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The technical efficiency of chrysanthemum flower farming: A stochastic frontier analysis

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ABSTRACT

Over the years, improvements in standard of living and well-being have resulted in an increase in the demand for chrysanthemums, however, the recent COVID-19 pandemic has resulted in a fall in demand. As a result, this study investigates the technical efficiency of chrysanthemum farming and its major determinants. The study was conducted in Bumiaji Village, Bumiaji District, Batu, East Java, Indonesia between January and September 2022. Data was collected via interviews with chrysanthemum farmers using a questionnaire. A total of 35 chrysanthemum farms were selected using random sampling technique. The data was then analyzed using the stochastic frontier method combined with Maximum Likelihood Estimation (MLE). The results reveal that the efficiency of chrysanthemum farming is dominated by 0.91 to 0.93. (65.71 percent). Since technical efficiency is close to one, most chrysanthemum farmers are close to achieving maximum efficiency. The technical efficiency of chrysanthemum blooms was influenced by land area, inorganic fertilizers, organic fertilizers, and pesticides, but not by seeds or labor. The land area negatively impacts technical efficiency, implying that increasing land size decreases technological efficacy of chrysanthemum farming. Inorganic fertilizers, organic fertilizers, and pharmaceuticals have a positive effect or contribute to an increase in inorganic fertilizers, organic fertilizers, and pesticides. In terms of technical efficacy, chrysanthemum cultivation is close to its zenith. It is not necessary to exert effort to reach this ideal land, but inorganic fertilizers, organic fertilizers, and pesticides can assist.

Keywords:
Chrysanthemum, Indonesia, Optimal input, Stochastic frontier, Technical efficiency

1. Introduction

Agricultural production was a consistent source of economic growth throughout Indonesia's COVID-19 pandemic, which began in early 2020 Agriculture contributes significantly to Indonesia's economic growth and development [1–3]. The increasing number of events that require flowers for decorations, presentations, and congratulatory sentiments, among other things, is increasing the demand for fresh cut flowers [4]. Chrysanthemum is a beautiful flowering plant that is widely cultivated in Indonesia and has the potential to generate income, especially in rural areas. This is supported by an increase in the area harvested, the quantity produced, and the yield of chrysanthemum blooms between 2014 and 2018. The province of West Java on the island of Java is the leading producer of chrysanthemums, followed by Central Java, East Java, and the Special Region of Yogyakarta. Chrysanthemums are produced not only on Java, but also on the islands of Sulawesi and Sumatra, with production increasing.

The cities of Pasuruan, Malang, Mojokerto, and Batu in East Java are renowned for their chrysanthemum cultivation. Bumiaji, Batu, and Junrejo are the three subdistricts of Batu City, a mountainous location in East Java. Most chrysanthemum plants are in the Bumiaji District of Batu City, particularly in the Gunungsari and Bumiaji villages. The Chrysanthemum flower, also known by its Latin name Chrysanthenum, is one of the attractive plants with a promising future, as its cultivation does not require a large amount of land and is sufficient for yard planting. Due to their resistance to volcanic ash, chrysanthemum flowers have several advantages over other types of cut flowers, including gladiolus, kerkrily, hebras, daisies, roses, and carnations [5].

In numerous countries throughout the world, including Indonesia [6–8], research on technological efficiency has been conducted utilizing the Stochastic Frontier technique in conjunction with the Maximum Likelihood Estimation (MLE) production function approach, for example in Vietnam [9], in Brazil [10], in China [11], in Malaysia [12], also in Europe [13]. However, no study exist that implicitly utilized this methodology to study technical efficiency of Chrysanthemum farming in Indonesia. This research investigates how production inputs, such as land, seedling, labor, fertilizers, and pesticides influence the technical efficiency of Chrysanthemum farming in Indonesia. The study has the following objectives: 1) to determine which production inputs affect chrysanthemums' technical efficiency, 2) to determine the distribution of technical efficiency among chrysanthemum farmers, and 3) to determine whether chrysanthemum farming is technically efficient. This study will explicitly focus on the village of Bumiaji, in the district of Bumiaji, in the city of Batu. By understanding and optimizing technical efficiency, farmers can maximize their output, reduce costs, and enhance overall profitability in chrysanthemum flower farming. Thus, the findings of this study can be used to benefit farmers and related policymakers in their efforts to raise farmers' income through efficient input allocation.

