively related to the newly planted area. This is expected, as tapping of these plants planted now can only be undertaken after 5-7 years. The price elasticity in this case works out to 0.591. Elasticity with respect to newly planted area is —0.102 and with respect to tappable area is 1.218.

Set II

A second set of regressions was run for monthly data as shown in the equation below.

(1964-65—1974-75)

II (1)

$$O_t = \underset{(8.807)}{63.089} - \underset{(1.969)}{3.034P_t} + \underset{(0.119)}{0.720t}$$

$R^2 = 0.342910$

O_t = monthly output of month t deseasonalised by the ratio to annual average method,

P_t = monthly market price of indigenous natural rubber given per 100 kg. for RMA 3,4 and 5 grades in Kottayam market, duly deseasonalised by the ratio to annual average method,

t = trend variable.

R^2 is not high yet the F statistic shows that the explanatory variables are significant. Price elasticity on the basis of this estimate is—0.203.

Eliminating the trend variable, the estimate is as follows:

II (2)

$$O_t = \underset{(10.489)}{57.609} + \underset{(1.924)}{3.842\, P_t}$$

$R^2 = 0.046348$ D.W. = 0.884279

R^2 diminishes if we don't include the trend variable. D.W. exhibits serial correlation. The price coefficient is positive and significant at .05 level and the short-run price elasticity works out to 0.255.

Set III

The third set of equations was estimated for the output of holdings.

(1965-66—1974-75)

III (1)

$$O_H = \underset{(6748.10)}{10010.8} + \underset{(14.364)}{0.872636\, P_t} + \underset{(259.290)}{6930.53t}$$

$R^2 = 0.991765$ D.W. = .882690

O_H = output of holdings,

P_t = market price of RMA grade I (adjustment made for years of control).

Though R^2 is high the price coefficient is not significant. This could be due to the short length of the time-series. The price elasticity is 0.009, that means the output of holdings in the short-run is price inelastic. The trend variable is significant. If we drop the trend variable, R^2 falls to a very low level. The price coefficient is not significant though it is positive. The price elasticity is 0.409. This is given in the following equation:

$$\text{III (2)} \qquad O_H = \underset{(68191.6)}{25926.4} + \underset{(144.932)}{40.392}\, P_t$$

$$R^2 = 0.11245 \qquad D.W. = 0.15395$$

The fourth set of regression that was run pertains to the estates. In the case of these equations too, the standard errors are high and, the estimates are not significant. This may be again due to the short length of the time-series.

The price elasticity estimates of Stern (11) and Chan (5) as reported in Bateman (1) are given in Table I.

TABLE I—ESTIMATES OF PRICE ELASTICITY

			Price elasticity
Stern	Estates	(1953-60)	0.0
Stern	Small holders	(1953-60)	0.02
Chan	Estates	(1951-61) (Annual data)	—0.02
Chan	Small holders	(1958-61) (Annual data).	0.12
Chan	Estates	(1954-61)	0.03
Chan	Small holders	(1953-60)	0.34

Short-run price elasticities calculated for each equation is given in Table II.

TABLE II—SHORT-RUN PRICE ELASTICITIES: SUMMARY OF RESULTS

Equation No.	Price elasticity
I (1) (Annual data)	0.726
I (2) (Annual data)	0.752
I (3) (Annual data)	0.814
I (4) (Annual data)	0.591
II (1) (Monthly data)	—0.203
II (2) (Monthly data)	0.255
III (1) (Holdings)	0.009
III (2) (Holdings)	0.409
IV (1) (Estates)	—0.066
IV (2) (Estates)	0.108

Note:—Our elasticity estimates for Set II, III, IV are comparable with Chan's and Stern's study but not Set I, because in Set I we have regressed output as a percentage of tappable area on price and other variables.

Set I refers to the price elasticity of (O/T) (*i.e.*, in a way the yield per mature acreage), while the rest refer to elasticity of production, but all refer to the tapping decision.

Economic Interpretation of the Short-Term Response to Price

The explanation for the negative relationship between current price and output, in the case of estates, *i.e.*, Set IV (1) may be found in the rigid cost structure of the estates. Trade unions and investments on housing, etc., render it uneconomical to withdraw any labour force in response to vagaries of prices, to reduce production. More than the current price, inventory/sales ratio affect the output as reported by Stern (11) in the Malayan study.

