

COST OF CAPITAL AND ECONOMIC EFFICIENCY OF SMALLHOLDER RUBBER PRODUCERS IN ACEH PROVINCE IN INDONESIA

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I. Introduction

Government financed development projects entail complex political and social considerations. The cost of borrowed capital through internal and/or external debt financing, financial feasibility of development projects, and social stability within the project area are all considerations that must be weighed in order to appraise the government's ability to recoup its investment directly through loan repayments, or indirectly through taxes and fees applied to a growing base of wealth if the project is successful. A critical determinant of the success of projects is the rate of interest on borrowed capital which is a required measure for the feasibility of government plans and for individual investors.

The purpose of this paper is to examine the behavior of individual smallholder rubber producers in Aceh Province who are participating in a government settlement scheme. The hypothesis being explored is that the rate of rubber exploitation varies by rate of interest faced by the smallholder. Higher discount rates are

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expected to be associated with more intense tapping systems, i.e. more intensive harvesting systems. There is concern that farmers may tap their rubber trees too frequently in order to gain short-term financial advantages, even though their behavior may result in long-term damage to the trees and reduced future earnings. We hypothesize that the perception of higher discount rates contribute to this behavior.

The behavior of the farmers can be examined in terms of the rate of tapping the rubber trees. The discount rate applied to project analysis and passed on, even in part, to producer participants will influence the tapping behavior and therefore the economic viability of the project and the well being of the farmers participating in the program. The divergence between the theoretical and the observed behavior will be examined for its implications on the economic productivity of the producers and the efficiency of investments in the project region.

II. Economic Framework and Project Setting

Natural rubber from the Far East is produced from latex, which is the sap of the tree named *Hevea Brasiliensis*. Depending upon management practices, rubber trees can be tapped 5-7 years after planting. When rubber trees are mature, latex is harvested by a sloped cut made with a tapping knife. The same cut is reopened in the next tapping time. Generally, tapping is conducted early in the morning to achieve maximum yield for the day (Dijkman, 1951). The economic life of the plantation and the amount of latex produced in each time period are determined by intertemporal decisions such as the intensity of tapping, application of fungicides, fertilizers, weed control, and natural factors.

1. Discount Rate

The discount rate is one of the critical variables in determining the optimal pattern of forestry resource exploitation, including latex from rubber trees. Generally, a low discount rate provides incentives for a slower pattern of harvesting, while a high

discount rate leads to a more rapid harvesting pattern over time. This generalization marks several important qualifications for understanding economic behavior. The choice of discount rate in economic analysis depends on perspective and preconditions. From the perspective of the producer, at least three principal considerations will influence the discount rate: (1) time preference for money, (2) alternative investment opportunities, and (3) rate of interest on borrowed money.

In addition, various factors such as risk, inflation and currency fluctuation shape the alternative use of funds. Government financed development projects require even broader considerations. The social rate of time preference used by the government is usually chosen exogenously for program planning and project devaluation. Theoretically, the concept of discount rate encompasses the composite of individual rates of time preference, as well as expected rates of economic and social change, which must be addressed by related government spending to offset social costs and other pecuniary and non-pecuniary externalities. Many of these factors are implicitly incorporated into political risk assessment, i.e. the governments calculation of political stability, threats to reelections, etc.

The government must also assess the costs of borrowed capital through internal and/or external debt financing, e.g. borrowing from the World Bank. Targeted projects are financed at interest rates that are set to achieve the multiple objectives of financial feasibility and social stability within the project area. The government must also be able to recoup its investment directly through loan repayment and indirectly through taxes and fees applied to a growing base of wealth, or a combination of these.

Smallholder rubber producers in this study area of Sumatra are given government loans at fixed interest rates, with specific repayment obligations. Both the rates and constraints of the repayment system influence the intertemporal decisions of the producers. The need to have liquid funds at specific times for alternative investment or for ceremonial and consumption expenditures must be weighed against repayment obligations and the cost of

alternative sources of borrowed funds. All these factors determine the appropriate discount rate for a particular producer. When economists choose a discount rate for comparing projects over a set time period, the choice is only a rough estimate of a discount factor that helps guide the many decisions being made by the producers. Against this background, objectives of this study are: a) to analyze observed tapping behavior to determine if the pattern is affected by the discount rate chosen, b) to identify implications of the above, and c) to clarify our understanding of observed differences in tapping patterns.

