Performance of Sugarcane Farmers in The Perspective of Cost Efficiency

Through Comparison of The Approach to Linear Programming Data Envelopment and Stochastic Frontier Analysis

Rosihan Asmara[1,*] Fahriyah[1,] Condro Puspo Nugroho[1,] Mahfudlotul Ula[1,] Susanti Evie Sulistiowati[1,] Intan Mega Maharani[1]

[1] *Department Of Agricultural Economics and Rural Development, Faculty Of Agriculture, Universitas Brawijaya, Brawijaya, Indonesia*
[*] *Corresponding author. Email: rosihan@ub.ac.id*

ABSTRACT
Efficiency is an important indicator in measuring the overall performance of farming activities. Efficiency problems can be analyzed through parametric and non-parametric approaches Therefore, this study attempts to analyze the capabilities of the parametric approach using Stochastic Frontier Analysis (SFA) and the non-parametric approach using Data Envelopment Analysis (DEA) in measuring cost efficiency. The research was conducted at sugarcane production centers in East Java Province, the location was determined purposively in Malang Regency which is a sugarcane center area with simple random sampling 145 sugarcane farmers. The results show that the level of cost efficiency in sugar cane farmers, both with the SFA and DEA methods, is not optimal because none of them reaches 100% and in this research these conditions indicate that the SFA approach can be used more to increase the cost efficiency of sugarcane farming in Indonesia.

Keywords: Cost efficiency, Stochastic Frontier Analysis, Data Envelopment Analysis

1. INTRODUCTION

Sugarcane is one of the important plantation commodities in the Indonesian economy. However, when viewed from the main need for sugarcane as the main raw material for the staple food of sugar, sugarcane production has not been able to keep up with the national sugar consumption needs, thus requiring Indonesia to import sugar on an average of 4.9 million tons [1]. According to [2], two important conditions are faced in the development of national sugarcane commodities in the on-farm sector, namely first, the latent problem of the limited availability of sugarcane land. According to [3] this is due to a shift in land use, there is competition between food crops and sugarcane, so that the availability of land for sugarcane cultivation is decreasing. Second, the low productivity of sugarcane which has implications for the decline in the performance of the national sugar industry. The realization is that Indonesia's sugarcane productivity from 2014 to 2019 fluctuated very much but tended to decrease by an average of 0.69% per year. One effort that can still be done by farmers to increase sugarcane production is through increasing the productivity of their farming business. Based on this, the level of use and costs of factors of production are important factors in determining the profits obtained by farmers and it is hoped that farmers can carry out rice farming more efficiently.

Efficiency is an important indicator in measuring the overall performance of farming activities. Efficiency is often interpreted as how farmers can produce at the lowest possible cost, but not only that efficiency also concerns the management of input and output relationships, namely how to allocate the available production factors optimally to produce maximum output. Farmers are said to have a higher level of efficiency if with a certain amount of input they can produce more output or at a certain amount of output they can use less input. Efficiency for the agricultural sector as a whole is the most important aspect to pay attention to in order to realize a sustainable performance.

In general, efficiency problems can be analyzed through parametric and non-parametric approaches. In the parametric approach, it requires strict assumptions about specific functional forms. This is necessary to guarantee the fulfillment of classical assumptions in data estimation problems further explained that the necessity to assume a functional form that underlies the technology and distribution of inefficiencies, makes parametric methods less flexible, so that a nonparametric approach that does not require an explicit functional form is a good approach in describing real data. However, there are drawbacks to the nonparametric approach, namely the method only focuses on technical optimization

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but ignores economic optimization. The weakness of other non-parametric approaches is that they do not have a specific way to get conclusions from statistical tests on deterministic parameter estimation as in stochastic procedures. Therefore, this study attempts to analyze the capabilities of the parametric approach using Stochastic Frontier Analysis (SFA) and the non-parametric approach using Data Envelopment Analysis (DEA) in measuring cost efficiency.

2. METHOD

The research was conducted at sugarcane production centers in East Java Province, the location was determined purposively in Malang Regency which is a sugarcane center area. The farmer sample was determined by simple random sampling which was calculated using the slovin formula. There were 145 sugarcane farmers who were respondents. In this research will be analyzed the calculation of cost efficiency with two methods. The parametric approach uses Stochastic Frontier Analysis (SFA) and the non-parametric approach uses Data Envelopment Analysis (DEA) using the assumption of Constant Return to Scale (CRS).

