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Characteristics of Farmers and Technical Efficiency in Cocoa Farming at Sigi Regency - Indonesia with Approach Stochastic Frontier Production Function

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Abstract
This research used cross section data to analyze the factors that affected the production and technical efficiency in the cocoa farming. The Sampling was done by simple random and the size of samples were 98 cocoa farmers. Analysis of the stochastic frontier production function with Cobb-Douglas models were used to answer the research objectives. The results showed fertilizer, pesticide and labor significant effect on cocoa production. Farmer characteristics such as education, farming experience, and frequency of follow counseling could help to increase the technical efficiency so that the cocoa production could be increased.
Keywords: production, technical efficiency, cocoa

1. Introduction

Needs of the world cocoa per year to reach 6.7 million tons and 2.5 million tons just be met. That means, less than 4.2 million tons to fulfill the growing needs of the market, so this could be an opportunity for Indonesia to increase production always (Anonimous 2011). While the production of cocoa beans in the country, ahead of the end of 2011 about 712,231 tons (Direktorat Jenderal Perkebunan, 2012). Indonesia is able to occupy the second position, while the Ivory Coast became the first country of the world's largest cocoa producer with production 1,200,000 tons, and Ghana rated third with 650,000 tons (Anonimous 2011).

Needs of the world cocoa increased from year to year, this is due to income and population growth also increased. Increasing needs of world cocoa invite debate about the contribution of cocoa farming in increasing farmers' income in Indonesia. Contribution of cocoa farming in increasing farmers' income in Indonesia is determined by the efficiency of production. A lot of literature write about how to improve agricultural production. Technical efficiency and allocative role in increasing the efficiency of agricultural production has been researched for example in Chen and Song (2008), Al-Feel and Al-Basheer (2012), Neumann *et al*. (2010), Tan *et al*. (2010), Feng (2008), Hidayah *et al*. (2013) and other researchers.

These researches use micro data. Estimation from micro data can give different results and therefore also different policy implications. Research with micro data are inferential statistics can provide conclusions and recommendations about the policy area. A similar study has been conducted in Indonesia, among others Khazanani and Nugroho (2011) about the efficiency of production factors chilli farm in Temanggung District - Indonesia and Tahir *et al*. (2010) on the efficiency of the production of soybean systems in South Sulawesi - Indonesia.

The problems faced by cocoa farmers in Sigi regency - Indonesia is the low level of productivity cocoa. Actually farmers are not able to reach high efficiency. The result who achieved is the influence of farmer characteristics such as age, education, farming experience, frequency of counseling followed, the frequency of the cocoa tree pruning and sanitation. In general, the production process is inefficient because of that.

One of the methods that can be used to estimate the level of technical efficiency is through stochastic frontier production function Cobb-Douglas. Analysis estimates a production function Cobb-Douglas stochastic frontier are used to analyze the factors that affect cocoa farm production function, technical efficiency of cocoa farming, and the factors which influence the technical inefficiency of cocoa farming. The objectives of this research are to analyze the factors that affect the production of cocoa farm and farmer characteristics influence in improving technical efficiency so that cocoa production can be increased.

2. Method

The research was conducted at Palolo District, Sigi Regency - Indonesia. Determining the location of this research was purposive with consideration of the district include cocoa production centers in Sigi regency - Indonesia. Sejahtera village and Bulili village used as the sample villages because both villages are the largest cocoa production center at Palolo District. The research was conducted from January to March 2013.

The population in this research are all cocoa farmers who live in the Sejahtera Village and the Bulili Village,

Palolo District. Totals of population in the sejahtera village are 106 cocoa farmers and Bulili village are 112 cocoa farmers.

As the research that used the survey method, determining of sample in this research was determined by probability sampling with simple random technique. Determination of samples number is done proportionally by using the the formula Parel *et al.*. (1973), with the following formula:

$$n = \frac{N\sum N_h s_h^2}{N^2 \frac{d^2}{z^2} + \sum N_h s_h^2} \quad (1)$$

where:

n = Number of Samples
N = Number of population
Nh = number of population in each village
d = Precision was set at = 10% (limits of error that can be tolerated 1% - 10%
z = 1.645 (90%)
sh = variance of each village

The samples from each village were determined proportionally to the population of farmers with the following formula.

$$n_h = \frac{N_h}{N} n \quad (2)$$

where:

nh = number of samples in each village

The result shows the number of samples in the Sejahtera Village are 48 cocoa farmers and Bulili Village are 50 cocoa farmers. Sampling is done randomly by lottery.

