Factors affecting the production of arabica coffee of smallholder plantations in Dairi District

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Abstract. The productivity of arabica coffee of community in Dairi District is still relatively low compared to other districts where in 2014 it was recorded at 12.13 qtl/ha/year, which was lower than the productivity of arabica coffee at Simalungun, Toba Samosir, and Madina Districts which were respectively of 15.46, 14.24, and 13.90 qtl/ha/year. This study aims to analyse the factors that affect the production of arabica coffee of smallholder plantations in Dairi District, North Sumatra Province. This study used primary data from interviews with arabica coffee farmers. Determination of sample is by Accidental Sampling method, while the sample size is determined by Slovin method where the number of respondents is 99 families. Data analysis was performed using the production function method of Cobb-Douglas. The results showed that simultaneously the number of plants, the age of plants, the number of labours, the amount of fertilizer, and the amount of pesticide have a significant effect; while partially the number of plants, the age of plants, and the amount of fertilizer have a significant positive effect, and the number of labours and the amount of pesticide have a positive but not significant effect on arabica coffee production of smallholder plantations in Dairi District.

1. Introduction

According to [1], the potential of coffee agribusiness resources has not been utilized optimally. Therefore, the level of productivity of Indonesia only reached 760 kg/ha, while Vietnam is able to reach 2000-3000 kg/ha and Brazil of 3000-4000 kg/ha. Dairi District is the third largest producing region of arabica coffee in North Sumatera Province. The potential area of 2014 is 10,465 ha with the average productivity of 12.13 qtl/ha/year.

The low productivity of arabica coffee in Dairi District is caused by various factors mainly due to the suboptimal use of production factors which include: the number of plants population per unit of planting area is not optimal, the presence of old coffee plants that are less productive, the dosage and amount of fertilizer used are not in accordance with the recommendation, the use of labours that has not been efficient and effective, and the use of pesticides that are not in accordance with recommended doses.

The problem to be analysed in this research is how the effect of the production factors (i.e., the number of plants, the age of the plant, the number of labours, the amount of fertilizer, and the amount of pesticide) used in the process of producing arabica coffee. The purpose of this study is to analyse the extent of the effects of production factors (the number of plants, the age of plants, the number of labours, the amount of fertilizer, and the amount of pesticide) on arabica coffee production of smallholder plantations in Dairi District.

The Cobb-Douglas production function is a function or equation involving two or more variables, in which one variable is called a dependent variable (Y), and the other is called an independent variable.
(X). The solution of the relationship between X and Y is usually by regression, where variations of Y will be influenced by variations of X. Thus, the rules on the regression line also apply in the solution of Cobb-Douglas function. The production function of Cobb-Douglas can be written as follows:

\[ Y = aX_1^{b_1}X_2^{b_2}...X_n^{b_n}e^u \]  

(1)

Where \( Y \) = Variable that are explained; \( X_n \) = Variable that explain; \( a, b_n \) = Quantities to be expected; and \( e \) = Errors (disturbance term).

Production factors in agricultural production systems generally consist of climate, land, labour, capital, and technology. The climatic factors in the perspective of agricultural production fall into external factors while capital, labour, seed, and technology are included in internal factors.

The result of previous research by [2] is to analyse the factors that affect the production of coffee in smallholder plantations in Temanggung District. The estimation results indicate that the factors that significantly influence the production of coffee in smallholder plantations are the area of land, the number of plants, and the use of fertilizers.

2. Methods

2.1. Types and sources of data

The data needed in this research is primary data and secondary data. The primary data was obtained by conducting direct interviews with farmers as respondents using structured questionnaires. The secondary data were obtained from various information and sources related to the research, among others, from the Agriculture Office of Dairi District, the Central Bureau of Statistics, the Regional Development Planning Board of Dairi District, and the Plantation Service of North Sumatra Province.

2.2. Sampling method

The population in this study was all farmers of arabica coffee in Dairi District consisting of 6871 families. Given the large population, the sampling method used is Accidental Sampling.

According to [3], the Accidental Sampling method is to determine a sample based on people encountered by chance or anyone regarded by the researcher as a suitable data source. The sample size determination is done using Slovin method, which according to [4] is as follows:

\[ n = \frac{N}{1+N\alpha^2} \]  

(2)

Where \( n \) = Sample size/number of respondents; \( N \) = Population size; \( \alpha \) = Percentage of clearance of accuracy for intolerable sampling error; \( \alpha = 10\% \) or 0.1.

