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Evaluation of strawberry supply chain efficiency level with data envelopment analysis (DEA) model approach in Lumbung Stroberi, Pandanrejo Village, Batu City

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KEYWORDS

Data envelopment analysis
Efficiency
Performance efficiency
Supply chain
Supplier selection

ABSTRACT

Supply chain activities are one of the considerations for business actors. However, several problems within these activities lead to inefficiencies in the performance of supply chain actors. This study aimed to describe the strawberry supply chain system and analyze its efficiency level at Lumbung Stroberi, and evaluate supplier selection based on the supply chain performance efficiency results. The respondents of this study were five partner farmers who supplied Lumbung Stroberi and were interviewed directly using questionnaires. Data analysis was conducted using two methods, namely descriptive analysis and quantitative analysis using the Data Envelopment Analysis (DEA) model approach. The study's findings revealed the occurrence of supply chain activities from suppliers to Lumbung Stroberi and the efficiency level of the strawberry supply chain, with three suppliers operating efficiently. This supplier selection based on supply chain performance efficiency results is crucial evaluation for maintaining the efficient suppliers and improving the inefficient ones.

Introduction

Batu City is a tourist destination that supports strawberry cultivation, with Pandanrejo Village in Bumiaji Subdistrict being one of the strawbery production areas. Data from the Central Bureau of Statistics (2020) indicated that a substantial land area of 780.21 ha dedicated to strawberry cultivation within the Bumiaji Subdistrict in 2019. Consequently, most local people engage in strawberry farming, supplying their productions to local businesses.

Lumbung Stroberi is a business unit located in the center of excellent strawberry production in Pandanrejo Village, Bumiaji Subdistrict, Batu City, Malang, East Java. Lumbung Stroberi exclusively sources strawberry products from partner farmers operating within its designated area. The strawberry supply chain at Lumbung Stroberi begins with these partner farmers, who actively cultivate and directly supply strawberries to the business. These farmers serve as suppliers due to their cultivation of strawberry varieties align with Lumbung Stroberi's requirements and their willingness to engage in collaborative business endeavors, which allow them to prioritize meeting consumer demands for strawberries.

A supply chain is a set of activity flows that work interrelatedly to efficiently make and deliver products to consumers (Subroto et al., 2015). The supply chain activities at Lumbung Stroberi encounter obstacles, including fluctuations in production from suppliers and the perishable nature of strawberries, leading to occasional failures in meeting consumer demand. Hence, evaluating the performance of these supply chain activities becomes necessary.

According to Heizer and Render (2017), supply chain performance involves assessing the activities and performance of supply chain actors. It encompasses the flow of goods, money, and information with the activities carried out by suppliers to end consumers. Good supply chain management is crucial to ensure efficient activities carried out by all parties, from suppliers to consumers. Measurement of supply chain performance requires the use of metrics or decision-making units. Various metrics tailored to business needs and objectives have been utilized in research by Soheilirad et al. (2017) and Saragih et al. (2021). Evaluation of supply chain activities within a business contributes to enhancing performance and fostering effective and efficient

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operations. This aligns with the finding of Tubagus et al. (2016), which suggests that efficient supply chain activities are supported by cooperative management and control of distribution channels by all involved parties.

Supply chain management involves planning and managing all flow activities within the supply chain, from material procurement to product delivery to end consumers (Chandrasekaran & Raghuram, 2014; Kleab, 2017). It aims to produce products with the correct quantity and quality, at the right time, and make the entire system efficient and effective (Lee, 2019; Ross, 2015). Poor business supply chain evaluation can lead to negative consequences such as increased costs, supply chain risks, customer dissatisfaction, and competitive disadvantages.

Data Envelopment Analysis (DEA) is a method used to calculate and evaluate the efficiency of an activity using input and output data. According to Charles et al. (2019) and Kraude et al. (2022), DEA represents an approach for evaluating the relative efficiency of a set of Decision-Making Units (DMUs) with several output and input factors. Several input and output variables are considered in evaluating relative efficiency as they directly relate to the activities conducted. This study employed the Constant Return to Scale (CRS) efficiency model, which focused on input addition as decision control was expected to be in the input resources. The calculation outcomes for each DMU indicate the efficiency level, whether it is efficient or inefficient, derived from processing the data into the DEA software.

