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RELATIVE TECHNICAL EFFICIENCY OF CALIFORNIA LEMON FARMING IN BANYUMAS REGENCY

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Abstract. This research aims to determine the efficiency and relative technical inefficiency of lemon farming in Banyumas Regency. The background of this research is the need for self-sufficient lemon production and the existence of several issues in the management of production inputs in lemon farming. This is quantitative research with a population of 9 lemon farmers in Banyumas Regency. All 9 farmers were used as samples, employing a saturation sampling technique. Data for this research were collected through questionnaires. The data analysis in this research utilized Data Envelopment Analysis (DEA) with an input-oriented approach. The results of this research indicate that the use of production inputs needs to be adjusted among Decision Making Units (DMU) to achieve optimization.

Keywords: Data Envelopment Analysis, Lemon

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INTRODUCTION

The population has increased, which results in a higher demand for health facilities for each individual. This aligns with anticipating outbreaks that are difficult to predict in the long term, such as Covid-19. A healthy quality of life can be achieved by ensuring an adequate intake of antioxidants, as these can reduce the development of free radicals in the body. (Krisnawan, Budiono, Sari, & Salim, 2017). Antioxidants can be obtained by consuming vitamin C, which is found in lemons.

Lemons are tropical fruits widely imported from other countries. Indonesia should be able to meet the public's demand for tropical fruits, especially lemons. The need for imported fruits can be reduced by increasing domestic production. Furthermore, when there is a production surplus, it can be allocated for export.

Banyumas Regency has great agricultural potential for growing lemons. However, lemon farmers in Banyumas Regency have not optimally used production factors or input variables. This study aims to analyze the relative technical efficiency and inefficiency of lemon farming in Banyumas Regency. (Isyanto, 2012) Stated that one of the factors affecting farmers' failure, particularly when productivity is low, is the inefficient use of production factors.

METHOD

This research was conducted in Banyumas Regency, Central Java Province. The location was selected purposively, considering that this area has the required Decision Making Unit (DMU), namely "lemon farmers," who have been running their farming activities until now. The research was carried out from January to June 2023. The research object in this study was nine lemon farmers at the DMU in Banyumas Regency, Central Java Province.

Primary data was obtained through direct interviews with relevant parties in the technical efficiency of lemon farming, using questionnaires containing a list of questions related to the variables being studied. The input variables used in this study are land area (hectares), plant age (years), nitrogen fertilizer (kilograms), phosphorus fertilizer (kilograms), potassium fertilizer (kilograms), manure fertilizer (kilograms), solid pesticides (kilograms), liquid pesticides (liters), labor (man-days). In contrast, the output variable is the yearly yield/total production (kilograms). Secondary data was obtained through literature studies, books, and data sources from related agencies, such as the Agricultural Office of Banyumas Regency, associated with the technical efficiency of using production factors in lemon farming in Banyumas Regency.

The research method is quantitative, using a Data Envelope Analysis (DEA) approach. DEA is a non-parametric statistical method that does not require a normal distribution, and the sample does not need to reflect the population, meaning the entire sample is taken. The primary data was processed using computer programs such as Microsoft Excel 2019 and Win4Deap version 2.1. Meanwhile, the quantitative method provides a general overview of the research location and the characteristics of the farmers, such as the DMU.

The technical efficiency analysis with the DEA method compares each unit to obtain an efficiency value. The weight for each input and output of each DMU can be more than one. As stated by (Fajar, Fitrijanti, & Sukmadilaga, 2020), DEA analysis is a non-parametric approach based on linear programming (Linear Programming) with the help of certain software. DEA is used to assess the relative efficiency level of an economic activity, in this case, farming activities.

DEA was first introduced by Charnes et al. (1978) in various fields and analysis contexts (Fauzi, 2019). Another journal mentions the DEA approach developed by Farrel. (Novandra, 2014) That measures technical efficiency with one input and output, which is then extended to many inputs and outputs, with relative efficiency values arranged as input-output ratios. The characteristic of DEA measurement differs from other methods, as it measures efficiency technically rather than economically. Secondly, the values generated are relative (comparisons of DMUs are only within one scope) (Agustin, 2019).

According to Coelli, in (Winarso, Syafrial, & Widyawati, 2021), DEA is an analysis method that is divided into two main focuses of discussion, namely CRSTE (Constant Return to Scale Technical Efficiency) or (DEA-CRS) and VRSTE (Variable Return to Scale Technical Efficiency) or (DEA-VRS). As stated by (Benicio & De Mello, 2015), a limitation of DEA is that all inputs and outputs must be specific and measurable (Nugraha, 2013).

