ESTIMATING SUGARCANE PRODUCTION EFFICIENCY BY STOCHASTIC COST FRONTIER ANALYSIS: A CASE STUDY IN QUANG NAM PROVINCE, VIETNAM

Huynh Tan Nguyen*

ABSTRACT

Sugarcane production is bringing much income in Quang Nam province (Vietnam), however production has not yet obtained efficiency, especially respondents still waste input resources while cultivating. To measure production efficiency of sugarcane, this study estimated sugarcane production efficiency by stochastic cost frontier analysis and identified the factors affecting inefficiency of production. The data for research was taken from the 2014 sugarcane farm costs and returns survey with amount of 550 participants, of which 103 questionnaires were valid. The study result showed that there were 4 factors affecting actually on inefficiency as follow: size, experience, bank credit, extension services. Contrary to our expectation bank credit didn't significantly affect cost inefficiency at 5% level due to many reasons. Through this study, we suggest local authority should enhance more supports to household, especially the authority have to employ Land Consolidation Policy to expand the size of land.

Keywords- Sugarcane production; cost stochastic frontier function; inefficiency of production; Land Consolidation Policy

Introduction

Today sugarcane is daily industrial plant cultivated popularly in Vietnam in general and Quang Nam province in particular. In Quang Nam province, total acreage of sugarcane cultivation is about over 10.75 thousand hectares (account for about near 4% total national acreage) (Gerneral Statistic Office of Vietnam, 2015). Moreover, sugarcane is one of several crops that makes income considerably in local and has been cultivating before 1962 (Hoang, Tran, Van, & Vo, 1999) (Ngo, Tran, Ho, Van, & Quan, 2010) (Nguyen & Van, 2007). Fig. 1 shows that production of sugarcane harvest is more and more increasing during the period from 2005 to now and increased average at 7.8% (Gerneral Statistic Office of Vietnam, 2015) (Bui, Huynh, Ho, & Ngo, 2012).

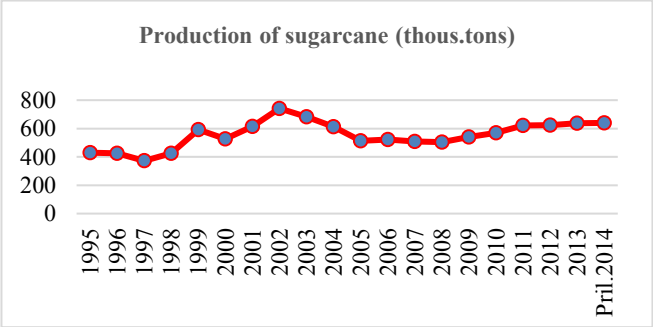


Fig. 1. Production of sugarcane the period 1995 – 2014

Although sugarcane production contributes considerably in enhancing income and improving life standard of local citizens, yet many challenges still exist, those are, peasants waste input resources while cultivating, and especially local government have not found effective solutions for renovation sugarcane cultivation. That is why it is important to evaluate sugarcane production efficiency and use the results to assess the farm-level impact of the recent changes in the industry.

Many studies recently conducted in local so as to analyze and evaluate efficiency of sugarcane production by using many other econometrics models. Le et tal,. (2011) found that there were a lots of factors impact sugarcane productions, in which seeds, and pesticides have most influence. If the producers use high productivity seeds, output may have increased by more than 20% in 2011, compared with average output [26]. Ngo et tal., (2010) and Huynh et tal., (2009) found a relationship between sugarcane productivity and loan quantity at 1% significance level (2-tailed) by using linear regression model, loan quantity rose by 1% productivity rose by more than 0.004%, ceteris paribus [27] [28]. Nguyen et al., (2007) and Ha (2010) used a Frontier version 4.1 software derived from Tim Collie (1996) to examine the efficiency indicators in sugarcane production. They found that technical efficiency of sugarcane production was only 0.62 – 0.71 on average [29] [30].

Some researchers above had some considerable contribution in improving sugarcane production in local. Yet their limitations have not been mentioned so far deal with the issue of sale price of sugarcane in relation to the prices of the input factors.

The data was used to measure the efficiency came from a 2014 Survey conducted in the July of 2014 and sponsored by PTC Investment and Trading JSC. The last sugarcane production survey in the Quang Nam province was conducted in 2003 by the Department of Agriculture and Rural Development (Report on sugarcane cultivation during the period 2005 - 2003, 2004) and, to the best of our knowledge, no comprehensive sugarcane surveys have recently taken place in local. Efficiency analysis permits

construction of cost frontier, which makes it possible to study the effect of some factors on efficiency, and thus derive implications for the effects of the policy changes on different farms.

