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Determination of Effectiveness and Efficiency of Production Factors in Sweet Potato Farming in Lamongan, Indonesia

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***Abstract*— Food crops have a strategic role in agricultural development, covering food security growth, opening up employment opportunities, and income sources in regional and national economies. This research aims to determine the relationship patterns of sweet potato farming production factors. This research utilized a quantitative approach with the survey method. The data were obtained through questionnaires, and the sampling method used a census of 348 respondent farmers in six sweet potato center villages. The Maximum Probability Estimation frontier 4.1 method was employed to calculate the technical efficiency of sweet potato farming. The results showed that the production factors significant at the trust level of 99 percent, 90 percent, and positive value for sweet potato production in Lamongan Regency, Indonesia, were land area production, Urea fertilizer, Phonska fertilizer, ZA fertilizer, and SP36 fertilizer. The technical efficiency attainment level of sweet potato farming was very high, indicating that sweet potato farming in the research was efficient, with an average technical efficiency of 0.90 percent. The achievement level of allocative efficiency on sweet potato farming was relatively low, implying that sweet potato farming was inefficient, with an average localized efficiency of 0.50 percent. The economic efficiency of sweet potato farming was very low, depicting inefficient sweet potato farming, with an average economic efficiency of 0.48 percent. Therefore, sweet potato farmers must optimize land use, ZA, Urea, SP36, and Phonska to produce sweet potatoes optimally to support food security.**

***Keywords*—Production factors; technical efficiency; allocative efficiency; stochastic frontier; production; sweet potato.**

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I. INTRODUCTION

Sweet potatoes are food crops that have a strategic role in supporting food security, opening job opportunities, regional and national sources of income. Food crops' potential as food sources includes rice, corn, cassava, sweet potato, beans, soybeans, etc. In addition to sweet potatoes, rice is an essential and strategic commodity. It plays a vital role as a primary food source and the main income source for most rural communities [1]. Sweet potato farming, cassava, corn, and various bean types are the livelihoods of strategic residents in Madagascar, and most of the island's population consists of smallholders and herders, ranchers and farmers [2]. Tuber plants that play an important role in Indonesia include sweet potatoes [3]. One of the root crops in many countries is sweet potatoes [4]. As the primary food security support source grown in the eastern Democratic Republic of Congo, plants are sweet potatoes [5]. The sweet potato can easily adapt to cold environmental conditions [6]. Sweet potatoes can be used as a helpful additive in the digestive process. This plant is consistent in developing the surrounding economy to improve the sustainability of small and medium dairy farms [7]. The ethanol production from a sweet potato for alternative uses exhibits commercial potential, which has not yet been fully explored [8]. Starch from sweet potatoes, pH, and FeSO4 concentrations affect bio-hydrogen production [9]. A mixture of sweet potatoes, banana flour, and pigeon peas can be used as raw materials for making biscuits with high protein, dietary purposes, and energy foods [10]. Introducing innovative potagurt products as processed food products contributes to sustainable food production and increased consumption of sweet potatoes [11].

Orange sweet potato variety is a staple food plant biofortified with beta-carotene, a precursor of vitamin A. Many types of sweet potatoes with high beta carotene result from plant breeding progress. Biofortified orange sweet potatoes grow faster than increasing vitamin A in other ways

[12]. Sensory and cultural attributes influence varieties of sweet potatoes received by society and consumption in households and children. These attributes affect increasing biofortified plants through nutrient-rich plant intake and lowering vitamin A deficiency in future development programs [13].

Planting resistant cultivars is an excellent step to control sweet potato viruses, such as mild mottle virus, chlorotic action virus, caulimo-like virus, cucumber mosaic virus disease, speckled virus, G hairy virus, latent virus, and ringspot virus [14]. The number of family members, the price of cassava, the cost of noodles, the price of sweet potatoes, the age of farmers, income level, and education affect the consumption of tuber food crops [15].

Sweet potato farming is generally profitable, with a financial return of 144% or a net income of 48,400.00 pesos per hectare. There is a positive correlation between labor costs, land area, access to buyers, and other input costs with farmers' income. There is a negative correlation between the length of the farmers' experience and the tenurial status with the farmer's income [16]. Most households in Ghana and developing countries adopt an easy way is substituting ingredients in a mixture of legume-cereal foods with orange sweet potatoes [17]. Men and women are involved in agriculture, but men have a more dominant role in cultivating agriculture as the primary producers of staple food crops, for example, cassava, sorghum, sweet potato, corn, and rice [18].

