MODELLING THE PATTERN OF SPREAD OF THE IDEA OF REPLANTING MORIBUND RUBBER TREES IN SRI-LANKA

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* The views expressed are those of the authors and are not necessarily endorsed by the Commonwealth Secretariat. I am grateful to the anonymous referees for their helpful comments.

Abstract

This paper focuses on the need for different extension methodologies to meet the needs of the different categories of rubber planters as one of the approaches of tackling the problems of declining rate of replanting uneconomic farms. Data on rubber replanted hectares in Sri Lanka are used as proxy for the number of producers who replanted their moribund rubber trees and fitted to two equations representing two model which are presumed to reflect rubber farmers' decision patterns. The first model represents an imitator pattern wherein the replanting process occurs through learning and imitation by potential replanters of farmers who have replanted their moribund trees previously. The second views the decision to replant as proceeding from a 'constant source' outside the farmer's social system and independent of the number who have already replanted their moribund trees.

The statistical analysis of the equations representing the two models indicates that data from the large-estate category fit the constant source model well while data from the medium and small-holding estates fit the imitator model well.

These findings suggest that extension agents in Sri Lanka should endeavour to follow an audience-segmentation strategy and employ different extension approaches with each category of farmers in that country.

Introduction

Periodic replanting of perennial crop stands becomes necessary as productivity declines with age. Consequently, most governments in developing countries, usually incorporate a replanting scheme in their Tree Crops Rehabilitation Programme (TCRP) in order to raise and maintain their productivity of the crops and the income of farmers whose livelihoods depend on these crops. Replanting of perennial crops involves considerable amount of capital investment. For example, cocoa, rubber, tea, kola and coffee replanting schemes involve felling and uprooting of moribund trees, field clearing, using soil conservation measures, raising and transplanting seedlings as well as applying fertiliser and spraying chemicals against pests and diseases. While all these activities are labour-intensive, there is also some time lag between time of replanting and the period farmers start to reap the fruit of their investment in replanting. The gestation period in cocoa and rubber, for instance, is about six to eight years. Hence, farmers' investment behaviour has an important bearing on the replanting decision.

Governments in developing countries usually provide some incentives to encourage farmers to replant moribund trees. For instance, in 1953, the government of Sri Lanka introduced a Rubber Replanting Subsidy Scheme (RRSS) to encourage rubber producers to replant their uneconomic rubber trees. The subsidy includes a cash payment which covers a considerable proportion of replanting costs and the provision of inputs such as planting materials, fertiliser and chemicals (Jayasena and Herath, 1986). Nevertheless, the rate of replanting in Sri Lanka has not been encouraging as many hectares of rubber farms are yet to be replanted. Some of the reasons advanced for this situation include an inadequate replanting subsidy, inadequate supply of inputs, and slow and cumbersome administrative procedures relating to the subsidy scheme.

The importance of the study of rubber replanting is reflected by the amount of literature published recently and the multidisciplinary nature of contributors. While considerable attention has been paid by some researchers to an examination of the socio-economic factors that influence farmers' decisions to replant, others have considered the economic conditions of rubber smallholders who constitute the largest proportion of rubber producers (Jayasena and Herath, 1984 and 1986, Yayasuriya and Carrad, 1977). However, in the Sri Lanka context, very little has been done in assessing and understanding rubber replanting process of rubber producers in the country. A knowledge of this process may help policy-makers and extension agencies to formulate appropriate policies and to use extension methods that would enhance the rate of replanting. The objective of this paper therefore is to model Sri Lankan farmers' replanting decision patterns over time with a view to providing a better understanding of the replanting process.

Section 2 describes the model, while Section 3 briefly discusses the Rubber Replanting Subsidy Scheme in Sri Lanka. The empirical results are presented in Section 4, while the final Section contains the concluding remarks.

The Model

Replanting of moribund trees can be likened to the process of adoption of innovation which an individual potential replanter does not accept hastily. It is a phenomenon which is almost always certain to improve yield but at a cost. The decision to replant requires, inter alliea, proper assessment of the new idea by comparing the cost of implementation with the potential benefits derivable therefrom.

Assessing the pattern of spread of the decision to replant moribund trees is necessary since the social and economic impacts of such a decision are only fully realised by all who decide to replant their moribund trees. It may also stimulate adoption of other related innovations that have a positive impact on the welfare of the producer whether or not they are directly related to rubber production.