Another reason could be that the yield per acre of estates has been declining due to the age-composition of trees.[2] The years 1961-62 and 1965-66 were the peak periods of newly planted and replanted trees respectively. Therefore, those trees became tappable in 1967-1968 and 1972-1973. Moreover, there was an absolute decline in new planting and replanting of the ordinary varieties in the estates. Hence, the estate production could not have risen in response to rise in price.

In the case of small holdings, the new planting and replanting of both the high-yielding variety and the ordinary variety have increased very much. During the period 1969-1974, the share of the small holding sector in the total area increased from 65 to 70 per cent.[3] This is borne out by our results in equation (1), Set III. We find there a positive relation between price and output. Weather, cost of living index and stealing, etc., could be the other explanatory variables (Chan, 5). Inverse relationship of price and output may also mean presence of monopolistic elements. But a regression equation of this type is not suitable for studying it.

As mentioned in the Note on Source of Data (Appendix 1), if figures of production are based on market arrivals, the negative relationship or otherwise between output and price cannot be said to be reflecting the producer's response. The adequate cushioning provided by the various marketing agencies may account for the distortion of results. Further study of channels of marketing of rubber is needed. If they are from returns filled in by the producers, then there are chances of omission in the case of small holders and deliberate errors in reporting by the estates.

We now proceed to estimate the long-term response.

LONG-TERM RESPONSE

Bateman (1) gives four types of Planting Decision Models that can be used in the case of tree crops. They are: (*i*) gross investment as a function of prices, (*ii*) stock of trees as a function of expected prices, (*iii*) desired stock of trees as a function of prices, and (*iv*) the liquidity model. Of these, we have chosen the first one which is specified by Bateman as given below.

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[2] Compare Tables 9 and 10 of the Indian Rubber Statistics, Vol. 14, 1975, pp. 28-29, Statistics and Planning Division, Rubber Board, Kottayam, Kerala.

[3] Indian Rubber Statistics, Vol. 13, 1974.

Gross Investment as a Function of Prices Model

$$X_t = a_0 + a_1 \tilde{P}_t + a_2 \tilde{S}_t + u_t \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

$$\tilde{P}_t = \sum_{i=0}^{n} P^*_{t+i} \,/\, n + 1$$

$$\tilde{S}_t = \sum_{i=0}^{n} S^*_{t+i} \,/\, n + 1$$

X_t = the number of acres planted in year t,

P^*_{t+i} = the expected real producer price in year $t + i$ of the product being planted,

S^*_{t+i} = the expected real producer price in year $t + i$ of an alternative crop,

n = the expected age after which the trees planted in year t cease to bear.

Price expectations are expected to be formed as follows:

$$\left.\begin{array}{l} \tilde{P}_t - \tilde{P}_{t-1} = \beta\,(P_t - \tilde{P}_{t-1}) \\ \tilde{S}_t - \tilde{S}_{t-1} = \beta\,(S_t - \tilde{S}_{t-1}) \end{array}\right\} \ldots\ldots\ldots (2)$$

Equations (1) and (2) are combined to eliminate the price expectation variable and to bring them in a form that can be estimated, which is:

$$X_t = a_0\,\beta + a_1\,\beta P_t + a_2\,\beta S_t + (1-\beta)\,X_{t-1} + v_t$$

where $v_t = u_t - (1-\beta)\,u_{t-1}$.

From this model we have dropped the explanatory variables S_{t+1} and n, *i.e.*, the expected price of an alternative crop and the age-composition of trees respectively. We have tried Fisherian and Nerlovian types of price expectations, which involve lagged independent variables and in the case of Nerlovian model even lagged dependent variables.

The problem with the use of lagged endogenous variables in the presence of serial correlation (amply discussed in the literature on econometric methods) is that the estimates got are subject to a marked bias and the use of the Durbin-Watson statistic in these cases is invalid.

Nerlove (10) starts with the proposition that 'normal' price expected in future depends on what prices have been in the past. This idea is earlier developed in Hicks (8), Koyck (9) and Cagan (4). So that this introduces lagged independent variables. In a planting decision model the newly planted area as a percentage of acreage under the tree being studied is the endogenous variable and in the Nerlovian model, this endogenous variable appears in a lagged form as an independent variable. Now by using the Ordinary Least Squares Method, we got biased estimates. Moreover, the use of Durbin-Watson statistic in this case is invalid.

