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(Research Article)

Production function estimation analysis of black grape farming in Buleleng District-Indonesia

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Abstract

This study aims to estimate the production function of black grape farming. The research was conducted in Buleleng Regency. This area was taken purposively. The sample village is Kalianget Village. The sample size was 33 farmers. Sampling was done by Simple Random Sampling method. The data used were primary data and secondary data. Data analysis method used Cobb-Douglas Stochastic Frontier production function model. The results showed that cultivation technology is relatively traditional, the use of production factors is not in accordance with the recommended dosage. The use of production inputs of urea fertilizer 1622 kg/ha/year, urea fertilizer 714 kg/ha/year, and Organic fertilizer 1544 kg/ha/year. The production achieved was only 18.49 kg/ha/year. The use of production inputs simultaneously had a significant effect on black grape production. Variables of land area, NPK fertilizer, Urea fertilizer, Organic fertilizer, and labor have a significant effect on black grape production. Technical efficiency; ET = 0.83, meaning that the achievement of black grape farming production is 83% of Frontier production, black grape farming can be concluded for the use of production inputs used by farmers has been technically efficient.

Keywords: Production; Black grape farming; Production Factors; Technical Efficiency

1. Introduction

Horticultural commodities production scale annually increases both domestically and abroad due to population growth, consumption and increased income. Indonesia is one of the tropical fruit producing countries that has diversity and excellence in flavor that is quite good compared to other tropical fruit producing countries. Consistent with FAO data, tropical fruit trade at the world level continues to increase so that the production of tropical fruit in the archipelago continues to increase from year to year. One group of horticultural crops is fruits. Horticultural commodities have excellent opportunities when cultivated intensively and periodically on an agribusiness and agro-industry scale, especially in fruit crops. A commodity that is prospective both to meet the needs of domestic and international markets is grape vines. The diversity of land characteristics, agro-climate and wide area distribution allows Indonesia to be used for horticultural development, especially grape vines.

According to data from the Director General of Horticulture, regional superior commodities whose development has been supported through APBN funding include 29 commodities spread across 90 districts. In Indonesia, the center of grape production is Buleleng Regency, Bali Province. Public interest in growing grapes in this area is increasing because grape cultivation is very profitable. In Bali Province, horticultural crops such as fruits and vegetables, besides being used for food, are also used in traditional ceremonies in every religious activity. Buleleng Regency geographically has great potential for increasing agricultural products, because it is a fertile area so that almost all agricultural commodities, especially food crops and horticulture, can grow and develop well. With this wealth of natural resources and high market demand, horticultural commodities, especially grapes, are products of high economic value, so that horticultural businesses are the main source of farmers' income.

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Data from Buleleng Regency Horticulture Statistics in 2019 states that the quality of grapes from Buleleng reaches the world market. In 2019, grape production was recorded to have increased by 26.87%. This increase was supported by an increase in grape population of 54.50% (an increase of 49,306 trees). The three sub-districts that were recorded as grape producers in 2019 were Seririt Sub-district with 6,233 tons (47.53%), Gerokgak Sub-district with 5,950.50 tons (45.55%), and Banjar Sub-district with 904.40 tons (6.92%). from the amount of grape production produced in Seririt Sub-district from year to year, it still fluctuates and in 2021 there was a decrease in production. The decline in grape production in Seririt Subdistrict must always be considered considering that the decline will affect the income of grape farmers which will also experience a decline. This will certainly affect the consumption of farmer households in meeting their needs. The production process will run well if the factors of production can be fulfilled. Each factor is intertwined with one another and has an important role in farming activities. Production factors are absolute components that must be available and it would be better if the adequacy requirements of each production factor are met so that they can provide optimal production results.

The decline in grape production from 2020 to 2021 in Buleleng Regency is thought to be influenced by the technical factors used that are not yet efficient in grape farming. Technical efficiency will be influenced by the production inputs used. A farm is said to be technically efficient if it produces a large output but only by using a few inputs. Technical efficiency analysis aims to determine the combination of production factors that are optimal in producing grape farming production and see technical factors that can affect the managerial ability of farmers in producing efficiently to increase the profit of the farmers themselves. Increased agricultural production is expected to increase income for farmers, but production in each farmer is different due to several factors that influence it. From this description, it is necessary to analyze the production function of black grape farming with the Stochastic Frontier production function model approach. Production factors in grape farming are estimated to be factors that are very influential in achieving optimal grape production results, namely land area, NPK fertilizer, Urea fertilizer, organic fertilizer, pesticides used, and labor.

