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A Bouncing Ball:
Long-Run Cyclical Instability in the Sri Lanka Rubber Industry

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Abstract: Data on the age distribution and yields of Sri Lanka rubber are used to generate forecasts of rubber production based on alternative replanting policies. Such projections do not take into account short-term fluctuations caused by weather or responses to changes in producer prices. Most of the replanting policies result in long-run cyclical instability in planting and production. Contrary to other studies, the results suggest that rubber output levels will decrease steadily over the next 10 years before starting to recover. The study also suggests that there is a substantial gap between productive capacity and likely output levels.

Introduction

This paper undertakes a simple forecasting exercise to examine the impact of past planting decisions on future Sri Lanka rubber production. Our reasons for reporting these results are our dissatisfaction with similar attempts by others and the recent availability of an improved data base.

Natural rubber production is unique among important commercial tree crops in that current harvesting techniques result in the gradual destruction of the tree by ring barking. For an individual tree of a particular clone in a given environment on a given soil, the current flow of production is determined by the age of the tree, how well it has been maintained, the rate at which its bark has been removed, and the rate at which it is currently being removed. For a particular farmer, the current flow of rubber production is determined by the existing stock of trees of each clone of different ages multiplied by the clone/age specific yields. Thus, current output is constrained by past planting and exploitation decisions. In the same way, future output will be constrained by present planting and exploitation decisions.

A baby boom in a human population results in a cohort "bulge" that gradually works its way up the demographic pyramid. In so doing it has ramifications on demand patterns, incomes, and dependency ratios. In parallel fashion, planting booms in tree crops work their way up the age profile with implications for production and processing. Marketing and national planning policy need to be able to forecast such long-run cyclical patterns. While short-run deviations from those trends are to be expected due to fluctuations in climatic conditions and in the response of producers to current market prices, the crucial policy perspective is that the long run trends themselves cannot easily be avoided without radical changes in the technology of exploiting the rubber tree.

The data used in this study come from two main sources: the *Annual Administrative Reports* of the Rubber Controller, which provide data on area, production, and prices; and the *Rubber Industry Master Plan (RIMP) Study of Sri Lanka*.[2] Unlike the Rubber Controller's data sources, the latter source is a cross-section survey carried out in 1978 to investigate age-specific area, bark consumption, and remaining life of the trees and their general condition.

Natural rubber prices have had a history of wide fluctuations with a log-normal distribution in which the peaks are followed by relatively flat troughs. Prices peaked in 1910, 1925, 1950/51, with lesser peaks in 1955, 1960/61, 1973/74, 1979/80, and 1983/84. Following the initial burst of planting in the period 1905 to 1910, plantings expanded rapidly during the 1920s. By the start of World War II, the total area under rubber was about 250,000 ha. The official statistics since 1945 are given in Table 1 (page 6). At the end of the 1970s, the total rubber area in nine main rubber growing districts of Sri Lanka was estimated by the aerial photographic analysis of the RIMP Study to be 210,465 ha. That figure is below the figure given by the Rubber Controller (226,400 ha) but is close to the estimates provided by the Agricultural Census (1972/73) and Agricultural Productivity Committee Survey (1973), with figures of 205,800 and 209,800 ha, respectively.

While the impression given by Table 1 is one of basic stability in the size of the area under rubber, the need for major periodic downward adjustments (in 1962 and 1981) suggests that the official records are not entirely satisfactory and belie an underlying downward trend of between 0.5 and 1.0 percent per year. The total area under rubber also gives no indication of the underlying dynamics of the life cycle of each stand of rubber trees. That cycle consists of an immature phase of about six years when no latex is harvested, followed by about five years of rapidly increasing yields, a ten-year plateau of reasonably constant yields, and then progressively declining yields. If senile rubber stands are not abandoned or withdrawn from rubber production, they must be replanted. Optimal

