PRICE RESPONSE OF A PERENNIAL CROP: A CASE OF INDIAN NATURAL RUBBER

Literature on crop supply response is concentrated mainly on the supply of annuals, and perennial crops received little attention till the sixties. Perhaps, the first attempt to analyse the supply of perennial crops was made by Ady (1949). Later Bateman (1968) and Behrman (1968) developed and estimated supply models for cocoa. French and Matthews (1971) developed a supply response model for perennials and the same was applied to the United States asparagus industry. Studies on supply of rubber include those of Chan (1963), Olayide (1972), Olayemi and Olayide (1975) and Uma Devi (1977). French et al. (1985) estimated the planting and removal relationships for cling peaches in California.

Perennial crop production differs from that of annuals by the long gestation period between initial capital investment and the first output, a long continuous period of output and finally a gradual decline in yield. Rubber (Hevea brasiliensis) is a perennial crop with a gestation period of six to seven years and an economic life of 25 to 30 years. It is the most important commercial source of natural rubber. The bark of the tree on tapping yields latex which is the rubber of commerce. The demand for rubber and rubber products is fast increasing in India and the world over. During the last many years in India, the supply has been short of demand necessitating its import. The Rubber Board is implementing a number of development schemes like replanting subsidy, plantation loan scheme, distribution of planting materials at subsidised rates, etc., to achieve the long run objective of self-sufficiency in raw rubber requirements. Price being an important stimulant to increase agricultural production, the Rubber Board is also trying to stabilise it at reasonable levels. In the light of the demand and supply situation, it may be useful to analyse the short-term and long-term supply response of Indian natural rubber to prices and the related variables.

METHOD OF STUDY

The analysis was based on the data over the period 1953-54 to 1983-84 published by the Rubber Board and the Kerala State Planning Board. Being a perennial crop, the yield response, new plantings and thus changes in the stock of trees will constitute the total price response.

Yield Response

In the short run, producers can adjust the supply only within their existing productive capacity. They may adjust the yield in response to short run price expectations through more intensive cultivation. The biological nature of rubber production requires at least one year to change the yield through cultural and manurial practices. The lag between fertiliser application and its effect on latex yield varies from one to three years. Thus the important variables influencing yield are short run price expectations, levels of technology, age composition of trees and climatic and other biological factors. Assuming the Nerlovian expectations model, the yield model becomes

\[ Y_t = b_o + \sum_{i=1}^{3} b_i PR_{t-i} + cT + u \quad \ldots(1) \]
where

\[ Y_t = \text{the average yield of rubber in year 't'}, \]
\[ PR_t = \text{the price of rubber in year 't'}, \]
\[ T = \text{the trend variable,} \]
\[ n = 1 \text{ to } 3, \text{ since the lag between fertiliser application and its effect on yield varies from } 1 \text{ to } 3 \text{ years,} \]
\[ u = \text{the random disturbance term.} \]

The effects of changing technology which act as supply shifters are represented by a trend variable. The random disturbance term accounts for the effects of climatic and other miscellaneous factors. The model assumes that the variations in yield due to age composition of trees are negligible and will not be projected as trends.

**Long-term Response**

A long-term supply response model for a perennial crop like rubber must explicitly consider the new plantings, removals and the changes in tappable area. It is assumed that the farmers in general have in mind a desired production and in the long run they will adjust the actual area to attain the desired production. If the desired area is greater than the actual area under rubber, they will undertake new plantings. On the other hand, if the desired area is less than or equal to the actual area there will not be any new planting.

The major variables influencing the desired area are expected price\(^1\) of the crop concerned and that of the competing crop, expectations regarding yield changes and the subsidy for planting rubber. Thus the desired change in tappable area under rubber in a year \((A_{t}^*-A_{t-1})\) may be specified as

\[
A_{t}^*-A_{t-1} = f(PR_{t}^e, PC_{t}^e, \Delta YR_{t}^e, \Delta YC_{t}^e, S_t, u)
\]

where \(A_{t}^*\) = the desired tappable area in year ‘t’,
\(A_{t-1}\) = the actual tappable area in year ‘t-1’,
\(PR_{t}^e\) = the expected price of rubber in year ‘t’,
\(PC_{t}^e\) = the expected price of coconut (competing crop) in year ‘t’,
\(\Delta YC_{t}\) = \(YC_{t}-YC_{t-1}\) = change in expected yield of coconut,
\(S_t\) = the variable to depict the effects of subsidy,
\(\Delta YR_{t}\) = \(YR_{t}^e - YR_{t-1}^e\) = the change in the expected yield of rubber,
\(u\) = the random disturbance term.

Being a perennial crop it requires ‘k’ years, where k is the gestation period to adjust the actual tappable area to the desired level. So operationally, \(A_{t}^*\) may be replaced by \(A_{t}^* + k\) in equation 3. Thus

\[
A_{t}^* + k - A_{t-1} = f(PR_{t}^e, PC_{t}^e, \Delta YR_{t}^e, \Delta YC_{t}^e, S_t, u) \quad \text{...}(3)
\]

Then, the desired plantings in year ‘t’ becomes

\[
P_{t}^* = A_{t} + k - A_{t-1} + RK_t - N_{t-1} \quad \text{...}(4.)
\]
where \( P_t^* \) = the desired plantings in year ‘t’,  
\[ \text{RK}_{t_k} = \] the expected removals during the next ‘k’ years including year ‘t’,  
\( N_{t-1} \) = the non-tappable area (young) in year ‘t-1’.