2. Project Setting

Three different types of plantation ownerships are common in Indonesia: private estates, government estates and smallholders. Management practices, especially harvesting systems of smallholders are different from that of private and government estates. In this study, we emphasize the tapping intensity, productivity and economic life of a sample of smallholder rubber producers and estates. Data on these factors are then used to construct a dynamic optimization model, which provides estimates of the net present value of the future income streams created by alternative observed tapping intensities and different discount rates. The externalities of tapping intensity are also incorporated in this analysis.

In order to obtain data that reflects the productivity of smallholders or of a rubber plantation for an entire production cycle, a study area was chosen which contained, on the one hand, as many production stages as possible, while, on the other hand, having minimal variation in planting technologies such as clones, planting density, and management practices during the grace period, etc. Nucleus Estate Smallholder (NES) projects in Alue-Ie-Mearh, Aceh, North Sumatra were selected due to the accessibility of eight different stages of tree growth with the same GT-1 clone in one contiguous area. A private estate in North Sumatra provided the required data for the analysis. Therefore, both primary data and best available secondary data of sample smallholder rubber

producers from NES projects in Aceh and a private estate in North Sumatra are utilized in this study to understand the economics of observed tapping intensity.

The NES development projects were initiated 1) to share the cultivation knowledge of the government estates and large-scale processing and purchasing facilities of the estate; and 2) for the government estates to generate revenue from the sale of planting material and to reduce overhead costs by greater utilization of processing facilities without bearing the cost of extending area planted. Smallholder Development Projects, Sumatra, available from the Library at the National Rubber Research Institute of Indonesia in North Sumatra. The date of this publication is estimated to be late 1960. The participant farmers consist of local residents of Aceh and immigrants from Java. These projects, sometimes named NES-TRANS, are aimed at small and landless farmers, and are part of the trans-migration program which transfers people from over-populated Java to other islands and helps to settle them in new areas.

These projects were funded through local government banks supported by a loan from the World Bank. PTP, the government-owned plantation company, primarily supervises the cultivation practices and exploitation system in each stage of tapping, hence PTP is recognized as nucleus of the project, and farmers are seen as plasma, thus the name "Nucleus Estate Smallholder (NES) Development Project". The NES project in Alue-Ie-Merah, Aceh, was established in the early 1970's. By 1993 there were approximately 3000 farmers in the project. In order to be eligible as a plasma farmer, a person must be married, between 20 to 40 years old, have help available from family members, and both husband and wife must be in good health. The husband must be able to maintain the rubber trees and the wife should be able to work on the food-crop land.

Each farmer receives two hectares of rubber trees, 0.25 hectare for the home-yard and 0.75 hectare for food crops. The farmers live in 14 established villages surrounded by plantation and food-crop land. Alue-Ie-Merah is the largest village with a

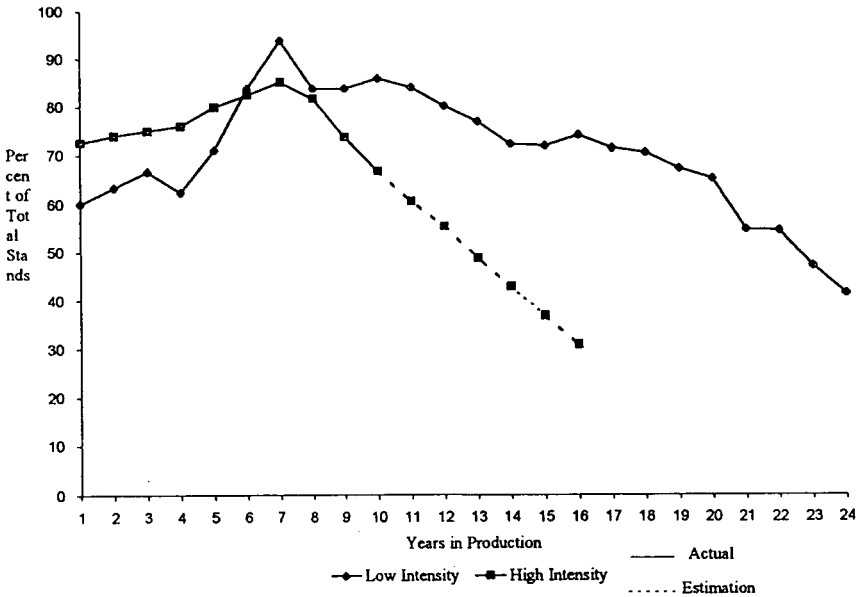
daily market and is growing rapidly. Each village has a primary or secondary school and a mosque.