The adoption rate of variety improvement technology in male farmers (23.7 percent) is higher than in women (18.3 percent). The level of awareness of the increased use of sweet potato varieties is 61.9 percent. The increase in the use of one or more new superior types by 21 percent shows that increased technology adoption using sweet potato varieties is still low [19]. In developing countries, sweet potatoes are the sixth major food crop globally, rice, wheat, potatoes, corn, and cassava [20]. Sweet potatoes have become a cash-generating commodity for Odisha farmers, but there are no particular sellers of these commodities. Sweet potato value chain actors in Odisha include producers, wholesalers, consumers, input suppliers, and aggregators.

Sweet potato farming in Lamongan Regency can still be developed to increase production and productivity in both the short and long term [21]. The productivity level of sweet potatoes depends on the amount of production and production factors. Therefore, farmers should work efficiently in managing their farming for optimal production. The average yield of sweet potatoes in Sherpur is 17.47 t/ha. The highest yield was 18.81 t/ha with intensive management.

The problem of production factors affecting production efficiency is the optimal combination of production factors [22]. Production factors such as fertilizer quality, low plant prices, irrigation, and transportation have increased production [23]. Production cost is used to determine the cost per unit of production. It determines farmers' real income, the basis for the government to decide on price policy, trade regulation piracy, production grant policy, subsidy policy, and tariff setting policy [24]. In most areas, sweet potato production is influenced by local varieties, soil processing and fragmentation, low soil fertility, high cost of fertilizers, pests and diseases, storage problems, and tubers processing. Due to soil fragmentation, the narrow land area cannot apply mechanization [25].

Efficiency consists of three kinds, namely economic efficiency, allocation efficiency, and technical efficiency [26]. Allocation efficiency describes how much the value of a marginal farm product is equal to the marginal cost [27]. There is a gap in the amount of technical efficiency in sweet potato farming in farming and family farming, and there are gaps for efficiency improvement. Fertilizer costs and labor costs are inputs with high value, and it is necessary to optimize these production factors [28]. Proper extension intervention programs can be performed to increase sweet potato producers. Extension intervention programs can increase the potential profit in sweet potato farming through improved allocation efficiency and technical efficiency [29]. Research analysis of the function of sweet potato production has been done a lot, but research on the effectiveness and efficiency of sweet potato farming is minimal. Research on factors affecting the development of sweet potato farming is also still rare.

The novelty of this study is the discovery of differences in the use of SP-36 and ZA fertilizers in different regions. In the Kalitengah sub-district, sp-36 is used without ZA like most farming businesses conducted in the various areas. In the Kedungpring district, we found the opposite case. Precisely in this research setting, ZA fertilizer has been used without SP36 fertilizer. Therefore, it is crucial to research factors that affect the effectiveness and efficiency of sweet potato farming that can be developed to support food security. This study analyzes the production function of sweet potato farming, including land area, the number of seeds, labor, Urea, Phonska, SP36, ZA fertilizer, varieties of white sweet potatoes as dummy variables, and determining the effectiveness and efficiency of sweet potato farming.

II. Material and Methods

A. Production Function Analysis

This study belongs to quantitative research using the survey method. The research was conducted purposively in the Kalitengah sub-district and Kedungpring centre for sweet potato production in Lamongan Regency, East Java, Indonesia (Fig. 1). The research location was chosen because it can represent the area of the research object according to the purpose of this study.

The selection of samples of respondents in the sweet potato farmer population was conducted in the initial stages of the study. The data were obtained from respondent farmers using questionnaires. The sampling method used a census of 348 farmers in two sweet potato centre districts, namely Kalitengah and Kedungpring subdistricts. 165 respondent farmers are located in Sugihwaras Village, Canditunggal, Kuluran, and Kideran Kalitengah Subdistrict. One hundred eighty-three respondent farmers are located in Gunungrejo village and Kradenanrejo district Kedungpring. The research was conducted from September to November 2019.

