Proceedings of 12th Agricultural Research Symposium (2013) 389-393

Technical Efficiency of Smallholder Rubber Farmers in Kurunegala District: A Quantile Regression Approach

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ABSTRACT

Lands are not available for further expansion of rubber cultivation in traditional rubber growing areas. As a result, rubber cultivation is expanded into non-traditional rubber growing areas where land is not a limiting factor. However, in non-traditional rubber growing areas like Kurunegala, there are other plantations crops that compete with rubber cultivation. Land is also comparatively limited for rubber cultivation in this area. Consequently, issues on rubber cultivation in this area and its economics will be different compared to the issues meet in other non-traditional rubber growing area. We did this research to investigate the existing economic status of rubber smallholders in this area. It was found that the average technical efficiency of rubber farmers in the area is about 33% indicating that more framers in the area are inefficient in terms of the productivity. We used Quantile Regression to see the conditional impact of various determinants on Technical Efficiency. It was further emphasized the importance of using experienced tappers for exploitation operation. Further, results suggest that determinants of the low efficiencies are not the same as the determinants of high TEs, which leave room for future research work.

KEYWORDS: Quantile regression, Rubber smallholders, Stochastic frontier, Technical efficiency

INTRODUCTION

Rubber (*Hevea brasiliensis*) is the second most important plantation crop grown in Sri Lanka. Rubber industry contributes enormously to development of the country by generating foreign exchange, employment and protecting the environment. Sri Lanka is the world's 6th largest exporter and the 8th largest natural rubber producer. It contributes 2.5 percent of global rubber production (Kumarashinhe and Edirisinghe, 2011). National rubber production in Sri Lanka is 157.9 million kg in 2011.

According to the land extent, there are two main categories of rubber sectors in Sri Lanka, smallholder sector (less than 50 acres) and estate sector (more than 50 acres). From total extent, 63% (79,395 hectares) belongs to the smallholders and 37% (46,250 hectares) belongs to the estate sector (Anon, 2012). Consequently the smallholder contribution is more influential to national rubber production. Decline of land extent under rubber was more prominent during 2001 and 2002. The major reason for this decline is due to unstable prices of raw rubber together with high cost of production. During that period most of rubber lands in traditional rubber growing areas were abandoned or diversified into other crops such as tea. Rubber prices were remarkably improved after 2002 resulting an increase in total extent under rubber due to replanting and new planting activities.

Increasing productivity and area under cultivation are the two possible solutions to achieve the national production targets in the rubber sector. However, new planting programmers are not successful in traditional rubber growing areas due to non-availability of lands due to various reasons. Hence, a great emphasis has given to rubber cultivation in non-traditional rubber growing areas in North-Western, Uva, Eastern and Northern provinces, where land and labor are not limiting factors. In potential rubber growing in North Western province lands are somewhat limiting compared to the other non-traditional rubber growing areas.

Kurunegala district has the highest land extent in the North Western province. Rubber is grown in the boundary of the Kurunegala district which is adjacent to Low Country West Zone where there are major rubber plantations are established. However, coconut plantation is more established in Kurunegala district which is a part of the coconut triangle. There are other plantation crops are also competitively grown with the rubber cultivation in this area. This situation is not apparent in other non-traditional rubber growing areas. Therefore the issues that would raise during the process of uplifting existing plantations and establishing new plantation will be expected quit different that of in other traditional and non-traditional rubber growing areas.

There are many studies found in the literature about the economics and related issues of rubber cultivation other non-traditional areas are reported that Technical Efficiencies (TE) of rubber cultivations in Kalutara and Gampaha districts are about 72% and 50% respectively (Herath *et al.*, 2005 and Kumarasingha and Edirisinghe, 2011). Chathurangi *et al.*, 2011 has found that TE of rubber farming in Monaragala district is about 59%. But no such attempts are reported about the focus area of this study. Consequently, we attempt to fill this gap in this study. Stochastic frontier is a common approach that is found in econometric literature to compute TE (Mangika *et al.*, 2009). Either a linear or nonlinear model is fitted to find the determinants of the calculated TEs. However, this fits the average impact of the determinants on TEs and it cannot handle the inconsistencies in the distribution of the TE score. However Quantile Regression is more flexible on handling data with heterogeneous conditional distribution. (Chen, 2005; Koenker and Hallock, 2001). Further it provides room to study the impact of different determinants at conditional quantile of TEs (Chidmi *et al.*, 2011). We have demonstrated in this study how Quantile Regression can be used to identify the determinants of TE.