2. Methods

2.1. *The Location, the Time Period, the Sample Size, and the Research Data*

The investigation was done in Bumiaji Village, Bumiaji District, Batu City, East Java, with Batu City as the epicenter of East Java's chrysanthemum production. The study took place between January and September 2022. Simple random selection was used to choose the sample, which consisted of 20% of 151 chrysanthemum growers, yielding a sample of 35 responses. Primary data were gathered via direct interviews with chrysanthemum farmers. Interviews were conducted using questionnaires as a guide for data collection. The research data set includes socioeconomic information about chrysanthemum growers, and information on all inputs utilized in chrysanthemum growing, including land area, seedlings, inorganic and organic fertilizers, pesticides, and labor. The data were analyzed using a stochastic production frontier model and MLE to estimate the regression coefficients.

2.2. *Data Analysis: Stochastic Production Frontier*

Technical efficiency is a fundamental concept that can be viewed from two perspectives. The input and output are the two components. The input element refers to the fact that production inputs can be modified to generate a variety of outputs. While the output element is concerned with the amount of change in output that can be achieved at a given input level, the input element is concerned with the amount of change in input that can be reached at a given output [14–16]. According to Kumbhakar et al. [17], a producer is technically efficient if and only if it is no longer possible to produce more output than it currently does without sacrificing a certain number of other outputs or adding a predetermined number of inputs.

According to Kusumaningsih [18], technically efficient farmers utilize fewer inputs than other farmers to achieve a certain quantity of output at a certain level or create more output with fewer inputs than other farmers. According to the definition above, technical efficiency can be measured from both the output and input. The observed to limit output ratio is used to calculate technical efficiency from the output side. This efficiency score is used in stochastic frontier analysis to quantify technical efficiency. The input or frontier cost ratio to the input or observation cost is used to quantify technological efficiency on the input side. Technical efficiency is determined using the stochastic frontier with Maximum Likelihood Estimation. The model for chrysanthemum flower farming is as follows:

$$\ln Y=\beta_0+\beta_1\ln X_1+\beta_2\ln X_2+\beta_3\ln X_3+\beta_4\ln X_4+\beta_5\ln X_5+\beta_6\ln X_6+ei \quad (1)$$

$\ln Y$: Log natural production chrysanthemum flower (bunches)
β_0 : constant
$\ln X_1$: Log natural land area (hectare)
$\ln X_2$: Log natural seedling (stalks)
$\ln X_3$: Log natural inorganic fertilizer (Kg)
$\ln X_4$: Log natural organic fertilizer (Kg)
$\ln X_5$: Log natural pesticides (liter)
$\ln X_6$: Log natural lavour (people)
$\beta_1 \dots \beta_5$: regression coefficient
ei : error term

Prior to analyzing the model of chrysanthemum farming, it is important to run it through the F_{test}. The F_{test} can be used to determine whether the model is significant. The following is the test hypothesis for the chrysanthemum farming model:

The following are the model test hypotheses:

$$Ho: \ \beta_1 = \beta_2 = \beta_3 \dots = \beta_6 = 0 \quad (2)$$

H_1: a minimum of one of $\beta_i \neq 0$

Decision-making rule:
If $F_{test} \leq F_{table}$, then accept Ho or reject H_1, indicating that no inputs used in chrysanthemum farming affect productivity. In other words, the model of chrysanthemum cultivation is irrelevant.

