TECHNICAL EFFICIENCY OF SMALLHOLDER TEA PRODUCTION: A CASE STUDY IN VIET NAM

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ABSTRACT

The objectives of the study were to estimate resource use efficiency and to identify the determinants of tea production in Yen Bai province of Vietnam using stochastic frontier approach and technical efficiency technique. The data was collected from 400 randomly selected tea farmers in Yen Bai province in 2019. Based on technical details, the study provided useful information on the method in which farms should utilize resources efficiently to produce tea in the research site. The result showed that the Technical Efficiency (TE) of tea farmers ranges from 27.27 percent to 95.45 percent, with an average technical efficiency of tea farms was 73.11 percent. And the coefficients of labor, fertilizer, pesticide, variety, tea age, education, and cooperative had positive signs with significant at 1 percent. And the coefficients of household size, ethic, and training had positive signs with significant at 5 percent. Meanwhile, the coefficients of distance and farming had negative signs as expected and it had significant at 10 percent and 1 percent respectively.

Keywords: Technical Efficiency, Productivity, Frontier Production Function

INTRODUCTION

Tea is the second most popular and cheapest beverage next to water. It is an important commodity in terms of jobs and export earnings for a number of developing countries. In Vietnam, tea has been cultivated and drunk there for thousands of years. Today, Vietnam is the fifth largest tea exporter in the world. Tea is grown in 36 of 64 Vietnamese provinces (Vietnam General Statistic Office 2013). The best quality products are achieved in the Northern mountainous area.

Tea is a very important crop of Vietnam. It plays a vital role in income improvement and poverty alleviation in rural areas, especially in the Northern mountainous region (Khoi et al., 2015). Assam, India's leading tea producer, small tea growers are a new phenomenon in the state. Over the past four decades, the field has experienced tremendous growth. Owners of small plots of land in the eastern hinterland of Assam have turned to small tea plantations. This sector has the potential to reduce underdevelopment (Karabi Das & Debarshi Das, 2020).

Despite its importance, Vietnamese tea sector is faced with a number of constraints affecting tea production's productivity, tea farmers' livelihood and environment. Tran, et al., (2004); Tran, (2008); Nguyen, et al., (2015) argued that the Vietnamese tea sector has some main weaknesses such as low and unstable quality of tea products, low productivity, preponderance of small producers, fragmentation of cultivation area, and irrational use of pesticides and fertilizers. Most of the tea cultivation area corresponds to the variety "Trung Du" which gives a low quality, small leaves, and a low productivity.

According to Nguyen to the & Anh Nguyen Tuan (2019), the average technical efficiency of organic tea farmers in Vi Xuyen, Ha Giang was 65.21% which is lower than that of conventional tea growers (70.1%). Phu Nguyen Van & Nguyen To The (2016) also found that average technical efficiency of tea production in northern Vietnam was only 41%. The results indicate that there is a great potential for improving production efficiency in the region of the study.

Total tea planted area in Vietnam was decreased from 133,600 ha in year 2015 to 123,300 ha in year 2019 (Vietnam General Statistic Office 2019). The main reason is that the area of old tea is not invested to care, low economic efficiency, and so farmers changed to plant forest trees and fruit trees. Tea productivity has a huge fluctuation according to each production area and level of intensive investment. Tea productivity and quality are not competitive enough in the market.

Resource use efficiency in agricultural production has been an important subject of empirical investigation in developing countries, where majority of the farmers are resource- poor. Through efficient use of resources, productivity of agricultural production can be expanded and sustained by farmers. Agricultural production is the process of transforming inputs such as variety, fertilizer, pesticide, labor, capital and other inputs into goods and services called output. These resources can be organized in a farm whose ultimate objectives are output maximization, cost minimization, and profit maximization. In this production process, the farmer should be concerned with efficiency in the use of resources to achieve his objectives. Efficiency estimation provides useful information about the manner in which farms should utilize inputs to produce goods and services. One of types of efficiency which is popularly identified in literature is technical efficiency. Technical Efficiency (TE) is measured as the ratio between the observed output to the maximum output, under the assumption of fixed inputs (output orientation), or, alternatively, as the ratio between the minimum input to the observed input, under the assumption of fixed outputs (input orientation) (Farell, 1957; Coelli et al., 2005).

The main objectives of the study were to estimate resource use efficiency and to identify the determinants of tea production in Vietnam using stochastic frontier approach and technical efficiency technique. Based on technical details, the study provided useful information on the method in which farms should utilize resources efficiently to produce tea in the research site.

