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## Research Article

# Technical Efficiency and Affecting Factors Analysis of Soybean Production in Southeast Sulawesi, Indonesia

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## Abstract

**Background and Objective:** The agricultural sector has an important role in long-term economic development. The development of the agricultural sector aims to fulfill the needs of food and nutrition as well as to increase the community's income and welfare. Soybean is a food source that produces vegetable protein. Its protein plays a role in improving people's nutrition. This study aims to: (1) Determine the level of technical efficiency of soybean farming, (2) Find out the factors that influence the production of soybean farming.

**Materials and Methods:** This study was carried out from January to June, 2019 in Southeast Sulawesi Province, by selecting three districts as the main producers of soybeans. The sample as 186 farmers was selected based on the multistage cluster random sampling. The data analysis method used the Stochastic Frontier 4.1c production function and the linear function analysis of the Cobb Douglas.

**Results:** The results showed that the average technical efficiency of soybean farming was 0.64 or 64%. In terms of the allocation of production factors, the area of land, seeds and fertilizers was positive and significantly effecting production factors of soybean farming.

**Conclusion:** The results of the analysis and discussion showed that the average technical efficiency was 0.64 or 64%. The index means that soybean farming in Southeast Sulawesi Province had not been efficient. Factors that have a positive and significant effect on the production of soybean farming in Southeast Sulawesi Province are land area, seeds and fertilizer.

**Key words:** Technical efficiency, production factors, affecting factors analysis, soybean, fertilizer

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

The agricultural sector has an important role in long-term economic development. The development of the agricultural sector aims to fulfill the needs of food and nutrition as well as to increase the community's income and welfare. Besides rice and corn, soybeans are also a priority crop of the government through program of PAJALE (paddy, corn and soybean). Soybean is one of the strategic commodities in Indonesia. Soybean is a food source that produces vegetable protein. Its protein plays a role in improving people's nutrition. The need for soybean gets more increasing as the number of population and customer grow higher. According to Sanful and Darko<sup>1</sup>, the crop virtually does not contain sodium, a mineral that causes fluid retention in tissues; consequently, soybeans are effective in preventing cardiovascular diseases. Soybeans also contain trace elements such as copper, zinc and manganese.

The average amount of domestic soybean production in the last 5 years was 982.47 t of dry beans or 43% of the national needs. The increasing demand for soybeans which is not followed by soybean production, it then induces a gap rate between demand and supply. In the short term, the way to overcome this is to implement an import policy. However, these import policies must be appropriate for long-term food sovereignty. Thus, the government through the Ministry of Agriculture of Republic of Indonesia proclaimed 2018 as the year of soybean production<sup>2</sup>. The authorities have been doing various efforts, to achieve this goal, one of which is to increase the area of planting land through by maximizing of idle land<sup>2</sup>. Besides, soybean farmers can also use paddy fields after the rice harvest period. This farming pattern is quite common in some regions. Southeast Sulawesi Province is one of the provinces that cultivate soybean food crops. When viewed from the amount of production, land area and soybean productivity in Southeast Sulawesi Province from 2004-2018 had fluctuated. Total soybean production in 2004 was 2.381 tons and in 2018 it was 9.853 t. The average land for soybean food plants for fifteen years was 4.644 ha. The average soybean production was 5.759 t and the average soybean crop productivity was 11.82 t ha<sup>-1</sup>. The data related to production, land and soybean crop productivity can be seen in Table 1.

Based on the data in Table 1, it is evident that Southeast Sulawesi Province is one of the soybean production centers in Sulawesi. However, from the amount of production, the use of arable land and the productivity level are still not optimal. Therefore, it needs continuously developing. Soybean production can be optimized through increased productivity supported by the use of production factors appropriately and

Table 1: Land area, production, productivity of soybean food plants in Southeast Sulawesi province in 2004-2018

Year	Harvested area (ha)	Production (t)	Productivity (t ha <sup>-1</sup> )
2004	2868	2.381	8.30
2005	3580	3.069	8.57
2006	3499	2.982	8.52
2007	3719	3.374	9.07
2008	4101	3.812	9.30
2009	6719	5.615	8.36
2010	2661	3.204	12.04
2011	5814	6.113	10.51
2012	3870	3.710	9.59
2013	3735	3.595	9.63
2014	5071	5.684	11.20
2015	7888	12.799	16.23
2016	8289	16.136	19.47
2017	2425	4.055	16.72
2018	5421	9.853	18.18

