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Determinant of Patchouli Production in Aceh Jaya Regency Aceh Province

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ABSTRACT

Purpose: It is undeniable that improving the agricultural sector is important to make the economy grow. One way is to improve the quality of better products. In order to achieve the improvement, challenges in maintaining quality consistency, such as production capabilities and the efficient use of resources, have to be addressed. To contribute to the literature in this direction, this study aims to examine the factors of land area, labor, financial capital, fertilizer, and education that influence patchouli production and determine the efficiency of patchouli.

Design/methodology/approach: We employ the theory of Cobb Douglas's production function and production theory in our study. We also use both multiple linear regression and efficiency approaches in our analysis.

Findings: The efficiency analysis revealed that patchouli farming was inefficient in terms of price, technical, and economic efficiency. We also find that land area, labor, financial capital, and fertilizer positively impacted patchouli production, whereas education had no effect on patchouli production in the Aceh Jaya Regency. The results of the analysis of price efficiency, technical efficiency, and economic efficiency show that patchouli production in the Aceh Jaya District, Aceh Province is inefficient.

Practical Implications: Our findings imply that necessitate technological advancements, as well as family labor to keep capital expenditures to a minimum, and organic fertilizers to improve patchouli production quality and income. To increase efficiency production in the Aceh Jaya District, Aceh Province, our findings also imply that it would be advisable for the government to promote patchouli oil production programs because this commodity has a very high selling value, and this commodity has high competitiveness in the international market.

Originality/value: This study investigates the farmer of patchouli in the Aceh Jaya regency by combining the theory of Cobb Douglas's production function and production theory in the study. This study is highly related to efficiency sciences since this study's framework assists policymakers in deciding what aspect to focus on. Our findings are new in the literature.

Keywords: Cobb-Douglas Production Function, Efficiency, Farming, Patchouli.

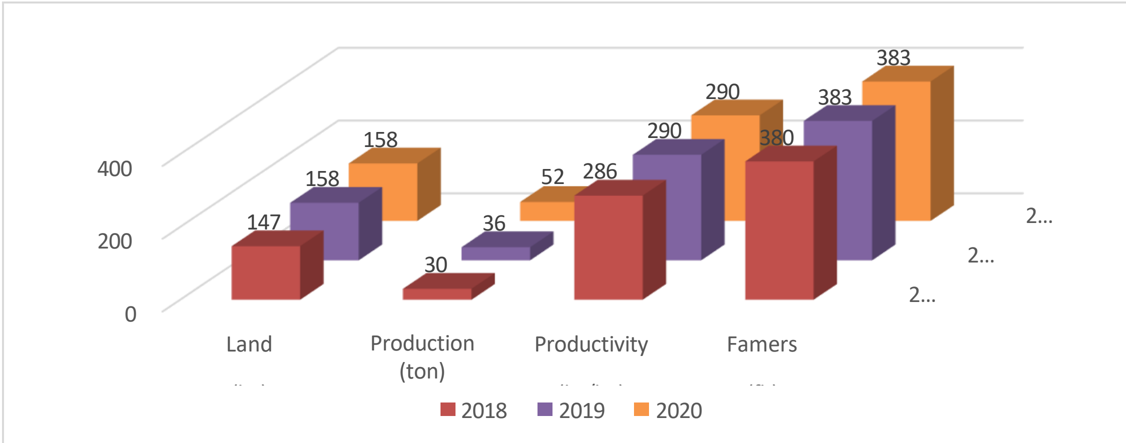
JEL Classification: C83, E23, O13.

1. Introduction

Patchouli is a raw material of atsiri oil production from the main agriculture sub-sector in Indonesia and is well known for its quality in the international market. Indonesia is the largest producer of patchouli oil and meets 70-90 percent of the global demand every year. The patchouli export from Indonesia is expected to fluctuate with an estimated annual increase of 6 percent or 700 to 2,000 tons of patchouli oil (Effendy et al., 2019). Patchouli, as the raw material of atsiri oil, plays a vital role in Indonesia. Atsiri oil is one of the raw materials that has a lucrative export value and contributes to the foreign exchange as well as the GDP of the plantation sector in Indonesia (Silvia & Fitra, 2023).

Based on the average patchouli production around the globe from 2015-2020, Indonesia was one of the top patchouli producers, contributing 95.60 percent of the total patchouli production worldwide (Directorate General of Estate Crops, 2020). The province of Aceh is the biggest producer of patchouli in Indonesia, followed by West Sumatra, Southeast Sulawesi, Jambi, North Sumatera, and West Java, with the respective contribution in the amount of 18.78 percent, 15.93 percent, 13.89 percent, 11.95 percents and 11,69 percent (Directorate General of Estate Crops, 2020). Patchouli, also known as progostemon cablin benth has a content range of 2.5 - 3.3 percent, making patchouli one of the best quality patchouli in the world (Mustika & Nuryani, 2006). According to Effendy et al. (2019), it is suggested that the quality of patchouli oil is strongly influenced by the patchouli substance, which is the vital element of the patchouli oil, and it is required that it must contain at least 30 percent of the substance for international trade requirements.

The Aceh Jaya Regency is one out of five Regencies in the province of Aceh that has a continuously increasing production of patchouli. The expansion of the patchouli farming area is considered to be one of the fastest-growing economic centers in the agriculture, plantation, and forestry sub-sectors. The land area and harvest rate of patchouli farming in Aceh Jaya are considered to be ecologically safe. This is because patchouli is a seasonal crop, so its productivity and production often fluctuate. The mainstay plantation commodity in Indonesia is palm oil, but the essential oils produced from patchouli significantly contribute to the foreign exchange reserves as well as being a non-oil and gas export commodity for Indonesia.



Source: Directorate General of Estate Crops, 2020.

Figure 1. Land Area, Production, Productivity, and Number of Farmers in Aceh Jaya Regency in 2018-2020.

