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Determinants and Technical Efficiency of Chili Production in Poleang Subdistrict of Southeast Sulawesi

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***Abstract*: The study aimed to (1) identify the factors influencing chili farming production, and (2) analyze the technical efficiency of chili farming. The study was carried in Biru village, Poleang Timur subdistrict, Bombana district, Southeast Sulawesi province. The sampling method employed a census approach, encompassing all chili farmers in the area, with a total of 30 individuals serving as respondents. Multiple linear regression analysis and the stochastic frontier production function were used to analyze the data. The findings revealed that the significant determinants influencing chili production in the survey village were the land area and fertilizer use. Conversely, seeds, pesticides, and labor were not significantly impacting production. The technical efficiency level of chili farming in the mentioned area was found to be technically efficient, with an average technical efficiency value of 81% or 0.81. This suggests that chili farming is operating efficiently, yet there remains an opportunity to enhance production by approximately 19%.**

***Keywords*: chili, determinants, farming, production, technical efficiency.**

1. Introduction

Chili (*Capsicum annum L.*) holds a unique position in Indonesia's socio-economic fabric. It serves as a cornerstone of the nation's horticultural agricultural landscape, acting not only as a source of nutrition and pivotal ingredients in food and medicine, but also in employment and income generation [1]. Indonesia's culinary heritage is profoundly intertwined with the spice, making it an indispensable component in daily meals. Chilies have traditionally been recognized for their ability to stimulate both palates and economies. For Indonesia, like other horticultural crops [2]–[4], chilli is a significant agricultural commodity with a high economic value. This importance is underscored by the vast quantities consumed domestically. Due to its high economic value, farmers in some areas have shifted from rice farming to horticulture, including chili farming [5].

While the demand for chili has been on an upward trajectory, meeting this demand has become a formidable challenge for the country. In 2020 alone, the national production averaged at 2.77 million tons, reflecting an increase of 7.11% from the preceding year. Yet, this surge in production is not entirely commensurate with the burgeoning demand. The economic effect of this imbalance became starkly evident in 2010 when the price of chili reached record highs, contributing significantly to the national inflation. At one point, chili, a staple for most Indonesians, transformed into a luxury item with its price skyrocketing, sometimes surpassing even that of beef and chicken meat.

Knowledge of efficiency status and understanding the factors that drive chili farm productivity are of utmost importance, particularly in nations where resources are limited and modern technological interventions are few. In Indonesia, chili production faces challenges such as poor crop management techniques, use of low-quality seed, high production costs, pest and disease attack [1], [6], and the sluggish adoption of improved cultivation methodologies. These issues are also found in Southeast Sulawesi. Even more challenging scenarios arise in areas like Biru Village in the Poleang Timur Subdistrict, where the farmers battle with increased input costs and cultivation management intricacies. These issues should be addressed as they can lead to inefficiencies in utilizing production resources.

However, the mere escalation in production volume is not the ultimate solution. Merely having access to production factors does not assure improved productivity [7],[8]. Instead, it is the proficient allocation and adept management of these resources that spur growth. Thus, technical efficiency stands out as the key to boosting productivity and to tackle the host of challenges beleaguering the chili production sectors.

With the backdrop of these multifaceted challenges and the crucial role of technical efficiency, this study sought to explore the determinants and technical efficiency of chili production. The focus will be on Southeast Sulawesi based on a study in a chili growing village.

2. Materials and Methods

This study was conducted in July 2022 in Biru Village, East Poleang Subdistrict, Bombana District. The location was purposefully selected based on the consideration that it serves as one of the primary chili production centers in Bombana district. A sample size of 30 respondents was utilized for this research. The sample selection was executed using a census method, where the entire population of 30 individuals was

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considered as the sample, given the relatively small size of the population. The research variables consisted of two main categories: respondent demographics—including age, formal education, farming experience, number of family dependents—and farmer characteristics that encompass both independent and dependent variables. The independent variables (X) in this study are land area (X_1), seeds (X_2), fertilizer (X_3), pesticides (X_4), and labor (X_5). The dependent variable (Y) is the production of chili pepper.