To answer the research objectives is used stochastic frontier production function. Stochastic frontier production function based on the model which is developed by Coelli *et al*. (2005). This model sets the technical inefficiency effects in a stochastic frontier production function model which is formulated as follow:

$$\ln Y_i = \lambda_0 + \sum_{j=1}^{k} \lambda_j \ln X_{ji} + (V_i - U_i) \quad (3)$$

Stochastic frontier production function in this research are assumed to have Cobb-Douglas form which is transformed into a linear form of the natural logarithm as follow:

$$\ln Yk = \lambda_0 + \lambda_1 \ln PU + \lambda_2 \ln PEST + \lambda_3 \ln TK + (V_i - U_i) \quad (4)$$

where:

Yk = cocoa production (kg);
PU = fertilizer (kg);
PEST = pesticide (lt);
TK = labor (HOK);
Vi = random error models
Ui = random variable that represents the technical inefficiency sample i

Technical efficiency of farm production is estimated by the following formula (Coelli *et al*. 2005).

$$TE_i = \frac{y_i}{y_i^*} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i) \quad (5)$$

which y is the actual production of the observations and y_i^* is the estimate production of frontier that be obtained from the stochastic frontier production function. technical efficiency for a farmer ranged between zero and one. Hypothesis which states that all farmers have made farming 100% efficient is tested with Likelihood Ratio Test (LR). LR test value is calculated using the formula:

$$LR = -2\left[\ln\left\{\frac{L(H_0)}{L(H_1)}\right\}\right] \quad (6)$$

where the LR has a mixed chi-square distribution.

Determining the factors that influence variation in technical efficiency or technical inefficiency is used a multiple linear regression model. Regressions are estimated simultaneously with the stochastic frontier production function. Multiple linear regression model technical inefficiency is expressed as follow:

$$U_i = \delta_0 + \delta_1 UR + \delta_2 PdR + \delta_3 PENGUT + \delta_4 FPYL + \delta_5 FPKS + \delta_6 SANI + \varepsilon_i \quad (7)$$

where:

Ui	=	technical inefficiency effects are estimated;
UR	=	age of respondent
PDR	=	education of respondents
PENGUT	=	farming experience
FPYL	=	frequency follow agricultural extension;
FPKS	=	frequency of pruning;
SANI	=	frequency sanitation

3. Result and Discussion

3.1 Estimation of Stochastic Frontier Production Function Cobb Douglas Model

The parameters of estimation stochastic frontier production function Cobb-Douglas models with OLS method gives an overview of the average performance of the cocoa farm production in the level of technology used. The result of Estimation with MLE method describes the best performance (production potential) of cocoa farming in the level of technology used.

Analysis of the stochastic frontier production function Cobb-Douglas models in cocoa farms shown in Table 1. Table 1 shows the The parameters estimation of the stochastic frontier production function Cobb-Douglas models with OLS and MLE method.

Table 1. Parameters of Stochastic Frontier Production Function Cobb-Douglas Model in Cocoa Farming

Variabel	Estemasi OLS		Estimasi ML	
	Koefisien	standard-error	Koefisien	standard-error
Constant	3.026	0.614	3.329	0.213
Fertilizer	0.282*	0.130	0.186**	0.061
Pesticide	0.345*	0.134	0.257**	0.041
Labor	0.314*	0.142	0.458**	0.072
Sigma-squared	0.047	-	0.019**	0.004
Gamma	-	-	0.952**	0.019
Adjusted R Square	0.794			
F statistic	125.518**			
Log likelihood function	12.628		102.629	
LR test			180.001	

Note: ** = significant at α = 1%, * = significant at α = 5%

Analysis showed generalized likelihood ratio (LR) of the stochastic frontier production function is 180.001 > χ^2 = 24.72 means the stochastic frontier production function can explain the existence of technical efficiency and technical inefficiency of farmers in the production process. The variables that significantly influence farmers' production limit (frontier) is relatively similar to the average production function (OLS).

Influence of each factor of production in cocoa production are as follows:

3.1.1 Fertilizer

Fertilizer significantly affect in cocoa production at Sigi regency - Indonesia, where t statistic = 2.175> t table = 1.985 in level α = 5%. Regression coefficient (elasticity of production) 0.282 means that for each 1% addition of fertilizer could increase cocoa production by 0.282%with the assumption that other factors are considered constant. This research was supported by: a study of LI *et al*. (2008), Khazanani and Nugroho (2011) and Tahir *et al*. (2010). This is due to the addition of each fertilizer in agricultural land will increase the nutrients in the soil that is needed by the plant cocoa.