Therefore, every business unit requires optimal supply chain activities for efficient performance (Azarkan, 2022). The activities within the strawberry supply chain at Lumbung Stroberi are influenced by suppliers who provide strawberries. As suppliers serve as the primary actors supplying resources for business units, it is crucial to determine the attainment of an efficient strawberry supply chain. This research aimed to describe the strawberry supply chain system analyze the efficiency level of the strawberry supply chain at Lumbung Stroberi, and evaluate supplier selection based on the results of supply chain performance efficiency. The anticipated outcome of this research is to provide insights into the actors and activities within the supply chain, ultimately leading to enhanced efficiency and valuable insight for Lumbung Stroberi. Subsequent research endeavors can utilize this study as a point of reference regarding supply chains for agricultural business.

Research and methods

This research was conducted at Lumbung Stroberi, Pandanrejo Village, Batu City, spanning from November 2022 to January 2023. Its primary aim was to analyze the efficiency level of the strawberry supply chain within Lumbung Stroberi by using a quantitative approach. The research approach involved data processing and hypothesis testing related to the supplier supply chain performance efficiency with several input and output variables. Respondents for this study were selected using a non-probability sampling technique, specifically snowball sampling, wherein the sample size gradually increased from a small number to a larger one based on previous respondents who are supply chain actors, ensuring relevant information retrieval (Sugiyono, 2017).

Respondents for this study were five partner farmers actively supplying strawberries to Lumbung Stroberi. These respondents became DMUs for efficiency evaluation. DMUs were compared based on their input and output levels. An advantage of utilizing the DEA method is that it does not require a standard limit on the number of DMUs and can handle numerous inputs and outputs without assuming a functional relationship between input and output variables (Izadikhah et al., 2018; Zhang and Cui, 2016).

Primary data collection methods, such as interviews and observations, were employed for data gathering (Mazhar et al., 2021; Sekaran and Bougie, 2016). Interviews involved direct questioning and discussions with the relevant respondents to obtain information about the issue's significance, whereas observation entailed analyzing and interpreting activities conducted within the study's scope.

Data envelopment analysis (DEA) *method*

This research employed two analytical methods: (1) descriptive analysis to describe the occurring supply chain system and evaluate supplier selection based on the supply chain efficiency level and (2) quantitative analysis, specifically the DEA approach model for data processing. DEA served as a method for evaluating efficiency by comparing input and output variables among DMUs. DMU is an efficiency measurement unit that can be observed (Daraio and Simar, 2016; Fatimah and Mahmudah, 2017).

Table 1. Research input-output variables

No	Variable Type	Variable Name	Measuring Unit	Description
1.	Input	Fulfillment Cycle	Day	Time taken by suppliers to fulfill orders in one order cycle.
2.	Input	Cash to Cash Time Cycle	Day	Time required to make payments for purchased products to supply chain actors.
3.	Input	Daily Inventory	Day	Time available for product availability that is sufficient to meet order needs.
4.	Output	Delivery Performance	%	Percentage of accuracy in the number of strawberry order fulfillment shipments from suppliers to Lumbung Stroberi.
5.	Output	Conformance to Quality Standards	%	Percentage of the number of conforming strawberry standards delivered from suppliers to Lumbung Stroberi.
6.	Output	Order Fulfillment	%	Percentage of order fulfillment from suppliers to Lumbung Stroberi in accordance with the agreement.

Input and output variables were derived from the relevant DMU to be evaluated. Input variables pertained to the resources used by the DMU in the production or operational process, while output variables described the results of the analyzed unit's activities. The input-oriented model aimed to minimize input while achieving distributed output levels, whereas the output-oriented model sought to maximize output without considering additional input values. The determination and elaboration of input and output variables can be seen in Table 1.

