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Technical Efficiency of Mango Production: Differences between Cooperative and Non-Cooperative Famer Groups in the Southern Vietnam

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ABSTRACT

This study employed a Cobb-Douglas stochastic production frontier function to estimate the level of technical efficiency. The results of the analysis showed that cropping season of mango growers have been round year. 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, especially was compared between cooperative and non-cooperative farmer groups. The findings revealed that technical efficiency of cooperative farmers was greater than that of non-cooperative farmers in season 1. However, technical efficiency of cooperative group was lower than that of non-cooperative group in season 2 and season 3. More so, the positive determinants of technical efficiency of cooperative farmer group were land area in three season and plant density in season 1 and season 2 while the negative factors were market access in season 1, credit in season 2 and age in season 2 and season 3. Besides, the positive determinants of technical efficiency of non-coopervative group were plant density and land area in three seasons, payment for agro-input wholesaler and market access in season 2 whereas the negative elements were wrapping bag in season 2 and season 3, and classifying sale in season 2. Based on these findings, policy makers should focus on effective inputs model that would boost technical efficiency through conducting regular workshops and orchard demonstrations on using input materials effectively for mango farmers. Also, the paper recommends that farmers should be empowered in land area acquisition and plant density to applied advanced technology in large-scale production more effectively among three seasons.

KEYWORDS: Technical efficiency, mango cooperative, the southern Vietnam

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1. INTRODUCTION

Mango was one of the most prevalent tropical fruit in the world, especially is in Asia. Vietnam was mango volume about 836 thousand tons in 2017[4]. It ranked fourth in terms of mango volume in Southeast Asia after Thailand, Indonesia and Philippines and was top 15 the largest mango producers in the world. In Vietnam, mango has been grown in all provinces of the county, in which Mekong Delta (MD) has considered center for mango production in Vietnam. Mekong Delta has provided to international and domestic market about fresh mango 460,000 ton/year with area nearly 40,000 ha[5].

The household survey carried out by [19] that indicated gross income from mango production was reported at an average of 186 million VND per household per year, with net income of 105.4 million VND (US$ 83.65 per person per month at exchange rate of US$1 = VND 21,000 and assuming average household size of 5 members), average household cultivation area of 0.68 hectares per. Mango cultivation was primarily a smallholder activity. Small farmers faced numerous challenges in utilization of available resources which affected their efficiency, productivity, awareness of quality requirements, poor technical skills and difficulties in funding investment.

Therefore, the objective of this study was to isolate the efficiency component in order to measure its contribution to productivity and pay particular attention on determinants of efficiency associated with structural variables that could influence efficiency differentials among production units [8, 10, 11,18]. This helped in formulating the policy measures to alleviate different constraints in the mango production among various mango seasons of year. The study specifically found out effective disparities among mango seasons of year, the technical relationships between inputs and output in mango production, determinants of technical efficiency in mango production.

2. METHODOLOGY

2.1 Sampling techniques

A multi-stage sampling technique was used to select the study area. Firstly, Mekong Delta region was purposively selected because of its comparative advantage in mango production system with accounting for 55% volume and making up 50% area in Vietnam. Secondly, Dong Thap, An Giang, Tien Giang, Hau Giang, Vinh Long, and Tra Vinh provinces were chosen because six provinces accounted for about 77% volume and making up 71% area in Mekong Delta[5]. Finally, simple random technique was used to select 821 sampling observations of cooperative farmer group (282 for season 1;

263 for season 2 and 276 for season 3), and 1,068 sampling observations of non-cooperative farmer group (309 for season 1; 415 for season 2 and 344 for season 3).

2.2 Conceptual underpinning

Technical efficiency (TE) was the ability of a farming unit to produce a maximum level of output given a similar level of production inputs, or to produce a given amount of output with minimum inputs [7,11]. Meanwhile,[3] stated that technical inefficiency ascended when actual or observed output from a given input is less than that of the maximum probable. Technical inefficiency reflected deviations from the frontier isoquant [7,11]. In agricultural field, technical efficiency was capacity of the farmer to produce maximum output frontier production given inputs and technology[14]. The differentials of technical efficiency among farmers could be linked to managerial decisions, environmental conditions (soil quantity, rainfall, temperature, and soil relative humidity), non technical and non economic factors and specific-farm features that could influence the farmers' ability to use technology.

