ISBN : 978-602-14917-9-9

MODELING OF THE FACTORS THAT INFLUENCE SUGAR PRODUCTION IN ASEMBAGUS SITUBONDO SUGAR FACTORIES

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Abstract. Sugar is a major national need that usually increases every time along with population growth. Sugar cane is one of the important crop commodities in the development of the plantation sub-sector in East Java. This commodity fulfills the needs of domestic sugar and exports of the National Sugar Productivity since 2001. Its progress is the sugar industry following the agreement which was first carried out by the quality of sugarcane. The aspects that affect the quality are sugar cane (on farm) and factory (off farm) aspects related to technical and technological processes. This study aims to get a model that is following the factors that affect sugar production, besides this mathematical model is expected to be able to provide recommendations to the factory leaders Asembagus Situbondo to increase sugar production. The method used to solve this problem is Cobb Douglas approach using multiple linear regressions by submitting six independent variables. They are sugarcane production, fertilization, irrigation, rainfall, the yield of sugar cane, and land area. The dependent variable is sugar production. This study aims to get a model that is following the factors that affect sugar production, besides this mathematical model is expected to be able to provide recommendations to the factory leaders Asembagus Situbondo to increase sugar production. The result of analysis obtained an appropriate regression model $\ln Y = \ln(-4{,}704) + 0{,}999 \ln(X_1) + 0{,}001 \ln(X_2) + 0{,}006 \ln(X_3) + 0{,}000 \ln(X_4) + 0{,}014 \ln(X_5) + 0{,}995 \ln(X_6)$.

1. Introduction

National sugar demand is expected to continue to increase along with population growth. To achieve the level of production that can meet these needs, the government has designed a national sugar self-sufficiency policy. Sugar self-sufficiency is intended to produce sugar-based sugar in the country has reached 90% of national needs [1]. Sugar cane is one of the important commodity crops in the development of the plantation subsector in East Java, among others, to meet the needs of domestic sugar and exports of the National Sugar Productivity since 2001 [2]. The need for sugar cane as a raw material for producing sugar will continue to increase along with the increase in the amount that consumes an average of 17 kg of sugar per capita per year so that the need for sugar per year is 4,039.2 million tons for refined sugar. This sugar need is still being met from imports because national production has only reached 2,318 tons [3]. Sugar agro-industry is held hostage by the selling price of the product which is lower than the production cost so it is powerless to face the latest developments [4]. The progress of the sugar industry in general is determined first by the quality of sugar cane. Therefore, each sugar factory is very interested in maintaining the best sugarcane as possible, so that it can produce the highest amount of crystals per hectare [5]. The aspects that affect the quality are sugarcane (on farm) and factory (off farm) aspects related to technical and technological processes [6]. In the aspect of on farm, increasing production per hectare and increasing the value of yield can be done through structuring varieties, providing healthy and pure seedlings, optimizing planting time, regulating water requirements, balanced fertilization, controlling pest organisms, determining early milling, determining the right sugar cane plantations felled by using maturity analysis, clean cutting of sugar cane and rapid transport of sugar cane [7].

ISBN : 978-602-14917-9-9

Asembagus Sugar Factory is a sugar factory in Situbondo Regency, which is included in the business unit of PT. Perkebunan Nusantara XI. Sugar production at the Asembagus Sugar Factory fluctuates every year due to unstable environmental factors and technical standards in sugarcane cultivation itself. In line with the Research Parent Design Study Program of the State Polytechnic Plantation Plant in Jember 2018-2019, namely the improvement of the technical standard of cultivation of estate crops. So this study aims to get a model that is following the factors that affect sugar production, besides this mathematical model is expected to be able to provide recommendations to the factory leaders Asembagus Situbondo to increase sugar production.

2. Method

The research was conducted at the Asembagus sugar factory in Situbondo. The research method in analyzing the factors that influence sugar production using Cobb Douglass approach by multiple linear regression.

2.1 Data Source

The data used in this research is secondary data from the results of records carried out by the factory, with the addition of some primary data results for supporters using direct interviews with employees and on-site observation. Data used from 2008 to 2018.