The land area or planting area and harvested area for patchouli farming in Aceh Jaya on average does not have great potential, due to seasonal characteristics that cause patchouli production and productivity to fluctuate. The fluctuation in the amount of production for the market is theoretically related to the price level received by patchouli farmers. The comparison between patchouli prices and input prices received by farmers will directly affect the motivation of the farmers.

Fluctuations in production theoretically have a major impact on prices. This fluctuation in production is what causes the motivation of farmers to decrease. Ridha et al. (2022) argue that producers see price as an important marketing mix component. In Rahim et al. (2012), Rhodes said price is feedback on the production of agricultural producers. As an exported product, the price of patchouli in the country depends on the price in the international market, which is in line with the motivation of farmers. If the price of patchouli soars high, the farmers will be more likely to cultivate patchouli and vice versa. This also affects the efficiency of patchouli farming.

Yield and the low price issue of patchouli may impact the efficiency of patchouli cultivation, whether it be technical efficiency or price efficiency, so patchouli cultivation will affect economic efficiency. Technical efficiency can be achieved if farmers can allocate production factors so that maximum output is obtained, and high production economic efficiency is achieved if farmers can get high output with low input prices and the same price with high yields (Anggraini et al., 2019). Wahid (2022) stated that the average production, labor production factors, and production factor costs incurred by farmers for patchouli farming in paddy fields are likely higher than in dry fields. The use of labor is not efficient, this shows that patchouli farmers are considered not efficient because they have not mastered how to apply technology appropriately to obtain maximum short-term profits. Patchouli farming in paddy fields is one of the best alternatives to be developed since it provides a fairly high-profit margin for farmers.

Yoko et al. (2014) stated that businesses in the agricultural sector have been efficient. The increase in efficiency will give better results if it is focused on areas outside of Java. Land is the main factor that increases farm production with the achievement level of technical, allocative, and economic efficiency which are deemed high and already efficient. Variables that affect the technical efficiency of farming include the number of productive-aging family members on the farm, farming experience, access to agricultural financing, and the frequency of agricultural counseling. On the other hand, Ernawati et al. (2021) state that the level of local economic efficiency of agricultural commodities is not yet efficient, and the factors that significantly affect the economic efficiency are farming experience and formal education of the farmers, while Farming experience is a factor that has a significant impact on the technical efficiency of farming.

Heriyanto and Darus (2019) declare that the number of plants, the age of the plant, the number of workers, and investment are the most important factors influencing agricultural commodity production. Production factors such as the number of plants and workers are inefficient from the technical, allocative, and economic standpoint. On the other hand, Fertilizer use could be technically and economically efficient, but it is allocatively inefficient. Silvia (2018) concluded that the production of agricultural commodities is influenced by factors such as land, plant number, capital, fertilizers, medicines, labor, and experience. All of the aforementioned variables are currently not optimal for farm production. Daris et al. (2018) state that there was a significant positive effect between the area of production on the production of agricultural commodities and a significant negative effect between the labor force on the production of agricultural commodities. Based on the economic efficiency test, it shows that there is no efficiency in the area of production and labor for the production of agricultural commodities.

Previous researchers have studied production efficiency using both the parametric and nonparametric approaches (Liu et al., 2020). These techniques have been used to evaluate efficiency in a wide range of fields, including industry, education, and agriculture. Research by Sutardi et al. (2022) shows the technical effectiveness of shallot farming in sandy Loam Soil in Tegalrejo, Gunungkidul, Indonesia. However, this study focuses on areas in the Yogyakarta province of Indonesia rather than evaluating the effectiveness of marketing. The Cobb-Douglas production function model is the only one employed in a study by Wahid (2022) on patchouli production efficiency, which is restricted to patchouli farms in Banyumas Regency, Indonesia. Agustiar and Sa'adan (2016) investigated the effectiveness of patchouli oil marketing in the West Aceh Regency, Aceh Province.

One of the reasons this research was carried out is that the patchouli oil agricultural production analysis needs to be understood in depth. The researchers improvised analysis, as a form of novelty, with a combination of efficiency and regression analysis. Previous studies only analyzed separately, such as Sutardi et al., (2022) and Wahid (2022), which discussed efficiency only. While determining the characteristics of farmers only by Heriyanto and Darus (2019) and Daris et al. (2018). Through this combination, the results found are more complex and provide input and direction for business actors to maximize the potential of patchouli oil and pursue the best efficient conditions. In addition, studies on patchouli oil in Aceh are still minimal, considering that this agricultural commodity is relatively new among farmers.

2. Review of Related Literature

2.1 Production Function

The manufacturing physical relationship between its input and output factors is shown by the production function. The production function is one of the equations that includes the production factors in such a way that there is only a certain amount of output for each combination of certain production factors (Silvia, 2016). The goal of every company is to convert inputs into outputs. For example, farmers combine their labor with seeds, soil, rain, fertilizer, and machine tools to obtain crops. Economists are interested in the choices that companies make to achieve their goals in which they develop quite abstract models of production. This model is reflected in the production function, namely the mathematical correlation between input factors and output factors that can be denoted (Mokgomo et al., 2022):

$$Q = f\ (\ K, L, M, ...), \qquad (1)$$

where Q is the output of patchouli production during one period, K is the machine (capital) used in one period, L is the input of labor hours, and M is the raw materials used. This model shows that the possibility of other variables of input factors can affect the production process. Of course, the majority of the analysis will apply to any two input factors influencing the production process that you may wish to investigate. Labor and capital are only employed for practical purposes. The application of this discussion to cases with more than two input factors would also be straightforward.