2.3 Empirical Model

The Cobb Douglas functional form of the stochastic frontier was employed because of its simplicity and appropriateness in computation and interpretation. The Cobb-Douglas (CD) production function was found to be an adequate representation of the data. The stochastic frontier model was defined by:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i$$

Where:

ln = logarithm to base e

Y_i = output of pineapple (kg);

β_0 = constant or Intercept of the model;

$\beta_1 - \beta_5$ = coefficients to be estimated;

X_1 = quantity of pesticide (litres);

X_2 = quantity of fungicide (litres);

X_3 = quantity of fertilizer_root (kg);

X_4 = quantity of fertilizer_leaf (kg) (spraying on mango leaves to stimulate mango flower);

X5 = family and hired labour (man-days);

Vi= random error term;

Ui= technical efficiency effect predicted by the model and the subscript *i* indicate the *ith* farmer in the sample.

The determinants of technical efficiency of mango farmers in line with [10] were modeled following specific characteristic of farmers in the study area. From equation the component was specified as following:

$$u_i = \alpha_0 + \sum_{r=1}^{10} \alpha_r Z_r + k$$

Where:

u_i = technical efficiency of i-th farmer,

α_0 and α_r = parameters to be estimated,

k = 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 (plants/ha)

Z_{10} = Land area (cong = 1,000 m^2)

The estimates for all the parameters of production functions and efficiency model were obtained by maximizing likelihood estimation (MLE)on the programme STATA15.0

3. EMPIRICAL RESULTS

3.1 Seasonal schedule of mango in the southern Vietnam

Nowadays, mango seasons of farmers in the southern Vietnam have been produced actively round year by flowering stimulation technique. This has brought harvesting season of mango to take place all year as following:

Natural season: flowering from January to February, harvesting from middle April to ending June.

Early season: flowering from November to December, harvesting from middle February to April.

Off-season: flowering from May to June, harvesting from middle August to October.

Late season: flowering form ending August – October, harvesting from ending November to February of next year (it is called festival-season because harvesting time focuses on important festivals such as middle October following Lunar calendar (Buddhist day), Noel, New Year, Lunar New Year and middle January of next year following Lunar calendar (Buddhist day).

Table 1: Seasonal schedule of mango in the southern Vietnam

Months		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Sunny season	Natural season		Flower			Harvest							
	Early season			Harvest								Flower	
Rainy season	Off-season					Flower				Harvest			
	Late season	Harvest								Flower			Harvest

Source: Field Survey Data, 2018

Although mango producers in the southern Vietnam are able to produce mango round year (Table 1) by flowering stimulation technique on off-season, they usually choose two seasons per year or maximize three seasons per year. Based on weather condition in the southern Vietnam where has sunny season and rainy season, the study divides three main mango seasons in the southern Vietnam. Firstly, **off-season** is considered main season in the southern Vietnam because selling price is often high compared to other seasons (it is called **season 1**). Secondly, **late season** (festival season) is called

season 2 with high selling price but it must be competed strictly with different fruits in the period. Finally, **natural and early season** of sunny season is called **season 3** and it is season to occur in favorable climate condition. Thus, production cost differs from off-season and late season of rainy season.

3.2 Estimation Procedure

The result obtained from the analysis of the maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic frontier production function parameters for mango farmers in the southern Vietnam were presented in Tables 2. The variance ratio parameters (γ) were statistically greater than zero and equal 0.6798; 0.8711 and 0.7676 of cooperative grower group in season 1, season 2 and season 3 respectively, implying that 67.998% of variation in season 1,87.11%of variation in season 2, and 76.76% of variation in season 3, which resulted from technical efficiency of the sampled farmers rather than random variability. Similarly, ratio parameters (γ) of non-cooperative grower group were 0.6998; 0.7427 and 0.5491 in season 1, season 2, and season 3 respectively. This indicated that there was 69.98%; 74.27% and 54.91% in technical efficiency to be explained by given input variables in season 1, season 2 and season 3 respectively.

Regarding season 1, the analysis of the estimated model of cooperative producer group pointed out that the coefficient of pesticide, fertilizer (root), fertilizer (leaf) and labor were positive and statistically significant at 1% level and fungicide was positive at 10% significant level. The positive relationship with yield suggested that a 10% increase in pesticide, fungicide, fertilizer (root), fertilizer (leaf) and labor will result to 1.087%, 0.866%, 1.577%, 2.564% and 3.045% respectively increase in yeild of mango farmers. Similarly, input variables were positive and significant influence on production of non-cooperative producer group including: pesticide at 10% level, fertilizer (root) at 5% level, fertilizer (leaf) and labor at 1% level without fungicide variable.

