Proceedings of 12th Agriculture Research Symposium (2013) 439-443

Investigation of Profit Efficiency Using Stochastic Frontier and Quantile Regression Techniques: A Case Study in Kurunegala District

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ABSTRACT

Rubber plays an important role in the Sri Lankan economy and the demand for natural rubber is increasing yearly. Rubber cultivation in Sri Lanka has been confined mainly to the wet zone where the extent of land under rubber declined rapidly with the urbanization and land fragmentation. Consequently expansion of rubber cultivation into non-traditional rubber growing areas is highly encouraged. However issues related to economics of rubber cultivation in areas like Kurunegala District is found to be different from the other non-traditional rubber growing areas. In the literature, no studies are reported addressing these issues. With this background this study aims at investigating the profit efficiencies of rubber farming in and its determinants in Kurunegala District. It was found that the average profit efficiency of rubber farmers the area is about 67 percent highlighting the need of prompt action to increase profit margins further. The study reveals that this can be effectively achieved through more awareness programs and farmer organizations. Further, the need of encouraging the youth to grow rubber is highlighted by the results of the study.

KEYWORDS: Profit efficiency, Quantile regression, Rubber smallholders

INTRODUCTION

Sri Lanka is one of the nine major producers of Natural Rubber (NR) in the world. In terms of productivity, it is now the third best (Yogaratnum, 2012). Rubber (*Hevea brasiliensis*) is one of the prime export agricultural crops which bring a significant amount of foreign exchange to the country. The total rubber production in year 2011 recorded 158,198 metric tons while the production from January to August 2012 was 106,120 metric tons. The total rubber production of Sri Lanka is 1.2% of the total global rubber production (Anon, 2012a). Fundamentally, there are two types of rubber sectors in Sri Lanka, *i.e.* smallholder sector (less than 50 acres) and estate sector (more than 50 acres). 63% of the total area under rubber (79,395 hectares) belongs to smallholders and 37% (46,250 hectares) belongs to estate sector (Anon, 2012b). This indicates that, the smallholder contribution is more influential to national rubber production.

The traditional rubber growing areas of Sri Lanka are located at the wet zone in the low country. However, there is virtually no potential for further expansion of the rubber cultivation in the traditionally rubber growing areas due to urbanization and industrialization. Presently, rubber cultivations are available in 14 administrative districts Colombo, Gampaha, Kalutara, Kandy, Matale, Galle, Matara, Kurunegala, Badulla, Ratnapura, Kegalle, Monaragala, Hambantota and Ampara (Anon, 2012a). The demand for natural rubber in Sri Lanka is likely to surge, predominantly with increasing local consumption of raw rubber. In order to increase the rubber production it is necessary to promote planting rubber in areas where suitable lands are available while appropriate measures are taken to uplift the productivity as well.

Currently, programs have been launched to popularize rubber cultivation in Moneragala District, and some parts in Eastern and Northern Provinces which are not traditionally rubber cultivation areas. However very little emphasis is given on existing rubber cultivations and further potentials in areas like Kurunegala District. In Kurunegala District, rubber is mainly cultivated in areas that border to low country wet zone (Matale, Kegalle and Gampaha Districts). Being a part of the coconut triangle, the major plantation crop grown in the district is coconut. Consequently, available lands for further rubber cultivations are limited. However in other non-traditional rubber growing areas *viz.* Monaragala, Ampara, Badulla and Hambatota, the availability of land for agriculture is higher. There is no any major plantation crop dominating over those areas. Therefore, issues related to rubber cultivation in the areas of Kurunegala District may be quite different from issues in other rubber growing areas.

Since there is no self-consumption, profit maximization is the major objective of rubber cultivators even in smallholder sector.

Therefore, according to the availability of profit margins farmers proceed their decisions to whether invest more on their cultivation or not. Certain farmers give up rubber cultivation due to low profitability (Edirisinghe *et al.*, 2010). Some farmers tend to shift from one crop to the other which could be more apparent in Kurunegala where there are number of other plantation crops are grown. Edirisinghe *et al.*, (2010) reported further that average profit efficiency of smallholder rubber farmers in Kegalle, Kalutara and Ratnapura districts was 61.8%. Those areas are key rubber growing and traditional areas. The efficiency level 61.8% cannot be generalized to other non-traditional areas such as Kurunegala. With this background this research aims at investigating the level of profit efficiency of small holder rubber farming units and their determinants.

