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Technical Efficiency of Tea Farms: Case Study in Thainguyen Province of Vietnam

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Abstract

Tea production plays a vital role in rural development and poverty reduction in the North region of Vietnam, specializing in Thainguyen, a northeastern province of Vietnam. This study aims to analyze the technical efficiency of tea farms in Thainguyen province and subsequently to identify the key factors affecting their technical efficiency. The data envelopment analysis (DEA) method was first used to compute the technical efficiency levels. Tobit model was then used to determine factors affecting the inefficiency level of tea farms in the study area. The data of 50 farmers were collected by interview technique. The findings investigated that the average technical efficiency of tea farms was 0.73, implying that tea farms could increase their efficiency level by using inputs more efficient. The results of the Tobit regression model in the second stage revealed that factors related to age, education, and experiences had a significant positive influence on the technical efficiency of tea farms, therefore, to improve the efficiency of tea farms, the government should address policies to encourage tea farms to attain more education through extension system and training and technological transfers activities to help tea farms in adopting high technology in production to improve their efficiency level.

Keywords: data envelopment analysis (DEA); tea farms; technical efficiency; Tobit model; Thainguyen, Vietnam.

1. Introduction

In terms of the economy, Green tea cultivation was considered one of the important livelihoods to increase income and contribute to reducing the poverty rate for the Nothern provinces of Vietnam. In Vietnam, due to the cultural tradition of green tea drinking, these specialty products are highly popular among Vietnamese people and tea is the most popularly grown in both northern mountain and highland regions. According to the report of Vietnam General statistic office, the green tea acreage was approximately 121.000 ha with 1045.000 tons [1]. Besides, Vietnam is known as one of the five tea exporting countries in the world. Current statistics indicated that Vietnamese tea products have been exported to 74 countries [1].

Thai Nguyen province is known as one of the provinces with many favorable conditions for tea production. Therefore, tea production plays an important role in the socio-economic

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development of Thainguyen. According to the survey conducted by Thainguyen province in 2020, the productive area of green tea was 22.399 ha with an output of 244.432 tons [1].

Although being one of the top tea producers in Vietnam, tea cultivation in Thainguyen province is facing challenges such as low unstable yields, quality and economic efficiency are found to be still low. Moreover, environmental pollution is an important problem in tea production of Thainguyen.

Therefore, the big question is whether production of tea crop in Thainguyen is technically efficient to award maximum benefits without deteriorating the future perspective of the environment? The computation of technical efficiency is far-reaching in addressing sources of inefficiency in the production process, i.e., ameliorating production without increasing the input usage. It is a strategy widely applied to intensify production for poor farming households that usually do not have sufficient funds to solicit more inputs.

Besides, using data envelopment analysis to measure technical efficiency was applied by many researchers in agricultural sciences fields. For example, Karimov et al. [2] and Koc et al. [3] used the DEA model to analyze the technical efficiency of maize farming households. In rice production, various authors applied DEA model to compute technical efficiency of rice farms such as Wardana et al. [4], Watkins et al. [5] and Zheng et al. [6]. Moreover, in coffee production, Poudel et al. [7] employed DEA model to measured and compared the technical efficiency of conventional and organic coffee farms in Nepal. Therefore, DEA model is considered the most popular method to evaluate efficiency in agricultural production.

This paper aimed to evaluate the technical efficiency level of tea farms and then to describe the factors of inefficiency. The results paramount in assisting farmers by decreasing the usage of inputs while output quantities were unchange. On the other hand, the findings could serve as references for policymakers to establish policy measures aiming at improving the performance of tea production in Vietnam. Moreover, to the authors' knowledge, studies analyzing the technical efficiency of tea production in Vietnam have been still limited. As such, the present study would fill up the gap in the literature.

2. Methodology

2.1. Data collection and data source

In Thainguyen province, tea farms in Phucxuan commune were chosen as the study sites due to the most tea farms follow the traditional way. Moreover, the output of tea households were low and unstable. A total number of 50 tea farms were chosen randomly to conduct the survey for this research.

The data were gathered by using a structured questionnaire. The questionnaire was designed in two sections. Firstly, a set of questions about socioeconomic characteristics of tea farms was shown such as age, education level, experience in tea cultivation, family size, credit access capacity, etc. The second part attempted to collect data about tea production of farms, including inputs like chemical fertilizer, pesticide, labor and output of tea producers.

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2.2. Empirical analysis model

According to Cooper et al. [8], Data Envelopment Analysis (DEA) is known as a data-oriented approach that is used to measure the performance of decision-making units (DMUs). Recently, the DEA approach was applied to evaluate the performance of many different activities and study sites, i.e., agricultural production, business, hospitals, countries, regions, etc. DEA was more popular using than other methods because it measures efficiency levesl without requiring specifying the production function and specification of a distributional form of the inefficiency term.

