JURNAL AKUNTANSI MANAJEMEN DAN EKONOMI

JURNAL AKUNTANSI, MANAJEMEN DAN EKONOMI
Vol.24, No. 1, 2022, pp. 19 - 24
Published online in http://jos.unsoed.ac.id/index.php/jame
ISSN: 1410-9336 / E-ISSN: 2620-8482

Efficiency Analysis Sand And Stone Mining: Production Stochastic Frontier Modeling

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Abstract

This research aims to analyze the effect of capital, cost, working hours, labor, technology, analyze the most influential variables on the production of sand and stone and determine the level of technical efficiency, allocative efficiency, and economic efficiency. The analysis technique uses the Stochastic Frontier Analysis MLE method. The results showed that capital, cost, and technology variables have no significant effect, labor has a positive and significant effect. The most influential variable on sand and stone production in Banyumas Regency is labor. The level of technical efficiency in the production of sand is 0,829418, and stone is 0,743271. The level of allocative efficiency of sand production is 1,799976 and stone 1,997888. The level of economic efficiency of sand production is 1,492933 and stone 1,484972. The production of sand and stone has reached technical efficiency but has not yet reached allocative efficiency and economic efficiency.

Keywords **Capital; Cost; Labor; Technology**

INTRODUCTION

The excavation sector is one of the most critical sectors of a country's economy, especially for developing countries, considering that the technology and equipment used are not yet sophisticated, so they still depend on natural resources. This makes the process of managing excavation materials significant (Siregar, 2016).

Excavation is a business that has a high risk. First, the risk of the number of mineral reserves, namely the risk of the number of remaining reserves considering that minerals are natural resources that take a very long time to be renewed and even cannot be renewed. Second, the technological risk is the capital that must be owned to buy the machines used to produce minerals. Third, the risk of changes in policies issued by the government regarding mining and quarrying policies so that companies must keep pace with changes and implement the latest policies (Idris, 2013).

In the Banyumas Regency area, the types of group C minerals found include limestone, andesite, kaolin, sand, sand, granite, and soil. This rock type is commonly found in the Kedungbanteng District, Karanglewas District, Jatilawang District, and Wangon District (Iqbal *et al*., 2019). Then the type of sand type C excavation is found in Patikraja District, Jatilawang District, Rawalo District, Wangon District, Gumelar District, Karanglewas District, and Somagede District. The sand excavation sites themselves are mostly carried out along the Serayu River, Logawa River, Klawing River, Tajum River, Banjaran River, Cangkok River, and Krukut River (Bilalodin & Irayani, 2007).

In general, the business of class C minerals with sand and stone types has constraints, including limited resource capabilities, the application of technology that has not been optimal, and the relatively large amount of capital used. In the mining business of class C, the type of sand generally has to have capital equipment such as boats, business land, and even a sand suction machine, but some only use simple tools operated by human power. Not much different from the stone business, relatively large capital is used for business land and machinery and equipment used to dig stones, but some only use simple tools operated by human power. In connection with these conditions, it is necessary to find a way to carry out a strategy to maximize productivity and achieve production efficiency. Socialization from the relevant service agencies is needed so that strategies to maximize production can be carried out to

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Received: 18 November 2021
Accepted: 7 January 2022
Accepted: 30 March 2022

technical problems (Suharno & Saraswati, 2019).

The profits obtained are not a determinant that production activities have created efficiency but must also minimize the costs used, so producers must pay attention to the production factors used so that the number of products produced can be maximized and production efficiency is created (Hata *et al.*, 2020). In addition to business and business interests, the production of minerals must also be carried out most efficiently. This is because minerals are natural resources that require a long time to renew and are even non-renewable. The availability of natural resources must be maintained to be used by the next generation, especially for these business actors who have an enormous responsibility for the sustainability of natural resources (Suharno *et al.*, 2019). Technical efficiency can be achieved if the use of certain factors of production can produce maximum profit. Allocative efficiency can be achieved if the input used is the same as the output produced. Economic efficiency can be achieved if there has been technical efficiency and allocative efficiency.