The desired plantings is an unobservable variable and will differ from actual new plantings due to resource restrictions. The relationship between actual and desired new plantings can be specified as

\[ P_t = \alpha N^*_t + \beta \left( \frac{1}{\alpha} \right) N_{t-1} + e \]

where \( 0 < \alpha < 1 \) is the coefficient of adjustment and \( 0 \leq \beta \leq 1 \) is the coefficient introduced to allow for some dampening of the residual effects of past unattained desired plantings.

Assuming \( \beta = 1 \) and combining equations (3),(4) and (5) the planting model becomes:

\[ P_t = f(\text{PR}^e_t, \text{PC}^e_t, \Delta Y\text{R}^e_t, \Delta Y\text{C}^e_t, A_{t-1}, N_{t-1}, P_{t-1}, S_t, u) \]

**Risk Response**

Area allocations of producers may also be conditioned by their expectations on price and yield risks. The squared deviations of expected values from the actual values were taken as an observation on risk. Thus the price risk, \( RPR_t = (\text{PR}_t - \text{PR}^e_t)^2 \)

Similarly, the yield risk, \( RY_t = (\text{Y}_t - \text{Y}^e_t)^2 \).

The final planting model was estimated with and without the risk variables.

**Expectations**

The new planting model developed above involves price and yield expectations which are unobservable and so should be derived from actual observations. Two expectation models were tried in the present study. In the first model, expectations were derived by the declining geometric lag weight scheme which assumes that the expectations for the current period are derived from all past actual observations in such a way that the recent past observation receives the maximum weight while the distant past observation receives minimum weight. Thus the expected value.

\[ E_t = \sum_{i=0}^{\infty} \beta_i \, O_{t-i} \] where \( \beta_i = \theta(1-\theta)^i \sim 0 \leq \theta \leq 1 \),

\[ E_t = \text{the expectation for the period ‘t’}, \]

\[ O_t = \text{the actual observation for the period ‘t’}. \]

The above model was estimated through a likelihood search procedure. Alternatively, the expected values are derived from the observed values through a seven-year moving average model.

**RESULTS AND DISCUSSION**

1. **Yield Response**

Ordinary least squares (OLS) estimates of the yield response functions are given below.
1. \( Y_t = -18.487 - 0.0448 \frac{PR_{t-1}}{(0.046)} + 1.0773 \frac{T}{(0.0943)} \quad R^2 = 0.9372 \)

\( D-W = 0.413 \)

2. \( Y_t = -18.299 - 0.0527 \frac{PR_{t-1}}{(0.088)} + 0.0110 \frac{PR_{t-2}}{(0.102)} + 1.074 \frac{T}{(0.099)} \quad R^2 = 0.9372, \ D-W = 0.415 \)

*Equation (1)*: With one year lagged price, the trend variable showed significant autocorrelation among the disturbance terms through the \( R^2 \) value which was 0.93. However, inclusion of further lags did not improve the results. So the trend variable was replaced by the lagged yield variable and the results obtained are given below:

3. \( Y_t = 24.342 + 0.0423 \frac{PR_{t-1}}{(0.022)} + 0.9480 \frac{Y_{t-1}}{(0.043)} \quad = R^2 = 0.9804, \ D-W = 1.591 \)

4. \( Y_t = 23.975 + 0.0700 \frac{PR_{t-1}}{(0.047)} - 0.0375 \frac{PR_{t-2}}{(0.057)} + 0.9558 \frac{Y_{t-1}}{(0.045)} \quad R^2 = 0.9807, \ D-W = 1.598 \)

When the trend variable was replaced by the lagged yield variable, the \( R^2 \) value improved to 0.98 and the \( D-W \) statistic showed no evidence of autocorrelation. The lagged price \( PR_{t-1} \) showed positive relationship with productivity. When the number of lags was increased to two, the results improved slightly but further lags did not improve the results. Due to problems of serious intercorrelation, the prices of competing crops were not included in the yield model.

The yield elasticities with respect to lagged rubber prices \( PR_{t-1} \) and \( PR_{t-2} \) were 0.0456 and \( -0.0209 \) respectively. Since cultural practices require at least one year to show the results, it is possible the rubber cultivators might have been influenced by prices, perhaps motivating them to use more inputs and thus productivity showing a positive elasticity with respect to \( PR_{t-1} \). UmaDevi (1977) obtained positive elasticity with respect to the current price. Chowdhury and Ram (1978) in their study on the price response of tea also got negative elasticities of yield with respect to lagged prices.

