Technical Efficiency and its Determinants of Small – Holder Rubber Farmers in Kalutara: Stochastic Frontier Analysis

N. N. S. De Costa and A. Thayaparan

Vavuniya Campus, University of Jaffna, Sri Lanka

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Introduction

Rubber is one of the prime agricultural export crops that brings an exceptional amount of foreign exchange and also provides sustained socio-economic benefits to the country. According to the Agalawatta Rubber Research Institute's (RRISL) statistical data, more than 63% of the national rubber production is significantly contributed by the small rubber cultivators who own less than 20 acres, and have provided a large number of direct and indirect employment opportunities. Rubber production grew by 5.1% to 83.1 million Kgs in 2017 from 79.1 million Kgs recorded in 2016. This growth in natural rubber production was achieved amidst unfavourable weather conditions, particularly during the first half of the year which resulted in severe floods in traditional rubber areas. Among the major categories of rubber produced, sheet rubber production increased by 4.4% while crepe rubber production decreased by 23.3 % in 2017. On the other hand, the cost of production of rubber has been increasing over the years making rubber production less attractive for the smallholder sector.

Sri Lankan rubber growing areas are mainly located in the wet zone and the top three growers in the rubber industry in the country are identified as Kegalle, Kalutara and Ratnapura Districts. Kalutara district is well-known for small rubber cultivation because its wet climate and fertile soil are favourable to cultivate rubber and most of the cultivators in the study area are engaged in cultivating rubber by utilizing their traditional knowledge and techniques. Technical innovation and more efficient use of existing technology are the main strategies of achieving high level of output in a small holder rubber sector (Hoang and Coeli, 2009). However, in developing countries like Sri Lanka, mostly new agricultural technologies have become partially successful in improving the productivity.

Objectives

The major objectives of the study are: to estimate the technical efficiency of small rubber cultivators in Kalutara district; and to evaluate the effect of demographic and farming characteristics on the technical efficiency of rubber milk (latex) production in the above district.

Methodology

Kalutara district was purposively selected to ensure the sample size for the study which has 14 Divisional Secretariat (DS) divisions in the district. Out of 14 divisions, 4 Divisional Secretariats - Agalawatta, Mathugama, Bellana and Wallavita - were taken as the study area and 25 small rubber cultivators who owned less than 20 acres were randomly selected from these four divisions. The study used a questionnaire to collect the relevant information from 100 respondents, as well as conducting group discussions and interviews during the end of 2018. The collected data were analyzed using frequency distribution, Cobb – Douglas production function and stochastic frontier model. Frequency test was analyzed for demographic and farming characters, and the Cobb – Douglas production function impact of each input on rubber milk was estimated in the study. The production function can be expressed as:

$$lnY_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + v_i - u_i$$

Where, ln represents the natural logarithm and the subscript i denotes the i^{th} cultivator in the sample $i = 1, 2, \ldots, n$. Y_i is the yield of rubber output/latex; X_1 is Land Extent (in acres); X_2 is labour cost (Rs); X_3 is fertilizer cost (Rs); and X_4 is tapping cost (Rs). v_i's are the iid random erros with mean (μ_i) zero and variance, σ_v^2. u_i's are non-negative random variables called as technical efficiency effects which are assumed to be independently distributed such that u_i is defined by truncation (at zero) of the normal distribution with mean (μ_i) and variance, σ_u^2. In addition to that, to estimate the technical efficiency scores and its determinants among the small holder rubber cultivators, stochastic frontier production function was also employed in the study. The stochastic frontier production function can be shown as:

$$Y_i = f(X_i, \beta) exp^{(v_i - u_i)}$$

and it can be simply defined as:

$$u_i = \sigma_0 + \sigma_1 z_{1i} + \sigma_2 z_{2i} + \sigma_3 z_{3i} + \sigma_4 z_{4i} + \sigma_5 z_{5i} + \sigma_6 z_{6i} + \sigma_7 z_{7i} + \sigma_8 z_{8i} + \sigma_9 z_{9i} + w_i$$

Where, Y_i represents the output of the i^{th} rubber farm, X_i is the vector of different input used and β shows a vector of unknown parameter to be estimated, v_i' s and u_i' s are the same meaning as explained above.

u = Technical inefficiency
z_1 = Age z_2 = Gender z_3 = Household size
z_4 = Education level z_5= Income z_6 = Farming experience
z_7 = Types of land z_8 = Types of labour z_8 = Credit accessibility
w_i = Unobservable random variable

Results and Discussion

Table 1 shows the results of production functions for Cobb-Douglas and stochastic frontier model estimated by the Ordinary Least Squares method and Maximum Likelihood method respectively. Comparing the production elasticity between the two functions, all variables were significant except fertilizer in both models. Out of four inputs, the highest elasticity was land and tapping costs in both functions; however compared to tapping cost, elasticity of rubber output with respect to labour was higher in stochastic function than in Cobb- Douglas.