2.2 Operational Definition and Research Variables

The research variables used here are independent variables (X) and dependent variables (Y). The dependent variable (Y) is the production of sugar from the milled result annually in the Asembagus sugar factory in tons. Then for the independent variables using six independent variables namely :

- Sugar cane production (X1) is the amount of sugar cane produced annually in the land of an Asembagus sugar factory either planted by itself or from a sugar cane farmer who has partnered with an Asembagus sugar factory in tons.
- Fertilization (X2) is the total fertilizer used each year in quintals. This fertilizer contains nutrients nitrogen phosphate potassium (NPK) needed by sugarcane.
- Irrigation (X3) is the frequency of irrigation from the beginning of planting to the cutting period. Irrigation is done by inundating beds with water sourced from irrigation around the land.
- Rainfall (X4) is the average annual rainwater discharge at a sugar cane planting location. Rainfall measurements are carried out with an ombrometer done at the station owned by the Asembagus sugar factory.
- The yield of sugar cane (X5) is the content of sugar contained in sugarcane stems and expressed in percent (%).
- Land area (X6) is the total land rented by the Asembagus sugar factory to grow sugar cane.

2.3 Construct Model

Cobb Douglas production function is an equation to involve dependent variable and two or more independent variable [8]

$$Y = \beta_0 X_i^{\beta_i} \tag{1}$$

The relationship between independent variables with the dependent variable is said to be linear if it transformed in the form of natural logarithms (ln). It can be stated in the regression model [9]:

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots + \beta_p \ln X_p \tag{2}$$

In the matrix notes, multiple linear regression models can be written in:

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$$\ln\begin{bmatrix} Y_1 \\ Y_2 \\ \ldots \\ Y_n \end{bmatrix} = \ln\begin{bmatrix} 1 & X_{11} & \ldots & X_{p1} \\ 1 & X_{21} & \ldots & X_{2p} \\ \ldots & \ldots & & \ldots \\ 1 & X_{n1} & & X_{np} \end{bmatrix}\begin{bmatrix} \beta_0 \\ \beta_1 \\ \ldots \\ \beta_p \end{bmatrix} \quad (3)$$

The measurement error to determine the feasibility of the model is by Mean Absolute Percent Error (MAPE) . The equation to compute MAPE is:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{Y_i - \hat{Y}_i}{Y_i} x100 \quad (4)$$

3. Result and discussion

The estimation results of the regression model must meet the regression assumptions that the regression residuals must be normally distributed, heteroscedasticity does not occur, there is no autocorrelation, and there is no multicollinearity between independent variables. The selection of the best model must meet these assumptions. Following Gauss Markov's theory that parameter estimation with Ordinary Least Square (OLS) in multiple regression must meet the Best Linear Unlimited Estimator (BLUE) [10] then the regression model must meet the four assumptions as follows.

3.1 Normality Test

The normality test is carried out to determine the residuals obtained from the difference y of the estimated y with the original data following the normal distribution. The data normality test uses the Kolmogorov Smirnov test with the following hypothesis test:

H_0: Data is normally distributed
H_1: Data not normally distributed
Level of significance: 5 % (0,05)
Normality test shows the following results :

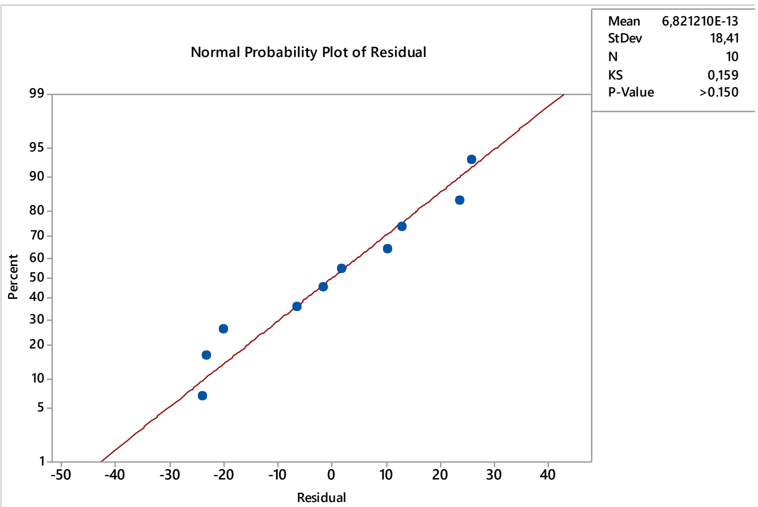

Figure 1. Normality test of residual

The normality test results can be seen from the magnitude of the p-value more than 0.05 and visually seen at fig. 1 that the residual points follow the normality line. This shows that the residuals fulfill the normal distribution assumption.