The strategy for analyzing supply chain efficiency models was divided into two categories: CRS and Variable Return to Scale (VRS) (Ghiyasi and Cook, 2021; Lim and Zhu, 2015; Sari et al., 2018). The CRS model depicted a change in output amount proportional to the change in input amount. Meanwhile, the VRS model encompassed two types of variable returns to scale: (1) decreasing return to scale, indicating that output increases proportionally slower than the increase in input used, and (2) increasing return to scale, signifying that output escalates faster than input augmentation (Ghiyasi and Cook, 2021).

Calculation of efficiency value

The efficiency of the input and output variables is based on the data's availability. In this study, the CRS model was used, oriented towards adding input, because decision control is expected to be on input resources. The results of the optimal input variable influenced output variable performance, with efficiency scores for all input and output variables ranging from 0 to 1. The DEA model approach uses a relative efficiency model, defined as follows (Gökşen et al., 2015):

$$\text{Maximum } h_o = \frac{\sum Ur\, Yr0}{\sum Vi\, Xi0} \leq 1 \quad \text{..... (1)}$$

Description:

r = Output variable
i = Input variable
0 = Decision-making units (DMU)
U_r = Weight of the output
V_i = Weight of the input
Y_{r0} = Output value
X_{i0} = Input value

The steps involved in using the DEA method in research (Subramanyam, 2016) were as follows:

1. Selecting the DMU or unit to be evaluated based on the selected input and output variables
2. Calculating the efficiency of the DMU to identify the efficient or inefficient variables

Interpretation of DEA calculation results

In the DEA method, DMUs were derived from several input and output variables, allowing for an assessment to measure the efficiency level of each DMU (Akhlaghi and Malkhalifeh, 2019). If the value obtained was less than one, the decision-making process was considered inefficient, whereas a value of one signified an efficient decision making. This aligns with the research of Kraude et al. (2022), which stated that efficiency scores range from 0 to 1, indicating efficiency when a company achieves a score of 1 and inefficiency when the score falls below 1. The framework for this study is illustrated in Figure 1.

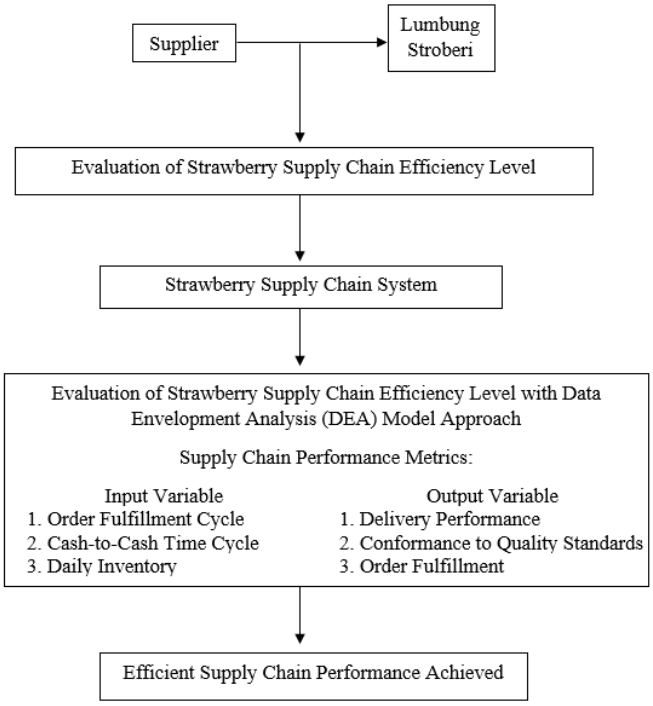

Figure 1. The scheme of the framework

The evaluation of the efficiency level of the strawberry supply chain at Lumbung Stroberi utilized input variables, namely the order fulfillment cycle, cash-to-cash time cycle, and daily inventory. Meanwhile, output variables included delivery performance, compliance with quality standards, and order fulfillment. Analysis using the DEA method on these input and output variables determined the supply chain efficiency level, whether categorized as efficient or inefficient suppliers. The study's findings are expected to provide insights into the evaluation of strawberry supply chain efficiency level. While inefficient results necessite evaluating supplier selection strategies based on the supply chance performance efficiency results.