If $F_{test} > F_{table}$, accept H_1 or reject Ho, indicating that all chrysanthemum farming inputs affect production. In other words, the model of chrysanthemum farming is noteworthy and worthy of further examination.

Along with the model test, the model must be evaluated for determination (R^2), which requires seeing all production inputs for chrysanthemum farming concurrently and being able to explain the chrysanthemum farming model. The computed R^2 indicates the extent to which all production inputs for chrysanthemum farming can explain chrysanthemum farming. After determining that the model is significant and obtaining the coefficient of determination, the following is a partial. The partial test was used to assess the influence of each farming input on the efficiency of chrysanthemum production, while the t-test was used to assess the effect of each farming input on the efficiency of chrysanthemum production. The following is the hypothesis for the partial test:

$$Ho: \beta_i = 0 \quad (3)$$

$$H_1 : \beta_i \neq 0 \quad (4)$$

Decision-making rule:

If $t_{test} \leq t_{table}$, accept Ho or reject H_1, which indicates that the i-th production input has no influence on production.

If $t_{test} > t_{table}$, accept H_1 or reject Ho, indicating that the i-th production input influences chrysanthemum flower production.

After obtaining regression coefficients for all inputs used in chrysanthemum farming, the regression coefficients are utilized to calculate the technical efficiency of each input using the variance ratio approach:

$$\gamma = (\sigma u^2) \quad (5)$$

If γ is near 1, σu^2 is near zero, and u_i is the error rate in the preceding equation, the manufacturing input is inefficient. The following calculations can be used to determine the technical efficiency (ET) of chrysanthemum farming:

$$ET = \exp [E(\mu i \mid ei)] \quad (6)$$

Where $0 \leq ETi \leq 1$ and $\exp [E(\mu i \mid ei)]$ is the stochastic production frontier. The following assessment can be used to estimate the technical efficiency of chrysanthemum farming [19]:

If the ET ≥ 0.7, chrysanthemum farming is considered efficient.

If the ET value is less than 0.7, chrysanthemum farming is inefficient.

3. Results and Discussion

3.1. Production Inputs that Affect Chrysanthemum Farming's Technical Efficiency

Technical efficiency is a metric used to determine the technical efficiency of chrysanthemum farming at the highest and lowest levels. Additionally, to ascertain the average degree of efficiency obtained by farmers engaged in chrysanthemum cultivation. Land space, seedlings, inorganic fertilizers, organic fertilizers, medications, and labor are all used in chrysanthemum farming [20]. These inputs may or may not influence the technical efficiency of chrysanthemum blooms, and further study will be required to determine this. The stochastic production frontier is used in this study to assess the value of technical efficiency. The MLE approach estimates production inputs that influence the production function's technical efficiency. Table 2 presents the estimation results for production inputs that affect the efficiency of chrysanthemum blooms.

The following is the efficiency model for chrysanthemum growing in Bumiaji Village, Bumijai District, Batu City:

$$Y= 3.184 – 0.000Land-0.010seedling+0.000IF+0.548OF+0.000Pest-0.02Labour+ 0.227\sigma^2+0.98\ \Gamma$$

The data analysis revealed that the technical efficiency model of chrysanthemum flowers obtained F-test to be 145.86 times greater than F-table, with a probability of 0.000. It may be inferred that the chrysanthemum farming efficiency model is highly significant (99 percent). This indicates that all inputs into chrysanthemum production, including land area, seeds, inorganic and organic fertilizers, medications, and labor, influence the technical efficiency of chrysanthemums. While the coefficient of determination is 0.969, which indicates that all production inputs for chrysanthemum farming can account for 96.9 percent of the variance in the chrysanthemum farming model, the remaining 3.1 percent is due to variables not included in the model, which could consist of climate factors. This model is quite good due to its relatively high R^2.