Griliches (6) suggested a way out of this by the use of Two-Stage Least Squares. That is, first regress Y_t on x_t then add x_{t-1}, x_{t-2} and so on as long as regression coefficients make sense, then regress Y_t on x_t and $\hat{Y}_{t-1}$ (*i.e.*, estimated $\hat{Y}_{t-1}$ which gives the highest R^2 and significant estimates).

Stage I $Y_t = \beta_1 x_t + \beta_2 x_{t-1} + \beta_3 x_{t-2} \ldots\ldots\ldots$

Stage II $Y_t = \beta_1 x_t + \beta_2 \hat{Y}_{-1}$

Now the Durbin-Watson statistic can be used and the estimates will be unbiased. This is what we have done in the Nerlovian model (TSLS). But it has been found that in such a model, multicollinearity presents a problem. Using the independent variables this way causes x_t, $x_{t-1} \ldots$, etc., to be linearly related.

Gwyer (7) uses Fisher's (1937) Method of Compound Variable to get round this difficulty of multicollinearity. Fisher suggested a method of constructing a compound variable which incorporates a lagged weighting system following a simple linear lag scheme.

$$
\begin{aligned}
X_1 &= (3X_t + 2X_{t-1} + X_{t-2}) \\
X_2 &= (4X_t + 3X_{t-1} + 2X_{t-2} + X_{t-3}) \\
X_3 &= (5X_t + 4X^{t-1} + 3X_{t-2} + 2X_{t-3} + X_{t-4})
\end{aligned}
$$

and so on.[4]

SPECIFICATIONS OF THE MODELS USED AND THE RESULTS OBTAINED

The six types of Fisher lags studied here are patterned on Gwyer's study of Tanzanian sisal.

A. Declining Weights Specification

Under this specification the producers are assumed to form their expectations as to future prices on the basis of current prices and past prices with declining weights. A long-run and a short-run response are implied, since the effect of a given price in one period is assumed to be distributed over more than one subsequent period.

For example, we give two examples of the Fisher model. In Fisher I we estimated:

$$
\begin{aligned}
(a)\ \ Pxw_2 &= 1/3\ (2P_t + P_{t-1}) \\
(b)\ \ Pxw_3 &= 1/6\ (3P_t + 2P_{t-1} + P_t)
\end{aligned}
$$

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[4] In the Fisherian Method, "The influence of any given variable X on Y is assumed to taper off by equal decrements for each successive time unit. In successive trials the best linear distribution curve is estimated, the "best" being that which gives maximum correlation. . . ." (*i.e.*, "with the variables X_1, X_2, X_3, etc., substituted in successive regression runs, choice being made on the basis of highest R^2 and significance of the regression coefficients"). See Gwyer (7).

and two more Pxw_5 and Pxw_7, *i.e.*, the price variable was formed as a weighted sum of current and past few years' price with declining weights (N_t/T_{t-1}) (*i.e.*, newly planted area as a ratio of tappable/mature acreage) was regressed on this price variable.

Similarly, in Fisher II the weighted sum of the logarithms of these prices was taken. Two equations were estimated with $Plxw_3$ and $Plxw_5$.

B. *Unweighted Average Specification*

Here equal weight was accorded to current price and previous year's price and its arithmetic mean was taken.

Nerlove method: In all the Fisherian equations except for Fisher II (*a*), we get a negative relation between the compounded price variable and the newly planted acreage as a percentage of tappable area. In all the cases, more or less the estimate of the coefficient of price attains significance at .05 level when the trend variable and the dummy variable are included. R^2 and D.W. in most cases are not satisfactory.[5]

Nerlove Model

We estimated quite a few equations starting with regressing the sum of the newly planted area and replanted area (N_t/T_{t-1}) on P_t, then on P_t and P_{t-1} and so on till we included P_t, P_{t-1}, P_{t-2}, P_{t-3}, P_{t-4}, P_{t-5}, P_{t-6}, P_{t-7}. We found the coefficients of P_{t-4}, P_{t-5}, P_{t-6}, P_{t-7} positive while the coefficients of P_t, P_{t-1}, P_{t-2}, P_{t-3} were negative. Choosing the estimated (N_t/T_{t-1}) t—1 from the equation where terms upto P_{t-7} were included as explanatory variables, we ran the Second Stage of Least Squares regressing (N_t/T_{t-1}) on P_t and (N_t/T_{t-1}) t—1, *i.e.*, the lagged endogenous variable to get our Two-Stage Least Squares Nerlovian estimates.