During the first five or six years after planting, while the rubber trees are immature, PTP recruits farmers to work on the plantation from 7 a.m. to 2 p.m. During that time the farmers receive housing and food-crop land and approximately 2,000 Rp. a day. When at least 60% of the trees in each two-hectare plot have reached approximately 45 cm girth at 150 cm above the union of stock and scion, PTP assigns plots to farmers through lottery. Although each farmer is assigned two hectares, the number of trees each individual actually receives varies from 350 to 700. The reported reason for this variation was corresponding variation in the topography. The size of loan is determined by the number of trees each farmer receives. The loan recovery period is up to 15 years with 10.5% interest per year. After one or two years of tapping, 30% of the latex from each harvest is collected by PTP as credit repayment. All the plasma farmers must sell their latex to PTP with the price determined by PTP, until the loan is cleared. Plasma farmers will become owners of the land at the end of the loan repayment period. If a farmer could not clear the credit until the end of the production cycle, PTP is to make the decision for the individual farmer about the type of crops to grow on their two hectares of land.

III. Exploitation Systems and Latex Productivity

In constructing the relationship between exploitation systems and latex productivity for smallholder rubber producers in Alue-Ie-Merah, Aceh, both primary and secondary data were utilized. Alue-Ie-Merah in Aceh is one of the earliest NES projects in Indonesia. The first planting date was 1977-78. Trees were tapped after six or seven years of age, and the actual production data is available for the last ten years. The production cycle (from the date of planting to the end of the production period) of 20-30 years has not been completed. San et al. (1995) estimated the remaining potential productivity of a rubber plantation in terms of kilogram

FIGURE 1 Percent Change in Tapped Trees for Low and High Intensity Exploitation Systems



Source: San, N.N. (1995).

per tree per year, based on the previous actual aggregate production, bark consumption per tapping, the length of left-over bark available to tap, condition of the bark, exploitation system applied, and the number of tapped trees. In their study, the exploitation system used was: half spiral cut, everyday for six out of seven days = $1/2$ S D/1 6D/7. This is defined as a high intensity exploitation (HIE) system, widely utilized by sample smallholder rubber producers.

The data for low intensity exploitation (LIE), an alternative to the HIE, used in this analysis was provided by a private estate from North Sumatra. The LIE exploitation system here is defined as a combination of (half spiral cut, alternate days = $1/2$ S D/2) and (half spiral cut, every third day = $1/2$ S D/3). Figure 1 illustrates

FIGURE 2 Yield in kg per Tree for Low and High Exploitation Systems



Source: San, N.N. (1995).

the changes in number of trees for HIE and LIE systems.

Observing the rate of change in the number of tapped trees in smallholders rubber plantations in the figure, it is clear that the HIE system results in a more rapid rate of tree loss as compared to the estates which are practicing the LIE system. Studies reveal that there is a significant negative relationship between girth increment and exploitation intensity. In untapped trees, synthesized carbohydrates are utilized only for vegetative growth. When trees are tapped, carbohydrates contribute to both latex production and vegetative growth.

Hence, the higher frequency of tapping reduces by as much as 50% both the shoot dry weight and the girth increment

as compared to untapped tress. As a result, the high intensity of exploitation causes gradual changes in the weight distribution between crown and stem, with the weight shifting more towards the crown, which creates more susceptibility to wind (Webster and Baulkwill 1989).

On the other hand, plantations in Aceh and North Sumatra are infected with white root disease which eventually uproots the trees. Therefore, the cause of tree loss may be due to both the tapping intensity and the white root disease. Figure 2 presents the relative productivity of plantations operated by smallholders compared to that of a private estate. The yield is reported in kilogram per tree per year. In HIE systems the economic life of the plantation is estimated to be 16 years, where year one to year ten represents the actual data and production estimates for years 11 to 16 were estimated by rubber plantation specialists (San, et. al 1995). For low intensity exploitation systems the economic life of a rubber plantation is 24 years. This is the average experience of three rubber clones on an estate which practices LIE system. As can be seen, the latex yield toward the end of the plantation life increases at increasing rate for both exploitation systems (Figure 2). In the final stages of economic life the rubber trees are exploited up to two times a day. This is sometimes referred to as the slaughter tapping period.