This study employs the DEA VRSTE approach or BCC model. The DEA model that provides a variable return scale is called the BCC model. (Nurlinda, 2014) Which adds convexity conditions for the values of the weighted X. The BCC model is also known as the Variable Return to Scale (VRS) model, where the increase in input and output is not proportionally the same. The proportion increase can be increased by increasing the return to scale (IRS) or decreasing the return to scale (DRS). The BCC model can be written with the following equation:

$$\Sigma_{j=1}^{n} \; xij\,\lambda\,ij \geq \pi\, io \quad \text{i= 1, 2, ..., m}$$

$$\Sigma_{j=1}^{9} \; yij\,\lambda\, j \leq y\, io \quad \text{r= 1, 2, ..., s}$$

$$\Sigma_{j=1}^{9} \; xij\,\lambda\, j = 1 \quad (\,Convexity\ constrain\,)$$

$$\Sigma_{j=1}^{9} \; \lambda\, j \geq 0 \quad \text{j= 1, 2, ..., n}$$

Description:

Π = efficiency of DMU (*Output* / *Input*).
n = number of DMU (all the DMUs used) (n: 9).
m = number of inputs (all the inputs from each DMU) (m: 9).
s = number of outputs (all the outputs from each DMU) (s: 1).
xij = amount of the i-th input of DMU j.
yrj = amount of the r-th output of DMU j.
λ j = weight of DMU j for the DMU being calculated.

(Putri, et al., 2022) Stated that technical efficiency is obtained based on the following linear programming model:

Maximize θ, λ

$$Subject\ to \sum_{j=1}^{n} \lambda j \cdot yj - \theta i \cdot yi - s = 0$$

$$\sum_{j=1}^{n} \lambda jXkj + ek = Xki$$

$$\lambda j \geq 0;\ s \geq 0;\ ek = 0$$

Where *i* represents the probability of an increase in the proportion of output for the *i-th* DMU (in this case is a lemon farmer), j represents the weight vector Nx1 relative to the efficiency of the DMU, *s* is the slack output, and ek is the slack input variable for the *i-th* unit. DEA CRS adapts to explain the situation of scale variables. By adding the convexity constraint N1'λ= 1, the model can be modified into VRS DEA. Proportional increases in the potential output are achieved when the slack production, i.e., *s* becomes zero. A DMU is efficient if the value of *i* equals 1 and *j* equals 0. Conversely, the DMU is inefficient if > 1, *i* = 0, and *j* = 0. By solving (1), we can obtain a *TE* measure that reflects the distance between the observed and the expected. This is similar to what was stated by (Nugraha, 2013). The optimal production result for a certain number of inputs:

$$TE = \frac{Y_i}{Y_i^*} = \frac{1}{\theta_i} \qquad 0 \leq TE_i \leq 1$$

Where *Yi* and *Yi** represent the potential optimal output for each of the CRSTE and VRSTE values. The difference between these two *TE* values indicates the existence of scale inefficiency that limits the achievement of optimal scale (constant).

$$TE_i^{CRS} = TE_i^{VRS} * SE_i$$

Therefore, it can be calculated as follows:

$$SE_i = \frac{TE^{CRS}}{TE^{VRS}} \;\; 0 \leq SE_i \; \leq 1$$

SEi = 1 indicates full-scale efficiency, and *SEi* < 1 indicates scale inefficiency. However, the weakness of the SE value is that it does not indicate whether a farm operation falls under the category of operating on a decreasing or increasing scale.

Return to scale determines whether a farm operates on an increasing, decreasing, or constant scale. (Setiawan & Prajanti, 2011) Stated that "Return to scale (RTS) aims to determine whether the activity of the business being studied follows the rules of increasing, constant, or decreasing to scale". Businesses that experience return to scale can be identified through DEA VSRTE analysis. There are 3 possibilities in return to scale values. (Soekartawi, 2003). Decreasing return to scale if (*b1* + *b2* +….+ *bn*) < 1. This situation can be interpreted as the proportion of additional production factors resulting in a more minor proportional increase in output. Constant return to scale, if (*b1* + *b2* + ….+*bn*) = 1. This situation means that adding production factors will be proportional to the increased production. Increasing return to scale if (*b1* + *b2* +....+ *bn*) > 1. This situation means that the proportion of additional production factors will result in a more significant proportional increase in output.