The purpose of this study is to analyze the effect of capital, cost, labor, and technology on the production of sand and stone in Banyumas Regency, analyze the variables that have the most influence on the production of sand and stone, and determine the level of technical efficiency, allocative efficiency, and economic efficiency.

This research is expected to increase knowledge and as a reference for further research regarding Production Analysis on Group C Minerals Types of Sand and Stone in Banyumas Regency. This research is also expected to be part of a reference source of thought in determining policies regarding business licensing in the mining and quarrying sector and can be a source of information to optimize production.

RESEARCH METHODS

This research is a type of quantitative research, which is research conducted based on quantitative data. This research was conducted in March 2021. The location of this research was conducted in Banyumas Regency, Central Java Province. The population in this study were all business units of class c minerals of sand and stone types located in Banyumas Regency as many as 42 sand business units and 40 stone business units. The sampling method used in this study using the Random Sampling technique is a sampling method by choosing randomly without regard to strata, and all members of the population have the same opportunity to be sampled (Suliyanto, 2018:112).

The sample size was taken based on a simple formula according to Yamane 1967:99) using a sampling error of 5% as follows:

$$n = \frac{N}{1+Nd^2}$$

Information:
n: Number of samples
N: Total Population
d: The level of error (sampling error) that can be tolerated

Based on the above formula, the minimum sample results in the sand business unit are as follows:

$$n = \frac{42}{1+42(0{,}05)^2}$$

$$n = 38$$

The results of the sample in the stone business unit are as follows:

$$n = \frac{40}{1+40(0{,}05)^2}$$

$$n = 36$$

So the minimum number of samples that must be met in this study is 38 sand business units and 36 stone business units.

The data collection method used is a questionnaire and direct interviews with respondents, namely the owner of a sand and stone business in Banyumas Regency.

Data Analysis

The method used is stochastic frontier analysis to analyze the level of technical efficiency, allocative efficiency, and economic efficiency. The stochastic frontier method is an analytical method used to estimate the magnitude of the efficiency coefficient of each independent variable (Darmawan, 2016:30). In addition, using the stochastic frontier analysis method can simplify the estimation of the relationship between production inputs and outputs and at the same time estimate the level of efficiency, which is written in the following form:

$$LnY = \beta_0+\beta_1 LnK+\beta_2 LnC+\beta_3 LnL+\beta_4 DT+Vi-Ui$$

Information:
Y : Production Quantity (m3/day)
LnK : Capital (Rupiah)
LnC : Production Cost (Rupiah)
LnL : Manpower (Person/Business Unit)
DT : Technology (Dummy)
$\beta_o \beta_1 \beta_2 \beta_3 \beta_4$: Coefficient of Independent Variable

Vi : Random Error
Ui : Level of Inefficiency

The analytical method using the stochastic frontier can be used to analyze several types of efficiency, including the following:

1. **Technical Efficiency**

Technical efficiency has a value ranging from 0 to 1. According to research conducted by Cordanis *et al*. (2020), a business can have achieved technical efficiency if the level of technical efficiency is more than or equal to 7.0. Technical efficiency shows the efficiency of production output in the use of production inputs (Darmawan, 2016: 53). The level of technical efficiency using the stochastic frontier method can be written with the following formula:

$$TE=\exp(-U)$$

Information:
TE: Technical Efficiency
exp: Exponent
-U: Accommodation from inefficiency
TE > 7.0; means that it has reached technical efficiency

2. **Allocative Efficiency**

Allocative efficiency is part of economic efficiency along with technical efficiency (Darmawan, 2016:56). In the stochastic frontier method, allocative efficiency is written as follows:

$$AE=NPMxi/Pxi$$

Information:
AE: Allocative Efficiency
AE > 1; it means that the use of input xi is not efficient
AE = 1; it means that the use of input xi is efficient
AE < 1; it means that the use of input xi is not efficient

