Proc. Of the 2nd International E-Conference on Advances in Engineering, Technology and Management - ICETM 2020

ISBN: 978-1-63248-189-4 DOI: 10.15224/978-1-63248-189-4-03

Cobb-Douglas Stochastic Frontier Production Approach: A Study Case Of Mango Production Efficiency in Mekong Delta, Vietnam

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

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. The result of study contributed to tropical fruits efficiency of three seasons instead of only focusing on efficiency of one season or total a year. The findings revealed that season 3 ranked first in terms of technical efficiency (58.2%), followed by season 1 (53.6%) and then season 2 (49.2%). Moreover, the input variables that explained technical efficiency were fertilizer (root), fertilizer (leaf) and labor in season 1; pesticide, fertilizer (leaf) and labor in season 2; and pesticide, fertilizer (root), fertilizer (leaf) and labor in in season 3. In addition, major determinants of socioeconomic characteristics influenced positively on technical efficiency were plant density and land area in season 1 and season 3; market access, plant density and land area in season 2. By contrast, the constraints to mango production were wrapping bag and classifying sale in season 2, and age and wrapping bag in season 3.**

Keywords— Technical efficiency, Cobb-Douglas, mango, Mekong Delta

I. Introduction

A. *Selecting a Template (Heading 2)*

Vietnam's achievements in terms of growth and exports in the agricultural sector are well known. However, there are sector wide concerns both about the quality of this growth and its sustainability. Vietnam specializes in large scale, low quality production – with low levels of labor productivity, lower prices than competitors, high wastage post-harvest and limited value added. In terms of sustainability, Vietnam is reaching the ceiling of potential productivity gains and the impact of many agricultural practices on the environment is heavy. Particularly, the Mekong Delta Region (MDR) of Vietnam has been identified as one of the most vulnerable deltas to the impacts of climate change. Agriculture and is increasingly affected by changes in freshwater supply due to salinity intrusion, flooding, increasing tropical cyclone intensity, and increasing temperatures.

Mango was one of the most popular tropical fruit in the world, especially is in Asia. Vietnam was mango volume about 836 thousand tons in 2017 [11]. 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 [12]. However, regional production is fragmented with few farmer organizations and weak supply chain linkages to export and processing companies. A survey of 166 mango growing households conducted by [15] in 2014 indicated an average growing area of 0.68 hectares per household. As smallholder farmers, most sell to local collectors and wholesalers with few incentives to improve quality, limited awareness of market demand and quality requirements, poor technical skills and difficulties in funding investment. Producers have very limited certainty or stability in terms of prices received, depending on prices offered by collectors. In turn, these issues prevent farmers from optimizing their income from mango production – both in terms of ensuring higher and more stable income. Mango farmers may be considered low income but do not constitute poor households according to national definitions. Mango cultivation does clearly, however, hold potential to help smallholders increase incomes and improve living standards. The survey [15] revealed that 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). This makes mango cultivation significantly more profitable than rice cultivation and a driver of poverty reduction.

Thus, the objective of this paper 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 [6, 10, 19, 22]. 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.

Truong Hong Vo Tuan Kiet and Nguyen Thi Kim Thoa
Mekong Delta Development Research Institute, Can Tho University
Vietnam

Truong Hong Vo Tuan Kiet
PhD student in Institute of Agricultural and Food Policy Studies, Putra University
Malaysia

Truong Hong Vo Tuan Kiet
SEARCA Scholar
Philippines

Proc. Of the 2nd International E-Conference on Advances in Engineering, Technology and Management - ICETM 2020

ISBN: 978-1-63248-189-4 DOI: 10.15224/978-1-63248-189-4-03

II. Methodology

A. Sampling Techniques

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 [12]. Finally, simple random technique was used to select 1,613 sampling observations (526 for season 1, 581 for season 2 and 506 for season 3).

B. 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 [10, 14]. Meanwhile, [9] 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 [10, 14]. In agricultural field, technical efficiency was capacity of the farmer to produce maximum output frontier production given inputs and technology [3]. 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.

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 is defined by:

$$lnYi = \beta o + \beta 1 lnX1 + \beta 2 lnX2 + \beta 3 lnX3 + \beta 4 lnX4 + \beta 5 lnX5 + Vi - Ui$$

Where:

ln = logarithm to base e

Yi = output of pineapple (kg);

βo = constant or Intercept of the model;

$\beta 1 - \beta 5$ = coefficients to be estimated;

X1 = quantity of pesticide (litres);

X2 = quantity of fungicide (litres);

X3 = quantity of fertilizer_root (kg);

X4 = 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 [19] were modelled following specific characteristic of farmers in the study area. From equation the component is specified as follows:

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

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 STATA15.0 programme.

