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RESEARCH ARTICLE

Technical efficiency of organic tea smallholders: Evidence from Uva region of Sri Lanka

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ABSTRACT

Today the society is moving towards sustainable agriculture, as a sustainable farming system, where cultivation is carried out without using chemically synthesized products such as urea, ammonium sulphate, pesticides, herbicides, hormones, activators, etc. With the introduction of organic agriculture to the world, organic tea also became important. Farmer productivity is one of the most important concerns in this regard. In the short run, the farmer productivity can be raised by improvement in technical efficiency. However, there is dearth of empirical evidence on technical efficiency of tea cultivation in Sri Lanka. Hence this article contributes to the pertinent literature by providing estimates of a stochastic frontier production model in a sample of organic tea smallholders in Diyathalawa region of Badulla district in Sri Lanka where the highest number of smallholders cultivate organic tea. The results reveal that the mean technical efficiency of organic tea smallholders is 24.7% implying that there is a scope of further increasing the output by 75.3%. Furthermore, livelihood diversification and crop diversification activities of smallholders contribute to decrease the efficiency.

Keywords: *Diyathalawa, organic tea smallholders, stochastic production frontier, technical efficiency*

INTRODUCTION

In Sri Lanka, agrochemicals have been used in tea cultivation since 1950's with the objective of obtaining higher yield. Prematilake (2003) noted that first serious attempt to apply chemicals in weeding in tea field was made in the late 1950's. Due to heavy use of chemical for a long period of time in the cultivation, some issues such as soil degradation, massive alteration of natural ecosystem, reduction in water, air and soil quality arise. As a solution, farmers started organic agriculture (Zoysa and Munasinghe, 2004). Gaffar (1999) has defined organic agriculture as a sustainable farming system where the cultivation is carried out without the use of chemically synthesized products such as urea, ammonium sulphate, pesticides, herbicides, hormones, activators, and the author further noted that it is not a system, which merely withholds application of chemically synthesized products but sustain crop by providing its nutrient requirements through organic inputs and protecting it through biological control methods. With the introduction of organic agriculture to the world, organic tea too became important. According to Vidanapathirana and Wijesooriya (2014), among the organic agriculture sector in Sri Lanka, organic and biodynamic varieties of tea occupy the major share with respect to the extent of cultivation and production. Furthermore, cultivated organic tea varieties are sold as value added teas as they fetch premium prices in many international niche markets. Vidanapathirana and Wijesooriya (2014) further highlight that Sri Lanka pioneered organic tea production and marketing in the world by establishing the first organic tea estate in Haldummulla in 1983, which made the first organic tea exports in 1987. Hughner *et al.* (2007) listed the top five reasons for organic food consumption: healthier, tastes better, environmental concern, concern over food safety, and concern over animal welfare. Also, Herath *et al.* (2001) show that benefit cost ratio of conventional tea is 2.41 while the benefit cost ratio of organic tea is 3.13. The major reason for having higher benefit cost ratio of organic tea is that it fetches minimum of 2-3 fold premium prices in the international markets. The main destinations of Sri Lankan organic teas are UK, Germany, Italy, France, USA, Canada, Australia, Singapore, Japan and Spain (Vidanapathirana and Wijesooriya, 2014). Organic tea is cultivated by both the estate sector as well as smallholder sector. Organic tea estates that are available in Sri Lanka are Needwood, Idalgashinna, Greenfield, Venture, Koslanda, Gemi Seva Sevana and small organic farmers group (Zoysa and Munasinghe, 2004).

Organic tea has higher economic value than that of black tea. Therefore, having high production will be advantageous to Sri Lankan economy. Hayami and Ruttan (1985) show that adoption of new technologies can increase the farm productivity and thereby the income. Under Sri Lankan context, tea smallholders lack interest on adopting new technologies due to the lack of credit facilities (Jayasinghe, 1995). Therefore, it is preferred to increase the productivity using existing technologies. Productivity and efficiency in agricultural production systems play a significant role in shaping up the lives of farmers. The productivity is found to be varying depending on the differences in production technology, environmental settings and production efficiency of the process (Jayasinghe and Tayoda, 2004). The level of production efficiency of organic tea smallholders is strongly affected by the use of inputs, technology and the management ability of the individual farmer. At present, the major issue that small farmers and policy makers face is ascertaining whether the organic tea productivity, using the present technology, could be increased without the use of high capital investment (Jayasinghe and Tayoda, 2004).