The research implementation stage began with a meeting with farmer groups in Kalitengah and Kedungpring subdistricts. Furthermore, four Focus Group Discussion was conducted with the Technical Service Unit of agricultural extensionists, the chairman of farmer groups, village devices, community leaders of six villages, and community leaders in Kalitengah and Kedungpring subdistricts. According to the situation and conditions, the interview was conducted with farmers who worked in the farmer's house. Discussions are also undertaken by farmers collected in one village device house. The implementation stage was also conducted with survey activities to the land of farmers respondents' sweet potato community leaders involved in the business of sweet potatoes in 5 villages and two subdistricts in Lamongan, East Java, Indonesia.

The final research stage is data collection by tabulating the survey results and interviews and verifying data so that the data obtained has high validity. Data with high validity shows that this research method is well done. Data verification results are analyzed and interpreted to determine the production function and efficiency of sweet potato farming.

The data in this research was analyzed in Cobb–Douglas production function and the stochastic frontier production function analysis to calculate technical efficiency, economic efficiency, and allocative efficiency. Analysis of the frontier stochastic production function was used to calculate the technical efficiency of sweet potato farming, explicitly using the MLE frontier 4.1 method. The production function of frontier stochastic is the maximum production function on several production factors at a certain technological level. The frontier stochastic production function establishes the relationship between the production factors and output, of which the position lies in isoquant [30].

