PERFORMANCE OF SOYBEAN FARMING IN JAVA - INDONESIA: DETERMINANTS AND IMPROVEMENT STRATEGIES

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ABSTRACT

The objective of this study is to analyse the performance and technical efficiency of soybean production in Indonesia. This study was conducted in Grobogan Regency, a district in Central Java, the Indonesian soybean production centre. Four hundred soybean farmers were selected for interview. The data observed are in the form of farm characteristic, capital, and production cost. Stochastic frontier production is used to analyse the technical efficiency of using production factors on soybean production income. This is considered the main culprit of the very low productivity of soybean. Further, the inefficiency model shows that no significant factor affecting efficiency. This is understandable since the production system is in the irrational stage. The main factor that is possible to influence such a condition is the level of education. On average, the level of farmers' education is just elementary school and junior high school. This condition leads to failure in adopting technology in the soybean farming system as farmers might misunderstand the advanced technology. The stochastic efficiency results indicate that this variable does not affect efficiency. Technical efficiency in soybean cultivation in Indonesia is very low. A comprehensive improvement strategy must be carried out for improvement to increase production to reduce dependence on imports.

Keywords: Economic Performance, Soybean Production, Technical Efficiency, Stochastic Efficiency.

JEL classification: Q10, Q12, Q13

INTRODUCTION

Soybean is an important commodity in Indonesia. The commodity is one of the foods consumed for daily diets. As the Indonesian population grows gradually, the consumption of soybeans follows leading to very high demand for soybeans. But soybean production is deficient (Mariyono, 2019a). This condition causes the government to import soybeans. Every year the Indonesian government has to import soybeans 85% of the national soybean needs. Efforts should be made to improve soybean production performance.

Soybean consumption in Indonesia is very high because the processed soybean products such as tofu, tempeh and other processed soybean products are top-rated from the Indonesian perspective. The quantity of imported soybean in Indonesia is very high; therefore, it is necessary to increase soybean production. The problems often faced by farmers' soybean business is semi-subsistence farming (Mariyono, 2019b), and consequently performance of soybean farming is low, as well as production and productivity. This leads to uncompetitive production in the global market. Patyka et al. (2021) suggested that production needs to be competitive to become an effective locomotive in the national economy.

Soybean production performance in Indonesia is still low due to the limited use of technology. Several researchers have analysed the use of technology in soybean production (Battisti et al., 2020; Mourtzinisa et al., 2021). Efficient use of technology is crucial to improve soybean performance. A study states a positive correlation between the amount of land and agricultural productivity (Wang et al., 2020).

There were three types of efficiency, such as technical efficiency (TE), allocative efficiency (AE), and economic efficiency (EE) (Constantini & Bacenetti, 2021). Decision making (DM) is a feasible output is obtained from a certain set of inputs or from a minimum number of feasible inputs to produce TE, while the latter definition is referred to as input-oriented TE, as referred to as the previous definition. The ability of a TE DM use optimal inputs in proportions that minimise production costs given input prices was called AE. The product of both TE and AE was called EE. Therefore, we can be called both technically and allocatively efficient when a DM was efficient. The study aims to measure TE and formulate strategies for improving soybean farming in Indonesia.

LITERATURE REVIEW

Soybean business productivity is strongly influenced by the ability to increase TE and land productivity and to minimise risks (Adusumilli et al., 2020; Asodina et al., 2020). Further, the stochastic approach was a predominance of methods for evaluating the net benefits associated with the adoption of cover crops along with various nitrogen levels in the first and second-tier untreated corn systems (Battese & Coelli, 1995). They further found that crops grown after other crops were concluded as a risk-saving alternative for farmers that reduced the risk of adopting a good agricultural system.

Willingness to pay to maintain or modify by decision-makers usually uses stochastic methods. Modelling attitudes, estimating risk premiums, many risks were the reason why stochastic is applied. An effort to increase the TE and EE using stochastic efficiency analysis needs to be conducted to improve crop farming (Belete, 2020). Stochastic production frontier analysis shows that the wheat production system and the intensive cropping system with land cultivation using conventional methods are considered technically and economically inefficient compared to the intensive cropping system. Battese & Coelli (1995) use stochastic production limits to measure efficiency, while a functional approach to analyse the relative economic feasibility of using production crop systems and compare conventional production.