Technologies that could implement for organic tea smallholders are organic fertilizers, organic pesticides and biodynamic practices. Katugaha and Premathilaka (2016) have found that these practices are followed by the organic tea farmers in Badulla district. However, the major issue is the variation in productivity from smallholder to smallholder. This variation is mainly due to the inefficiency of farmers. The output from the existing inputs and technology is maximized when farmers operate efficiently. Therefore, the question rises here are; (1) what determines the efficiency of production (2) what level of efficiency the smallholders have (3) whether the farmers use resources efficiently. Therefore, the main purpose was to find the technical efficiency of tea smallholders and its determinants. Thus, this study would provide better insights into improving the productivity of organic tea smallholders as computing technical efficiency constitutes a more important source of information for policy makers. The results and findings of the study will also be valuable to government and other development agencies that are interested in improving the livelihoods of tea smallholders.

LITERATURE REVIEW

Organic agriculture can be defined as integrated, humane, environmentally and economically sustainable agricultural production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed (Lampkin and Padel, 1994). Scofield (1986) stated that organic farming is not limited to the usage of living material but also wholeness concept which is a systematic coordination has been introduced. Organic agriculture has the potential to provide improved livelihood opportunities, increased income and social benefits for resource-poor small-scale farmers (Qiao *et al.,* 2016). Moreover, the price premium received by farmers for the organic tea compensated for the extra labor input and lower yield, resulting in a net profit. However, given the relatively small plots of tea gardens of each household, organic production could not fully provide for the households' livelihood (Qiao *et al.,* 2016). Sri Lanka pioneered the growth and processing of certified organic tea (Hajra, 2001) and is the third largest organic tea producer in the world. Organic tea is the single largest organic product in Sri Lanka and has a major share among the exported organic agricultural commodities (Jayasinghe and Tayoda, 2004). The authors further highlight that the expansion of organic tea production by smallholders has been restricted by factors such as substantial yield drop during and after the conversion; changing attitudes of farmers (farmers who had converted their lands for organic production have later given up their commitment); high labour requirements especially for compost making; poor access to capital and credit, and difficulty in rearing livestock, which in turn provides manure for organic crop production. One of the major problems in tea cultivation is higher cost of production. Therefore, one option is to engage in organic farming. In other words, to avoid increasing input costs in conventional tea production, some of these tea lands were converted to organically grown tea in the early 1990s, owing to the influence of the organic movement helped by international NGOs (Qiao *et al.,* 2016). The concern and the solution for the problem of high cost of production is how we should increase the famer productivity. If the farmer's income could be increased by higher productivity, it would encourage their involvement in organic tea production (Qiao *et al.,* 2016). In the case of productivity improvement, an estimation of technical efficiency of organic farmers would provide insights into how we should increase the efficiency and subsequently the productivity. If we investigate the relationship between technical efficiencies and various socio-economic variables, it is undoubtedly a valuable exercise and provides vital information to policy makers who are attempting to raise the average level of organic tea farming efficiency.

In estimating the technical efficiencies, stochastic frontier can be applied to farm level data (Bravo-Ureta and Pinheiro, 1993). However, literature related to measurement of technical efficiency in relation to organic tea cultivation is limited in Sri Lanka. Although, the case is such, Jayasinghe and Tayoda (2004) find that there is a great potential to increase production by 55% through efficient use of the organic farming technology although it is comparatively low in comparison to the conventional tea smallholder's technical efficiency of 61.06% (Basnayake and Guneratne, 2002).

