Research Article

Economic Efficiency of Mango Cultivator in The Southern Vietnam

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Abstract - The paper employed a Cobb-Douglas and translog of stochastic frontier profit function to measure the level of economic efficiency and its determinants. Structured questionnaires were used to collect data from 1,889 of sampling observations (591 for season 1, 678 for season 2, and 620 for season 3) randomly selected from designated locations in the study area. Difference of the study compared to past researches related to tropical fruits analyzed efficiency of three seasons instead of only focusing on efficiency of one season or total a year. The study established a mean economic efficiency of 26.19% in season 1, 27.15% in season 2, and 24.62% in season 3. The paper found out positive determinants of economic efficiency were farming experience, wrapping bag, market access among three seasons; education in season 1 and plant density in season 1 and 2. By contrast, the constraints to profit of mango producers were age, and payment for agro-input wholesale on ending of season in three seasons; credit access and classifying sale in first and second seasons; education in second and third seasons; plant density in season 3. Based on these findings, policy makers should focus on effective inputs models that would boost profit efficiency through conducting regular workshops and orchard demonstrations on using input materials effectively. More so, farmers should design mango gardens with appropriate trees density as well as encourage gardeners to use bags for wrapping mango fruits in farming in order to increase economic efficiency.

Keywords: Economic efficiency, profit, mango in the southern Vietnam

I. INTRODUCTION

Export of vegetables and fruit has contributed significantly to exporting value of agro-forestry and fishery. It has joined in exporting group of important agricultural products with 3.26 U.S billions in 2020 vegetables and fruit [1]. Usually, fruit export percentage is approximately 80% of vegetables and fruit export. It is main motivation for exporting vegetables and fruit. Total fruit production area was 1,100 thousand ha. Mango is one of major fruit types in Vietnam. Mango has been grown in all provinces of the county with mango production volume about 815,200 tons, and mango production area approximately 104,000 ha in 2019 [2]. Besides, mango is popular tropical fruit in developing countries over the world, especially is in Asia. According to [3], Vietnam took the 16^{th}, 7^{th} position in terms of mango volume in the world, and in Asia, respectively. In Southeast Asia, Vietnam ranked 3^{rd} in terms of mango volume after Thailand, Indonesia.

Economic efficiency is also known as production efficiency is the capacity of a firm to maximize profit (when marginal value product is enough to counterbalance marginal cost). It is an economically efficient input/output combination must be attained in equally on the frontier and the expansion path way [4]. Thus, this study aims to know whether mango farmers in the study area are economically efficient in production, by estimating their technical, allocative, and economic efficiency.

II. METHODOLOGY

2.1 Sampling Techniques

A multi-stage sampling technique was used to select the study area. Firstly, both south-eastern region and Mekong Delta region were purposively selected for the study because of its comparative advantage in mango production with accounting for 75% volume and making up 72 % area in Vietnam. Secondly, Dong Nai province occupied approximately 55% volume and making up 54% area in south-eastern region, and Dong Thap, An Giang, Tien Giang, Hau Giang, Vinh Long, and Tra Vinh provinces accounted for about 77% volume and making up 71% area in Mekong Delta [2]. Finally, simple random technique was used to select 1,889 sampling observations (591 for season 1, 678 for season 2 and 620 for season 3).