The Cobb-Douglas production function proves useful in many applications because the equation shows a nonlinear model and it is linear in logarithm: $\ln q = \ln A + a + b + \ln K + \ln L$. The constant denotes the elasticity of capital input, while b denotes the elasticity of labor input. In addition to being used to measure scale (by adding a + b), constants can also be estimated as actual data. The maximum output a company can produce for any given set of input variables is described by a production function equation. The Cobb-Douglas function is a production function that is frequently used as an analytical tool in agricultural production. Cobb-Douglas production takes the following general form:

$$Q = \delta . \mathrm{I}\alpha, \qquad (2)$$

where Q is the output I of the type of input used in the production process and is considered for review, δ the efficiency index of using inputs in producing output, and t, α d the production elasticity of the inputs used (Silvia, 2016). The production function where $\delta = 1$, between the two polar cases, there is a function known as the Cobb-Douglas production function. The Cobb-Douglas production mathematical model is presented as follows.:

$$q = f(K, L) = AK^{a} L^{b}, \qquad (3)$$

where A, a, and b are constants that must be positive.

The Cobb-Douglas function can prove that the rate of return of any scale is highly dependent on the values of a and b. Suppose that all inputs are increased by a factor of m. Then

$$F(mK, mL) = A(mK)^{a} (mL)^{b} = Am^{a+b} K^{a} L^{b} = m^{a+b} f(K, L). \qquad (4)$$

If a + b = 1, then the Cobb-Douglas function demonstrates that the returns to scale are constant because the output increases by a factor of m. If a + b > 1, then this function also indicates that the scale of the results obtained is increasing, whereas a + b 1 indicates that the scale of results is decreasing. This is a simple problem because it demonstrates that the elasticity of substitution in the Cobb-Douglas production function is 1. This evidence prompted researchers to use a generalized version of the constant returns to scale function to describe the relationship between aggregate production in different countries. The Cobb-Douglas production function also shows that it is useful in many applications, and the Cobb_Douglas production function is a nonlinear model, so the model can change to be linear using logarithms and the model can be shown in linear:

$$\ln q = \ln A + a \ln K + b \ln L. \qquad (5)$$

The constant is described as having both a labor input and a capital input/output elasticity. These constants can also be calculated from actual data and used for other things, such as measuring a scale (by adding a + b) (Nicholson & Snyder, 2012).

2.2 Production Theory

Production theory is a theory that explains the nature of the correlation between the level of production to be achieved and the number of production factors used. The main concept known in this theory is to produce the maximum possible output with certain inputs and produce a certain number of outputs with minimum production costs (Nicholson & Snyder, 2012). Production is an activity to increase benefits by combining the factors of production of capital, labor, technology, and skills. Production is an effort to increase benefits by changing shape, moving places, and storing (Varian, 2014). Based on this definition, farm production is the yield obtained from the farming process for a certain period (one growing season) whose amount is stated in certain units.

Factors of production in farming can be interpreted as all of the time given in the production process of farming so that plants can grow well in order results.

A production theory can be explained as the maximum output that the firm can produce for each specified combination of inputs. Thus, in the short term, one or more production process inputs are fixed. On the other hand, in the long run, all input factors have the potential for variables. Production with a single variable input, such as labor, which measures output per unit of labor input, and the marginal product of labor (which does the same), can be usefully explained in terms of both (which measures the additional output as labor is increased by 1 unit). The law of diminishing marginal product states that if one or more inputs are fixed, it is likely that a variable input (usually labor) will have a marginal product that declines as the level of input increases. (Pindyck & Rubinfeld, 2013). Expansion and innovative human capital on GTFP showed a trend of diminishing marginal. There was a significant threshold feature of industrial structure upgrading. Expansion gradually increased with the growth of tertiary industry.

2.3 Production Efficiency

Production Yao et al. (2023) efficiency refers to the amount of cost, expense, and dedication that must be paid or incurred to obtain a product. Technical efficiency shows the relationship between input and output, especially when it can be revealed by using the Cobb-Douglas function (Rahim et al., 2012). Technical efficiency (technological efficiency) relates to the physical sum of all factors used in the production process of a particular commodity (Pougkakioti & Tsamadias, 2020). Production efficiency mainly depends on the development of high-performance cell factories, or further increase the production efficiency of microbial shikimate, a valuable compound widely used in the pharmaceutical and chemical industries, ten key target genes contributing to shikimate production were identified by exploiting the enzyme constraint model (Li et al., 2023).

The production of a given output is technical inefficiency if there are other ways of producing the output that can use less of all the inputs. Production is considered to be technical efficiency if there is no alternative way that use all inputs with a small amount (Lin & Zhou, 2022). Economic efficiency is related to the value of all inputs used to produce a certain output, which consists of technical efficiency and price efficiency, relative prices K and L, a high-quality economic system requires an efficient energy system to support it, which provides a safe and reliable energy supply for economic development. Thus, improving energy efficiency has important practical significance for high-quality economic development as shown in the following relationship:

$$\frac{MP_k}{P_k} = \frac{MP_L}{P_L} . \qquad (6)$$

There will be technical efficiency if the factors of production can be used to the maximum. Price efficiency is realized when the price of the factors of production equals marginal product cost. So that efficiency is met if it reaches technical and price efficiency (Soekartawi, 2010). To calculate the technical efficiency of each respondent, it can be calculated by the following formula (Widodo, 1989):

$$ET_1 = \frac{Y_i}{\widehat{Y_i}} X\ 100, \quad (7)$$

where the ET_1 is the technical efficiency level. Y_i is the amount of actual production of the i-th farm. $\widehat{Y_i}$ is the amount of potential production of the i-th farm.

The approach used to analyze price efficiency is by looking at the Marginal Physical Production (MPP), Value of Marginal Product (VMP), and Production Factor Efficiency Index. Marginal Physical Product (MPP) describes the change in the use of one input unit. The value can be searched by using the formula (Rahim et al., 2012):

$$MPPxi = b_i \frac{\bar{Y}}{\overline{X_i}}, \quad (8)$$

where MPPxi is the Marginal Physical Production of Xi. $\bar{Y}$ is geometric mean of the output. $\bar{X}$ is the geometric mean of the input Xi. b_i is the regression coefficient of each factor of production (Xi).