Based on the methodologies used for measuring efficiency, the stochastic cost frontier analysis was chosen because the survey data of variables were suitable for estimation and satisfied the assumptions of cost efficiency function (Banker, Charnes, & Cooper, 1984) (Fare, Grosskopf, & Lovell, 1994).

This study proceeds as follows: Section 2 introduced the methods used in this study, including the questionnaire design, sampling, estimation technique. The results and discussion of the empirical research are presented in Section 3. In the last section of this study, the main conclusions are summarized, and the policy implications of the work are presented.

II. MATERIALS AND METHODS

The data was used for efficiency estimation was taken from the 2014 sugarcane farm costs and returns survey. The original sample size was 550 based on formula $n \geq 4*K + 50$, in which K defined as items of questionnaire (Smith, Lee, & Clark, 1993), out of which only 103 samples were chosen because of providing valid responses and entered the dataset. Most of the samples were from Phu Ninh town, and Thang Binh town since they are the largest sugarcane producing town in the province (Gerneral Statistic Office of Vietnam, 2015).

The investigation questionnaire contains a wide array of items grouped by 09 topics structured by the following cost parts: land, mixed expenses, sugarcane acreage and seeding, fertilizer, chemicals and pesticides, transportation, labor, irrigation services and other crop costs and production.

This study uses stochastic cost frontier function for estimating cost efficiency of sugarcane cultivation. There are two methods utilized to calculate economic efficiency (EE): Stochastic Frontier Function method (SFF) and Data Envelopment Analysis method (DEA) (Coelli T. J., 1994). The use of the two methods is suitable and can be compared in terms of the ranking of the operators in the sample (Smith, Lee, & Clark, 1993). In particular, the calculating results may be checked by comparing efficiency using Spearman correlation coefficient (Nguyen & Van, 2007) (Fare, Grosskopf, & Lovell, 1994).

DEA (Data Envelopment Analysis) is the optimization method of mathematical programming to generalize the Farrell (1957) single-input/single-output technical efficiency measure to the multiple-input/ multiple-output case by constructing a relative efficiency score as the ratio of a single virtual output to a single virtual input (Farrel, 1957). Thus DEA become a new tool in operational research for measuring technical efficiency. It originally was developed by Charnes et al. (1978) with CRS (Charnes, Cooper, & Rhodes, 1978) and was extended by Banker et at. (1984) (Banker, Charnes, & Cooper, 1984) to include variable returns to scale. So the basic DEA models are known as CCR and BCC.

The main limitation of the DEA model is that any deviation from the frontier is interpreted as an indication of inefficiency (Nguyen T. V., 2014) (Banker, Charnes, & Cooper, 1984) (Hughes, 2007). In the presence of random disturbances that affect household operations, such as weather, climate, water system... So households may be erroneously defined as inefficient (Nguyen & Van, 2007). This inflexibility of deterministic DEA may lead to overestimation of inefficiency of production (Hughes, 2007).

Stochastic frontier analysis (SFA) is a method of economic modeling. It has its starting point in the stochastic production/cost frontier models (CambridgeScholar, n.d.). Simply this method suggests a stochastic frontier function for a cross-sectional data with two-component disturbance specification: one error term and inefficiency (Fare, Grosskopf, & Lovell, 1994). The positive characteristics of this method is to contain statistical noise, so avoiding overestimation of inefficiency (Hoang, Tran, Van, & Vo, 1999) (Fare, Grosskopf, & Lovell, 1994).

The two approaches have important differences. Most importantly, they differ in terms of *data requirements*. While production efficiency analysis requires data on input use and output provision, cost efficiency analysis requires input prices, output quantities, and total input expenditure. For decomposition of the inefficiency term into technical and allocative inefficiency components in the cost efficiency analysis, data on output quantities or cost shares are also required. The survey data in question provides detailed information on input expenditure, cost shares, and output value. However, the survey does not contain data on input quantities, which makes cost efficiency analysis the only viable choice of methodology.

The cost and production efficiency estimation also rely on different *behavioral assumptions*. In fact, the production frontier analysis does not impose any behavioral assumptions because it is concerned with technical efficiency only. However, the cost frontier analysis supposes cost minimization. This makes cost frontier method a more suitable option of estimating efficiency (Hughes, 2007).

