Stochastic Frontier Approach on Technical Efficiency of Rice Farming in Jember

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Abstract. In 2022, the rice harvest area will reach around 118.49 thousand hectares with production of 607.37 thousand tons of GKG. The production of rice, if converted, would total 350.71 thousand tons in 2022. The rice harvest area in Jember Regency is expected to be approximately 118.49 hectares in 2022; this is a 4.47 percent decline, or 5.54 thousand hectares, from the 124.03 thousand hectares in 2021. The average yield of rice per hectare might fluctuate due to a number of factors, such as issues with the fertility of the soil, fertilizer use, seeds, agricultural practices, pests, weather, and so forth. The purpose of this research is to analyze the technical efficiency of rice farming in Jember. Since there were no sampling frames available in the research area, the approach employed to sample farmer families was purposive. The data analysis method uses a stochastic frontier production function model. According to the research findings, Jember's rice farming has an average technical efficiency rating of 70%. It may be claimed that Jember's rice growing is highly technically proficient.

Keywords: Rice harvest decline, technical efficiency analysis, stochastic frontier model

INTRODUCTION

Rice is a strategic food commodity whose availability is very important for the continuity of food security in Indonesia. According to [1], the rice harvest area in Indonesia in 2022 will be 10.45 million hectares with a total rice production of 54.75 million tons of dry milled grain. Data from [2] shows that in 2023 the rice harvest area is estimated to be around 10.20 million hectares while rice production is estimated at 53.63 million tons. Based on data from [1], rice production according to provinces in Indonesia, the three provinces with the largest rice production centers in 2022 are East Java, West Java and Central Java. East Java is included in the number 1 rice producing province in Indonesia which is supported by several districts, one of which is Jember Regency, which according to BPS data is the number 4 highest district after Lamongan, Ngawi and Bojonegoro.

TABLE 1. 10 Largest production regency in Jawa Timur.

No	Regency	Paddy1 Production (ton)		Rice Production (ton)	
		2021	2022*	2021	2022*
1	Lamongan	792.662	920.936	457.699	531.767
2	Ngawi	786.476	785.038	454.127	453.297
3	Bojonegoro	674.002	715.199	389.182	412.970
4	Jember	615.698	613.237	355.516	354.096
5	Banyuwangi	513.490	462.585	296.500	267.106
6	Tuban	489.419	502.136	282.600	289.944
7	Madiun	461.798	419.978	266.652	242.504
8	Nganjuk	429.311	387.897	247.893	223.980
9	Ponorogo	404.665	370.435	233.662	213.897
10	Gresik	379.666	410.323	219.227	236.929

Source: [3]

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Jember Regency is one of the national food buffer districts. As one of the rice barns for Jember Regency with production of 983,663 tons during 2022 with a productivity of 61.1 Kw/Ha [4]. In 2022, the rice harvest area will reach around 119,808.13 hectares with production of 613.24 thousand tons of GKG. If converted into rice, rice production in 2022 will reach 354.10 thousand tons. However, the potential rice harvest area of Jember Regency in 2022 will decrease by 4.22 thousand hectares or 3.4 percent compared to 2021 which was 124,027.77 hectares. Rice production in 2022 is 613.24 thousand tons of GKG, a decrease of 2.46 thousand tons of GKG or 0.40 percent compared to 2021 which was 615.70 GKG. Potential rice production in 2022 for food consumption for the population reaches 354.10 thousand tons, a decrease of 1.42 thousand tons or 0.40 percent compared to rice production in 2021 which was 355.52 thousand tons [5].

According to [6] several factors that can influence the rise and fall of the average rice production per hectare based on expert opinions are soil fertility, rainfall, humidity, use of fertilizer, selection of seeds, farming methods, pests. , etc. Efforts that can be made to increase production results can be done through agricultural extensification and intensification. Agricultural extensification cannot yet be carried out due to limited agricultural land and also the problem of changing the function of agricultural land to non-agricultural land. One effort that can be made to increase rice production in Jember is to increase production efficiency through agricultural intensification.