This condition needs to be improved both technically and economically, which is inefficient. Farmers tend to be very risk-averse and tend to prefer moderate systems that sequester less carbon because the potential for increased risk tends to increase returns. We used stochastic efficiency methods to examine the net benefits of a sustainable crop production system (Bewley et al., 2010; Bibi et al., 2020). Economic efficiency was measured in order to increase farmers' income to be higher. Fertilisers used in optimal amounts are a viable alternative to conventional farming. Farmers' income, which is risk-free to risk-averse, shows a data set of experiments carried out over the long term to determine the effect of four crop with tillage systems on optimal nitrogen use levels, increasing net income and yields (Battisti et al., 2020). Other researchers used a stochastic model in which risk was used to calculate the risk of farmers' decisions to plant crops and implement more profitable tillage systems. Reducing the risk of crop cultivation by increasing efficiency will increase farmers' income. The researchers found that farmers prefer conventional tillage systems but find that when farmers' efforts to reduce risk are successful, income from agriculture increases. The efficiency of the agricultural business by using stochastic efficiency will increase income. The productivity, which has been widely researched, is carried out with various models and objectives. Several studies were conducted to determine the sources and determinants of productivity in various sectors, such as agriculture (Bravo-Ureta et al., 2007).

The results of the research have been used to recommend the right policies for increasing productivity, and it is hoped that the positive impact of increased productivity will be projected on the economy in a country. Agriculture has been researched regarding its productivity, as well as the factors that influence it. Research has been carried out to investigate productivity in various countries, regions, national and provinces. Based on data and commodities, research has also been conducted using national and international data to measure productivity. Research on the use of stochastic efficiency focused on the productivity of the agricultural sector, both soybeans, corn and other commodities. Other studies (Farrell, 1957; Goodness & Gupta, 2018) attempt to pay attention to agricultural productivity growth related to technological innovations over the last few years. Mariyono (2018) has found that spending on research, education and irrigation infrastructure development is important to determine the performance of the agricultural sector.

There is no empirical evidence to suggest a slowdown in growth in agricultural productivity if the agricultural infrastructure is done right. Mariyono (2018) stated that agricultural production increased sharply during 1990-2000 in Indonesia. Rice productivity growth with a positive trend can be identified as the advantage of technological innovation applications in the agricultural sector. Other studies by Huang & Jiang (2018) and Jin et al. (2010) investigate TE and productivity of agricultural commodities in China, finding that the application of technology and innovation in the agricultural sector can increase productivity well.

Several previous studies have found that an important factor affecting agricultural productivity growth is an increase in natural, human and technological capital. Important policies that can be taken include land reform and tenure recommendations intended to increase the amount of agricultural production. Investments in education, research and development of agricultural infrastructure was developed to increase human and technological capital. Agricultural TE and productivity growth in China have been identified from investing in research and development capital to drive the success of the agricultural sector (Gomez, 2014).

Júnior & Sentelhas (2019) state that the main determinants of agricultural technical progress, which is a major factor of productivity, are cuts in agricultural taxes and investment in research. Several studies have found that investment in research and development has been shown to be effective at driving innovation in the agricultural sector. Investment also plays an important role in increasing sustainable agricultural productivity. Natural resource management intervention programs have a positive impact on technical changes and technical efficiency. The results of this study give a strong contribution that understanding production improvement intervention programs must also be done to increase farmers' income through increased productivity (Battisti et al., 2020). Productivity is also associated with effective trade policies. Kamali et al. (2017) show that government support greatly affects variations in increasing agricultural productivity. The level of protection and subsidies needs to be increased for rice farming. Differences in agricultural infrastructure development, such as irrigation and input distribution systems also affect rice productivity in Indonesia. The different levels of market openness and high import barriers will also widen the rice productivity gap between developed and developing countries (Mariyono, 2018). Furthermore, Mariyono (2018) states that the role of the public services is needed to increase rice production and productivity.