Based on considerations above, the stochastic cost frontier analysis is used for calculating sugarcane efficiency. In the stochastic frontier analysis, the cost function is denoted as follow (Coelli T. J., 1994):

$Y_i = x_i\beta + (V_i + U_i) \quad i = 1, 2,...n$

Where Y_i is the (logarithm of the) cost of production of the i-th firm

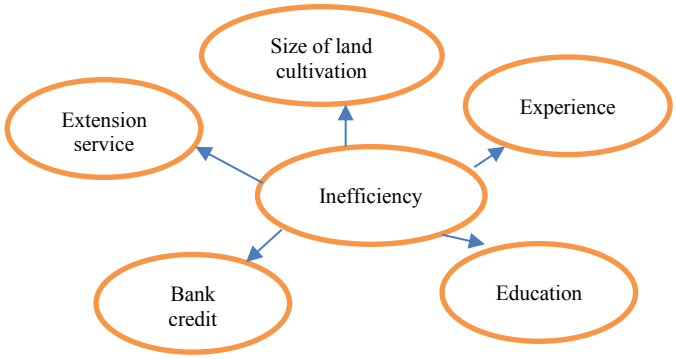
x_i is a Kx1 vector of (transformation of the) input prices and output of the i-th firm

β is a vector of unknown parameters

The V_i are random variables which are assumed to be *iid* $N(0,\sigma_v^2)$ and independent of the U_i which are non – negative random variables which are assumed to account for the cost of inefficiency in production, which are often assumed to be *iid* $N^+(0,\sigma_u^2)$. With these specifications, the measure of cost efficiency, CE_i, can be denoted as: $CE_i = E(\exp\{U_i\})$ (Coelli T. J., 1994).

This measure contains inefficiency points that is limited to producer - specific estimates of the cost of inefficiency. Estimation of U_i can be calculated by equation: $\hat{U}_i = \sum \alpha_i Z_i + \varepsilon_i$, where Z_i's are the variables that explain the inefficiency.

We suggest analysis framework:



Based on framework above, in this paper we utilize **Cobb-Douglas** cost function for estimating efficiency because it is very simple and allows the focus to be on the error term (Kumbhakar & Knox Lovell, 2000) and is denoted as follow:

$$\ln C_i = \beta_0 + \beta_y \ln Y_i + \sum \beta_n \ln P_{ni} + (V_i + U_i)\ i = 1,2,...n$$

Where C is cost of sugarcane cultivation, Y is defined as output factor, P is vector of input prices. V_i and U_i are assumed normal and half – normal distributed, respectively (Coelli T. J., 1994).

This article uses Frontier 4.1 computer program written by Tim Coelli to estimate efficiency and measure factors that affect inefficiency of production.

III. RESULTS AND DISCUSSION

The variables used for estimating efficiency are summarized in Table 1. The cost variable indicates total costs of production per hectare and consists of: the cost of paid labor and the costs of seeds, fertilizer, pesticides,... Output is measured per hectare and is defined as value of the total sugarcane production.

Table 1. Data description and summary statistics

Variables	**Defined as**	**Mean**	**SD**	**Min**	**Max**
Output (value of sugarcane in M.VND/hectare)	Y	72	11	50	90
Total Cost of production (value in M.VND/hectare)	C	60	10	45	80
Price of land (M.VND/hectare)	P1	2	0.6	0	6
Price of fertilizer (M.VND/hectare)	P2	37	6	20	48
Price of seeds (M.VND/hectare)	P3	5	0.56	3	8
Price of pesticide (M.VND/hectare)	P4	10	0.9	4	14
Price of paid labor (VND/day)	P5	3	0.7	0	4
SIZE (acreage of land cultivation)	Z1	2.01	0.2	0.99	6.78
EXP (experience in years)	Z2	65	9	27	86
EDU (education in years)	Z3	6.98	0.77	0	17
CREDIT (bank credit in M.VND)	Z4	50	16	12	200
EXTENSION (Extension services in times)	Z5	10	0.5	4	20

(Source: Calculated from survey results)

This study hypothesizes that there are five factors affect negatively inefficiency as follow: SIZE, EXP, EDU, CREDIT, and EXTENSION.

The results from estimation of the stochastic regression model are shown in Table 2. As expected, all input prices affect positively and actually have an influence on total cost of production. The coefficients of output are negative but is rejected at 5% level, indicating that output of sugarcane production doesn't affect cost of production. This find is similar to the study of Ha, et al. [29].

Table 2. Panel A. Cobb-Douglas stochastic frontier—normal/half-normal model.