Results and Discussion

Overview of Lumbung Stroberi

Lumbung Stroberi operates as a business unit under Bumdes Raharjo, offering strawberry-picking tourist destinations and selling a variety of products. It was established in 2019 and received strawberries from partner farmers. Lumbung Stroberi is located in a strategic area of Pandanrejo Tourism Village, Bumiaji District, Batu City, East Java. It has the potential to produce strawberries supported by a favorable climate of around 17 to 25 degrees Celsius so that strawberry plants can grow well. Therefore, many strawberry-producing farmers exist in the area, facilitating a swift and efficient supply chain. Lumbung Stroberi's presence in the area aims to stabilize strawberry prices, ensuring they remain reasonably priced and steady. Lumbung Stroberi has several core administrators, including the head manager, picking management, fresh strawberry management, administration, and social media marketing to organize and carry out the business activities. Lumbung Stroberi offers a diverse range of strawberry-related products, such as fresh strawberries and various processed items (i.e., juice, jam, ice cream, and strawberry juice).

Respondent characteristics

The characteristics of the farmers who participated as respondents in this study varied based on age, gender, latest education, and duration in partnership. The respondents comprised five strawberry farmers who supply strawberries to Lumbung Stroberi. Details regarding these respondents are presented in Table 2.

The characteristics of respondents were used to assess their diversity based on several criteria. These characteristics aimed to clearly depict the respondents' conditions and their relevance to the research topic. Analysis of the data from Table 2 revealed that the highest proportion of respondents fell within the 46-65 age category, with four respondents, constituting 80% of the total. Conversely, the lowest proportion was in the 26-45 age category, represented by one respondent, accounting for 20%.

Table 2. Characteristics of respondents at Lumbung Stroberi in 2022

No	Respondent Characteristics		Total	
			People	Percentage (%)
1	Age (Year)	5-11	0	0
		12-25	0	0
		26-45	1	20
		46-65	4	80
2	Gender	Male	4	80
		Female	1	20
3	Education	Elementary School	2	40
		Junior High School	3	60
		Senior High School	0	0
4	Time in Partnership (Year)	1	0	0
		2	2	40
		3	0	0
		4	3	60

The predominance of respondents in the productive age range aligns with Setiyowati et al. (2022) findings, indicating that individuals in this group exhibit a high working spirit in running and developing farms. In terms of gender distribution, male suppliers dominated the respondent pool, comprising four out of five suppliers, while female suppliers constituted only one.

Most suppliers in Lumbung Stroberi have the junior high school level,, with three people (or 60%). Conversely, the lowest educational attainment is at the elementary school level education, with two individuals (or 40%). This suggests a low level of formal education among farmers, which may impact their ability to acquire knowledge or skills and advance farm development, consistent Rusanto et al. (2022) findings.

Partnership durations with Lumbung Stroberi vary among suppliers. Three suppliers (or 60%) have been partnering with Lumbung Stroberi for four years or since its establishment, while the remaining 40% have been partners for approximately one to two years. The duration of farming experience influences the farmer's skills, knowledge, and overall quality of human resources (Šūmane et al., 2018), with longer partnerships likely yielding more favorable outcomes in strawberry supply.

Supply chain system of strawberry in Lumbung Stroberi

A supply chain system encompasses a network or activities comprising various flows and processes aimed at distributing products to end consumers. The strawberry supply chain system involves actors, activities, and flows. The supply chain mechanism is formed and coordinated from upstream to downstream and carried out by supply chain actors (Timisela et al., 2014). The description of the strawberry supply chain system in Lumbung Stroberi aimed to provide a comprehensive understanding of current supply chain activities and to identify any issues that arise in the process, spanning from the involvement of supply chain actors to the execution of flows. Some of the actors involved in the supply chain business flow are labeled as supply chain actors. The main actors involved in the supply chain are suppliers, manufacturers, wholesalers, retailers, and consumers (Sabbaghi, 2022; Sibuea et al., 2023). Suppliers are the initial providers of materials for the distribution chain or business, including raw materials and components. Forming an optimal supply chain performance requires an integrated network between all actors (Maulidah et al., 2021). The robust supply chain management system will facilitate cooperation and collaboration between suppliers, business partners, and customers.