The reduction and exemption of agricultural taxes is predicted to be one of the determinants of the progress of technical success that contribute to agricultural productivity (Lee & Choe, 2019). Various studies have been conducted to measure the sources that influence productivity growth in the agricultural sector. Three papers (Li-wei et al., 2015, Mariyono, 2018; Mitter & Schmid, 2021) tried to analyse agricultural productivity in several countries and found that the production technology that has been applied has made various advances, but there is a decrease in technical efficiency, in addition, different combinations of input and output will drive changes to increase productivity. in the agricultural sector. Technical change is the main driver in increasing productivity in the agricultural sector (Ogundari et al., 2010). In Brazil, improvements in technical efficiency marked by technical progress have contributed to the observed acceleration of agricultural productivity growth rates and have an effect on the development of the agricultural sector as a whole (Jin et al., 2010).

There is very limited evidence that agricultural productivity is achieved through increased technical efficiency. Advances and improvements in agricultural innovation technology are very supportive of increasing agricultural productivity. Investments in agricultural research and well-done technology adoption positively affect agricultural productivity growth (Gomez, 2014). Decreasing farming implies that production costs increase with increasing agricultural production and cost efficiency occurs, but this is not followed by an increase in productivity (Shee & Stefanou, 2015; Sanneh et al., 2001). The study found that land area is not related to agricultural productivity growth, but the effective application of innovative technology will increase agricultural productivity (Caudill, 2003).

Previous research has shown that the efficiency of the production scale is a positive and significant source of growth in agricultural productivity; increasing production scale will increase productivity. Inefficient use of resources shows the inability of farmers to reduce production costs, which results in low technical efficiency. Thus, achieving sustainable agricultural transformation in South America will require more efforts to improve technical efficiency in the agricultural sector. Farmers can only achieve technical efficiency through the efficient use of productive inputs (Mahama et al., 2020). The source of productivity growth advances in the use of technology, and to reduce regional disparities, it is getting worse due to low efficiency (Mariyono, 2018). A study by Wang et al. (2010) showed that the allocative technical efficiency component is a factor that negatively affects productivity performance. Inputs that are not allocated in the right proportion and in accordance with needs are not selected for a combination of inputs that reduce production costs; this is related to the characteristics and efficiency of the use of inputs and labour. Inefficient agriculture is indicated by poorly trained workers, and this can hinder the use of inputs adequately and in the right proportions, both in terms of quantity and quality.

Mariyono (2018) and Ogundari et al. (2010) analysed the effect of increasing agricultural efficiency on the total factor productivity (TFP) of small-scale farmers and the impact of increased productivity on income. Bravo-Ureta et al. (2007) and Mariyono (2018) revealed that one of the determinants of positive trends in agricultural productivity is the adoption of superior rice varieties which are applied in the rice agricultural sector.

The farmers indicated that significant efforts were made to increase efficiency. The potential for increasing agricultural output is carried out by increasing technical and economic efficiency. Improved technical efficiency and economic coverage will provide significant productivity gains in the short, medium and long term. Positive technical changes indicate productivity. Mariyono (2019c & d) propose that credit in the agricultural sector should be made available adequately to farmers for financing agricultural technology adoption.

Further agricultural development programs should be implemented to increase agricultural productivity in several countries (Bravo-Ureta et al., 2007). Agronomic technology is thought to be one of the sources that indirectly affects agricultural productivity (Mariyono, 2019c). Efforts to increase technical efficiency need to be carried out continuously to affect agricultural productivity.

The improvement of rice varieties has changed the focus before is high production to be high quality in several countries around the world (Farrell, 1957; Scaillet & Topaloglou, 2010). Rice productivity has been stagnant in terms of production in several countries. While according to Mariyono (2018), the income disparity between the agricultural and non-agricultural sectors has increased in Korea compared to Japan. This is due to an excess supply of rice due to a decrease in rice consumption per capita along with economic growth, which is increasing. Large-scale rice production in farm households is not seen in either Japan or Korea. Mahama et al. (2020) encourage the government to continue to encourage more efficient technical innovations to be applied in the agricultural sector in Indonesia. Renewable energy innovation drives the speed of technological progress faster than technical and economic efficiency. Technological changes make a significant contribution to the increase in TFP.

