

A Study on Technical Efficiency of Small-Scale Farmers of Key Mango Varieties in Vietnam

[Truong Hong Vo Tuan Kiet, Nguyen Thi Kim Thoa, Pham Thi Nguyen]

Abstract — The paper employed a Cobb-Douglas stochastic production frontier function to estimate of technical efficiency (TE) with 770 observations of the cooperative farmer group (272, 243, and 255 in seasons 1, 2 and 3, respectively), and 900 observations of the non-cooperative farmer group (300, 324, and 276 in seasons 1, 2, and 3, respectively). The findings showed that TE of the cooperative farmer group was greater than that of the non-cooperative farmer group in season 1, while TE of cooperative group was lower than that of non-cooperative group in seasons 2, and 3. More so, the positive determinants of TE of the cooperative farmer group were the land area and plant density in three seasons, while the negative factors were the market access in season 1, the age and credit access in season 2. In the non-cooperative farmer group, the positive determinants were the plant density and land area in three seasons, the market access in season 2, whereas the negative elements were the wrapping bag in seasons 1, and 3, and the classifying sale in season 2. The paper helps more understanding role of TE as well as identify some technical constraint exists. This helps policy and decision makers associated with farming practice offer policy implications in order to improve productivity in mango farming. A difference of the study compared to others on tropical fruits, the paper analysed the TE of the cooperative and non-cooperative farmer group during three seasons instead of only during one or throughout an entire year.

Keywords— Technical efficiency, cooperative, non-cooperative, key mango varieties

I. Introduction

Vietnam is geographically located in the tropical zone, Vietnam's achievements in terms of agricultural growth are well known. It is not only well-known for rice production, but it is also resplendent with tropical fruits galore. The southern Vietnam is the largest fruit granary of the whole country, since the region's weather is warm with long hours of sunshine, high average temperature and humidity year round. Fruit production plays an important role in Vietnamese agriculture. Vietnamese fruit production in recent years has marked significant progress in both terms of scale and product structure. Various kinds of special fruits with high quality have been developed and brought high yield thanks to the sector's application of advanced cultivation techniques. It has gained satisfactory achievements in domestic consumption and export. The results and effects which fruits sector bring about are still limited and have not been corresponding with the big potential of the country.

Thanks to different ecological features of fruits, suitable with given climate, fruit trees are planted in concentrated areas. There are more than 30 different kinds of fruit-trees in Vietnam, in which 27 kinds have commercial value, and grown on big land area, in which mango is one of fruits which brings high economic effect. In Vietnam, mango is grown in many regions, but more suitable in the southern Vietnam. The

southern Vietnam has comparative advantage in mango production with accounting for 75% of mango production volume (552,000 ton/year), and 72 % of mango production area (51,500 ha) in Vietnam [1]. However, the study result of [2] showed that each mango household get average gross income approximately 186 million VND/year, profit average about 105.4 million VND/year, and average farming area around 0.68 hectare. It means that most of mango farmers are small-scale. They must confront with challenges such as selling price, depending on prices offered by collectors, controlling of pests and diseases, overusing of chemical pesticide, especially is in over-ripe and indiscriminate harvesting.

The main objective of the paper estimates factors to influence on production efficiency via Stochastic Frontier Analysis (SFA) as well as comparison production efficiency between the cooperative and non-cooperative grower groups in three seasons.

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II. Methodology

A. Sampling Techniques

The study focused on three kind of popular mango varieties in Vietnam (Key mango varieties: HoaLoc, Chu, and Tuong). The study area was Dong Nai, Dong Thap, An Giang, Tien Giang, Hau Giang, Vinh Long, and Tra Vinh. More specific, Dong Nai province accounts for 55% of the mango production volume and 54% of the mango production area in south-eastern region, and Dong Thap, An Giang, Tien Giang, Hau Giang, Vinh Long, and Tra Vinh provinces make up 77% of the mango volume and 71% the mango production area in Mekong Delta [1]. The study selected 770 observations of the cooperative farmer group (272, 243, and 255 in season 1, 2,

and 3, respectively), and 900 observations of the non-cooperative farmer group (300, 324, and 276 in seasons 1, 2, and 3, respectively).

B. Conceptual underpinning

The measurement of farm efficiency is vital, especially for farmers in developing countries [3]. Overall, the factors that affect farmers' efficiency could be grouped into agent and structural factors. Agent factors are those linked to the farmer, such as the educational level, family size, age, and social capital. These factors are categorised into farm-specific variables (intensity of inputs such as labour, fertilisers, and seeds), economic factors (input and output prices), and environmental factors (rain, relative humidity, and temperature).

In agricultural field, technical efficiency is capacity of the farmer to produce maximum output frontier production given inputs and technology [4]. The differentials of technical efficiency among farmers can 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.