Source: Department of Agriculture of Southeast Sulawesi, 2018

efficiently such as technological development like quality superior seeds, tools and machinery, cultivation improvement, pest control and plant diseases, post-harvest handling, wide planting area, utilization of idle land and the skillful farmers. This is in line with the theory conveyed by Soekartawi<sup>3</sup>, that the causes of high and low level of production are influenced by the level production factors. The main purpose of a farmer is certainly a source of livelihood to fulfill family needs. Therefore, a farmer must be trained to be able to conduct good farming with the use of appropriate, effective and efficient production factors. Muin<sup>4</sup> states that most farmers do not implement factors of production optimally which then it causes a decrease in production and low income.

Soybean is a bush dorm plant that grows upright. This plant is one type of legumes which is the basic ingredient of many Asian typical foods such as soy sauce, tofu, tempeh and many others. Soybean is a subtropical plant which mostly grows in Asian regions such as China and Japan. Indonesian people began to recognize soybean plants since the 17th century. The distribution begins on the island of Java, Bali, Nusa Tenggara and other islands<sup>5</sup>. According to Arif<sup>6</sup>, efficiency is the ratio between out put with the target. Efficiency performance is measured by the comparison of the out put and in puts. Fitri *et al.*<sup>7</sup> states that's the ability of farmers to achieve maximum out put from the use of various factors of production is a reflection of the study of technical efficiency analysis. Technical efficiency can be achieved if to produce a certain amount of out put using the smallest combination of in puts (in physical units).

The production function explains the physical relationship between the amount of real input and output produced. To be able to explain the physical relationship, one of the models

that can be used is the Frontier production function. This production function is to analyze the efficiency or inefficiency of a production process technique. Aigner *et al.*<sup>8</sup> were the first figures to develop the frontier production model. Frontier deterministic parametric models do not consider the possibility of factors outside the company's control that are thought to affect the production process. Therefore, a parametric stochastic frontier analysis model was developed to measure the unexpected effect (stochastic effect) within the production limit. In the stochastic-frontier approach includes the alleged frontier production function in which production output is a function of production factors, random errors and technical inefficiencies.

The Stochastic Frontier production function according to Coelli *et al.*<sup>9</sup> can be written in the equation:

$$Y_i = x_i \gamma_i = x_i^b e^{\epsilon_i}$$

Production is influenced by several factors involved in the production process. One production function that has been widely used in economic studies is the Cobb-Douglas production function.

The Cobb-Douglas Production function can be written as follows<sup>3</sup>:

$$Y = aX_1^{b_1} X_2^{b_2} \dots X_n^{b_n} e^u$$

where, Y is the variable explained, X is the variable that explains, a, b is the amount to be expected and e is the error.

To simplify the estimation, it is then converted into a form by equating the equation to:

$$Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + \dots + b_n \log X_n + e$$

The production factor is defined as all the sacrifices enable crops to grow well and produce well. Classifying factors that affect production into 2 major groups are: (1) Land biological factors like seeds, fertilizers, pesticides and others, (2) Socio-economic factors such as production costs, labor prices, education levels, management and others<sup>3</sup>. According to Manurung and Mandala<sup>10</sup>, based on its relationship with the level of production, factors of production are divided into fixed and variable factors of production. The fixed factor of production is a factor whose number of uses does not depend on the amount of production. The presence or absence of production factor production must remain available. The variable production factor depends on the amount of production.

Studies related to the implementation of soybean farming using efficient technical analysis in the use of farming inputs in Southeast Sulawesi Province and what factors can affect soybean farming production are not yet comprehensively known. For that reason, the researcher is interested in carrying out research related to this topic. The purpose of this study is (1) To determine the level of technical efficiency of soybean farming and (2) Knowing the factors that influence soybean farming production in Southeast Sulawesi Province.