Value of Marginal Product (VMP): Marginal Product Value can also be calculated by multiplying the marginal physical product (MPP) with the price of the unit of production to be produced, namely (Py). The formula is as follows (Rahim et al., 2012):

$$\text{VMPxi} = \text{MPPxi} \ . \ \text{Py}, \quad (9)$$

where VMPxi is the Marginal Product Value of input Xi. Py is the average price per unit of production (Y).

Indicator of the ability of the Factor of Production: The trick is to divide the marginal yield of production (VMP) of the factor of production by the price of the factor of production obtained:

$$Ef = \frac{NPM_{xi}}{P_{xi}} = 1, \quad (10)$$

where Ef is the Production Factor Efficiency Index (Xi). NPM_{xi} is the Value of Marginal Production due to using. $X_i P_{xi}$ is the price of the factors of production used.
The approach used to analyze economic efficiency is by looking at the ratio of the minimum total production costs observed to the actual total production costs, where $0 \leq EE \leq 1$ so that the equation is obtained (Rahim et al., 2012):

$$\text{Economic Efficiency} = \text{Technical Efficient. Price Efficiency.} \quad (11)$$

3. Research Method

3.1 Research Method

This study relied on primary data gathered through direct interviews with patchouli farmers. A questionnaire was used to collect primary data, while secondary data was obtained from the Central Bureau of Statistics (BPS), the Department of Agriculture and the Directorate General of Plantations. Determination of the sample can be done by purposive Sampling, where the researchers must select the sample based on an assessment of several sample characteristics (Silvia et al., 2016). Of the 16 regencies/cities that produce the patchouli commodity, Aceh Jaya Regency was selected by looking at the criteria for an area and sub-district selection with consideration for the largest, medium, and smallest areas. Random Sampling determines the sample villages. Thus, the population in this study was patchouli farmers in Aceh Jaya Regency, amounting to 383 farmers. Using the Slovin formula, the number of samples was 79 people taken proportionally from each identified sub-district as follows (Silvia, 2016):

$$n = \frac{N}{1+ N_{e^2}},$$

$$n = \frac{383}{1+383\ (0{,}1)^2},$$

$$n = \frac{383}{1+3.83},\ n = \frac{383}{4.83},$$

$$n = 79.29, \qquad n = 79.$$

Table 1. Number of Respondents in Each District in Aceh Jaya District Based on the Slovin Formula

No.	Subdistrict	Number of Farmers	Sample Size	
			Slovin	Rounding
1.	Teunom	35	35/383x79= 7.21	7
2.	Panga	67	67/383x79= 13.81	14
3.	Krueng Sabee	65	65/383x79= 13.40	13
4.	Setia Bakti	25	25/383x79= 5.15	5
5.	Sampoinet	20	20/383x79= 4.12	4
6.	Jaya	55	55/383x79= 11.34	11
7.	Indra Jaya	25	25/383x79= 5.15	5
8.	Darul Hikmah	52	52/383x79= 10.72	11
9.	Pasie Raya	39	39/383x79= 8.04	8
Amount		383	78.94	79

Source: Data processing results, 2022.

3.2 Data Analysis Method

The analytical method used in this research is a quantitative analysis using two analytical techniques: multiple linear analysis and efficiency analysis using the Cobb-Douglas production function. Before analyzing the data, classical hypothesis testing is needed to determine if the structural model has normality, does not occur in multicollinearity, and heteroscedasticity. The Cobb-Douglas production function approach is defined as follows (Rahim et al., 2012):

$$Q = f\,(K, L). \tag{12}$$

The Equation (12) above can then be converted into the following equation:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \varepsilon. \tag{13}$$

Equation (13) is then formulated into the following equation:

$$\text{LnQP} = \beta_0 + \beta_1 \text{LnLand} + \beta_2 \text{LnLab} + \beta_3 \text{LnCap} + \beta_4 \text{LnFer} + \beta_5 \text{LnEdu} + \varepsilon, \tag{14}$$

where Qp is the amount of actual production of the i-th (i= 1,2,3,..n) patchouli farm. $Land$ is the Land Area. Lab is the Labor. Cap is the Capital. Fer is the Fertilizer. Edu is the Education. ε is the disturbing factor. β_0 to β_5 are parameters.

Technical, price and economic analyses were used to see the efficiency level of patchouli farming in the Aceh Jaya Regency. The approach to technical efficiency was by dividing the actual yields obtained by farmers with potential yields or frontier production in the study area. This equation is used to determine a factor of the level of efficiency as well as the relationship between input and output in the production process (Widodo, 1989).

$$\beta_O + \sum_{i=1}^{7} \beta_i x_i, \tag{15}$$

under the following conditions:

$$\beta_O + \sum_{i=1}^{7} \beta_i x_i \leq y_i, \tag{16}$$

$$\beta_O + \sum_{i=1}^{7} \beta_i x_i \leq y_{in}. \tag{17}$$

To calculate the technical efficiency of each respondent can be calculated by the following formula (Widodo, 1989).

$$ET_1 = \frac{Y_i}{\hat{Y}_i} X\ 100, \tag{18}$$

where ET_1 is the technical efficiency level. Y_i is the amount of actual production of the *i* farm. $\hat{Y}_i$ is the amount of potential production of *i* farm.

The approach used to analyze price efficiency is by looking at the Marginal Physical Product (MPP), Value of Marginal Value Product (VMP), and Production Factor Efficiency Index. Marginal Physical Product (MPP) describes the change in the use of one input unit. The value can be searched by using the formula of Rahim et al., (2012):

$$MPPx_i = \beta_i \frac{Qp}{X_i}, \tag{19}$$

where $MPPx_i$ is the marginal physical product of X_i. Qp is the geometric mean of the output. $\bar{X}$ is the geometric mean of the input X_i. β_i is the regression coefficient of each factor of production (X_i).

