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Economies of Scale Analysis in Robusta Coffee Production Using Regression in Balik Bukit

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Abstract

The agricultural sector plays a vital role in national economic development, particularly in employment provision and its contribution to the Gross Domestic Product (GDP). One of the leading subsectors is coffee, especially robusta, which is a major commodity in several regions of Indonesia, including West Lampung Regency. Although this region has relatively high coffee productivity compared to other areas, fluctuations in production trends and limitations in the management of production factors highlight the need for an in-depth analysis of the determinants of coffee production. This study aims to analyze the effects of the number of coffee trees, labor, land area, and fertilizer use on robusta coffee production in Balik Bukit District, West Lampung Regency. The method used is multiple linear regression with primary data collected from 70 coffee farmers. The results show that all independent variables have a positive and significant effect on coffee production. The number of coffee trees contributes 22.59%, labor 14.67%, land area 80.46%, and fertilizer use 9.73% to production increases. The obtained R^2 value of 0.701 indicates that 70% of the variation in production can be explained by these variables. These findings imply the need to improve production capacity through better management of these factors to enhance the welfare of coffee farmers.

Keywords: Coffee Production, Number of Trees, Labor, Land Area, Fertilizer Use, Balik Bukit District

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INTRODUCTION

The agricultural sector is a major pillar of Indonesia's economy, contributing 13.57% to the national Gross Domestic Product (GDP) in 2023 and employing approximately 29% of the total national workforce (Huzaimah, 2024; Limanseto, 2024). One of the leading subsectors in the plantation field is coffee, which serves as a strategic export commodity and a source of income for around 7.8 million Indonesians (Sayekti, 2023). Indonesia is the fourth-largest coffee producer in the world, with a planted area reaching 1.27 million hectares. However, national productivity remains low at approximately 0.56 tons per hectare per year, far below its optimal potential (Dewangga, 2023).

Lampung is one of the main coffee-producing provinces in Indonesia, particularly known for its Robusta variety. West Lampung Regency holds a strategic position with a total production of 54,104 tons in 2023, contributing around 70% of the national Robusta coffee exports (Rezki, 2024). However, annual production fluctuations, along with limited access to capital, technology, and farmer regeneration, indicate serious challenges to the sustainability of productivity and the welfare of coffee farmers.

Balik Bukit Subdistrict, as one of the Robusta coffee production centers in West Lampung, possesses distinctive agronomic characteristics. According to data from the Central Bureau of Statistics (2024), there are approximately 6,174 coffee farmers, the majority of whom are male (5,863 individuals). The age range of the farmers spans from 30 to 72 years, indicating the involvement of both the productive age group and the elderly. Each farmer tends between 1,000 to 3,500 coffee trees, with farm sizes ranging from 4,417 to 14,957 square meters depending on the village area. Fertilizer use increased from 2 quintals in 2023 to 3 quintals in 2024, while pesticide use rose from 10 liters to 15 liters, with the price remaining steady at Rp65,000 per liter (Hartaji, 2024).

Coffee production in this subdistrict is influenced by four main factors: the number of coffee trees, the amount of labor (measured in Person Work Days/PWD), land area, and fertilizer usage. Survey data show that farmers with more than 2,500 coffee trees, fertilizer usage exceeding 2,000 kg, and labor input of over 2,000 hours per season tend to achieve average yields of over 1,500 kg per harvest season. In contrast, farmers with lower input levels produce less than 1,000 kg. This highlights the importance of optimizing production factors to improve productivity and the welfare of coffee farmers (Mubyarto, 1989).

The challenges faced include suboptimal land productivity, high production input costs, and limited access to technology and modern cultivation knowledge. Therefore, this study focuses on analyzing the effects of the number of coffee trees, labor, land area,

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and fertilizer use on the level of coffee production in Balik Bukit Subdistrict. This research is essential for formulating data-driven strategies to enhance productivity and can serve as a reference for designing sustainable agricultural policies and improving farmer welfare.