DEA model can be specified an input-oriented or output-oriented. This study used the input-oriented method to evaluate the performance of tea farms because there is only one output with several inputs [9].

A two-step DEA methodology was employed to evaluate the efficiency score of tea farms and to show factors affecting he inefficiency of farms. In the first stage, the input-oriented DEA, including constant returns to scale (CRS) and variable returns to scale (VRS) was used to compute the technical efficiency score of farms. In the second step, the Tobit model was applied to investigate the relationship between the technical efficiency score of household and socioeconomic variables.

The empirical model for the first step

In the first stage, CRS and VRS model were employed to evaluate the technical efficiency level of tea farms. These model described as follow:

$$\begin{aligned} TE_{CRS} &= Min_{\theta i\lambda}\,\theta, \\ Subject\ to \quad & Y\lambda - y \geq 0 \\ & X\lambda - \theta_i X_i \leq 0 \\ & \lambda \geq 0 \end{aligned} \qquad (1)$$

Where Y and X illustrate output and input vectors, respectively, θ_i represents the technical efficiency score of the i-th farm under CRS, and λ is a N × 1 vector of constants. The θ value is retricted from 0 to 1. For any farm, if $\theta = 1$, implying that the farm is fully technically efficient under the assumption of CRS. On the other hand, if $\theta < 1$, meaning that the farm is considered technically inefficient [10].

The VRS model was expressed by equation as follow:

$$\begin{aligned} TE_{VRS}(PTE) &= Min_{\theta i\lambda}\,\theta, \\ Subject\ to \quad & Y\lambda - y_i \geq 0, \\ & X\lambda - \theta_i X_i \leq 0 \\ & N1'\lambda = 1;\ \lambda \geq 0 \end{aligned} \qquad (2)$$

where θ denotes the TE under VRS model of tea farms, and N1'λ illustrates a convexity constraint to ensure that an inefficient tea farm was only benchmarked against farms of a similar-size farm.

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Tobit regression model

In the second stage, Tobit model was employed to show the factors influenceing on technical efficiency of farms. Tobit is a model propoded by Tobin [11]. In this study, this model involved the separate regression of TE scores on a vector of socio-economic characteristics independent variables. According to Linh [12] and Vu et al. [13], Tobit regression model was more appropriate than other methods because the efficiency scores of farms range between 0 and 1. The Tobit model was illustrated as follow:

$$\theta^* = \beta Z_i + \varepsilon_i, i = 1, 2, ...N$$
$$\theta_i = \theta^* \; if \; \theta^* > 0,$$
$$\theta_i = 0 \; if \; \theta^* \leq 0 \qquad (3)$$

where β is unidentified coefficients; θ* denotes the latent variable; and ε_i represents the error term, $\varepsilon_i \sim N(0, \sigma^2)$. θi describes the inefficiency scores of the i^{th} tea farm which was computed in the first step. Zi is the vector of exploratory variables related to tea produccers.

3. Results and discussion

3.1. Descriptive statistics

The descriptive statistics of some variables used to analyze in this study is described in Table 1.

Table 1. Descriptive statistic of variables used in this study

Variables	Unit	Mean	Std. Dev.	Min.	Max.
Production Variables					
Output					
Tea yield	Kg/acre	61.28	10.14	39.24	85.00
Inputs					
Capital	Million VND/acre	16.02	7.07	2.88	35.00
Chemical fertilizer	Kg/acre	55.63	48.24	5.00	275.00
Labor cost	1000 VND/acre	1,347.15	1,369.93	333.30	9,400.00
Pesticide cost	1000 VND/acre	177.34	135.58	36.67	990.00
Socioeconomic variables					
Age of head household	Years	43.8	10.92	26.00	72.00
Education	Years	7.87	2.67	4.00	12.00
Experiences	Years	21.58	9.52	5.00	45.00
Market distance	Km	2.20	1.21	0.20	4.00
Household size	Members	3.33	1.05	1.00	6.00
Extension visit	Dummy	0.07	0.26	0.00	1.00

Note: In the North of Vietnam, 1 acre = 360 m^2 = 0.036 ha.