To develop an analytical model for studying the process of rubber replanting by Sri Lankan farmers, it is assumed that they are an economic entity in a social system who are exposed to new farming ideas and interact among themselves within their community. Consequently, it is hypothesised that the number of producers who have already replanted their farms influences those who are yet to replant and therefore affects the rate at which moribund trees are replanted. The central characteristic of the replanting process is therefore the 'band-wagon' effect after, at least, one producer in the community has already put the idea of replanting into practice. The replanting process occurs through learning and imitation, by potential replanters, of producers who have already replanted previously. This imitator model implies that most rubber producers depend mainly upon information on replanting that is conveyed to them from others like themselves who have previously replanted their moribund trees.

This proposition, which derives from the pioneering work of the anthropologists and sociologists in the spread of new ideas, has been extensively used to model the spread of epidemic diseases and technologies (Coleman, 1964; Griliches, 1957; Mansfield, 1961).

The form of the equation used can be represented as:

$$\frac{\Delta A_t}{\Delta t} = b A_t (N - A_t) \qquad (1)$$

Where A_t is the cumulative number of individuals (or units) already in contact with a piece of information at time t, N is the fixed population size of the community, the parameter b indicates 'the potency of spread'. Equation (1) indicates that the number of new replanters per unit time is proportional to the number who have already replanted (A_t) and to those who are yet to replant ($N - A_t$).

By integration and some algebraic manipulations, equation (1) becomes

$$\frac{A^t}{N - A_t} = \frac{A_o}{N - A_o} e^{bt} \qquad (2)$$

(e means exponental)

Assuming $\frac{A_0}{N - A_o}$ equals a, some algebraic manipulation gives:

$$\ln \frac{A_t}{N - A_o} = a + bt \quad (3)$$

Equation (3) is the well known logistic time curve which implies that the process of spread which begins at initial point A ends asymptotically at N_∞(Davies 1979). In the logistic curve the point of inflexion occurs at the point when 50 per cent of the population have adopted the new idea. This indicates that the spread of the new idea acelerates until half the population has put the idea into practice at which point it begins decelerating.

An alternative proposition in modelling the Sri Lankan rubber replanting pattern is that a decision to replant proceeds from a constant source and independent of the number who have already replanted their moribund trees. Here, the number of new replanters per unit time is proportional to the total number who are yet to replant. The mathematical formulation of this theory is of the form:

$$\ln \frac{A_t}{N - A_t} = b (N - A_t) \qquad (4)$$

where b is a constant measuring the rate of innovativeness of the potential rubber replanters; other symbols are as defined above.

By intergration and some algebraic manipulation

$$\ln (N - A_t) = a + bt \qquad (5)$$

This model yields an inverted exponential curve with an upper limit determined by the population of the community (Leik and Meeker 1975).

In the constant-source replanting theory, it is believed that individuals evaluate the idea of replanting on the basis of its advantages as revealed to them by mass media and/or extension personnel. Each farmer makes the decision to replant without any influence whatsoever from his neighbours. This category of farmers play an important role in the replanting process by launching a new idea among the community and are considered by the society to be venturesome and courageous (Rogers 1983). They play a 'gate-keeping' role in the flow of replanting moribund rubber trees in the society. Although they may be in contact with other replanters in the community they are not influenced by them.

The Rubber Replanting Scheme in Sri Lanka[1]

Rubber was introduced into Sri Lanka towards the end of the 19th century by British-owned companies who established and cultivated large rubber plantations. By 1900 about 729 hectares of rubber were under cultivation. The area continued to expand at an increasing rate until the 1930s when its rate of growth declined. There were also considerable increases in both rubber output and the number of smallholders engaged in rubber production until the 1940s, when there was a turning point in the history of rubber industry in the country. Some of the early plantings were then old and the 'slaughter tappings' introduced during the war left a decadent industry with a considerable number of moribund rubber trees.

Although rubber output continued to decline considerably, there was little or no well established government policy regarding replanting when the first set of rubber plantations were 30-40 years old; the limited replanting done at that time was undertaken as a result of individual farmer initiative.

The gravity of neglecting the replanting of moribund trees was revealed by a number of studies. For instance, the Rubber Master Plan Study, conducted by the Commonwealth Development Corporation (CDC, 1979), estimated that about 70,850 hectares of rubber were uneconomic by 1947 but than only about 8 per cent of the total rubber area in the country were replanted by 1950. The CDC study also showed that moribund rubber trees were a major problem of all categories[2] of farms, as 19-26 per cent of the rubber area belonging to all of them were due for immediate replanting. Another investigation by Ramachandra (1963) revealed that about 30 per cent of privately owned rubber lands were beyond the state of economic exploitation.