We estimated another set of Nerlovian Two-Stage Least Squares regressions with six-year lag using in the Stage I terms upto P_{t-5} as explanatory variables. These two lags were chosen, because the rubber tree matures after 5-7 years.

Results of Nerlove Model (OLS)

R^2 is high in this case. Price coefficient is negative and significant at .10 level of significance. The lagged dependent variable is positive and significant at .05 level. D.W. is not a proper measure in this case. The intercept term is positive and significant at .05 level.

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[5] For detailed results, please refer to the table of regression results in Appendix 2.

Results of Nerlove Model: Two-Stage Least Squares (with a six-year lag)

In these sets of equations the price coefficient and the coefficient of lagged dependent variable are positive. Though the price coefficient is not significant, the coefficient of the lagged dependent variable is significant at .05 level. The trend coefficient and the coefficient of dummy variable are negative all through (unlike in the case of the eight-year lag). A comparison of the eight-year lag equations and the six-year lag equations would throw light on the long-term decision. Upto six years it means, they positively respond, while the eight-year period is farther off. Though even for the eight-year lag we get positive price coefficients in the absence of the trend variable.

Elasticity Estimates

From these equations we have estimated the price elasticities of planting —long-run and short-run—, which is presented in Table III and also in the last three columns of the consolidated table presenting the results of the regression equations (Appendix 2). The long-run elasticities in the Fisherian equations are derived by multiplying the price coefficients by their respective ratios of the means of price and total area (as a sum of newly planted and re-planted area) as a ratio of mean of tappable area (*i.e.*, the mean of dependent variable). The short-run elasticities in these cases are got by multiplying the long-run elasticity by the respective weight (<1) attached to the current price in the coefficient of the compounded price variable.

TABLE III — ESTIMATES OF LONG-RUN AND SHORT-RUN PRICE ELASTICITIES OF PLANTING DECISION

Type of equation		Type of lag	Long-run elasticity	Short-run elasticity	β
Fisher I	(a_1)	Pxw_2	—0.812	—0.568	
	(a_2)	Pxw_2	—0.750	—0.525	
	(a_3)	Pxw_2	—0.167	—0.117	
Fisher I	(b_1)	Pxw_3	—0.803	—0.402	
	(b_2)	Pxw_3	—0.747	—0.374	
	(b_3)	Pxw_3	—0.163	—0.082	
Nerlove	OLS	None	—0.306	—0.106	—0.379
Nerlove	TSLS				
	(b_1)	Six-year Nerlovian	0.176	0.061	0.346
	(b_2)		0.551	0.193	0.350
	(b_3)		0.261	0.101	0.386
	(b_4)		1.04	0.581	0.556

In the Nerlovian model the short-run elasticity is derived by multiplying the current price coefficient by the ratios of mean of P_t and (N_t/P_{t-1}). The long-run elasticity in this case is got by dividing the short-run elasticity by β, the coefficient of expectation. In the Nerlovian case with the help of β we can find out how far back in time price influences. When $\beta=0.379$ as in the case of Nerlove (OLS) from $1-(1-\beta)^N$ we find that six years' prices explain 94.3 per cent of the variation in planting.

CONCLUSION

For policy use, the results with the Nerlovian specification, particularly TSLS may seem to be more reliable. It shows that the producers are influenced by the past six years' prices in their planting decision, and that they positively respond to price. The negative results in the case of the Fisherian specifications may be explained by the fact that the equations using upto five years' prices are not helpful, as the gestation period of a rubber tree to be tappable is seven years. But the seven-year prices equation also gives a negative result. We would have to see what happens if age composition of trees is included as an explanatory variable. To be able to choose between the Fisherian and Nerlovian, we would have to conduct field enquiries to find out whether it is price or age of trees or government subsidies or the price of an alternative crop which weighs more with the producer while taking a decision to plant.

In conclusion, we may say that so far as the tapping decision is concerned, the small holder's supply responds more to current price in the short-run. This is more significant as it is the small holder who predominates in the production of rubber in India to-day. The estates' supply does not seem to be responsive to current price; while long-term planting decision is influenced by the past six years' prices.