Table 1—Area Replanted, 1945-1978

Year	Total Area	Replanted Area	New Planted Area	Replanted Area as a Percentage of Total Area
	'000 ha	ha	ha	percent
1945	267	38	1,104	0.02
1946	267	666	613	0.25
1947	267	857	183	0.33
1948	267	592	119	0.23
1949	265	890	232	0.34
1950	265	1,565	272	0.59
1951	265	1,387	570	0.53
1952	266	1,700	553	0.64
1953	266	2,348	348	0.89
1954	267	7,472	619	2.80
1955	268	8,464	502	3.17
1956	268	9,809	1,130	3.67
1958	269	8,355	935	3.11
1959	271	7,503	813	2.78
1960	271	7,244	786	2.68
1961	272	7,565	572	2.79
1962	230	7,269	277	3.17
1963	230	6,442	268	2.81
1964	230	5,487	171	2.39
1965	230	5,061	260	2.20
1966	231	4,689	57	2.04
1967	230	4,083	55	1.78
1968	230	5,155	237	2.24
1969	230	4,892	126	2.13
1970	230	4,145	112	1.80
1971	230	3,431	238	1.50
1972	230	3,539	180	1.55
1973	229	2,946	186	1.29
1974	228	2,865	34	1.26
1975	228	3,230	142	1.42
1976	227	2,550	56	1.12
1977	227	2,617	45	1.15
1978	226	3,225	378	1.42
1979	*226	5,381	582	2.37
1980	*227	5,433	977	2.39
1981	*206	6,442	1,055	3.13
1982	*206	6,376	1,650	3.10
1983	*206	4,862	†	2.37
1984	*206	5,530	†	2.69

[Sources: 1945-77, 1979-81, and 1983—Department of Rubber Control, Sri Lanka; and 1978, 1982, and 1984—Central Bank of Ceylon. *Preliminary estimate. †Not available. Data for 1957 were missing from the authors' table—Eds.]

replacement dates typically occur when the trees are between 25 and 35 years of age (Etherington, 1977). The dynamics of the cyclical pattern are reflected in the replanting statistics in Table 1. Replanting decisions have been significantly influenced by the periodic introduction of government replanting subsidy schemes (1953-64 and 1979-84).

Replanting Policies

Bursts of replanting activity and the production cycle are reflected in output statistics. Thus, trees planted in the early 1950s are now in the replanting phase. The impact of that can be demonstrated simply by the application of a set of alternative replanting policies. Given the RIMP estimates of the size and age distribution of the national rubber "estate" for different farm size groups, a set of five purely mechanistic "demographic" replacement models are applied to the data. The models are mechanistic in the sense that three of them do not allow deviations from deterministic cohort or vintage replacement cycles. Thus, changes in the relative price of rubber are assumed to have no impact; yet we know that, historically, the Sri Lanka rubber industry has responded to high prices by increasing the intensity of exploitation, raising output, and, consequently, altering the length of the replacement cycle (Hartley, Nerlove, and Peters, 1984).

Using 1978 (the year of the RIMP survey) as the starting date, five replacement policies are applied to the national estate: a 26-year replanting cycle, a 30-year replanting cycle, a 33-year replanting cycle, replanting 3 percent of the area per year, and a replanting policy based on farmers' expressed intentions to replant.

The first three policies are based purely on the age of the trees; that is, whenever a rubber tree is either 26, 30, or 33 years of age, it is replanted. The first two cycle lengths were selected on the basis of the analysis of optimal replacement ages under varying assumptions. The selection of the 33-year policy is particularly important since the official rubber replanting scheme operates within an implied replacement cycle of that length. That has been the accepted "rule of thumb" of the rubber industry. While a crop cycle of 33 years implies 3 percent annual replacement, a major distinction must be drawn between a cycle based on age and one based on a percentage of the area planted. In the former case, the annual replanted area depends critically on the cohort structure of past planting. In the latter case, the annual replanting depends only on the total area under rubber and not on the age structure of the trees. An age-specific replanting policy will only match a corresponding "percentage-of-area" policy if the latter policy is in fact implemented every year.

The final "policy" under investigation is probably the most realistic since it is based on responses to a RIMP survey question regarding the replanting intentions of the farmers. A significant aspect of that approach is its capability to capture both the "infant" and "juvenile" mortality of the trees. In reality, whatever the replanting policy adopted, it is also important to consider the premature "death" of trees due to wind, drought, excessive rains, disease, or pests. The survey results bore out the contention that replacement should be viewed as a probability distribution rather than a deterministic fact (Etherington, 1977). The cumulative distribution of intended removal dates showed that 4.1 percent of replacement is premature in the sense that removal takes place at ages less than that normally considered to be economic (i.e., 25 years), 80.8 percent is within the range 25 to 33 years, 10.6 percent are allowed to continue into "old age" (34 to 39 years), and 4.3 percent into "senility" (40 years and over).