In view of the growing competition in the world tea market and high production costs, production efficiency becomes an important determinant of the future of Vietnam's tea industry. Developing and adopting new production technologies could improve productivity efficiency. In addition, the industry could maintain its economic viability by improving the efficiency of existing operations with a given technology. In other words, the industry's total output can be increased without increasing the total cost by making better use of available inputs and technology. Following the above discussion, this study examined the individual farm as well as industry level efficiency of tea production. It enhanced identification of the sources where improvements can be made. The relationship between efficiency level and various factors can provide useful policy relevant information. Given those reasons above the researcher conducted the study about technical efficiency of smallholder tea production in Yen Bai province, Vietnam.

METHODOLOGY

Research Area

Yen Bai province is located in the Northern mountainous region of Vietnam as the land transitions from river basin to the rugged high mountains of Hoang Lien Son. Yen Bai is one of largest tea plantation area in Vietnam with total tea area is 7,819.9 ha. And total tea production is 65,866.8 tons per year (Yen Bai Agriculture Department, 2018). Van Chan district has the largest area of tea material with the highest productivity throughout Yen Bai province. In 2018, the tea area reached 4,780 ha, in which total harvesting tea area was 7,050 ha.

Three representative communes (Nghia Lo, Lien Son & Suoi Giang) of Van Chan district in Yen Bai province were chosen for the survey. A total of 400 tea farmers in the Van Chan District were interviewed in 2019. The selected tea farms are representative of topographical conditions in tea production areas of Yen Bai province. Nghia Lo, Lien Son & Suoi Giang commune are the most well-known for having the highest tea quality in Vietnam.

Technical Efficiency Theory

Technical Efficiency (TE) reflects the ability of a farmer to obtain the highest possible output from a given set of inputs and available technology. Conceptually, TE measures the difference between the yields of the average farmers and the yields of the best farmers exhibiting the potential/maximum output of a given production system. Mathematically, TE is the ratio of the operator's actual output (Y) to the technical maximum possible output (Y*) given a fixed set of resources and technology. In many empirical studies, technical inefficiency (TIE), instead of technical efficiency (TE), is often measured and represented simply by the following formula:

$$TE = 1 - TIE.$$

Measuring the technical efficiency or inefficiency of tea farmers in the study site can provide key information in formulating alternative options to improve tea productivity of farmers in a specific locality. Generally, farmers are either efficient or inefficient (at varying degrees) in their production operation. Consequently, these two scenarios require entirely different strategies in improving or increasing productivity. For example, for farmers who are currently inefficient in their production system, the strategy to improve their productivity is to focus on the factors that can increase efficiency. Hence, factors that contribute directly to inefficiency must be identified in order to address them. On the other hand, if operators are already efficient in their production system, then the way to enhance their productivity is to introduce or shit to a new technology that will increase output level.

The procedure for measuring technical efficiency/inefficiency entails several options in estimating the underlying production function that defines the input-output relationship of the farmer. Among the existing approaches, the stochastic frontier model has been one of the most popular and appropriate models in assessing farm efficiencies (Jayasinghe, 2004; Karambu-Kiende Gatimbu, 2020; Suranjan-Priyanath, 2018; Shrabanti-Maity, 2021).

The technical efficiency model based on the works of Aigner, Lovell & Schmidt (1977); Meeusen & van den Broeck (1977) specified the production function as follows:

$$Y_i = f(X_i; \beta) \exp(V_i - U_i)$$

Where:

Y_i is the output of the i^{th} farm ($i=1, 2, 3,\ldots, n$);

X_i is a l x k vector of input quantities applied by the i^{th} farm;

B is a k x l vector of model parameters to be estimated;

U_i is a non-negative random error term associated with technical inefficiency in production;

V_i is a random error term assumed to be normally distributed with mean zero and variance σ^2_v, *i.e.*, $V_i \sim N(0, \sigma^2_v)$ and is independent of U_i.

Note that the technical efficiency model includes two types of error terms, *i.e.,* Vi which accounts for the usual random effects in the model while Ui represents the technical inefficiency in production. Tan, et al., (2009), following Battese & Coelli (1995), assumed the error term Ui to be independently distributed and has a half-normal distribution with truncation at zero, *i.e.,*

$U_i \sim |N(\mu_i, \sigma^2_{u)}|$

The farm-specific frontier production function (Y*) representing the maximum possible output can be expressed as:

$Y^* = f(x; ß) \exp(U\ )$

The technical efficiency of the individual farmer can be predicted based on the conditional expectation of exp ($-U_i$). The level of efficiency depends on the value of U_i and is interpreted as follows: a) if $U_i>0$, then production lies below the frontier function and the farm is considered technically inefficient; and b) if $U_i=0$, then production lies on the frontier function and the farm is deemed technically efficient. Figure 1 shows the graphical illustration of technical inefficiency given the yield difference between the "best" and "average" farmers as represented by the frontier and mean production functions, respectively.