In addition to sigma square (σ^2) and gamma (Γ), the results of the data analysis for the technical efficiency model employing the stochastic production frontier approach are presented as sigma square (σ^2). The σ^2 is more significant than zero by 0.227, indicating that technical efficiency influences the model of technical efficiency for chrysanthemum blooms, whereas 0.98 suggests that the model contains an error term.

Table 1. Inputs into production affecting the technical efficiency of chrysanthemum cultivation

Variable	Parameter	Coefficient	Standard Error	t_{ratio}
Constant	β_0	3.182	1.019	3.125
Land area	β_1	-0.000	0.000	-13.970*
Seedling	β_2	-0.010	0.023	-0.431
Inorganic fertilizer	β_3	0.000	0.000	1.491*
Organic fertilizer	β_4	0.548	0.085	6.439*
Pesticide	β_5	0.000	0.000	3.693*
Labour	β_6	-0.020	0.038	-0.526
Sigma square	σ^2	0.227	0.104	2.193*
Gamma	Γ	0.982	0.022	44.441*
Log likelihood function = 17,103				
Adjusted Rsquared = 0.967				
$t_{test}>t_{table-}$ (α = 0.05; dB = 28) = 1,056				
Mean Efficiency = 0.818				

Source: Author's computations, 2022
*=sig 0.01

Following a discussion of the chrysanthemum flower's significant and good technical efficiency model, the impact of each production input on the technical efficiency of chrysanthemum flower farming is explained.

1. ***Land area.*** Land, as well as chrysanthemum flowers, is the most significant place or location for farming. Agribusiness-ready land can generate high-quality crops

and a large volume of production. The results of data analysis indicate that land area has a significant impact on farming efficiency. This is demonstrated by the fact that t hit value exceeds the t tab's value. The calculated regression coefficient is minimal, 0.00001 and negative, implying that a 1% increase in the land area reduces technical efficiency by 0.000001 percent. The findings of this study indicate that chrysanthemum farmers' land area is sufficient to meet farming standards while increasing land area does not boost technological efficiency. Thus, farmers do not need to expand their agricultural space to grow chrysanthemums, but they can improve the efficiency of other farm inputs.

2. ***Seedling.*** Seedling is a critical ingredient in chrysanthemum growth. Superior seeds can provide technical and economic benefits for the development of an agricultural business, including uniform plant growth, which enables simultaneous harvests, higher yield quality that conforms to consumer preferences, plants that are highly resistant to pests and diseases, and plants that are highly adaptable to their environment, which reduces the need for inputs such as fertilizers and pesticides. Seeds have little effect on chrysanthemum farming's technical efficiency. Due to many variables, the seeds have no effect and a negative coefficient: The utilization of chrysanthemum seeds in Bumiaji Village is more advanced, coming from a production plant rather than a parent plant. Seedlings derived from plants that have been in use for an extended period will often generate poor–quality seeds. Additionally, the quantity of seeds utilized is impacted by the quality of the seeds used or seedling growth power. Because chrysanthemums in Bumiaji Village are spaced on average 10x10 cm apart, the number of plants per square meter increases, creating competition for nutrients, light, and air, resulting in poor plant growth and production. but the proper spacing in 1 m^2 is 12.5 × 12.5 cm. Flower seeds were found to boost chrysanthemum yield in this study. This indicates that the seeds used by farmers are of high quality [21].

3. ***Inorganic fertilizers.*** Inorganic fertilizers are created from inorganic sources and typically contain specific nutrients or minerals. Additionally, this sort of fertilizer is referred to as chemical fertilizer. Significant in the growth and development of plants. This relates to the primary role of fertilizers, which is to supply nutrients required by plants, which will become increasingly scarce in nature as plats consume them. Due to the requirement for nutrients and their unequal availability in nature, fertilizer is a solution to the problem of farmed plants' nutrient inadequacy. The study of data revealed that inorganic fertilizers had a significant impact on farming efficiency. This is demonstrated by the fact that the value of t_{test} exceeds the value of t_{tab}. The regression coefficient obtained is minimal, 0.000001 and positive, indicating that a one-percent increase in inorganic fertilizers boosts technical efficiency by 0.000001 percent. The findings of this study indicate that the inorganic fertilizers used by chrysanthemum growers meet farming criteria, as adding inorganic fertilizers increases technical efficiency. Thus, farmers must add inorganic fertilizers to chrysanthemum growing, but other farm inputs.