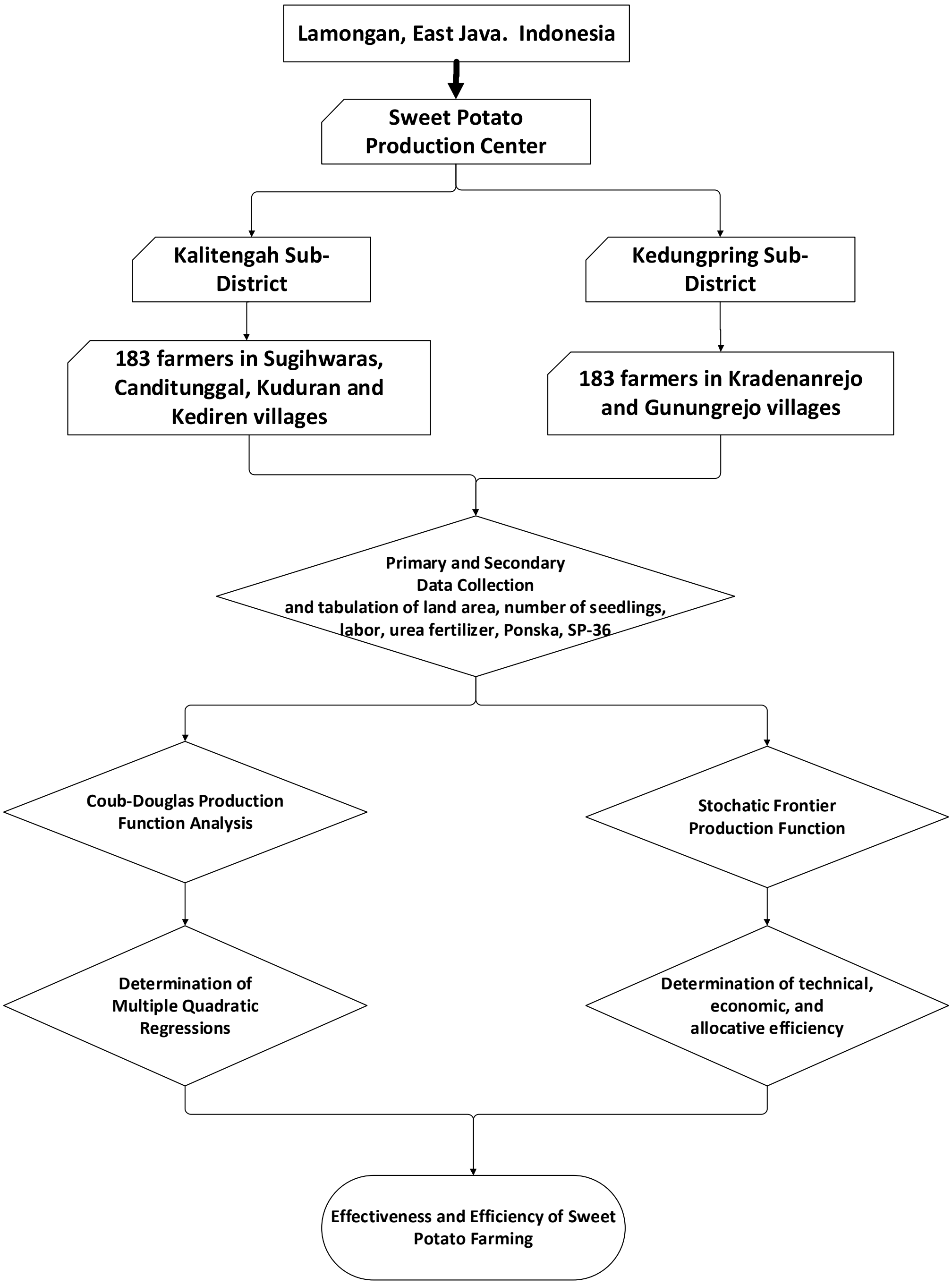

Fig. 1 Quantitative Research Flow Chart with Survey Method

The production function of frontier stochastic was applied to calculate resource inefficiencies and technical efficiency by determining the relationship between output and input levels using a two-period error approach, i.e., standard normal error with zero average constant variants [31]. Technical efficiency in agriculture refers to agriculture's capacity to give full results at a certain level of input or affect the output of a technology given a minimum number of inputs [27]. The technical efficiency of a farm was calculated using the Cobb-Douglas frontier stochastic production function with cross-sectional data.

The stochastic frontier model is Y=1(x; β)+ε, with an error value of ε=V−U. The symmetrical component V represents measurement errors β, and non-negative technical inefficiencies component U. The stochastic border section of the company with the same input x has a difference in frontiers. Irreparable interference in the company's inefficiency model to achieve maximum production [32]. Cobb-Douglas's production function is a multiple non-linear regression model. It must be transformed into a linear equation, that is, by performing a natural logarithm to be analyzed. Frontier stochastic production cost function was assumed using the Maximum Likelihood Estimation (MLE) method. Cobb-Douglas was considered this cost function and changed it to the natural logarithm (ln) in equation 1 [33].

$$Y = \beta o + \beta 1\, X1 + \ldots + \beta k\, Xk\, (vi + ui) \qquad (1)$$

Where:

Y = Production of sweet potato farming in natural logarithm (Ln)

X1 = Normalized production factors in natural logarithm (Ln)

βo = Constant

β1-k = Estimated parameters

vi = error caused by factors that farmers cannot control

ui = errors influenced by factors that farmers can control

It was suspected that the production factors affecting the production of sweet potato farming were land area, number of seeds, labor, Urea, Phonska, SP36, ZA fertilizer, and varieties of white tuber seeds as the variable dummy.

The frontier stochastic production function stated the formula of Cobb-Douglas production function in this study in sweet potato results by inserting production factors into the frontier equation. Then, the equation of frontier stochastic production function of sweet potato farming was formulated in equation 2 [34].

$$LnY = \beta 0 + \beta 1 lnX1 + \beta 2 lnX2 + \beta 3 lnX3 + \beta 4 lnX4 + \beta 5 lnX5 + \beta 6 lnX6 + \beta 7 lnX7 + d1D1 + vi - UI \qquad (2)$$

Where:

Y: Production of Sweet potato (Kg)

X1: Land area (Ha)

X2: Seedlings number (Kg)

X3: Number of Labour (Men's Working Days /MWD)

X4: Urea (Kg)

X5: Phonska (Kg)

X6: SP36 (Kg)

X7: ZA fertilizer (Kg)

D1 = Dummy variable of white sweet potato varieties. D1 = 1 means the tuber color is white, D1 = 0 means the tubers' color is not white.