Specifically, technical efficiency (TEi) of the ith farm is derived as follows:

$TE_i = Y_i / Y_i^* = \exp(-U_i)$

The variance of the model (σ^2) can be expressed as the sum of the variance parameters σ_v^2, *i.e.,*

σ2=σv2+σ 2

γ=σu2/ σ2

The value of gamma (γ) ranges from 0 to 1 which indicates the possible source of deviation of a given production level from the frontier production function specifically, a value of γ equal to 1 implies that the production deviations from the frontier function are due entirely on technical inefficiency (Coelli et al., 1998).

To investigate the possible sources of technical inefficiency, TE can then be expressed as the function $TE_i = \sigma Z_i$ where Z_i is a l x m vector of farm-specific variables that may help explain the observed technical inefficiency among farmers while σ is a m x l vector of parameters to be estimated.

Conceptual Framework

Figure 1 shows the paradigm of the conceptual framework of the study where the relationships between and among inputs and outputs of the study are being shown.

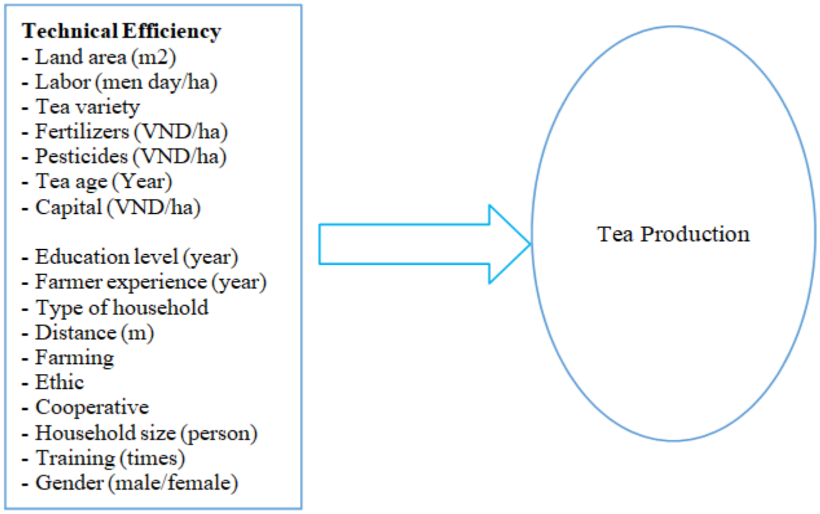

FIGURE1
CONCEPTUAL FRAMEWORK

Descriptive of Variables in the Model

Table 1
DESCRIPTION OF VARIABLES

Descriptive of Variable	Obs.	Mean	Std. Dev.	Min	Max
Tea production characteristics					
Yield (tons)	400	9.40675	5.498947	0.5	20
Labor (man/day)	400	177.3675	337.5498	30	6781
Fertilizer (000'VND)	400	14562.26	10449.09	0	49500
Pesticide (000'VND)	400	3042.819	1914.521	0	7960
Capital (000'VND)	400	63949.99	15001.65	28042	103600
Variety	400	0.655	0.4759636	0	1
Household head characteristics					
Education (years)	400	9.2525	3.139009	0	18
Experience (years)	400	22.4475	11.11581	2	48
Type of household	400	0.8175	0.3867398	0	1
Household size (persons)	400	3.7075	1.235216	1	8

Gender (male/female)	400	0.4475	0.4978588	0	1
Ethic	400	0.6325	0.482728	0	1
Tea farm characteristics					
Distance (meters)	400	742.2	852.0529	10	5000
Land area (ha)	400	10489.1	7029.649	2000	45000
Tea age (years)	400	19.38	22.69699	3	200
Farming (organic/inorganic)	400	0.46	0.4990261	0	1
Training (times)	4 00	2.2575 1.561181	0	7	
Cooperative (member/not member)	4 00	0.235 0.4245298	0	1	

In total, 400 tea farmers from the three communes in Van Chan District (*i.e.*, Nghia Lo, Lien Son & Suoi Giang) underwent an interview for this study using the random method. 160 out of the 400 tea farmers were from the Nghia Lo commune, 140 were from the Lien Son commune, and 100 were from the Suoi Giang commune.

Table 1 shows the descriptive statistics of the important variables applied in stochastic frontier production model including specific farm characteristics. The sample consisted of data on their yields of fresh tea, tea land size; inputs used fertilizers, pesticides, labor, variety, and tea age. In addition, the sample included data on social indicators such as level of education, experience, distance, household size, gender, ethic, farming, training, cooperative, and type of household in a year.