As the organic farming has widespread and is popular in the world, it has become one of the major income generating activities in most the countries and sectors in the world. In a study conducted related to dairy sector in USA, Mayen *et al.* (2010) find that the organic dairy technology is approximately 13% less productive. However, they further find a little difference in technical efficiency between organic and conventional farms when technical efficiency is measured against the appropriate technology. Koeijer *et al.* (2003) suggest that efficiency improvements can be achieved by demonstrating the economic effects associated with specific farm-management practices. Management specialization, represented by farmers who have committed the whole farm to organic production, has a significant positive impact on organic farm income. Acreage flexibility and crop diversification are also important. The effects of these variables do depend on the farmer's previous level of experience with organic production methods (Lohr and Park, 2006). In a study conducted in Kandy district related to vanila farmers in Sri Lanka, Kariyawasam *et al.* (2019) use a Stochastic Frontier function incorporating farm level inefficiency factors to provide estimates of technical efficiency and its determinants. They found that vanilla farmers are not fully technically efficient and the mean technical efficiency estimated is 37.32%. Madau (2007) applies a Stochastic Frontier production model to estimate technical efficiency in a sample of Italian organic and conventional cereal farms and finds that conventional farms were significantly more efficient than organic farms, with respect to their specific technology.

RESEARCH METHODOLOGY

Data and data collection

Most of the organic tea smallholders are concentrated in Diyathalawa, Bandarawela and Welimada in Uva Region. Diyathalawa belongs to the Huputale Divisional Secretariat in Badulla district and it has around 600 organic tea smallholders. Diyathalawa was selected since organic cultivation has been practiced for more than 10 years in some villages and most of the organic smallholders in Uva region are scattered in Diyathalawa area. Data were collected through a structured questionnaire covering 4 sections: household information, occupation and income details, production details and information on organic cultivation practices. The survey was carried out in 9 organic tea smallholding societies namely Heennarangolla, Rathkarawwa, Kirinda, Horadorowwa, Werallapathana, Walgahawela, Othumbe, Attampitiya and Wewakelle covering the entire Diyathalawa area. A sample of 100 organic tea smallholders was drawn from the population of organic tea smallholders in Diyathalawa area using a stratified sampling method where each strata represents organic tea smallholding societies.

Estimation of technical efficiency

Two main methods are generally used to analyze the efficiency of production. They are parametric method where the stochastic production frontier which was independently proposed by Aigner *et al.* (1977) and Meeusen and Van den Broek (1977) is used, and non-parametric method where Data Envelopment Analysis (DEA) is used to compute technical efficiency scores. This study employs stochastic production frontier as it makes allowance for stochastic errors due to statistical noise or measurement errors while it accounts for firm specific inefficiency (Forsund *et al.,* 1980; Battese, 1992; Coelli *et al.,* 1998).

Although, there are its well-known limitations, the stochastic production frontier is specified using the Cobb-Douglas functional form (Table 1) in this study as it provides an adequate representation of the production technology as long as interest rests on efficiency measurement and not on the analysis of the general structure of the production technology. We specify its Cobb-Douglas stochastic production frontier in the following way:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + V_i - U_i$$

where,
ln - denotes Natural logarithms; Y - is the average green tea leaf production, v - is a pure noise component with mean 0 and constant variance σ_v^2 and that $u_i \geq 0$ follows a half normal distribution with variance σ_u^2. βs - are unknown parameters to be estimated. The subscripts, *j, i* and refer to the jth input (j = 1, 2, 3), i-th tea smallholder (i=1,2, …, 100), respectively.