The strawberry supply chain activities at Lumbung Stroberi involve multiple actors, spanning from suppliers to Lumbung Stroberi and ultimately reaching consumers. The cooperative relationship between Lumbung Stroberi and its suppliers was built on mutual trust and communication. Partnership or cooperation with farmers can occur informally, based on trust between parties (Leite et al., 2021; Stallman and James 2017). The supplier becomes the first supply chain actor in the strawberry chain activities at Lumbung Stroberi, adhering to agreed-upon strawberry quality standards. Lumbung Stroberi

conducts several activities ranging from scheduling, purchasing, sorting, and packaging, to marketing strawberries upon receiving supplies from suppliers.

Supply chain activities consist of three flow patterns: the flow of goods, the flow of money, and the flow of information (Mizani and Azis, 2021). Each of these flows has a different flow pattern. The flow pattern of goods has a flow that flows from upstream to downstream, while money flows from downstream to upstream. Information flows in both directions, from upstream to downstream and vice versa. The supply chain flow pattern observed in strawberries at Lumbung Stroberi can be seen in Figure 2.

a. Flow of Goods

The flow of goods involves several stages in the process of moving goods from production to consumers. The flow pattern of goods in the strawberry supply chain is illustrated in Figure 3a.

The flow progresses from upstream to downstream. The flow of goods in the strawberry supply chain at Lumbung Stroberi starts from the supplier to Lumbung Stroberi. The delivery of strawberries from suppliers to Lumbung Stroberi was based on orders placed according to the agreed time and the specified standard or grade of strawberries. Upon reaching agreements, suppliers can directly deliver strawberries to Lumbung Stroberi as per the agreed terms. After receiving the strawberries, Lumbung Stroberi will conduct a strawberry sorting process in accordance with the quality standards. These mutually established standards serve as benchmarks in assessing the quality of harvested products. Farmers employ selective harvesting practices, ensuring adherence to quality standards to maintain and guarantee product safety (Willersinn et al., 2015). This underscores the significance of maintaining high quality and standards throughout the supply chain process to ensure the delivery of high-quality strawberries.