IMPLEMENTATION METHOD

Data Collection

This study utilizes two types of data: primary data and secondary data. Primary data are obtained directly from original sources through observations and interviews with respondents, in accordance with the method described by Edy Riadi (2011) in Zefri (2019). Meanwhile, secondary data are obtained from indirect sources such as the Department of Agriculture and Plantation of West Lampung Regency, the Central Bureau of Statistics of West Lampung Regency, as well as relevant literature to support this research (Zefri, 2019)

Data Collection Method

Population

The population in this study consists of coffee farmers in Balik Bukit Subdistrict, which includes 12 farmer groups across various villages such as Sebarus, Sedampah Indah, and others. The determination of this population aligns with the definition provided by Sugiyono (2011), which describes a population as a generalization area consisting of individuals who have certain qualities and characteristics to be studied and from which conclusions can be drawn.

Table 1. Population of Robusta Coffee Farmers in Balik Bukit Subdistrict in 2023 (People)

No	Pekon Name	Number Of Farmers
1	Sebarus	71
2	Sedampah Indah	53
3	Wates	47
4	Bahway	75
5	Gunung Sugih	49
6	Padang Cahaya	64
7	Padang Dalom	32

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8	Sukarame	53
9	Way Empulau Ulu	70
10	Way Mengaku	95
11	Pasar Liwa	62
Population Number		671

Source:Publication of the Plantation Department of West Lampung, Data Processed (2025)

Sample

Sampling Techniques

The sampling technique used is simple random sampling, where sample members are selected randomly without considering strata within the population (Setiawan, 2021). The sample size (n) is calculated using the Fisher formula.

Sample Size:

$$n = \frac{Z^2.p.(1-p)}{E^2}$$

$$n = = \frac{(1,96)^2.0,5.(1-0,5)}{(0,11)^2}$$

$$n = \frac{3,8416.0,5.0,5}{0,0121}$$

$$n = \frac{0,9604}{0,0121} = 79,34$$

Due to the limited population, the population correction formula will be used:

$$n_{adjusted} = \frac{n}{1+\frac{n-1}{N}}$$

$$n_{adjusted} = \frac{79,34}{1+\frac{78,34}{671}}$$

$$n_{adjusted} = \frac{79,34}{1,116} \mathbf{= 71,14 = 70}$$

Description:

Populationsize (N) = 671
Margin of error (E) = 11% = 0.11
Estimated proportion (p) = 0.5 (if unknown)
Z for 95% confidence level = 1.96

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Based on the calculation of the Fisher formula, using the simple random sampling method, the resulting number of coffee farmers in Balik Bukit Subdistrict is:

Table 2. Coffee Farmer Respondents in Balik Bukit Subdistrict Based on Villages

No	Pekon Name	Number Of Farmers	Farmer Sample
1	Sebarus	71	9
2	Sedampah Indah	53	7
3	Wates	47	6
4	Bahway	75	10
5	Gunung Sugih	49	7
6	Padang Cahaya	32	8
7	Padang Dalom	64	4
8	Sukarame	53	7
9	Way Empulau Ulu	70	9
10	Way Mengaku	95	13
11	Pasar Liwa	62	8
Total sample (n)			70

Source:Publication of the Plantation Department of West Lampung, Data Processed (2025)

Data Analysis

The analysis method used is Ordinary Least Squares (OLS), with tests including the Four Classical Assumptions Test (Normality, Heteroscedasticity, Autocorrelation, Multicollinearity) and Hypothesis Testing (T-Test and F-Test) (Maharani et al., 2014).

a. Cobb-Douglas Production Function.

$$Q = f(L,K,T)$$

b. Derivative of the Cobb-Douglas Production Function:

$$Q=A \cdot L^{\alpha} \cdot K^{\beta}$$

The data analysis model used to measure the impact of the number of coffee trees, labor, education level, pesticide use, fertilizer use, and coffee farmer experience on the income of Robusta coffee farmers is an econometric model with

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Ordinary Least Squares (OLS) analysis technique. The model equation is as follows:

$$\ln Y = a + \beta_1 \ln JPK + \beta_2 \ln TK + \beta_3 \ln LL + \beta_4 \ln PP + €$$

Description:

Y = Coffee Production (Kg/Ha)
a = Constant
β = Coefficient
JPK = Number of Coffee Trees (Trees)
TK = Amount of Labor (PWD)
LL = Land Area (M^2)
PP = Amount of Fertilizer Use (Kg)
€ = Standard Error

DISCUSSION

The Effect of the Number of Coffee Trees on Coffee Production in Balik Bukit District

The test results indicate that the number of coffee trees has a positive and significant effect on Robusta coffee production. A regression coefficient of 0.225983 suggests that each additional coffee tree increases production by approximately 0.23 kg in Balik Bukit District.