4. ***Organic fertilizers.*** Organic fertilizers or biodegradable fertilizers comprises living organisms, such as weathered plant, animal, and human remnants. Organic fertilizers provide several advantages, including the ability to mobilize or bridge nutrients already in the soil, allowing them to form ion particles easily absorbed

by plant roots, increasing land productivity, and preventing long-term land degradation. The results of the data analysis indicate that organic fertilizers have a significant impact on farming efficiency. This is demonstrated by the fact that the t hit value exceeds the t tab's value. The calculated regression coefficient is 0.548, which is positive, indicating that a 1% increase in organic fertilizers boosts technical efficiency by 0.548 percent.

5. ***Pesticides.*** Pesticides are a significant input into chrysanthemum farming, as healthier plants produce fresher, whole, and high-quality chrysanthemums. The data analysis revealed that medications significantly impact the technical efficiency of chrysanthemum farming. This is demonstrated by the t-count value is more than the t-table's value. The regression coefficient calculated is 0.0000009, which indicates that increasing drug use by 1% increases technical efficiency by 0.0000009 percent. Although medications have a negligible influence on technical efficiency, their use is necessary to preserve chrysanthemums' thecnical efficiency and quality.
6. Labor. Labor is a critical component of the manufacturing process. Labor was necessary at every step of chrysanthemum cultivation. The workers can be drawn from inside or without the family. Labor in the family is unpaid labor in agriculture. Meanwhile, non-family workers are agricultural laborers whose wages are paid, so they are referred to as wage workers. Workers in chrysanthemum flower cultivation are descendants of family workers. This is consistent with field data indicating that many families have more than four individuals. As a result, chrysanthemum farmers frequently avoid hiring outside workers, believing that the labor available inside the family is adequate. The results of the data analysis reveal that labor has a 0.02 regression coefficient effect on the technical efficiency of chrysanthemum blooms. The regression coefficient is negative, indicating that increasing the workforce of one person decreases technical efficiency by 0.02 percent.

3.2. Technical Efficacy of Chrysanthemum Flowers

This sub-chapter discusses the distribution of chrysanthemum farming's technical efficiency. This technical efficiency analysis was undertaken to ascertain the technical efficiency of each chrysanthemum farmer in greater detail. Table 2 contains the technical efficiency data analysis results for chrysanthemum farming. At Bumiaji Village, Bumiaji District, Batu City, using the MLE (Maximum Likelihood Estimation) approach, the distribution of technical efficiency derived from the analysis is shown in Table 2.

Table 2. Chrysanthemum farming's technical efficiency

Technical efficiency	Frequency (farmers)	Percentage (%)
0.82-0.86	3	8.57
0.87-0.90	5	14.29
0.91-0.93	23	65.71
0.94-0.96	4	11.43
Average	0.912	
Maximum	0.96	
Minimum	0.82	

Source: Author's computation, 2022

According to Table 2, chrysanthemum farmers with a technical efficiency level of 0.82-0.86 are three farmers (8.57 percent), those with a technical efficiency level of 0.87-0.90 are five farmers (14.29), those with a technical efficiency level of 0.91-.93 are 23 farmers (65.71 percent), and those with a technical efficiency level of 0.94-0.96 are four farmers (11.43 percent). The average distribution of technical efficiency in Bumiaji Village, Bumiaji District, Batu City is 0.912, indicating that while 91.2 percent of chrysanthemum farming is efficient, an additional 8.8 percent must be added, among other things, by input improvement and optimization. And enhance inputs that have little effect on chrysanthemum production efficiency.