β0: intercept

β1 – β8: regression coefficient

vi = error caused by factors that farmers cannot control

UI = error caused by factors that farmers can control

B. Allocative efficiency analysis and economic efficiency

Allocative efficiency and economic efficiency analyses were measured by lowering Cobb-Douglass production functions. The Cobb-Douglass production function is a dual cost function by minimizing input cost with production function constraints on equation (2). The dual cost frontier function is presented in equation (3).

$$LnC = \beta 0 + \beta 1 lnY + \beta 2 lnP1 + \beta 3 lnP2 + \beta 4 lnP3 + \beta 5 lnP4 + \beta 6 lnP5 + \beta 7 lnP6 \qquad (3)$$

Where:

C = sweet potato production costs (Rp)

Y = amount of sweet potato production (kg)

P1 = average price of sweet potato seedlings MWD (Rp)

P2 = labor costs (Rp)

P3 = average price of urea fertilizer (Rp)

P4 = average price of ponska fertilizer (Rp)

P5 = average fertilizer price SP36 (Rp)

P6 = average price of ZA fertilizer (Rp)

β1, β1, β2, β3, β4, β5, β6, β7 are economic efficiency estimation parameters, defined as the ratio of the total observed minimum production cost (C*) to the total actual production cost (C), as presented in equation (4).

$$EE = \frac{C^*}{C} = \frac{E(C_i / \mu_i = 0, Y_i, P_i)}{E(C_i / \mu_i, Y_i, P_i)} \qquad (4)$$

EE is 0 ≤ EE ≤ 1. Economic efficiency (EE) is a combination of technical efficiency (ET) and allocative efficiency (AE) so that AE can be obtained in equation (5).

$$AE = \frac{EE}{TE} \qquad (5)$$

In the future, the cob-Douglas production function and Production Function Analysis of Stochastic Frontier results of this study are expected to contribute to the development of sweet potato farming in Lamongan, Indonesia.

III. Results and Discussion

A. Production Function Analysis of Stochastic Frontier

The stochastic frontier production function of sweet potato farming analyzed using the MLE Frontier 4.1 provided maximum possible estimates of various production stochastic frontier and cost functions. The production function expressed the maximum output obtained from a given set of inputs with a particular technology. Tobit and stochastic frontier models determined factors and calculated sweet potato farming [35]. The frontier stochastic production model measured allocative, technical, and economic efficiency by lowering the dual cost function. The alleged production model of the sweet potato frontier in Lamongan Regency is formulated in equation 6.

$$LnY = 9.838 + 0.870 LnX1 - 0.005 LnX2 - 0.024 LnX3 + 0.068 LnX4 + 0.053 LnX5 + 0.014 LnX6 + 0.021 LnX7 - 0.009\, Di \quad (6)$$

Table 1. points to the alleged Cobb-Douglas stochastic frontier production model of sweet potato farming using the Maximum Likelihood Estimation (MLE) method in Lamongan Regency. The variables with a significant effect at the 99 percent and 90 percent confidence level on the production of sweet potato frontier are land area, Urea fertilizer, Ponska fertilizer, ZA fertilizer, and SP36 fertilizer. Moreover, the number of seedlings, labor, and dummy variable of white sweet potato varieties are insignificant. Gamma value of 0.93 means that 93 percent of variables are due to technical efficiency differences. In contrast, the remaining 7 percent are due to stochastic effects outside the model, such as weather or climate, pest attacks, and natural disasters.

Variance sigma-squared (δ2) has a positive and significant value at alpha 10%. It indicates that the specified distribution assumption of a composite error has a good value. The lambda (λ) value greater than one indicates that the specified model has a match and is well-reviewed from the correctness of the composite error's selected distribution assumption. The identified model is also evidenced by a Gamma value of 0.950, less than one. The model indicates that the specified model has a significant technical inefficiency effect [36]. Statistically, all the parameters show significant value. Sigma-squared (δ2) variance is significant, with a zero value of 0.01. This value indicates the correctness of the assumption of a suitable and reasonable distribution of composite errors. The variance ratio (α) of 0.428 is significant at the level of 0.01.