C. 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 mango (kg);

β_0 = constant or Intercept of the model;

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

X_1 = pesticide quantity (litres);

X_2 = fungicide quantity (litres);

X_3 = root fertiliser quantity (kg);

X_4 = leaf fertiliser quantity (kg) (sprayed on mango leaves to induce flowering in mango trees);

X_5 = family and hired labour (man-days);

V_i = random error term;

U_i = technical efficiency effect predicted by the model and the subscript i indicate the i th farmer in the sample.

The determinants of technical efficiency of mango farmers in line with [5] were modelled 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 = Educational level (years spent acquiring formal education)

Z_3 = Farming experience (year)

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

Z_5 = Payment for agro-input wholesaler (ending of crop =1, immediate payment =0)

Z_6 = Wrapping bag (wrap = 1, no wrap =0) (applied mango wrap technique against incursion of pest, insect)

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

Z_8 = Classifying sale (classification =1, no classification = 0) (selling mango is classified including: first level with best price, second level with medium price, and third level with lowest price)

Z_9 = Plant density (plants/ha)

Z_{10} = Land area (cong = 1,000 m²)

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

III. Empirical Results

A. Estimation Procedure

The off-season (season 1) is considered to be the main mango production season in Vietnam because during this period the selling prices often higher than during the other seasons. The late season (festival season; season 2) is characterised by high selling prices, there is tough competition between mango and different seasonal fruits during this period. The natural and early season of sunny season are collectively known as season 3, which takes place in favourable climate conditions. Thus, the production cost during this season differs from those of season 1 and season 2.

The result of maximum likelihood estimation (MLE) of the Cobb-Douglas based stochastic frontier production function parameters for mango farmers in the southern Vietnam were presented in Table 1. The variance ratio parameters (γ) were statistically greater than zero and equal 0.6694, 0.8329, and 0.6651 of the cooperative farmer group in seasons 1, 2, and 3, respectively, thereby demonstrating that 66.94%, 83.29%, and 66.51% of variation in seasons 2, and 3,

respectively, which resulted from technical efficiency of the sampled farmers rather than random variability. Similarly, ratio parameters (γ) of the non-cooperative farmer group were 0.7061; 0.7029 and 0.6164 in seasons 1, 2, and 3, respectively. This showed that there was 70.61%; 70.29% and 61.64% in technical efficiency to be explained by given input variables in seasons 1, 2, and 3, respectively.

TABLE I. MLE Estimates For SFA Model of cooperative and non-cooperative growers

Variables	Season 1		Season 2		Season 3	
	Coop	Non-Coop	Coop	Non-Coop	Coop	Non-Coop
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Dependent Variable [Y: Ln Yeild (kg)]						
Constant	5.37***	5.88***	6.97***	6.81***	7.21***	6.97***
X ₁	0.09**	0.05	0.19***	0.06	0.19***	0.07*
X ₂	0.08*	0.04	0.13**	-0.01	0.04	0.02
X ₃	0.14***	0.08*	-0.05	-0.01	0.03	0.08***
X ₄	0.30***	0.27***	0.15***	0.34***	0.11***	0.08*
X ₅	0.25***	0.26***	0.23***	0.20**	0.16**	0.19***
Diagnostic Statistics						
Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
σ^2	1.0501	1.2637	1.8413	1.6651	1.3001	1.2037
λ	1.4229	1.5499	2.2326	1.5386	1.4096	1.2677
σ_v	0.5892	0.6095	0.5547	0.7032	0.6597	0.6795
σ_u	0.8384	0.9446	1.2384	1.0819	0.9299	0.8614
γ	0.6694	0.7061	0.8329	0.7029	0.6651	0.6164
Log-likelihood	-315.29	-368.65	-321.27	-443.49	-323.44	-347.17
N	272	300	243	324	255	276

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

In season 1, the analysis of the estimated model of the cooperative gardener group indicated that coefficients of the root fertiliser, leaf fertiliser, and labour were positive and statistical effect at the 1% significance level, and the pesticide, fungicide variables were positive at the 5%, and the 10% significance level, respectively. The positive relationship between these variables with yield suggested that a 10% increase in the pesticide, fungicide, root fertiliser, leaf fertiliser, and labour would lead to 0.917%, 0.828%, 1.452%, 3.055%, and 2.519% increase in yield for mango farmers, respectively. Similarly, input variables that were positive and significant influence on productivity of the non-cooperative gardener group included: the root fertiliser at the 10% level, the leaf fertiliser, and labour at the 1% level, without pesticide and fungicide variables.

For the cooperative grower category in season 2, the variables of the pesticide, laef fertiliser and labour were positive impact on yield with coefficient of 0.18, 0.15 and 0.22 at the 1% significance level, respectively. Alternatively, a 10% increase in the pesticide, leaf fertiliser, and labour would bring to 1.8%, 1.5%, and 2.2%, respectively, growth in yield for mango farmers. The coefficient of the fungicide was positively signed and significant influence at the 5% level of probability, thereby increasing 10% of the fungicide would improve yield of mango producers approximately 1.2%.