METHODOLOGY

Study Area

The study was carried out in the rubber growing areas in Kurunegala district. There are about 350,000 households are living in the District. Study area includes two Rubber Development Officers (RDO) ranges (Rideegama and Polgahawela) in which there are about 10% of the total households in the district are managing their living. Since this area is at the border of Low Country Intermediate Zone and Low country Wet Zone, the variability of the climate in this area is very diverse. There are six agro ecological zones *viz,* IL1a, IM3b, WL3, WL2b, WM3a and WM3b can be found in this area.

Sampling and Data Collection

A multistage sampling procedure was used to select the study sample. Total sample was restricted to150 farmers due to cost and time limitations. All RDO ranges were considered during the sampling process. About twelve Grama Niladhari (GN) divisions were selected probability proportionately to the total number of GN divisions in each RDO division. Farmers were selected randomly and probability proportionately from a list of mature rubber farmers available at the RDO office. Data collection was carried out using a semi structured and pretested questionnaire during the first quarter of the 2013. Data were cross sectional in nature and included information on demographic, production and socioeconomics characteristics of smallholder rubber farmers in the area.

Model

There were two steps involved in the modeling procedure. In the first step, a production frontier was fitted following the procedures by Battese and Coelli, 1995. As it is suggested in large number of literature, a Cobb-Douglas model was used to fit the production frontier. It can be presented as,

$$y_i = f(x_i\beta) + e_i \tag{1}$$

$$e_i = v_i - u_i \qquad i = 1,2,\ldots\ldots,n \tag{2}$$

Where,
y_i = Logarithm of the production of i[th] firm.
f = Cobb-Douglas production function.
x_i = Input quantities of i[th] firm.
β = A vector of unknown parameters.
e_i = Composed error term.
v_i = A symmetric error.
u_i = i[th] firm inefficiency of production.

u_i is a non-negative random variable which distributes morally with a zero mean and stand a variance of one. An index for TE can be defined as the ratio of the observed output (y) and maximum feasible output (y^*):

$$TE_i = \frac{y_i}{y_i^*} = \frac{f(x_{ij};\beta).exp(v_i - u_i)}{f(x_{ij};\beta).exp(v_i)} = \exp(-u_i) \tag{3}$$

In the second step, the study uses Quantile Regression to regress TE on a set of variables, z_i which influence the efficiencies.

$$E(TE/Z = z_i) = \textstyle\sum_{j=0}^{k} \gamma_j z_{ij} \tag{4}$$

$$\hat{\gamma} = \text{argmin} \textstyle\sum_{i=1}^{n} \rho_\tau(\text{TE}_i - \sum_{j=0}^{k} \gamma_j z_{ij}) \tag{5}$$

Where, $\rho_\tau = \tau$ if the observation belongs to the τ^{th} quantile and $\rho_\tau = 1 - \tau$ if not Smallholder's age (Years), Smallholder's gender (Dummy: Male=1, Female=0), Smallholder's education (Years), Membership in rubber society (Dummy: Yes=1, No=0), Tapper's age (years) and Tapper's education (years) were considered as possible set of determinants of TE.

RESULTS AND DISCUSSION

The summery statistics of variables used in the production frontier are given in Table 1.Total productivity varied from 47.35 to 887.48 kilograms per year per hectare. Present stand of rubber in the area varies from 55 to 610 trees per hectare with a mean value of 366 trees per hectare. Tapping man days per year varies from 110 to 300 indicating that some farmers engage in over tapping.