On the other hand, Table 1 presents a number of facts about the tea production characteristics, household head characteristics and tea farm characteristics. Specifically, the average output per farmer is 9.40675 tons per hectare. The 9.40675 tons yield per hectare is higher than the average tea yield in the entire province which is 9.34 tons per hectare. In addition, the average labor usage was 177.3675 man-days while the fertilizer expense was VND 14,562,260 per hectare. The table further indicates that on the average, a farmer was spending VND 3,042,819 per hectare for pesticides. Table 1 also shows that the average tea farmer area in Yen Bai is 10,489.10 square meters, with a minimum and maximum land area of 2,000 and 45,000 square meters, respectively. Also, the average tea age was at 19.38 years and tea age in the sample had stands ranging from 3 - 200 years. (Exchange rate 1$=22500 VND)

Moreover, Table 1 shows that on the average, the tea farmers had a total of 9.2525 years of schooling which is equal to finishing a first year in high school education. Also, in the study site, the farmers had an average of more than 22.4475 years of tea farming experience. The average distance from the farmers' house to the tea farm was 742.20 meters. The total number of farmers planting LDP2 variety is 262 and the other varieties is 138. And the mean of capital is 63,949,990 VND.

And the mean of household size is 3.7075 persons with range from 1 to 8 people per household. It means most farmers have small family. In term of training, the average number of training is 2.2575 times with range from 0 – 7 times. That means some tea farmers did not attend any training courses. And the dummy variables of gender, ethic, farming and cooperative with mean value of 0.4475, 0.6325, 0.46, and 0.235 respectively.

ESTIMATED RESULTS

Stochastic Frontier Production Model

The Stochastic Frontier Production Model was applied in this study in order to control data for reliability and validity. In addition, a number of tests were used for the measurement of sampling errors as well as for obtaining unbiased estimates. The Variance Inflation Factor (VIF) procedure was also applied to detect multicollinearity and was preferred over the correlation coefficient method which failed to yield conclusive results (Pindyck & Rubinfield, 1981). The principal rule is that if the VIF is greater than 10, then there is a potential multicollinearity problem (Neter et al., 1989). As reflected in the results, no serious multicollinearity problem among variables in the sample was detected by the VIF test. To be specific, all independent variables had VIF less than 10, and the mean VIF was 2.67 and 1.31.

Table 2
OLS AND STOCHASTIC FRONTIER PRODUCTION ESTIMATES

Variable	OLS		Stochastic frontier	
	Coefficient t-statistics		Coefficient z-statistics	
Ln (Labor)	0.12729759***	3.1	0.1217285***	2.94
Ln (Fertilizer)	0.0309706***	7.61	0.0387385***	9.43
Ln (Pesticide)	0.09432***	19.72	0.0803979***	15.8
Ln (Capital)	0.0179541	0.28	0.0007718	0.01
Variety	0.418704***	8.4	0.4729573***	10.38
Constant	0.1431189	0.2	0.6769759	1.09
*R*2	0.922			
F-statistic	930.92			
Problem>F	0			
□v			0.1405	
□u			0.428	
□□			0.2029	
α=□u/□v			3.0468	
□ □ □□u/□□			0.9028	
Note: *** indicate statistical significance of the 0.01 level				
Source: Author’s estimation				

The results show that the coefficients estimated in models were statistically significant at 1 percent. As this study used Cobb-Douglas production frontier function, the coefficient value of the variables can be used as direct elasticity of the function. The elasticity of independent variables represents how proportion changes in fresh tea yield if the inputs change in the production process. It can be seen from Table 2 that input variables such as: labor, fertilizer, pesticide, and variety had significant positive impact on tea yield. The elasticity of variety (0.473) was highest. This implies that new tea variety had significant effects on increase in technical efficiency. Farmers applied new tea variety was more efficiently than tea farmers did not applied new tea variety. The positive coefficients of labor (0.122), fertilizer (0.039), and pesticide (0.080) indicate that one percent increase in the amount of each kind of these variables will lead to the increase in tea yield by 0.122 percent, 0.039 percent, and 0.080 percent, respectively.

Frequency Distribution of Technical Efficiency

Based on the estimation of the production frontier function, the frequency distribution of the technical efficiency of tea farming is presented in Table 3.

