

EFFICIENCY OF ALLOCATION OF PRODUCTION FACTORS IN THE MODEL RICE-BEEF CATTLE DIVERSIFICATION BUSINESS IN THE CENTER RICE LAND AGRICULTURE IN MOJOKERTO, EAST JAVA

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ABSTRACT

This study aims to analyze the technical, allocative, and economic efficiency of the rice-beef cattle diversification business model in Mojokerto Regency through a survey method of 120 respondents determined by stratified random sampling. Using the Cobb-Douglas production function and Marginal Product Value (NPM) analysis, the results revealed that this business is in a condition of increasing returns to scale ($\sum b_i = 1.738$), which indicates a large opportunity for business scale expansion. However, the findings indicate that allocative efficiency has not been achieved optimally ($NPM/P_x \neq 1$), where production factors such as land, fertilizer, feed, and livestock population are still less than optimally used ($NPM/P_x > 1$), while labor and pesticides are actually overused ($NPM/P_x < 1$). The average economic efficiency value of 0.73 indicates that there is still room for economic efficiency improvement by 27%. Policy implications include the need to optimize input use, develop integrated farming institutions, and strengthen market access for subsidized production inputs.

Keywords: allocative efficiency, Cobb-Douglas production function, rice-beef cattle diversification, rice fields, Mojokerto

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INTRODUCTION

Mojokerto Regency plays a strategic role as one of East Java's rice granaries, supported by impressive beef cattle farming potential. According to 2023 data from the Department of Agriculture and Livestock, with 37,462 hectares of rice paddies and a beef cattle population of 98,000, the region offers ideal ecological and economic conditions for implementing an integrated crop-livestock farming system. The synergy between rice biomass as a feed source and livestock waste as organic soil nutrients makes Mojokerto a highly promising model for developing sustainable, circular agriculture.

The integrated rice-beef cattle system is a manifestation of strategic farming diversification that optimizes ecological synergy between the food crops and livestock subsectors. Through a circular economy approach, rice straw waste is converted into high-quality animal feed, while cow feces and urine are reprocessed into organic fertilizer to reduce dependence on external chemical inputs. This integration not only increases the efficiency of holistic resource utilization but also effectively reduces production costs while creating sustainable economic value for farmers.

In agricultural production economics, efficiency is measured through the integration of three fundamental dimensions: technical, allocative, and economic efficiency. **Technical efficiency**

represents a farmer's managerial capability to produce maximum output using a given combination of inputs within the limits of existing technology. This then leads to **allocative efficiency** (or price efficiency), which emphasizes the farmer's ability to align input use in such a way that the marginal value of the product equals the marginal cost of that input. Ultimately, **economic efficiency** emerges as the result of technical and allocative efficiency, comprehensively reflecting the farmer's success in minimizing costs or maximizing profits to achieve optimal competitive advantage in the market.

The use of the Cobb-Douglas production function in agricultural efficiency analysis remains a dominant paradigm in the managerial economics literature due to its theoretical robustness and broad applicability (Coelli et al., 2005; Soekartawi, 2003). The fundamental advantage of this model lies in its flexibility in transforming nonlinear relationships into linear ones through the natural logarithm, so that the resulting regression coefficients automatically represent intuitive production elasticities. Furthermore, this approach facilitates the precise identification of *returns to scale conditions*, which serves as a strategic instrument for farmers and policymakers in determining the optimal business scale to achieve maximum allocative efficiency.

Although numerous studies have been conducted on rice farming efficiency in East Java, in-depth studies integrating allocative efficiency analysis into the rice-beef cattle diversification model in Mojokerto Regency's rice paddies are still very limited. The urgency of this research is further heightened by the fluctuating price dynamics of agricultural inputs due to adjustments to fertilizer and animal feed subsidy policies following the COVID-19 pandemic, which have created new economic pressures for farmers. Therefore, an empirical evaluation is needed to understand the extent to which the integration of these two subsectors can optimize resource allocation amid current market uncertainty.