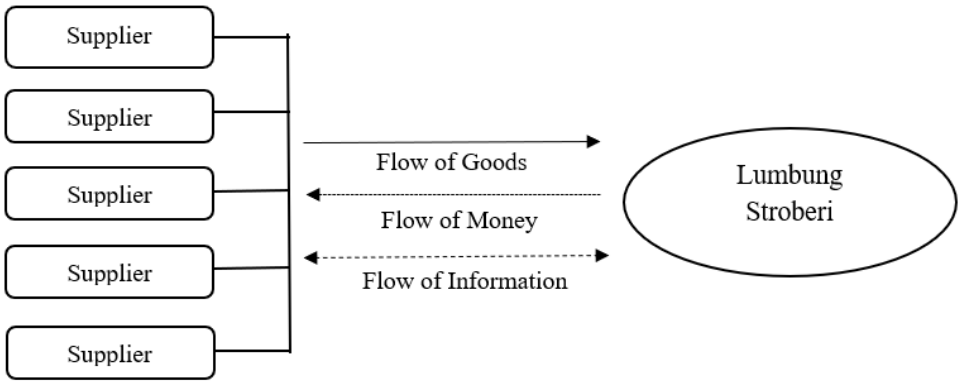

Figure 2. Flow pattern of strawberry supply chain in Lumbung Stroberi

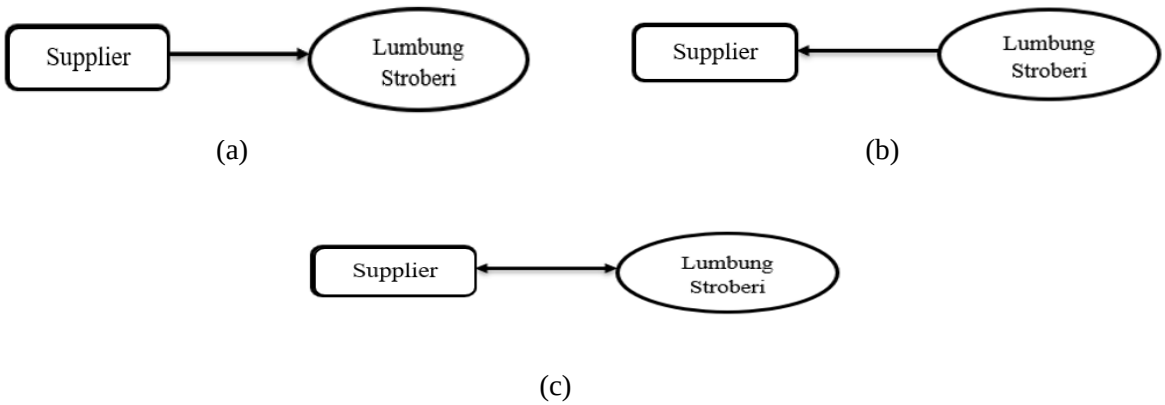

Figure 3. Pattern of goods flow (a), money flow (b), information flow (c) in strawberry supply chain at Lumbung Stroberi

b. Flow of Money

The flow of money pertains to financial transactions occurring among supply chain actors in supply chain activities. The flow of money pattern of the strawberry supply chain is depicted in Figure 3b.

This flow pattern progresses from downstream to upstream. In the strawberry supply chain, money flows from Lumbung Stroberi to the suppliers. The pricing offered by Lumbung Stroberi for purchasing strawberries was determined through mutual agreement and adjusted to the market price of strawberries to serve as a pricing benchmark. Payment terms for strawberry purchases are established between the supplier and Lumbung Stroberi prior to transactions. Lumbung Stroberi makes payments to suppliers either in cash or via transfer as per the agreed terms. Each supplier has varying payment terms stipulated in the agreement.

The arrangement of payment terms between a supplier and a business is a crucial aspect of their relationship, impacting cash flow and overall operational efficiency. According to research by Flynn and Li (2023), a company's commitment to ensure fair treatment and timely payment to suppliers yields positive benefits. These benefits include fostering positive relationships with business partners and enhancing the business's reputation.

c. ***Flow of Information***

The flow of information relates to the exchange of information occurring among supply chain actors. The flow of information pattern of the strawberry supply chain can be seen in Figure 3c.

This pattern flows from upstream to downstream and vice versa. The flow of information in the Lumbung Stroberi occurs between its supply chain actors, namely suppliers and the Lumbung Stroberi itself. Information exchanged in supply chain activities must be transparent and accurate, reflecting the actual circumstances to establish a robust relationship built on trust between actors. Information shared by suppliers with Lumbung Stroberi, or vice versa, encompasses various aspects such as the quantity of strawberry orders, total strawberry prices, payment time, sales conditions, and strawberry delivery time. In the study conducted by Toding et al. (2019), the information provided in this flow is related to product quality, product price, order numbers, and purchases made. The flow of information in the supply chain activities between suppliers and Lumbung Stroberi underscores the importance of effective communication process.

Evaluation of strawberry supply chain efficiency level with data envelopment analysis (DEA)

Performance measurement in supply chain activities greatly benefits business operations (Balfaqih et al., 2016; Machado et al., 2019), serving as a fundamental tool for enhancing management efficiency. Efficient supply chain activities can support business development and meet consumer needs effectively. Quantitative analysis was carried out to measure the efficiency of strawberry suppliers' supply chain performance, shedding light of the efficiency levels of each supplier providing strawberries to Lumbung Stroberi. The assessment of supply chain performance efficiency used both input and output variables. The input variables included the order fulfillment cycle, cash-to-cash time cycle, and daily inventory. The output variables comprised of delivery performance, conformance to quality standards, and order fulfillment. The data obtained from the variables was then processed using the DEA method approach with the CRS model into the DEA software to obtain a value to determine the efficiency level of each DMU. This study used the CRS model, emphasizing input addition as the locus of decision control was placed on input resources. DEA evaluates the relative efficiency of a set of DMUs with several output and input factors.

