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Technical Efficiency of Rubber Farmers' in Changwat Sakon Nakhon: Stochastic Frontier Analysis

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ABSTRACT

The study was conducted to analyze the technical efficiency of smallholding rubber farmers in Changwat Sakon Nakhon. The numbers of 375 smallholding rubber farmers were analyzed using stochastic frontier analysis. The smallholding rubber farmers were sampled using stratified random sampling technique with one output and only three inputs (age of plantation, labor, cultivated aras). Results clearly show that the mean technical efficiency of rubber product in Changwat Sakon Nakhon is 0.69% or 69% with the variance of parameters (gamma and sigma squared) of the frontier production function were both significant at $P < 0.05$. However, the inefficiency model revealed that education, training, gender and age of smallholding rubber farmer were found to have significant effect on rubber farmers' efficiency at $P < 0.05$.

Keywords: Technical Inefficiency, Stochastic Frontier, Changwat Sakon Nakhon
JEL Classifications: Q12, Q13

1. INTRODUCTION

Para rubber cultivation was first planted in Thailand in 1899 due to suitable climate. The original of para rubber were promoted in the southern and eastern regions of the country. Later, para rubber tree was spread to the north and northeastern region. Currently, para rubber has significant economic plant for these region. In 1990, the rubber area totaled 10 million rai while the total area in 2013 amounted to 18 million rai (http://www.wrm.org.uy/oldsite/countries/Thailand/Rights_of_rubber_farmers_in_Thailand.pdf.). Further, the Bank of Thailand's Northeastern office reported that the average cultivated area had increased to 24.2% per year over the past 10 years (from 2000 to 2010). As a result, this region represents the second largest cultivated area in the region of Thailand. In the study of Thongyou (2014), he presented that currently rubber areas in the Northeast region were 3.36 million rai. Especially Changwat Nongkhai, Loei, Udorthani and Sakon Nakorn had the largest rubber areas. These areas had the most suitable climate for rubber cultivation.

Moreover, there has been an increasing demand for rubber and its products but productivity seems to be inadequate to supply the growing demand in a variety of para rubbers. Considerable research has been conducted on the natural rubber in the areas of crop improvement and other production innovations (Alika, 1982; Esekhade et al. 1996; Omokhafe and Nasiru, 2004). However, there was little attention on how to improve technical efficiency. Consequently, the main purpose of this study is to measure and investigate factors affecting the technical efficiency of smallholding rubber farmers in Changwat Sakon Nakhon.

2. LITERATURE REVIEWS

There were two basic methods of measuring technical efficiency: The classical and the frontier approach. However, classical approach had shortcomings consequently economists had to develop advanced econometric, statistical and linear programming techniques aimed at analyzing technical efficiency related issues. The concept of stochastic frontier production function implied that efficient product was based on the production frontier, while inefficient product was operating below the production frontier (Coelli, 1995).

The initial of stochastic frontier production function was based on the econometric model (Farrell, 1957). Aigner et al. (1977) used stochastic frontier analysis (SFA) which is basically a linear programming technique. The stochastic frontier parameters are statistically testable as their confidence levels and the accuracy of the estimated models are known. The usefulness of SFA was developed by Battese and Coelli (1995) which could estimate both technical efficiency scores and simultaneously able to identify factors affecting the level of a firm's inefficiency.

The SFA used maximum likelihood method to estimate the frontier function in a given set of inputs and technology. The SFA separated error components from inefficiency components. In particular, it requires separate assumptions to be made to the distributions of the "inefficiency" and "error" components, potentially leading to more accurate measures of relative efficiency.

There are some previous researcher utilized the SFA in examining technical efficiency such as the analysis of the U.S agricultural data by Aigner et al. (1977). Currently there are empirical researches of the SFA reported by Battese and Coeli (1993); Ajibefun and Daramola (1999); Ojo and Ajibefun (2000). Further, the SFA could be used in agricultural product efficiency. Especially, the study of Hashim and Mustapha (2011) concluded that quantity of fertilizer, husbandry practice, skill, motivation and experience of operators, management competence of the supervisors, soil fertility, and species of the rubber trees and weather conditions are factors affecting productivity and technical efficiency. Also, Tran et al. (1993) studied the technical efficiency of state rubber farms in Vietnam using the stochastic frontier production function for 33 farms. A mean technical efficiency of 0.59 was obtained with varied indices of the technical efficiency and the variations were attributed to that of management and different field husbandry methods adopted in the farms. Furthermore, Poungchompu and Chantanop (2015) summarized that all inputs (except chemical fertilizer) are major factors that have influenced on the changes of output of rubber production. The mean technical efficiency index for the farmers was found to be 0.573 and the efficiency factors, which were comprised of age of farmers, education, gender and age of the rubber trees, were found to be the significant factors that affected the variation in technical efficiency among the farmers.