Therefore, this research is expected to fill this research gap and provide both theoretical and practical contributions. Theoretically, this research contributes to the development of an integrated farming efficiency analysis model that considers the interactions between agricultural and livestock subsystems. Practically, the research findings can serve as a reference for the Mojokerto Regency Agriculture and Livestock Service in designing more targeted intervention programs to increase farming productivity and efficiency.

RESEARCH OBJECTIVES

Based on this background, this study aims to analyze the performance of the rice-beef cattle diversification business in the rice field agricultural center of Mojokerto Regency through four main focuses: first, measuring the level of **technical efficiency** to determine the ability of farmers and livestock breeders to achieve the maximum production frontier; *second*, evaluating **allocative efficiency** to identify the existence of excessive input use (*over-use*) or suboptimal (*under-use*); third, determining the condition of **the business scale** (*returns to scale*) and its managerial implications for business capacity development; and fourth, identifying the factors causing **economic inefficiency** to formulate targeted policy recommendations in optimizing the allocation of production factors in the region.

RESEARCH METHODOLOGY

Research Location

This research was conducted in Mojokerto Regency, East Java, focusing on four rice-beef cattle diversification centers: Jetis, Dawarblandong, Kemlagi, and Gedeg Districts. The locations were selected purposively based on strategic considerations, including the significance of the livestock population and the size of productive rice fields, which are the highest in Mojokerto Regency, making them representative for illustrating the integration of the agricultural and livestock sectors in the region.

Sampling Determination Method

The population in this study includes all farmer-breeder households in the four research sub-districts in Mojokerto Regency that integrate rice cultivation with the maintenance of at least two beef cattle, with a total population reaching 2,800 households based on data from the Department of Agriculture in 2025. To ensure data representation, a sample of 120 respondents was determined through a *proportionate stratified random sampling technique* with strata division based on sub-district areas. In detail, the sample allocation was spread across Jetis Sub-district with 34 respondents, Dawarblandong Sub-district with 31 respondents, Kemlagi Sub-district with 29 respondents, and Gedeg Sub-district with 26 respondents.

Data Collection Methods

This study uses primary data collected through in-depth interviews with respondents using a structured questionnaire instrument, covering production input variables (land area, labor, fertilizer, pesticide, livestock population, and feed) and output variables (rice productivity in kg/ha and beef cattle weight in kg/head) during the 2025 planting season. To strengthen the analysis, the data was synthesized with secondary data sourced from the Central Statistics Agency (BPS) of Mojokerto Regency, the Department of Agriculture and Animal Husbandry, and the local Agricultural Extension Center to ensure the validity and regional context of the research .

Cobb-Douglas Production Function Model

This study uses an analysis of the relationship between production factors and the total output of diversification efforts, using the Cobb-Douglas production function in the form of a logarithmic equation as follows:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + \dots + b_n \ln X_n + \epsilon$$

Where: Y is the total output of diversified farming (rice + beef cattle production value in rupiah); X_1 is the area of cultivated land (hectares); X_2 is labor use (HKO/season); X_3 is fertilizer use (kg/season); X_4 is pesticide use (liters/season); X_5 is livestock feed expenditure (rupiah/year); X_6 is the number of beef cattle raised (head); b_1 – b_6 is the production elasticity of each input; a is a constant; and ϵ is the error. Parameter estimation was carried out using the Ordinary Least Squares (OLS) method using SPSS 26.0.

Allocative Efficiency Analysis

Therefore, allocative efficiency is analyzed using the concept of marginal product value (NPM) compared to the price of production factors (P_x). Marginal product value is calculated using the formula:

$$NPM_{xi} = b_i \times (P_y \times Y) / X_i$$

The decision rules used are: (a) if $NPM_{xi}/P_{xi} = 1$, then the use of the i-th input is allocatively efficient; (b) if $NPM_{xi}/P_{xi} > 1$, then the use of the i-th input still needs to be increased (under-use); and (c) if $NPM_{xi}/P_{xi} < 1$, then the use of the i-th input is excessive and needs to be reduced (over-use). The condition of the business scale (returns to scale) is determined based on the value of $\sum b_i$: if $\sum b_i > 1$ then increasing returns to scale; $\sum b_i = 1$ then constant returns to scale; and $\sum b_i < 1$ then decreasing returns to scale.