TABLE I
ESTIMATED FUNCTION OF STOCHASTIC FRONTIER PRODUCTION FACTOR OF SWEET POTATO FARMING

Variable		Coefficient	Standard Error	Significant	t-ratio
Constanta	β0	9.838	0.107	<0.001	92.069
Ln Land	β1	0.870 ***	0.019	<0.001	46.632
Ln number of seedlings	β2	-0.005 ns	0.004	0.174	-1.362
Ln Labour	β3	-0.024 ns	0.017	0.155	-1.426
Ln Urea fertilizer	β4	0.068 ***	0.008	<0.001	8.900
Ln Ponska fertilizer	β5	0.053 ***	0.006	<0.001	8.809
Ln Fertilizer SP-36	β6	0.014 *	0.005	0.010	2.587
Ln ZA	β7	0.021 ***	0.005	<0.001	4.025
D1 = variable white sweet potato dummy	d1	-0.009 ns	0.006	0.101	-0.647
Sigma – squared	σ2	0.448			
Gama	χ	0.930			
Log-likelihood function	LLF	0.616			
Generalized Likelihood Ratio (LR) test	LR test	0.265			

Source: Primary Data processed 2020. Information: *** Significantly different at α = 1%; ** Significantly different at α = 5%; * Significantly different at α =10%

The expected Generalized Likelihood Ratio (LR) of the farmers' sample's sweet potato production model's stochastic frontier is 0.27. It indicates that technical efficiency is not affected by sweet potato farming activities. The regression coefficient value of variables used in production factors in fertilizers, labor, land, seeds, and pesticides is positive. One unit increase in one positive value input increases sweet potato output by the same value, and all other input variables are constant. The seed variable statistically shows an insignificant value [34].

The stochastic frontier analysis production model shows that the land area has significantly affected sweet potato production at a 99 percent confidence level. The land area and the education level are statistically significant at a trust level of 99 percent [37]. The land area's value is worth 0.870 positive, indicating that the increase in each 0.870 percent of sweet potato production is affected by one percent increase in land area. The average size of land farmed in the research area was 0.21 hectares. The land area tended to plant sweet potatoes highly affected production. Therefore, farmers should work on their farming using optimal production inputs.

The Urea fertilizer variable significantly affects sweet potato production at a 90 per cent confidence level. Its coefficient value is worth posited of 0.068, meaning that everyone per cent increase in urea will increase sweet potato production by 0.068 per cent. The average use of Urea fertilizer in the research area is 183 kg per hectare. Urea fertilizer contains 46 per cent nitrogen element, meaning in 100 kg Urea fertilizer, there is 46 kg of nitrogen. The nitrogen fertilizers percentage absorbed by plants increased from 31.1 to 38.7 per cent., Nitrogen use efficiency (NUE) as markers of nitrogen, nitrogen agronomic efficiency (NAE), and nitrogen harvest index can be used to evaluate nitrogen use. There was a significant positive correlation between NUE and marketed yield (0.774). Split N is a better source of N for crop development and can be applied to increase crop yields and NUE on land with low N content in sweet potato farming in China [38]. There was a significant positive correlation between NAE and increased yield (0.727). The highest correlation value was found in the relationship between urea and inhibitors in both trial periods' sweet potato yield component [39]. Humic acid Urea fertilizer's application increased Nitrogen use efficiency from 33.5 to 44.8 percent, significantly increasing the sweet potato tubers' yield [40]. Humic acid has been used for plant root growth and increased fertilizer efficiency combined with nitrogen [41].

The Phonska fertilizer variable significantly affects the production of sweet potatoes at a confidence level of 95 per cent. The value of the coefficient Phonska fertilizer is worth a positive of 0.053. It means that adding one percent of Phonska fertilizer will increase sweet potatoes production by 0.053 percent. The average use of Phonska fertilizer in the research area is 349 kg per hectare. In multi-site research, potassium doses cause differences in anthocyanin content, anthocyanin production, and sweet potato glucose production [42]. K application is positively correlated with the accumulation of sweet potato starch. K application spurs tuber yield through starch accumulation by setting activity and transcription of several controlling genes in the conversion of sucrose into starch [43].

The SP36 fertilizer variable significantly affects sweet potato production at a 90 per cent confidence level. The SP36 fertilizer coefficient value is 0.014 positive, meaning that everyone per cent application of SP36 will increase sweet potato production by 0.014 per cent. The average SP36 fertilizer use in the research area is 72 kg per hectare. The availability of nitrogen, phosphorus, and potassium is the most decisive factor for the growth and maximum production of sweet potatoes, so it is worth noting where to grow, the type, and dosage of fertilizer at the time of fertilization [44]. There are differences between sweet potato cultivars in response to P doses against the average specific root length, root diameter, colonization by AMF, total root length, root tissue density, and root mass fraction [45].