The maximum value for chrysanthemum flower technical efficiency is 0.96, indicating that the chrysanthemum growers in Bumiaji Village have attained a technical efficiency of 96 percent. Chrysanthemum flower producers still have the opportunity to improve their technical efficiency by 4% to optimize their chrysanthemum flower production. With a minimal technical efficiency value of 0.82, chrysanthemum farmers still have an 18% opportunity of improving technical efficiency. Figure 1 illustrates the distribution of technical efficiency among chrysanthemum farmers.

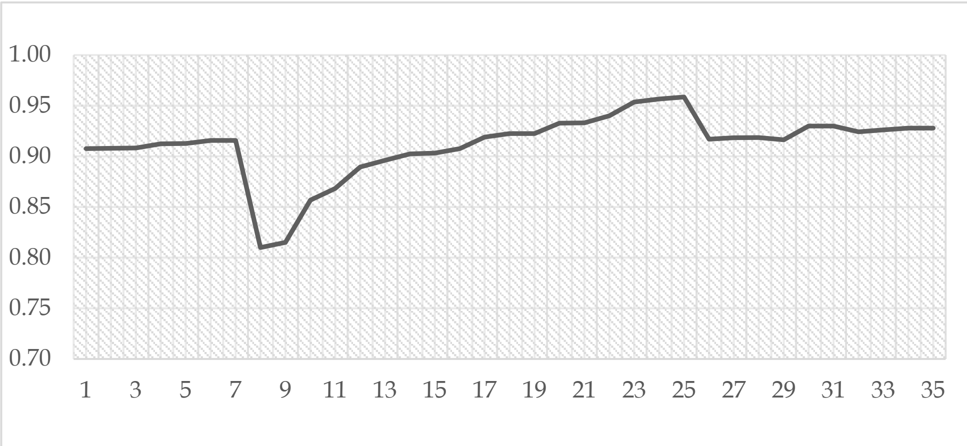

Figure 1. Illustrates the distribution of chrysanthemum farming's technical efficiency

4. Conclusion

This study investigates the production inputs that influence the technical efficiency of chrysanthemum farming and demonstrates how a stochastic production frontier model and Maximum Likelihood Estimation are used to estimate the distribution of chrysanthemum farmers' technical efficiency levels. The investigation was conducted in Bumiaji hamlet, Bumiaji subdistrict, in Batu City, East Java, Indonesia. The primary data were collected through direct interviews with 35 sample chrysanthemum flower farmers. Technical efficiency of chrysanthemum farming was affected by land area, inorganic fertilizers, organic fertilizers, and medicines, with regression coefficients of 0.000 (negative), 0.000 (positive), 0.548 (positive), and 0.000, respectively (positive). Increased use of inorganic, organic, and medicinal fertilizers will enhance the technical efficacy of chrysanthemum cultivation. Meanwhile, seedlings and labor have little effect on the technological efficiency of chrysanthemum farming.

The technical efficiency of chrysanthemum flower farmers has been attained. The fact that the highest value of 0.96 is more significant than zero demonstrates this. It can be assumed that chrysanthemum flower farmers in Bumiaji Village have achieved a technical efficiency of 96%. The distribution of technical efficiency in chrysanthemum flowers is dominated by the range 0.91 to 0.93 (65.71 percent), followed by 0.87 to 0.90 (14.29 percent) and 0.94 to 0.96 (11.43 percent) (8.57 percent). In Bumiaji Village, Bumiaji District, Batu City, the average distribution of technical efficiency is 0.912, indicating that while 91.2% of chrysanthemum farming is efficient, 8.8% more must be added by means such as input improvement and optimization. And improve inputs that have little effect on the production efficiency of chrysanthemums. To optimize chrysanthemum production, it is proposed that chrysanthemum farmers increase their technical efficiency by 4 percent by seedlings and labor.

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