RESULTS AND DISCUSSION

Respondent Characteristics

The socio-demographic characteristics of the research respondents are summarized in Table 1 below:

Table 1. Socio-Demographic Characteristics of Respondents

Characteristics	Category	Number of people)	Percentage (%)
Age (years)	< 35	18	15.0
	35–50	67	55.8
	> 50	35	29.2
Education	Elementary School	44	36.7
	JUNIOR HIGH SCHOOL	38	31.7
	High School/Vocational School	28	23.3
	D3/S1	10	8.3
Land Area (ha)	< 0.5	51	42.5
	0.5–1.0	47	39.2
	> 1.0	22	18.3
Total	-	120	100.0

Source: Primary data, processed (2025)

Based on the demographic distribution in Table 1, it shows that the majority of respondents are in the productive age group, namely 35–50 years (55.8%), a phase that theoretically reflects optimal physical capacity and managerial experience in managing a farm. However, this potential clashes with the low quality of human capital, where the dominance of elementary and junior high school graduates (68.4%) becomes a structural barrier to the adoption of advanced agricultural technology. This phenomenon reinforces the thesis of Uematsu & Mishra (2012) that limited formal education is a major determinant of technical inefficiency in developing countries. This condition is further complicated by limited production assets, where the majority of respondents (42.5%) manage land less than 0.5 hectares, which confirms the characteristics of the study area as a base for small-scale farming (gurem) with limited economic space.

Results of Cobb-Douglas Production Function Analysis

The results of the Cobb-Douglas production function parameter estimation using OLS are presented in Table 2 below:

Table 2. Cobb-Douglas Production Function Estimation Results

Variables	Coeff. (bi)	Std. Error	t-count	Sig.
Constant (ln a)	2,347	0.412	5,698***	0,000
Land Area (X ₁)	0.423	0.087	4,862***	0,000
Labor (X ₂)	0.318	0.074	4,297***	0,000
Fertilizer (X ₃)	0.267	0.063	4,238***	0,000
Pesticide (X ₄)	0.089	0.041	2,171**	0.032
Animal Feed (X ₅)	0.354	0.079	4,481***	0,000
Number of Livestock (X ₆)	0.287	0.068	4,221***	0,000

$R^2 = 0.847$ $F = 74.23^{***}$ $\Sigma b_i = 1.738$				
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Note: *** significant at $\alpha = 1\%$; ** significant at $\alpha = 5\%$. Source: Primary data, processed (2025)

The coefficient of determination R^2 of 0.847 indicates that 84.7% of the variation in output of the rice-beef cattle diversification business can be explained by the six input variables included in the model. A significant F-test at the 1% level confirms that the model is a good fit and suitable for analysis.

All input variables have a positive and significant effect on output. Land area has the highest elasticity among agricultural inputs ($b_1 = 0.423$), followed by animal feed ($b_5 = 0.354$) and livestock number ($b_6 = 0.287$). The relatively high elasticities of animal feed and livestock number reflect the significant contribution of the livestock subsystem to the total output of diversified businesses. This value is consistent with research by Raharto et al. (2020), which found that the livestock component contributes 38–45% to the total income of rice-livestock farming businesses in East Java.

The total production elasticity ($\Sigma b_i = 1.738$) indicates that the rice-beef cattle diversification business in Mojokerto Regency is experiencing increasing returns to scale. This means that a 10% proportional increase in all inputs will increase output by 17.38%. This indicates significant room for scale-up to achieve optimal efficiency.