Policy Projections

With the first three policies, the computer simulations assumed that the area older than the cycle length is "senile" and is replanted in the first year. For policy 5, all trees 41 years of age and older are pooled and the relative frequency of intended removals (3.944 percent) is applied to that area. The fourth policy selects the oldest 3 percent of the area and replants that amount every year. If that policy had commenced in 1978, the total senile area would only have been eliminated by the year 2010.

The rubber production potential is largely predetermined by the yield profile of the trees that are already being exploited. Standard yield curves have been constructed by the Rubber Research Institute of Sri Lanka (RRISL) for large estates (above 40.5 ha) and for smaller rubber holdings. Those yield curves are largely based on the yield pattern of the PB 86 clonal variety operated under good management. Both curves are based on a 33-year replanting cycle. In this study, those yield curves have to be modified to fit the length of each replanting cycle and to distinguish between estates and smallholdings. For projections of future output, two sets of assumptions have been made. The first assumes that new plantings will be of high yielding varieties and, together with the application of fertilizer and stimulants, will give better yields than in the past. For large estates, rubber yields are assumed to peak at between 1,300 and 1,400 kg per ha. For the smaller farms, yields peak about 200 kg lower. Projections based on those yields will be referred to as "production capacity." The second assumption is that current yield levels, which are about 30 percent lower, will continue to hold.

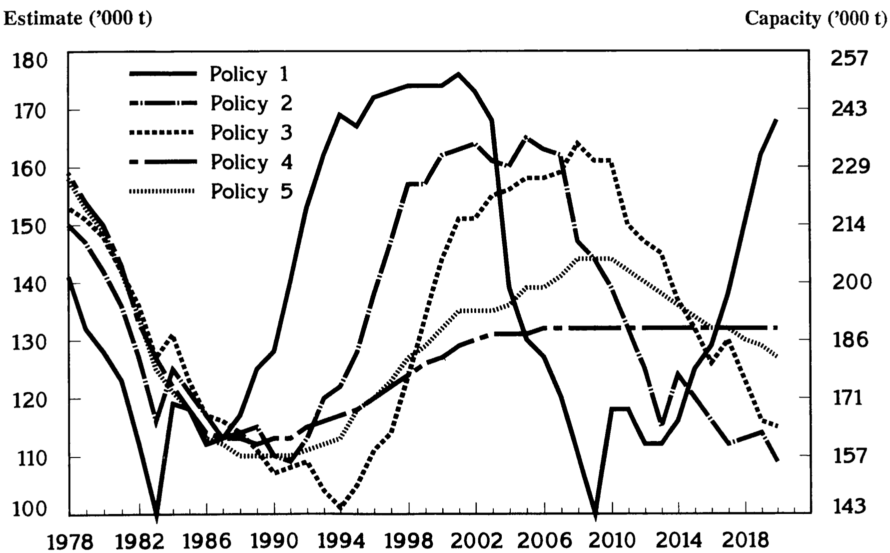
Rubber production is determined by the mature area and the yield curve. Thus, the age forecasts based on the replanting policies and the yield curves together provide forecasts of either "production capacity" or "production estimates," depending on the yield curves selected. The following equation gives this formal expression:

$$(1)\ Q_t = \Sigma a_i X_{i,t} + \Sigma b_i Z_{i,t},$$

where Q_t is the "production capacity" in year t, a_i and b_i are the yield levels of one hectare of rubber in the ith year of tapping for smallholders and estates, respectively, and $X_{i,t}$ and $Z_{i,t}$ are the areas, in hectares, in their ith year of tapping in year t.

Rerun with the lower yields, Q_t gives the "production estimate." The results are summarized in Figure 1. The overall pattern clearly demonstrates the long-run cyclical fluctuations caused by the cohort structure and the age-yield relationship. The cyclical patterns become progressively less extreme and become delayed in time as one moves from Policy 1 to Policy 3 because of the declining size of the senile area replanted in the first year, and because of the greater peakedness of the shorter yield cycles. Policy 4 results in a constant amount to be replanted each year since it is based on 3 percent of a total area which is itself fixed by assumption. Although the area replanted each year is constant, the age structure of the total area at the beginning of the policy is variable so that recovery to constant production levels of about 190,000 t is not achieved until the next century. Policy 5 is expected to be closest to reality. Irrespective of the model chosen, a major decline in Sri Lanka rubber production is predicted to occur between 1978 and 1990.