An increase in the number of coffee trees will drive higher production yields. This result aligns with the study by Azzahrah et al. (2023), which showed that the more coffee trees a farmer owns, the higher the percentage of production per harvest season.

This finding is also consistent with the research by Indarwati et al. (2022), which demonstrated that the number of plants significantly affects coffee production—the more plants, the higher the yield. However, this increase must be supported by the use of high-quality seedlings to maximize output. This result is also relevant to David Ricardo's production theory (1772–1823), which states that there is a relationship between input and output in the production process. According to this theory, continuous increases in production input will yield additional output that gradually diminishes after reaching a certain point (Malthus et al., 1917).

The Effect of Labor on Coffee Production in Balik Bukit District

The significance test results show that the labor regression coefficient is 0.146665 with a probability value of 0.0268, indicating a positive and significant influence. This

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means that labor—predominantly male—contributes to an increase in coffee production by approximately 0.146665 kg. Some large-scale coffee farmers employ 5–7 workers, mostly relatives, and hire additional outside labor during the harvest season on a wage basis. Outside the harvest period, garden maintenance is usually done by the farmers themselves. To prevent fruit drop during harvesting, farmers increase the number of workers. The majority of farmers (74%) work an average of 3 hours per day, while only 8% work 5 hours, resulting in an average working time of about 3 hours per day for coffee farmers.

These results are in line with the findings of A. Putri et al. (2018), which showed that labor has a significant effect on production, where additional labor can increase coffee yields. Mankiw (2000) also stated that optimal utilization of labor will improve output. Similar findings were reported by Indarwati and Choibar (2022), who noted that most labor is used during the harvest season and is dominated by males (56.8%) compared to females (43.2%).

The Effect of Land Area on Coffee Production in Balik Bukit District

The significance test shows that land area has a positive and significant effect on coffee production, with a regression coefficient of 0.804629 and a probability of 0.0000. These results support the hypothesis that the larger the land area, the higher the coffee production of farmers in Balik Bukit District. Farmers with land larger than 1 hectare tend to be able to plant more coffee trees and increase production. This is in line with David Ricardo's production theory, which states that an increase in input will increase output, although the additional yield will decrease after a certain point.

Research by Titisantri (2024) shows that land area significantly influences coffee production. This finding aligns with Mubyarto's (1989) opinion that the larger the land area, the higher the production yield. Land plays a crucial role in determining the amount of production, and its limitations can reduce the harvest potential.

The Effect of Fertilizer Use on Coffee Production in Balik Bukit District

The significance test shows that fertilizer use (PP) has a positive and significant effect on coffee production, with a regression coefficient of 0.097274 and a probability of 0.0159. This means that each increase in fertilizer use will add 0.097274 kg to Robusta coffee production per harvest season.The results show that the regression coefficient for fertilizer use (LN_PUPUK) is 0.097274, meaning that every 1% increase in fertilizer use will increase coffee production by 0.0973% (in logarithmic scale), with other variables held

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constant. Effective fertilizer use has a positive and significant impact on coffee production, indicating that proper fertilizer management can improve crop yields. Educational support and the provision of quality fertilizers by the government or related agencies will help increase productivity and the welfare of coffee farmers.

This research aligns with the findings of Rohani (2024), which show that capital and fertilizer use significantly influence Robusta coffee production, while land area and labor have little impact. This indicates that the management of technical inputs such as capital and fertilizer has a greater effect on coffee production. Therefore, strategies to improve coffee production should focus on access to capital, efficient fertilizer use, and the development of sustainable agricultural technologies.

Determination of Economies of Scale

Table 3. Determination of Economies of Scale

Variable	Coefficient (β)
Ln(Number of Coffee Trees)	0,2259
Ln(Labor)	0,1466
Ln(Land Area)	0,8046
Ln(Fertilizer Use)	0,0972
Total	1,2743

Source: Multiple Linear Regression Results, Data Processed (2025).