Based on the above calculation, the sample of the respondents in this study was adjusted to be as many as 99 people.

2.3. Data analysis method

To determine which factors, have an effect on the level of coffee production, the Cobb-Douglas production function model is used by the Ordinary Least Square (OLS) method, the formula of which is:

\[ Y = AX_1^{\beta_1}X_2^{\beta_2}X_3^{\beta_3}X_4^{\beta_4}X_5^{\beta_5} \]  

(3)
Where \( Y \) = Coffee production (kg); \( X_1 \) = Number of plants (Tree); \( X_2 \) = Number of labours (person); \( X_3 \) = Amount of fertilizer (kg); \( X_4 \) = Amount of pesticide (kg); \( X_5 \) = Age of plants (year), \( A \) = Constant, \( \beta_1 \), \( \beta_2 \), \( \beta_3 \), \( \beta_4 \), \( \beta_5 \) = Regression coefficients; \( \mu \) = Compounding error.

3. Results

3.1. Classical assumption tests

To ascertain whether this estimation model is appropriate, it is necessary first to test the classical assumptions. The classical assumptions in this study include normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test.

3.1.1. Normality test. The data spread around the diagonal line and follows the direction of the diagonal line, so it shows the normal distribution pattern, so it can be concluded that the assumption of normality has been fulfilled.

3.1.2. Multicollinearity test. The test aims to test whether in the model there is a correlation between the independent variables found. Based on the Variance Inflation Factor (VIF) and tolerance rules, if VIF is greater than 10 or tolerance is less than 0.10, then it is stated that there is a multicollinearity symptom. Conversely, if the VIF value is less than 10 or tolerance greater than 0.10, then it is stated that no symptoms of multicollinearity.

| No. | Variable                  | Tolerance Value | Value of VIF |
|-----|---------------------------|-----------------|--------------|
| 1   | \( \log X_1 \) (Number of Plants) | 0.151           | 6.612        |
| 2   | \( \log X_2 \) (Age of Plants)    | 0.390           | 2.564        |
| 3   | \( \log X_3 \) (Labours)        | 0.926           | 1.080        |
| 4   | \( \log X_4 \) (Amount of Fertilizer) | 0.181       | 5.511        |
| 5   | \( \log X_5 \) (Amount of Pesticide) | 0.840       | 1.191        |

Source: Processed Primary Data, 2017 (SPSS Output)

Based on Table 1 above, then the value of VIF can be known for each variable that is: the number of plants equal to 6.612 < 10 and tolerance value of 0.151 > 0.10, plant age equal to 2.564 < 10 and tolerance value of 0.390 > 0.10 , labours equal to 1.080 <10 and tolerance value of 0.926 > 0.10, the amount of fertilizer equal to 5.511 < 10 and the tolerance value of 0.181> 0.10, the amount of the pesticide equal to 1.191 < 10 and the tolerance value of 0.80 > 0.10. Thus, it is stated that there are no symptoms of multicollinearity.

3.1.3. Heteroscedasticity test. The data (dots) spread freely and does not form a certain pattern so it can be concluded that there is no problem of heteroscedasticity.

3.2. Analysis of factors affecting the production of arabica coffee

From the results of data processing, the values of \( R^2 \), F-test, and t-test are obtained as can be seen in Table 3:

From Table 3, it can be seen that the value of the coefficient of determination (\( R^2 \)) is 0.956 which means that the variables used in this study (the number of trees, the age of the plant, the amount of fertilizer, the amount of pesticide, and the number of labours) gave an explanation of arabica coffee production of smallholders plantation of 95.6% while the other 4.4% is explained by other variables not included in the estimation model.
Table 2. The value of the coefficients of determination in the F-test and the t-test

| No. | Variable | Coefficient | t-counted | t-table | Sig. |
|-----|----------|-------------|-----------|---------|------|
| 1   | Constants | -0.300      | -2.153    | 1.989   | 0.035|
| 2   | Number of Plants ($X_1$) | 0.774       | 9.687     | 1.989   | 0.000|
| 3   | Age of Plants ($X_2$) | 0.196       | 4.574     | 1.989   | 0.000|
| 4   | Labours ($X_3$) | 0.026       | 0.651     | 1.989   | 0.517|
| 5   | Amount of Fertilizer ($X_4$) | 0.187       | 4.014     | 1.989   | 0.000|
| 6   | Amount of Pesticide ($X_5$) | 0.017       | 0.792     | 1.989   | 0.431|

The results of t-test Analysis

It can also be seen from the same table that the variables of the number of plants ($X_1$), the age of plants ($X_2$), and the amount of fertilizer ($X_4$) have the value of t-counted greater than t-table hence H0 is accepted and H0 is rejected. It means that partially the variables of the number of plants, the age of plants, and the amount of fertilizer have a significant effect on the production of arabica coffee of smallholder plantations in Dairi District.