The concept of input-oriented efficiency refers to minimizing the farmer's use of inputs to achieve a constant output. The input-oriented efficiency concept is used when input prices are still high or when farmers face financial constraints. Therefore, farmers need to optimize the use of these inputs to produce a certain amount of output. (Asri, 2018). This statement aligns with (Simamora & Sinuhaji, 2021), who mentioned that "Input orientation assumes that management has more control over inputs than outputs, or in other words, management can easily increase and decrease inputs."

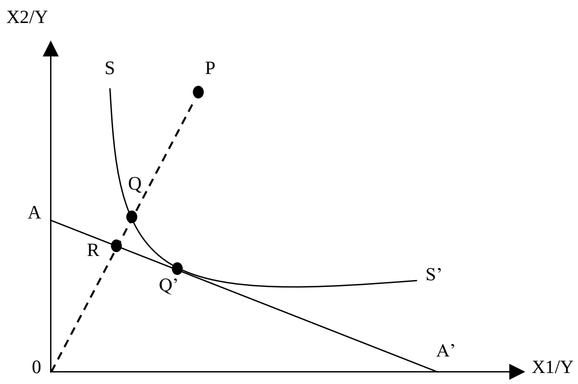

Figure 1. Input Orientation Production Function Curve
Source: Coelli *et al. in* (Asri, 2018)

Description:
P = input
QQ' = technical efficiency
AA' = input price ratio curve (allocative)
SS' = isoquant fully efficient

RESULT AND DISCUSSION

Banyumas Regency is one of the regencies in Central Java, located between 7°15' and 7°37' South Latitude and between 108°39' and 109°27' East Longitude. The total area of Banyumas Regency is recorded as 1,327.59 km², or about 4.04% of the total area of Central Java Province. 9 farmers are the subjects of this research, with the following characteristics: 100% male, 55.56% are aged between 20-40 years, and the rest are over 40 years old. The education levels of the farmers are as follows: 11.11% are elementary school (SD) graduates, 33.33% are high school (SMA) graduates, 22.22% are bachelor's (S1) graduates, and 33.33% have a master's degree (S2). Regarding land ownership, 44.44% of the farmers lease the land, while 55.56% own the land.

This study's relative technical efficiency analysis uses the Data Envelopment Analysis (DEA) approach, aimed at understanding the various influences of inputs on lemon production in the Banyumas Regency. The study assumes an input-oriented approach and employs the Variable Return to Scale (VRS) model. The VRS model helps determine the condition of the output proportion that can result in an increase in input at the same proportion. At the same time, Constant Return to Scale (CRS) indicates that if the input is increased, the output will also increase at the same proportion. (Winarso R. H., 2020).

In this study, CRS achieved an efficiency value of 0.451 (45.1%), which indicates an inefficiency in input usage of 0.549 (54.9%). This shows that the average technical efficiency is lower than the technical inefficiency. The farmer who showed inefficiency is DMU number 3.