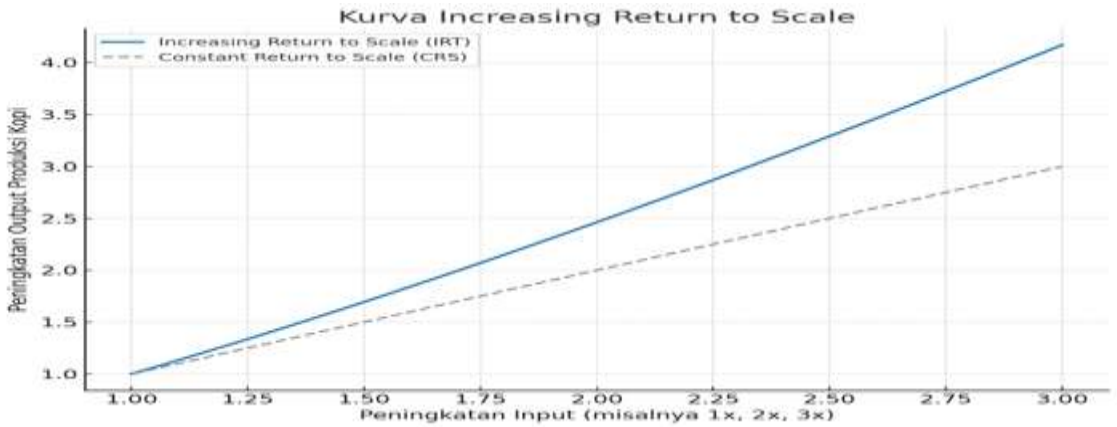
Based on the results of the multiple linear regression presented in the table, the influence of each variable on coffee production and the decision regarding return to scale (IRT or DRT) can be analyzed. The number of coffee trees (LN_JPK) with a coefficient of 0.225983 shows that an increase in the number of coffee trees contributes positively to production, indicating the potential for IRT, as this increase in input has the potential to significantly boost output. Labor (LN_TK) with a coefficient of 0.146665 also shows a positive influence, meaning that an increase in labor contributes to increased production, supporting IRT, especially when well-managed. Land area (LN_LL) with a coefficient of 0.804629 has the most significant influence on production, indicating that an increase in land area can increase production proportionally, supporting the decision for IRT. The use of fertilizer (LN_PUPUK) with a coefficient of 0.097274 also contributes positively to

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production, although its impact is smaller than the other variables, but still supports IRT, albeit with a more limited effect.

Based on the regression results, the decision regarding return to scale (IRT or DRT) can be determined by considering the influence of each variable on output. Increasing return to scale (IRT) is the right decision if all independent variables show a positive and significant influence on output, because increasing all inputs—such as the number of trees, labor, land area, and fertilizer use—can increase coffee production more than proportionally. On the other hand, decreasing return to scale (DRT) may be considered if any variable shows a negative influence or if increasing inputs does not result in a proportional increase in output. However, in this regression result, all variables show a positive influence, so the decision to increase return to scale is more appropriate. Increasing all production factors has the potential to significantly boost output, which in turn can improve the welfare of coffee farmers in Balik Bukit.



Source: Author's Documentation, 2025

Picture 1. Curve of Increasing Return to Scale in Coffee Production.

This graph illustrates the relationship between input and output increases in coffee production with two curves: Increasing Return to Scale (IRT) and Constant Return to Scale (CRS). The IRT curve shows that an increase in inputs results in a more than proportional increase in output, with an increasingly steeper slope. In contrast, the CRS curve represents a linear relationship where input increases are proportional to output. The IRT curve being higher than the CRS indicates that adding inputs can significantly increase coffee production, reflecting a more efficient use of resources

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CONCLUSION

This study shows that the number of coffee trees, labor, land area, and fertilizer use have a positive and significant effect on coffee production in Balik Bukit Subdistrict, West Lampung. Farmers with more coffee trees, longer working hours, land areas above 1 hectare, and proper fertilizer use tend to produce higher coffee yields. Overall, these four variables significantly contribute to the increase in coffee production in the area.

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