Agribusiness Journal
https://usnsj.id/index.php/AJ
journalagribusiness@gmail.com
e-ISSN: 2548-2211, p-ISSN: 2548-379X

DOI : https://doi.org/10.31327/aj.v8i1.2505

Analysis of Allocative and Economic Efficiency of Corn Farming

Jullyo Gideon Rohi[2]*, Frengky Lambu Apu[2]
[1]Agribussiness Study Program, Faculty of Agriculture, Universitas Nusa Cendana,
[2]Defense University, NTT Province, Indonesia
*Correspondence email:jullyo_rohi@staf.undana.ac.id

Abstract

Corn is the main commodity in dry land farming for most farmers in NTT Province and acts as a food source to maintain food security and as a source of income (cash income). Kupang Regency is one of the corn centre districts in NTT Province because it prioritises economic development in the agricultural sector in the food crop sub-sector. This study aims to measure the level of allocative efficiency of the use of corn farming production factors. This research was conducted in Kupang Timur District, Kupang Regency, East Nusa Tenggara Province in 2024. The research was conducted using a survey method with simple random sampling. The sample determined as respondents was 92 farmers based on the area of cultivated land. The method used is the calculation of marginal product analysis, used to measure allocative efficiency and economic efficiency, which is measured by the division between technical and allocative efficiency. The results of the research analysis show that the factors that have a significant effect on corn farming production are land area, seeds, urea, KCL, SP36 and Pesticides. Furthermore, from the results of the analysis of allocative and economic efficiency, the efficiency values for the overall farmer category are 0.47 and 0.35, respectively and based on the division of land area, it shows that corn farming in East Kupang District is still inefficient. Corn farming efficiency needs to be improved through the use of production factors that have a significant effect on technical efficiency, such as land area and the addition of technology. Allocative and economic efficiency of corn farming can also be improved by reducing the use of excessive inputs and expensive input prices that which can save high farming costs so that it can affect farmers' income.
Keywords: efficiency, maize farming, stochastic frontier

A. Introduction

Corn (Zea mays l) is a strategic food crop that contributes to Gross Regional Domestic Product (GRDP) (Zubachtirodin and Najmuddin 2005). Corn farming households are the second largest with 5.06 million households (7.57 per cent) after rice farming households of 14.15 million households, and the total number of food crop farming households in Indonesia is 17.83 million households, so this condition illustrates that corn farmers still have economic opportunities in running better farming businesses (Kementerian Pertanian, 2012).

Corn is a very important crop for most farmers in East Nusa Tenggara Province who farm dry land. It is a food source that helps make sure people have enough to eat (food security) and a source of money (cash income). One problem in the food crop sector, especially for corn farming across the country in the Province, is that production is still low compared to the rest of the country. This may be because farmers are not using resources and what they produce in the best way to increase their income. For example, they may not be using the right farming supplies or the best farming methods. So, to increase corn production, it is very important to use the right resources (inputs) to reach the production or output goals. Because it is becoming harder to find more farmland (extensification), since farmland is decreasing and being used for other things, such as other crops or industries, which gives a return to the land, it is important to focus on making better use of the land we have (intensification). This can be done by being more efficient and using appropriate technology that can improve farmers' management skills. Therefore, intensification is important for efficiency, production, and income.

In the farming activities carried out by farmers in Kupang Timur District, it is known that the goals to be achieved are high income levels and effective and efficient use of inputs. It is said to be effective if farmers in allocating production inputs can produce maximum output at a certain level of expenditure. It is said to be efficient if farmers can minimise the input costs that have been incurred to achieve certain predetermined production targets. Farming conditions that produce maximum profits are expected to encourage corn farmers to continue farming. The results of the study show that all variables in the significant model are land, seeds, Urea, KCL, SP36, pesticides and have signs that are by expectations. This study also found that farmers are technically efficient with an average of 75 per cent and factors that have a significant influence on increasing technical personnel, namely age, formal education and income (Rohi et.al., 2019).