Table 1. Summary statistics of variables in the stochastic frontier production function

Variable	Average	Minimum	Maximum
STA	366	55	610
AOT	18	6	42
FER	237.9	0	1050
CHE	6.29	0.75	54
TMD	205	110	300

Note: STA= stand (trappable trees per hectare), AOT=Age of trees(Years), FER=fertilizer amount. (kg/ha/Yr), CHA=chemical (l/ha/Yr), TDM=tapping man days per year per hectare

Results of the production frontier analysis are provided in Table 2. Positive coefficients imply that any increase in the value of variable would lead to increase in the level of the production. Any negative coefficient implies that any increase in the value of the variable would lead to a decrease in the level of production. All variables except TMD while coefficient stand, chemical and age of tree were statistically significant. The positive sign of the coefficient with stand and age of trees suggest that rubber cultivations of farmers with high performance are in the increasing phase of the growth curve.

Table 2. Maximum likelihood estimate (MLE) for parameters in the stochastic production frontier model

Variable	Coefficient	SD	T value
Constant	5.00	0.700	7.12***
Stand	0.45	0.073	6.23***
Chemical	0.12	0.048	2.47**
TMD	-0.07	0.067	1.05
Fertilizer	0.065	0.069	0.94
Age of tree	0.16	0.068	2.36**

*Note: *Significant at 5 percent level. **significant at 10 percent level*

The distribution of the technical efficiencies computed in the stochastic frontier analysis is depicted in the histogram shown in Figure 1. It is right skewed with an average technical efficiency of 32.4 %. This indicates that the output rubber stallholders in the area could be increased by 67.6% if all farmers could achieve the full technical efficiency level. This indicates that more actions are needed beginning from the policy setup to uplift the productivity of farmers in rubber growing areas in the District.

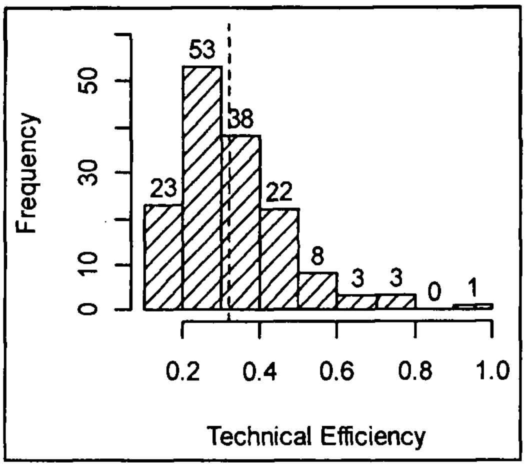

Figure 1. Frequency distribution of technical efficiency of rubber smallholders in Kurunegala district

The farm and farmer specific factors that determine the technical efficiency of rubber smallholders in the area were identified using fitted Quantile Regression. Results of conditional Quantile Regression are shown in Table 3.

The results indicate the determinants of TE of rubber smallholders at different levels of TE. It can be noticed that owner's experience has a significant ($p<0.05$) negative effect on technical efficiency of the farmers who are efficient more that 60%. In this we have considered the time which they have engaged in rubber cultivation as the experience. This indicates that the time that they spend with rubber cultivation will not increase the productivity unless they manage plantations well. This was further verified by the low levels of farmers awareness about proper management practices reported during the study.

The distance to land has a negative effect on the efficiency of rubber farmers. Farmers whose lands were located far away from their residence reported low technical efficiencies. This was statistically significant of farmers shown more efficient. This indicates farmers who live in the land or who has the rubber land near the house has become more efficient.