The efficiency model specified for Battese and Coelli (1995) specification is,

$$u_{ij} = \delta_0 + \sum_{j=1}^{17} \delta_j Z_{ij} + W_i$$

where,

δ_j (j=0,1,….,17) are unknown parameters; W_i is unobservable random variables.
We specify the inefficiency model in the following way;

$$U_i = \delta_0+\delta_1Z_1+\delta_2Z_2+\delta_3Z_3+\delta_4Z_4+\delta_5Z_5+\delta_6Z_6+\delta_7Z_7+\delta_8Z_8+\delta_9Z_9+\delta_{10}Z_{10} +\delta_{11}Z_{11}+\delta_{12}Z_{12}+\delta_{13}Z_{13}+\delta_{14}Z_{14}+ \delta_{15}Z_{15}+\delta_{16}Z_{16}+\delta_{17}Z_{17}+W_i$$

Table 1: Variables of the cobb-douglas production function.

Notation	Variable	Unit
Y	Green Leaf Yield	kg/month
X_1	Land	Acres
X_2	Labor	Man days/month
X_3	Organic fertilizer	kg/month

Source: Sample survey (2018)

The expression of Technical Efficiency relies on the value of the unobservable $\boldsymbol{U_i}$, which must be predicted. These predictions are obtained by deriving the expectation of the appropriate function of $\boldsymbol{U_i}$ conditional on the observed value of $\mathbf{v_i} - \mathbf{u_i}$.

The maximum likelihood method is used to estimate the parameters of both the stochastic frontier model and inefficiency effects model (Table 2). According to Battese and Corra (1977), the variance parameter of the likelihood function is estimated in terms of $\sigma^2 = \sigma^2_u + \sigma^2_v$ and $\gamma = \sigma^2_u/\sigma^2$. So that $0 \leq \gamma \leq 1$.

Much of stochastic frontier analysis is directed towards the prediction of inefficiency effects. The most common output-oriented measure of technical efficiency is the ratio of observed output (Yi) to the corresponding stochastic frontier output.

$$TE=\frac{Y_i}{\exp(x_i\beta+v_i)}=\frac{\exp(x_i\beta+v_i-u_i)}{\exp(x_i\beta+v_i)}=\exp(-u_i)$$

The technical efficiency of production for the *i*-th tea smallholder could be defined by $TE = \exp(-U_i)$.

Finally, a stochastic translog production function was estimated to test the robustness of the functional form. The following is the translog specification of the function;

$$\ln Y=\beta_0 +\beta_1\ln x_1+\beta_2\ln x_2+\beta_3\ln x_3+\beta_4(\ln x_1)^2+\beta_5(\ln x_2)^2+\beta_6(\ln x_3)^2+\beta_7\ln x_1\ln x_3 +\beta_8\ln x_2\ln x_3+\beta_9\ln x_1\ln x_2+v_i-u_i$$

Table 2: Explanatory variables used in technical inefficiency model.

Explanatory variable	Variable name	Units
Z_1	Age of the farmer	Years
Z_2	Experience of the farmers	Years
Z_3	Household size	Number
Z_4	Availability of livestock	Yes=1, No=0
Z_5	Duration of organic tea	Years
Z_6	Gender of the farmer	Male=1 Female=0
Z_7	Other crops cultivated	Yes=1, No=0
Z_8	VP	Yes=1, Other=0
Z_9	Seedling	Yes=1, Other=0
Z_{10}	Education level: Some primary	Yes=1, Others=0
Z_{11}	Education level: Some secondary	Yes=1, Others=0
Z_{12}	Education level: Up to OL	Yes=1, Others=0
Z_{13}	Education level: OL passed	Yes=1, Others=0
Z_{14}	Education level: Up to AL	Yes=1, Others=0
Z_{15}	Education level: Al passed	Yes=1, Others=0
Z_{16}	Education level: Technical college	Yes=1, Others=0
Z_{17}	Education level: Graduate	Yes=1, Others=0

Source: Sample survey (2018)

RESULTS AND DISCUSSION

This section describes the empirical results of study in estimating the technical efficiency of the organic tea smallholders in Diyatalawa of Huputale Divisional Secretariat division of Uva region. We first present the summary statistics of some selected variables omitting dummy variables used in the study. Secondly, we present the results related to estimating technical efficiency using the stochastic production functions and finally, we check the robustness of the estimated functions.