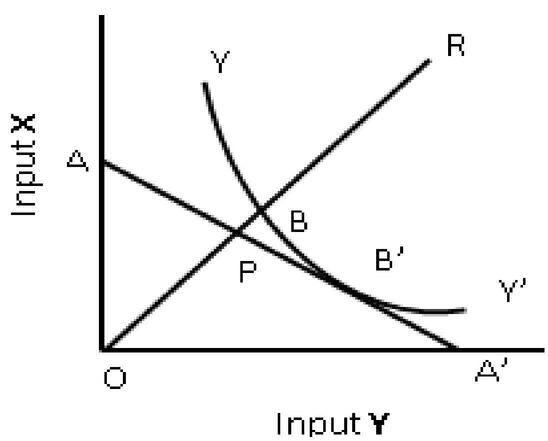
Mariyono (2018) states that policies in the agricultural sector, technical progress that coincided with the loss of TE, are highly dependent on technical advances and technological advances that have not been adequately disseminated in Indonesia. Agricultural production must rely on the spread and innovation of advanced technology to utilise the natural resources owned by the country. The research was tried to analyse the components of agricultural productivity and link them with policies that need to be done to increase agricultural productivity. The increase in TFP in agricultural production is indicated to have specific distinguishing features compared to other sectors.

Technical factors and random factors very clearly illustrate the changing trends and characteristics of agricultural productivity. To increase the efficiency of agricultural production, several policies that support agriculture are needed. Government policies need to be implemented to improve better technical efficiency. Measures such as encouraging the standardisation of land-use change, operating agricultural land towards a more suitable business scale, strengthening agricultural infrastructure development in rural areas and increasing investment in human resources through training are forms that show that one of the main obstacles faced is increasing agricultural productivity.

Improving effective extension programs (Huang & Jiang, 2018) encouraging more farmers to improve their informal education will have a positive and significant impact on improving the technical efficiency of farmers (Gomez, 2014). Increasing market competitiveness for agricultural products and other factors will reduce transaction costs resulting in relatively high prices at the farm level. Encouraging more optimal cropping patterns and input use, and enabling farmers to realise more efficient agriculture and identifying the factors leading to the use of more optimal amounts of fertiliser, in particular, and taking the necessary strategic steps to address significant and direct impacts on agricultural productivity. Farmers are still operating on a small scale under economies of scale, a competitive market that will have a significant impact on agricultural productivity. Increasing the efficiency and total scale of production will have a cumulative effect on total agricultural productivity.

An important factor in agricultural productivity research is identifying sources of productivity growth, measuring whether productivity arises from the acquisition of fundamental technological advances, technical efficiency and scale of production. Policies and performance management are reformed to improve technical efficiency. The method applied is to assess agricultural productivity growth. The method commonly used has assumptions, such as total efficiency, technical change, allocative technology, and constant production scale. These assumptions tend to be unrealistic and less precise (Mariyono, 2018). The most suitable method for measuring productivity is especially in describing technology-based productivity measures (Jin et al., 2010). Each technique for measuring productivity has its main advantages and disadvantages in productivity modelling and efficiency analysis. However, these methods depend on specific objectives (Júnior & Sentelhas, 2019).