The ZA fertilizer variable significantly affects sweet potato production at a 99 percent confidence level. Its coefficient value is 0.021 positive, meaning that adding one percent ZA will increase sweet potato production by 0.021 percent. The use of ZA fertilizer average in the research area is 116 kg per hectare. ZA fertilizer contains 20.8 percent nitrogen element, meaning that in 100 kilograms of ZA fertilizer, there is 20.8 kg of nitrogen. Nitrogen is the primary nutrient affecting various cell production developments, photosynthesis, and amino acid synthesis to grow and increase sweet potato yields [46].

The variable of the number of seedlings has not significantly affected the sweet potato production at a 90 percent confidence level, with the coefficients of labor in the family at -0.005. It suggests that the reduction or addition of seeds does not affect the increase in sweet potato production. The average use of seedlings in the research area is 118 kg per hectare. Planted sweet potato seedlings will grow roots and develop, while shoots and roots grow continuously through photosynthesis [46].

The variable of labor has no significant effect on sweet potato production at a 90 percent level of trust, with the coefficient of labor in the family at -0.024, which means the reduction or addition of labor does not affect the increase in sweet potato production. The average use of labor in the research area is 195 men's working days per hectare. This study's work was started by the men's working day per growing season, which was 8 hours per day. The highest production cost is labor, reaching 41.80 per cent of the total costs of production.

The log labor variable's coefficient is significant and positive at the 5 per cent confidence level. The coefficient of the insecticide log variable is significant and positive at a 1 per cent confidence level. The log value of the land area's variable is positive and significant at a confidence level of 1 per cent. The variable coefficient logs the number of insignificant and negative seeds at a 10 per cent confidence level.

The value of the labor variable coefficient is significant and positive at a 1 per cent confidence level. In contrast, the variable coefficient value of planting material is significant and negative at a confidence level of 1per cent. The variable coefficient value of farmers' land area is significant and positive at a 1 per cent confidence level. The variable coefficient value of the amount of fertilizer is significant and positive at a 5 per cent degree of ability.

Three relationships are high yields with high labor demand requiring increased machine investment to reduce labor inputs; low output with low labor demand requires better plant management. By comparison, low products with high labor demand require a better combination of investment and crop management to reduce labor [47]. The dummy variable of white sweet potato varieties has no significant effect on sweet potato production at a 90 per cent confidence level. It implies that the varieties of white sweet potatoes do not affect sweet potato production.

B. Technical Efficiency Analysis

Technical Efficiency (TE) was analyzed using the stochastic frontier production model. By looking at the distribution of technical efficiency value per farmer, 22 farmers or 6.32 percent obtain a technical efficiency value of 0.8, and 326 farmers, or 93.97 percent, have a technical efficiency value of 0.9 (Table 2). The technical efficiency value is declared efficient if it is above 0.7. The technical efficiency analysis using the stochastic frontier production model in the research area states that 348 farmers working on sweet potato farming have achieved technical efficiency. The average technical efficiency value in the research area is 0.95, the technical efficiency maximum value is 0.99, and the minimum technical efficiency value is 0.86. The analysis results reveal that the average technical efficiency in the Constant Return to Scale assumptions is 0.68 on the return to scale variable, beliefs are 0.78 [27].

TABLE II
TECHNICAL EFFICIENCY VALUE DISTRIBUTION

Technical Efficiency Distribution	**Number (Person)**	**Per cent (%)**
<0.50	0	0.00
0.50 – 0.59	0	0.00
0.60 – 0.69	0	0.00
0.70 – 0.79	0	0.00
0.80 – 0.89	22	6.32
0.90 – 0.99	326	93.68
Amount	348	100.00
Average	0.95	
Maximum	0.99	
Minimum	0.86	

The results mentioned that the average value of Economic Efficiency (EE), Allocation Efficiency (AE), and Technical Efficiency (TE) assuming a constant Return to Scale (CRS), respectively of 0.301; 0,445; and 0.685 [27]. More than half of farmers have technical efficiency value above-average efficiency (66.1%) between 12.6% and 93.7%. This value shows that there is a gap for improved technical efficiency to increase the profits of farming [29]. The results of data analysis showed that technical fission, local efficiency, and economic efficiency have an average value of 0.733, 0.872, and 0.684, respectively.