2. Material and methods

The research was conducted in Buleleng Regency by taking a sample village, Kalianget Village, which was drawn purposively with the consideration that this village is the center of the famous black grape plantation in Bali Regency. The sample size was 33 farmers, which was determined by the slovin method (Sugiyono, 2010). Data collection using the interview method using a questionnaire. Simple random sampling was conducted in Kalianget Village, Seririt Subdistrict, Buleleng Regency. The location of this research was chosen purposively with the consideration that Kalianget Village is one of the central villages of black grape plantation in terms of land area and almost all people of Kalianget Village plant their land with black grape plants. The object used in this research is black grape farmers.

2.1. Stochastic Frontier Production Function Analysis

In this study, the production function estimation used the Cobb-Douglas Stochastic Frontier production function model (Coelli, T and battesse, (1998), Soekartawi (2003) and Tasman, A (2008). The selection of production factor variables in the estimation model is based on economic theory and existing research results. Empirical model of stochastic frontier Cobb-Douglas production function used in this study is formulated in the following equation:

$$\ln Y = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + \beta_6 lnX_{6i} + (vi - ui)$$

Where:
Y: Black grape production (kg)
β_0: Constant or intercept
X_1: Land area planted with black grapes (ha)
X_2: NPK fertilizer allocation used (kg)
X_3: Urea fertilizer allocation used (kg)
X_4: Allocation of organic fertilizer used (kg)
X_5: Allocation of pesticides used (L)
X_6: Allocation of labor used (HOK)
v_i: random disturbance terms
u_i: technical inefficiency effect
i: indicates the i-th farmer

Analysis of the production function of black grape farming using Maximum Likehood Estimation (MLE) aims to identify production factors and see the technical efficiency of farmers. MLE parameters are also used to describe the relationship between maximum production achieved by using existing production factors.

2.2. Technical Efficiency Analysis

Coelli and Battese (1998) Technical efficiency is a reflection of a firm's ability to obtain maximum output from a set of available inputs. Defined as the ratio of the actual production of farmers at the technical level of maximum production possibility. The method of analysis to answer the research objectives regarding the level of technical efficiency of black grape farming in the research area was estimated using the equation formulated by Tasman (2008) as follows:

$$TE_i = \frac{Y_i}{Y_i^*} = e^{-u_i}$$

Where:
TE_i: technical efficiency achieved by the i-th farmer
Y_i: actual farm output
Y^*: potential output
u_i: one-side error term ($ui \geq 0$) or random variable

The criteria for farmers who are classified as technically efficient in this study are if the efficiency index value ≥ 0.58 then the black grape farm is technically efficient. Conversely, if the efficiency index value < 0.58 then the black grape farming is not technically efficient (Cahyono, 2010).

3. Results and discussion

3.1. Description of Farmers and the Use of Production Inputs in Kalianget Village, Seririt Sub-district

Farmer characteristics are factors that influence farmers in managing their farms. The characteristics of farmers studied in the research area are farmer age, education level, and farming experience. Production factors are very important factors in efforts to increase farm production. The use of production factors should be in accordance with the recommended in order to obtain maximum results. Description and use of production inputs can be seen in Table.

Table 1 Farmer Description and Use of Production Inputs in the Research Area, 2022

Farmer Characteristics	**Average**
Age of farmer	47 years old
Education level	51.52 % Junior High School
Farming experience	18 years old
Use of Production Inputs	Average
Land area (ha)	1,06
NPK fertiliser (kg/ha)	1.622
Urea fertiliser (kg/ha)	714
Organic Fertiliser (kg/ha)	1.544
Pesticides (litres/ha)	31
Labour (HOK/ha)	235

Source: Processed Primary Data, 2022

Table 1 illustrates that farmers are still of productive age with an average age of 47 years. The formal education level of farmers is relatively low. The variable land area of sample farmers is at an average of 1.06 ha per farmer. The average NPK, Urea, and Organic fertilisers are not in accordance with the recommendations of the agriculture office with an average of 1,622 kg/ha, 714 kg/ha, and 1,544 kg/ha. The pesticide variable used by farmers has 31 litres/ha and for the labour variable is 235 HOK/ha.