Several studies have been conducted by researchers regarding the efficiency of rice production, for example, previous research found that the factors that greatly influence the technical efficiency of rice production in Abia State, Nigeria are land area and labor where gender and occupation have a significant effect on the level of inefficiency [7]; research on lowland rice farming in Karanganyar Regency has achieved technical efficiency, the factors of farmer age, education, rice farming experience, type of irrigation, and location (altitude of the area) influence the technical inefficiency of rice farming [8]; research on technical efficiency of rice production in Fogera District, Ethiopia The average technical efficiency score predicted from the Cobb-Douglas stochastic frontier production function estimation was calculated as 77.2 percent, which implies that there is room for increasing rice yields by increasing the efficiency of home resource use stairs [9]; research on the technical efficiency of rice production in East Java shows that the stochastic frontier results show that input factors including seeds, fertilizer, labor and land area have a positive effect on rice production and technical efficiency varies between farmers with an average of 89 percent.

Different from previous research on rice production and efficiency, this research has several special specifications. This research analyzes the technical efficiency of rice in Jember, especially in three sub-districts that have the highest productivity in Jember but not the amount of production, namely Ambulu, Wuluhan and Balung [10]. This research aims to determine the technical efficiency of rice farming in Jember, especially these three sub-districts.

RESEARCH METHOD

The research was conducted in Jember Regency, especially the southern Jember area (Ambulu District, Wuluhan District, and Balung District). The South Jember region is a rice center in the Jember Regency, but in these district has the lowest productivity based on data ini BPS so this was taken into consideration when choosing the location.

Since there were no sampling frames available in the research area, the approach employed to sample farmer families was purposive. The total responden in this research are 50 farmer ini three districts which using random sampling.

The primary data used is the planting area, the number of inputs used (land area, seeds, chemical fertilizers, pesticides, labor and other inputs). Secondary data used to support this research was obtained from the Central Statistics Agency (BPS), Ministry of Agriculture, East Java Plantation Service, and Jember Regency Agriculture, Plantation and Horticulture Service.

The analysis used is the Cobb-Douglas stochastic frontier production function. The factors used in the production function are land, seeds, use of fertilizers, pesticides, and number of workers). The model specifications used to estimate the estimated parameters of the Cobb-Douglas rice production function for rice farming in Jember using the stochastic production frontier approach can be written as follows:

$$Ln\,Y = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + (V_i - U_i)$$

Information:
Y= Rice production (kuintal)
X_1= Rice land area (ha)
X_2= Seeds (kg)
X_3= Urea Fertilizer (kg)
X_4= Ponska Fertilizers (kg)

X_5= Pesticide
β_0= Estimated parameters
β_i= The effects of technical inefficiencies in the model

To determine the distribution parameter value (μi) of the effects of technical inefficiency in this research, the formula was used (Coelli, Rao, and Battese 1998; Kusnadi et al. 2011):

$$U_i = \delta_0 + cZ_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \omega_1 D_1 + \omega_2 D_2 + \omega_3 D_4$$

Information:
Ui = the effects of technical inefficiency
Z_1 = Farmer age (year)
Z_2 = Farmer Education (tahun)
Z_3 = Family Size (orang)
D_1= Dummy of Irrigation (join irrigation = 1 and do not join irrigation =0)
D_2= Dummy of Seed Certification (use seed Certification= 1 and do not use seed certification=0)
D_3= Dummy of Plantation Technical (use Plantation Technical = 1 and do not use Plantation Technical= 0)
Sign of the expected parameter magnitude $\delta_0, \delta_1 > 0$ dan $\delta_2, \delta_3, \delta_4, \omega_1, \omega_2, \omega_3 < 0$

RESULT AND DISCUSSION

The production function analysis used is the Cobb-Douglas stochastic production frontier function model. This analysis aims to analyze the factors that influence the production function of rice farming in Jember Regency. Apart from that, it is also to analyze the technical efficiency of factors that influence the efficiency of rice farmers. This research consists of five variables including land, seeds, use of fertilizers, pesticides, and number of workers. The results of the production function analysis can be seen in Table 2.

TABLE 2. Estimation of the Cobb-Douglas rice production function in Jember in 2022.