IV. Estimation Method

The optimization model, utilized to estimate the net present value of the future income of a sample smallholder rubber producer, is described as:

$$\text{Max} \quad \sum_{t=1}^T Df_t \cdot [\text{LATEX}_t \cdot \text{PLATEX}_t - \text{PAY}_t - \text{RCOST}_t]$$

Subject to

$$\begin{aligned} \text{BALANCE}_t &= \text{BALANCE}_{t-1} - \text{PAY}_{t-1} + \text{INT}_{t-1} \\ \text{PAY}_t &\leq \text{REV}_t \cdot \text{PHI} \\ \text{INT}_t &= \text{BALANCE}_t \cdot \text{SIGMA} \end{aligned}$$

$$\begin{aligned}
 \text{PPAY}_t &\leq \text{PAY}_t - \text{INT}_t \\
 \text{LATEX}_t &= (\text{TAPTREE}_{t-1} \cdot \text{TECH}_t) \cdot \text{YLATEX}_t \\
 \text{RUBBER}_1 \cdot \text{LAB} &\leq \text{LABS} \\
 \text{RUBBER}_1 \cdot \text{SPACE} &\leq \text{LAND} \\
 \text{REV}_t &= \text{LATEX}_t \cdot \text{PLATEX}_t \\
 \text{NET}_t &= \text{REV}_t - \text{PAY}_t - \text{RCOST}_t \\
 \text{PROB}(\text{NET}_t \geq 0) &\geq p
 \end{aligned}$$

Where:

- BALANCE_t = Credit balance in the beginning of year ($t \geq 3$)
- Df_t = Discount factor for time t
- INT_t = Interest charge for the loan in the year t ($t \geq 3$)
- LAB = Labor requirement per tree per year
- LABS = Skilled labor available for plantation
- LAND = Total land available for rubber tree
- LATEX_t = Dry rubber production in year t
- NET_t = Net revenue for rubber in year t
- P = Measure of the risk preference of a farmer
- PLATEX_t = Price of latex in year t
- PAY_t = Payment made for plantation loan in year t
- PPAY_t = Principal paid for plantation loan in year t
- PHI = Percent, credit repayment policy
- RCOST_t = Operating costs for the rubber plantation in year t
- REV_t = Revenue from rubber sale in year t
- RUBBER_1 = Number of trees grown in the beginning year
- SPACE = Land area occupied by each tree
- SIGMA = Annual interest rate
- TAPTREE_{t-1} = Number of tapped trees in year $t-1$
- TECH_t = Parameter for changes in number of trees
- TEX_t = Dry rubber yield in kg per tree in year t

The estimation period is 16 years for the HIE system and 24 years for the LIE system. The farmer's price expectation for 16-24 years is forecast by the Auto-Regressive Integrated Moving

Average (ARIMA) process and combined into the equation system. The forecast rubber price series of ARIMA [(1, 4), 4] is estimated from time domain analysis. The data used in the rubber price forecasting is based on export unit value reported in Commodity Review and Outlook (FAO Economic and Social Development Series 1967-93). A total of 27 observations from 1965 to 1991 were used to forecast the next 16 years of rubber prices.

The chance constraint is also incorporated into the equation system to analyze the risk associated with rubber price uncertainty. The basic concept here is to relate the level of probability representing risk and positive revenue (Standiford 1989). This programming model is specified as linear and solved by GAMS/MINOS software developed by Brooke, Kendrick and Meeraus (1988). This software uses the primal simplex method (Dantzig 1963) to solve the model described above. The results from the optimization model over discount rates ranging from 10-17% are reported in Table 1.

TABLE 1 Results of the Optimization Model

Discount Rate	Net Present Value Rp. (000)			
	Low Intensity	High Intensity (A)	High Intensity (B)	High Intensity (C)
10%	61,859	54,029	47,816	49,749
11%	54,945	49,877	44,473	46,097
12%	49,173	46,273	41,548	42,924
13%	44,122	43,006	38,870	40,003
14%	39,683	40,004	36,414	37,397
15%	35,767	37,334	34,160	34,986
16%	32,299	34,868	32,087	32,778
17%	29,217	32,616	30,176	30,752

Low Intensity = 24-year economic life

High Intensity (A) = 16-year economic life

High Intensity (B) = 16-year economic life with 25% yield reduction from year 12 to 16

High Intensity (C) = 14-year economic life

The results in Table 1 indicate that the net present value of the future income is higher in LIE than HIE (A) systems when evaluated at 10% to 13% discount rates. At a rate of 14% discount rate and above, the net present value of the future income is higher in HIE (A) than LIE. In the cases of HIE (B) and (C), the HIE systems have significantly higher net present income at a 17% discount rate. On the other hand, the cumulative yields for the HIE system range from 20-30 tons per hectare, while LIE systems yield 48 tons per hectare. Therefore, HIE systems produce a relatively smaller amount of total dry rubber than the private estates LIE system. However, the results of the optimization model reflect the profit maximization behavior of a producer. That is, it would be economical to practice HIE systems when the cost of capital is raised above 15% if the 16 year economic cycle is assumed. At 17% and above all HIE systems yielded higher net present value.