2.1 Stochastic Frontier Analysis (SFA)

Analysis of cost efficiency and profit using farm calculations and the Stochastic Frontier cost function. The model of the estimator equation for the frontier cost function of farming can be written as follows:

$$\text{Ln } (W'x) = b_0 + 1/r \ln y + \sum_{j=1}^{n}\left(\frac{\beta}{\gamma}\right)\sum_{j=1}^{n}\left(\frac{\beta}{\gamma}\right) \ln W_i - 1/r\,(v-u) + E$$

(1)

Where:

Y : Output(kg)
X_1 : Cost of seeds used
X_2 : Cost of Phonska fertilizer
X_3 : Cost of ZA fertilizer
X_4 : Cost of pesticides
X_5 : Labor costs during the growing season (HOK)
β_0 : intercept
β_j : coefficient of estimator parameter where j=1,2,3...4
$v_i - u_i$: error term (ui) the effect of technical inefficiency in the model.

Expected coefficient values: β_1, β_2, β_3, β_4, $\beta_5 > 0$. A positive coefficient value means that by increasing inputs in the form of seeds, phonska fertilizer, ZA fertilizer, pesticides and labor it is hoped that it will increase the income of sugarcane farming.

2.2 Data Envelopment Analysis (DEA)

The function of the DEA is to determine the weights or scales for each DMU input and output. The weight has no negative value and is universal, that is, each DMU in the sample must be able to use the same set of weights to evaluate the ratio (total weighted output/total weighted input) and the ratio cannot be more than one (total weighted output/total weighted input). inputs ≤ 1). In the DEA model, there are two optimization approaches or assumptions that can be used, namely the Variable Return to Sale and Constant Return to Scale (CRS) models. In this study, a model with the assumption of CRS or called the CCR (Charnes-Cooper-Rhodes) model will be used.

$$\text{Efficiency of DMU} = \frac{\sum_{k=1}^{p}\mu_k y_{ko}}{\sum_{i=1}^{m} v_i x_{io}} \frac{\sum_{k=1}^{p}\mu_k y_{ko}}{\sum_{i=1}^{m} v_i x_{io}}$$

(2)

Where:

DMU : Decision Making Unit
n : DMU to be analyzed
m : input used
p : output
x_{ij} : the number of i inputs used by DMU_j
y_{kj} : the number of k outputs produced by DMU_j

The efficient value in DEA ranges from zero to one. An efficient DMU will have a value of 1 or 100%, while a value close to zero indicates lower DMU efficiency.

3. RESULTS AND DISCUSSION

The cost efficiency of each farmer with a parametric approach, namely through SFA, is found by equation (1) and a non-parametric approach with DEA is used by equation (2), the average results are presented in Table 1.

Table 1. Comparison of Average Cost Efficiency in Sugarcane Farming DEA and SFA Models

Model		Minimum	Maximum	Mean	Std. Deviation
DEA	Pure Cost Efficiency	0.000	0.190	0.009	0.034087
SFA	Efficiency (%)	1.000	11.278	2.197	1.392

The average cost efficiency obtained with the DEA approach is 0.009, which indicates that the performance of sugar cane farmers from a cost efficiency standpoint is not efficient. Keep in mind that the resulting efficiency value between DEA and SFA is different.

The efficiency value generated by DEA is between 0-1, the closer to 0 it is said to be inefficient and vice versa. Meanwhile, the efficiency value of SFA ranges from 1 to infinity, so the optimal cost is 1.00 or 100%. The results of the analysis show that the average efficiency value of sugarcane farmers using SFA shows a value of 2,197, which means that the sugarcane farming of the respondent farmers has not reached efficiency. This also means that the level of cost inefficiency is 120%, meaning that farmers incur costs of 120% above the optimal cost.

From the Tabel 1 it is known that the level of cost efficiency in sugar cane farmers, both with the SFA and DEA methods, is not optimal because none of them reaches 100%. Compared to DEA, the SFA method requires accurate information for input prices and other exogenous variables. SFA also considers some deviations as noise in the regression model. Then, considering several deviations which are a picture of inefficiency, the DEA approach is called a deterministic frontier. Whereas the DEA method does not use information, so less data is needed, fewer assumptions are needed and fewer samples can be used. However, statistical conclusions cannot be drawn using the DEA method.

Table 2. Models Classification of Respondent Farmer Efficiency Levels

Classification	Efficiency Level	Frequency	Percentage
Low	1.15-4.53	140	96.55
Currently	4.53-7.90	3	2.07
High	7.91-11.28	2	1.38
Total		145	100
Savings			80.52

Source: Primary Data, 2023 (processed)

Even though SFA has more completeness in estimating the level of efficiency, it does not mean that DEA does not have an advantage. In measuring efficiency, DEA identifies units that are used as references that can help to find causes and solutions for inefficiencies [4]. In addition, DEA does not require a complete specification of the functional form that shows the production and distribution relationships of observations.