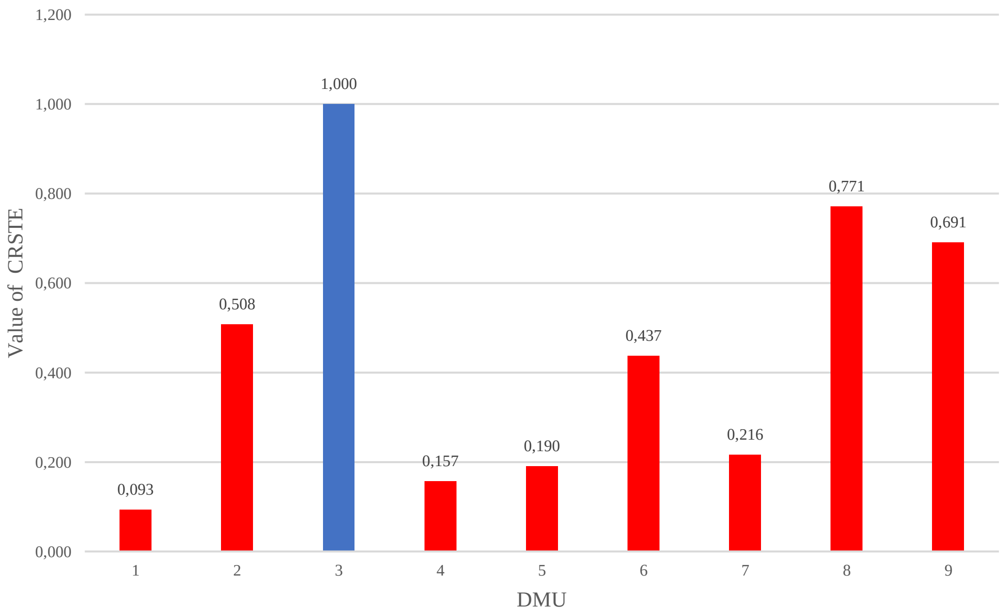

Figure 2. Value of CSRSTE

Source: Microsoft Excel (processed)

In this study, VRS achieved an efficiency value of 0.451 (45.1%), indicating an inefficiency in input usage of 0.549 (54.9%). This shows that the average technical efficiency is higher compared to technical inefficiency. The farmers who showed inefficiency are DMU numbers 1, 2, 4, 5, and 8.

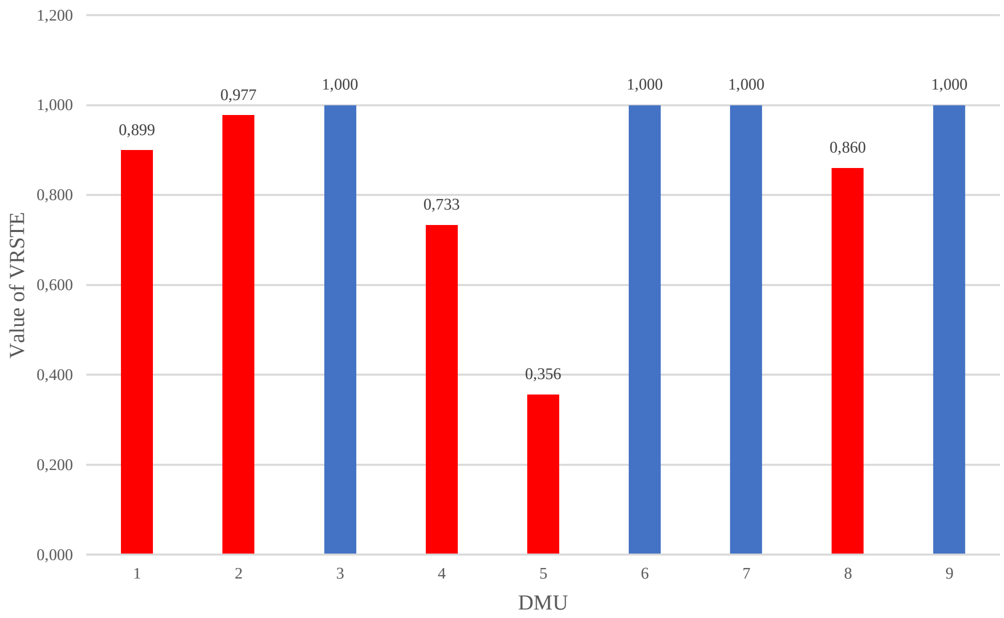

Figure 3. Value of VRSTE

Source: Microsoft Excel (processed)

This study's scale efficiency results in production efficiency, which refers to the farmers' production scale condition when cultivating lemons in the Banyumas Regency. The scale is as follows: CRS accounts for 11%, with only 1 DMU. IRS accounts for 89%, with the remaining 8 DMUs. This shows that most farmers have not reached optimal production scale because they are not at a constant return to scale (where the ratio of input and output increases proportionally, without any discrepancy in the ratio), or more accurately, they are in increasing return to scale. Increasing return to scale occurs when an increase in input proportionally increases output by more than the increase in input. Decreasing return to scale, on the other hand, happens when the rise in output proportionally requires more input than the increase in production. IRS occurs when $\beta < \alpha$, and DRS occurs when $\beta > \alpha$ (Fauzi, 2019).

Peer-to-peer comparison is one of the features of DEA that provides an overview of how the production efficiency of one DMU can be compared to other DMUs. The comparison of DMUs with their peers is exemplified with DMU 2 as the target, which has received the most references for improvement from DMU 3, DMU 6, and DMU 9.