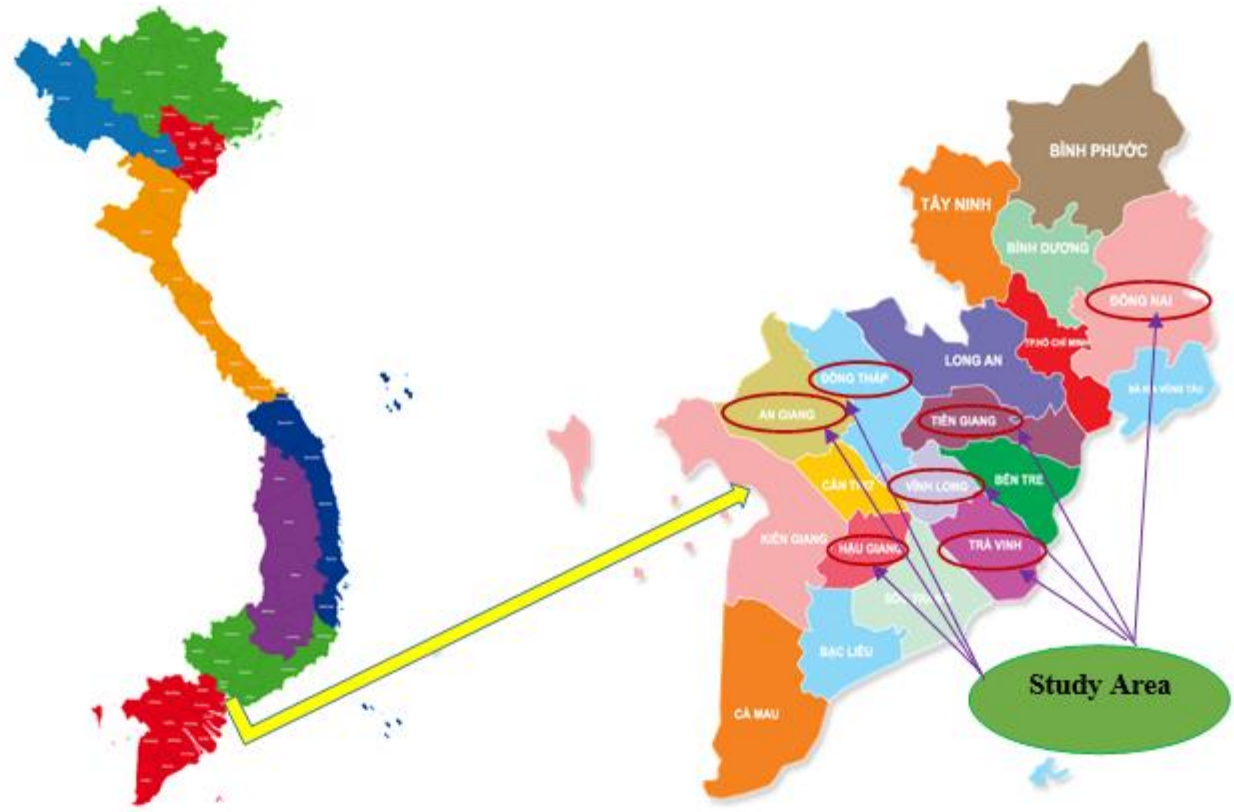

Figure 1- Study area in the southern Vietnam

2.2 Profit Function Model

Efficiency was usually understood as economic efficiency, had a technical and an allocative component. The technical component referred to the ability to avoid waste, either by producing as much output as input usage allowed (output orientation) or by using as little input as required by technology and the output production (input orientation). The allocative component referred to the ability to combine inputs and/or outputs in optimal proportion in light of prevailing prices. Therefore, if technical efficiency only pertained to the adherence to the own production plan and did not require any assumption on the producer behavior, economic efficiency needs an a priori on the economic objective of the producer and information on relevant prices.

In order to achieve the objectives for this study the stochastic frontier production and profit function models were used to analyze the socio-economic characteristics and economic efficiencies respectively of the farmers.

The stochastic profit function was defined as:

$$\pi * = \frac{\pi}{\rho} = h(qi, z)\exp\,(vi - ui)$$

Where: $\pi *$= normalized profit of i-th farmer; $\frac{\pi}{\rho}$= description of the normalized profit, qi = vector of variable inputs; Z = vector of fixed input(s); P = output price used to normalize variables in the model; π= farmer's profit defined as total revenue minus total cost of production (here mango revenue consists of returns from the sales of mango output; while total cost was made up of the cost of fertilizer, labor and agrochemical); $\exp(vi - ui)$= composite error term.