METHODOLOGY

Study Area

The study was carried out in the Kurunegala District which is in North Western province of the Island. There are about 350,000 households living in the District. Study area included two Rubber Development Officers (RDO) ranges (Redeegama and Polgahawela) in which there are about 10% of the total households 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.* lL1a, IM3b, WL3, WL2b, WM3a and WM3b found in this area.

Sampling and Data Collection

A multistage sampling scheme was adopted to select the study sample. It was restricted to 150 rubber cultivating households (Mature rubber holdings) due to the limited time and the budget. At the level one, two rubber growing RDO divisions were selected purposely. In the second step there were 12 GramaNiladari (GN) divisions selected randomly and probability proportionately to the number of total GN divisions in two RDO divisions. Households were picked randomly and probability proportionately from each GN division using a list of rubber growing farmers available at the RDO office. Data collection was carried out by face to face interviews with rubber farmers using a pre tested semi structured questionnaire during February to April 2013.

Analysis

Efficiency is concerned with the optimal production. Economic, pricing (allocative) and technical are the three forms of efficiencies. Using a profit frontier, the economic efficiency can be directly studied as the ability of the farmer to achieve the potential maximum profit, given the level of fixed factors and prices faced by the farmer (Abdulai and Huffman, 2000).

The Stochastic Profit Frontier Function

The stochastic profit frontier can be specified by incorporating a random error (u_i) and the displacement from the profit frontier (z_i).The stochastic profit function is defined as;

$$\Pi_i = f(P_{ji}, A_{ki}).\exp(U_i - Z_i) \quad (1)$$

Where,

Π_i = Normalized profit of the i^{th} farmer
P_{ji} = Normalized price of the j^{th} input used by the i^{th}famer
A_i = Fixed inputs
U_i = Random error, $u_i \sim N(0,\sigma_u)$
Z_i = One sided error depicting the displacement from the frontier

Literature suggests that the most common functional form of the stochastic profit frontier is a Cobb-Douglas function. The econometric specification of the Cobb-Douglas model used is,

$$\ln\pi_i = \beta_0 + \sum_{j=1}^{4} \beta_j \ln p_{ij} + \beta_A \ln A_i + u_i - z_i \quad (2)$$

Where, p_i includes normalized prices of inputs used in production of rubber (labour, fuel, acid, fertilizer and rolling). Land extent is used as fixed input A_i.

Farmer specific factors were used in order to explain the smallholder's inefficiency. They are listed below together with abbreviations.

FAGE = Age of the famer in years
FEDU = Education of the farmer in years
TPELAB = Dummy for type of labour used (If family labour = 1, hired labour= 0)
DISMKT = Distance to the market in Kilometers (km)
MEMRS = Dummy for member of rubber society (If member =1, non-member =0)
PRGRM = Dummy for participating rubber training programs (If participated = 1, otherwise=0)

The efficiencies and the determinants of the inefficiencies were estimated jointly by using the software FRONTIER 4.1.

To improve the interpretability of the Frontier results quantile regression approach was used. The conditional quantile parameter can be estimated by solving,

$$\hat{\theta} = \text{argmin} \sum_{i=1}^{n} \rho_\tau(PI_i - x'_i\theta) \quad (3)$$

Where, $\rho_\tau = \tau$, if the observation belongs to the τ^{th} quantile and $\rho_\tau = 1 - \tau$ if not. x is a vector of covariates, θ is a vector of parameters and $\hat{\theta}$ is its estimated values.

PI=1-PE where, PI = Profit Inefficiency and PE = Profit Efficiency

RESULTS AND DISCUSSION

Nature of Production

Summary statistics of P_i variables used in the profit function are depicted in Table 1. Ribbed Smoked Sheets (RSS) were produced by 98% of the farmers in the study area. There were only 1% latex producers and 1% scrap sellers. Thus, this study has considered only RSS producers in the analysis. There were five major types of inputs that are used in RSS production at the smallholder level.