For data analysis, this study employed two methods: multiple linear regression [9] and technical efficiency, which were implemented to address the first and second objectives, respectively. The multiple linear regression was utilized to identify factors influencing the production of chili farming. The equation for the multiple linear regression is as follows:

$$Y = b_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+e$$

Where:
Y = Yield or production (Kg)
b_0 = Constant
b_1,b_2,b_3,b_4 = Coefficient
X_1 = Land size (Ha)
X_2 = Seed (gr/ha)
X_3 = Fertilizer (Kg/ha)
X_4 = Pesticide (ml/ha)
X_5 = Labor (man-day)
e = error term

To assess the model's overall and individual performance, F-test, t-test, and Coefficient of Determination (R^2) were employed. F-test is employed to determine if all independent variables, collectively, significantly influence the dependent variable. The t-test is used to evaluate the individual impact of each explanatory variable on the dependent variable. It assesses the significance of each independent variable in the model. Coefficient of Determination (R^2) indicates the proportion of variance in the dependent variable explained by the independent variables. A value of 1 signifies that the model fully explains the variability, while a value of 0 indicates no relationship between the variables.

The analysis of technical efficiency is employed to address the second objective: to ascertain the level of technical efficiency in the utilization of production factors. According to Farrell as quoted in [10], technical efficiency is the ability of a Decision-Making Unit (DMU) to create the maximum output from a given quantity of inputs. The technical efficiency level for chili farming for the i^{th} farmer can be estimated using the following formulation [11] :

$$ET = \frac{Yi}{Yi'}$$

Where:
ET = Technical efficiency level
Yi = Actual chili harvest output (kg/ha)
Yi' = Potential chilli output (kg/ha)

The technical efficiency index is deemed technically efficient if its value is > 0.7 and considered not yet efficient if its value is ≤ 0.7 [12].

3. Results and Discussion

A. Socio-Economic Characteristics of Farmers

1) Age

Age significantly influences a respondent's physical capacity in managing a business or activity. The productive age category spans from 15-54 years, and ages beyond that fall into the non-productive category [13]. Out of the 30 respondents based on age characteristics, all were categorized under the productive age bracket. This indicates that the chili farmers in Biru village possess both the physical and cognitive abilities associated with productive ages. This is consistent with that reported in Saediman et al. [14] that a farmer's age is directly related to their working ability in agricultural undertakings. Farmers operating within their productive age tend to perform more optimally than those outside this age range.

2) Education

Education plays a pivotal role in shaping a farmer's thought processes and actions. A higher education level of a respondent indicates broader knowledge and perspectives, predisposing them to be more receptive to innovations. In this study, education refers to the levels attained by chili farmers. The table below details the educational levels of chili farmers.

Table 1
Number of respondents according to their educational level

No.	Education Level	Number of Farmers	%
1	Elementary School	10	27.90
2	Junior High School	9	25.59
3	Senior High School	11	46.51
	Total	30	100.00

It can be inferred from Tabel 1 that the majority of chili farmer respondents (46.51%), completed Senior High School. This suggests that chili farmers in the survey village have the foundational knowledge to enhance their agricultural practices. It is generally believed that higher educational attainment invariably translates to a better-quality workforce, inherently leading to increased work productivity.

3) 3) Number of dependents

The number of dependents refers to the total family members reliant on the family's breadwinner. Having more dependents can bolster agricultural activities. Leibo [15] classifies family dependents into three categories: 1-3 persons (small), 4-6 persons (medium), and ≥6 persons (large).

Table 2
Number of respondents according to family dependents

No.	Dependents	Number of Farmers	%
1	1 - 3 (small)	29	90.7
2	4 - 6 (medium)	4	9.3
3	≥ 6 (large)	0	0.0
	Total	30	100.0

Table 2 suggests a dominance of small families, with maximum three dependents. This finding is consistent with those reported in other studies that that the average family size is four persons [16], [17]. Lesser family members generally means lesser household expenditure, but may bring about pressure on labor availability for chili cultivation, processing and marketing. A greater family size allows for the adoption of chili farming techniques and enhances the amount of family labor that is potentially available for cassava cultivation and processing.

4) Farming experience

Agricultural experience is an informal educational process crucial for chili farmers in their farming practices. Soeharjo and Patong [13] define a farmer with 5-10 years of experience as moderately experienced, >10 years as experienced, and ≤5 years as less experienced. Respondents' farming experience is presented in Table 3.

Table 3
Number of respondents according to farming experience

No.	Farming Experience (Years)	Number of Farmers	%
1	Less Experienced (<5)	4	11.62
2	Moderately Experienced (5-10)	18	67.44
3	Experienced (>10)	8	20.94
	Total	30	100.00

As can be seen in Table 3, the predominant experience level among respondents is moderate (5-10 years) with a percentage of 67.44%. This suggests that most respondents are reasonably experienced and possess the know-how to enhance their farm's productivity. More years of farming generally augments the skills in maintaining and managing agricultural ventures. Continuous experience in farming invariably results in positive changes in a farmer's management practices [13].