Table 2: MLE estimates for SFA model of cooperative and non-cooperative farmers

Variables	Season 1		Seaon 2		Season 3	
	Coop	***Non-Coop***	***Coop***	***Non-Coop***	***Coop***	***Non-Coop***
	Coef.	*Coef.*	*Coef.*	*Coef.*	*Coef.*	*Coef.*
Dependend Variable (Y: Ln Yeild(kg))						
Constant	5.2479***	5.7964***	6.8843***	6.6653***	7.3885***	7.0165***
(X_1) Ln pesticide (litres)	0.1087***	0.0705*	0.2316***	0.0531	0.2316***	0.1234***
(X_2) Ln fungicide (litres)	0.0866*	0.0410	0.1790	0.0328	0.0610	0.0750*
(X_3) Ln fertilizer_root (kg)	0.1577***	0.0959**	-0.0598	0.0135	0.0303	0.0794***
(X_4) Ln fertilizer_leaf (kg)	0.2564***	0.2647***	0.1098**	0.3158***	0.1021***	0.0189
(X_5) Ln labor (man day)	0.3045***	0.2734***	0.2638***	0.2221***	0.1368**	0.1785**
Diagnostic Statistics						
Prob>χ2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sigma sqaure (σ^2)	1.1096	1.2647	2.0577	1.6624	1.4991	1.1941
Lamda (λ)	1.4570	1.5268	2.6003	1.6992	1.8191	1.1035
sigma_v (σ_v)	0.5960	0.6161	0.5148	0.6539	0.5898	0.7337
sigma_u (σ_u)	0.8685	0.9407	1.3388	1.1112	1.0720	0.8097
Gamma (γ)	0.6798	0.6998	0.8711	0.7427	0.7676	0.5491
Log-likelihood function	-332.88	-381.06	-353.14	-556.81	-351.10	-443.76
Number of observations (N)	282	309	263	415	276	344

Source: Field Survey Data, 2018

Parameter gamma $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$. *Sigma square* $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

** significant at 10% level, ** significant at 5% level, *** significant at 1% level*

Turning to season 2, pesticide and labour of cooperative farmer category were positive with coefficient of 0.2316, 0.2638 and significant at 1% level. Alternatively, a 10% rise in pesticide and labour will lead to 2.316% and 2.238% growth in yield obtained from mango production. There was positively signed and significant coefficient of fertilizer (leaf) at 5% level of significance, thus increasing 10% of fertilizer (leaf) will improve yield of mango production in 1.098% of cooperative farmer category. Besides, fertilizer (leaf) and labour variables of mango production in non-cooperative farmer category were positive with coefficient of 0.3158, 0.2221 and significant at 1% level.

For season 3, the results also showed that the coefficients of the explanatory variables of pesticide and fertilizer (leaf) in cooperative farmer group were positively significant at 1% level and labour variable was positively significant at 1% level. It meant that a 10% increase in pesticide, fertilizer (leaf) and labour would result in 2.316%; 1.021% and 1.368% increase in productivity respectively. For non-cooperative farmer group, labour and pesticide variables played important role in impacting on mango production with coefficient of 0.1785 and 0.1234 at 5% and 1% level of significance. Two variables affected less than to be fertilizer (leaf) and fungicide with coefficient of 0.0794 and 0.0750 at 1% and 10% level.

3.3 Determinants of technical efficiency

The analysis results of Table 3 showed he factors influencing technical efficiency of mango farmers in the southern among three seasons. The purpose of estimating to determine the relationship between technical efficiency and household characteristics.

Table 3: MLE of the determinants of technical efficiency

Variables	**Season 1**		**Season 2**		**Season 3**	
	Coop	***Non-Coop***	***Coop***	***Non-Coop***	***Coop***	***Non-Coop***
	Coef.	*Coef.*	*Coef.*	*Coef.*	*Coef.*	*Coef.*
Depend end Variable (Y: Ln Yield (kg))						
Constant	0.5314***	0.5483***	0.5866***	0.4422	0.5734***	0.5476***
(Z_1) Age	-0.0002	-0.0012	-0.0029**	-0.0008	-0.0022**	-0.0006
(Z_2) Education	0.0034	-0.0012	-0.0027	-0.0023	-0.0004	-0.0031
(Z_3) Farming experience	-0.0002	0.0002	0.0003	0.0010	-0.0003	0.0009
(Z_4) Credit	0.0095	0.0300	-0.0732**	0.0108	0.0286	0.0188
(Z_5) Payment for agro- input	-0.0294	-0.0008	-0.0322	0.0410**	-0.0147	0.0037
(Z_6) Wrapping bag	0.0170	-0.0638***	-0.0356	-0.0170	0.0106	-0.0340**
(Z_7) Market access	-0.0693***	0.0180	-0.0082	0.0663***	-0.0183	0.0231
(Z_8) Classifying sale	-0.0075	-0.0202	-0.0227	-0.0389**	0.0128	-0.0178
(Z_9) Plant density	0.0001**	0.0001***	0.0001***	0.0001**	0.0000	0.0001***
(Z_{10}) Land area	0.0029**	0.0071***	0.0065***	0.0085***	0.0032***	0.0091***