Increasing the productivity of corn farming can be done by making corn farming more efficient. According to Farrel (1957), Lau and Yotopoulos (1971), in farming, the concept of efficiency can be divided into three, namely: (1) technical efficiency, (2) price efficiency (3) economic efficiency. Technical efficiency is the ability of a farm to produce maximum output from the use of farm inputs, and allocative efficiency is the ability of a farm to use inputs proportionally at the price level and production technology, respectively. The combination of technical and allocative efficiency is called economic efficiency.

The problem in the research area is low productivity, so the limitation of this research only refers to the analysis of input factors that affect the production, efficiency and income of corn farming based on the area of land cultivated by corn farmers in Kupang Timur District because this farming is an activity that is directly related to production, use of inputs, prices and income that provide benefits to farmers. Thus, the limitation of the research area is taken in one sub-district, namely Kupang Timur District, Kupang Regency.

B. Methodology

This research was conducted in Kupang Regency, East Kupang District, NTT Province, and the determination of the research area was determined purposively with the consideration that the research location is one of the centres for and development of corn production. The time of data collection in this study was carried out from August to October 2017. The determination of the sample in this study was carried out using stratification (proportionate stratified random sampling), the sample taken was 19 percent, namely 100 people from the total population who were used as the main respondents, however, after the verification process was carried out, 8 samples were eliminated due to incomplete data so that the total population of research respondents was 92 people. This research utilises an econometric approach, by establishing a mathematical model as a means of calculation and will involve steps that are able to determine the results of the study, as well as models used to explain and describe abstract aspects of the conditions that have been studied.

Stochastic Frontier Production Function Analysis

The production function used in this study is the Cobb-Douglas production function, which is used to determine the relationship between inputs and output and measure the influence of various price changes from inputs to production. Battese (1992) stated that the method of using the stochastic frontier model is carried out through 2 stages, namely the first stage with the Ordinary Least Squares (OLS) method to estimate production input parameters. β_m, The second stage uses the Maximum Likelihood Estimation (MLE) method to estimate the overall parameters of the production factors. β_m, intercept β_o and variants of both error components v_i and u_i (σ_v^2 and σ_u^2). The purpose of using the Cobb-Douglas production function is to include variable inputs and fixed inputs.

The OLS and MLE methods are used to analyse the corn production function. Regression is the dependence of one dependent variable (X) on another explanatory variable (Y) to estimate and predict the values (Mean) or average of the dependent variable population (Y) viewed in terms of known values in repeated sampling of the explanatory variable. Thus, the corn production function model used in this study to measure OLS and MLE, with the mathematical form of measuring the technical efficiency of corn farming is:

$LnY_i = ln\beta_{0i} + \beta_{1i}lnX_{1i} + \beta_{2i}lnX_{2i} + \beta_{3i}lnX_{3i} + \beta_{4i}lnX_{4i} + \beta_{5i}lnX_{5i} + \beta_{6}lnX_{6i} + \beta_{7i}lnX_{7i} + (v_i - u_i)$

Information

Y_i	=	*Corn Production*
X_1	=	*Land Area*
X_2	=	*Corn Seed*
X_3	=	*Urea Fertilizer*
X_4	=	*KCL Fertilizer*
X_5	=	*SP36 Fertilizer*
X_6	=	*Pesticide*
X_7	=	*Non-family labor*
β_0	=	*Intercep*
β_1	=	*The coefficient of the estimator parameter where I* = 1,2,3,…, N
$v_1 - u_i$	=	*Error term (v_1 is a noise effect, u_i is technically inefficient in the model)*

The hypothesis of the model above is that if $H_0: \beta_i = 0$It means there is no significant influence between the independent variables on the dependent variable, and if otherwise it $H_0: \beta_i \neq 0$Is there a significant real influence between the independent variables on the dependent variable? The expected coefficient values are : β_i , β_2, β_3,……….., β_8, > 0 A positive coefficient value means that with increasing input in the form of land, seeds, urea fertiliser, SP36 fertiliser, KCl fertiliser, pesticide and labour, it is expected to increase corn production.