Performance measurements were conducted on strawberry suppliers in Lumbung Stroberi. Table 3 shows the data information from each supplier to calculate the supply chain performance efficiency. The data was for the input and output variables of all Lumbung Stroberi's suppliers.Based on Table 3, the data generally shows that the performance of each supplier varies according to their respective performance. The performance efficiency measurement criteria indicate efficiency when it scores 100% for each DMU. The desired target for the input variables, especially order fulfillment and daily inventory for strawberry supply, is set every two days to ensure the consistent availability of required strawberries. Meanwhile, for the output variables, the desired target is to achieve 100% for delivery performance, compliance with quality standards, and order fulfillment. Based on the data from each supplier, an analysis of supply chain performance was conducted using the DEA model approach.

Table 3. Input and output variable data in 2022

Supplier (DMU)	Input Variable (Day)			Output Variable (%)		
	Fulfillment Cycle	Cash-to-Cash Time Cycle	Daily Inventory	Delivery Performance	Conformance to Quality Standards	Order Fulfillment
1	2	7	2	98	100	96
2	2	3	3	100	100	100
3	3	7	3	100	100	100
4	3	4	3	100	100	100
5	3	2	4	99	100	98

Table 4. Analysis result of evaluation of efficiency level of chain performance supply chain performance of strawberry suppliers

DMU (Supplier)	Te^{CRS}	Decisions
1	1.000	Efficient
2	1.000	Efficient
3	0.810	Inefficient
4	0.945	Inefficient
5	1.000	Efficient

The supply chain performance efficiency results were obtained from the conditions of Lumbung Stroberi's suppliers in 2022, as shown in Table 4. Based on these results, the efficiency value determined whether the suppliers had an efficient supply chain performance or otherwise.

Upon processing the data, it was found that three suppliers demonstrated efficient supply chain performance, while two suppliers exhibited inefficient supply chain performance. According to Kraude et al. (2022), a performance efficiency calculation using DEA yielding a one signifies efficiency, whereas a value less than one ($0 \leq x > 1$) indicates inefficiency. Suppliers with an overall efficiency value of 100% consistently meet Lumbung Stroberi's requirements as per the mutual agreement, which is reflected in the data, particularly in the input variables such as the order fulfillment cycle and daily inventory. Meanwhile, inefficient suppliers with values below 100% may encounter issues related to order fulfillment cycles, daily inventory, delivery performance, and non-compliant order fulfillment.

The inefficient suppliers include supplier 3 and supplier 4, whose the efficiency values falls below one. High input values and low outputs or vice versa can also affect the efficiency level of supply chain performance. Based on field conditions, the two suppliers carried out supply chain activities that did not meet predetermined plans or targets. Thus, the performance efficiency value obtained was inefficient.

Regarding input variables for order fulfillment, particularly concerning order fulfillment cycles and daily inventory, supplier 3 and 4 fail to meet the desired targets. Lumbung Stroberi's desired order frequency for each supplier was every two days to ensure order fulfillment. This affected the calculation results for the input variables, leading to inefficient efficiency values. On the other hand, the output variable data obtained from the supplier was at its maximum. However, when comparing these input and output variables, the imbalance observed affected the overall efficiency values obtained. Based on the research of Indrarini and Canggih (2019), the results of the supplier calculation are efficient because the ratio between output and input is equal to one.

Therefore, both suppliers need to improve by reducing input variables' value or enhancing output variables' value to achieve efficient supply chain performance. This aligns with the findings of Fadhilah et al. (2017), where inefficient results prompted adjustments such as decreasing inputs or increasing outputs to improve performance efficiency. A decrease in input can be done by optimizing inputs such as the planning intervals from every three days to every 2 days so that it could lead to increased output value.