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3.2 Heteroskedasticity Test

The heteroscedasticity test aims to determine whether the residuals are homogeneous invariance (homoscedasticity). The best regression model must fulfill homoscedasticity or homogeneous residual requirements. Heteroscedasticity testing uses the Glejser test, that is a regression result of absolute residuals with the independent variables.

Table 1. Glejser Test

Source	DF	Adj SS	Adj MS	F-Value	P-value
Regression	6	0,000001	0,00000	0,58	0,742
Residual	3	0,000001	0,00000		
Total	9	0,000002			

Based on the glejser test results showed that the p-value is greater than 0.05. This shows that the homogeneous residual or heteroscedasticity does not occur. Apart from the glejser test visually it can be seen from the residual plot versus the estimated y variable as follows.

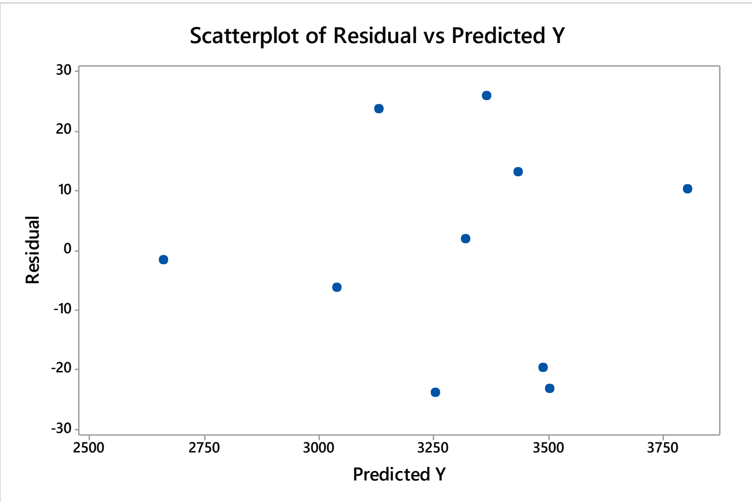

Figure 2. Scatterplot residual versus y predicted.

Figure 2 shows that the scatterplots that are formed spread randomly and do not form a particular pattern, so the residuals are assumed to be identical or homogeneous in the variants.

3.3 Autocorrelation Test

The third assumption that must be met is that there is no autocorrelation between residuals, or there is no relationship or influence from the first data residual to the next data residue. Detecting the presence of autocorrelation is one of them with the Durbin Watson test.

Hypothesis :

$H_0: \rho = 0$ (there is no autocorrelation)

$H_1: \rho \neq 0$ (there is autocorrelation)

Critical area: failed to reject (accept) H_0, if $dU < DW < (4 - dU)$

Durbin Watson Statistics :

$$DW = \frac{\sum_{t-2}^{n}(e_t - e_{t-1})}{\sum_{t=1}^{n} e_t^2} \quad (5)$$

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Table 2. Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1.000[a]	1.000	1.000	.00155	1.088

Where Durbin-Watson Statistics = 1.088, while from the Durbin Watson table with the number of variables 7 (p = 7), and the number of observations 10 (n = 10), we obtain dU = 3, 0045; 4-dU = 0,995 and dL= 0.2025. Because the Durbin Watson statistical value is between dU and dL, it is concluded that the Durbin Watson test results are not conclusive. So checking autocorrelation uses another method. One way to detect the presence of residual or autocorrelation can be seen from plotting ACF.