Besides, the leaf fertiliser, and labour variables in the non-cooperative grower category were positive with coefficient of 0.34, and 0.20 at the 1%, and 5% significance level, respectively.

For season 3, the findings demonstrated that the coefficients of the explanatory variables of the pesticide and leaf fertiliser of the cooperative farmer group were positively significant at the 1% level, and the labour variable was positively significant at the 5% probability level. It meant that a 10% upturn in the pesticide, laef fertiliser, and labour would result in 1.9%; 1.1% and 1.6% increase in productivity for mango growers, respectively. For the non-cooperative farmer group, the root fertiliser, and labour variables played important role in impact on yield of key mango varieties in Vietnam with coefficient of 0.08 and 0.19, respectively, at the 1% significance level. Two variables affected less than to be the pesticide and leaf fertiliser with coefficients of 0.07, and 0.08 at 10% significance level, respectively.

B. Determinants of technical efficiency

The analysis results of Table 2 presented the factors influencing on technical efficiency of mango farmers in Vietnam in all three seasons. The aim of estimating to identify the relationship between technical efficiency and household characteristics.

TABLE II. MLE Of Determinants Of Technical Efficiency

	Season 1		Season 2		Season 3	
	Coop	Non-Coop	Coop	Non-Coop	Coop	Non-Coop
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Dependent Variable: [Y: Ln Yield (kg)]						
Const	0.56***	0.52***	0.56***	0.44***	0.56***	0.53***
Z ₁	-0.001	-0.001	-0.002*	-0.001	-0.002	-0.001
Z ₂	0.002	-0.002	-0.002	-0.002	-0.000	-0.0037
Z ₃	-0.00	0.001	-0.000	0.001	0.00	0.0007
Z ₄	-0.001	0.028	-0.08***	0.027	0.03	0.027
Z ₅	-0.03	0.0014	-0.0399	0.0196	-0.02	-0.014
Z ₆	0.0316	-0.062***	-0.002	-0.023	0.02	-0.033*
Z ₇	-0.065***	0.02	-0.03	0.06***	-0.01	0.03
Z ₈	-0.0083	-0.018***	-0.014	-0.04**	0.01	-0.03
Z ₉	0.00**	0.00***	0.00***	0.00**	0.00*	0.00***
Z ₁₀	0.003**	0.01***	0.01***	0.01***	0.00***	0.012*

Source: Field Survey Data, 2018

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

In season 1, the coefficients of the plant density and land area in the cooperative and non-cooperative farmer profile was positive and significant at the conventional significance levels. This implied that the variables had a positive influence on technical efficiency among the mango farmers sampled. On the contrary, the market access in cooperative gardener category and the wrapping bag in non-cooperative gardener category were negative at the 1% significance level.

In season 2, the coefficients of the plant density and land area in the cooperative and non-cooperative farmer profiles also were positive and significant. Besides, in the non-cooperative farmer group, market access variable affected positively on technical efficiency with coefficient of 0.063 at the 1% level of probability, while the classifying sale variable

was negative at the 5% significance level, thereby suggesting that farmers sold mango with classifying form reaching lower productivity compared with mango growers selling non-classification. Moreover, the cooperative farmer group experienced a negative impact of the age and credit access at the 10%, and 1% probability level. This implied that younger farmers were relatively more efficient than older farmers. The finding of age was in conformity with the previous results [6 - 9], however; the research was disagreement with some earlier studies [10, 11]. The result of credit access was different from past studies of [9], [12].

In season 3, the coefficients of wrapping bag of the non-cooperative grower profile was found negative and significant effect on farmers' technical efficiency at the 10% level. The negative sign of the wrapping bag variable suggested that if gardeners carried out to wrap mango in farming, mango yield could decrease. The main reason for is that farmers focused on quality rather than quantity and they only wrapped quality mango fruits, while also securing low wrapping bag costs, thereby achieving high selling prices.

Especially, the land area variable was positive and highly significant coefficients among three seasons in the cooperative and non-cooperative farmer group at the conventional significance levels. Similar findings were obtained by [13 - 15]. However, this went against the findings of [7], [9].