B. Production Factors Affecting Yields

The regression analysis was conducted using the SPSS software version 16.0 to evaluate chili farming practices. This model estimation was carried out to determine whether at least one variable within the model was statistically significant at a 95% confidence level. Furthermore, it sought to ascertain the extent of variability in the dependent variable, chili production (Y), as jointly determined by the independent variables (X) incorporated into the estimation model. Here, the dependent variable (Y) represents chili production, while the independent variables (X) encompass land area (X_1), seeds (X_2), pesticides (X_3), fertilizers (X_4), and labor (X_5).

To discern the significance of the influence of the independent variables, a t-test was utilized. If the regression coefficient for each independent variable proves significant at a confidence level of 95% or higher, it suggests that any change in variable X will induce a significant alteration in the dependent variable Y (production). The results of regression analysis is presented in Table 4.

Based on the SPSS output results in Table 4, significant values can be identified for the constant, land area, and fertilizer. Meanwhile, insignificant values were observed for seeds, pesticides, and labor. Consequently, the regression model equation can be constructed by examining values in the 'B' column.

The coefficient of determination (R^2) is employed to ascertain the accuracy of the model and to understand the extent of influence exerted by the independent variables on the dependent variable, which is the chili production level. The obtained R^2 value, also known as R Square, is 0.807, derived from squaring the correlation coefficient or R. This coefficient of determination value is 0.820 or 82%, indicating that the independent variables account for 82% of the variance in the chili production (Y). The remaining 19.35% of the variance is explained by other variables not included in the regression model.

The F-test is utilized to determine whether all the independent variables included in the model collectively influence the dependent variable (production). The results of the F-test analysis can be assessed by comparing the significance value against the 95% confidence level or at the α5% (0.05) threshold. If the test rejects the null hypothesis (H0) and accepts the alternative hypothesis (Ha), it indicates that the independent variables jointly have a significant effect on the dependent variable. The criteria for this are that if the significance value is less than the α5 value or 0.05, then all the independent variables will significantly affect the dependent variable and vice versa.

The t-test, or partial testing, is employed to examine the influence of each independent variable - land area, seeds, fertilizer, pesticides, and labor - on the dependent variable, which is chili production (Y).

1) Factors significantly affecting production

Based on the analysis, the variable pertaining to the land area exhibits a regression coefficient value of 63.567, with a significance value of 0.005, which is $\leq \alpha = 0.05$. This implies a statistically significant influence on the production of chili in the survey village. The estimated regression coefficient of 63.567 suggests that a 1 percent increase in the land area would result in a 63.567 percent augmentation in chili production, assuming all other variables remain constant (ceteris paribus).

This finding is consistent with research conducted by Sitanggang [18], Maemunah et al. [19], and Adhiana and Riani [20]. In their studies, the land area was identified as the most responsive variable in the chili production function. Kusnadi et

Table 4
Results of regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	13.622	6.755		2.016	0.055*
Land size	63.587	20.771	0.759	3.061	0.005*
Seed	0.028	0.029	0.300	0.993	0.331ts
Fertilizer	-1.240	0.555	-0.450	-2.235	0.035*
Pesticide	4.909	3.441	0.277	1.427	0.167ts
Labor	.218	.418	0.046	0.521	0.607ts

Notes: dependent variable is production

al. [21] mentioned that, to boost chili production, the land area variable should be given primary consideration. Land plays a significant role in agricultural operations and stands as a pivotal determinant in production factors.

Based on research findings, it was determined that the fertilizer variable has a regression coefficient of -1.240 and a significance value of 0.035, which is ≤ α = 0.05. This suggests that the fertilizer has a statistically significant effect on yield. The estimated regression coefficient of -1.240 indicates that a 1% increase in fertilizer usage would lead to a decrease in chili production by 1.240%, assuming all other variables remain constant (ceteris paribus).

This finding aligns with studies conducted by Sitanggang [18], Sumastuti and Sutanto [22], and Adhiana and Riani [20], all of which indicate that the fertilizer significantly affects chili production. The use of fertilizer plays a pivotal role in enhancing production since it stimulates the growth and development of crops. An increase in production response is observed when fertilizers are used at the right dosage, applied to the intended targets, introduced at the appropriate time, and employed correctly [23]. The utilization of fertilizer is crucial in chili cultivation due to the nutrients it contains, which are necessary to stimulate the growth and development of chili plants.