Table 1. Summary of production statistics

Item	Sample mean	Min value	Max value
Wage rate (Rs/Man day)	273.4	0	181.2
Fertilizer price (Rs/kg)	8.76	0	140.5
Acid Price (Rs/l)	326.6	0	380
Fuel wood price (Rs/yard)	309.8	0	370
Rolling price (Rs/kg)	4.5	0	31.7
Sheet (Rs/kg)	329.8	235.9	355
Production cost (Rs/kg)	72.39	1.24	251.8
Profit (Rs/ac./month)	13009	1640	58154
Number of observations	147		

The most important is labour, which was used mostly for tapping. Higher portion of the cost of production were aggregated towards the wage of those labours. Although there is a fixed wage rate in estate level, smallholder level farmers pay their labours in different ways. In the study area, three major payment methods were identified. Those were daily wage (Rs/man day), pay according to amount of collecting latex (Rs/kg) and pay half of the day's income. Fertilizer, acid, fuel wood and rolling were the other major inputs which showed high cost. The average cost of production of RSS was Rs.72.39/kg.

Efficiency Levels

The mean profit efficiency of rubber smallholding sector in Kurunegala District was found to be 67%. This implies that 33% of the potential maximum profit lost due to inefficiencies. It shows slightly increasing of efficiently than in Kalutara (62.8%) and Kegalle (53.3%) districts (Edirisinnghe *et al.*, 2010). However, the productivity levels of these districts were reported greater than the productivity in the area under investigation. The distribution of efficiencies is depicted in Figure 1.

It is bimodal and show two clear clusters of efficiency levels *viz.* low and high. There were 52 farmers who had efficiency level less than 50%.Majority of farmers (64.62%) had efficiency higher than 50% and 52.38% of farmers had profit efficiencies more than 80%.

Results of the Cobb-Douglas profit frontier are illustrated in Table 2. The higher variance ratio (γ) indicates that the one sided error term depicting the displacement from the frontier dominates the random error implying that the variation in profit is mainly due to inefficiency.

The fixed input (land extent) returned expected significant positive sign. The price of acid and the price of fuel wood returned non-significant negative signs. The price of rolling returned significant with negative sign and the price of fertilizer was significant with positive sign. The wage rate reported non-significant and positive in sign.

Determinants of Profit Inefficiencies of Rubber Smallholder in Kurunegala District

The farmer specific factors were simultaneously estimated with the profit frontier to identify the determinants of inefficiency of smallholder. Results are presented in Table 3.

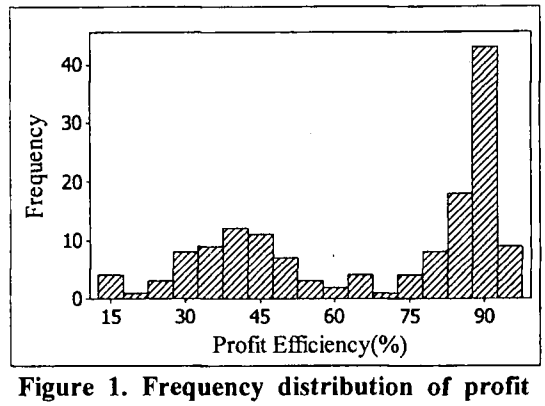

Figure 1. Frequency distribution of profit efficiency

Table 2. Maximum likelihood estimates of Cobb-Douglas profit frontier

Model Term	Estimate	Std. Error	t.Ratio
Constant	12.352	0.332	37.178*
Wage rate	0.0612	0.052	1.175
Fertilizer price	0.067	0.031	2.118*
Acid price	-0.0103	0.0538	-0.191
Fuel price	-0.0089	0.0231	-0.387
Rolling price	-0.098	0.0414	-2.369*
Land extent	0.719	0.0754	9.527*
σ^2(Total variance)	0.219	0.061	4.799*
γ (Variance ratio)	0.379	0.195	1.949**
λ(Likelihood ratio)	27.01		
N	147		

Significant at 0.05 level Significant at 0.1 level*

Age of the smallholders was significant with positive sign. This implies that the younger farmers take better decisions than elders. Older farmers may have tried to continue their cultivation with their own routine while youngers tend to identify the potentials for cultivation and methods which yields more profit margins. Subsequently, youngers have been able to increase their competence than older farmers.

Farmers' education levels (in years) were also found to be significant with positive sign, denoting that when farmers become educated then their efficiency levels for rubber cultivation decline. This is the real story of Kurunegala district. Compared to other rubber growing non-traditional areas *i.e.* Monaragala and Ampara urbanization, education level and employment are higher in Kurunegala district.