3. METHODOLOGY

The stochastic frontier production function, proposed and improved by Aigner et al. (1977), Batteses and Coeli (1995); Amaza and Olayemi, (2002); Helfand, (2003); Maurice, (2004) and Ebong et al. (2009), was used in analyzing data generated from this study. It is specified as:

$Y_i = f(X_i;\beta)\exp(V_i - U_i)$ i=1, 2..., N (3)

Where, Y_i = Production of ith smallholding rubber farmers, X_i = Vector of input quantities of ith smallholding rubber farmers, β = Vectors of unknown parameters, V_i = Assumed to account for random factors such as weather risk and measurement error, and U_i = Due to technical inefficiency.

The stochastic frontier production function model was specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + \beta_3 \ln x_{3i} + \beta_4 \ln x_{4i} + \beta_5 \ln x_{5i} + V_i - U_i$$

Where, Y_i = Output of para rubber (kg/tree tapped area per rai) of ith household rubber farmers,

X_1 = Age of plantation (in years), X_2 = Tree tapped areas (in rai), X_3 = Fertilizer (in kg.), X_4 = Labor (in man days), X_5 = Cultivated areas (in rai), V_i = Random noise which is N (0, σ_V^2), and U_i = Inefficiency effect which is non-negative, half normal distribution N (0, σ_U^2).

The inefficiency model was defined as follows:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5$$

Where,
U_i = Inefficiency effect
Z_1 = Tapping experienced of smallholding rubber farmer (in years)
Z_2 = Education (schooling in years)
Z_3 = Training of smallholding rubber farmer in cultivating and tapping (in years)
Z_4 = Gender (1 for male, 0 for female) (in years)
Z_5 = Age of smallholding rubber farmer (in years)

The summary statistics of variables used in the stochastic frontier production function is presented in Table 1. The table revealed that the mean of output is 210.25 kg/tree tapped area per rai with a standard deviation of 5.43. The variability shows that the age of plantation of par rubber tree is 11.05 years with a standard deviation of 2.41. The mean tree tapped areas were 6.09 rai with a standard deviation of 1.07. Fertilizers were used with an average of 101.71 kg/rai with a standard deviation of 6.43, while the mean total man-days of labor used was 6.03 with a standard deviation of 1.75. Finally, the mean cultivated areas of para rubber tree were also 10.11 rai with a standard deviation of 2.02.

Table 2 indicates that the variance parameters of the stochastic frontier production function (sigma squared and gamma) are

Table 1: Description and descriptive statistics of variables

Variables	Description	Mean±SD
Production function		
Y	Output of para rubber	210.25±5.43
X_1	Age of plantation	11.05±2.41
X_2	Tree tapped area	6.09±1.07
X_3	Fertilizer	101.71±6.43
X_4	Labor	6.03±1.75
X_5	Cultivated areas	10.11±2.02
Inefficiency model		
Z_1	Tapping experience	4.25±1.25
Z_2	Education	5.40±2.34
Z_3	Training	3.10±1.05
Z_4	Gender (male, female)	62.54, 35.64±5.79, 3.68
Z_5	Age of smallholding rubber farmers	60.58±2.65

significantly different at $P < 0.05$, respectively. The parameter sigma squared was 0.21, which means that it is a good fit and shows the correctness of the distributional form. The value of gamma is equal to 0.76 and is statistically significant at $P < 0.05$, implying that more than half of the residual variation is due to the efficiency effect. All the coefficients of the inputs in the production function are positive and significant at $P < 0.05$, but only the fertilizer (X_3) is not significant. This implies that the age of plantation, tree tapped areas, labor, and cultivated areas have influenced on outputs of para rubber and that these variables have increased as the para rubber yields increased.

