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FACTORS AFFECTING THE TECHNICAL EFFICIENCY OF COFFEE PRODUCERS - CASE STUDY IN DAK LAK PROVINCE, VIETNAM

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Abstract

This research analyzed the technical efficiency (TE) of coffee producers and figured out the potential for improvement. The survey was selected 92 coffee producers in Dak Lak province, Vietnam in 2019. The Stochastic Production Frontier (SPF) was applied to estimate TE. The results show that mean TE was 72.88%, indicated that coffee producers are technical inefficiency. Fertilizer and labor have positive significant impact on TE; meanwhile tree age and tree density have negative impact on TE. The analysis also reveals that the diversification and access to credit are the major socioeconomic variables influencing the producers' TE. Finally, the findings prove that government could play important role to improve TE in the study site.

Keywords: Coffee producers, technical efficiency (TE), Stochastic Production Frontier (SPF), Dak Lak Province

INTRODUCTION

Coffee is the second most important agricultural commodity in Vietnam, contributed $ 3 billions to the economy and accounted for 2-4 percent of GDP. Vietnam becomes the world's second largest exporter of coffee after Brazil and the largest exporter of Robusta coffee in Asia, in which the Central Highlands- the agricultural center of the country provides around 90 percent of Vietnam's coffee production (George, 2019).

In recent years, the global coffee prices are so volatile, causing significant impacts on the income of coffee producers. Small scale coffee producers in Dak Lak are facing with a number of great challenges such as the old-fashion farming model has lost comparative advantages in land-use; old coffee tree, high tree density and low techniques application leading to higher costs meanwhile income and supply chains do not innovate. In order to further clarify the above issues in Dak Lak coffee production, measuring technical efficiency of coffee producers and identifying factors affecting technical efficiency that can provide useful informationfor policy recommendations. In addition, this study aims to contribute to an understanding of the technical efficiency of coffee producers in developing countries. More specifically, the study aims to: (1) Estimate the level of technical efficiency of coffee producers; (2) analysis factors affecting their technical efficiency; and (3) Policy recommendations related to increasing technical efficiency in coffee production.

METHODOLOGY

Study area

Dak Lak is located in the central of the Central Highlands with a favorable climate for the development of high-value industrial crops, especially coffee. Dak Lak has 203,063ha coffee land, accounting for nearly 41% of the coffee land of the Central Highlands and 30% of the country's coffee land. The annual output is over 450,000 tons of green coffee (Dak Lak Statistical Office, 2018). Coffee accounted for 86% of total agricultural productsexport and contributed more than 60% of the total annual provincial revenue. In addition, coffee production also creates jobs for more than 300,000 direct labors and more than 100,000 indirect labors (Dak Lak Department of Agriculture, 2018).

The main study sites focus on Cu M'gar district (Quang Phu town and Cu Suecommunes) and Cu Kuin district (Ea Tieu and Ea Tul communes)(See Figure 1); in where are the keycoffee production areas of Dak Lak province (accounted for 24 percent of total provincial coffee land). Most of the coffee landin Cu M'gar and Cu Kuin are planted by small-scale producers with high density and diversification. There are many old-age coffee farms that need replanting.Since 2010, Cu M'garhas always been over 34,000 ha coffee land – the largest coffee land in the province.