The profit/economic efficiency (EE) of an individual farmer in the context of stochastic frontier profit function was derived as a ratio of the predicted, observed or actual profit (πi) to the corresponding predicted maximum profit ($\pi i *$) for the best farm or frontier profit given the price of variable inputs and the level of fixed factor(s) of production of that farmer. Mathematically, it was expressed as following:

$$\text{EE} = \frac{\pi i}{\pi i *} = \frac{(qi,z)\exp\,(vi-ui)}{(qi,z)\exp(vi)}$$

Then,

$$\text{EE} = \frac{\exp\,(vi-ui)}{\exp(vi)}$$

The stochastic disturbance term (ei) consisted of two independent elements: *"v" and "u"*. The symmetric two sided error term (v) accounted for random variation in profit attributed to factors outside the farmer's control (random effects, measurement errors, omitted explanatory variables and statistical noise). The one-sided component (u) was a non-negative error term accounting for the inefficiency of the farm. Thus represented the profit shortfall from its maximum possible value that would be given by the stochastic profit frontier. However, when u = 0, it implied farm profit lies on the efficiency frontier (i.e. 100% profit efficiency) and u < 0 implied that the farm profit lied below the efficiency frontier. Both v and u were assumed to be independently and normally distributed with zero mean and constant variance [5].

2.3 Empirical Model

A multiple regression model based on the stochastic frontier profit function which assumes Cobb-Douglas functional form was employed to determine the profit efficiency of mango producers in the study area. The frontier model estimated following [7] was therefore specified as following:

$$ln\pi_i^* = \beta o + \beta 1 ln\ X^*1 + \beta 2 ln\ X^{*2} + \beta 3 ln\ X^*3 + \beta 4 ln\ X^*4 + \beta 5 ln\ X^*5 + \beta_k lnX_k^* + Vi - Ui$$

The translog production function is alternatively defined as follows:

$$ln\ \pi_i^* = \beta o + \beta 1 lnX^*1 + \beta 2 lnX^*2 + \beta 3 lnX^*3 + \beta 4 lnX^*4 + \beta 5 lnX^*5 + \beta_6 \ln(X_k^*) + 0.5\beta 7(ln\ X^*1)^2 + 0.5\beta 8 ln(lnX^*2)^2 + 0.5\beta 9 ln(ln\ X^*3)^2 + 0.5\beta 10 ln(ln\ X^*4)^2 + 0.5\beta 11 ln(lnX^*5)^2 + 0.5\ \beta_{12}(X_k^*)2 + \beta 13 lnX^*1lnX^*2 + \beta 14 lnX^*1lnX^*3 + \beta 15 lnX^*1lnX^*4 + \beta 16 lnX^*1lnX^*5 + \beta 17 lnX^*1lnX^*_k\ \beta 18 lnX^*2lnX^*3 + \beta 19 ln\ X^*2lnX^*4 + \beta 20 lnX^*2lnX^*5 + \beta 21 lnX^*2lnX^*_k + \beta 22 ln\ X^*3lnX^*4 + \beta 23 lnX^*3lnX^*5 + \beta 24 lnX^*3lnX^*_k + \beta 25 lnX^*4lnX^*5 + \beta 26 lnX^*4lnX^*k + \beta 27 lnX^*5lnX^*_k + Vi - Ui$$

Where:

Ln = Natural logarithm,

π_i^*= Normalized profit computed for i-th farmer,

X_1^*= Price of pesticide (VND/litres) normalized by price of mango,

X_2^*= Price of fungicide (VND/litres) normalized by price of mango,

X_3^*= Price of fertilizer_root (VND/kg) normalized by price of mango,

X_4^*= Price of fertilizer_leaf (VND/kg), (spraying on mango leaves to stimulate mango flower) normalized by price of mango,

X_5^*= Price of labor (VND/ man day) normalized by price of mango,

X_k= Area of land cultivated (cong=1,000 m^2),

β_0, $\beta_{1\ldots5}$, and β_k are parameters to be estimated, represents statistical disturbance term and u_i = represents profit inefficiency effects of i-th farmer.