Analysis of Allocative Efficiency of Production Factors

The results of the allocative efficiency analysis based on the calculation of the marginal product value (NPM) and the price of each input are presented in Table 3 below:

Table 3. Analysis of Allocative Efficiency of Production Factors

Production Factors	NPM _{xi} (Rp)	P _{xi} (Rp)	NPM/P _{xi} Ratio	Information
Land (X ₁)	4,127,500	3,500,000	1,179	Not yet efficient
Labor (X ₂)	87,340	95,000	0.919	Excessive
Fertilizer (X ₃)	18,650	14,500	1,286	Not yet efficient
Pesticide (X ₄)	46,200	52,000	0.888	Excessive
Animal Feed (X ₅)	21,340	17,500	1,219	Not yet efficient
Number of Livestock (X ₆)	3,456,000	3,200,000	1,080	Not yet efficient

Description: Allocatively efficient if $NPM/P_x = 1$; Inefficient (under-use) if $NPM/P_x > 1$; Excessive (over-use) if $NPM/P_x < 1$. Source: Primary data, processed (2025)

The analysis results show that none of the production factors have achieved allocative efficiency ($NPM/P_x = 1$). Land, fertilizer, animal feed, and livestock are underutilized ($NPM/P_x > 1$), indicating that adding these inputs will still generate additional production value that exceeds the input costs. In other words, farmers at the research site have not utilized these production factors optimally.

In contrast, labor ($NPM/P_x = 0.919$) and pesticides ($NPM/P_x = 0.888$) are in a state of over-use. The excess use of labor is likely caused by the structure of the family farm workforce which is labor surplus, where the opportunity cost of family labor is considered low, so farmers tend to use more labor than is economically optimal. The excess use of pesticides reflects the behavior of farmers who are still oriented towards prevention and tend to apply pesticides excessively in response to the uncertainty of pest attacks, without considering the aspect of cost efficiency.

The fertilizer factor, with an NPM/Pxi ratio of 1.286, indicates potential for increased fertilizer use, which would provide additional production value greater than its costs. However, this should be interpreted with caution, given the policy of limiting fertilizer subsidies, which could potentially increase fertilizer prices at the farm level.

Economic Efficiency and Managerial Implications

The average economic efficiency (EE), calculated as the product of technical and allocative efficiency, was 0.73. This value indicates that, on average, farmers and livestock breeders are only able to achieve 73% of the theoretical maximum output possible with current technology and prices. In other words, there is still 27% of economic inefficiency that can be improved.

The sources of inefficiency identified in this study include: (1) business scales that are still too small so that they have not fully utilized economies of scale; (2) limited access to high-quality inputs, especially superior rice seeds and concentrated animal feed; (3) weak managerial capacity of farmers in calculating input opportunity costs; and (4) imperfections in local input markets that cause input prices to be higher than reference prices.

The finding of increasing returns to scale ($\Sigma bi = 1.738$) has important managerial implications. Increasing business scale through land consolidation or cooperation between farmers in the form of integrated agricultural and livestock cooperatives can be an effective strategy for increasing economic efficiency. This finding aligns with Ohajianya et al. (2013) who emphasized that small-scale integrated farming in developing countries can generally significantly increase their efficiency through business scale expansion.

CONCLUSION

Based on the results of the analysis and discussion that have been described, the following conclusions can be drawn:

The analysis results show that the rice-beef cattle diversification business in Mojokerto Regency is in a condition of *increasing returns to scale* $\Sigma bi = 1.738$, which indicates that business scale expansion still has great potential to increase output significantly. However, allocative efficiency has not been achieved optimally where production factors such as land, fertilizer, feed, and livestock population are still in *under-use status* ($NPM/Px > 1$), while labor and pesticides are actually *over-used* ($NPM/Px < 1$). With an average economic efficiency value of 0.73, there is room for improvement of 27% through optimization of input allocation to overcome managerial obstacles, limited access to quality inputs, and constraints of too small a business scale.

To address these inefficiencies, strategic policies are needed that focus on land consolidation through farmer corporations and improving managerial capacity through integrated farming training. The government needs to reallocate policy support by increasing accessibility to concentrated feed and superior seeds, while reducing pesticide subsidies and shifting them to more efficient Integrated Pest Management (IPM) programs. Furthermore, developing a digital-based price information system is crucial for improving transparency in local input-output markets, enabling farmers to make more precise and competitive economic decisions.

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