Table 1: Estimated results of production functions

Variables		Coef.	t - value		Coef.	t – value
Constant	β_0	3.572	9.25	β_0	3.640	9.62
Ln land	β_1	0.669	10.42*	β_1	0.666	10.59*
Ln fertilizer	β_2	-0.008	-0.36	β_2	-0.012	-0.53
Ln tapping	β_3	0.329	5.99*	β_3	0.327	6.07*
Ln labour	β_4	0.032	2.16**	β_4	3.397	2.15**
Sigma squa.	σ^2	0.050	5.01*	σ^2	0.004	6.04*
Log- like.		124.77			128.56	
Adjusted R^2 value = 0.998		F- Value = 6828.199		P - Value = 0.000		

Note: * and ** represent 1% and 5% significant levels respectively.

In the stochastic frontier model, the highest elasticity was for labour which is 3.39, implying that a 1% increase in labour cost would increase the production of rubber by 3.39%. The sum of all production elasticity coefficients was more than one in both models indicating that on average rubber farms were operating under increasing returns to scale. The technical efficiency of the sampled rubber cultivators ranged between 0.91 and 0.99 and the average technical efficiency was found to be 0.96 percent which shows that rubber cultivation attained 96% efficiency in the study area.

Table 2: Determinants of technical efficiency on rubber farms

Variable	Coefficient	Standard error	t – value
Constant	0.231	0.071	3.25
Gender	0.001	0.025	0.04
Age	-0.007	0.001	-2.32**
Secondary educatioı	-0.027	0.031	-1.87
Higher education	-0.020	0.032	-0.64
Family size	0.013	0.012	1.09
Farm experience	-0.002	0.004	-2.86*
Types of land	-0.028	0.046	-2.62**
Types of labour	-0.028	0.027	-2.05**
Credit accessibility	-0.226	0.036	-3.62*

Note: *and **represent 1% and 5% significant levels respectively

The results of efficiency achieved by demographic and farming characteristics are depicted in Table 2. According to that, out of nine explanatory variables only five of them were significant determinants of technical efficiency of rubber, and others were insignificant. Coefficient of age has a negative sign revealing that increase in age of the cultivator could reduce the inefficiency in the model. In other words, younger farmers are more likely to be technically inefficient than older farmers and it is statistically significant at 5% level. This may happen due to their good managerial skills and experience which they acquired over time. Therefore, the younger farmers should be encouraged to work with older farmers in rubber cultivation which may help raise efficiency in the future. Negative sign of the farming experience implies that, the cultivators who have more experience in rubber cultivation could increase the efficiency of rubber farms in the study.

Type of land is significant at the 5% level implying that cultivators who have their own lands are more technically efficient than the cultivators who have rented or tenanted lands. This may be because compared to tenant cultivators, own-land cultivators would be motivated to use innovative production techniques in their cultivation which may raise the technical efficiency of rubber farms. Further, the estimated coefficient of types of labour was negative and significant at 5% level revealing that cultivators who used more hired labours in rubber farms were found to be technically efficient than those who used family labour. Hence, the effect of hired labour is higher than family labour and, since rubber tapping is a heavy labor intensive activity and latex extraction is a skilled job, using skilled hired labour may raise rubber yields in the cultivation.

Frequency analysis also revealed that the majority of rubber plantation owners used hired labor for tapping of rubber in the rural areas. Like the other agricultural sector, family labour cannot simply engage in rubber farming, because tapping experience, knowledge and skills are important to increase rubber productivity. Tappers with experience, knowledge and tapping skills are different across hired and family labour and thus compared to family workers, hired workers have these aspects which would help enhance the technical efficiency of rubber in the study. The coefficient for farmer's access to credit was negative at the 1% level of significance implying that the use of credit could decrease the inefficiency effect on rubber production. This finding suggests that rubber cultivators who have credit facilities face less financial constraints which oblige them to use the inputs in the optimal way.

Conclusion

This study evaluates technical efficiency and its influencing factors on rubber farms using a Cobb- Douglas production function and stochastic frontier model with data obtained from a survey conducted among small-holder rubber cultivators during October to December, 2018. The findings of the study proved that all estimated parameters in both models had significantly influenced the rubber farms in the study area except fertilizer cost. Sum of the elasticity coefficients being greater than one reflects rubber cultivation being operated at increasing returns to scale. The policy implication of the study is that, on average the sampled rubber cultivation farms had technical efficiency at 0.96 which showed that rubber cultivators could increase its output by about 4% at the given inputs. Significant determinants of efficiency of rubber cultivation were age, farming experience, type of land, and type of labour and credit accessibility while gender, both primary and secondary education levels and farm size were insignificant in the model. This study recommends that the government should give more education about rubber cultivation by training including tapping trees and managing rubber farms especially for family labour for tapping that can be applied in farming to enhance productivity and efficiency in the future.

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