C. Allocative Efficiency Analysis

This study's Allocative Efficiency (AE) level was seen in production inputs based on the farmer level's input price. In contrast, AE analysis was derived from the divide between economic efficiency (EE) and technical efficiency (ET). The average value of localized efficiency is 0.50 (Table 3). Farmer respondents have a maximum localized efficiency of 0.99 and a minimum of 0.15. The organic efficiency distribution of farmers who have been efficient by 14.66 per cent means that 14.66 per cent of respondent farmers can allocate inputs at each input price to create a minimum cost. If the average farmer can achieve the highest allocative efficiency level, the farmer will save 0.49 per cent or 1-(0.50|0.99). The least efficient farmers will save costs of 0.85 per cent or 1-(0.15|0.99). Allocative efficiency measures the extent to which agricultural marginal value products can be equated with marginal costs taking into account the utilization of inputs by agricultural companies, about the current price in the market maximizing profits and minimizing costs [27].

TABLE III
ALLOCATIVE EFFICIENCY VALUE DISTRIBUTION

Allocative Efficiency Distribution	Number (Person)	Per cent (%)
<0.50	163	46.84
0.50 – 0.59	134	38.50
0.60 – 0.69	0	0.00
0.70 – 0.79	0	0.00
0.80 – 0.89	0	0.00
0.90 – 0.99	51	14.66
Amount	348	100.00
Average	0.50	
Maximum	0.99	
Minimum	0.15	

D. Economic Efficiency Analysis

Economic efficiency is a combination of technical efficiency with allocative efficiency. The level of economic efficiency is analyzed with dual cost functions. Table 4 shows that the average economic efficiency value is 0.48, with a range of 0.15 to 0.99. Based on the importance of economic efficiency, it is not economically inefficient. Farmers who have been efficient by 14.91 per cent and 85.09 per cent are financially inefficient. Other research results [35] show that. Average economic efficiency of 0.61 demonstrates the excellent potential to increase profitability by reducing costs through increased efficiency.

TABLE IV
ECONOMIC EFFICIENCY VALUE DISTRIBUTION

Economic Efficiency Distribution	Number (Person)	Per cent (%)
<0.50	153	44.00
0.50 – 0.59	143	41.09
0.60 – 0.69	0	0.00
0.70 – 0.79	0	0.00
0.80 – 0.89	0	0.00
0.90 – 0.99	52	14.91
Amount	348	100.00
Average	0.48	
Maximum	0.99	
Minimum	0.15	

Furthermore, the respondent farmers have a maximum economic efficiency of 0.99 and a minimum of 0.15. Suppose farmers want to achieve maximum economic efficiency; in that case, it must save costs of 0.52 per cent or 1-(0.48|0.99), and for the least efficient farmers will keep costs of 0.85 per cent or 1-(0.15|0.99), if it can achieve the highest level of economic efficiency. Economic efficiency is still low due to expensive production inputs, such as labor costs, wherein sweet potato farming requires much labor—the estimates of agricultural economic efficiency range from 0.13 to 0.99.

Factors of land area production are Urea fertilizer, Phonska, ZA, and SP36. Increase the production of sweet potatoes in Lamongan Regency, East Java, Indonesia. So, in the future, efforts to increase the production of sweet potatoes can be made by increasing land, fertilizer Urea, Phonska, ZA, and SP36. Sweet potato farming at the research site has not been efficient in achieving allocation efficiency and average economic efficiency. In the future, it is necessary to increase the efficiency of sweet potato farming to encourage the development of sweet potato farming in Lamongan, Indonesia.

IV. CONCLUSIONS

Production factors that can increase the production of sweet potatoes in Lamongan Regency, East Java, Indonesia are land area, Urea, Phonska, ZA, and SP36 fertilizer. Sweet potato farming at the research site has been efficient, with a very high average technical efficiency value of 95 per cent. Sweet potato farming at the research site is inefficient, shown by the relatively low average allocation efficiency achievement rate of 0.50 per cent. Sweet potato farming at the research site is inefficient, with a very low average economic efficiency of 0.48 per cent.

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