## MATERIALS AND METHODS

This research was conducted from January to June, 2019, in Southeast Sulawesi Province in 3 different regencies, namely Konawe, Kolaka and South Konawe. The locations were carried out purposively with the consideration that these regions are the main potential soybeans productions Southeast Sulawesi Province. The researcher chose one village which was active in soybean farming. The numbers of respondents were 186 people who were selected using multistage cluster random sampling. To find out the technical efficiency analysis of soybean farming, this research used analysis of the production function of stochastic frontier 4.1c. The value of technical efficiency index can be categorized as technically efficient if its value is 7, 0.7 and categorized as not efficient<sup>11</sup> if its value is 7, 0.7. To find out the factors that influence soybean farming production, it is analyzed by the linear function of Cobb Douglas model. The Cobb-Douglas function is showed as follows<sup>3</sup>:

$$Y = \beta_0 + X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + X_5\beta_5 + X_6\beta_6 + X_7\beta_7 + e$$

The equation is transformed into the natural logarithmic multiple linear:

$$\ln Y + \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + e$$

where, Y is the soybean production (t),  $\beta_0$  is the constant,  $\beta_1 - \beta_7$  is the elasticity of production of the i-th production factor (i = 1, 2, 3, ... 7),  $X_1$  is the seed use (kg ha<sup>-1</sup>),  $X_2$  is the use of NPK fertilizer (kg ha<sup>-1</sup>),  $X_3$  is the pesticide use (L ha<sup>-1</sup>),  $X_4$  is the labor usage (people's day work) and  $X_5$  is the land area (ha).

**F-test (simultaneous):** The results of the F-test analysis presented that the significance value of the F-test is  $0.000 < \text{value } \alpha = 0.05$ . It can be explained that the variable seeds, fertilizers, pesticides, labor and land together have a significant effect on production soybeans in South Sulawesi Province.

**T-test (partial):** T-test analysis results can be explained partially. Land area regression coefficient ( $X_1$ ) of 342.532 had a positive and significant correlation to the production of soybean farming with a significance value was  $0.000 < \alpha = 0.05$ .

## RESULTS

**Analysis of technical efficiency of soybean farming:** Analysis of the technical efficiency of soybean farming is related to farmer's managerial ability. The distribution of technical efficiency of soybean farming in Southeast Sulawesi Province is presented in Table 2.

Based on the results of the Stochastic Frontier analysis (Table 2), from 186 farmers, 122 farmers or 65.6% have not yet reached technical efficiency because the TE value is  $\leq 0.7$ . Farmers who have an index below 0.7 are farmers who have not been efficiently farming soybeans. Therefore, they can be targeted in counseling to improve farming management properly, effectively and efficiently. Furthermore, 64 soybean farmers or 34.4% have achieved technical efficiency as indicated by the value of TE is 0.7%.

Factors that Influenced Soybean Farm Production: Production factors (inputs) must be managed properly and correctly so that the results will also be optimal and in line with expectations. According to the result, the study shows that the correct use of production factors will be the determining factor for farm success. There has been a change of paradigm that was oriented towards output or production

Table 2: Analysis of the technical efficiency of soybeans in Southeast Sulawesi Province

Technical efficiency	Number of farmers	Percentage
TE $\leq$ 0.7	122	65.6
TE $>$ 0.7	64	34.4
Total	186	100
Minimum TE	0.3452	
Maximum TE	0.8019	
Average TE	0.64	

Source: Primary data, TE: Technical efficiency

Table 3: Results of regression analysis of soybean farming production factors

Variables	Coefficient regression		Partial test
	B	T	Significance
Constant	72.435	0.845	0.430
Land width ( $X_1$ )	342.532	6.142	0.000 <sup>s</sup>
Seeds ( $X_2$ )	8.453	0.721	0.042 <sup>s</sup>
NPK fertilizer ( $X_3$ )	3.845	3.293	0.002 <sup>s</sup>
Pesticide ( $X_4$ )	-41.246	-1.285	0.280 <sup>ns</sup>
Employee ( $X_5$ )	-0.084	-0.284	0.058 <sup>ns</sup>
F (simultaneous test)		2420.171	0.000 <sup>*</sup>
Determination coefficient ( $R^2$ )	0.992		
R-value	0.998		

Source: Primary data, ns: No significant, s: Significant, \* $\alpha$ : 0.0.5

results. It lifts to an income oriented farmers. Cobb-Douglas production function model was used to find out the factors that influenced soybean farming production in Southeast Sulawesi Province.