We have used a simple model and have not included many other explanatory variables like Government subsidies, inventory/sales ratio, age composition. More variables in an equation means loss of more degrees of freedom and may lead to the problem of multicollinearity. Including more variables would be advisable in a simultaneous equation model framework.

APPENDIX 1

NOTE ON THE SOURCE OF DATA AND THE VARIABLES USED

We have taken (N_t) the total area at the end of each year which includes newly planted area and replanted area from Table 7 of the Indian Rubber Statistics, Vol. 14, pp. 24-25.

An alternative method could have been to take newly planted area from Table 9 and replanted area from Table 10 or the sum of both from Table 8 of the Indian Rubber Statistics (Vol. 14), which gives the year of planting of the various trees at the end of 1974-75. The problem with this is that some of the trees due to uneconomic tapping may have perished in between the years. Hence we preferred Table 7. Thus in a way our (N_t/T_{t-1}) is total area as a percentage of tappable area. But this should serve our purpose as this means that if the total area increases proportionately more than the tappable area, it means newly planted area is increasing.

Our price variable is an average of the averge maximum prices of all grades and average minimum prices of all grades as declared by government with due adjustments for control and decontrol years. An alternative way could have been to take only the price of RMA grade I. But that would have meant considering the area producing only RMA grade I. This cannot be separately studied as from the same tree different qualities of rubber can be produced from the lump or the proper flow.

We have also not included in the independent variable any variable to account for the age factor or price of some other commodity, say, *e.g.*, rice, as in some other studies.

In the equation using monthly data, because the years included in it are years of decontrol, market price of RMA grades 3, 4 and 5 was available. So we used it in the case of the equation using monthly data.

The data on production as given in the Indian Rubber Statistics do not make it clear whether they refer to production or market arrivals. It only states that, "Data relating to production, consumption, indigenous purchase and stock are computed from the various returns received from rubber growers, dealers and manufacturers of rubber goods." This implies that production figures are not pure production figures, but are also based on market arrivals, to the extent they are calculated from returns from dealers and manufacturers.

Our source of data for all these statistics is the Indian Rubber Statistics, Vol. 13 and Vol. 14 (1974, 1975) compiled by the Statistics and Planning Division of the Rubber Board, Kottayam.

APPENDIX 2

REGRESSION RESULTS—LONG-RUN RESPONSE TO PRICE: THE PLANTING DECISION

(DEPENDENT VARIABLE N_t/T_{t-1})

(1955-56—1974-75)

Equation No.	Intercept	Form of price variable	Price co-efficient	Dummy variable	Time	N_{t-1}/T_{t-2}	Error degrees of freedom	D.W.	R^2	Long-run elasticity	Short-run elasticity	β
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Declining Weight Specification												
Fisher I (a$_1$)	233.405* (34.1577)	Pxw$_2$	—.677* (.308)	—8.811 (16.492)	5.206* (2.974)		15	.681574	.250585	—.812	—.568	
(a$_2$)	228.815 (32.313)	Pxw$_2$	—.625* (.286)		4.225* (2.286)		16	.66723	.236325	—.750	—.525	
(a$_3$)	183.267 (22.3279)	Pxw$_2$	—.139 (.120)				17	.073353	.424433	—.167	—.177	
Fisher I (b$_1$)	239.404* (34.881)	Pxw$_3$	—.730* (.314)	—8.779 (16.190)	5.417* (2.919)		15	.585463	.271661	—.803	—.402	
(b$_2$)	234.823* (33.088)	Pxw$_3$	—.679* (.293)		4.453* (2.262)		16	.578550	.257382	—.747	—.374	
(b$_3$)	184.596* (22.766)	Pxw$_3$	—.148 (.124)				17	.412607	.077642	—.163	—.082	
Fisher I (c$_1$)	242.117* (36.319)	Pxw$_5$	—.733* (.328)	—7.968 (15.493)	4.859* (2.817)		15	.491004	.264412	—.806	—.269	
(c$_2$)	194.550* (25.051)	Pxw$_5$	—.235* (.164)	8.385 (12.989)			16	.450805	.118506	—.259	—.086	
(c$_3$)	237.352* (34.301)	Pxw$_5$	—.682* (.305)		3.973* (2.176)		16	.489750	.251442	—.750	—.250	
(c$_4$)	187.965* (22.485)	Pxw$_5$	—.169* (.126)				17	.380065	.095545	—.186	—.062	
Fisher I (d$_1$)	253.066* (45.705)	Pxw$_7$	—.817* (.409)	—7.692 (15.994)	4.812* (3.074)		15	.471982	.225451	—.899	—.225	
(d$_2$)	195.432* (28.278)	Pxw$_7$	—.244* (.189)	7.565 (13.243)			16	.432357	.098936	—.269	—.067	
(d$_3$)	246.836* (42.764)	Pxw$_7$	—.754* (.377)		3.911* (2.378)		16	.469360	.213509	—.829	—.207	
(d$_4$)	188.296 (24.861)	Pxw$_7$	—.176 (.144)				17	.373632	.080556	—.194	—.049	
Fisher II (a$_1$)	—9.008 (9.204)	Plxw$_3$	5.263 (4.511)		—.436 (1.332)		16	2.505772	.141260	4.79	2.49	
(a$_2$)	—6.650 (5.587)	Plxw$_3$	4.042* (2.476)				17	2.484217	.135500	3.68	1.84	
Fisher II (b$_1$)	343.602* (36.135)	Plxw$_5$	—.633* (.178)		.191* (.051)		16	1.286425	.479830	—.633	—.211	
(b$_2$)	243.644* (31.830)	Plxw$_5$	—.108 (.142)				17	.415527	.032870	—.108	—.036	
Nerlove (OLS)	75.416* (27.658)	P_t	—.105* (.075)			.621* (.135)	17	.849068	.609282	—.306	—.116	.379