DMU 2 has a CRSTE value of 50.8% and shows a slack movement value in the DEA-VRS analysis results. This value arises due to movement in the VRS efficient frontier curve to achieve fully efficient production (reaching both CRS and VRS frontiers), aligning with the frontier of DMU 3. The DEA-VRS analysis results of DMU 2 show both slack and radial movements because DMU 2 is not yet on the VRS efficient frontier curve and has not reached full efficiency (efficient both in VRS and CRS). Thus, a movement towards DMUs with VRS efficiency is necessary to approach full efficiency, particularly DMU 6, with a peer weight of 55.6%.

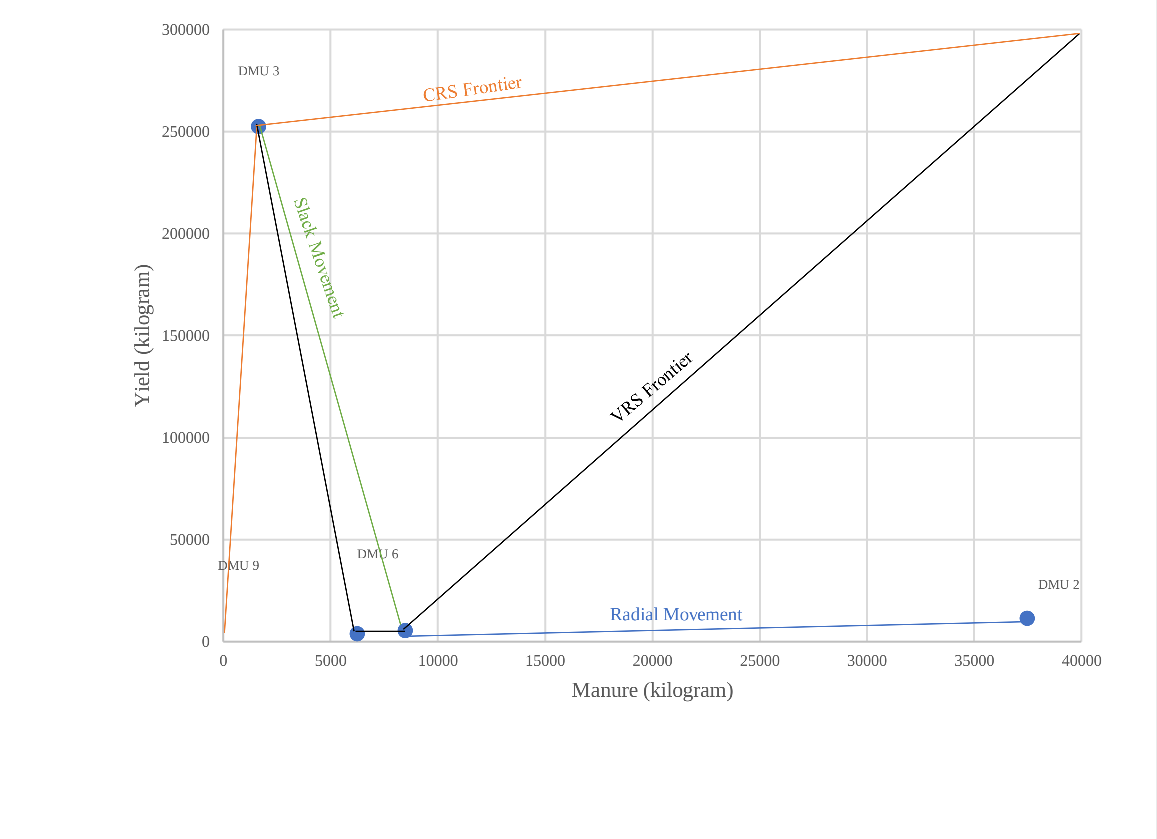

Figure 4. Peer-to-Peer DMU 2

Source: Microsoft Excel (processed)

CONCLUSION

The DEA-CRS value obtained is 45.1%, indicating an inefficiency of 54.9% in lemon production under this assumption. The DEA-VRS value obtained is 86.9%, showing an inefficiency of 13.1% with this assumption. The DEA-Scale Efficiency value, with an overall efficiency of 51.2%, indicates an overall inefficiency of 48.8%. The lemon farming in Banyumas Regency can reduce input (input slack) with the following allocation: Seedlings with a reduction of 285 trees, nitrogen fertilizer (N) by 7.073 kg, phosphorus fertilizer (P) by 7.573 kg, potassium fertilizer (K) by 8.894 kg, manure by 16,461.074 kg, pesticides by 19.922 liters, and labor by 45.754 HOK (man-days).

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