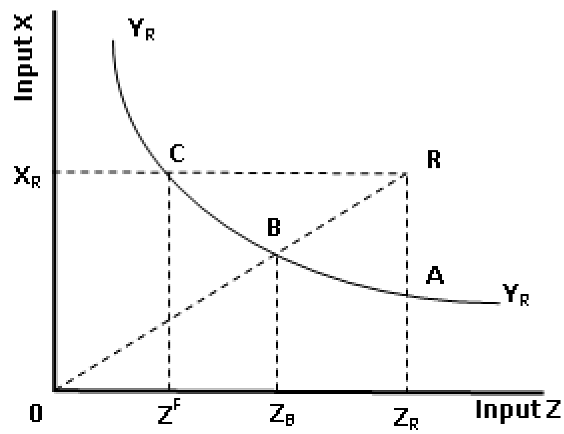
Researchers should select the appropriate productivity indicators depending on the ultimate goal to be achieved: namely measuring TFP or measuring technological changes that result in changes in efficiency both technically and economically (Júnior & Sentelhas, 2019). Productivity analysis has been recognised in several areas of performance evaluation in recent years. The method of calculating productivity, as long as the objective is clear and theoretically accountable; there are no obstacles, so that research on the subject must be carried out validly and reliably. The theoretical framework in Mariyono (2018) explicitly defines the core components of productivity growth should prioritise that the productivity concept is well defined using assumptions suitable for a study. To distinguish between these things. First, this research on productivity allows for non-constant and non-neutral yield scale technological changes. Second, this study relaxes the assumption that producers are in technical and allocative efficiency in production. Third, this study is expressed in physical quantities on valid data (Mariyono, 2018).



Source: Farrell (1957)

FIGURE 1
TECHNICAL EFFICIENCY

The agricultural business which is assumed to use two factors, namely X and Y to produce an output of R, will produce the same scale (Farrell, 1957). As shown in Figure 1, R depicts the combination of the two inputs for work that can be used to produce the output. The output is generated at points R and B so that an isoquant occurs and is displayed at the lower bound of the isoquant YY'. As shown in Figure 1, YY´ isoquants which also have different combinations of the two production factors can be used to produce output for technically efficient agricultural enterprises. Figure 2 shows the efficient combination of two factors of production used in the same ratio as R, and produces the maximum number of OR/OB output from the same number of inputs. Meanwhile, for technical inefficiency, it shows the BR gap, namely the quantity in which all production factors can be reduced proportionally without reducing production output. The agricultural sector, which is technically efficient, uses a ratio equal to 1, even though it is inefficient if the value is less than 1. The technical efficiency is OB/OR. The line shown in the figure by AA´ has the same slope as the proportion of the two factors of production prices (Figure 2).



Source: Reinhard et al. (1999)

FIGURE 2
PRODUCTION FRONTIER

The optimal combination of the two production factors occurs where the isoquant point is tangent to the budget line AA´. Technical efficiency is a relative concept that reflects the level of output relative to the efficient level of output for agricultural enterprises that use the same set of inputs. Efficient at point B´ technically occurs when the optimal combination of the two factors of production. The best production is an efficient frontier in considering both side error terms, including exogenous factors over which the farmer has no control. To produce frontier output levels is impossible for farmers. Additional error terms indicate technical efficiency.

The firm is technically efficient at point B´ with the optimal combination of the two factors of production. Global warming has become the most important environmental problem. Therefore, the optimal combination of the two factors of production is the point where the isoquants intersect with the AA´ budget line. Technical efficiency is a relative concept that provides an output level relative to an efficient output level for farmers using the same set of inputs. The best efficient production boundary is one that takes into account both side error terms, including exogenous factors over which the farmer has no control. For farmers, to produce frontier levels of output is impossible. Therefore, additional error terms will help indicate technical efficiency.

Efficiency is a very important factor that affects the growth of agricultural productivity, especially in developing agriculture when resources are very few and opportunities to develop and adopt better technologies are decreasing (Mariyono, 2018). Technical efficiency analysis is generally associated with the possibility of agriculture producing optimal levels of output. The variation of rice production varies due to technical inefficiencies in rice production in Indonesia (Mariyono, 2018). The existence of a deficiency in productivity means that output can be increased without the need for additional conventional inputs and without the need for new technology.

Many researchers have recently used a stochastic frontier analysis (SFA) approach to analyse technical efficiency in the production of various agricultural commodities; for example, Painii-Monteroa et al. (2020) analyse the SFA approach to evaluate the technical efficiency of agricultural commodities. Anang et al. (2016) compute technical efficiency in agricultural production in northern Ghana. The result is different in the levels of technical efficiency in these countries. Shee & Stefanou (2015) analyse technical efficiency in Colombian food, and the result, overall, companies are technically more efficient than crop farming. The study recommends using agricultural technology at the macro level. Painii-Monteroa et al. (2020) analyse the efficiency of small scale farmers. Research evaluating small-scale food processors is still technically inefficient. Soybean production has been disrupted by volatile economic trends in Asia (Battisti et al., 2020). Several problems plaguing the soybean industry make existing companies develop better than others. Technical inefficiencies such as the use of fertilisers, diseases and the cultivated land are not too significant.