III. Empirical Results

A. Estimation Procedure

Harvesting seasons in Mekong Delta 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.

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 Mekong Delta were presented in Table I. The variance ratio parameter (γ) was statistically greater than zero and equal 0.7395; 0.7476 and 0.5718 for season 1, season and season 3 respectively, implying that 73.95% of variation in season 1, 74.76% of variation in season 2, and 57.18% of variation in season 3, which resulted from technical efficiency of the sampled farmers rather than random variability.

Proc. Of the 2nd International E-Conference on Advances in Engineering, Technology and Management - ICETM 2020

ISBN: 978-1-63248-189-4 DOI: 10.15224/978-1-63248-189-4-03

TABLE I. MLE Estimates For SFA Model

Variables	Season 1	Season 2	Season 3
	Coef	Coef	Coef
(Y): Ln Yield (kg)			
Constant	5.7891***	7.1101***	7.1145***
(X_1) Ln pesticide (liters)	0.0392	0.0645*	0.0962***
(X_2) Ln fungicide (liters)	0.0430	0.0484	0.0410
(X_3) Ln fertilizer_root (kg)	0.0831**	-0.0384	0.0505**
(X_4) Ln fertilizer_leaf (kg)	0.2803***	0.2503***	0.0860***
(X_5) Ln labor (man day)	0.3008***	0.1985***	0.1705***
Diagnostic Statistics			
Prob > $\chi 2$	0.0000	0.0000	0.0000
Sigma square (σ^2)	1.2347	1.7032	1.1345
Lamda (λ)	1.6850	1.7210	1.1557
Sigma_v (σ_v)	0.5670	0.6556	0.6969
Sigma_u (σ_u)	0.9555	1.1284	0.8054
Gamma (γ)	0.7395	0.7476	0.5718
Log-likelihood function	-628.49	-784.43	-633.85
Number of obs (N)	526	581	506

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*

In season 1, the analysis of the estimated model indicated that the coefficient of fertilizer (leaf) and labor were positive and statistically significant at 1% level and fertilizer (root) was at 5% significant level. The positive relationship with yield suggested that a 10% increase in fertilizer (root), fertilizer (leaf) and labor will result to 0.831%, 2.803%, and 3.008% respectively increase in yield.

Turning to season 2, pesticide was positive with a coefficient of 0.0645 and significant at 10% level. Alternatively a 10% growth in pesticide will lead to 0.645% increase in yield obtained from mango production. There were positively signed and significant coefficient fertilizer (leaf) and labor at 1% level of significance, thus increasing 10% of fertilizer (leaf) and labor will improve yield of mango in 2.593% and 1.985% respectively.

B. *Determinants of technical efficiency*

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

TABLE II. MLE Of Determinants Of Technical Efficiency

Variables	Season 1	Season 2	Season 3
	Coef	Coef	Coef
Constant	0.5069***	0.4634***	0.5605***
(Z_1) Age	-0.0010	-0.0011	-0.0010**
(Z_2) Education	0.0002	-0.0022	-0.0018
(Z_3) Farming experience	0.0008	0.0011	0.0007
(Z_4) Credit access	0.0125	-0.0198	0.0209
(Z_5) Payment for agro- input	-0.0108	0.0132	-0.0048
(Z_6) Wrapping bag	-0.0316*	-0.0347**	-0.0315**
(Z_7) Market access	-0.0038	0.0485**	0.0224
(Z_8) Classifying sale	-0.0109	-0.0486***	-0.0195
(Z_9) Plant density	0.0001***	0.0001***	0.0001***
(Z_{10}) Land area	0.0099***	0.0120***	0.0149***

Source: Field Survey Data, 2018

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

In season 2, the coefficient of market access was positive and significant at 5% level of probability. This implied that the variable had a positive influence on technical efficiency among the mango producers sampled. By contrast, coefficient of classifying sale was negative and significant at 1% level which showed that farmers sold mango with classifying form reaching lower productivity compared with mango growers selling non-classification.

In season 3, the coefficients of age was found to have 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 was in conformity with the result of [1, 2, 5, 7, 21]. However, the research was disagreement with some earlier studies [16, 17].

The parameters estimates pointed out that wrapping bag was negative and significant at 10% in season 1 and at 5% in season 2 and season 3. The negative signs of the wrapping bag variable indicates that if farmers increase mango wrap in 10%, mango yield could decrease in 0.316% of season 1, 0.347% of season 2 and 0.315% of season 3. 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, plant density and land area variables were positive coefficients and highly significant at 1% among three seasons. This finding of land area agrees with the reports by [4, 8, 17]. However, this result was different from study of [1, 7].