3. **Economic Efficiency**

Economic efficiency analysis presents the coefficient of the total cost used for production and the actual total cost. The formula for economic efficiency using the stochastic frontier method can be written in the following way (Darmawan, 2016:56):

$$EE=TE\times AE$$

Information:
EE: Economic Efficiency
TE: Technical Efficiency
AE: Allocative Efficiency
EE > 1; means that economic efficiency is not achieved
EE = 1; means that economic efficiency is achieved
EE < 1; means that economic efficiency has not been achieved

RESULTS AND DISCUSSION

1. STOCHASTIC FRONTIER ANALYSIS

A. SAND

This study uses a frontier production function with five variables, namely capital (X_1), production costs (X_2), labor (X_3), and technology (X_4). The analytical tool used to analyze the frontier production function uses Frontier 4.1 with the MLE (Maximum Likelihood Estimation) method which produces the following analysis estimates:

$$\ln Y = 1{,}31423 + 0{,}24669\ln X_1 – 0{,}53277\ln X_2 + 1{,}24241\ln X_3 + 0{,}03453\ln X_4 + vi - ui$$

Based on the above equation, it can be seen the meaning of each coefficient as follows:

a. The coefficient of the constant in the above equation is 1,31423. This value indicates that if all variables are zero, then the sand production is 1,31423 m3.
b. The coefficient of capital variable (X_1) of 0,24669 means that if capital (X_1) is added by one percent, the sand production will increase by 0,24669 percent with the assumption that other variables are constant.
c. The cost variable coefficient (X_2) of -0,53277 means that if the cost (X_2) is added by one percent, the sand production will decrease by 0,53277 percent, assuming other variables are constant.
d. The labor variable coefficient (X_3) of 1,24241 means that if labor (X_3) is added by one percent, the sand production will increase by 1,24241 percent, assuming other variables are constant.
e. The technology variable coefficient (X_4) of -0,03453 means that if using technology (X_4) instead of machines, the sand production will be 0,034530 percent less than if using machine technology (X_4), assuming other variables are constant.

B. STONE

Based on the analysis of the stone business, the equation function of the estimation results is obtained as follows:

$$\ln Y = 2{,}63760 + 0{,}17865\ln X_1 – 0{,}22067\ln X_2 + 0{,}96739\ln X_3 – 0{,}64249DX_4 + vi - ui$$

Based on the above equation, it can be seen the meaning of each coefficient as follows:

a. The coefficient of constant in the above equation is 2,63760. This value indicates that if all variables are zero, the producer can produce 2,63760 m3 of stone.
b. The coefficient of capital variable (X_1) of 0,17865 means that if capital (X_1) is

added by one percent, then stone production will increase by 0,17865 percent with the assumption that other variables are constant.

c. The cost variable coefficient (X_2) of -0,22067 means that if the cost (X_2) is added by one percent, the stone production will decrease by 0,22067 percent, assuming other variables are constant.

d. The labor variable coefficient (X_3) of 0,96739 means that if labor (X_3) is added by one percent, the stone production will increase by 0,96739 percent with the assumption that other variables are constant.

e. The technology variable coefficient (X_4) of -0,64249 means that if using technology (X_4) instead of machines, stone production will be 0,64249 percent more than if using machine technology (X4), assuming other variables are constant.

2. Technical Efficiency, Allocative Efficiency, and Economic Efficiency

Calculations of technical efficiency, allocative efficiency, and economic efficiency were carried out using the Frontier 4.1 analysis tool with the MLE (Maximum Likelihood Estimation) method. The following is data regarding the results of the analysis of technical efficiency estimates, allocative efficiency, and economic efficiency:

The average technical efficiency in the sand business is 0,829418. According to research conducted by Cordanis *et al*. (2020), a business can have achieved technical efficiency if the level of technical efficiency is not less or equal to 0,70. On average, sand production can be said to have reached technical efficiency. Producers can still take 0,170582 opportunities to increase sand production. Meanwhile, the average technical efficiency in the stone business is 0,743812, so that, on average, stone production can be said to have reached technical efficiency. Manufacturers can still take the opportunity 0,256729 to increase stone production.