Table 3
FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY FOR TEA FARMING

TE (%)	Frequency	Relative frequency
<40	7	1.75
40-50	21	5.25
51-60	62	15.5
61-70	56	14
71-80	95	23.75
81-90	112	28
>90	47	11.75
Total	400	100
Minimum TE (%)	27.27	
Maximum TE (%)	95.45	
Mean TE(%)	73.11	

Source: Author's estimation

The Technical Efficiency (TE) of tea farmers ranges from 27.27 percent to 95.45 percent, with an average of 73.11 percent, suggesting that there was significant variation in technical efficiency among tea farmers. The highest frequency range of TE more than 90 percent comprises 47 farms, which is 11.75 percent of the total. The farms with frequency range of TE is less than 60 percent comprises 90 farms, which is 22.50 percent of total, indicating that many farms still achieve low technical efficiency in production. The results also show that the average technically efficiency farmers could reduce their cost by 23.41 percent [{1-(73.11/95.45)}*100] (Bravo-Ureta & Pinheiro 1997) if they could achieve maximum level of technical efficiency. Similarly, the most technically inefficient farmers could enjoy 71.43 percent cost savings [{1- (27.27/95.45)*100] if they achieve the most technical efficient counterparts.

Efficiency Effects Model

Table 4
MULTIPLE REGRESSION ESTIMATES OF THE SOURCES OF TECHNICAL EFFICIENCY

Variable	Coefficient	t-statistics
Age	0.0016035^{***}	4.72
Education	0.0080796^{***}	3.4
Gender	0.0049331	0.32
Experience	0.0008638	1.27
Distance	-0.0000158^{*}	-1.85

Household size	0.0077510**	1.24
Ethic	0.0369865**	1.99
Cooperative	0.0606618***	3.12
Training	0.0110772**	2.44
Type of household	-0.0148085	-0.8
Farming	-0.0516576***	-2.75
Land	1.03E-06	1.21
Constant	0.5465652***	12.72
Note: significant at ***=0.01; **=0.05, *=0.10		

The sign of the variables in the efficiency model is very important in explaining the observed level of technical efficiency of the farmers. A positive sign on the coefficient implies that variables had an effect in increasing technical efficiency, while a negative coefficient significant the effect of reducing technical efficiency. The coefficient estimates from the technical inefficiency model reveal that tea age, education, cooperative has positive signs with significant at 1 percent. And the coefficient of household size, ethic, and training also has positive sings but with significant at 5 percent. Meanwhile, the coefficients of distance and farming had negative sign as expected and it also has significant at 10 and 1 percent respectively.

Tea age had positive sign with significant at 1 percent, revealing that the more tea age will have more efficient. Education coefficient was positive sign and significant at 1 percent, revealing that educated farmers was more efficient than others. The distance had negative sign as expected and it has significant at 10 percent. The farmers who live far from the tea farms will have less efficient. The household size had positive sign with significant at 5 percent. It means that the farmers who have more people will have more efficiency since they have more labors to take care of the tea farm. The coefficient of ethic has positive sign with significant at 5 percent. It means that the famers who are King Ethic will have more efficient than other ethics. Because they are able to access new technologies and knowledge in tea production better than the other minority ethics. The coefficient of training had positive effect to technical efficiency as expected with significant at 5 percent. Farmers who access training services to cultivate tea better and more efficiently than others. One of the variables most worth mentioning in relation to technical efficiency is Cooperative. Its estimation coefficient shows a significant positive effect to technical efficiency, signaling that famers participating in cooperative could produce tea more efficiently than others. Similarly, farming had negative effect on technical efficiency, statistically significant at the level of 1 percent. The negative coefficient of farming implies that safe tea growers are less technically efficient than conventional tea growers.

CONCLUSION

This study sought to estimate tea production's technical efficiency and its determinants in the Yen Bai Province of Vietnam using stochastic frontier analysis. The estimated mean technical efficiency level is 73.11%, suggesting that increase output and decrease cost could be obtained by using the available technology. There was big difference in technical enhance productivity of tea production in the Yen Bai province efficiency among farmers in the sample, suggesting the potential ability of output increase by using inputs more efficiently.

The result also showed that increasing tea yield depends on the quantity of labor, fertilizer, pesticide and variety as well. Given of important of farm inputs in raising tea productivity, further policies should be aimed at increasing investment in labor, fertilizers, pesticide and new variety.

The farmers' socio-economic and farm characteristics such as tea age, education, household size, ethic, cooperative, and training were found to be significant in increasing technical efficiency level of tea production in Yen Bai province. To improve technical efficiency, the government should encourage farmers to increase level of education by study more and attend the short training courses, promote farmers to join cooperatives. The study also reveals that distance and farming has significant with negative sign as expected. It means that will decrease technical efficiency level of tea production.

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