# Estimation of Technical Efficiency and Its Determinants of the Rubber Small Holding Sector in the Kalutara District

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## ABSTRACT

**The study was carried out to analyze current level of technical efficiency of the Sri Lankan rubber industry with respect to smallholding sector. It also allows for the identification of factors influencing technical inefficiency of small holding sector.**

**The primary data were collected from 112 small holder rubber producers in Kalutara District. The frontier production function approach provides a better framework for this study. Maximum likelihood estimates of that model were determined latex yield as a function of land extent, age of tree, number of tapping days & number of tappers. The Cobb-Douglas and Translog models were used to examine technical efficiency. Out of the two models tested, Cobb-Douglas was found to be best fitting the data .The variables such as farmer experience, number of plants & fertilizer application were analyzed using SAS stepwise procedure. According to Cobb Douglas specification, extent of land, number of tapping days & number of tappers showed significant effects on yield. The measured mean technical efficiency indicated that there was a potential for further increase of productivity .The study showed that the experience, education, occupation, land extent ,number of plants &fertilizer application have a significant impacts on efficiency .**

**KEYWORDS: - Rubber (*Hevea brasiliensis*) Industry, Small Holder, Frontier Production Function, Technical Efficiency**

## INTRODUCTION

The history of Sri Lanka rubber industry goes back to 1876 with the planting of rubber seed which took place in Henarathgoda garden. Rubber was first grown in large estates (plantations) & then was gradually introduced to small holder sector .Rubber industry plays an important role in Sri Lankan economy making an export earning of 39 million dollars in 2003. The Total Exports of natural rubber were 35 million of kilogram in 2003. It has 114357 hectares under cultivation, produces 92 million kilograms of rubber & employs about 500,000 persons (Anon, 2003a).

Rubber cultivation is done at three levels at present .Small Holder level (less than 10 Ac) ,median estate (10-50Ac) and estate level (more than 50 Ac) .Small and medium sector occupy 65% of the total rubber extent in Sri Lanka .About 155,000 small holders are engaged in rubber cultivation today .

The main problem faced by rubber sector is reducing level of income. It is also noted that the average holding size is on the decline .In addition, the low productivity of existing lands is another problem .A recent study showed that there is a high variation in productivity (237-1950Kg/ha/yr) of rubber small holder in the country ( Anon, 2003b ). This influences income levels of smallholders and leads to drive them out of rubber cultivation. In addition, national productivity is far below the potential (1500-2000 Kg/ha/yr)(Anon, 2003a) .It is also evident that domestic consumption is on the rise and it has risen by 4.4% from 2002 to 2003. The total import of rubber has also increase to 9000 metric tons. The foregoing implies that production of rubber in the country needs to be increased. This can be achieved in 3 ways. One is to increase the cultivated extents, which is time consuming & limited due to ever increasing pressuring on land. The second is to increase productivity mainly by breeding new clones, which are a longer term solution .Third, is to improve efficiency, which can be achieved without any additional costs on inputs. Thus, objective of this study is to identify factors affecting technical efficiency of small holder rubber production in Kalutara district through estimation of a production function and to estimate level of technical efficiency of small holder rubber producers in Warakagoda, Yatagampitiya, Bulathsinhala Rubber Development Officers(RDO) divisions in Kalutara District.

## METHODOLOGY

***Sample Selection***

This study covered rubber small holders in Warakagoda, Yatagampitiya & Bulathsinhala (RDO) Divisions in Kalutara District .Small holder sector was purposely selected as it accounts for a major portion of the total rubber extent in the country. Therefore any increase in productivity /efficiency would greatly enhance natural rubber production in the country. Kalutara district was selected as it is the second largest rubber growing region in the country. Warakagoda RDO Division was selected because it is one of the largest RDO Division in the Kalutara District. Close proximity to Rubber Research Institute is the reason for select Yatagampitiya & Bulathsinhala Divisions, with the view of saving time & costs on data collection.

***Data Collection***

Data were cross sectional in nature & collected through a pre-tested questionnaire during the period from March to April 2005. A random sample of 112 farmers was selected from all three Divisions. The respondents were the farmers who own mature rubber extents. Data included information on physical quantities of production inputs as well as output for each farmer. To identify the relevant factors that influence inefficiency, socio economic data of farmers were also collected.

*Analytical method*

**Technical Efficiency**

The production can be viewed as composed of those parts of the firm's production function that yield maximum output for a given set of inputs. Hence, it is possible that a firm with its scale of operation may not be able to reach the frontier that is the production of the firm. The notion of how close the individual production plans are to the individual production plans to the maximum levels, as defined by the frontier, given inputs levels, is the measure of technical efficiency of each firm.