In the SFA approach, the data must pass the classic assumption test, namely the assumption of normality and homogeneity. This will later affect the regression estimation of the SFA approach so that the proposed model can be representative. So that the data can be more balanced, in this study SFA is more suitable for measuring the level of cost efficiency in sugarcane farming. The SFA method can predict that there are infinite sample errors, especially if the input and output variables are relatively large compared to the number of observational variables [5]. The results of cost efficiency with the SFA method can be divided based on several categories as listed in Table 2.

The efficiency level of the respondent farmers is seen from the cost efficiency index based on the SFA calculation, it is known that 98% of the farmers are inefficient, there are only 2% or 2 of the respondent farmers who have cost efficiency. Farmers need cost savings of 80.52% to achieve the status of the most economically efficient producer. This result is

different from the DEA calculation (See Table 1) which shows that 100% of sugar cane farmers are inefficient, judging from the efficiency value which is <1. Thus, the overall performance of sugarcane farming has not reached efficiency, whether calculated using SFA or DEA. Thus it is necessary to make improvements in the sugarcane farming processing system for the respondent farmers. For example, by optimizing the workforce used by respondent farmers.
The frontier calculation (Table 3) shows the coefficients of seed and labor have a significant effect on farmer acceptance, which means that each additional number of these variables, labor will increase the income received by the respondent farmers. While the variables ZA fertilizer, Phonska, and pesticides have no significant effect. No significant variables indicate that the use of these variables in rice farming has been excessive. This is due to the attitude of farmers who are still dependent on fertilizers and pesticides in overcoming the increase in sugarcane production.

Table 3. Stochastic Frontier Cost Function Estimation

Variable	Coef.	Std. Err.	t
Intersep	-3.620	1.019	-3.552*
Log (Pupuk ZA)	0.013	0.009	1.538
Log (Pupuk Phonska)	-0.008	0.006	-1.321
Log (Bibit)	0.229	0.056	4.085*
Log (Pestisida)	-0.001	0.004	-0.339
Log (Tenaga Kerja)	0.368	0.060	6.165*
Sigma-squared	0.762	0.145	5.271*
Gamma	0.854	0.075	11.402*
Log likelihood Function			-125.099
LR Test			9.384

*signifikansi pada taraf kepercayaan 1%

T tabel 0.01 = 2.610

The value of the gamma parameter (Ɣ) is 0.854 and statistically significant at an error rate (α) of 1%. This shows that the variation of the model error from the interference error in the model due to technical inefficiency is 85.4% so that it can be seen that the difference between actual production and maximum possible production is due to differences in cost inefficiencies. While the value obtained by sigma squared (σ) is 0.762 which is significant at the 1% level indicating that there is a technical inefficiency effect in the model. The sigma squared criterion (σ) measures whether there is an effect of technical inefficiency in the model, if σ = 0 then there is no effect of technical inefficiency.

The LR test calculation value that has been presented in frontier results using MLE is 9,384. After that, it is compared with the critical value (Kodde and Palm, 1986) with the number of restrictions of 1 and the α level of 1%, which is 5,412. LR test > Kodde and Palm values, thus accepting Ho where there is no evidence that $\sigma_u^2 \sigma_u^2 = 0$ or not all farmers have reached a 100% efficient sugarcane farming management level.

4. CONCLUSION

The results of the estimation of the cost function show that the inputs that have a significant effect at the 99% level on the cost of sugarcane are seed and labor inputs. The cost efficiency of the SFA approach obtained an average of 2,197 with 98% of sugar cane farmers being in the inefficient category. Meanwhile, using the DEA non-parametric approach, a value of 0.009 was obtained with 100% of the sugarcane farmers being inefficient respondents. From these results it is known that there are differences in the results of the level of cost efficiency with the SFA and DEA methods, so that in this study these conditions indicate that the SFA approach can be used more to increase the cost efficiency of sugarcane farming in Indonesia.

The Stochastic Frontier method has limitations in assessing the inefficiency of each input used by farmers compared to the DEA method. However, the SFA method can describe the diversity of data so that the efficiency value obtained is the absolute efficiency value of each farmer, whereas in the DEA method the efficiency value obtained is the efficiency value relative to other farmers who are the most efficient.

In assessing the value of efficiency, SFA requires a model of the technical production function. This requires a lot of assumptions that must be met so that the production function meets the classic assumptions, namely BLUE (Best Linear Unbiased Estimator). Meanwhile, the DEA method does not require a functional technical production model to estimate efficiency.

AUTHORS' CONTRIBUTIONS

Rosihan Asmara developed the theory and performed the computations, verified the analytical methods, and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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