RESEARCH METHOD

Stochastic Efficiency

This study adopted a stochastic frontier analysis method as explained by Painii-Monteroa et al. (2020), which state that a form of an effective stochastic frontier measures the efficiency of agricultural commodity production. By using cross-sectional data, a functional form of stochastic production technology is specified as:

$$Y_i = f(\boldsymbol{X}_i, \beta)\, exp\{\varepsilon_i\} \qquad (1)$$

for $i = 1,2, \ldots$

where Y is output, $\mathbf{X}$ is a vector of inputs, and β is a vector of parameter estimation. The white noise (ε_i) is then broken down as:

$$\varepsilon_i = v_i - u_i \qquad (2)$$

The systematic component v_i seizes random variation in output due to factors beyond the control of the farmer, assumed to be independently and identically distributed (iid) as $N(0, \sigma_v^2)$, independent of u_i measures the technical inefficiency comparable to the best practices as the stochastic frontier. In many empirical studies, it is assumed that u_i it has a non-negative (one-sided) half-normal distribution with $N(0, \sigma_u^2)$. Consequently, based on the assumption that u_i and v_i are independent, the production technology parameters can be assessed using econometric software with the maximum likelihood method. Furthermore, the producer's farm-specific technical efficiency i is defined as the fraction of the conditional expectation of output, given the inefficiency effect, comparative to its expectation if the inefficiency effect is zero. As shown by Battese & Coelli (1988), technical efficiency can be calculated using a formula as follows.

$$\phi_i = \frac{E(Y_i|u_i,\boldsymbol{X}_i)}{E(Y_i|u_i=0,\boldsymbol{X}_i)} = exp\{-u_i\} \quad (3)$$

It is shown that technical efficiency presents between zero and one. When technical efficiency equals one, the actual output is exactly on the stochastic production frontier.

This study applied a one-step procedure to analyse the source of inefficiency. The sources of inefficiency are defined as a function of the farm-specific factors incorporated directly into the maximum likelihood estimation (Coelli, 1996).

Empirical Model

This study utilised a primal approach, or the direct estimation of the production functions, with a functional form of a Cobb-Douglas model as formulated as:

$$ln\, Y_i = \beta_0 + \sum_{k=1}^{4} \beta_k\, ln\, X_{ki} \quad (4)$$

where k=1, 2, 3, 4 represent fertilisers (kg), land (m^2), operating capital (IDR) and labour (man-day), respectively, and ln represents an operation of the natural logarithm.

The Source of inefficiency is modelled as:

$$\mu_i = \delta_0 + \delta_1 AG + \delta_2 ED + \delta_3 FM + \delta_4 GD \quad (5)$$

where *AG* is age of farmers (year), *ED* is education (1= elementary school, 2= junior high school, 3= senior high school, 4= tertiary education), *FM* is number of family members (person), GD is gender (1= male, 0= female).

Hypothesis and Estimation

This study established two hypotheses related to production frontier technology and sources of inefficiency as follows.

Production frontier technology, H_0: $\beta_k = 0$; H_1: H_0 is false
Sources of inefficiency, H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$; H_1: H_0 is false

The production frontier function technology and sources of inefficiency were simultaneously estimated using one-step procedure, run by STATA software.

Study Site

This study was conducted in Grobogan Regency, Central Java, one of the centres of soybean production in Indonesia. The study site can be seen in Figure 3. Four hundred soybean farmers in Grobogan were randomly sampled for a survey to answer the research objectives. Characteristics of farmers, total production, land, number of workers, productivity, cropping patterns, types of diseases, pesticides and fertilisers were observed during January-

December 2020. Production costs for one year were also analysed to understand the level of efficiency of soybean cultivation.