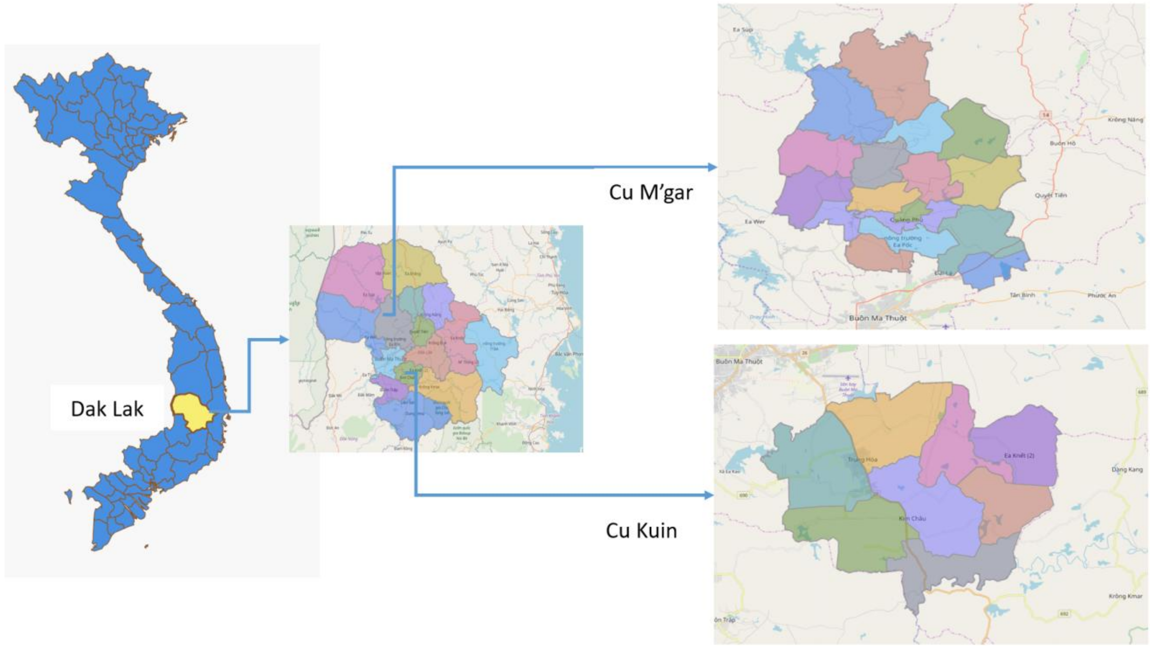

Figure 1. Study site

Sampling design

Random sampling method was applied. Based on Cochran (1977), the sample size was selected by following formula:

$$\mathbf{n} = \frac{\mathbf{Z}^2 \times p \times (1-p)}{\mathbf{e}^2},$$

Where, n is the sample size; Z is the statistical value containing the area under the normal curve (e.g., Z = 1.96 for 95% level of confidence); p is the estimated proportion of a feature that is present in the population (in general, the p value is equal to 0.5); and e is the desired level of precision.As a results, the sample size is 92 which appropriate to represent coffee producers in Dak Lak.

Data collection instrument

Data collection instrument was questionnaire. The questionnaire survey in which included two main parts: (1) socioeconomic characteristics of coffee producers and (2) the input and output of coffee production was conducted among 92 randomly chosen coffee producers.

Data analysis

To clarify the limits of production capacity, we used the method of measuring technical efficiency and identifying the factors affecting the technical efficiency of coffee producers in Dak Lak. The technical efficiency reveals the producer's ability to produce the greatest possible amount of output from a fixed amount of inputs.In other word, with a given quantity of goods, an efficient producer can use the least possible quantity of inputs possible. Based on the researches of Debreu (1951) and Koopmans (1951), Farrell (1957) initiated the first analyses of efficiency measure. The evaluation of a producer's technical efficiency level results from the estimation of a frontier production function. There are two main approaches to model efficiency frontiers. The first is nonparametric approach, in which data envelopment analysis (DEA) methods that was initiated by Farrell (1957) and transformed into estimation techniques by Charnes et al. (1978) is commonly used. The second approach is the parametric approach, in which the stochastic production frontier (SPF) is the most popular. SPF is based on econometric estimation of a production frontier whose functional form is specified in advance and has the advantage of taking into account measurement errors or random effects. Coffee production are greatly affected by climate change, plant diseases and harmful insects. Moreover, small coffee producers do not have up-to-date data on their activities that resulted in uncompleted data collection. Therefore, this study uses the SPF to calculate the production possibility frontier while simultaneously handle statistical errors and test statistical hypotheses.

Technical efficiency defined as the ratio of observed output to maximum feasible output. TEi = 1 shows that the i-th producer obtains the maximum feasible output, while TEi < 1 provides a measure of the shortfall of the observed output from maximum feasible output.Technical efficiency functions include (1) and (2), where (1) is a technical efficiency and (2) is a statistical error.

$$Y = \left(\beta_0 + \sum_{n=1}^{N} \beta_0 \ln X_n + \sum_{n=1}^{N} \sum_{m=1}^{N} \beta_{nm} \ln X_n \ln X_{nm} + (V_i + U_i) \right) \quad (1)$$

$$U = \delta_0 + \delta_1 Z_{1i} + \delta_1 Z_{2i} + \cdots + \delta_n Z_{ni} \quad (2)$$

Where ;

Y = Production per hectare β_0–β_{nm} = Regression coefficient including constant (β_0)

X_0–X_{nm} = Production input per hectare V_i = Random error term

U_i = Non-negative random variables which assumed to account for technical inefficiency

δ_0-δ_n = Inefficient parameters

Z_{1i}-Z_{ni} = Socio-economic variables

Null hypotheses

Coffee producers in Dak Lak have achieved technical efficiency. In other words, this hypothesis stipulates that no productivity increase related to improved technical efficiency can be made in coffee production.