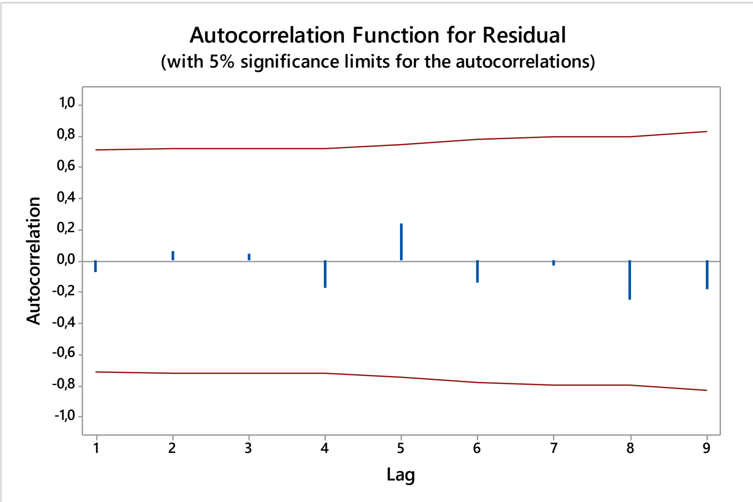

Figure 3. Plotting ACF

Based on the results of the ACF image shows that no lag exceeds the red line, where the red line is the upper and lower limit of the ACF. So it can be concluded that there was no autocorrelation between residues from observation t to observation t-1. Besides, that autocorrelation can be detected by a non-parametric test that is a run test, where:

Hypothesis:
H_0: residuals are not independent
H_1: residual are independent

Table 3. Run Test

	Unstandardized Residual
Cases < Test Value	5
Cases >= Test Value	5
Total Cases	10
Number of Runs	5
P-value	0,737

The run test results show that the p-value is greater than α (0,737> 0.05) so that it is concluded that H0 rejected, it means that the residual is independent, or there is no relationship between the residuals with each other. So that the assumption does not occur autocorrelation is fulfilled.

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3.4 Multicollinearity of variable

The fourth assumption that must be met is that there is no multicollinearity between independent variables. One way to detect the presence of multicollinearity is by looking at the Variance Inflation Factor (VIF), if the VIF value> 10 means multicollinearity has occurred.

Table 4. Partial test of Independent variable

Variable	*Coef.*	*SE Coef.*	*T-value*	*P-value*	*VIF*
Constant	-4.704	0,155	-30,313	0,000	
Sugarcane Production	0.999	0,010	104,892	0,000**	4,115
Fertilizer	0.001	0,003	0,439	0,690	4,549
Irrigation	0.006	0,012	0,513	0,643	7,166
Rainfall	0,000	0,003	0,152	0,889	1,679
Yield of sugarcane	0,014	0,018	0,803	0,480	1,652
Land area	0,995	0,011	92,876	0,000**	7,253

Based on the partial test results it is known that the VIF value on all independent variables < 10, so it can be concluded that there is no multicollinearity between the independent variables in the regression model.

3.5 T-test for regression

T-test is used to see the effect of each variable separately or partially. It can be seen in Table 4 that partially significant variables are sugarcane production and sugarcane yield. This is indicated by the value of the P-value less than 0.05, other than that when compared with the value of T- statistic on student-t distribution table (3.18) the T-value on table 3 is greater than T-statistic so that the conclusions of the two variables are partially significantly influential on production sugar.

3.6 F-test for the regression model

The F test is used to determine the effect of the independent variables simultaneously on sugar production or it can be said to be a simultaneous test. This is one determinant of the merit of the regression model.

Hypothesis

$H_0 : \beta = 0$

$H_1 : \beta \neq 0$

Critical Value : $\alpha = 0{,}05$

Table 5. ANOVA

Model	*df*	*Adj SS*	*Adj MS*	*F-value*	*P-value*
Regression	6	0,085	0,014	5868.116	0,000
Residual	3	0,000	0,000		
Total	9	0,085			

Table 4 shows that the simultaneous test results of P-value are less than 0.05, or the F-value is greater than F table on f-distribution (8.94) so that it is decided against starting H0, this means that all independent variables simultaneously influence sugar production.

After fulfilling the four residual assumptions that are normally distributed, heteroscedasticity does not occur, autocorrelation does not occur, and multicollinearity does not occur in the goodness of the regression model can be seen from the magnitude of the coefficient of determination or R^2. Based on table 2 the value of R^2 is 100%, which means that the contribution of sugarcane production, fertilization, irrigation, rainfall, yield, and land area to the fluctuation of sugar production is 100%.