Allocative and Economic Efficiency Analysis

Measuring allocative and economic efficiency is done by deriving the dual cost function from the homogeneous Cobb-Douglas production function (Debertin 1986). This efficiency is related to the success of farmers who achieve maximum profits in the short term, namely the efficiency achieved by conditioning the value of the product, assuming that the form of the Cobb-Douglas production function uses two inputs. Thus, to obtain the dual frontier cost function, the equation X_1, X_2 is X_6Substituted into the cost equation as follows:

$$C^* = P_1\left[\frac{Y}{\beta_0 P_1^{\beta 2} P_2^{-\beta 2} \beta_2^{\beta 2} P_1^{-\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5}}\right]^{\frac{1}{\beta 1+\beta 2}} + P_2\left[\frac{Y}{\beta_0 P_1^{\beta 2} P_2^{-\beta 2} \beta_2^{\beta 2} P_1^{-\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5}}\right]^{\frac{1}{\beta 1+\beta 2}}$$
$$+ P_3\left[\frac{Y}{\beta_0 P_1^{\beta 2} P_2^{-\beta 2} \beta_2^{\beta 2} P_1^{-\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5}}\right]^{\frac{1}{\beta 1+\beta 2}} + \cdots \ldots \ldots \ldots \ldots \ldots$$
$$+ P_5\left[\frac{Y}{\beta_0 P_1^{\beta 2} P_2^{-\beta 2} \beta_2^{\beta 2} P_1^{-\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5}}\right]^{\frac{1}{\beta 1+\beta 2}}$$

Where :

$CapCapC^*$	=	The minimum observed total cost of production or. Duafr ooduction costs (P_i, Y)
$P_1, P_2, \ldots \ldots, P_5$	=	Prices of seeds, fertilisers, pesticides and labour
$X_1, X_2, \ldots \ldots, X_5$	=	The amount of input of land area, seeds, fertiliser and labour
Y	=	Corn output/production
β_0	=	Exponentialized β_0 coefficients
$, \beta_2, \ldots \ldots, \beta_5$	=	Exponentialized input coefficients

The actual cost function is:

$$C_A = P_1X_1 + P_2X_2 + \cdots + P_5X_5$$

Then, Economic Efficiency (EE) can be found by substituting the equation above. Economic efficiency is defined as the ratio of the total cost of minimum production observed (C*) to the total cost of actual production or the total cost of observed production (C_A) Ogundari and Ojo (2008). So the equation can be simplified to:

$$EE = \frac{C^*}{C} = \frac{E(C_i|u_i = 0, Y_i, P_i)}{E(C_i|u_i, Y_i, P_i)} = E[exp.(U_i/\varepsilon)]$$

Information: EE worth 0 ≤ EE ≤ 1.

Economic efficiency is a combination of technical and allocative efficiency, so that allocative efficiency (AE) can be obtained by the equation:

$$AE = \frac{EE}{TE}$$

Information: EE worth 0 ≤ AE ≤ 1.

C. Findings and Discussion

Maximum Likelihood Estimation Method

The Stochastic Frontier Cobb-Douglas production function is a model used to estimate the production function of corn farming in the research location. One of the estimation methods used in estimating the production function model is Maximum Likelihood Estimation (MLE) using Frontier Program 4.1, which is conducted through two stages. The estimation results of the stochastic frontier production model serve as the basis for measuring allocative efficiency and economic efficiency by deriving the dual cost function. The results of the stochastic frontier production model conjecture on corn farming using the MLE method are presented in Table 1.

Table 1. Results of Stochastic Frontier Production Function Using MLE Approach

Variabel	Metode *Maximum Likelihood Estimation*		
	Koefisien	Standar Error	*t* Hitung
Corn Production (β_0)	4.55	0.89	5.12
Land Area (β_1)	0.35****	0.10	3.47
Corn Seed (β_2)	0.42****	0.14	2.93
Urea Fertiliser (β_3)	0.21***	0.10	2.23
L Fertiliser (β_4)	0.18**	0.10	1.87
(β_5)	0.00*	0.00	1.37
Pesticide (β_6)	0.07**	0.03	1.88
lyla(β_7)	0.03	0.04	0.80
Sigma Square	0.04	0.01	3.29
Gamma	0.68	0.35	1.97
Log Likelihood Function	21.81		
LR Test of the one-sided error	19.83		
RTS	1.27		