Source: Field Survey Data, 2018

** significant at 10% level, ** significant at 5% level, *** significant at 1% level*

In season 1, the coefficients of plant density and land area in both cooperative and non-cooperative farmer profiles was positive and significant at 5% level of cooperative farmer profile and at 1% of non-cooperative farmer profile. This implies that the variables had a positive influence on technical efficiency among the mango producers sampled. By contrast, coefficient of market access in cooperative grower category and wrapping bag in non-cooperative grower category were negative and significant at 1% level.

In season 2, the coefficients of plant density and land area in both cooperative and non-cooperative farmer profiles also were positive and significant. Besides, in non-cooperative farmer profile had two variables to affect positively and significantly comprising payment for agro-input wholesale on ending of havest season and market access with coefficient of 0.0410 and 0.0663 at 5% and 1% level of probability while classifying sale variable was negative at 5% significant level which showed that farmers sold mango with classifying form reaching lower productivity compared with mango growers selling non-classification. Meanwhile, in cooperative farmer profile experienced negative impact of age and credit access at 5% level. The finding of age was in conformity with the result of [1, 6, 9, 15]. However, the research was disagreement with some earlier studies [12, 13]. The result of credit access was different from past studies of [6,7].

In season 3, the coefficients of age of cooperative grower profile was found negative and significant effect on farmers' technical efficiency in production at 5% level. This was an important finding because younger farmers were relatively more efficient than older farmers. This finding concurred with the study of [1, 6, 9, 15]. However, these result was in contradiction with [12, 13].Regarding non-cooperative grower profile, the parameter estimate pointed out that wrapping bag was negative and significant at 5% level. The negative signs of the wrapping bag variable indicates that if farmers increase mango wrap in 10%, mango yield could decrease in 0.340%. 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.

Particularly, land area variable was positive and highly significant coefficients among three seasons in both cooperative and non-cooperative farmer groups. Similar findings were obtained by [2, 16,17]. However, this went against the findings of [6, 15].

Looking at season 1, the analysis of study revealed that technical efficiency ranged from 0.1029-0.8515 with a mean of 0.5617 in cooperative producer category, and from 0.0764-0.8430 with a mean of 0.5415 in non-cooperative producer category. This displayed that the technical efficiency mean of cooperative producer category was greater than that of non-cooperative producer category. The result presented technical efficiency gap of about 43.83% of cooperative producer category, and 45.85% of non-cooperative producer category. This implied that the average farmer in the study area could increase productivity by 43.83% and 45.85% respectively by improving their technical efficiency. The implication of the result showed that the average mango farmer of cooperative farmer group and non-cooperative farmer group required 34.03% ((1 – 0.5617/0.8515)*100) and 35.76% ((1 – 0.5415/0.8430)*100) respectively cost saving to attain the status of the most efficient mango grower of production, while the least performing of of cooperative farmer group and non-cooperative farmer group needed 87.91% ((1 – 0.1029/0.8515)*100) and 90.94% ((1 – 0.0764/0.8430)*100) respectively cost saving to become the least efficient mango grower in the southern Vietnam.

3.4 Technical Efficiency Distribution

Table 4: Efficiency level distribution of TE scores

Technical efficiency level	Season 1		Season 2		Season 3	
	Coop	*Non-Coop*	*Coop*	*Non-Coop*	*Coop*	*Non-Coop*
	%	%	%	%	%	%
<0.1	0.00	0.32	4.18	1.45	0.36	0.00
0.1-<0.2	1.77	2.59	11.79	4.82	5.07	0.29
0.2-<0.3	4.61	5.50	12.17	10.12	9.42	2.62
0.3-<0.4	8.16	9.71	17.49	10.36	14.86	5.81
0.4-<0.5	17.73	18.12	13.69	19.04	17.03	15.41
0.5-<0.6	19.15	21.36	10.65	22.41	17.03	28.49
0.6-<0.7	29.43	28.16	15.97	21.20	20.65	30.52
0.7-<0.8	17.02	12.62	12.93	9.88	14.86	16.57
0.8-<0.9	2.13	1.62	1.14	0.72	0.72	0.29
0.9-<1.0	0.00	0.00	0.00	0.00	0.00	0.00
1.0	0.00	0.00	0.00	0.00	0.00	0.00
Number of obs (N)	**282**	**309**	**263**	**415**	**276**	**344**
Minimum	0.1029	0.0764	0.0096	0.0343	0.0488	0.1267
Maximum	0.8515	0.8430	0.8363	0.8592	0.8065	0.8154
Mean	0.5617	0.5415	0.4412	0.4962	0.5028	0.5806
Std.deviation	0.1518	0.1571	0.2104	0.1714	0.1796	0.1245