The value of the marginal product (VMP) can be calculated by multiplying the marginal physical product (MPP) by the price of the units of production produced (P_y). The formula is as follows (Rahim et al., 2012):

$$VMPx_i = MPPx_i \cdot P_y, \tag{20}$$

where $VMPx_i$ is the value of the marginal product of input x_i. P_y is the average price per unit of production (Y).

Where the indicator of the ability of the production factor is to divide the marginal yield of production () by the price of the production factor obtained:

$$Ef = \frac{VMP_{xi}}{P_{xi}} = 1, \tag{21}$$

where Ef is the production factor efficiency index (x_i). VMP_{xi} is the value of marginal production due to using. P_{xi} is the price of the Production Factor used.
The approach used to analyze economic efficiency is by looking at the ratio of the minimum total production costs observed to the actual total production costs, where $0 \leq EE \leq 1$ so that the equation is obtained (Rahim et al., 2012).

$$\text{Economic Efficient} = \text{Technical Efficient x Price Efficiency.} \tag{22}$$

4. Result and Discussion

4.1 Results of Normality Test, Multicollinearity Test, and Heteroscedasticity Test

The results of the normality test showed that the residual data was normally distributed. This is because the distribution of residual values was around the diagonal line.

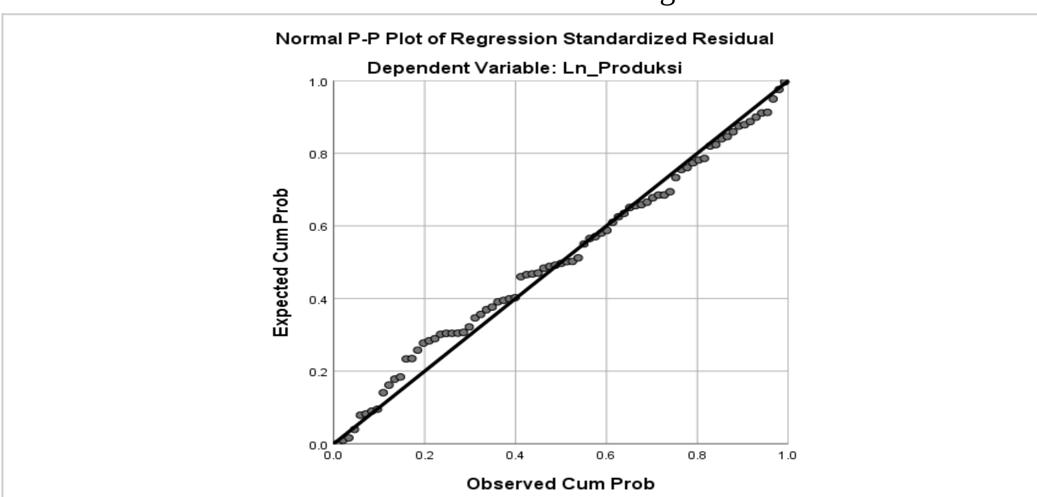


Figure 2 Normal P-P Plot of Regression Standardized Residual.

According to the findings of the multicollinearity test, the VIF value of each variable was 3.967, 7.967, 7.674, 2.328, and 1.058 respectively. Each variable had a value of VIF < 10, therefore multicollinearity assumption was not found in the estimation data.

Table 2. Multicollinearity Test

Independent Variable	VIF	Description
Land area	3.967	Non-Multicollinearity
Labor	7.967	Non-Multicollinearity
Capital	7.674	Non-Multicollinearity
Fertilizer	2.328	Non-Multicollinearity
Education	1.058	Non-Multicollinearity

Source: Data processing result, 2022

Finally, the results of the heteroscedasticity test show that the resulting scatterplot shows that the data in the study met the assumption of heteroscedasticity. This was because the distribution of the data on the scatterplot did not form any pattern but was randomly distributed.

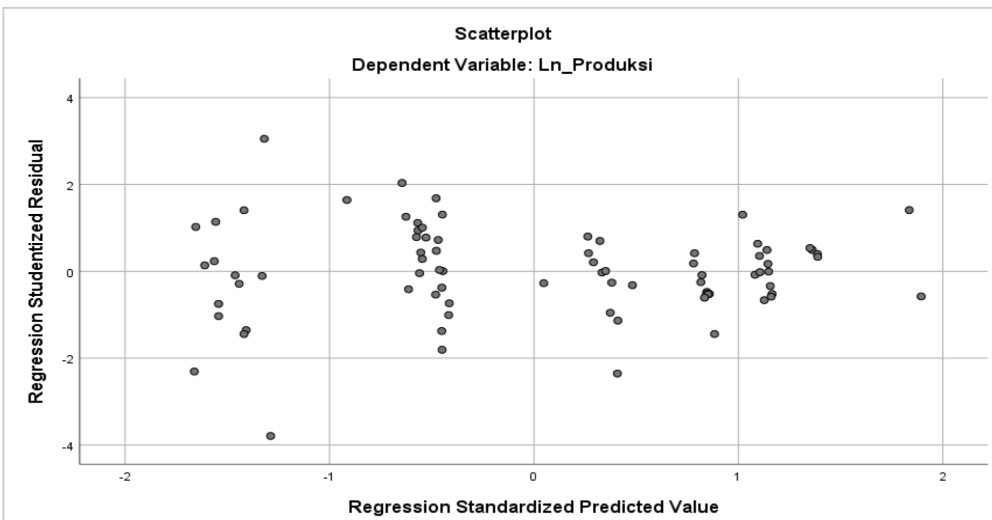


Figure 3 Scatterplot of Regression Standardized Predicted Value

Multiple Linear Regression Analysis Results

Table 3 Multiple Linear Regression Analysis Results

Variable Name	B	Standard Error	Beta	T Count	Sig.
(Constant)	-2,979***	0.451		-6.602	0.000
Ln Land	0.184***	0.052	0.153	3.563	0.001
Ln Lab	0.096***	0.028	0.111	3.440	0.001
Ln Cap	0.335***	0.045	0.359	7.448	0.000
Ln Fer	0.354***	0.067	0.391	5.241	0.000
Ln Edu	-0.026	0.023	-0.14	-1.172	0.245