2) Factors not significantly affecting production

Based on the research findings, the regression coefficient of the seed variable is determined to be 0.028 with a significance value of 0.331, which is ≥ α = 0.05. This suggests that the seed variable has a positive but statistically insignificant influence on chili production. Specifically, the estimated regression coefficient indicates that a 1% increase in seed quantity would lead to a 0.028 unit increase in chili production.

These results are consistent with the earlier study conducted in Sawang Subdistrict of North Aceh District [24]. This study found that the seed variable had no significant effect on chili production and emphasized that seed quality is a crucial factor influencing chili production outcomes. The use of inferior or poor-quality chili seeds, or an inadequate quantity of seeds, can adversely affect production outcomes. Recommended seed usage for a one-hectare area is between 200-350 grams, and it is advised to use high-quality seeds [25].

Based on the research results, it is ascertained that the regression coefficient of the pesticide has an insignificant but positive influence on chili production. The significance value of 0.167 is ≥ α = 0.05. The estimated regression coefficient is 4.909, indicating that a 1% increase in the pesticide variable can lead to an increase in chili production by 4.909 units.

This finding aligns with prior research conducted in Sawang Subdistrict, North Aceh District [24], which also found that the pesticide variable had no significant effect on chili production. It is crucial that pesticide usage adheres to the six principles of precision, namely: targeting accuracy, correct quality, appropriate type of pesticide, timely application, precise dose or concentration, and proper usage method. Over-reliance or excessive use of pesticides can lead to detrimental outcomes, including environmental contamination, decreased productivity, poisoning of animals, and even potential human toxicity.

Based on research findings, it is evident that the regression coefficient of the labor correlates positively but insignificantly influential to chili production, with a significance value of 0.607, which is ≥ α = 0.05. A regression coefficient of 0.218 implies that a 1% increase in the labor variable would lead to a 0.218% rise in chili production.

This finding contrasts with previous research conducted in Pattinoang Village, Galesong Subdistrict, Takalar District [26]. The study demonstrated that the labor variable significantly influenced the production of red chili, with a significance value of 0.000, which is less than α = 0.05. The labor utilization ratio affects the production capacity of chili farming; the more labor employed, the greater the impact on both the quantity of production and farmer income [27]. Many farmers tend to rely heavily on family labor, often disproportionate to the land size they manage. Consequently, this results in reduced costs associated with labor allocation.

C. Technical Efficiency

Technical efficiency is employed to measure the level of production achievable based on the potential production capacity of farmers, using the stochastic frontier production function model. According to Yoko et al. [28], technical efficiency reflects the farmers' capability to obtain the maximum output from a given set of inputs. The technical efficiency level of chili production achieved by farmers in Biru Village can be observed in Table 5. Efficiency values range from 0.46 to 0.99, with an average of 0.82. The subsequent table displays the range of technical efficiency achieved by chili farmers in the study village.

Table 5
Number of respondents according to their efficiency level

Efficiency level	Number of respondents	%
TE ≤ 0,7	8	10%
TE ≥ 0,7	22	90%
Total	30	100%
Minimum	0.48	
Maximum TE	0.99	
Average TE	0.81	

Table 5 above demonstrates that the minimum technical efficiency of chili farmers is 0.48, or 48% of the production output. This suggests that there is a potential for farmers to enhance their chili farming production by up to 52%. The maximum technical efficiency for chili production is 0.99 or 99%. This indicates that farmers have almost reached the pinnacle of technical efficiency for chili production, with a mere 1% opportunity for potential improvement. On average, the technical efficiency level of chili farmers is 0.81, signifying that chili farmers in the study location have achieved an average technical efficiency of 81%. This further implies that chili farming is technically efficient, with a 19% potential to increase production.

4. Conclusion

Factors that significantly affect the chili production are the land area and fertilizer use. Conversely, factors such as seeds, pesticides, and labor do not have a significant impact on chili production. On average, the technical efficiency level of production factors in chili farming is approximately 81%. This suggests that the chili farming operations are technically efficient, yet there remains a potential of 19% to enhance chili production on farmers' lands through optimal resource utilization. Given that the land area and fertilizer use are the primary determinants of chili pepper production, it is essential to ensure that these resources are allocated and used optimally. Farmers could benefit from training sessions that educate them on best practices for maximizing land utilization and applying fertilizer efficiently. At the same time, efforts should be directed towards bridging the 19% efficiency gap. This could be achieved through introducing modern farming techniques, leveraging technology, and continuous farmer training.

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