The determinants of profit inefficiency of mango farmers in line with [6] were modelled following specific characteristic of farmers in the study area. From equation the component was specified as follows:

$$\boldsymbol{u_i = \alpha_0 + \sum_{r=1}^{9} \alpha_r Z_r + \mathbf{k}}$$

Where:

$\boldsymbol{u_i}$ = Profit inefficiency of i-th farmer,

α_0 and α_r = Parameters to be estimated,

Z_r = Variables explaining inefficiency effects, r =1,2,3....,n, k is truncated random variable.

Z_1 = Farmer`s age (year),

Z_2 = Level of education (years spent in acquiring formal education)

Z_3 = Farming experience (year)

Z_4 = Credit access (access =1, no access = 0)

Z5 = Payment for agro-input wholesaler (ending of crop =1, payment immediately =0)

Z_6 = Wrapping bag (wrap = 1, no wrap =0)

Z_7 = Market access (access = 1, no access = 0)

Z_8 = Classifying sale (classification =1, no classification = 0)

Z_9 = Plant density (plant/ha)

The estimates for all the parameters of profit functions and inefficiency model were obtained by maximizing the likelihood function on the FRONTIER 4.1 program.

III. EMPIRICAL RESULTS

3.1 Estimation Procedure

To select functional form for the data, hypothesis test base on the generalized likelihood ratio test (LR) was conducted. = - 2 {log [L (H_0) – log [L (Ha)]} formula was used to carry out the likelihood ratio test. The first null hypothesis was the statement that the Cobb-Douglas profit function was the best fit for the data. Result indicated that it was not rejected the null hypothesis in three cases because Lambda value of $\boldsymbol{\lambda 2}$ = 28.52 were less than critical value (32.67) at 5% level of significance, meaning that Cobb-Douglas form was the best functional form for the data in first season. Two cases rejected the null hypothesis with $\boldsymbol{\lambda 1}$ = 41.16, and $\boldsymbol{\lambda 3}$ = 65.32 was greater than critical value (32.67) at 5% level of significance, showing that Translog form was the best functional form for the data in first and third season (Table 1).

Table 1- Generalized likelihood ratio test for stochastic profit model

Season	**Null Hypotheses**	**Log likelihood (H_0)**	**Log likelihood (H_1)**	**Test statistic (λ)**	**Degree of Freedom**	**Critical value (5%)**	**Decision**
Season 1	Cobb-Douglas is the best fit	-1252.53	-1231.95	41.16	21	32.67	Rejected
Season 2	Cobb-Douglas is the best fit	-1530.59	-1516.33	28.52	21	32.67	Not rejected
Season 3	Cobb-Douglas is the best fit	-1423.78	-1391.11	65.32	21	32.67	Rejected

** Critical values with asterisk are taken from Kodde and Palm (1986). For these variables the statistic λ is distributed following a mixed χ2 distribution*

The expected parameters and the related statistical test results obtained from the analysis of the maximum likelihood estimates (MLE) of the Cobb-Douglas and Translog based on stochastic frontier production function for mango farmers in the southern Vietnam were presented in the Table 2. The sigma squares (σ^2) were 62.3 in season 1; 244.8 in season 2; and 82.3 in season 3, which were found to be significantly different from zero, suggested a good fit of the models and the correctness of the specified distributional assumptions respectively. In addition, the gamma parameters (γ_1=0.9999, γ_2=0.9994, γ_3=0.9999) were quite high and significant at 1% level of probability. This revealed that there were over 99% in profit efficiency to be explained by given variables in three seasons.