Variables	Coefficient	standard-error	t-ratio	P(|t|>t-ratio)
Const	-3.029	0.064	-47.328	0.019
lnY	-0.076	0.071	-1.070	0.422
P1	0.356	0.092	3.870	0.001
P2	0.014	0.087	0.161	0.029
P3	0.129	0.076	1.697	0.013
P4	0.209	0.034	6.147	0.000
P5	0.476	0.099	4.808	0.009
Chi^2	187.576			
Log-Likelihood	-19.675			
Observations	103			

(Source: Results from Frontier 4.1 Program)

The estimated coefficients in the inefficient variables are of particular interest to this study. Table 3 shows the results from OLS estimation, where the inefficiency estimate is regressed on Z1, Z2, Z3, Z4, and Z5 as defined in table 1. While size of land cultivation has a positive effect on inefficiency, it is not significant at 5% level, indicating the more land increase the more inefficiency declines. So to improve efficiency of sugarcane production need employing Land Consolidation Policy, which is the reallocation of parcels with the aim the landowners to obtain larger parcels at one or more places in exchange of their former smaller and fragmented land plots.

Table 3. The OLS estimation on the predicted inefficiency term

Variables	Coefficient	standard-error	t-ratio	P(|t|>t-ratio)
Const	1.098	0.046	23.870	0.061
Z1	0.065	0.024	2.708	0.876
Z2	-0.076	0.006	-1.267	0.033
Z3	-0.035	0.098	-0.357	0.042
Z4	0.056	0.029	1.931	0.022
Z5	-0.0827	0.041	-2.017	0.000
R-squared	0.4569			0.000
Adj.R-sq	0.4087			
Observations	103			

(Source: Results from Frontier 4.1 Program)

As expected, experience, education, extension service have a negative effect on inefficiency and are significant at 5% level. Only credit bank affect positively on inefficiency and is significant at 5% level, that means the more money peasants borrow the more efficiency decreases, due to utilization of loan is not effective really. The study of Ha, et al. also showed that when peasants received too much money, they would spend it on daily expenses, not for production [29]. Nguyen et al. stated that authority's loan support would not bring efficiency to where peasants were short of knowledge of cultivation and production [30].

In addition the fact that R^2 equals to 0.4569 and has significance at 1% level. This shows that 5 variables of OLS model explain 54.69% of changes of inefficiency. This result was proper to the study of Ngo et al. and Hoang et al. [2, 3].

IV. CONCLUSIONS

The purpose of this paper is to find factors that affect inefficiency of sugarcane production. Among five variables in OLS model, there are 4 factors really have a negative influence on inefficiency as expected.

However, bank credit affected positively on inefficiency and this result could be explained as follow. Mr. Thanh Nguyen Van – an official of Department of Agriculture and Rural Development of Quang Nam said to us that "*the major failure of households is the utilization of loans, the households usually spend a part of loans to purchase an asset and other goods for their family expenditure*" (Nguyen T. V., 2014). Moreover Bui et tal., (2013) stated that one of reasons had an influence on loans utilization was loans utilization knowledge, and this article also showed that loans utilization knowledge in Quang Nam province was only 2.35/5 points. (Bui, Huynh, Ho, & Ngo, 2012).

In summary, the paper presents preliminary results of the analysis of cost efficiency of sugarcane production in the Province of Vietnam in 2014. Through this study, we suggest local authority should enhance more supports to household and need Land Consolidation Policy to expand the size of land.

ACKNOWLEDGEMENT

We would like to thank Dong Nai Technology University, PTC Investment and Trading JSC r for logistic support to conduct this research work.