Variable	Coefficient	Standard error	t-ratio
Constant	7,93***	0,04	193,48
Land Area	0,78***	0,00	289,34
Seeds	0,17***	0,02	9,18
Urea Fertilizers	- 0,01	0,07	- 0,13
Ponska Fertilizers	- 0,01***	0,00	- 5,40
Pesticides	- 0,02***	0,00	- 16,15
Labor	0,08	0,07	1,06
Gamma	0,99	0,00	48,75
Log-likelohood function OLS	- 20,26		
Log-likelohood function MLE	- 4,56		
LR Test of the one=sided error	31,38		

Note: * significant at =0.1; **significant at =0.05; *** significant at =0.01

Production factors that have positive and significant values are the variables land area and use of seeds, while those that have negative and significant values are the use of phonska fertilizer and pesticides. Outside area and seeds have a real and positive influence on rice production in Jember Regency. The area coefficient value is 0.78. This value shows that an increase in rice land area by 1 percent will increase rice production in Jember Regency by 0.78 percent, assuming ceteris paribus. Land area is the most responsive variable compared to other variables. This has the implication that farmers can increase rice production by increasing the area of rice land. The results of this research are in line with research conducted by [7] and [11] that land area has a positive and significant value. Meanwhile, the seed coefficient value of 0.17 indicates that increasing seed use by 1 percent will increase rice production in Jember Regency by 0.17%, assuming cateris paribus. The results of this research are in line with research conducted by [8] and [11] that land area and seeds obtained significant results.

The use of phonska fertilizer and pesticides has a negative effect on rice production in Jember Regency. The effect of ponska fertilizer is -0.01. This value means that increasing the use of ponska fertilizer will reduce rice production in Jember Regency. This result can occur because the use of ponska fertilizer in Jember has been too much or exceeded the usage limit. Therefore, it is necessary to reduce the use of Ponska fertilizer to increase rice production in Jember Regency. The results of this research are in line with research [11] where the results of using chemical fertilizers had negative results, whereas in research [9] the value of the fertilizer coefficient showed positive results. Meanwhile, the effect of pesticides is -0.02. This value means that increasing pesticide use will reduce rice production in Jember Regency. Excessive use of pesticides will reduce rice production. In the opinion of several experts, pesticide use that is too high and carried out continuously will cause several losses, including pollution of the agricultural environment, decreased productivity, and poisoning of humans and animals.

TABLE 3. The estimated parameters of technical inefficiency of rice in Jember in 2022.

Variable	coefficient	Standard error	t-ratio
Constant	0,35	1,02	0,34
Farmer age	0,02	0,02	0,96
Farmer Education	- 0,00	0,09	- 0,02
Family Size	- 0,23	0,20	- 1,12
Dummy of Irrigation	- 0,91***	0,32	- 2,81
Dummy of Seed Certification	- 0,36	0,42	- 0,85
Dummy of Plantation Technical	- 1,18**	0,57	- 2,07

Note: * significant at =0.1; **significant at =0.05; *** significant at =0.01

Farmer age has a positive effect on the technical inefficiency of rice farming in Jember Regency. The influence value of farmer age is 0.02. This means that increasing the age of farmers will increase the technical inefficiency of rice farming in Jember Regency. This is due to the condition of farmers in Jember Regency on average who are more than 50 years old, so this will increase inefficiency or reduce the technical efficiency of rice farming.

Education and number of family members have a negative influence on the technical inefficiency of rice farming in Jember Regency. The education influence value is -0.00, meaning that increasing the education level of farmers will reduce the technical inefficiency of rice farming in Jember Regency. Increasing farmer education will increase the efficiency of rice farming. Meanwhile, the value of the number of large family members is -0.23, meaning that increasing the number of farming family members will reduce the level of technical inefficiency of rice farming.

The irrigation dummy is an important variable that influences the technical inefficiency of rice farming in Jember Regency. The irrigation variable has a negative influence, which means that the existence of technical irrigation will reduce the technical inefficiency of rice farming or will increase the technical efficiency of rice farming. This is because the existence of technical irrigation facilities will increase farming efficiency. The results of this research are in line with research conducted by [8], [12], [13] where irrigation is a factor that has an important role with a negative coefficient value, different from the results of research in [14] where irrigation has a positive and significant relationship.

CONCLUSION

Production factors that have positive and significant values are the variables land area and use of seeds, while those that have negative and significant values are the use of phonska fertilizer and pesticides. The irrigation dummy is an important variable that influences the technical inefficiency of rice farming in Jember Regency.

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