C. *Technical Efficiency Distribution*

TABLE III. Efficiency Level Distribution Of TE Scores

TE level	Season 1		Season 2		Season 3	
	Fre	%	Fre	%	Fre	%
<0.1	3	0.57	8	1.38	0	0.00
0.1-<0.2	19	3.61	29	4.99	3	0.59
0.2-<0.3	30	5.70	50	8.61	14	2.77
0.3-<0.4	55	10.46	82	14.11	27	5.34
0.4-<0.5	104	19.77	108	18.59	76	15.02
0.5-<0.6	102	19.39	127	21.86	146	28.85
0.6-<0.7	123	23.38	122	21.00	138	27.27
0.7-<0.8	80	15.21	48	8.26	96	18.97
0.8-<0.9	10	1.90	7	1.20	6	1.19
0.9-<1.0	0	0.00	0	0.00	0	0.00
1.0	0	0.00	0	0.00	0	0.00
Number of obs (N)	**526**		**581**		**506**	
Minimum	0.0648		0.0297		0.1163	
Maximum	0.8589		0.8472		0.8277	
Mean	0.5363		0.4915		0.5822	
Std. Deviation	0.1668		0.1729		0.1280	

Source: Field Survey Data, 2018

ISBN: 978-1-63248-189-4 DOI: 10.15224/978-1-63248-189-4-03

The result indicated that it ranged from 0.064-0.8589 with a mean of 0.5363 in season 1, from 0.029-0.847 with a mean of 0.4915 in season 2, and from 0.116-0.827 with a mean of 0.5822 in season 3. The result presented technical efficiency gap of about 46.37% in season 1, 50.85% season 2, and 41.78% in season 3. This implied that the average farmer in the study area could increase productivity by 46.37% in season 1, 50.85% in season 2, and 41.78% in season 3 by improving their technical efficiency. The implication of the result was that the average mango farmer required 35.56% ((1 – 0.5363/0.8589)*100) in season 1, 41.98% ((1 – 0.4915/0.8472)*100) in season 2, and 29.66% ((1 - 0.5822/0.8277)*100) in season 3 cost saving to attain the status of the most efficient mango producer of production, while the least performing farmer needed 92.46% ((1 – 0.0648/0.8589)*100) in season 1, 96.49% ((1 – 0.0297/0.8472)*100) in season 2, and 85.95% ((1 - 0.1163/0.8277)*100) in season 3 cost saving to become the least efficient mango grower in Mekong Delta.

IV. Conclusions

Result of technical efficiency revealed that season 3 ranked first in terms of technical efficiency nearly 58.2%, followed by season 1 about 53.6% and then season 2 approximately 49.2%. This implied that farmers could rise their production on average by 41.8%, 46.4% and 50.8% respectively when they were technically efficient.

More so, results from the study showed that adjustments in input factors could lead to improved production of mango in Mekong Delta. In detail, the inputs that were important in determining output in season 1 were fertilizer (root), fertilizer (leaf) and labor, in season 2 were pesticide, fertilizer (leaf) and labor, and in season 3 were pesticide, fertilizer (root), fertilizer (leaf) and labor.

Empirical findings indicated that the positive determinants of technical efficiency were plant density and land area in season 1 and season 3; market access, plant density and land area in season 2. By contrast, the constraints to mango production were wrapping bag and classifying sale in season 2, and age and wrapping bag in season 3.

Acknowledgment

I am Truong Hong Vo Tuan Kiet, a researcher in Can Tho university inVietnam, a PhD student in Putra Malaysia univeristy, a scholar of SEARCA. I confirm that my article has been carried out from data source of project in Vietnam with the title “Value chain development of Vietnamese mango fulfilling requirement for domestic and international markets” (2017-2020) by Professor Tran Van Hau being project leader, in which I has been a key member to be responsible for content of mango value chain analysis. This data source was collected in 7 provinces in the southern Vietnam. Thanks for coordination from Professor Tran Van Hau (project leader) from school of Agriculture, Can Tho University. Thank you for support my colleague (value chain analysis team of the project), especially is Nguyen Thi Kim Thoa. There is not any conflict in the article 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.

References

[1] R. S. M. Abdur, “A Study On Economic Efficiency And Sustainability of Wheat Production In Selected Areas of Dinajpur District,” M. Sc Thesis, Bangladesh Agricultural University, 2012, 149p.

[2] A. Alam, H. Kobayashi, I. Motsumura, A. Ishida, M. Esham, “Technical efficiency and its determinants in potato production: evidence from northern areas in Gilgit-Baltistan region” *International Journal of Research in Management, Economics and Commerce*, *2*: 2012, pp.1–17.