As a result of the continued decline in the yield and income of rubber farmers in Sri Lanka, the government introduced a Rubber Replanting Subsidy Scheme (RRSS) in 1953 to encourage farmers to replant their moribund rubber trees. Under the Scheme, the government provides cash to cover part of the replanting costs and to purchase essential inputs such as planting materials and fertiliser. Another motive behind introducing the Scheme was to reduce hardship on farmers as replanting of rubber always results in deferment of present incomes which may be a serious disincentive to embarking on the project. Subsidy rates, which varied between 1953 and 1973 according to whether replanting was to be done on large estates, medium estates or smallholdings were revised annually : the rate became uniform in 1974. Rubber

producers wishing to benefit from the Scheme must register their rubber land with the Rubber Control Department and provide evidence of ownership. The land must be suitable for rubber cultivation and the rubber plantation more than twenty years old.

Although it has always been the intension of the government to replant about 3 per cent of the moribund hectares annually, Tables 1 and 2 indicate that the rate of replanting has fallen below the minimum replanting rate over the past thirty-three years with few exceptions. For Sri Lanka as a whole, the expected target rate was only met between 1955 to 1958. The uncertainty created by government threats in the 1960s and 1970s to nationalise foreign assets and to restrict foreign investment, and the 1972 land reform laws which limited individual land ownership by foreigners to 20.2 hectares as well as other changes in land ownership, may have attributed to the declining rate of replanting uneconomic farms in the country up till the late 1970s. Other possible reasons include government policies deliberately made to promote the growth of more traditional export crops like cocoa, coffee and spices, the escalating cost of producing rubber and the declining world market prices for rubber in the late 1960s and early 1970s (Jayasena and Herath 1986, Yayasuriya and Carrd 1977). The relatively higher rate of replanting by smallholders may be attributable to a slower rate of decline in profitability in their rubber enterprise as family labour is mainly used for working in their farms. Even when hired labour is employed, the cash costs are relatively small when compared with the expenses of the estates which have to provide housing and other facilities for their workers as stipulated in the wages and remuneration law (Jayasena and Herath 1984). Besides, institutional uncertainties which affected the large and medium estates are likely to have little or no effect on smallholders.

Empirical Results and Discussions

The annual time series data used in this study are drawn from Jayasena and Herath (1986). Replanted rubber hectares[3] from 1953 to 1984 are used to test the models described in section 2. The first-order autocorrelation estimates of equations (3) and (5) using the Cochrane-Orcutt[4] procedure to correct for autocorrelation are presented in Table 3. The results indicate that data from the large estate fit the constant-source model reasonably well while data from the middle and smallholding estates fit the imitator model well with their R^{-2} values ranging from 0.27 to 0.79. The coefficient measuring the rate of innovativeness of farmers is statistically significant, at the 7 per cent level, only in the large estate category, while the ones measuring the rate of imitativeness of farmers are statistically significant, at the 2 and 8 per cent levels, in the medium and small estate categories respectively. Although all the coefficients have the expected positive sign the ones measuring the rate of innovativeness of farmers in the medium and small estate categories and the one measuring the rate of imitativeness of farmers in the large estate are statistically insignificant.

The empirical result of the models developed in this study suggests that the time pattern of rubber replanting decision among large estate farmers in Sri Lanka may be represented by a constant-source model which is based on a decision that is taken independent of the number of farmers who have already replanted their moribund trees. As for the medium estate, and the smallholders it is estimated that farmers would consider the experience of their near-peers before deciding to replant their moribund rubber trees. Four reasons may be given for the pattern observed in this study. First, because large estate farmers are relatively richer, more educated, more metropolitan, and are more commercially oriented, they tend to make more use of extension services, such as those of the Rubber Research Institutes, mass media, journals, leaflets and extension agents, than others. They are therefore in a better position to learn more quickly about new ideas and be able to perceive more quickly the advantages of

replanting their moribund rubber trees. Secondly, because of their financial and political position in the community, they tend to have more access to bank loans which may be used to carry them through the gestation period of replanting their moribund trees. Thirdly, as indicated earlier, rubber farmers in Sri Lanka consist of foreign large estates companies who have enough capital and experience to exploit international markets to best advantage. By the 1930s the early plantings were already old to make any economic return leaving farmers the option of replanting. Because large estate companies are business oriented, it is not unlikely that they would be willing to consider instantly the proposition to replant moribund trees. Finally, felling and replanting two or three hectares of rubber each year may be insignificant for the large-scale estate farmers who control about 40.5 or more hectares of rubber plantation. As for the other categories of farmers, especially the smallholders, the idea of felling part of already small farm holdings would need to be carefully considered before any decision is taken. Such farmers are therefore more likely to be influenced by the experience of neighbours who have successfully replanted their holdings.