2. *Long-term Response*

The long-term response functions developed above were estimated with the expectations derived through the geometric lag weight method and the moving average model. The estimates showed that the moving average model performed better than the other in terms of both the \( R^2 \) values and the rationality of the individual regressors. Thus it may be concluded that producers may not consider all past observations to arrive at the expectations for the current period. Instead, they may consider only a few recent observations. Because of the low \( R^2 \) values, the estimates obtained with expectations derived from the geometric lag weight scheme are not reproduced here.

Due to problems of serious intercorrelation with the price of rubber, price of the competing crop (coconut) was not included in the estimation. The subsidy variable was represented
by the amount of subsidy disbursed during the year. OLS estimates of the plantings
response functions are given below:

\[
P_t = 15.749 + 2.1598 \overline{PR}_t + 0.0067 \triangle \overline{YR}_t - 0.1472 A_t + 0.0057 N_{t-1} \\
(0.730) \\
+ 3.2642 S_t + 0.1761 P_{t-1} \quad R^2 = 0.8217, \ D-W = 1.852 \\
(3.966) + (0.267)
\]

Evidently, the expected prices, the change in the expected yield and the subsidy variable
had positive influence on areas planted. When the change in expected yield of coconut and
the risk in rubber prices were included in the above model, the \( R^2 \) value improved slightly.

\[
P_t = 28.347 + 0.1355 \overline{PR}_t + 0.0532 \triangle \overline{YR}_t - 0.3036 A_t \\
(1.891) + (0.052) (0.115)
- 0.0109 N_{t-1} + 0.0657 S_t + 0.0105 P_{t-1} + 3.4886 \overline{RPR}_t - 0.0865 \triangle \overline{YC}_t \\
(0.075) + (0.002) (0.290) (2.588) (0.081)
\]

\[R^2 = 0.8479, \ D-W = 1.730.\]

All the variables considered had the expected signs for their coefficients. Notably, the
change in the expected yield of coconut showed negative relationship which is only to be
expected. Thus the increase in the expected yield of rubber, fall in the yield of coconut and
the increasing rubber prices have made rubber cultivation relatively more profitable which
in turn have accelerated the planting of rubber. Notably, the subsidy variable though not
significant turned out to be positive.

Elasticities with respect to the expected rubber price and the change in the expected yield
at the mean levels were 0.760 and 0.1049 respectively. The elasticity with respect to the
price risk was 1.9759 which implies that rubber growers in general are prepared to take
risk associated with prices. Uma Devi (1977) through two-stage least squares technique
got elasticities ranging from 0.176 to 1.04 for Indian rubber over the period 1948-72.

3. Change in Tappable Area

OLS estimates of the relationships depicting the change in tappable area are given
below:

\[
\triangle A_t = 13.044 + 2.861 \overline{PR}_{t-k} + 0.8296 A_{t-1} + 0.2240 \triangle \overline{YR}_{t-k} \\
(1.282) + (0.078) (0.093)
- 0.1728 \triangle \overline{YC}_{t-k} + 0.0191 \overline{RPR}_{t-k} + 0.6455 S_{t-k} \\
(0.096) + (0.285) (4.314)
\]

\[R^2 = 0.9971, \ D-W = 1.969.\]

\[
\triangle A_t = 12.576 + 2.7583 \overline{PR}_{t-k} + 0.2011 A_{t-1} - 0.1791 A_{t-2} \\
(0.9848) + (0.222) (0.077)
\]
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\[ + 0.209 \triangle \overline{YR}_{t-k} - 0.0822 \triangle \overline{YC}_{t-k} + 0.1408 \overline{RPR}_{t-k} \\
(0.098) \quad (0.1129) \quad (0.274) \]
\[ + 1.241 \overline{S}_{t-k} R^2 = 0.7160, \quad D-W = 2.414. \]

(4.119)

The variables representing the effects of rubber prices, the change in the expected yield, and the subsidy variable had the expected signs and are in line with the estimates of the planting function. However, the subsidy variable and the change in the expected yield of coconut were not significant. The elasticities with respect to the expected price and the change in the expected yield of rubber and coconut were 0.0855, 0.0297 and -0.0035 respectively.

Concluding Comments

The long run elasticities with respect to the expected price, change in expected yield of rubber and coconut and the subsidy variable had the expected signs. Thus the increasing prices and yield of rubber, fall in the productivity of coconut due to pests and diseases and the subsidy scheme for planting rubber might have accelerated the planting of rubber in new areas and substitution of coconut by rubber. Other factors which might have accelerated rubber cultivation are the differential slab rates and exemptions provided in the Agricultural Income-Tax Act in Kerala and the Plantation Labour Act which did not apply to holdings below 10.17 hectares. The Agrarian Relations Bill of Kerala which exempted rubber and other plantation crops from the ceiling level might have resulted in the conversion of large areas into rubber.

As in the case of most other studies on the supply of perennials, the present study also suffers from non-availability of adequate data. All the models considered explained more than 70 per cent of the total variation, showing positive response of yield, plantings and change in tappable area to prices and are consistent with the earlier studies.

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NOTE

1. Since continuous data series relating to the cost of production or an index of input prices are not available, absolute prices were used in the present analysis.

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