3.2. Analysis of Factors Affecting Black Grape Production Frontier Production Function Analysis with MLE Method

Analysis of the production function of black grape farming with the use of Maximum Likehood Estimation (MLE) aims to identify production factors and see the technical efficiency of farmers. MLE parameters are also used to describe the relationship between maximum production achieved by using production inputs. The estimated production function can be seen in Table 2.

Table 2 Estimation of Stochastic Frontier Production Function of Black Grape Farm with MLE Method, 2022

Variabel	Parameter	Koefisien	t-hitung
Konstanta	β_0	3.937084	5.965757***
Luas Lahan	β_1	0.060283	6.111551***
Pupuk NPK	β_2	0.087532	5.809838***
Pupuk Urea	β_3	0.609077	7.221849***
Pupuk Organik	β_4	0.085424	2.796340***
Pestisida	β_5	0.008247	0.248906
Tenaga Kerja	β_6	0.124063	3.216141***
Sigma-squared		0.008317	2.685655
Gamma		0.999999	92648.48
$\Sigma\beta i$		0.889202	
LR test of the one-sided error			9.099542
Log-likehood function MLE			71.13511
Log-likehood function OLS			66.58534
R^2 = 0,962948			
t-table α (0,01), df : 27 = 2,770683			
t-table α (0,05), df : 27 = 2,051831			
t-table α (0,10), df : 27 = 1,703288			

Source: Processed with Frontier, 2022; Notes: *** = highly significant difference at α (0.01)

Table 2 shows the R2 value of 0.9629, which means that the model precision is 96.29%. In other words, the independent variables (land area, NPK fertiliser, Urea, Organic, and labour) together can explain the dependent variable (production) by 96.29%, while the remaining 3.71% is determined by other factors outside the model. The value of gamma (γ) indicates the presence or absence of the influence of inefficiency in the model. Statistically, the value of gamma (γ) 0.9999 is close to 1, meaning that the error term is caused by technical inefficiency by 99.99%, and the remaining 0.01% is caused by external influences. The value of Σβi = 0.8892 < 1, meaning that it is in region II of the production curve or the Decreasing Return to Scale region, which means that each addition of production input with the same amount of proportion will result in a decreasing increase in grape production. All independent variables used in the model have a very significant effect on productivity at the α = 0.01 level, namely land area, NPK fertilizer, Organic Urea, and labour. The input variables used in farming will be analysed in the frontier productivity function model. The results of the estimation of the forntier productivity function with the following equation:

$$\text{Ln } Y = 3,937 + 0,060 \ln X_1 + 0,087 \ln X_2 + 0,609 \ln X_3 + 0,086 \ln X_4 + 0,008 \ln X_5 + 0,124 \ln X_6 + (0,01 - 0,99)$$

3.3. Effect of Land Area on Production

Table 2 shows that the t-count value of the production factor of land area of 6.111551 is greater than the t-table value at α (0.01) which is 2.770683. This means that the production factor of land area (X1) has a significant effect on the production of black grape farming at the 99% confidence level. The elasticity value of the production factor of land area (β1) is positive at 0.060283 (β1 > 0) which means that every additional production factor of land area by 10% will increase the production of black grapes by 0.6%. The increase in black grape production can be done by increasing the land area followed by the use of appropriate inputs in accordance with good management principles in order to produce maximum additional production (Cahyono, 2010). Consistent with the results of research conducted by sa'diyah (2021), the coefficient value of land area of 0.630 contributed significantly to watermelon production. This means that each addition of one unit of land area can increase production by 63.0% assuming other variables remain, therefore efforts to increase production can still be done by expanding land (extensification). Consistent with the theory that land as one of the factors of production is the factory of agricultural products that have a considerable contribution to the farming business.