The results of regression analysis as presented in Table 3 can be explained by the form of an equation as follows:

$$Y = 72.435 + 342.532 \ln X_1 + 8.453 \ln X_2 + 3.845 \ln X_3 - 41.246 \ln X_4 - 0.084 \ln X_5 + \ln e$$

**Coefficient determination ( $R^2$ ):** The coefficient of determination ( $R^2$ ) value is 0.992. This shows that 99.2% of the contribution of soybean production variables in Southeast Sulawesi Province can be explained by the free variable land, seeds, fertilizers, pesticides and labor. The other 0.8% can be explained by other variables which are not included in the model this regression.

## DISCUSSION

Based on the results, the average technical efficiency of soybean farming in Southeast Sulawesi Province is 0.64. This means that the average productivity achieved is around 64% of the frontier which is the maximum productivity limit (the best practice). The average value of technical efficiency is still below 0.7 or 70%, which means that the average soybean farmer in Southeast Sulawesi Province has not achieved technical efficiency and still does not reflect good farmer managerial skills. This can be seen from the production and productivity of soybean farmers which so far have not been optimal. However, it still has a 36% chance to be able to increase productivity by optimizing the use of farming inputs, technological innovation and improving farm management. According to Tanjung<sup>11</sup>, the technical efficiency can be said to be efficient if it is 0.7 and the value of technical efficiency is categorized as inefficient if its value is  $\leq 0.7$ . The production factors determined the size of soybean production. The important factors of production are used such as land, seeds, fertilizers, pesticides, labor and management<sup>3</sup>.

The result of research shows that each additional land per unit would increase the amount of soybean farm production by 342.532 units and the other way around. As a result, it can be said that the more extensive the land, the more efficient the production of soybean farming will be. It was because the land has a high economic value. The large and fertile land had a higher value and the large but infertile land. The results of the analysis were under the opinion of Mamondol<sup>12</sup> which stated that the scale of business and whether or not an efficient agricultural business is influenced by the area of land owned.

Seed regression coefficient ( $X_2$ ) with a value of 8.453 had a positive and significant correlation to the production of soybean farming whose significance value is  $0.043 < \alpha = 0.05$ . This showed that adding one unit of seed can increase soybean production by 8.453 units and the other way around. This is in line with Supadi<sup>13</sup> who revealed that the procurement of quality soybean seeds and available during the planting period is a strategic effort to increase soybean production.

Fertilizer regression coefficient ( $X_3$ ) with a value of 3.845 has a positive and significant correlation to the production of soybean farming whose significance value is  $0.002 < \alpha = 0.05$ . This shows that each addition of one fertilizer unit can increase soybean production by 3.845 units. The pesticide regression coefficient  $X_4$  and labor  $X_5$  were -41.246 and -0.084, respectively, which were negatively correlated and not significant with significance values of 0.280 and 0.058  $\alpha = 0.05$ , respectively. This means that the pesticide variable had no significant effect on the production of soybean farming. This was by the opinion of Badrudin and Jazilah<sup>14</sup> which stated that negative impacts were arising from the use of pesticides to environmental pollution. It also disrupted the health of living-being and can reduce crop production. This is in accordance with the opinion Linh<sup>15</sup>, that provided plenty information on farmers at farm level; however fertilizer costs were used to estimate technical efficiency because of unavailable data on fertilizer quantity.

Labor also had no significant effect on soybean production because the use of labor is effective and efficient only at the beginning and end of the production process. The use of the right technology also can replace or reduce the use of human labor. According Etwire *et al.*<sup>16</sup>, that extension services could be improved through scaling up of current agricultural interventions, implementation of new agricultural projects, employment of more agricultural extension agents, improvement in logistical support for agricultural extension agents among others.

## CONCLUSION

The results of the analysis and discussion showed that the average technical efficiency was 0.64 or 64%. The index means that soybean farming in Southeast Sulawesi Province had not been efficient. Factors that have a positive and significant effect on the production of soybean farming in Southeast Sulawesi Province are land area, seeds and fertilizer.

## SIGNIFICANCE STATEMENT

The increasing demand for soybeans which is not followed by soybean production, it then induces a gap rate between demand and supply. In the short term, the way to overcome this is to implement an import policy. However, these import policies must be appropriate for long-term food sovereignty. This study will help the researcher to determine the level of technical efficiency of soybean farming and find out the factors that influence the production of soybean farming. Thus, a new theory that's the positive and significant effect on the production of soybean farming in Southeast Sulawesi Province i.e.: land area, seeds and fertilizer

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