4. Discussion

4.1. The interpretation of the effect of the number of plants ($X_1$) on the production of arabica coffee ($Y$)

From the above equation can be seen that the value of the coefficient of the variable of the number of plants is equal to 0.774 with the positive and significant direction of influence. It states that if the variable of the number of plants increases by 1%, it will cause an increase in the production of arabica coffee plant by 0.774% assuming other variables are considered fixed (Cateris Paribus). The results of this study indicate that the more the number of plants per unit area of land, the production will increase.

4.2. The interpretation of the effect of the age of plants ($X_2$) on the production of arabica coffee ($Y$)

From the above equation can be seen that the value of the coefficient of the variable of the age of plants is equal to 0.196 with the positive and significant direction of influence. It states that if the variable of the age of plants increases by 1%, it will cause an increase in the production of arabica coffee plant by 0.196% assuming other variables are considered fixed (Cateris Paribus). It shows that as long as the coffee plant is still in productive age, the increase of coffee plant age will lead to increased production of arabica coffee that is at the age of 6-20 years.

4.3. The interpretation of the effect of the number of labours ($X_3$) on the production of arabica coffee ($Y$)

From the above equation can be seen that the value of the coefficient of the variable of the number of labours is equal to 0.026 with the positive and not significant direction of influence. It states that if the
variable of the number of labours increases by 1%, it will cause an increase in the production of arabica coffee plant by 0.026% assuming other variables are considered fixed (Cateris Paribus). From the results of research can be seen that the labours variable does not have a significant effect on the production of arabica coffee of smallholder plantations in Dairi District. It is in accordance with research by [6] who analysed the factors affecting the production of smallholder coffee plantation in Silo District of Jember District. The estimation results show that capital has a significant effect, while labours do not have a significant effect on the production of folk coffee.

4.4. The interpretation of the effect of the amount of fertilizer ($X_4$) on the production of arabica coffee ($Y$)

From the above equation can be seen that the value of the coefficient of the variable of the amount of fertilizer is equal to 0.187 with the positive and significant direction of influence. It states that if the variable of the amount of fertilizer increases by 1%, it will cause an increase in the production of arabica coffee plant by 0.187% assuming other variables are considered fixed (Cateris Paribus). It explains that increasing the use of the amount of fertilizer to the optimum limit in a production process can increase coffee production. Fertilizer is one of the important production factors in increasing production. It is in accordance with the results of previous research conducted by [2] who analysed the factors affecting coffee production in Tulungagung District. The results of her research show that the use of fertilizers has a significant effect on coffee production.

4.5. The interpretation of the effect of the amount of pesticide ($X_5$) on the production of arabica coffee ($Y$)

From the above equation can be seen that the value of the coefficient of the variable of the amount of pesticide is equal to 0.017 with the positive and not significant direction of influence. It states that if the variable of the amount of pesticide increases by 1%, it will cause an increase in the production of arabica coffee plant by 0.017% assuming other variables are considered fixed (Cateris Paribus). The use of pesticides can reduce the productivity of land due to the death of soil microorganisms that are useful in the process of decomposition of organic matter in the soil.

5. Conclusions

Based on the results of data analysis of factors affecting coffee production in Dairi District, it can be concluded that simultaneously variables of the number of plants ($X_1$), the age of plants ($X_2$), the number of labours ($X_3$), the amount of fertilizer ($X_4$), and the amount of pesticide ($X_5$) has a significant effect on Arabica coffee production in Dairi District. Meanwhile, partially the number of plants ($X_1$), the age of plants ($X_2$), and the amount of fertilizer ($X_4$) has a significant positive effect, but the number of labours ($X_3$) and the amount of pesticide ($X_5$) has an insignificant positive effect on the production of arabica coffee in Dairi District.

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