Allocative efficiency is calculated by comparing the NPM value of a variable with its price level. The variables used are only variables that have a positive and significant effect. In the sand and stone business, the positive effects variables include capital (X_1) and labor (X_3). However, in both the sand and stone business, the only significant variable is the labor variable (X_3), so that only the labor variable (X_3) is calculated.

It is known that the allocative efficiency in the sand business is 1,799976 or more than one, then the allocative efficiency in the sand business has not yet reached allocative efficiency. The allocative efficiency in the stone business is 2,001999 or more than one, so the allocative efficiency in the stone business has not yet reached allocative efficiency. Sand and stone producers must add other inputs to increase production to achieve allocative efficiency.

Economic efficiency can be achieved if technical and economic efficiency has been achieved. Economic efficiency is calculated by multiplying the value of technical efficiency with the value of allocative efficiency. The economic efficiency obtained in the sand business is 1,492933 or more than one, meaning that economically the sand business has not experienced economic efficiency. Likewise, the economic efficiency obtained in the stone business is 1,488028, meaning that economically the stone business has not experienced economic efficiency. Sand and stone producers must add more inputs to increase production and achieve economic efficiency.

CONCLUSION

Based on the results of research conducted to find out the effect of capital, cost, labor, and technology on the production of class c minerals, sand, and stone types in Banyumas Regency and the level of technical efficiency, allocative efficiency, and economic efficiency of class c minerals, sand and stone types in Banyumas Regency. Banyumas Regency, it can be concluded as follows:

1. Based on the results of the Stochastic Frontier Analysis using the MLE (Maximum Likelihood Estimation) method with the Frontier 4.1 application, the results of the study of the effect of the independent variable on the dependent variable are as follows:
   a. Capital has no significant effect on the production of sand and stone in the Banyumas Regency.
   b. The cost has no significant effect on the production of sand and stone in the Banyumas Regency.
   c. Labor has a positive and significant effect on the production of sand and stone in the Banyumas Regency.
   d. Technology has no significant effect on sand production, and technology has a significant and negative effect

on stone production in Banyumas Regency.
2. The most influential variable on the production of sand and stone in Banyumas Regency is labor.
3. This study which analyzes technical efficiency, allocative efficiency, and economic efficiency, results that the production of sand and new in Banyumas Regency has achieved technical efficiency, but neither sand nor stone production has not achieved allocative efficiency and economic efficiency.

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List of Tables

Table 1. Results of Business Estimation Analysis for Group C Types of Sand Using the Method MLE

Variable	Coefficient	Standard Error	t-Ratio

Constanta	1,31423	0,96248	1,36546
Capital (X1)	0,24669	0,85078	0,28996
Cost (X2)	-0,53277	0,59688	-0,89259
Labor (X3)	1,24241	0,68953	*1,80182
Technology (X4)	-0,03453	0,41707	-0,08279
Sigma-squared	0,06509	0,07097	0,91716
Gamma	0,97616	0,57014	1,71214
Log likelihood function	20,76177		
LR test one-side error	6,11514		

Remarks: *significant at 10% level

Table 2. Results of Business Estimation Analysis of Group C Types of Minerals Using the Method MLE

Variable	Coefficient	Standard Error	t-Ratio
Constanta	2,63760	1,05857	2,49167
Capital (X1)	0,17865	0,11044	1,61760
Cost (X2)	-0,22067	0,23602	-0,93496
Labor (X3)	0,96739	0,02263	*42,75633
Technology (X4)	-0,64249	0,09262	-6,93652
Sigma-squared	0,15096	0,01538	9,81534
Gamma	0,99996	0,00002	40904,59
Log likelihood function	7,03837		
LR test one-side error	8,36497		

Remarks: *significant at 5% level

Table 3. Results of the Estimation of Technical Efficiency, Allocative Efficiency, and Economic Efficiency of Class C Minerals Business Types of Sand and Stone

Type of Business	Technical Efficiency	Allocative Efficiency	Economic Efficiency
Sand	0,829418	1,799976	1,492933
Stone	0,743812	2,001999	1,488028