Source: Data processing result, 2022. *** mean significance at 1%

The outcomes of multiple linear regression analysis performed using the Cobb-Douglas production function approach model are as follows:

$$\text{LnQp} = -2.979 + 0.184\ \text{LnLand} + 0.096\ \text{LnLab} + 0.335\ \text{LnCap} + 0.354\ \text{LnFer} - 0.026\ \text{LnEdu}, \quad (23)$$

where the multiple linear regression equation above can be interpreted as follows:

1. The constant was -2.979, which means that if the variables of the total area of land, labor, capital, fertilizer, and education are assumed to be constant, then the dependent variable, namely patchouli production, will decrease by 2.979 percent.
2. The coefficient of the land area was 0.184, meaning that an increase in land area of one percent affects the increase in patchouli production by 0.184 percent.
3. The labor coefficient was 0.096, meaning that a one percent increase in labor will cause an increase in patchouli production by 0.096 percent.
4. The capital variable coefficient was 0.335, meaning that the percentage increase in capital by one percent will cause an increase in patchouli production by 0.335 percent.
5. The fertilizer variable coefficient was 0.354, meaning that the percentage increase in fertilizer by one percent will cause an increase in oil production by 0.354 percent.
6. The coefficient of the education variable was -0.026, meaning that education has no impact on patchouli production.

The regression estimation results are consistent with the results in Lawalata et al. (2015), which concludes that land area has a positive and significant effect on Robusta coffee production in the Candiroto District. Nurjati et al. (2018) conducted research that concluded that land area has a significant positive effect on shallot production in the Pati Regency. According to Ma et al. (2021), land area affects the efficiency of agricultural production through changes in factors and allocation ratios. Land circulation helps to transfer farmland from households with low APE to households with high APE, thus improving the efficiency and fairness of land allocation.

The labor variable is in line with research conducted by Yoko et al. (2014), which states that labor partially has a significant positive effect on rice production in the Aceh Province. In addition, it is also in line with research conducted by Muin (2017), concluding that labor in the Tellulimpoe District, Sinjai Regency, has a favorable and significant impact on pepper production in Era Baru Village.

The variable of capital is in line with research conducted by Pambudi and Bendesa (2020), where the results of the study conclude that capital has a significant positive effect on the production of salt farmers in the Buleleng Regency. Then the fertilizer variable is supported by research conducted by Lawalata et al. (2015), which concludes that fertilizer has a favorable and significant impact on lowland rice farming production. It is also supported by a study conducted by Ambarita and Kartika (2015), which concludes that the fertilizer variable has a significant positive effect simultaneously and partially on coffee farming in the subdistrict of Pekutatan, Jembrana Regency. This is also in line with a study conducted by Miftachuddin (2014), which states that the fertilizer production factor has a significant positive effect on rice farming production in the subdistrict of Undaan, Kudus Regency.

The education variable, on the other hand, does not affect patchouli production because patchouli farming in Aceh Jaya Regency is a small-holder plantation business that does not pay attention to the level of education of farmers. Patchouli farming in the Aceh Jaya Regency still uses traditional agriculture without paying attention to education. Education did not significantly affect production, because each of the reports was written by policy experts within or around the federal government’s education policy apparatus, and they reflected a shift away from concerns about equity and toward ideals such as ‘excellence’ (Griffen, 2022). The results of the study show similar results to Attaqi (2021) that education does not drive productivity. According to Benos and Karagiannis (2016), there is no relationship between education and production due to low worker education. As a result, understanding the use of resources is done inefficiently. This is supported by field conditions which show that the patchouli farmers have very little expertise. In addition, most of the patchouli farmers obtained high school and junior school educations.

The traditional patchouli planting on farms is the main cause of the low level of patchouli farmers' productivity in the Aceh Jaya Regency, Aceh Province. As a result, the government needs to move quickly to create plans to implement targeted and precise budgeting programs to adopt cutting-edge technology in the patchouli agro-industry and fully support the development of the patchouli industry. The most effective way to increase farming productivity and efficiency is through technological intervention (Ernawati et al., 2021).

4.1.1 Price Efficiency Analysis Result

Based on Table 4, it is found that the absence of a price efficiency variable can be influenced by several production factors, namely, the price of the crop produced for one patchouli harvest is not proportional to the amount of product received, and the use of labor is not proportional to the product so that wages obtained is deemed not optimal. If farming is not allocatively efficient, then it can be influenced by several production factors, namely, the price of plants produced for one harvest period is not proportional to the amount of production, and the use of labor is not proportional to the production so that the wages obtained are deemed not optimal. According to Oglend et al. (2022), the price momentum observed for ported salmon suggests a bilateral market with price inefficiencies and consistency with optimal price revisions under expensive information. Finally, the moments point to asymmetric price revisions. The asymmetry is such that price revisions are more likely to occur when the relationship price is low relative to the reference price. Price could be more efficient because the transaction terms are private. The price index represents the transaction price of salmon.

Table 4. Price Efficiency

Variable	MPP	MVP	EH	Allocation
Land Area	28.50	17099996.70	1.55	Not efficient
Labor	0.20	122667.17	0.08	Not efficient
Capital	0.00	5.21	0.00	Not efficient
Fertilizer	0.06	33160.35	16.58	Not efficient

Source: Data processing result, 2022

4.1.2 Technical Efficiency Analysis Result

Based on Table 5, the ET values obtained for all variables <1 (less than one). This means that patchouli farming is technically not efficient, because technical efficiency is the correlation between the input used and the resulting output, the maximum value is 1. The failure to achieve technical efficiency is caused by several production factors, such as the use of traditional technology, which increases the refining time and cost. According to Khan et al. (2022), technical inefficiency is caused by education level, age, and the farmer's ability to seek, interpret, and utilize available information and input.