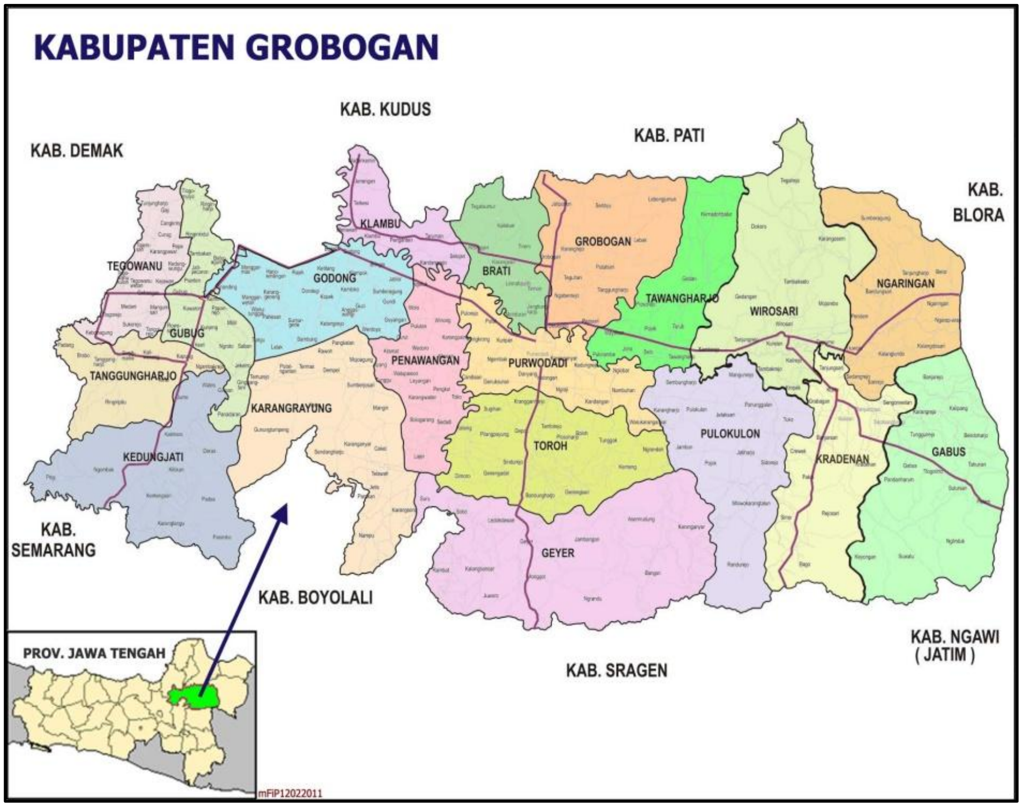


FIGURE 3
STUDY SITE: GROBOGAN DISTRICT, CENTRAL JAVA, INDONESIA

RESULTS AND DISCUSSION

As shown in Table 1, the average amount of land used for soybean production is 0.28 ha. The cultivated land is relatively small, so that production is also tiny. The cropping pattern that farmers usually do is rice-corn-soybean. The variety that farmers often plant is local Grobogan. This variety is native Indonesian germplasm. This variety is included both in terms of production and productivity per hectare. Soybean production per 0.28 ha per period was 615 kg. Farmers have nine years of experience in soybean farming on average. The average farmer is 52 years old, so that age is still categorised as a productive age. About 90% of farmers graduated from elementary and junior high school, and only around 10% graduated from high school. Based on the results of research, soybean farmer education is relatively low. The average soybean farmer has four family members. Farmers use urea and livestock manure in planting soybeans.

As shown in Table 2, the land rent per period was IDR 2,092,000; every soybean cultivation period is four months. The depreciation cost of the equipment was IDR 57,414. The wage of a farmworker was IDR 1,249,000. Fertiliser cost was IDR 432,000. The transportation cost of bringing the soybean crop to the market is IDR 267,450. Soybean price was IDR 6,950. The income earned by soybean farmers per period is IDR 3,074,000.