3.4. Effect of NPK Fertiliser on Production

Table 2 shows that the t-count value of the NPK fertiliser variable listed in Table 17 is 5.809838. This value is greater than the t-table value α (0.01) which is 2.770683. This means that the NPK fertiliser variable has a significant effect on black grape production at the 99% confidence level. The elasticity value (β2) of NPK fertiliser is positive at 0.087532 or $\beta2 > 0$ which means that every 10% addition of NPK fertiliser will increase production by 0.8%. To increase the production of black grape farming, farmers can do so by increasing the use of NPK fertiliser.

The elasticity value of NPK fertiliser which is positive and has a significant effect on black grape production means that it is in accordance with the research hypothesis where this result shows that the use of NPK fertiliser is one way to improve the quality and quantity of black grapes produced. Consistent with research conducted by Ismawati (2014), the effect of NPK fertiliser on production is positive so that to increase production can be done by adding NPK fertiliser. Plant growth and yield can be optimal if NPK fertiliser is applied at the right dose, right time, and right placement. Excessive or insufficient fertilisation will adversely affect the plants, i.e. the plants will grow poorly and will not increase production. Excessive NPK fertilisation will also cause black grape plants to die (Cahyono, 2010). Plantation commodities will be more competitive from the comparative advantage and competitive advantage if the use of NPK fertiliser is done optimally (Saad, Murdy et al 2021).

3.5. Effect of Urea Fertiliser on Production

Table 2 shows that the t-count value of the Urea fertiliser variable is 7.221849 which is greater than the t-table value at α (0.01) of 2.770683. This means that the Urea fertiliser variable has a significant effect on black grape production at the 99% confidence level. The elasticity value of Urea fertiliser (β3) is positive at 0.609077 or $\beta3 > 0$ which means that if Urea fertiliser is added by 10%, it will increase the production level by six%. From this description, black grape farmers can increase their farm production by adding Urea fertiliser use.

The elasticity value of Urea fertiliser which is positive and has a significant effect on black grape production is also in accordance with the research hypothesis where this result shows that the use of Urea fertiliser is one way to improve the quality and quantity of black grapes produced. The use of Urea fertiliser on grape plants is based on the age level of the plant. One of the fertilisers that play an important role in the cultivation of grape plants is Urea fertiliser. The application of Urea fertiliser to grape plants greatly affects the grapes produced. Thus, the proper application of Urea fertiliser will affect grape production (Sukadi, 2020).

3.6. Effect of Organic Fertiliser on Production

It can be seen in Table 2 that the organic fertiliser variable has a significant effect on the production of black grapes with a 99% confidence level. This can be seen from the t-count value of Organic fertiliser of 2.796340 which is greater than the t-table value at α (0.01) which is 2.770683. The elasticity value of Organic fertiliser variable is positive ($\beta4 > 0$) at 0.085424 which means that every additional use of Organic fertiliser by 10% will increase the production level by 0.8%.

Organic fertiliser has a significant effect on black grape production with positive elasticity, meaning that it is in accordance with the research hypothesis where this result explains that the use of organic fertiliser is one way to increase black grape production. The use of organic fertiliser on grape plants is adjusted to the dose and number of plants. Organic fertiliser has an influence in increasing soil fertility. The application of organic fertiliser will improve soil structure and increase the availability of nutrients to plants so that it will affect the growth of grapevines to produce good quality fruit (Ichwan, 2020). The results of this study are also in line with the results of research conducted by Nada (2021), namely that the organic fertiliser variable has a significant effect on papaya production in Sungai Gelam District, Muaro Jambi Regency.

3.7. Effect of Pesticides on Production

Table 2 shows that the pesticide variable has no effect on the production of black grape farming in the wine area is research. This can be seen from the t-count value of 0.248906 which is smaller than the t-table value at α (0.1) of 1.703288. If the t-count value is smaller than the t-table value, it means that the independent variable has no significant effect on the dependent variable. The elasticity value of pesticide is positive at 0.008247 ($\beta 5 > 0$). The pesticide variable has no significant effect on production but has a positive relationship. This insignificance occurs because the use of pesticides is not routinely done, spraying is done when the pest population according to farmers has increased too much. Consistent with the results of research by Luluk Rofiqoh (2018) where liquid pesticides and solid pesticides have no significant effect on watermelon production in Mayangan Village, Gumukmas District, Jember Regency. The results of research by Hamdan (2012) also stated that pesticides had no significant effect on watermelon production in Sunggal District, Deli Serdang Regency.