Source: Field Survey Data, 2018

The outstanding feature of season 2 was technical efficiency of cooperative farmer group to achieve between 0.0096 and 0.8363 with the mean technical efficiency of 0.4412 and that of non-cooperative farmer group to acquire from 0.0343 to 0.8592 with the mean technical efficiency of 0.4962. This depicted that the technical efficiency mean of cooperative producer category was lower than that of non-cooperative producer category. The average technical efficiency index of 0.4412 and 0.4962proposed that an average mango farmer of cooperative and non-cooperative farmer groups in the southern Vietnam had the capacity to rise technical efficiency in mango production by 55.88% and 50.38% to obtain the maximum possible level. Thus, the sample frequency distribution indicated that there were efficiency gap but with scope for improvement in mango production among mango farmers.

This pointed that average mango farmer of cooperative farmer group and non-cooperative farmer group could experience a cost saving of 47.24% ((1 – 0.4412/0.8363)*100) and 42.25% ((1 – 0.4962/0.8592)*100) respectively whereas the worst efficient farmer of cooperative farmer group and non-cooperative farmer group proposed an improvement in technical efficiency of 99.99% ((1 – 0.0096/0.8363)*100) and 96.00% ((1 – 0.0343/0.8592)*100) respectively.

At the season 3, results also showed that the technical efficiency mean of cooperative grower category (50.28%) was lower than that of non-cooperative grower category (58.06%). These figures indicated that there were efficiency gap but with scope for improvement in mango production among mango farmers. The implication of the result revealed that average mango farmer of cooperative farmer group and non-cooperative farmer group could experience a cost saving of 37.65% ((1 – 0.5028/0.8065)*100) and 28.79% ((1 – 0.5806/0.8154)*100) respectively while the least efficient farmer of cooperative farmer group and non-cooperative farmer group proposed an enhancement in technical efficiency of 93.95% ((1 – 0.0488/0.8065)*100) and 84.46% ((1 – 0.1267/0.8154)*100) respectively.

4. CONCLUSIONS AND POLICIES RECOMMENDATIONS

The study aimed at finding out production seasons of mango farmer in the southern Vietnam, differential efficiency of among mango seasons in one year, determinants of technical efficiency level of mango farmers in three seasons.

First and foremost, harvesting seasons in the southern Vietnam have taken place round year with 4 main periods including: April – June (Natural season), February – April (Early season), August - October (Off-season), November - February (Late/festival season). Selecting of farming season has been determined by mango farmers. It usually is two seasons/year or maximum three seasons/year because the period from flowering to harvest of mango spend 4 months/season.

In addition, the result revealed that technical efficiency of cooperative farmer category was greater than that of non-cooperative farmer category in season 1. However, technical efficiency of cooperative grower group was lower than that of non-cooperative grower group in season 2 and season 3.Results from the study showed that adjustments in the input factors could lead to improved production of mango in the southern Vietnam. In detail, the inputs that were important in determining output such as pesticide, fungicide, fertilizer (root), fertilizer (leaf) and labor.

More so, empirical findings indicated that the positive determinants of technical efficiency of cooperative farmer group were land area in three season and plant density in season 1 and season 2 while the negative factors were market access in season 1, credit in season 2 and age in season 2 and season 3. Moreover, the positive determinants of technical efficiency of non-cooperative farmer group were plant density and land area in three seasons, payment for agro-input wholesaler and market access in season 2 whereas the negative elements were wrapping bag in season 2 and season 3, and classifying sale in season 2.

To address the issue of technical inefficiency in mango production the following recommendations were suggested:

The results of the study give information to policy makers on how use important input elements (pesticide, fungicide, fertilizer (root), fertilizer (leaf), labor) to improve technical efficiency among seasons. Policy makers should focus on effective inputs model that would boost technical efficiency by farmers through deployment of participatory methods such as lead-farmer model. Particularly, the Ministry of Agriculture and Rural Development via the Provincial Department of Agriculture should organize regular workshops and orchard demonstrations on input materials use effectively for mango farmers in the southern Vietnam.

The study recommends that policies would focus on ways that farmers should be empowered in land area acquisition and plant density to applied advanced technology in large-scale production more effectively among three seasons as well as rural transportation development help farmers connect market (central fruit markets) better.

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