Table 2 - MLE estimates for SFA model of mango in the southern Vietnam

Variables	**Season 1**		**Season 2**		**Season 3**	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
(Dependent Variable: Ln profit (vnd))						
Constant	5.049***	1.171	8.262***	0.376	14.294***	0.592
(X_1) Ln pesticide price (vnd/litres)	0.583	0.596	-0.031	0.075	-0.378***	0.119
(X_2) Ln fungicide price (vnd/litres)	2.901***	0.725	-0.063	0.121	2.317***	0.045
(X_3) Ln fertilizer_root price (vnd/kg)	-2.959***	0.436	0.186*	0.119	4.660***	0.320
(X_4) Ln fertilizer_leaf price (vnd/kg)	0.462	0.666	-0.034	0.088	-1.012***	0.045
(X_5) Ln labor price (vnd/day)	-0.125	0.832	-0.159	0.172	-4.916***	0.418
(X_6) Ln land area (cong = 1,000m^2)	-1.549***	0.498	0.955***	0.056	0.184**	0.091
½ *Ln (X1)^2	-0.136**	0.067			-0.393***	0.008
½ *Ln (X2)^2	-0.112	0.169			0.173***	0.025
½ *Ln (X3)^2	-1.290***	0.203			1.998***	0.101
½ *Ln (X4)^2	0.007	0.095			-0.420***	0.038
½ *Ln (X5)^2	0.594*	0.415			2.181***	0.170
½ *Ln (X6)^2	-0.089**	0.041			-0.162***	0.029
Ln (X1)*Ln (X2)	-0.175	0.185			-0.225***	0.030
Ln (X1)*Ln (X3)	0.009	0.171			0.076**	0.041
Ln (X1)*Ln (X4)	0.445***	0.131			-0.058***	0.005
Ln (X1)*Ln (X5)	-0.206	0.234			0.596***	0.032
Ln (X1)*Ln (X6)	-0.029	0.054			0.021***	0.006
Ln (X2)*Ln (X3)	0.342*	0.239			-0.325***	0.024
Ln (X2)*Ln (X4)	0.188	0.170			-0.013	0.021
Ln (X2)*Ln (X5)	-0.742**	0.335			-1.169***	0.027
Ln (X2)*Ln (X6)	-0.407	0.145			0.351***	0.021
Ln (X3)*Ln (X4)	0.108	0.196			-0.648***	0.018
Ln (X3)*Ln (X5)	0.989***	0.212			-0.597***	0.109
Ln (X3)*Ln (X6)	-0.739***	0.119			-0.285***	0.033
Ln (X4) *Ln (X5)	-0.587***	0.208			0.615***	0.012
Ln (X4) *Ln (X6)	-0.045	0.117			-0.135***	0.006
Ln (X5) *Ln (X6)	1.280***	0.167			-0.020	0.018
Diagnostic Statistics						
Sigma square (σ^2)	62.394		244.890		82.392	
Gamma (γ)	0.9999***		0.9994***		0.9999***	
Log-likelihood function	-1,231.9		-1,530.3		-1,391.1	
Observations (N)	591		678		620	

Source: Field Survey Data, 2018
** Significant at 10% level, ** significant at 5% level, *** significant at 1% level*

In season 1, the analysis of the estimated model pointed out that the coefficient of fungicide price was positive and statistically significant at 1% level while the coefficient of fungicide price and land area were negative at 1% significant level. The positive relationship of fungicide price with profit suggested that a 1% increase in fungicide, will result to 2.901% growth in profit of mango growers while alternatively a 1% rise in fertilizer (root) price and land area will lead to 2.959% and 1.549% decline in profit of mango gardeners. Similarly, the coefficients of the square term for pesticide price, fertilizer (root) price and land area was negative, implying increase of the variables in production was limited to output. Besides, the coefficient of interaction between pesticide price and fertilizer (leaf) price, fungicide price and fertilizer (root) price, fertilizer (root) price and labor price, labor price and land area was positive at the conventional significance levels. This implied that the combination would bring to higher profit for mango producers. Meanwhile, the coefficient of interaction between fungicide price and labor price, fertilizer (root) price and land area, fertilizer (leaf) price and labor price were negative and significant at 5% and 1%l level respectively, indicating that increases in the combinations lead to decrease in profit of mango growers.