Summary statistics

Table 3 shows some summary statistics of a few selected variables and it shows that the average production of green leaf is 142.4 kg per household per month. Green leaf production highly varies from 50 to 350 kg among the smallholders. Average man-days employed in the organic tea cultivation in Diyathalwa is 14.6 man-days per month where the maximum number of man-days of labourers including hired labourers are 25 man-days.

Table 3: Summary statistics some selected variables.

Variable	Mean	Std. Dev.	Min	Max
Yield	142.4	71.05	50	350
Labour	14.61	3.993	9	25
Land	0.853	0.545	0.25	2.5
Organic fertilizer	377.5	319.5	50	1400
Age	61.71	9.782	34	82
Experience	26.05	11.81	3	55
Household size	4.134	1.505	1	8
Duration of organic tea	9.896	4.309	3	18

The average extent of organically cultivated tea lands is 0.853 ac and it ranges from 0.25 to 2.5 ac in the selected area. Around 377.561 kg of organic fertilizer have been applied for a month. It also highly varies from smallholder to smallholder and the amount applied ranges from 50 to 1400 kg of organic fertilizer. According to Table 3, the typical organic farmers in Diyathalwa are of the age of 61 y whereas experience in tea cultivation is 26 y including 9.8 y of organic tea cultivation. The mean household size of organic tea smallholder is four.

Results of the estimates of stochastic production frontier

To understand whether the farmers are operating at its optimum level or there is a room for improvement we estimated regression function using Ordinary Least Square (OLS) method. Multicollinearity and heteroscedasticity were tested as pre-requisites for the variables used in the function. To test the multicollinearity, calculation of Variance Inflation Factor (VIF) for independent variables was done. Mean VIF is 1.66 which is less than 10 showing that there is no collinearity among the independent variables. For heteroscedasticity, Breusch-Pagan/Cook-Weisberg test was performed. Here, the chi-squared value is 1.31, where H_0 is not rejected, which means there is a constant variance and regression disturbances are normally distributed.

According to the Table 3, the returns to scale of the function are 1.144, which is an increasing returns to scale. Adedeji *et al.* (2011) show when the returns to scale are increasing, optimum efficiency has not yet been achieved and farmers are under utilizing the technology i.e. there is a technical inefficiency. In the model land, labour and organic fertilizer significantly affect the organic tea production.

Table 4 shows the estimates of the Cobb-Gouglas OLS model and ML estimates for the organic tea smallholders.

Table 4: Estimates of the Cobb-Douglas OLS model and ML estimates for the organic tea smallholders.

Variable	Parameter	Coefficient		Standard error		T statistics	Z statistic
		OLS	MLE	OLS	MLE	OLS	MLE
Constant	β_0	1.783***	1.830***	0.260	0.201	6.85	9.09
lnLand	β_1	0.217***	0.212***	0.042	0.034	5.11	6.23
lnLabour	β_2	0.694***	0.744***	0.113	0.095	6.10	7.83
lnOrganic Fertilizer	β_3	0.233***	0.245***	0.035	0.027	6.55	8.74
R^2		0.82456					
F-statistics		122.26					
σ^2			0.389				
γ			0.790				
LR Test			6.55				

*, **, *** significant at 10, 5 and 1% significance levels, respectively.

According to the OLS estimates of the production function when the land extent is increased by 1% the production increases by 0.217% while the man days of labour is increased by 1%, the amount of production increases by 0.694%. Elasticity of production with respect to organic fertilizer is 0.233% which encourage farmers to apply more organic fertilizer in order to increase the production. Jayasinghe and Toyoda (2004) also shows that compost land and labour are positively significant in smallholder's organic tea production in mid country organic tea production in Sri Lanka. Basnayake and Gunaratne (2002) show that in convention tea, land labour and fertilizer positively affect the tea smallholder's production.

The maximum likelihood estimates of the parameters of the stochastic frontier production function are presented in Table 4. Before running the model, the continuous variables were transformed into log linear form. The dependent variable of the model was yield which is organic tea production in kilograms. The independent variables were land in acres, labour in man days and organic fertilizers in kilograms.