C. Technical Efficiency Distribution

TABLE III. Efficiency Level Distribution Of TE Scores

TE level	Season 1		Season 2		Season 3	
	Coop	Non-Coop	Coop	Non-Coop	Coop	Non-Coop
	%	%	%	%	%	%
<0.1	0.00	0.33	2.88	0.93	0.39	0.36
0.1-<0.2	1.47	2.67	7.41	3.40	1.96	0.36
0.2-<0.3	3.31	5.33	13.17	9.26	4.31	3.99
0.3-<0.4	8.46	10.67	15.64	11.73	12.16	8.33
0.4-<0.5	17.65	16.33	16.87	20.06	16.08	16.30
0.5-<0.6	20.59	24.00	13.99	23.15	26.27	27.17
0.6-<0.7	26.84	26.33	15.64	21.91	22.75	24.28
0.7-<0.8	20.22	12.67	13.58	8.95	15.69	18.48
0.8-<0.9	1.47	1.67	0.82	0.62	0.39	0.72
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
(N)	227	300	243	4324	255	276
Min	0.1099	0.0775	0.0143	0.0443	0.0883	0.0938
Max	0.8622	0.8492	0.8243	0.8434	0.8065	0.8152
Mean	0.5714	0.5403	0.4644	0.5029	0.5431	0.5642
Std	0.1481	0.1588	0.1967	0.1624	0.1517	0.1386

Source: Field Survey Data, 2018

Regarding the first season, the analysis of study stated that technical efficiency ranged from 0.1099-0.8622 with a mean of 0.5714 in the cooperative gardener group, and from 0.0775-0.8492 with a mean of 0.5403 in the non-cooperative gardener group. This showed that the technical efficiency mean of the cooperative grower category was greater than that of the non-cooperative grower category. The result pointed out technical efficiency gap of approximately 42.86% of the

cooperative producer profile, and 45.97% of the non-cooperative producer profile. This implied that the average farmer in the study area could increase productivity by 42.86% and 45.97% by improving their technical efficiency. The implication of the result indicated that the average mango farmer of the cooperative and non-cooperative farmer group required 33.73% $[(1 - 0.5714/0.8622)*100]$, and 36.38% $[(1 - 0.5403/0.8492)*100]$, respectively, cost saving to attain the status of the most efficient mango farmers, while the least performing of the cooperative and non-cooperative farmer group needed 87.25% $[(1 - 0.1099/0.8622)*100]$, and 90.87% $[(1 - 0.0775/0.8492)*100]$, respectively, cost saving to become the least efficient mango farmers.

Turning to the second season, technical efficiency of the cooperative producer group achieved between 0.0143 and 0.8243 with the mean technical efficiency of 0.4644 and that of the non-cooperative producer group acquired from 0.0443 to 0.8434 with the mean technical efficiency of 0.5029. This depicted that the technical efficiency mean of the cooperative producer category was lower than that of the non-cooperative producer category. The average technical efficiency index of 0.4644 and 0.5029 proposed that an average mango farmer of the cooperative and non-cooperative farmer group had the capacity to increase technical efficiency in mango production by 53.56% and 49.71% 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 farmers. This showed that average mango farmer of the cooperative and non-cooperative farmer group could experience a cost saving of 43.66% $[(1 - 0.4644/0.8243)*100]$, and 40.37% $[(1 - 0.5029/0.8434)*100]$, respectively, whereas the worst efficient farmers of the cooperative and non-cooperative farmer group suggested a boost in technical efficiency of 98.27% $[(1 - 0.0143/0.8243)*100]$, and 94.75% $[(1 - 0.0443/0.8434)*100]$, respectively.

In the third season, the findings indicated that the technical efficiency mean of the cooperative grower category (54.31%) was lower than that of the non-cooperative grower category (56.42%). These figures showed that there were efficiency gap but with scope for improvement in production among mango farmers. The implication of the result revealed that average mango farmer of the cooperative and non-cooperative farmer group could experience a cost saving of 32.66% $[(1 - 0.5431/0.8065)*100]$, and 30.79% $[(1 - 0.5642/0.8152)*100]$, respectively, while the least efficient farmers of the cooperative and non-cooperative farmer group proposed an enhancement in technical efficiency of 89.05% $[(1 - 0.0883/0.8065)*100]$ and 88.49% $[(1 - 0.0938/0.8152)*100]$, respectively.

The paper helps more understanding role of technical efficiency as well as identify some technical constraints exists. This helps policy and decision makers associated with farming practice offer policy implications in order to improve productivity in mango farming. A difference of the study compared to past researches on tropical fruits, was that we analysed the technical efficiency of the cooperative and non-cooperative farmer group during three seasons instead of only during one or throughout an entire year.

iv. Conclusions

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

The findings indicated that the positive determinants of technical efficiency of the cooperative farmer group were the land area and plant density in three seasons, while the negative factors were the market access in season 1, the age and credit access in season 2. Besides, the positive determinants of technical efficiency of the non-cooperative farmer group were the plant density and land area in three seasons, the market access in season 2, whereas the negative elements were the wrapping bag in seasons 1, and 3, and the classifying sale in season 2.

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I would like to publish my article in order to share my result. Should I be of any assistance, or should you need more information, please do not hesitate to contact with me.

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