Table3. Determinants of profit inefficiencies in Kurunegala district as per stochastic Cobb-Douglas frontier

Variable	Coefficient	Std.Error	t.Ratio
FAGE	0.0134	0.005	2.547*
FEDU	0.052	0.019	2.765*
TPELAB	-1.607	0.811	-1.98*
DISMKT	0.005	0.020	0.237
MEMRS	-0.004	0.202	-2.00*
PRGRM	-0.398	0.168	-2.37*

**Significant at 0.05 level*

When people become more educated they attempt to diverge from rubber cultivation. With employment, rubber cultivation has become a secondary income source. Then they disregard their rubber lands and use hired labour to manage rubber lands which eventually cause less margins of profit efficiency.

The type of labour used for tapping was significant with expected negative sign proposing that those who tap their own land had higher profit efficiencies (88%). As well in the lands where hired labour used had 42% average efficiency. The reduction in efficiency was due to the additional cost incurred for wage of hired labour. The distance to market was non-significant with the expected positive sign.

Member of rubber society and participation of rubber training program were highly significant with a negative sign. This shows that those who were members of rubber society and participated in rubber training programs had been able to increase their efficiency levels. Farmers can share resources and have more access to available resources and Government subsidies through their rubber societies. They have an opportunity to get reduced the cost of production by getting the membership of a farmer society. For an instance during the survey found that some societies had processing facilities which can be used by the members at a subsidized rate that consequently reduce their cost of production. Rubber training programmes also help farmers to gain technical knowledge on various aspects of their rubber cultivation including low cost and quality production techniques. This too leads higher efficiency than who do not participate in rubber training programs. However, it was found that those who had membership with rubber society were very influencing to participate training programs.

Impact of the determinants will be variable in distinguish efficiency clusters depicted in Figure 1. Conditional impact of the determinants in different efficiency clusters can be evaluated by fitting conditional quantiles. Fitted conditional quantiles at the medians of the efficiency clusters (40% and 90%) for the education level *vs.* profit efficiency is illustrated in Figure 2.

Education showed higher impact on low efficient group with a statistically significant higher slope (-0.06, std. error =0.01). This indicates that when education levels are higher, the profit efficiency decreases drastically in low efficient group. The slope parameter at the high efficient group also recorded statistically significant and is -0.004 with a std. error of 0.002.

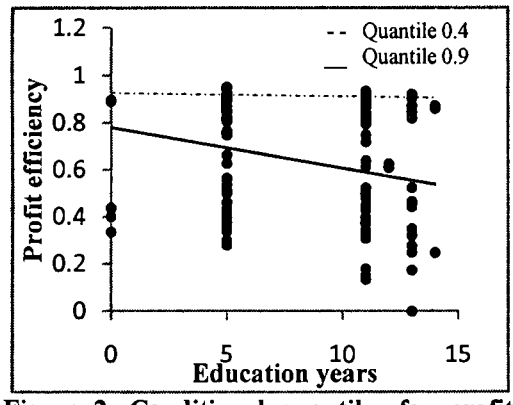

Figure 2. Conditional quantiles for profit efficiency vs. education

CONCLUSIONS AND POLICY IMPLICATIONS

The mean profit efficiency of smallholder rubber farmers in rubber growing areas of Kurunegala District was 67%. The average productivity level of the area is about 610 kg per hectare which is far below the national average for the small holder sector. The third quartile of the productivity is 780 kg hectare. This indicates that more emphasis should be given to uplift the productivity and the efficiency of rubber farmers in the area. As the study revealed the efficiency of the farmers can be increased through more awareness programs. Further rubber smallholders can be empowered through encouraging them to form rubber farmer organizations. Consequently the profit margin of the rubber cultivation will be increased due to the diffusion of novel techniques to the farmers and getting opportunities to use inputs more efficiently. Further this study revealed that more the education level of farmers lesser the profit efficiencies of rubber cultivation. This should be taken up seriously during the policy set up to find out what reasons make this to happen. As the study revealed, young farmers have made higher profit efficiencies emphasizing the need of making actions to encourage young blood to take up the responsibility of rubber cultivation form their elders.

ACKNOWLEDGEMENTS

Authors wish to express their sincere gratitude Mr. M.M.R. Udayakumara, S.Subawikrama (RDOs) and Mr. D.E.P.M. Nanayakkara (REO) for their assistance during the questionnaire survey. Further, we are grateful to Dr. Jagath Edirisinghe, for his valuable guidance to make this study success.

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