The skewness of the OLS residual was computed as a preliminary test for stochastic frontier. The test value is -0.393 which implies that OLS residuals are skewed to the left and confirm the validity of the model's stochastic frontier specification. Likelihood ratio test was used to test the existence of the inefficiency component in the stochastic frontier model of the organic tea smallholders. H_0: of σ^2=0 is rejected at 1% significant level according to the Table 4. This means that there is inefficiency and it is worth to measure. Also, the frontier was stochastic rather than deterministic.

As shown in Table 4, gamma parameter has been estimated as 0.790 which is greater than zero and close to one, which means majority of the error is due to the technical inefficiency. On the other hand, technical inefficiency significantly contributes to the degree and fluctuation of organic tea yield of the smallholders. The Maximum Likelihood (ML) estimates indicated that cultivated land extent, labour and organic fertilizers are significant at 1% significant level. The observed positive effect of land, labour and organic fertilizers were in line with studies of Jayasinghe and Toyoda (2004), Basanyake and Guneratne (2002) and Premaratne and Priyanath (2018).

According to ML estimates when the cultivated land is increased by one percent, output will increase by 0.212%. When the labour is increased by one percent the output will increase by 0.744%. When the organic fertilizer is increased by one percent the output will increase by 0.245%. Among the three inputs used for the production function the elasticity of labour was the highest. Therefore, use of more labour for organic tea production affects the yield largely. Jayasinghe and Toyoda (2004) also confirm that the highest elasticity is by the labour for organic tea smallholders. But, according to the Basnayake and Guneratne (2002) land has the highest elasticity in conventional tea cultivation of smallholders.

Estimation of stochastic translog production function

A stochastic translog production frontier was estimated to test the interaction effect among the variable in the Cobb-Douglas production function. The ML estimates are given in Table 5. In the translog model, only land and labour are significant at 5 and 1% significant levels, respectively. Here, the γ=0.863 which is close to the one, showing that the error is due to the technical inefficiency.

Technical inefficiency estimates

The maximum likelihood estimates of the parameters of the inefficiency model are presented in Table 6. The coefficients of the variables of age of the smallholders, experience of the smallholders, and gender of the smallholders, other crops cultivation and technical college education are significant at 10% significant level. Availability of livestock, duration of organic tea cultivation and education level of farmers up to O/L are significant at 5% significant level and the indicator for the education level of farmers who passed A/L is significant at 1% significant level.

The age of the farmer has positive association, indicating that age is a significant determinant in inefficiency. This means that younger farmers are more efficient than older farmers. This can be due to the fact that old farmers are reluctant to move into new technologies when cultivating and they do not go for innovative ways of cultivation that would increase the yield and also they might ignore the advices of the authorized institutes such as Tea Research Institute. The results further indicate that more experienced farmers in tea cultivation are more efficient. This is because they try to use their inputs in an optimum way with their experience. Jayasinghe and Toyoda (2004) confirm that experience really matters in increasing the efficiency. However, this result is contradicted to the result of the Basnayake and Guneratne (2002). They showed that with experience the technical inefficiency increases in conventional tea smallholders because most of the experience farmers tend to use seedling teas. Household size shows negative association with the output indicating technical inefficiency decreases with the increase in household size.

Table 5: Maximum likelihood estimates for parameters of the stochastic translog frontier.

Variable	Parameter	Coefficient	Standard error	Z statistics
ln Land	β_1	0.872 **	0.302	2.88
ln Labour	β_2	2.434***	0.706	3.44
ln Organic fertilizer	β_3	0.066	0.354	0.19
$(ln\ \text{Labour})^2$	β_4	-.523	0.745	-0.70
$(ln\ \text{Land})^2$	β_5	0.117	0.103	1.13
$(ln\ \text{Organic fertilizer})^2$	β_6	0.045	0.082	0.56
ln land* ln labor	β_7	-0.149	0.139	-1.07
ln land* ln organic fertilizer	β_8	-0.048	0.059	-0.82
ln labor* ln organic fertilizer	β_9	-0.037	0.247	-0.15
σ^2		0.409		
γ		0.863		

*, **, *** are significant at 10, 5, 1% significant levels, respectively.