The major implication of the result of this study is that extension agents in Sri Lanka should endeavour to stratify a somewhat heterogeneous rubber farmers into a series of relatively more homogeneous sub-audiences. Different extension approaches involving the use of different communication channels or messages can be employed with each category of farmers in that country. Personal face-to-face communication methods could be used to transmit information about the replanting exercise among the medium and smallholders who tend to be more 'conservative' and less innovative and among whom interaction and communication with other members in the community is essential. Conversely, impersonal communication systems which include mass media and reach a large number of people per message over a greater spatial range would be more appropriate in transmitting information to the large estate farmers who tend to be more dynamic and innovative producers.

Since the decision pattern of large estate farmers concerning replanting of moribund rubber trees is different from that of others, it is recommended that the Sri Lanka government should, *inter allied,* identify farmers in each category and use different extension methods to promote the idea of replanting moribund rubber trees in the country. An effort should therefore be made to intensify the activities of the Rubber Research Institute, mass media and other change agents that are concerned with promoting the idea of replanting moribund rubber trees. The farmers' programme on rubber replanting could feature prominently in national and local radio and television stations, as well as newspapers. As for the other categories of farmers, the government should promote the establishment of co-operative societies among the medium and smallholders so as to increase their social interaction. An effort should also be made to see that farmers participate actively in the activities of their various local societies and that the extension agents also play an active part in promoting interaction and exchange of ideas among members. If such measures are taken, in addition to providing incentives, many farmers would be encouraged to replant their moribund rubber trees and the government target of annual rate of rubber replanting may be achieved.

[1] This section is based largely on Agrarian Research and Training Institute (ARTI) Research Study No. 74 (Jayasena and Herath, 1986).

[2] Three categories of farms are identified: the large estate over 40.5 hectares, the medium estate with 4.1 — 40.5 hectares and the smallholding with less than 4.1 hectares.

[3] Although the number of producers who replanted their moribund rubber trees have been specified in the models in section 2, it is not uncommon to use farm size replanted as a proxy for the number of producers in the absence of data to estimate the equations. Hence A becomes the cumulative hectares by the time the process ceases (Griliches 1957, Jarvis 1981).

[4] The estimates obtained using OLS show low Durbin-Watson statistics (D W ranged from 0.20 to 0.80). This indicates that serial correlation is likely to be present in the estimated residuals. In order to correct the presence of positive first-order serial correlation the equations were re-estimated using the Cochrane-Orcutt differentiating procedure which involves a series of iterations. The DW statistics improve considerable to about 2 as shown in Table 3.

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Table 1

PROGRESS IN RUBBER REPLANTING ACCORDING TO HOLDINGS; 1953 — 1983

Item	*Large Estate (above 40.1 hectares)*	*Medium (4.1 — 40.5) hectares)*	*Smallholdings (below 4.1 hectares)*	*Total*
Target (hectares)*	100,744.0	59.965.5	85,300.5	246,010.0
Actual (hectares)	73,741.5	37,446.0	59,639.5	170,045.5
Percentage of target	73.2	61.1	69.9	69.1

Source: Calculated from records of the Rubber Control Department

Note: *Area expected to be replanted during 1953 — 1983, at 3% annual replanting rate.