V. Conclusions

This analysis of net present values calculated over a reasonable range of discount rates provides insight into the dynamics of economic decision making among smallholder rubber producers in Aceh Province of Indonesia. The loan recovery period for smallholders is 15 years at a 10.5% interest rate. Accordingly, we began with 10% discount rate and calculated net present value for two alternative tapping systems, which are being practiced in the Province. Plasma farmers will become owners of the land at the end of the loan repayment period but do not have opportunities in the interim time to replant rubber trees on additional land. Interplanting of new trees among the existing rubber trees cannot be feasibly undertaken because of the lack of sunlight due to the canopy of the older trees. Therefore, farmers must look ahead and plan to clear the existing crop of rubber trees and replant at a given point in the future. This would require a significant investment at a given point in time under conditions which are uncertain for the smallholder. Clear institutional

provisions do not exist to enable the farmer to depend upon a future source of credit and financing to undertake such significant investments.

This lack of a clear framework to support continuing rubber production may be a factor which leads farmers to undertake a more intensive system of tapping and, in the process, shortens the life of rubber trees. This institutional uncertainty adds to many other uncertainties which may lead smallholders to severely discount the future income streams from rubber production. The practical results of this set of uncertainties would be high intensity tapping when the perceptual discount rate is 17% or greater.

The discount rates assumed for the optimization model create varying rates of exploitation of the rubber trees depending upon the perceptions of the smallholders (Table 1). In other words, these discount rates are not actual rates of borrowing in the local capital markets, but are composite perception stimulated by several factors that include actual borrowing rates, alternative investment returns, social obligations, and future economic needs with appropriate discounts associated with uncertainty about future social and economic conditions which change the farmers perceived security in the local economy. Higher degrees of uncertainty about the future result in the smallholder discounting future revenues at a higher rate. As the numbers in Table 1 show, higher discount rates lead to high intensity tapping practices, which have been widely observed in Indonesian smallholder rubber production.

Social and economic risks stem from fear of market changes and price fluctuations which cannot be controlled by the smallholder, and include such factors as political strife, lack of trust in government contracts, and institutional uncertainty governing other components of social and economic life. These are common perceptual factors which lead to economic behavior consistent with high discount rates. To the extent that social and economic risks stem from imperfect information, educational programs and extension efforts can be undertaken to provide a clearer understanding for smallholders about future government policy and institutional

arrangements regarding the smallholders.

Other factors may also lead to high discount rates and high intensity tapping. Among these are potentially high returns on alternative agricultural or industrial investment opportunities available to the smallholder. In Aceh Province, it was observed that there seemed to be a good market for livestock, particularly sheep. These returns may be sufficiently high to stimulate the smallholder to tap intensely in order to accumulate immediate income for alternative investments which may yield a higher rate of return, say in sheep production, than that provided by the rubber production. Other food crops and agriculture export alternatives may also exist. In addition, nonfarm investment opportunities may be available in small businesses and in manufacturing activity.

Immediate family needs, such as education for children, care for aging parents, medical emergencies, and other critical financial needs can be an incentive to tap rubber trees as frequently as possible to generate the needed income. In a perfect capital market, the smallholder could borrow sufficient funds to offset these short-term needs if the rate of interest was less than that yielded by the rubber production. In the absence of a competitive capital market, higher intensity tapping of rubber trees may be the only alternative available for immediate farm family income. These plausible alternatives would lead to the observed behavior of intensive tapping even at the risk of a shortened economic life of the rubber trees.

These results reveal how critical it is to assess the broader socio-economic circumstances surrounding development projects. Many cultural and family circumstances shape the perceived discount rate of each family. That rate will govern the economic behavior of the rational person. Achieving a desired economic outcome depends upon sensitivity to these fundamental determinants of economics behavior. Project planning and implementation can be carried out more effectively when these behavioral factors are understood and incorporated into the analysis.

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