Table 6: Inefficiency effects model.

Variable	Parameter	Coefficient	
		MLE	Translog
Constant	Z_0	-4.608*	0.499
Age of the farmer	Z_1	0.052*	0.305
Experience of the farmer	Z_2	-0.038*	-0.048**
Household size	Z_3	-0.195	-0.208
Livestock	Z_4	0.951**	0.853*
Occupation	Z_5	-0.664	-0.620
Gender of the farmer	Z_6	-0.920*	-0.726
Other crops cultivated	Z_7	0.940*	-0.468
VP Tea	Z_8	-0.554	0.565
Seedling Tea	Z_9	0.102	-0.177**
Duration of organic tea	Z_{10}	-1.516**	1.253**
Edu dummy 1	Z_{11}	-10.98	-7.407**
Edu dummy 2	Z_{12}	-4.705	-3.647*
Edu dummy 3	Z_{13}	-4.575**	-3.618**
Edu dummy 4	Z_{14}	-2.516	-1.721
Edu dummy 5	Z_{15}	-3.610**	-2.526
Edu dummy 6	Z_{16}	-5.161***	-4.656**
Edu dummy 7	Z_{17}	-7.078*	-35.98

*, **, *** are significant at 10, 5, 1% significant levels, respectively.

These findings lead to the conclusion that more family members can be used for the field practices as result of increase in family size. Coelli and Battese (1996) stated that hired labour is less productive than family labour. Therefore, usage of more family labour than hired labour could increase the production. Availability of livestock shows positive association with the technical inefficiency. When rearing animals more labour and time have to be dedicated to those activities and therefore, it results less devotion towards organic cultivation and technical inefficiency can be increased. Occupation has negative association with the technical inefficiency which means that technical efficiency increases if the farmers are engaged in tea cultivation only as their occupation. When farmers devote their full time to the organic tea cultivation the efficiency increases.

According to the Table 6 gender of the farmer shows negative association meaning that males are more efficient than females. If farmers diversify into many crops, the technical inefficiency increases as farmers have to maintain and treat those crops as well. Thus, their time spending on tea cultivation reduces creating more inefficiency. According to the study cultivation of VP teas shows negative association with the technical inefficiency while cultivation of seedling teas shows a positive association with the organic tea output indicating that VP teas are more efficient than seedling teas. This result is confirmed by the Jayasinghe and Toyoda (2004) for organic tea cultivation and for conventional cultivation too by Basnayake and Guneratne (2002). Duration of organic tea cultivation shows negative association with the technical inefficiency. This can be due to the fact that, with the time, amount of organic fertilizer applied will be high and more production can be expected. According to our findings, education of any type leads to increase the efficiency of organic tea cultivation.

The mean technical efficiency of the organic tea smallholders in Diyathalawa is 0.247 and efficiency ranges from 0.033 to 0.653. This shows that the output can be increased by 75.3% without increasing the input levels. In the study of Jayasinghe and Toyoda (2004) the mean technical efficiency of the organic tea smallholders in mid country was 0.45 which is higher than that of Diyathalawa. Further, Basnayake and Guneratne (2002) shows that mean technical efficiency of conventional tea smallholders was 0.61 which is higher than the organic tea cultivation in the mid country.

Table 7 shows the distribution of technical efficiency of organic tea smallholders in Diyathalawa. The majority lies in the range of 11 to 20%. 32.9% of the farmers lie above the average technical efficiency and the majority are below the estimated average technical efficiency. Only two farmers' efficiency lies between 61 and 70% and no farmers have technical efficiency more than 70%.

Table 7: Distribution of technical efficiencies (based on Cobb-Douglas specification).