Table 2

ANNUAL RUBBER REPLANTED AREA AND RATES IN SRI LANKA
1953 — 1984

Year	Large estates		Medium eatates		Small holdings		Sri Lanka	
	Area Repl. *(hect.)*	Rate (%)	Area Repl. (hect.)	Rate (%)	Area Repl. (hect.)	Rate (%)	Area Repl. (hect.)	Rate (%)
1953	1,760.0	1.2	401.0	0.6	188.0	2.6	2,349.0	0.8
1954	3,810.0	2.7	2,076.0	3.5	1,589.0	2.1	7,475.0	2.8
1955	3,711.0	2.7	3,294.0	5.5	2,271.0	3.0	9,276.0	3.7
1956	4,375.0	3.3	2,840.0	6.5	2,742.0	3.7	9,957.0	3.7
1957	4,025.0	3.0	3.030.0	4.8	2,758.0	3.7	9,813.0	3.7
1958	3,349.0	1.5	2,358.0	3.7	2,652.0	3.4	8,359.0	3.1
1959	2,505.0	1.9	1,849.0	3.9	3,151.0	4.0	7,505.0	2.7
1960	2,496.0	1.9	1,838.0	2.8	2,912.0	3.7	7,246.0	2.6
1961	3,085.0	2.3	1,675.0	2.6	2,808.0	3.6	7,568.0	2.7
1962	3,026.0	2.3	1,414.0	2.2	2,831.0	3.5	7,271.0	2.7
1963	2,864.0	2.2	1,091.0	1,7	2,490.0	3.1	6,445.0	2.4
1964	1,943.0	1.5	1,560.0	2.5	1,986.0	2.4	5,489.0	1.8
1965	1,822.0	1.4	1,285.0	1.1	1,975.0	2.4	5,064.0	1.9
1966	1,866.0	1.4	1,268.0	2.0	1,961.0	2.4	5,095.0	0.6
1967	1,889.0	1.4	1,586.0	2.5	1,337.0	1.5	4,812.0	0.6
1968	2,471.0	1.9	953.0	1.5	1,734.0	2.1	5,158.0	1.9
1969	2,521.0	1.9	708.0	1.1	1,665.0	2.0	4,494.0	1.8
1970	2,024.0	1.6	692.0	1.1	1,431.0	2.0	4,147.0	1.5
1971	1,673.0	1.3	553.0	0.8	1,208.0	1.4	3,434.0	1.2
1972	2,140.0	1.7	449.0	0.7	952.0	1.1	3,541.0	1.2
1973	1,641.0	1.4	375.0	0.5	931.0	1.0	2,947.0	1.1
1974	1,541.0	1.3	339.0	0.5	987.0	1.1	2,867.0	1.1
1975	1,695.0	1.5	377.0	0.5	1,160.0	1.3	3,232.0	1.2
1976	1,102.0	0.9	316.0	0.4	1,132.0	1.2	2,550.0	0.9
1977	1,107.0	0.9	313.0	0.4	1,198.0	1.3	2,618.0	0.9
1978	1,492.0	1.4	320.0	0.6	1,415.0	2.0	3,227.0	1.4
1979	1,920.0	1.7	391.0	0.6	1,858.0	2.1	4,169.0	1.5
1980	2,310.0	2.0	696.0	1.0	2,432.0	2.7	5,438.0	2.0
1981	3,052.0	2.7	829.0	1.2	2,563.0	2.8	6,444.0	2.4
1982	2,709.0	2.4	1,180.0	1.7	2,945.0	3.1	6,834.0	2.5
1983	1,818.0	1.6	650.0	1.0	2,396.0	2.6	4,864.0	1.8
1984	1,777.0	1.6	741.0	1.1	3,014.0	3.2	5,532.0	2.0
Total	75,519.0	(1.8)	37,446.0	(1.9)	62,653.0	(2.4)	175,618.0	(1.9)

Source: Calculated from records of the Rubber Control Department Colombo, Sri Lanka
Figures in parentheses are averages

Table 3

FIRST ORDER AUTOCORRELATION RESULTS FOR THE RUBBER REPLANTING DECISION ACCORDING TO FARM CATEGORIES IN SRI LANKA

Farm category	*Model*	*Estimated Value of*				
		Parameters;		*Level of significance*	$\overline{R}^2$	*Durbin-Watson*
		a	*b*			
Large Estate	Constant Source	4.2877 (4.63)	0.0174 (1.88)	7	0.79	1.67
	Imitator	4.3264 (2.66)	0.0002^{NS} (0.97)	34	0.47	1.65
Medium Estate	Constant Source	2.0301 (1.83)	0.0172^{NS} (0.75)	4.6	0.23	1.64
	Imitator	0.2275 (0.16)	0.0021 (2.53)	2	0.27	1.59
Smallholding Estate	Constant Source	4.2288 (3.13)	0.0001^{NS} (0.42)	68	0.20	1.61
	Imitator	7.5733 (3.0)	0.0407 (1.79)	8	0.41	1.56

Figures in parentheses are the t-ratios

NS means not significant at the 10 per cent level