Table 3. Efficiency analysis with quantiles

Variable	Quantile 0.1	0.2	0.4	0.5	0.6	0.8
OED	-0.00294	-0.00283	-0.00334	-0.00449	-0.00484	-0.00522
OEX	-0.00129	-0.00107	-0.00211*	-0.00200*	-0.00211**	-0.00251**
PTA	-0.01104	-0.00777	-0.02791	-0.01582	-0.01493	-0.02492
MEM	0.01582	0.01148	0.05634	0.03155	0.02714	0.03643
DTL	-0.00281	-0.00334	-0.00389	-0.00432*	-0.00459**	-0.00627***
TED	0.00121	0.00205	0.00345	0.00427	0.00554	0.00956
TEX	0.00057**	0.00049***	0.00061***	0.00072***	0.00092***	0.00122***
TDY	-0.00093	-0.00173*	-0.00119	-0.00039	-0.00003	0.00017
CON	0.15655**	0.29767***	0.29555***	0.33255***	0.302642***	0.27329***

*Note: *0.10 significant level **0.05 significant level ***<0.01 significant level, CON=constant, GEN=gender, OED=owner's education, OEX=owner's experience, PTA= Participate to training, MEM= Member of rubber society, DTL= Distance to land, TED= Tapper education, TEX= Tapper experience, TDY= Tapping days per year, SS= Sigma- squared, GMM= gamma*

If the land is located very far, then it will be difficult to manage the plantation well. Especially the exploitation of the latex will be disturbed severely resulting low productivity levels

Technical efficiency of rubber lands located at different distances is depicted in Figure 2. It can be clearly visible the negative relationship between efficiency and the proximity of the farmers who reported high efficiency levels.

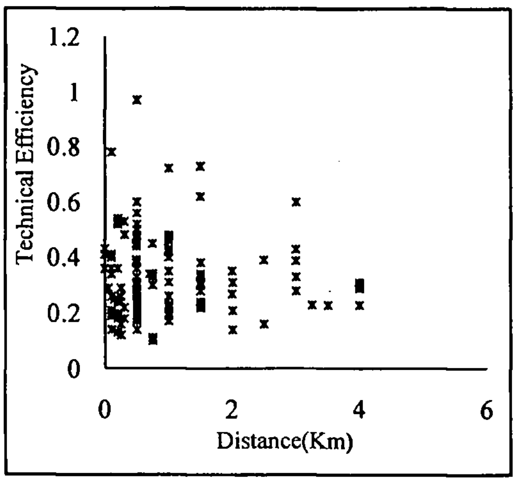

Figure 2. Relationship between technical efficiency and distance to land

Taping is one of the most sensitive operations that can affect the productivity of rubber lands. Its impact on the productivity of rubber plants is various. Latex yield will be low if plants are either over exploited or under exploits. Any damage cause during tapping will detrimentally affect the latex yield during the whole yield cycle. Therefore the person who taps rubber plant must very causes in his operation. Results in Table 3 indicate that the experience of the tapper would significantly affect the productivity of rubber lands even if farmers are less efficient, more the experience of tappers higher the efficiency of rubber cultivation. It can be noticed that all expected determinants except tappers experience do not significantly affect the farmers with low efficiency levels. There will be a separate set of issues that lead to their low efficiency levels, where more future research should be focused on.

CONCLUSIONS AND POLICY IMPLICATIONS

It can be noticed the more than 50% of the smallholder rubber farmers in the study area are inefficient compared to those who perform much better. This indicates the need of prompt action to make existing rubber farmers in the area more productive. It indicates that existing awareness program do not have an impact on the farmers efficiency suggesting the need of reformulating existing awareness programs so that expected productivity levels can be achieved.

It is very clear from the study that issues affect the farmers with poor productivity are different from the issues faced by the farmers shown high productivity levels. We suggest the policy makers to take up this situation in the process of policy making. Further we emphasis the need of future research to investigate the real issues that leads the low efficiency of rubber smallholder in the area.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to all the Mr. M.M.R. Udayakumara, S.Subawikrama (RDOs) and Mr. D.E.P.M. Nanayakkara (REO) in Kurunegala district for their assistance to collect data. Dr. WasanaWejesuriya from Rubber Research Institute in Agalawaththa and Dr. Jagath Edirisinghe from Department of Agribusiness Management Wayamba University of Sri Lanka are highly appreciated for their valuable suggestions to make this a great success. Respondent of the survey and other supported renders are highly acknowledged for their kind cooperation in making this study a reality.

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