Accessibility to credit, farming models andsocio-economic factors do not have significant impact on technical efficiency of coffee producers.

RESULTS AND DISCUSSIONS

The situation of coffee production in Dak Lak province

Table 1 shows the descriptive statistics of coffee producers. There are two categories of variables: the given input of production with regard to coffee productivity, and the socio-economic characteristics for explaining inefficiency effect.

Table 1. The situation of coffee production in surveyed producers (n=92)

Variable		Explanation	Unit	Mean	Std. Dev.	Min	Max
Y	Productivity	Coffee yield	Ton/ha	0.97	0.47	0.12	2.15
Production input							
X1	Fertilizer	Total of chemical fertilizer applied	kg/ha	524.78	102.94	330	730.00
X2	Pesticide	Total of pesticide applied	1.000 đồng/ha	1,795.21	452.52	700.00	2,600.00
X3	Labor	Working day of hired & family labor	Man-day/ha	52.96	19.91	20.00	102.00
X4	Tree density	Weighted coffee tree	number/ha	1,301.08	393.48	500.00	1,800.00
X5	Tree age	Tree age	Year	19.88	5.07	8.00	29.00
X6	Irrigation	Irrigation costs	1.000 đồng/ha	2,253.80	818.10	800.00	4,300.00
Inefficiency variable							
Z1	Gender	1 = Male 0=Female	Dummy	0.63		0	1
Z2	Education	Years of coffee producer education	Year	10.04	2.30	5.00	16.00
Z3	Age	Head of households age	Year	49.15	11.32	24.00	70.00
Z4	Diversification	1 = Have farm diversification 0 = Otherwise	Dummy	0.70	0	0	1
Z5	Credit	1 =Get access to credit 0 = Otherwise	Dummy	0,45		0	1

The average coffee productivity of the surveyed producers is about 1 ton/ha which indicated a low level comparing the national yield. The low coffee productivity can be explained by the following reasons. The first one is that the main part of coffee farms are old-age tree (around 20 years). Moreover, the high and different tree density (average of 1,300 trees/ha) among producersshow the inconsistent techniquesapplied on farm. In addition, the mean age was 49 years old, implying that producers in study area were relatively ageing, these producers have limitation on access to new farming techniques, led to the reduction ability to increase productivity. Fertilizers and pesticides are widely used, with an average use of 524.78 kg and 1,795 million VND, respectively.The average number of employees is 52.96 days-workers per ha and and each producer invest average 15 million VND in assets for coffee farm. The low value of asset investment resulted in labor-intensive using in coffee farm. About 70% of producers have farm diversification in which coffee must be considered as the key crop as it has proven to be effective and stable over a long period.

Technical efficiency of Dak Lak coffee producers

The mean technical efficiency (TE) of coffee producers is 72.88%,which indicated that producers can increase their productivity by 27.12% if they can use inputs effectively . According to Ho et al. (2014), TE of coffee producers in Krong Ana (a district in Dak Lak province) reached to 74.66% in 2014. Thus, it can be seen that theability to increase productivity in the study area is getting limitation. Table 2 shows the TE of the surveyed producers.

Table 2. TE of the surveyed producers (*Software: Frontier 4.1*)

TE	Number of producer	(%)
$0.58 \leq TE < 0.6$	6	6,52
$0.6 \leq TE < 0.7$	34	36,96
$0.7 \leq TE < 0.8$	38	41,30
$0.8 \leq TE \leq 0.89$	14	15,22

TEi = 1 shows that the i-th producer obtains the maximum feasible output. However, in the study area, 78.26% of producers have TE from 60% to less than 80%; producers have the highest and lowest TE at 89% and 58% respectively. Thus, all producers are technically inefficiency and can increase coffee productivity by using inputs effectively. The ability to increase productivity depends on the TE that producers achieved.