(Contd.)

APPENDIX 2 (*Concld.*)

Equation No. (1)	Intercept (2)	Form of price variable (3)	Price co-efficient (4)	Dummy variable (5)	Time (6)	N_{t-1}/T_{t-2} (7)	Error degrees of freedom (8)	D.W. (9)	R^2 (10)	Long-run elasticity (11)	Short-run elasticity (12)	β (13)
Nerlove (2SLS) (7-year lag)												
(1)	21.441	P_t	.206	—2.844	—2.935*	.824*	14	.611252	.554068	1.297	0.227	0.176
	(71.726)	(8-year lag)	(.281)	(11.242)	(2.613)	(.292)						
(2)	81.396*	P_t	—.085	0.636*		.636*	15	.633741	.510793	—0.253	—0.092	0.36
	(48.357)	(8-year lag)	(.109)	(0.241)		(.241)						
(3)	19.543	P_t	.225		—3.280*	.824*	15	.604062	.551873	1.41	0.248	0.176
	(68.907)	(8-year lag)	(.261)		(2.154)	(.282)						
(4)	104.781*	P_t	—.155*			.535*	16	.618385	.477687	—0.365	—0.170	0.4
	(41.893)	(8-year lag)	(.081)			(.218)						
Nerlove (3SLS) (5-year lag)												
(1)	62.059	P_t	.055	—4.80	—1.137*	.654*	14	.593988	.535998	0.176	0.061	0.346
	(60.431)	(6-year lag)	(.494)	(11.249)	(1.053)	(.302)						
(2)	37.744	P	.176	—13.006*		.650*	15	.658390	.494374	0.551	0.193	0.350
	(56.411)	(6-year lag)	(.484)	(—8.340)		(.304)						
(3)	62.275	P_t	.093		1.440*	.614*	15	.581670	.529512	0.261	1.101	0.386
	(58.036)	(6-year lag)	(.472)		(.753)	(.279)						
(4)	6.425	P_t	.528			.444*	16	.503668	.406520	1.04	0.581	0.556
	(55.176)	(6-year lag)	(.449)			(.287)						
B. Unweighted Average Specification												
Fisher III												
(1)	204.069*	P_{x_2}	—.389*	4.643	2.021		15	.524288	.159773	—0.428	—0.214	
	(27.978)		(.238)	(16.636)	(2.165)							
(2)	203.027*	P_{x_2}	—.384*		2.303*		16	.538708	.155409	—0.421	—0.210	
	(26.927)		(.230)		(1.860)							
(3)	182.650*	P_{x_2}	—.139				17	.413820	.250585	—0.152	—0.076	
	(21.648)		(.119)									
Naive Expectations												
	185.081*	P_t	—.145*				18	.418862	.092612		—0.158	
	(20.726)	(no lag)	(.110)									

Note:—Figures in brackets refer to the standard errors of the coefficients.
*Significant at .05 level or at least .01 level.

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