Efficiency level (%)	Frequency	Percentage
0-10	21	25.6
11-20	25	30.5
21-30	9	11.0
31-40	10	12.2
41-50	8	9.8
51-60	7	8.5
61-70	2	2.4

Robustness of technical efficiency

Figure 1 shows the robustness of technical efficiency estimates obtained by Cobb-Douglas and translog models. It clearly shows that there is no much difference of the technical efficiency value from Cobb-Douglas function and the translog function since the line is approximately 45-degree line.

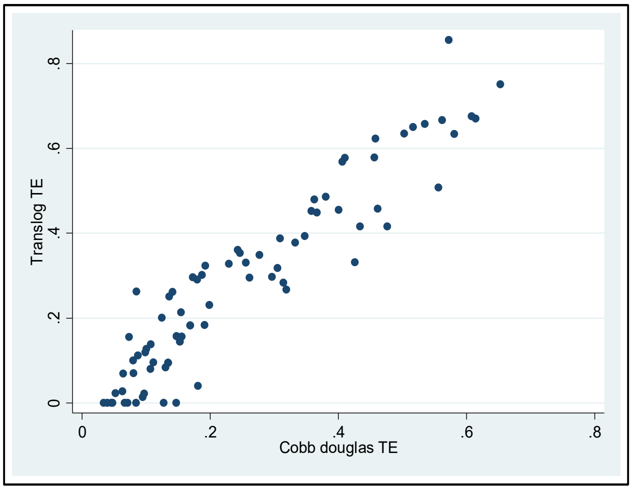

Figure 1: Robustness of the technical efficiency estimates.

The mean technical efficiency from Cobb-Douglas function is 0.247, and from translog is 0.278 which is approximately equal. This is implying that considerable interaction effect cannot have in the chosen stochastic frontier model. Therefore, technical efficiency estimates are not sensitive to the functional form specified.

CONCLUSION AND RECOMMENDATIONS

Stochastic frontier production model has been used with inefficiency effects to analyze the relationships between total green leaf production and organic fertilizer using data that have been collected from organic tea smallholders in Diyathalawa of Uva region. Cultivated extent, labour usage and amount of organic fertilizer added significantly affect the organic tea production. The estimated average technical efficiency of organic tea smallholders using Cobb-Douglas Function is 24.7%. This implies that there is a scope of further increasing the output by 75.3%. Education level of the tea smallholder is an important determinant of efficiency of the organic tea production while experience of the tea smallholder contributes positively to the efficiency in production. Experience farmers have good managerial skills which they have gained over the period. Furthermore, older farmers are less efficient. This could be due to the fact that the older farmers are reluctant to use new technologies and also they might not listen to the advice from the organic associations. Therefore, good extension services should be provided to the older organic smallholders in an effective way. The older farmers are new to the organic tea cultivation so their inefficiency is high.

Male farmers contribute to increase the efficiency in organic tea cultivation. Most of the female farmers are engaged in other household activities. Therefore, time spent on organic tea cultivation by females is less. Thus, they contribute less to increase the efficiency. It is then recommended to encourage male to engage in organic tea farming. As smallholders have to engage in livestock management when they have animals, they are not well-engaged in organic tea cultivation and it has led to decrease their efficiency. When smallholders move into diversifying their crop cultivation their technical efficiency in tea cultivation reduces as their labour has to be reallocated among all other activities. If the other crops are cultivated it is recommended to encourage farmers to use hired labour for organic tea cultivation especially when weeding and pruning have to be done. The soil on which tea is cultivated needs come period to convert from conversional farming to organic farming. More organic fertilizer should be added to the soil with the time and it takes some time decay and release nutrients to the soil. Therefore, longer the period of cultivation, higher will be the technical efficiency. It was also found that technical inefficiency model is not sensitive to the functional form because technical efficiency value of Cobb-Douglas model and Translog model does not vary significantly for organic tea smallholders in Diyathalawa. For further research, this study can be done in panel data considering few years in order to understand how productivity and technical efficiency has varied over the time.

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