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3.7 Regression model

Cobb Douglas models that are formed are as follows :

$$lnY = \ln(-4{,}4704) + 0{,}999ln(X_1) + 0{,}001\ln(X_2) + 0{,}006\ln(X_3) + 0{,}000ln(X_{4)} + 0{,}014ln(X_5) + 0{,}995ln(X_6)$$

from the Cobb Douglas transformation function, the original function form is changed to be as follows:

$$Y = -1{,}545 X_1^{0,999} X_2^{0,001} X_3^{0,006} X_4^{0,000} X_5^{0,014} X_6^{0,995}$$

Based on the analyst above the elasticity of the each variable can be seen from the magnitude of the regression coefficient on each independent variable. The regression model shows that the regression coefficient on the sugarcane production variable (X1) is 0.999, which means it has a positive effect on sugar production. The elasticity sugarcane production (X1) increases by 1%, the increase in sugar production is 0.999% cateris paribus. Then the regression coefficient on the fertilization variable (X2) of 0.001, which means a elasticity of fertilization is 0,001. This can be assumed if fertilization (X2) increases 1%, the increase in sugar production by 0,001% cateris paribus. While the regression coefficient on the irrigation variable (X3) of 0,006, which means elasticity of irrigation value (X3) is increased by 1%, there will be a increase in sugar production by 0,006% . For the regression coefficient on the rainfall variable (X4) of 0,000 which means no elasticity . The regression coefficient of the yield variable has a positive effect on sugar production, this can be seen that elasticity the yield rises by one percent, the sugar production rises by 0,0014% cateris paribus. Then the variable regression coefficient of land area harms sugar production, it can be seen that when the area of land increases by 1 %, sugar production increases by 0,995% cateris paribus. Return to scale of sugar production is greater than 1 (0,999 + 0,001 + 0,006 + 0,000 + 0,014 + 0,995 = **2,015**), its mean that the proportion of the addition of production factors will produce additional production of a greater proportion (increasing return to scale).

The measurement of error from this model seen by value of mean absolute percentage error (MAPE). The value of MAPE is 0,0064, that is shown a measure of prediction accuracy of model less than 10. So, it can be concluded the model is feasible to be used to determine production.

4. Conclusion

The regression model that are formed is $Y = -1{,}545 X_1^{0,999} X_2^{0,001} X_3^{0,006} X_4^{0,000} X_5^{0,014} X_6^{0,995}$

Partially the influential variables are the yield and production of sugarcane, while simultaneously the variables of sugarcane production, fertilization, irrigation, rainfall, a yield of sugarcane, and land area together affect the production of sugar with a determination coefficient of 100% and MAPE 0,0064. To increase the sugar production of Asembagus sugar factory, the yield and production factor of sugar cane is very important, besides that too often the intensity of irrigation can only negatively affect sugar production.

5. Acknowledgments

This research was supported by PNBP State Polytechnic of Jember 2019.

6. References

[1]. Rukmana Rahmat 2015 *Luckily Exorbitant From Sugar Cane Agribusiness* (Yogyakarta : Lily Publisher)

[2]. East Java Provincial Plantation Office 2011 *Strategic Plan* 2008-2013.

[3]. Central Bureau of Statistics 2012 *Plantation crop production* (http://bps.go.id)

[4]. [Directorate of Annual Plant Cultivation 2008 *Sugar Self-Sufficiency Acceleration*

[5]. Suwandi, A 2015 *Sugar Industry Transformation* Surabaya XI News.

[6]. Sutaryanto, T 2009 *The Importance of Sugar Cane Quality Improvement. Indonesian Sugar* Vol. 33 chapter 2 p 60 Indonesian Sugar Expert Association (IKAGI) Pasuruan

ISBN : 978-602-14917-9-9

[7]. Sugar Research Institute Of Indonesia 2008b *Overview of the Current Condition of Milled Sugar Cane Planting and Predictions of Indonesian Sugar Production in 2008* (http://www.p3gi.co.id)
[8]. Soekartawi 2003 *Production Economy Theory with Analysis Cobb Douglas Fuction* (Jakarta : Radar Jaya Offset)
[9]. Gujarati, D 2003 *Basic Econometrics Fourth Ed* (New York: Mc Graw Hill)
[10]. Greene, William H 2012 7 *Econometric Analysis* 7th ed. Prentice Hall.