Note: **** significant at α 0.01, *** α 0.05, ** α 0.1, * α 0.2

The gamma value (γ) is 0.68 and has a significant effect at the 1 per cent level. This means that 68 per cent of the variation in output among farmers is caused by differences in technical efficiency, while the remaining 32 per cent is caused by stochastic effects outside the model, such as climate influence, natural disasters, and pest and disease attacks. The gamma (γ) value in this study is still lower than the gamma (γ) value in the Situmorang (2013) study on corn farmers in Dairi Regency, North Sumatra, which was 0.99; Msyua et al. (2008) in Tanzania was 0.98; Zalkuwi et al. (2010) in Adamawe State, Nigeria was 0.91. The generalised-likelihood ratio (LR) value in this study is 21.81, which is greater than the Kodde and Palm table value of 14.85, significant at α=5%. This means that there is an influence of technical efficiency and inefficiency of farmers.

The estimated parameter values parameter estimates in the stochastic frontier production function can indicate the elasticity values of the inputs used. The input variables that have a significant effect and positive coefficients on corn production in this study are land area, amount of seeds, urea fertiliser, KCl, SP36, and pesticides. The variables of external and internal labour have positive coefficients, but do not have a significant effect.

a. Land Area Factor

The variable of land area is a variable that has a positive and significant effect on corn efficiency in the study area. This finding follows the results of empirical research conducted by Gul et al. (2009), Otitoju and Arene (2010), Hussain et al. (2012), and Piya et al. (2012). Their findings also indicate that the larger the land owned by farmers, the more efficient the farming operation becomes. The land area variable in the production function used has the highest elasticity value and significantly affects corn farming production at a 99 per cent confidence interval. This is evident from the t-value of land area (3.47) being greater than the t-table at α 1 percent (2.63), which means that each increase in the land area input by 1 percent, assuming ceteris paribus (other inputs remain constant), will increase corn production by the elasticity value or the coefficient of land area, which is 0.35 percent.

b. Seed Factor

The amount of seeds has a significant effect at the 1 per cent level and has a coefficient or elasticity value of 0.42. This means that if the input amount of seeds is increased by 1 per cent, assuming ceteris paribus, it will increase corn production by 0.42 per cent. The corn seeds that are commonly used include the old superior varieties such as Lamuru, Bisi 2, and for new superior varieties, the one used is Bisma. The average seed requirement for all respondents is 26.41 kg/ha, and farmers are used to planting 2-3 seeds per hole, with a spacing of 75 x 20 cm to 100 cm, and some farmers also use the legowo planting system. Soil moisture and irrigation are also some of the factors affecting corn plant growth, and replanting activities are no longer carried out, as it can save labour costs. The results of this finding are consistent with the research of Fadwiwati et al. (2013), Situmorang (2013), Isaac (2011), Zalkuwi et al. (2010), and Paudel and Matsuoka (2009), which states that the number of seeds has a positive and significant effect on corn production.

c. Chemical Fertiliser Factors

The chemical fertiliser variables for urea, KCl, and SP36 each have different significant levels; for urea, it has a significant effect at the 5 per cent level with a coefficient of 0.21. For SP36 fertiliser, it is at the significant level of 10 per cent with a coefficient value of 0.18. For KCl fertiliser, it is at the significant level of 20 per cent with a coefficient value of 0.00. This means that if the input is increased by 0 per cent or has no impact, assuming ceteris paribus, it will increase corn production by the value of the generated coefficient. The difference in fertiliser usage is due to the differences in farming characteristics, cultivation methods, and the differences in planting times for corn farming, as well as the differences in corn input prices caused by the corn planting times. Farmers in the research area generally have been using these three types of fertilisers by a consensus reached by the group (RDKK), and from the financial aspect of farmers in making purchases, it is still controlled by the farmer group, adjusted according to the size of the land area and the commodities other than corn that are planted.