The application of pesticides on grape plants is very important considering that grape plants are very susceptible to pests and plant diseases. The effectiveness of pesticide use on grape farms according to the recommendation of the Department of Agriculture based on operational standards for grape production is 25 litres per hectare (Deptan, 2011). The use of appropriate pesticides will certainly suppress the growth of pests and plant diseases so that the growth of grape plants is not disturbed and produce quality production.

3.8. Effect of Labour on Production

The labour variable has a t-count value listed in Table 2 of 5.809838. This value is greater than the t-table value α (0.01) which is 2.770683. This means that the labour variable has a significant effect on black grape production at the 99% confidence level. The elasticity value of labour has a positive sign of 0.087532 ($\beta 6 > 0$) which means that every 10% addition of labour will increase production by 8.7%. This is inconsistent with the results of research by Zainol Arifin (2021), namely that labour has no significant effect on strawberry production in Pandanrejo Village, Bumiaji District, Batu City. Efforts to increase the production of black grape farming can be done by increasing the use of labour.

The use of labour in grape farming recommended by the Buleleng Agriculture Office is 75 HOK/year or equal to 25 HOK per harvest season. The effective use of labour will certainly affect the sustainability of the grape farming process. With a good level of labour use, the tasks of each worker will be better coordinated, farming activities will be more organized so that they are more focused on managing the farm. This will certainly affect the production of the grapes. If the use of labour is effective, it will certainly increase the production of grapes (Deptan, 2011). Consistent with research conducted by Sa'diyah (2021), there is an influence between labour variables on watermelon production on dry land on Poteran Island. Therefore, efforts to increase production can still be done by adding labour. The adequacy of labour needs to be considered in the production process, but it is also necessary to pay attention to the quality of labour (Soekartawi, 1990).

3.9. Technical Efficiency Analysis of Black Grape Farming

Technical efficiency analysis describes the ratio of actual production to frontier production. This technical efficiency determines the size of the farmer's productivity achievement. High technical efficiency will result in high productivity and vice versa. The research data showed that the estimation results of technical efficiency analysis showed that the lowest level of efficiency of black grape farmers was 0.61 to 0.84. The average value of actual technical efficiency of black grape farming is 0.73. This shows that the average black grape farming is 73% of frontier production. Black grape farming can be said to be technically efficient (ET = 0.73 > 0.58). Meanwhile, if seen based on table 4 that the frontier technical efficiency level that can be achieved by black grape farmers ranges from 0.87 to 0.99. The average potential technical efficiency obtained from the frontier regression is 0.95. This means that black grape farmers have an actual efficiency of 73% and can increase efficiency by 27% to reach the frontier efficiency limit of 95%. The technical efficiency figure obtained in this study is still below the technical efficiency value in Harefa's research (2021) which obtained an average technical efficiency of 0.86.

4. Conclusion

Black grape farming is still carried out traditionally with very limited adoption of modern technology. Farm management starting from land preparation, from land provision, the use of NPK fertiliser, Urea fertiliser, Organic fertiliser, pesticides, and labour are still far from the recommended technology of the Department of Agriculture. Black grapes are still classified as productive age so they have the potential to achieve optimal production. Harvesting activities are carried out three times a year. Black grape farming consists of land cultivation, preparation of planting holes, planting, fertilisation, irrigation, pruning, fruit thinning, and harvesting. The average production yield of black grape farming is 18,429 kg/ha/year which is still far from the production potential (48 kg/ha/year).

Production factors simultaneously have a significant effect on the production of black grape farming. Production factors that significantly affect black grape production are land area, NPK fertiliser, Urea fertiliser, Organic fertiliser, and labour. While the pesticide variable has no significant effect on black grape production. The technical efficiency level of black grape farming is 73% of frontier production or the opportunity to increase production is still available by 27%.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors gave permission for publication of this article; the first author collected the data and conducted the experiments, the second and third authors analysed and prepared the article for publication.

Statement of informed consent

All parties involved in the study have given permission for observations and data collection that support this article.

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