Frontier Version 4.1 was used to estimate stochastic Frontier production functions .(Battese & Coelli ,1995) Here Stochastic Frontier production functions can be estimated using maximum likelihood method .This model can be expressed in following form.

$$\ln Y_i = X_i\beta + \varepsilon_i \quad \text{------------(1)}$$

$$\varepsilon_i = V_i - U_i \; ; \; i=1,2,..........,n$$

Where,

$Y_i$ denotes production level (or logarithm of production) of $i^{th}$ firm.

$X_i$ is input quantities of i $^{th}$ firm.

β is a vector of unknown parameters to be estimated.

$\varepsilon_i$ is the composed error term

$V_i$ is the random error, which is associated with random factors not under the control of the firm .Which is assumed to be independently & identically distributed as N (0, σv2).

$U_i$ is the inefficiency effects which are non negative random variables which are independently & identically distributed as N (0, $\sigma u^2$).

According to Battese & Coelli (1995) (cited in Basnayake & Gunaratne, 2002), technical inefficiency effects are defined by;

$$Ui = Zi\delta + Wi \quad \text{----------- (2)}$$

$$i=1,......, n$$

Where,

$Z_i$ is a vector of explanatory variable associated with the technical inefficiency effects δ is a vector of unknown parameter tobe estimated.

$W_i$ is unobservable random variables, which are assumed to be identically distributed

According to Battese & Corra (1977), the variance ratio parameter γ which relates the variability of ui to total variability (σ2) can be calculated in following manner.

$$\gamma = \sigma u^2/\sigma^2 \quad \text{------------- (3)}$$

Where, $\sigma^2 = \sigma u^2 + \sigma v^2$

So that $0 \le \gamma \le 1$

If the value of γ=0, the difference between farmers yield & the efficient yield is entirely due to statistical noise. If γ=1 indicate the difference attributed to the farmers less than efficient use of technology i.e, technical inefficiency (Coelli, 1995)

The following model specifications were used in the analysis.

**Cobb - Douglas Model**

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + (V_i - U_i) \quad \text{----- (4)}$$

**Translog Specification**

$$\ln Y_i = \sum_{i=1}^{4} \beta_i \ln X_i + \sum_{i=1}^{4}\sum_{j=1}^{4} \alpha_{ij} (\ln X_i)(\ln X_j) + (V_i - U_i) \quad \text{-------(5)}$$

Where,

*Ln* = denotes logarithms to base e.
Y = total yield per year (Kg of Rubber)
X1 =Extent of Land (ac)
X2 = Age of tree (years)
X3 =number of tapping days per year
X4 =total number of tappers per year .

Model for results of regression procedure inefficiency measures & farmer factors.

$$INEFFi = \alpha_0 + \alpha_1\, EXPi + \alpha_2 EDU_i + \alpha_3 OCCU_i + \alpha_4 EXT_i + \alpha_5\, NP_i \quad \text{--- (6)}$$

Where,

$INEFF_i$ = Inefficiency of the $i^{th}$ farmer
$EXP_i$ = Experience in rubber cultivation of the $i^{th}$ farmer
$OCCU_i$=Occupation of the $i^{th}$ farmer, a dummy variable equal to one if the small holder are involved in rubber holding only, zero otherwise
$EDU_i$ = Education level of $i^{th}$ farmer
$EXT_i$ = Extent cultivated by the $i^{th}$ farmer
$NP_i$ = No. of plants in the farm of the $i^{th}$ farmers
$\alpha_0$ to $\alpha_5$ = Co-efficient to be estimated

## RESULTS AND DISCUSSION

The summary statistics related to the variables used for the analysis are depicted in Table 1.
Latex yield per year per hectare varied 60 to1920 kilograms. Farmer land extent has varied from 0.25 to15 acres .Age from inception of tree vary from 1 year to 55years .Tapping days vary from75days to 250 days per year . Total number of tapping laborers per year varied from75 to750. (Table 1)

Both Cobb Douglas & translog stochastic frontier production functions were estimated and the estimated functions were statistically tested to select function that best describe the data. The Cobb Douglas production function was fitted to annual rubber yield which was considered a function of farm size, age of trees and number of tapping days & total number of tappers for each small holder.

**Cobb- Douglas Production function results**

The Ordinary Least Square (OLS) as well as maximum likelihood estimates (MLE) of the estimated Cobb Douglas model are presented in Table 2.

Only the age of tree has a negative coefficient & all other variables has positive coefficients. The Positive coefficient implies that any increase in the value of variable would lead to increase of level of production while the negative coefficient implies that any increase in the value of the variable would lead to a decrease in the level of production. These all variable had the theoretically expected sign.