Determinants of technical inefficiency of Dak Lak coffee producers

In this study, Gamma = 0.99 at 1% statistical significance level indicates that there are definitely ineffective factors in coffee production; as a result, the first null hypothesis is refused. Determinants of technical inefficiency were selected based on the theory of SPF, coffeproducers' socio-characteristics and references from studies by Ana and Gerald (2005), Son et al. (2007), Amadou (2007) and Ho et al. (2014). The results of technical inefficiency are presented in Table 3.

Table 3. The estimation rsults of SFA (*Software: Frontier 4.1*)

Variable	Coefficients	Std. Dev
Production input		
Constant	3,93***	2,19
Ln(X1)- Fertilizer	0,23*	0,14
Ln(X2)- Pesticide	-0,11	0,12
Ln(X3)- Labor	0,40***	0,12
Ln(X4)- Tree density	-0,23***	0,11
Ln(X5)- Tree age	-0,36***	0,15
Ln(X6)- Irrigation	0,15	0,11
Inefficiency variable		
Z1- Gender	-0,12	0,09
Z2- Education	0,00	0,02
Z3- Age	0,06	0,16
Z4- Diversifcation	-0,17**	0,09
Z5- Credit	-0,14**	0,08
σ2	0,13***	0,02
Gamma	0,99	0,00

Note: ***, ** and * are the statistical significance levels at 1%, 5% and 10%, respectively.

Fertilizers and labor are two main inputs of coffee production. The results show that with a statistical significance level at 10%, if producers increase the amount of fertilizer used to 0.23%, the coffee yield can be increased by 1%. Meanwhile, at 1%statistical significance level, if producersspend an additional 0.4% day - person, the coffee yield could increase by 1%. The similarresultswould find in the researches of Ana and Gerald (2005), and Ho et al. (2014).

In contrast, the study found that, at 1%statistical significance level, the higher tree age and higher tree density can cause the lower coffee yield. The average tree density in the study site is about 1300 trees / ha, but according to the recommendations of D'haeze et al (2005), the optimal tree density is 1,100 trees / ha. This result can guide producers to replant and apply new farming techniques to coffee farms.

Although the irrigation variable is not statistically significant impact on coffe yield , the trend shows that if producers increase irrigation costs, coffee productivity could increase.

If producers get access to credit, they have better and more access to inputs,thereby improving technical efficiency. Moreover, due to the pressure of debt repayment, producers would tend to be more cautious when using inputs to produce more effactively. This result is consistent with previous studies of Amadou (2007), Nyagaka et al (2009), Jude et al (2011) and Mustefa et al (2017).

Diversification also contributes to improving the technical efficiency of coffee producers because diversification helps shade, block wind for coffee, limit evaporation, retain moisture for coffee in climate change event. In addition, diversification has diversified many agricultural products, created more jobs, improved and stabilized incomes, limited price risks and market volatility.

The above empirical results revealed that the second hypothesis postulated in the study has been rejected.

CONCLUSIONS AND RECOMMENDATIONS

The main purposes of this study are to assess TE and the factors affecting TE of coffee producers in Dak Lak province by using Stochastic Production Frontier (SPF). Results show that the TE of coffee producers ranged from 58% to 89% with mean TE is 72.88%. It has the ability to increase coffee yield. The SPF estimations present that producer should reduce the tree density and replace old coffee trees; at the same time, producers can increase the amount of fertilizers and labor to increase coffee productivity. In addition, access to credit and diversification have significant positive impacts on productivity growth.

Based on the results obtained, this study suggests some policy recommendations as follows: Firstly, many of coffee farms have old and dense trees, which greatly affects the coffee yield. To overcome this situation, local authorities need to focus on providing technical assistance to plantation and replanting.

Secondly, it is necessary to have policies to support coffee producers in diversification such as the crop, cropping time and appropriate techniques to ensure income and optimize land use.

Thirdly, producers should be trained in using chemical fertilizers, pesticides and watering appropriatelyto avoid overuse. In the context of limited asset investment in farm, reasonable use of labor is also needed in detail instructions.

Fourthly, it is necessary to create good conditions for coffee producer getting access to credit, especially formal credit in the study site.

Finally, while thisstudy has provided much useful information about technical efficiencyof coffee producers, it has several limitations that must be acknowledged. The major issue is that data was generated from district level and we use such data to represent province level. As a consequence, the present results can be interpreted as indicative aggregative efficiency measures of all producers in the province.

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