At the season 2, fertilizer (root) price and land area variables were found out a positive effect on output of mango farmers at 10% and 1% level of probability. It meant that if fertilizer (root) price rise 10%, profit of mango producers will improve 1.86% and 9.55%.

Fro season 3, the findings revealed that variables of fungicide price, fertilizer (root) price, and land area were positive factors at 1% and 10% level of significance. Alternatively a 1% increase in fungicide price, fertilizer (root) price, and land area will result in 2.317%, 4.660%, and 0.184% growth in profit of mango production contrasting with being decrease in 0.378%, 1.012%, and 4.916% of profit due to negative impact of pesticide price, fertilizer (leaf) and labor price variables at 1% significant level. Similarity took place with coefficients of the square term for these mentioned variables, without coefficients of the square term for labor price and land area. Moreover, the coefficients of interaction between pesticide price and fertilizer (root) price, pesticide price and land area, fungicide price and land area, fertilizer (leaf) price and labor price were positively significant at 1% level of probability, implying that the more pesticide price and fertilizer (root) price, pesticide price and land area, fungicide price and land area, fertilizer (leaf) price and labor price, the better profit of mango growers.

3.3 Economic Inefficiency Function

The variables influencing inefficiency were specified as those relating to farmers' socioeconomic characteristics. The analysis of the inefficiency model showed that the signs and significance of the estimated coefficients have important implications on the profit efficiency of main mango varieties producers (Table 3).

Table 3 - MLE of the determinants of economic inefficiency score

Variable	**Season 1**		**Season 2**		**Season 3**	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Constant	-19.610***	2.150	-124.682***	53.217	-29.341***	6.005
Age (Z1)	0.225***	0.031	1.059***	0.416	0.232***	0.046
Education (Z2)	-0.390***	0.112	1.733***	0.715	0.348***	0.120
Farming experience (Z3)	-0.021	0.055	-0.377***	0.152	-0.186***	0.052
Credit access (Z4)	2.469***	0.971	13.595***	5.137	0.360	0.966
Payment for agro-input (Z5)	3.192***	0.878	3.217**	1.675	1.852**	0.858
Wrapping bag (Z6)	-3.202***	0.955	-11.120***	4.258	-1.349*	0.925
Market access (Z7)	-1.430*	0.955	-20.020***	7.375	-6.200***	1.251
Classifying sale (Z8)	2.464***	0.984	11.967***	5.032	-0.785	0.913
Plant density (Z9)	-0.013***	0.002	-0.015***	0.006	0.002*	0.002

Source: Field Survey Data, 2018
** Significant at 10% level, ** significant at 5% level, *** significant at 1% level*
Note: *A negative sign of the parameters in the inefficiency function means that the associated variable has a positive effect on profit efficiency, and vice versa.*

The parameters estimates showed that the coefficients of age, payment for agro-input wholesale on ending of harvest season was found negative and significant impact on farmers' economic efficiency among three seasons at the conventional significance levels, and variables of of credit access and classifying sale negative influence on economic efficiency in first and second seasons at 1% significant level. For finding of age variable, the result was consistent with the studies of [7], [8] who stated that farmers were older, they were difficult to apply the available technology and had a negative effect on profit efficiency. However, this went against the finding of [9]. The negative sign of credit access pointed out that the study was similar with result of [10] who contended that receiving credit decreased farmers' economic efficiency contrasting with researches of [8], [9].