**Table 1-Summary statistics for variables in the stochastic frontier production functions for rubber small holdings:**

| Variable | Sample Mean | Standard Deviation | Min Value | Max Value |
|---|---|---|---|---|
| Output(latex kg/yr) | 630.928 | 348.79 | 60 | 1920 |
| Extent(Ac) | 2.177 | 2.528 | 0.25 | 15 |
| Age from inception of tapping | 10.772 | 6.488 | 1 | 35 |
| Tapping days(days) | 151.62 | 38.99 | 75 | 250 |
| Total number of tapping labors/yr | 215.73 | 135.40 | 75 | 750 |

The estimated ML coefficients for number of tapping days, land extent & total number of tappers showed positive values of 1.01, 0.62 & 0.24 respectively. All these values were significant at 5 percent probability level. This indicates that an increment of the inputs number of tapping days, land extent & total number of tappers by one percent will increase the output by 1.01 percent, 0.62 percent & 0.24 percent respectively. Results showed number of tapping days has a significant effect on the production .Promotion of using of rain guards could be used as s strategy to increase number of tapping days. Rubber Research Institute found using rain guards would increase rubber yield from 20 to 25 percent.

Estimate ML coefficient of age showed a value of -0.665 this implies that with the age of the tree yield goes down. The negative sign obtained because most of the farms in the sample were in latter part of the production cycle. This is one of the major problems in the country due to negligence of replanting in time of low prices in the past. Intact yield of rubber tree is increased during the first few years and after reaching its maximum at the age of ten years began to decline. Even the translog function tested was unable to capture this due to most of the farms in the sample were in latter part of the production cycle.

Information and data on weedicide & fertilizer use were not available because most of farmers do not apply weedicide & fertilizer in the mature fields. . Farmers' attitude on with fertilizer and low income levels had led them to refuse from applying fertilizer. Therefore, these variables were omitted from the production function.

Tapping cost & total number of tappers correlated with each other. Most of the farmers used their family labors for tapping & they could not say number of tapping days or number of tapping hours. Therefore total number of tappers was included in the production function as a proxy.

In addition, a stochastic translog production function was estimated. Cobb Douglas is a reduced form of the translog production function. Significance of cross terms of translog function can be tested to determine whether translog or Cobb Douglas form suits the data. The ML estimates of the translog function are given in Table 3.

**Table 3- The ML estimates of translog function:**

| Variable | Parameter | Coefficient | t-ratio |
|---|---|---|---|
| Constant | β0 | -21.96 | -21.967 |
| Extent | β1 | 0.621 | 0.621 |
| Age(from inception) | β2 | 0.232 | 0.232 |
| Tap.days | β3 | **7.015 | 7.015 |
| No tapers/year | β4 | **3.078 | 3.078 |
| Extent*extent | β5 | 0.153 | 0.153 |
| Age*age | β6 | -1.904 | -0.019 |
| Tap.days*tap.days | β7 | -0.987 | -0.987 |
| No tappers/year* No tappers/year | β8 | -0.618 | -0.618 |

**significant at 5 percent level.

**Table 4: Distribution of technical efficiencies (based on Cobb-Douglas specification**

| Technical Efficiency | Number of Farmers |
|---|---|
| 30-40 | 1 |
| 40-50 | 1 |
| 50-60 | 10 |
| 60-70 | 24 |
| 70-80 | 49 |
| 80-90 | 27 |

Few cross terms were significant in the translog form. Therefore the Cobb Douglas form was selected to measure the technical efficiency. The obtained technical efficiencies from the Cobb-Douglas production frontier is given in Table 4.

**Table 2- OLS estimates & MLE for parameters of the stochastic frontier (Cobb- Douglas modell) for rubber small holders:**

| Variable | Parameter | Coefficient OLS | Coefficient MLE | Standard Error OLS | Standard Error MLE | T-Ratio OLS | T-Ratio MLE |
|---|---|---|---|---|---|---|---|
| Constant | β0 | 0.207 | 0.626 | 0.902 | 0.906 | 0.229 | 0.691 |
| Land extent | β1 | 0.609 | **0.621 | 0.758 | 0.743 | 8.034 | 8.354 |
| Age from the inception of tapping | β2 | -0.681 | -0.665 | 0.578 | 0.563 | -1.178 | -1.179 |
| No tapping days/year | β3 | 1.000 | **1.010 | 0.230 | 0.225 | 4.345 | 4.495 |
| Total no tappers/year | β4 | 0.268 | **0.244 | 0.136 | 0.137 | 1.974 | 1.782 |
| $\sigma^2$ | | | 0.333 | | | | 2.845 |
| γ | | | 0.576 | | | | 1.896 |
| LR test | | | 0.726 | | | | |