3.1.2 Pesticide

Pesticide significantly affect in cocoa production at Sigi regency - Indonesia, where t statistik = 2.578 > t table = 1.985 in level α = 5%. Regression coefficient (elasticity of production) 0.345 means that for every additional 1% pesticide could increase cocoa production by 0.345% with the assumption that other factors are considered constant. This is due to each addition of pesticide in cocoa crops are attacked by diseases of pests will reduce the damage of cocoa pods, so that production can be maintained. Pesticide is used to control pests and diseases of cocoa plants that can cause crop failure.

This research was supported by research of Sahara and Idris (2005) which shows that pesticide has the real and

positive effect on rice production in Indonesia. But this research contrary with research of Khazanani and Nugroho (2011) which states pesticide have no real effect on the production of chilli in Temanggung Regency - Indonesia. This was because the habit of farmers spraying pesticide routinely and ignore the extent to which the plant has been exposed to the disease.

3.1.3 Labor

Labor significantly affect in cocoa production at Sigi Regency - Indonesia, where t statistic = 2.221> t table = 1.985 in level α = 5%. Regression coefficient (elasticity of production) 0.314 means that for each additional 1% of the workforce could increase cocoa production by 0.314%with the assumption that other factors were considered constant. This research was supported by: the research of LI, et al. (2008), Khazanani and Nugroho (2011), Suciaty (2004) and Effendy (2010). The addition of labor led to the implementation of activities in cocoa farming will be done right on target and time such as: fertilization, pest and disease control, pruning, sanitation and harvest, which will tend to increase cocoa production.

3.2 Technical efficiency Cocoa Farmers

3.2.1 Distribution of Technical Efficiency Levels

Level of technical efficiency and inefficiency cocoa farming were analyzed simultaneously by using stochastic frontier production function Cobb-Douglas models. Distribution of technical efficiency levels of cocoa farming in Sigi regency - Indonesia shown in Figure 1.

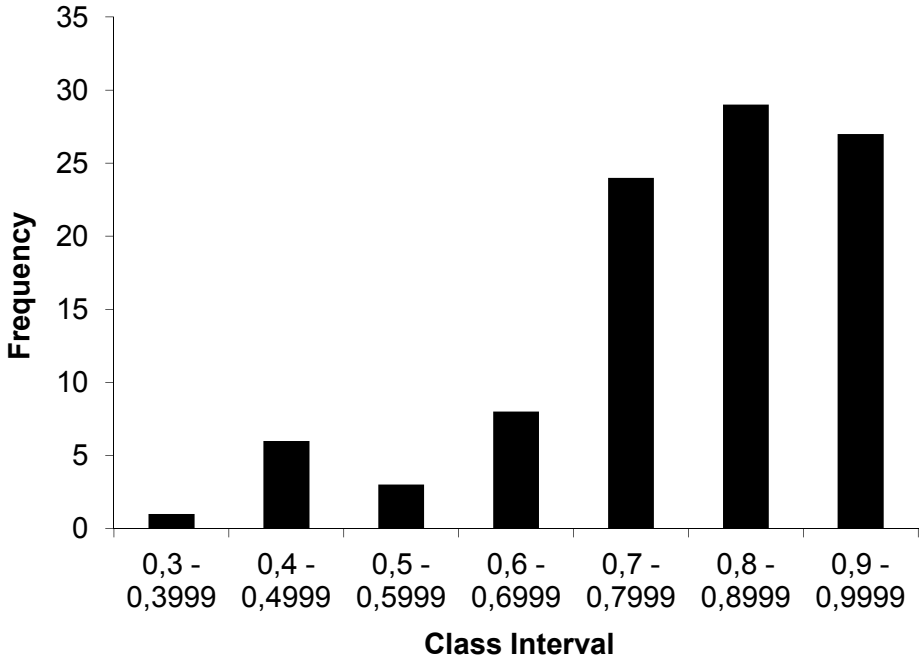

Figure 1. Technical Efficiency Levels of Cocoa Farming
at Sigi Regency – Indonesia

Figure 1 shows that the class level of technical efficiency of 0.8 to 0.8999 has the highest frequency that is equal to 30.30%. Technical efficiency levels minimum = 0.3896 and maximum = 0.9922 with an average = 0.8082. Cocoa farmers in Sigi regency - Indonesia, which has a low technical efficiency levels category need to make efforts to increase managerial farming through increased non-formal education and training such as attending counseling. This effort can be achieved by applying the skills and techniques of cultivation are obtained so that the level of efficiency can be increase.