Figure 1—Sri Lanka Rubber Production Estimates and Capacities



Comparisons and Conclusions

The comparison of our projections of production "capacity" and "estimate" with other projections is given in Table 2, below.

Table 2—Comparison of Results of Different Sources ('000 t)*

Year	Policy 5 Estimate	Policy 5 Capacity	RRISL (1)	ANRPC (2)	World Bank (3)	Smit (4)
1980	147	210	173	180	180	165
1985	118	168	169	193	185	165
1990	110	156	172	174	195	180
1995	114	163	201			195
2000	132	188	245			210

[*These studies and Hartley *et al.*'s (1984, pp. 43-44) results may largely be caused by econometric techniques influenced by a terminal date occurring at or near 1978, the year of peak production. Sources: (1)—Rubber Research Institute of Sri Lanka, 1979; (2)—The Association of Natural Rubber Producing Countries, 1976; (3)—World Bank/FAO, 1978; and (4)—Smit, 1981 (references not provided—Eds.)]

The projections are quite different, particularly in regard to our suggestion of a major decline in production up to about 1995. Our predicted values from Policy 5 are based on the expressed intentions and expectations of the rubber farmers/planters in 1978, prior to any recommendations or proposals under the Rubber Industry Master Plan. It is, therefore, interesting to compare declared intentions with actual replanting in the period 1978 to 1982. Actual replantings have been 26,857 ha as against a declared intention of replanting 25,990 ha. That suggests that the "estimated" output projections should be taken seriously. In particular, the relatively low levels of output during the next 10 years should be noted. A study of the Sri Lanka Ministry of Finance and Planning (*Public Investment Report 1983-87*, May 1983) comes to a similar conclusion regarding those trends: "If the replanting programme continues...production will decline to a low of [100,000 t] by 1986 and then commence increasing rapidly as the replanted acreages mature, regaining the 1978 peak of [158,000 t] by 1995" (paragraph 4.48). Our estimate is for a slightly longer trough with a new peak occurring well after the turn of the century. Actual output figures since 1978 and our production estimates read as follows:

Year	1978	1979	1980	1981	1982	1983	1984	1985
Actual output	155	152	133	124	123	140	*142	†
Estimated output	157	151	147	140	134	129	123	118

[*Preliminary estimate. †Not available. Source: Central Bank of Ceylon.]

The actual output for 1983 and the preliminary estimate for 1984 reflect very substantial yield increases that may be associated with increased "slaughter tapping" in response to the high rubber prices from mid-1983 to mid-1984.

Two conclusions stem from this analysis: many of the projections of Sri Lanka rubber output do not take adequate account of the long-run cyclical fluctuations caused by past bursts of planting and replanting activity and a considerable gap exists between output "capacity" based on technically feasible yield curves and the yield levels actually achieved. The RRISL yield estimates are modest. The International Rice Research Institute has made detailed investigations into the "constraints" that prevent farmers from achieving either experimental yields or those of better farmers. Clearly, a "yield gap" of 30 percent is well worth exploring. The policy implications are fourfold:

- Sri Lanka may reap substantial returns from improvements in the effectiveness of the extension service—especially to the smallholders because their low yield levels provide the greatest potential source of increasing output above historic levels;
- to the extent that yields can be raised by improved practices on existing trees (i.e., disembodied technical change), lessening the extremes of the cyclical instability in the industry may be possible;
- since replanting subsidies exert a specific influence on the replanting, the government should be encouraged to adopt a countercyclical approach whenever low current prices permit; and
- for planning purposes, assembling age-specific data for tree crops with marked life cycles is a useful and important activity.

Notes

[1]The Australian National University.

[2]The major problem encountered in the RIMP survey data was in using sample parameters for estimating population parameters. As a result, in some areas the sample strata had to be added using "best guess" weights. The other main limitation of the RIMP survey was the lack of information on stock depletion.

References

Hartley, M.J., Nerlove, M., and Peters, R.K. Jr., *The Supply Response for Rubber in Sri Lanka: A Preliminary Analysis*, Staff Working Paper No. 657, World Bank, Washington, D.C., 1984.

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