Table 5. Technical Efficiency

Variable	ET	Allocation
Land Area	0.49	Not efficient
Labor	0.09	Not efficient
Capital	0.00	Not efficient
Fertilizer	0.10	Not efficient

Source: Data processing result, 2022.

4.1.3 Economic Efficiency Analysis Result

Considering the findings of the analysis of economic efficiency, which combines price efficiency and technical efficiency, it was found that the fertilizer production factor (P) is not efficient. (TK), and Capital (M) are not economically efficient, meaning that the use of inputs is not optimal so the maximum profit has not been achieved. If economic efficiency can be achieved, the greater the opportunity for farmers to earn higher incomes even though production and production prices remain constant.

Table 6. Economic Efficiency

Variable	EE	Allocation
Land Area	0.75	Not efficient
Labor	0.01	Not efficient
Capital	0.00	Not efficient
Fertilizer	1.72	Not efficient

Source: Data processing result, 2022.

4. Conclusion

It is undeniable that improving the agricultural sector is important to make the economy grow. One way is to improve the quality of better products. In order to achieve the improvement, challenges in maintaining quality consistency, such as production capabilities and the efficient use of resources, have to be addressed. To contribute to the literature in this direction, this study employs the theory of Cobb Douglas's production function and production theory and use both multiple linear regression and efficiency approaches to examine the factors of land area, labor, financial capital, fertilizer, and education that influence patchouli production and determine the efficiency of patchouli.

he findings of this study show that fertilizer, labor, capital, and land area significantly increase patchouli production in the Aceh Jaya Regency, Aceh Province. In contrast, education does not affect patchouli production in the Aceh Jaya Regency. The results of the analysis of price efficiency, technical efficiency, and economic efficiency results show that patchouli production in the Aceh Jaya District, Aceh Province is inefficient. Thus, it is necessary to update technology and use labor within the family to minimize capital spent. On the other hand, our results imply that using organic fertilizers can also improve the quality of patchouli production and increase income. Moreover, Patchouli farming in the Aceh Jaya Regency requires assistance from government and non-government institutions in the form of training, counseling, coaching, and supervision to improve production quality and quantity.

Moreover, our results imply that it would be advisable for the government to promote patchouli oil production programs because this commodity has a very high selling value and high competitiveness in the international market. To increase efficiency, the government should encourage the intensification of patchouli oil farming by increasing inputs such as seeds, fertilizers, and other recommended staples (at the proper dosage and time). In addition, the government should also pay more attention to market prices and the marketing chain to make these economic activities more efficient.

Future studies can add other relevant variables to increase productivity, such as lifestyle, geography, history, and cultural factors. Thus, there are still opportunities for additional research that can be studied further on this topic as well as a more complex research context that can be our carried out for the development of the digital era and modernization. To carry out this research, one could incorporate some new theories in the study so that the results obtained are even stronger with more useful opinions. Further studies could also include provincial or inter-country sizes, and world trade in the study.

References

Agustiar, A., & Sa’adan, I. (2016). Analisis dan Efisiensi Pemasaran Minyak Nilam di Desa Kubu Kecamatan Arongan Lambalek Kabupaten Aceh Barat. *Jurnal Bisnis Tani*, 2(1), 96-104.

Ambarita, J. P., & Kartika, I. N. (2015). Pengaruh luas lahan, penggunaan pestisida, tenaga kerja, pupuk terhadap produksi kopi di Kecamatan Pekutatan Kabupaten Jembrana. *E-Jurnal Ekonomi Pembangunan Universitas Udayana*, 4(7), 44553.

Anggraini, R., Arida, A., & Hakim, L. (2019). Faktor-faktor yang mempengaruhi minat petani terhadap usahatani nilam di Kabupaten Aceh Jaya. *Jurnal Ilmiah Mahasiswa Pertanian*, 4(1), 337-347.

Attaqi, L. F. (2021). Analisis pengaruh tingkat pendidikan, upah, usia, pengalaman kerja dan jam kerja terhadap produktivitas tenagakerja pada industri manufaktur (Studi kasus bagian produksi PT. Waskita Beton Precast Plant Sidoarjo). *Journal of Development Economic and Social Studies*, *1*(1), 123–141.

Benos, N., & Karagiannis, S. (2016). Do education quality and spillovers matter? Evidence on human capital and productivity in Greece. *Economic Modelling*, 54, 563-573.

Daris, D. M., Silvia, V., & Syahnur, S. (2018). Pengaruh Luas Produksi dan Tenaga Kerja Terhadap Produksi Sawit pada Perkebunan Kelapa Sawit Besar Negara di Aceh. 1–10.

Directorate General of Estate Crops. (2020). *Tree crop estate statistics of Indonesia 2018-2020*. Jakarta, Indonesia.

Effendy, E., Romano, R., & Safrida, S. (2019). Analisis Struktur Biaya Produksi dan Kesenjangan Pendapatan Petani Akibat Fluktuasi Harga Minyak Nilam. *Jurnal Ekonomi Pertanian dan Agribisnis*, 3(2), 360-374.

Ernawati, E., Masbar, R., Majid, M. S. A., & Jamal, A. (2021). Production and marketing efficiency of patchouli oil industry in Indonesia. *Regional Science Inquiry*, 13(2), 135-148.

Griffen, Z. (2022). The ‘production’ of education: the turn from equity to efficiency in US federal education policy. *Journal of Education Policy*, 37(1), 69-87.

Heriyanto, H., & Darus, D. (2019). Analisis efisiensi faktor produksi karet di Kabupaten Kampar Provinsi Riau. *Dinamika pertanian*, 33(2), 121-128.

Khan, S., Shah, S. A., Ali, S., Ali, A., Almas, L. K., & Shaheen, S. (2022). Technical efficiency and economic analysis of rice crop in khyber pakhtunkhwa: a stochastic frontier approach. *Journal of Agriculture, 12*(4). 503.