d. Pesticides Factor

The variable of agricultural chemicals has a significant effect at a 10 per cent level and has a coefficient value of 0.07, which means that every 1 per cent increase, assuming ceteris paribus, will increase production by 0.07 per cent. The chemicals used by corn farmers in the study area are a combination of herbicides such as Roundup and Decis, as well as insecticides like Kalaris and Lindomin. Herbicide use is carried out by the majority of farmers, totalling 58 people, and insecticide use by 61 people. The need for chemicals is during the land preparation and plant maintenance stages; in addition, there are still farmers who choose to burn weeds.

e. Non-Family Labour Factor

The variable of Family Labour Outside the Household has a positive value and does not have a significant impact. However, this variable indicates that this input plays a major role in maize production. The use of Non-Family labour for farming activities tends to be carried out by male labour from land preparation to post-harvest, while female labour is only utilised during planting, fertilisation, harvesting, and drying when necessary. The average use of Non-Family Labour is 33.62 HOK/ha. However, in land cultivation, it is done using a tractor (contract wage) so that farmers can effectively manage labour and costs incurred, especially for family labour outside the household.

Allocative Efficiency of Corn Farming Based on Cultivated Area

Based on Table 3, the average allocative efficiency of corn farming is 0.47, with efficiency levels ranging from 0.17 to 0.83. Farmers who generally engage in corn farming are not allocatively efficient due to the low average allocative efficiency value. If farmers in the East Kupang District wish to achieve maximum allocative efficiency, they must save costs by (1 - (0.47/0.83)) x 100 or 43 p The results of this study are in line with the results of the study by Paudel and Matsuoka (2009) which stated that the wider the corn land in the Chitwan region, Nepal, the more it reduces cost inefficiency (allocative inefficiency) significantly at $\alpha = 0.05$. In other words, the wider the corn land in the Chitwan region, Nepal, the more efficient the farmers are in allocating costs. If the farmers achieve the highest allocative efficiency, on average, narrow, medium, and wide corn farmers have the opportunity to save costs of [1-(0.36/0.70) x 100] or 49 percent; [1-(0.47/0.79) x 100] 41 percent; and [1-(0.53/0.83) x 100] 36 percent of the total farming costs. In other words, great attention must be paid, especially to sharecroppers with different land areas, so that farmers can allocate costs to purchase corn farming inputs more efficiently. Per cent.

Table 2. The results of the allocative efficiency of corn farmers based on the area of cultivation

Efficiency Level	Allocative Efficiency			Overall
	Narrow Land (<0.57)	Medium Land (>0.58-1.19)	Wide Land (>1.2)	
0.15 - 0.39	16	11	12	39
0.40 – 0.59	6	8	11	25
0.60 - 0.89	2	8	18	28
Total	24	27	41	92
Average	0.36	0.47	0.53	0.47
Maximum	0.70	0.79	0.83	0.83
Minimum	0.17	0.22	0.22	0.17

Based on land area, the average allocative efficiency of corn farmers ranges from lowest to highest, starting from farmers with narrow land, followed by farmers with medium and large lands. The allocative efficiency of farmers with medium land is equal to the average allocative efficiency of all farmers. The allocative efficiency of farmers with narrow land is 2.3 per cent or 0.11 lower than the average allocative efficiency of all sampled farmers. However, the allocative efficiency of farmers with large land is 1.88 per cent or 0.06 higher than the average allocative efficiency of all sampled farmers. In other words, the larger the land planted with corn, the more allocatively efficient the farmers are. Therefore, in this case, high production in corn farming becomes a determining factor for achieving high allocative efficiency.

The variation in allocative efficiency levels provides an overview of the conditions in the research area, indicating that it can be said to be inefficient. This means that farmers are using inputs while considering the prevailing prices; in this case, farmers feel unsatisfied with their agricultural input purchases, so their purchasing power must be adjusted to the farmers' purchasing power. The low technical efficiency (74.7 per cent with TE index > 0.7) is also reflected by the majority of farmers being technically inefficient, and the low allocation is indicated by the many farmers (all farmers) being inefficient in allocation (47 per cent with AE index < 0.7).