3.2.2 Sources of Technical Inefficiency

Factors that affect technical inefficiency of cocoa farmers is shown in Table 2.

Table 2. Estimation Parameter of Maximum Likelihood Model Technical Inefficiency Cocoa Farming

Variables	Parameter	Coefficient	Standard error
Constant	δ_0	0.912	0.121
Age	δ_1	-0.001	0.002
Education	δ_2	-0.068**	0.027
Experience	δ_3	-0.031***	0.008
Counseling	δ_4	-0.015*	0.010
Trimming	δ_5	-0.001	0.008
Sanitation	δ_6	-0.051***	0.007

Note: ***= significant at α 1%, **= significant at α 5%, *= significant at α 10%

Table 2 shows:

3.2.2.1 Age of Farmers

Age of farmers correlated negative and not significant to the technical inefficiency of cocoa farming at level α = 10%.

3.2.2.2 Education

Education of farmers correlated negative and significant to the technical inefficiency of cocoa farming at level α = 5%. Negative correlation means that the higher the education of a farmer, the lower the level of technical inefficiency in other words, the higher the education of a farmer, the higher the level of technical efficiency. The higher education of a farmer, the farmer has a better ability to apply technology and more efficiently allocate resources.

This research was supported by research Mohapatra (2011), concluded the average of education of the head of household farmers in India are correlated negative and statistically significant. This shows that education has a significant contribution in increasing the efficiency advantages sugarcane farmers in India. Krasachat (2012), education and organic farming can improve the technical efficiency of durian farmers in Thailand. Furthermore Yigeju *et al*. (2013), education will increase the efficiency of irrigation water use in Syria.

3.2.2.3 Experience of Farming

Experience of farming correlated negative and significant to the technical inefficiency of cocoa farming at level α = 1%. Negative correlation means that the higher the farming experience of a farmer, the lower the level of technical inefficiency in other words, the higher the farming experience of a farmer, the higher the level of technical efficiency.

This research was supported by research Wollini and Brummer (2012), concluded that the most important factor affected the level of technical efficiency of coffee farming in Costa Rica was an experience in coffee cultivation, the availability of additional work and membership in the cooperative. Further it was said, that policy measures need to be taken was the extension services in connection with farm management skills.

3.2.2.4 Frequency follow counseling

Frequency followed counseling correlated negative and significant to the technical inefficiency of cocoa farming at level α = 10%. Negative correlation means that the higher the frequency of counseling followed by a farmer, the lower the level of technical inefficiency in other words, the higher the frequency of counseling followed by a farmer, the higher the level of technical efficiency. Counseling is a non-formal education. Non-formal education which associated with of cocoa farming could affect the the ability of cocoa farmers in decision making and the ability to apply technology in farming, so as to increase technical efficiency.

This research was supported by research of Rahman and Hasan (2008) concluded that agricultural resources could increase technical efficiency farmers in Bangladesh. Furthermore Jahan and Pemsl (2011) training had a positive impact and a significant on farmers' technical efficiency, total factor productivity and net income of small-scale farmers in Bangladesh.

Research of Rahman and Rahman (2008) stated that every 1% increase in family labor and technology adoption would increase the technical efficiency of 0.04%. Increased counseling services and the application of technology would increase the technical efficiency of farmers so as to increase the production of rice in Bangladesh.

3.2.2.5 Frequency Trimming of Cocoa Tree

Frequency trimming of cocoa tree correlated negative and not significant to the technical inefficiency of cocoa farming at level α = 10%.

3.2.2.6 Sanitation

Frequency did sanitation correlated negative and significant to the technical inefficiency of cocoa farming at level α = 1%. Negative correlation means that the higher the frequency did sanitation by a farmer, the lower the level of technical inefficiency in other words, the higher the frequency did sanitation by a farmer, the higher the level of technical efficiency. In general sanitation aims to reduce the moisture so that tends safe from pests and diseases. Sanitation promotes cleanliness and increase the health of the tree crops (Konam *dkk*. 2009).

Sanitation which was done in Sigi regency - Indonesia was to clear the land and dispose all of cocoa fruits which indicated infection. Sanitation was done by dispose all the fruits that showed symptoms of the attack / decay on the tree. The fruits collected in one place to be planted in the ground.

4. Conclusion

The results showed fertilizer, pesticide and labor had positive and significant effect on cocoa production in Sigi regency - Indonesia. The average level of technical efficiency achieved cocoa farmers were 0.8096. The characteristics of farmers such as education, experience cocoa farming, Frequency followed counseling and frequency did sanitation could increase technical efficiency of cocoa farming.

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