The inefficiency model include tapping experienced of smallholding rubber farmers (Z_1), education of smallholding rubber farmers in schooling system (Z_2), training of smallholding rubber farmers in cultivating and tapping (Z_3), gender (Z_4) and the age of smallholding rubber farmers (Z_5). The coefficient of age variables was significantly positive in relation to the production efficiency, which suggests that the older the farmers are the more experienced and efficient they would be. Similarly, education showed a significant ($P < 0.05$) negative coefficient, meaning that the level of technical efficiency of the farmers increases with the level of education. On the other hand, the coefficient of tapping experience is not significant. Moreover, training experience of smallholding rubber farmer had a positive sign and was statistically significant at $P < 0.05$.

4. RESULT AND DISCUSSION

The discussion of the results begins with descriptive statistics of data which consist the outputs and inputs of rubber in Changwat Sakon Nakhon (Table 1), consisting 375 smallholding rubber farmers. All the coefficients of the inputs in the production function are positive and significant at $P < 0.05$, but only the fertilizer (X_3) is not significant. This implies that the age of plantation, tree tapped areas, labor, and cultivated areas have influenced on outputs of para rubber and that these variables have increased as the para rubber yields increased. An increase of 1% in age of plantation, tree tapped areas, labor, and cultivated areas will result an increase output by 2.12%, 1.27%, 0.10% and 0.28% respectively. The production of para rubber is statically significant at 0.05, which implies that positive and statistical influence the output of para rubber.

The inefficiency model in Table 2 paves way to find out the sources of inefficiencies smallholding rubber farmers in the study area. The signs and coefficients in the inefficiency model are interpreted in the opposite direction, such that a negative sign means the variable increases efficiency and vice versa. The result of the inefficiency model shows that the coefficients for tapping experience were not statistically significant. This implies that these characteristics do not contribute to para rubber production inefficiency. The coefficient of education and gender of smallholding rubber farmer were estimated to be negative and statistically significant at 0.05. This shows that increase in education and age of smallholding rubber farmers will result in increasing output of rubber. These results were in line with the study of Kingsley et al. (2015) revealed that education, training, gender, and age of smallholding rubber farmers

Table 2: Maximum likelihood estimate of stochastic frontier production function for rubber production in Chanagwat Sakon Nakhon

Variables	Parameter	Coefficient	t-ratio
Production function			
Constant	β_0	1.53	3.12*
Age of plantation	β_1	2.12	4.72*
Tree tapped area	β_2	1.27	2.55*
Fertilizer	β_3	0.21	0.38
Labor	β_4	0.10	2.57**
Cultivated areas	β_5	0.28	3.14**
Inefficiency model			
Constant	δ_0	2.15	0.74
Tapping experience	δ_1	−0.087	−0.75
Education	δ_2	−0.58	−2.41*
Training	δ_3	0.89	1.95*
Gender	δ_4	−3.53	−2.18*
Age of rubber household farmer	δ_5	2.27	3.28*
Variance parameter			
Sigma-square	δ^2	0.21	5.47*
Gamma	γ	0.76	12.15*
Mean TE		0.69	
Number of observation	375		

Source: Computer output from frontier 4.2. *significant at P<0.05

in rubber farming have positive impact and is statistically significant.

5. CONCLUSION AND RECOMMENDATION

The result of the SFA showed that the entire production coefficient had only three inputs (age of plantation, labor, and cultivated areas) that were positive signs, indicating that increase in any of the variables will lead to increase in output.

The technical efficiency of sole smallholding rubber farmers was less than one, indicating that the farmers were not operating on the efficiency frontier. The mean technical efficiency index was 0.69, suggesting that farmer's output can be improved by 21% through improved resource allocation. Variables such as education, training, gender, and age of smallholding rubber farmer were found to be significant in reducing the inefficiency levels of smallholding rubber farmers in Changwat Sakon Nakhon.

The level of education might influence the smallholding rubber farmers' ability to use available technology. Thus, the recommendation is that the government policy for para rubber should give more education through training about rubber production, including tapping trees, especially family tapping labor and tapping labor employment. Furthermore, more education will impact the farmers' knowledge in order to enhance efficiency.

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