REFERENCES

[1] "Gerneral Statistic Office of Vietnam," 15 January 2015. [Online]. Available: http://www.gso.gov.vn.
[2] T. L. Hoang, M. Q. Tran, N. D. Van and T. T. Vo, "Science and Technique," in Technique for sugarcane cultivation in South East of Vietnam, Hanoi, Hanoi National University, 1999, pp. 25-26.
[3] T. M. H. Ngo, P. V. Tran, H. T. T. Ho, D. T. Van and T. M. Quan, "Economic Journal," 17 12 2010. [Online]. Available: http://eco-journal.org//effsee. [Accessed 17 12 2010].
[4] T. K. Nguyen and B. N. Van, "Difference between non - parametric and parametric model," in The application of mathematics and statistical methods to the analysis of economic data, Hue city, Hue University Publisher, 2007, pp. 45-51.
[5] T. D. Bui, L. N. Huynh, M. T. Ho and T. L. Ngo, "An analysis of the factors affecting utiliztion of loans," Econometrics Journal, vol. 13, pp. 12-13, 2012.
[6] "Report on sugarcane cultivation during the period 2005 - 2003," Department of Agriculture and Rural Development, Dong Nai, 2004.
[7] R. D. Banker, A. Charnes and W. W. Cooper, "Some models for Estimating Technical and Scale Inficiencies in Data Envelopment Analysis," Management Science, vol. 30, pp. 1078 - 1092, 1984.
[8] R. Fare, S. Grosskopf and C. A. K. Lovell, "Production Frontier," Cambrigde University Press, pp. 12-13, 1994.
[9] J. A. Smith, B. Lee and C. P. Clark, in Applied Statistics in Social Economics, Toronto, McGraw Hill, 1993, pp. 34-35.
[10] T. J. Coelli, "Econometrics," in A guide to FRONTIER version 4.1: A computer program for Stochastic Frontier Production and Cost Function Estimation, Department of Econometrics, University of New England, 1994, pp. 8-9.
[11] M. J. Farrel, "The measurement of Productive Effeciency," The Royal Statistical Society, vol. 120, no. 3, 1957.
[12] A. Charnes, W. Cooper and E. Rhodes, "Measuring the efficiency of Decision Making Units," European Journla of Operation Research, vol. 2, pp. 429 - 444, 1978.
[13] T. V. Nguyen, Interviewee, Effectiveness of loans utiliztion of respondents. [Interview]. 01 12 2014.
[14] M. Hughes, "A Stochastic Frontier Cost Function for Residential Child Care Provision," Journal of Applied Econometrics, vol. 3, pp. 203 - 214, 2007.
[15] "CambridgeScholar," Cambrigde University, [Online]. Available: http://www.cambridgescholars.com/review/econometrics. [Accessed 11 December 2014].
[16] D. Kumbhakar and C. A. Knox Lovell, "Stochastic Frontier Analysis," Cambride University Press, pp. 14-17, 2000.
[17] P. C. o. T. T. -. H. Province, "Outcomes of agricultural production in Thua Thien - Hue Province for the period 2010 - 2013," People's Committee of Thua Thien - Hue Province, Hue, 2014.
[18] N. T. Nguyen, T. N. Phan and A. G. Bell, Vietnamese Agriculture: oppurtunites and challenges, Ho Chi Minh city: Science and Technique, 2014.
[19] "Thua Thien Hue Statistic Office," [Online]. Available: http://thuathienhue.gov.vn/cucthongke. [Accessed 29 7 2014].
[20] D. T. Le, O. L. T. Huynh and M. T. M. Vo, "Impove peanuts production in Huong Thuy town, Thua Thien - Hue Province," Ha Noi city, 2011.
[21] T. V. Huynh, M. M. Dang, D. V. H. Le and T. N. H. Bui, "Agricuture and Rural Development Journal," The Centre for Rural Development in Central Vietnam (CRD), July 2009. [Online]. Available: http://www.crdvietnam.org . [Accessed July 2009].
[22] T. V. Ha, "Using frontier 4.1 software: a case study in peanuts production," Science Journal, vol. 5, pp. 17-20, 2010.
[23] T. J. Coelli, "A guide to DEAP version 2.1: A Data Development Analysis Computer Programme," Economics Letters, vol. 8/96, pp. 11, 25, 1996.
[24] L. H. Le, C. T. M. Phan and P. V. Nguyen, Assessing enterprises via finacial indices, 2 ed., T. D. Bui, Ed., Hanoi: Science and Technique, 2008, pp. 45-55.
[25] V. H. Pham, D. N. Le, N. L. T. Nguyen and T. N. Tang, Research Hue, Hue, Thua Thien - Hue: Hue University, 1999, pp. 203-215.
[26] D. T. Le, O. L. T. Huynh and M. T. M. Vo, "Impove peanuts production in Huong Thuy town, Thua Thien - Hue Province," Ha Noi city, 2011.
[27] T. M. H. Ngo, P. V. Tran, H. T. T. Ho, D. T. Van and T. M. Quan, "Economic Journal," 17 12 2010. [Online]. Available: http://eco-journal.org//effsee. [Accessed 17 12 2010].
[28] T. V. Huynh, M. M. Dang, D. V. H. Le and T. N. H. Bui, "Agricuture and Rural Development Journal," The Centre for Rural Development in Central Vietnam (CRD), July 2009. [Online]. Available: http://www.crdvietnam.org . [Accessed July 2009].
[29] T. V. Ha, "Using frontier 4.1 software: a case study in peanuts production," Science Journal, vol. 5, pp. 17-20, 2010.
[30] T. K. Nguyen and B. N. Van, "Difference between non - parametric and parametric model," in The application of mathematics and statistical methods to the analysis of economic data, Hue city, Hue University Publisher, 2007, pp. 45-51.

Huynh Tan Nguyen*
Faculty of Business Administration, Dong Nai Technology University,
Dong Nai, Vietnam
Email: huynhtannguyen@dntu.edu.vn