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The statistic in Table 1 reveals that there was a large range in all variables. The average the yield of green tea was 61.28 kg/acre ranging from 39.24 kg to 85.00 kg. It is reasonable to believe there was a difference between tea farms in using various inputs. The difference among household for each input is described in Table 1. The capital was an important input in agricultural production. In tea cultivation, the average capital investment per acre was 16.02 million VND with a range from 2.88 to 35.00 million VND. The labor cost per acre was 1,347.15 thousand VND ranging from 333.30 to 9,400.00 thousand VND, implying that tea production tended to be highly labor usage. The usage of pesticides in tea production was found to be decreasing trend in recent years. The mean pesticide cost of tea farms was 177.34 thousand VND. For the socioeconomic variables, the study used six independent variables for analysis, i.e., age of head household, education, experiences, market distance, household size, and extension contact. The summary statistic of independent variables was shown in Table 1.

3.2. Technical efficiency level of Tea farms in Thainguyen province

The DEAP version 2.1 program [14] was applied to measure the technical efficiency of tea farms. The results are expressed in Table 2.

Table 2. The distribution of technical efficiency of tea farms

Efficiency scores	**TE_{CRS}**		**TE_{VRS}**	
	No.of farms	Frequency (%)	No.of farms	Frequency (%)
Less than 0.5	10.0	18.18	9.0	16.36
0.51-0.60	7.0	12.73	8.0	14.55
0.61-0.70	6.0	10.91	4.0	7.27
0.71-0.80	7.0	12.73	8.0	14.55
0.81-0.90	13.0	23.64	11.0	20.00
> 0.90	12.0	21.82	15.0	27.27
Mean	0.73		0.75	
Min.	0.37		0.37	
Max.	1.00		1.00	

Table 2 illustrates the technical efficiency scores of tea farms and their distribution. The finding revealed that the mean technical efficiency under VRS was slightly higher than overall technical efficiency (TE under CRS). Moreover, the technical efficiency scores under CRS showed that tea production of farms in Thai Nguyen city can be improved by reducing 27.0% of inputs usage while the output quantity of green tea was stable. The number of households with efficiency scores of more than 0.90 was higher in pure technical efficiency with 15 farms (or 27.27%) while it was 12 farms for TE under CRS.

The differences in returns to scale of tea producers are described in Table 3.

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Table 3. Summary of returns to scale of tea farms

Characteristics	**No. of farms**	**Percentage (%)**
Increasing returns to scale	16	29.09
Decreasing returns to scale	25	45.45
Constant returns to scale	14	25.45

The finding indicated that 29.09 % of total tea farms were being operated under increasing returns to scale. Comparetively the number of farms operating under decreasing returns to scale was higher, with 25 farms (45.45%), implying that farms could improve their efficiency by technical change in tea production instead of increasing their scale production.

3.3. Factors influence on the technical efficiency of tea farms

This study employed Tobit model to show the relationship between technical efficiency and characteristics of tea farms. The results were expressed in Table 4.

Table 4. Factors influencing on technical efficiency of tea farms

Explanatory variables	**Coeff.**	**Std.D**
Age	0.04**	0.002
Education	0.032***	0.007
Experiences	0.013***	0.002
Market distance	-0.030	0.017
Household size	0.011	0.018
Extension visit	-0.001	0.066
Constant	0.005	0.156

*Note: Significance level at 5 % ** ($p < 0.05$); Significant level at 1 % *** ($p < 0.01$).*

The findings unveiled that three variables affected the technical efficiency of tea farms, including age, education, and experience. The results indicated that age had a positive significant influence on the technical efficiency level of tea farms, meaning that old producers were more technically efficient than young farmers. This statement is in line with the investigation of Chiona [15] and Vu [13].

Moreover, the findings investigated that the factor of education plays a vital role in tea cultivation. The coefficient for education was a positive significant effect on technical efficiency, implying that farmers with higher education levels were found to be better technical efficiency levels because of their capacities in accessing information and applying high technology in production. This finding is content with the results of Ateka [16], Nargis and Lee [17], Ghaderi [18], and Linh [12].

In addition, the factor related to experiences had also a significantly positive influence on the technical efficiency of tea farms. It illustrated that the level of technical efficiency of households with more experience was higher than counterparts with fewer years of tea cultivation.

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4. Conclusion

This study used a two-stage DEA to estimate the technical efficiency. In the first stage, the technical efficiency of tea farms was measured by using input-oriented DEA under CRS and VRS models. The findings showed that the average technical efficiency of tea farms was 0.73, implying that tea farms could increase their efficiency level by using inputs more efficient.

The results of the Tobit regression model in the second stage revealed that factors related to age, education, and experiences had a significant positive influence on the technical efficiency of tea farms. Based on the findings of this study, to improve the efficiency of tea farms, the government should address policies to encourage tea farms to attain more education through extension activities. Besides, the support policies should focus on training and technology transfer activities to help tea farms in adopting high technology in production to improve their efficiency level.

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