[3] P. S. Amaza, and J. K. Olayemi, “Technical efficiency in food crop production Gombe State, Nigeria,” *The Nigeria agricultural Jounal 32(2),* 2001, *pp.140-151.*

[4] R. T. Baloyi, A. Belete, J. J. Hlongwane, and M. B. Masuku, “Technical efficiency in maize production by small-scale farmers in GaMothiba, Limpopo Province, South Africa,” *African Journal of Agricultural Research*, 7, 2011, pp. 5478-5482.

[5] T. Bealu, G. Endrias, and A. Tadesse, “Factors Affecting Economic Efficiency In Maize Production: The Case of Boricha Woreda In Sidama Zone, Southern Ethiopia,” 2013, 28p.

[6] T. J. Coelli, P. D. S. RAO, C. J. O'Donnell, and G. E. Battese, “*An introduction to productivity and efficiency analysis,” 2nd Ed.* New York- USA: Springer Science and Business media, Inc, 2005.

[7] H. G. Daniel, “*Analysis of economic efficiency in potato production: The case of smallholder farmers in Welmera district, Oromia special zone, Oromia, Ethiopia*” MA thesis in development economics. Department of econmics, College of business and economics, School of graduate studies, Hawassa University, 2016.

[8] A. Dorward, “Farm size and productivity in Malawian smallholder agriculture,” *Journal of Development Studies*, 35, 1999, pp. 141–61.

[9] E. O. Effiong, and C. I. Idiong, “Measurement and sources of economic efficiency in rabbitm production in AkwaIbom State, Nigeria. A stochastic frontier profit function approach,” *Nigeria Agricultural Journal*; 4(1), 2008, pp.5-8.

ISBN: 978-1-63248-189-4 DOI: 10.15224/978-1-63248-189-4-03

[10] M. J. Farrell, "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society*, Series A, 1957, pp. 53-81.

[11] F.A.O, "Major tropical fruits - Statistical compendium 2017," Rome, 2019, 38 p.

[12] General statistic office of Vietnam (GSO), "Statistical YearBook 2017," Publisher: Statistical Publishing House, Hanoi city, Vietnam, 2018.

[13] R. J. Kopp, and W. E. Diewert, "The decomposition of frontier cost function deviations into measures of technical and allocative efficiency," *Journal of Econometrics, Elsevier*, vol. 19(2-3), 1982, pp. 319-331.

[14] H. Khan, and H. Saeed, "Measurement of Technical, Allocative and Economic Efficiency of Tomato Farms in Northern Pakistan," International Conference on Management, Economics and Social Sciences (ICMESS'2011) Bangkok, December 2011.

[15] V. T. T. Loc, T. H. V. T. Kiet, N. P. Son, N. T. T. An, N. H. Tin, T. H. Tho, and L. Huon, "Report: Analysis of mango value chain in Dong Thap province", 2014.

[16] N. G. Malinga, M. B. Masuku, and M. O. Raufu, "Comparative Analysis of Technical Efficiencies of Smallholder Vegetable Farmers with and Without Credit Access in Swazil and the Case of the Hhohho Region," *International Journal of Sustainable Agricultural Research, 2*(4), 2015, pp.133-145.

[17] S. M. Maria, "*Analysing the technical and allocative efficiency of smallscale maize farmers in Tzaneen municipality of Mopani district: A Cobb-Douglas and logistic regression approach,"* Master thesis of Agricultural Management (Agricultural Economics), Department of Agricultural Economics and Animal Production, Faculty of Science and Agriculture School of Agricultural and Environmental Sciences At the University of Limpopo, 2015.

[18] P. Martin, and L. M. Ernest, "Technical Efficiency of Smallholder Tomato Production in Semi-Urban Farms in Cameroon: A Stochastic Frontier Production Approach," *Journal of Management and Sustainability*; 7 (4), 2017.

[19] L. T. Ogunniyi, "Profit efficiency among maize producers in Oyo State, Nigeria," *ARPN Journal of Agricultural and Biological Science,* vol. 6, 2011, pp. 11–17.

[20] S. Sentumbwe, "Intra-House Labour Allocation and Technical Efficiency among groundnuts producers in Eastern Uganda," *Msc. Thesis, Makerere University Kampala Uganda*, 2007.

[21] K. W. Sibiko, J. K. Mwangi, E. O. Gido, O. A. Ingasia, and B. K. Mutai, "Allocative efficiency of smallholder common bean producers in Uganda," *International Journal of Development and Sustainability.* 2(2): 2013, pp. 640-652.

[22] K. B. Wambui, "*Technical effiiciency in Kenya's Maize production: An application of the stochastic frontier approach*," Msc. Thesis, Department of Agricultural and Resource Economics. Colorado State University Fort Collins, Colorado, USA, 2005.