Economic Efficiency of Corn Farming Based on Cultivated Area

Based on Table 3, the average economic efficiency value of corn farming is 0.35, with a range of economic efficiency values from 0.13 to 0.72. This economic efficiency value indicates that corn farming in Kupang Regency is not yet efficient. If farmers want to achieve maximum economic efficiency, they must reduce costs by (1-0.35/0.72) or by 90 per cent. Cost savings through the use of production inputs can increase economic efficiency, so there needs to be control over input and output prices.

The average economic efficiency of all corn farmers, from the lowest to the highest, starts from narrow land farmers, followed by medium and high land. The economic efficiency of narrow land farmers is lower by 0.34 per cent, or 0.09, and medium land farmers have the same economic efficiency value as the total average of all corn farmers. However, the average economic efficiency of large land farmers is higher by 0.13 per cent or 0.05 than the average economic efficiency of all sample farmers. If farmers want to achieve the highest economic efficiency, the average narrow, medium, and large land corn farmers have the opportunity to save costs of [1-(0.26/0.05) x 100] or 48 percent; [1-(0.35/0.56) x 100] 38; and [1-(0.40/0.72) x 100] 35 percent of the cash costs of the farm. In other words, great attention must be paid, especially to small-scale farmers, so that farmers can combine input and cost allocation in corn farming to be more economically efficient. The results of this study differ from those found by Bravo-Ureta and Pinheiro (1997), who stated that the wider the farmer's land in the Dominican Republic, the more it reduces economic inefficiency significantly at α = 0.01. In other words, the wider the farmer's land in the Dominican Republic, the more economically efficient the farmer is.

Table 3. The results of the economic efficiency of corn farmers based on the area of cultivation

Efficiency Level	Allocative Efficiency			Overall
	Narrow Land (<0.57)	Medium Land (>0.58-1.19)	Wide Land (>1.2)	
0.10 – 0.30	15	11	14	40
0.31 – 0.50	9	12	16	37
0.51 – 0.70	-	4	10	14
0.71 – 0.80	-	-	1	1
Total	24	27	41	92
Average	0.26	0.35	0.40	0.35
Maximum	0.50	0.56	0.72	0.72
Minimum	0.13	0.14	0.16	0.13

The low level of economic efficiency of corn farming in Kupang Regency is because there are still expensive production factors such as labor costs during harvest in corn farming ranging from Rp1,500,000 to Rp2,000,000 per hectare and the selling price of wet corn which is still low, namely the average selling price of corn for farmers in rice fields is Rp4,800 per kilogram.

However, the level of economic efficiency of corn farming in Kupang Regency is still higher when compared to previous research by Fadwiwati (2013) which stated that the average economic efficiency of corn farmers in Gorontalo Province was 0.41; Situmorang (2013) which stated that the economic efficiency of corn farmers in Dairi Regency, North Sumatra was 0.38, Kurniawan (2008) which stated that the economic efficiency of corn farmers in South Kalimantan Province was 0.49 and was still higher than the average value of Nursan's research (2015), stating that the combined economic efficiency of corn farmers on dry land and rice fields in Sumbawa Regency was 0.65.

Economic inefficiency can be caused by the fact that corn farming requires a lot of labor and a lot of seeds, so that the large use and high prices result in high expenditures. In field conditions and calculations of farm income, the cost of labour and seeds is quite high. Therefore, because the allocation efficiency (AE) in the research area is lower than the technical efficiency (TE), it has an impact on low economic efficiency (EE). In this case, the low economic efficiency (EE) is more due to the problem of allocation inefficiency than technical inefficiency. This is because the input price information that non-transparent, unpredictable output price information (because it is determined in the market and occurs after harvest), or if the price is known to farmers, they cannot make input purchases by considering the price, because the use of inputs has been determined in doses and standards. The solution is the need for input and output price support, so that farmers can make savings and achieve maximum profits.

D. Conclusion

The technical efficiency of corn farming on narrow land, medium land and large land, based on the research results, can be said to be efficient, and for allocative and economic efficiency of corn farming can be said to be efficient. This is because the cost of corn farming is still high, causing it to be less efficient.

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