Lawalata, M., Dwidjono, H. D., & Slamet, H. (2015). Relative Efficiency of Red Onion Farming in Bantul Regency With Data Envelopment Analysis (DEA) Approach. *Jurnal Ilmu Pertanian*, 18(1), 1-8.

Li, Z., Gao, C., Ye, C., Guo, L., Liu, J., Chen, X., ... & Liu, L. (2023). Systems engineering of Escherichia coli for high-level shikimate production. *Metabolic Engineering*, 75, 1-11.

Lin, B., & Zhou, Y. (2022). Does energy efficiency make sense in China? Based on the perspective of economic growth quality. *Science of the Total Environment*, 804, 149895.

Liu, J., Wang, M., Yang, L., Rahman, S., & Sriboonchitta, S. (2020). Agricultural productivity growth and its determinants in south and southeast asian countries. *Sustainability*, 12(12), 4981.

Ma, L., Long, H., Tang, L., Tu, S., Zhang, Y., & Qu, Y. (2021). Analysis of the spatial variations of determinants of agricultural production efficiency in China. *Computers and Electronics in Agriculture*, 180, 105890.

Miftachuddin, A. (2014). Analisis efisiensi faktor-faktor produksi usaha tani padi di Kecamatan Undaan Kabupaten Kudus. *Economics Development Analysis Journal*, 3(1).

Mokgomo, M. N., Chagwiza, C., & Tshilowa, P. F. (2022). The impact of government agricultural development support on agricultural income, production and food security of beneficiary small-scale farmers in South Africa. *Agriculture*, 12(11), 1760.

Muin, M. (2017). Pengaruh faktor produksi terhadap hasil produksi merica di desa era baru kecamatan tellulimpoe kabupaten sinjai. *Jurnal Economix*, 5(1), 203-214.

Mustika, I., & Nuryani, Y. (2006). Strategi pengendalian nematoda parasit pada tanaman nilam. *Jurnal Litbang Pertanian*, 25(1), 7-15.

Nicholson, W., & Snyder, C. M. (2012). *Microeconomic theory: Basic principles and extensions*. Cengage Learning.

Nurjati, E., Fahmi, I., & Jahroh, S. (2018). Analyzing the efficiency of shallot production in Pati regency using the Cobb-Douglas stochastic frontier production function. *Jurnal Agro Ekonomi*, 36(1), 55-69.

Oglend, A., Asche, F., & Straume, H. M. (2022). Estimating pricing rigidities in bilateral transactions markets. *American Journal of Agricultural Economics*, 104(1), 209-227.

Pambudi, N. P. S. A., & Bendesa, I. K. (2020). Pengaruh Lahan, Modal, Tenaga Kerja, Pengalaman Terhadap Produksi dan Pendapatan Petani Garam di Kabupaten Buleleng. *E-Jurnal Ep Unud*, 9(4), 873-906.

Pindyck, R., & Rubinfeld, D. (2013). Microeconomics (The Pearson Series in Economics).

Pougkakioti, I. D., & Tsamadias, C. (2020). Measuring the efficiency and Productivity Change of Municipalities: empirical evidence from Greek Municipalities over the time period 2013-2016. *Regional Science Inquiry*, 12(1), 55-74.

Rahim, A., Supardi, S., & Hastuti, D. R. D. (2012). *Model Analisis Ekonomika Pertanian*.

Ridha, A., Masbar, R., & Silvia, V. (2022). Asymmetric price transmission in the cocoa supply chain in Indonesia. *Economia agro-alimentare/Food Economy*, 24(1).

Silvia, V. (2016). *Optimisasi usahatani komoditas kelapa sawit rakyat di kabupaten nagan raya dan aceh tamiang provinsi Aceh*. In electronic theses and dissertations Syiah Kuala University.

Silvia, V. (2018). Profit of smallholder palm oil in Nagan Raya and Aceh Tamiang Aceh province. *IOSR Journal of Agriculture and Veterinary Science*, *11*(11), 44–52.

Silvia, V., & Fitra, M. R. (2023). Demand for Indonesian Patchouli Oil Exports: the Panel Autoregressive Distributed Lag (Ardl) Approach. *Revista de Gestão Social e Ambiental*, 17(2), e03090-e03090.

Silvia, V., Muhammad, S., Masbar, R., & Nasir, M. (2016). Optimization of smallholder palm oil in Nagan Raya and Aceh Tamiang Aceh province. *International Journal of Contemporary Applied Sciences*, 3(4), 1-17.

Soekartawi. (2010). *Agribisnis teori dan aplikasinya*. Jakarta: PT. Rajawali Persada.

Sutardi, K. H., Widyayanti, S., Arianti, F. D., Pertiwi, M. D., & Wihardjaka, A. (2022). Nutrient Management of Shallot Farming in Sandy Loam Soil in Tegalrejo, Gunungkidul, Indonesia. *Sustainability*, 14(19), 11862.

Varian, H. R. (2014). *Intermediate Microeconomics with calculus: a modern approach*. Eighth Edition. WW. Norton & Company. New York.

Wahid, S. (2022). Feasibility Analysis of Patchouli Business in Lere Village Basala District Konawe Selatan Regency. *Agripreneur: Jurnal Pertanian Agribisnis*, 11(1), 25-33.

Widodo, Y. (1989). Prospek dan strategi pengembangan ubi jalar sebagai sumber devisa. *Jurnal Penelitian dan Pengembangan Pertanian*, 8(4), 83-88.

Yao, H., Gu, X., & Yu, Q. (2023). Impact of Graduate Student Expansion and Innovative Human Capital on Green Total Factor Productivity. *Sustainability*, 15(2), 1721.

Yoko, B., Syaukat, Y., & Fariyanti, A. (2014). Analisis efisiensi usahatani padi di Kabupaten Lampung Tengah. *Journal of Indonesian Agribusiness*, 2(2), 127-140.