*Log likelihood function value=-71.49 **significant at 5 percent level*

**Table 5- Results of regression procedure:**

| Variable | Parameter Estimate | Pr>F |
|---|---|---|
| Intercept | 0.525 | <.0001 |
| Experience | **-0.002 | 0.019 |
| Education | **-0.013 | 0.022 |
| Occupation | **-0.096 | 0.019 |
| Extent | **0.063 | 0.049 |
| Number plant | **-0.00036 | 0.049 |

*significant at 5 percent level.

The mean technical efficiency of rubber small holding sector was found to be 72.7 percent, which indicates that the output could be increased by 28 percent if all farmers achieved the full technical efficiency level. Technical efficiency ranges from as low as 36 percent to as high as 90 percent.

Obtained inefficiency measures were related to farmer factors. The procedure adopted here was stepwise regression procedure in SAS programme. Results of regression procedure are given in Table 5.

All other variables showed negative coefficient except for land extent. Negative coefficient implies that any increase in the value of the variable lead to increase in the level of technical efficiency (a decrease in inefficiency) (Table 5).

The negative and significant coefficient for education suggests that the educated farmers are more efficient than others. The inefficiency decreases the years of experience. This can be explained by the fact most of the educated and experienced farmers have been used to use improved technical methods and ready to accept advises given by extension services .Occupation shows negative and significant coefficient explaining those farmers who are involved only in rubber holding as full time farmers were found to be more efficient than others. Number of plants on land unit implied negative and significant coefficient and that means increases of number of plant show increased efficiency. However, positive and significant coefficient for extents suggests that with the increase of land extent of small holders their inefficiency is also increased. This can be due to the fact that the small holding are efficient because such holding are least affected by restrictions such as tapper shortage while larger holdings may are severely affected.

## CONCLUSIONS AND POLICY IMPLICATIONS

Results obtained from the stochastic frontier estimation showed that the average technical efficiency of rubber small holding sector given by Cobb Douglas model is 72.79 percent. This indicates that there are possibilities for further increases in output by 27.21 percent without any increase of the levels of input.

High efficient realized only if recommended number of plant present attempts should be made to maintain the recommended number of plant from planting to uprooting.

Among the factors which affect technical inefficiency, experience of farmers, education level, occupation, extent & number of plants were significant at 5 percent probability level.

Experienced farmers appeared to be more efficient than others. This may be due to their good managerial skills, which they have learnt during their working period. Therefore the in experienced farmers should be encouraged to work with experienced farmers.

Educated farmers were found to be more efficient than the less educated .This may be due to the fact that their knowledge gained through education helps them to make correct decisions .Therefore it is necessary to increase educational facilities in the area .Farmers who were involved in rubber cultivation as full time farmers are found to be more efficient than others. However, most of the small holders do not devote their full time for rubber. Reason being the constant fluctuation of price & unfavorable climatic conditions. Implementation of a guaranteed price scheme might be one solution. A fertilizer program (such as subsidy or credit scheme) to encourage farmers to apply fertilizer appears to be necessary to increase there output.

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## REFERENCES

Anon.(2003a)Central Bank of Sri Lanka , Annual Report, Sri Lanka

Anon. (2003b) 1st annual report of Interactions between the Environment Society & Technology (INTEREST).

Basnayake, B.M.J.K, H.P.Gunaratne (2001).Estimation of Technical Efficiency and its Determinants in the tea small holding sector in the mid country wet zone of Sri Lanka.

Battese, G.E. and G. S. Coelli (1995).A Model for Technical Inefficiency in a Stochastic Frontier Production Function Empirical Economics, 20:325-332.

Battese and Corra (1977).Estimation of a Frontier Model:Australian Journal of Agricultural Economic.

Kodithuwakku, H (2001).Econometric Model Building, National Library of Sri Lanka.

Talgaswatta, H (1995). Technical Efficiency of Rubber Production in Sri Lanka: Frontier Production Function Approach, Lincon University.

Plantation Sector Statistical Pocket Book (2004) Ministry Of Plantation Industries, Colombo, Sri Lanka.

Rubber Plantation Sector (2004). Current Trends & Future Challenges, Symposium on Plantation Crop Research TRI, CRI, RRI.

.Karunaratne, M.A.K.S.S and H.M.G.Herath (1989). Efficiency of Rice Production under Major Irrigation Conditions: a Frontier Production Function Approach .Agrarian Research and Training Institute, Colombo.