On the other hand, variables of wrapping bag and market access had positive effect on profit efficiency in three seasons at the conventional significance levels. The wrapping bag was an important variable of economic efficiency. The positive sign of the wrapping bag variable showed that if farmer use bags to wrap mangoes in production, their profit could increase. The main reason is that farmers focused on quality rather than quantity and they only kept high quality mango fruits to wrap as well as ensure wrap cost economically, especially was high selling price. Moreover, the coefficient of farming experience was positive and statistical meaning in season2 and season 3 at 1% level of probability. It meant that if farming experience of farmer was more and more, economic efficiency of mango farmers could improve better and better. The study concurred with result of researches [8], [9], which stated a positive relationship between economic efficiency and farming experience.

Besides, education variable had negative coefficient in second and third seasons, and positive sign in season 1 at 1% significant level. The result of season 1 agreed with some previous researches [7], [9] who found a statistical significant correlation between education and economic efficiency whereas findings of season 2 and season 3 differed with those of [11], [12].

3.4 Economic Efficiency Distribution

The frequency distribution of economic efficiency estimates was displayed in the Table 4. The findings showed that mango farmers achieved the average 26.19%, 27.15%, and 24.62% level of economic efficiency in season 1, season 2, and season 3 respectively. The result indicated economic efficiency gap of about 70.59% in season 1, 71.58% season 2, and 71.03% in season 3. This implied that the average farmer in the study area could increase profit by around 73.81% in season 1, 72.85% season 2, and 75.38% in season 3 by improving their economic efficiency. The result pointed out that it ranged from 0.00-0.9992 in season 1, from 0.00-0.9363 in season 2, and from 0.00-0.9986 in season 3. This implied that average mango farmer could experience a cost saving of 73.79% ((1 – 0.2619/0.9992)*100) in season 1, 71.00% ((1 – 0.2715/0.9363)*100) in season 1, and 75.35% ((1 - 0.2462/0.9986)*100) in season 3 to achieve the status of the most efficient mango grower in production while the worst efficient farmer proposed an improvement in economic efficiency of 100% ((1 – 0.00/0.9992)*100) in season 1, 100% ((1 – 0.00/0.9363)*100) in season 2, and 100% ((1 - 0.00/0.9986)*100) in season 3.

Table 4 - Efficiency level distribution of economic efficiency scores

Economic efficiency level	**Season 1**		**Season 2**		**Season 3**	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
<0.1	214	36.21	252	37.17	270	43.55
0.1-<0.2	106	17.94	87	12.83	75	12.10
0.2-<0.3	62	10.49	69	10.18	72	11.61
0.3-<0.4	69	11.68	54	7.96	51	8.23
0.4-<0.5	37	6.26	60	8.85	48	7.74
0.5-<0.6	24	4.06	50	7.37	26	4.19
0.6-<0.7	22	3.72	41	6.05	22	3.55
0.7-<0.8	17	2.88	53	7.82	14	2.26
0.8-<0.9	12	2.03	11	1.62	11	1.77
0.9-<1.0	28	4.74	1	0.15	31	5.00
1.0	0	0.00	0	0.00	0	0.00
Number of obs (N)	**591**		**678**		**620**	
Minimum	0.0000		0.0000		0.0000	
Maximum	0.9992		0.9363		0.9986	
Mean	0.2619		0.2715		0.2462	
Std.deviation	0.2715		0.2605		0.2778	

Source: Field Survey Data, 2018

IV. CONCLUSIONS

Firstly, the finding stated that season 2 ranked first in terms of economic efficiency about 27.15%, followed by season 1 nearly 26.19%, and then season 3 around 24.62%. Results from the study showed that adjustments in the input factors could lead to improve profit of mango producers in the southern Vietnam.

Additionally, empirical findings indicated that the positive determinants of economic efficiency were farming experience, wrapping bag, market access among three seasons; education in season 1 and plant density in season 1 and 2. By contrast, the constraints to profit of mango producers were age, and payment for agro-input wholesale on ending of season in three seasons; credit access and classifying sale in first and second seasons; education in second and third seasons; plant density in season 3.

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