Table 1
SOCIOECONOMICS FARMER CHARACTERISTICS

No	Items	Number
1.	Land (ha)	0.28
2.	Experiences (year)	9
3.	Age (year)	52
4.	Variety	Local Grobogan
5.	Education	
	Elementary school	70 %
	Junior high school	20 %
	Senior high school	10 %
6.	Production (kg)	615
7.	Cropping pattern	Rice-corn-soybean
8	Fertiliser	Urea, animal manure
9	Family number	4

Table 2
PRODUCTION COST PER PERIOD

No	Items	Amount
1.	Land rent (IDR)	2,092,000
2.	Depreciation cost (IDR)	57,414
3.	Salary of farmworker (IDR)	1,249,000
4.	Fertiliser cost (IDR)	432,000
5.	Medicine cost (IDR)	70,000
6.	Transportation cost (IDR)	267,450
7	Soybean price/kg (IDR)	6,950
8	Income per period (IDR)	3,074,000

The estimated production shown in Table 3 indicates that soybean farming is not in the rational stage. Fertilisers show a significant negative elasticity; capital and labour have zero elasticity. Fertilisers, along with pesticides and operating capitals, have been highly promoted to farmers during the Green Revolution (Mariyono et al., 2010).

Table 3
ESTIMATED FRONTIER PRODUCTION TECHNOLOGY AND INEFFICIENCY MODEL

Factors	Coef.	s.e	z-value	p>z
Production frontier				
Fertilisers	-0.122	0.034	-3.58	0
Land	0.374	0.040	9.37	0
Capital	0.007	0.006	1.23	0.218
Labour	-0.035	0.035	-1.00	0.318
Constant	6.897	0.260	26.58	0
Determinant of inefficiency				
Age	-0.133	0.124	-1.07	0.282
Household size	-0.616	0.701	-0.88	0.379
Gender	24.485	1318.294	0.02	0.985
Education	0.290	1.261	0.23	0.818
Constant	-22.209	1318.306	-0.02	0.987
Wald $\chi2(4)$ = 104.24, p> $\chi2$ = 0.000, #observation = 400				

This makes strong dependency and misinterpretation of farmers on the agrochemicals. The only rational factor is land use, which is obvious. The total factor productivity is very high, meaning that the use of production factors has been saturated, consistent with negative and zero elasticity of fertilisers, labour, and capital. This condition indicates that the production system of soybean in the studied areas has been irrational. This fact is considered the main culprit of the very low productivity of soybean.

Further, the inefficiency model shows that no significant factor affecting efficiency. This surprising finding is understandable since the production system is in the irrational stage. With this condition, it is almost impossible to improve the productivity of soybean through the existing farming system. The main factor that is possible to determine such a condition is the level of education. On average, the level of farmers' education is just elementary school and junior high school. This condition leads to the massive failure in adopting technology in the soybean farming system. Farmers might misinterpret the advanced technology. The educational background of the farmers was low. It is necessary to have appropriate training (Mariyono, 2019a) to improve soybean farmers' skills. Supporting more advanced agricultural technology (Mariyono, 2019c), such as good land cultivation, soil fertility, and fertiliser application. This can be accompanied with proving soft-loans as the catalyst for process of technology adoption in the Indonesian agricultural sector (Mariyono, 2019d).

CONCLUSIONS

Indonesia still imports soybean to meet domestic demand. To reduce the dependency on imported soybean, the productivity of soybean farming needs excellent improvement. One of the ways is to increase the production efficiency of soybean farming. By using the stochastic efficiency model, this study finds that the technical efficiency of soybean cultivation in Indonesia was very low. This is due to many factors, such as low level of education for most farmers, cultivation technology such as fertilisation, land processing, and other production factors are still low; this causes low technical efficiency. Strategic action is that the soybean cultivation system should be comprehensively re-formulated. The action starts from the land preparation, soil fertility, technology related to fertiliser application, agronomic technology and post-harvest technology. Low education level could be the case that farmers failed to uptake the package of technologies. Training on good soybean cultivation needs to be done since most farmers only pass elementary and junior high school education. A comprehensive improvement strategy needs to be implemented to improve efficiency and increase soybean productivity in Indonesia.

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