Effective strategy in company management is essential to improve its performance in line with according to the company's desired expectations (Maulidah and Megayanti, 2016). Based on the efficiency results of the strawberry supply chain, it is imperative to conduct supply chain performance evaluation to ensure effectiveness and efficiency in achieving desired goals. Drawing insights from interviews with Lumbung Stroberi and previous research by Andani and Koesdiningsih (2018), decision criteria for evaluating supplier performance

are used to determine whether to select or exclude the strawberry suppliers at Lumbung Stroberi. Supplier scoring decision criteria can be seen in Table 5.

Based on the criteria outlined in Table 5, supplier assessment decisions were determined across several value ranges. Suppliers scoring between 70% and 100% are deemed superior and should be retained. Those scoring between 50% and 69% can continue their partnership as suppliers. However, if a supplier's score falls between 30% and 49%, it necessitates direct communication to address performance issues. Scores ranging from 20% to 29% require the issuance of a report letter directly to the supplier regarding the encountered supply chain activity problems. Meanwhile, if the value range is <20%, it is necessary to consider removing the supplier from the supplier list.

Table 6 shows three suppliers performed efficient supply chain performance while the remaining ones performed poorly. The variations in results obtained from all suppliers indicate differences in their supply chain performance. Suppliers demonstrating efficient supply chain performance are suppliers who always carry out supply chain activities in accordance with the agreement; thus, optimizing their performance efficiency. Meanwhile, suppliers who perform inefficient supply chain performance deviate several times from agreements based on field conditions, leading to suboptimal performance. Therefore, decisions need to be made regarding the suppliers providing strawberries to Lumbung Stroberi.

Table 7 shows the decision results for all suppliers providing strawberries to Lumbung Stroberi, classified as superior suppliers. A superior supplier is recognized as the best in providing strawberries to Lumbung Stroberi. Supplier 1, supplier 2, and supplier 5 are suppliers that perform supply chain activities efficiently, earning an efficiency value of 1. These three suppliers consistently meet established criteria and should be maintained by Lumbung Stroberi. Meanwhile, supplier 3 and supplier 4 get a total efficiency value below 1, suggesting that their supply chain performance is not fully efficient but still classified as superior suppliers. Research by Vistasusiyanti et al. (2017) showed that a planned supply based on the demand and time carried out with both parties, resulting in an efficient delivery time.

These outcomes from inefficient suppliers reveal that the supplier's problems are related to insufficient availability to meet the Lumbung Stroberi's demands fully. Improving supply chain performance requires certain strategies tailored to the supply chain activities. Improved performance within the supply chain will eventually enhance overall company performance (Qrunfleh and Tarafdar, 2014; Hüseyinoğlu et al., 2020). Therefore, evaluation and improvements are essential for these inefficient suppliers to enhance supply and meet the demand for strawberries.

Table 5. Scoring decision criteria

No	Range of Values	Decisions
1.	70%-100%	Superior Supplier
2.	50%-69%	Remains the Supplier
3.	30%-49%	Complain Directly
4.	20%-29%	Letter of Report
5.	<20%	Removed from Supplier List

Table 6. Results of DEA calculation for each supplier

DMU (Supplier)	Total Value	Description
1	100%	Efficiency
2	100%	Efficiency
3	81%	Inefficiency
4	94.5%	Inefficiency
5	100%	Efficiency

Table 7. Supplier performance assessment decision result

No	Supplier	Total Value	Decisions
1.	1	100%	Superior Supplier
2.	2	100%	Superior Supplier
3.	3	81%	Superior Supplier
4.	4	94.5%	Superior Supplier
5.	5	100%	Superior Supplier

Managerial implication to improve efficiency

The managerial implications related to improvement strategies aimed at enhancing efficiency to meet targets effectively. These improvement strategies are geared towards elevating the efficiency of each DMU, thereby transforming inefficient conditions into efficient ones. Lumbung Stroberi needs to establish performance measures related to processes, plans, and procedures for running activities and customer satisfaction to ensure activities and customer satisfaction yield effective and efficient outcomes (Kakwezi and Nyeko, 2019). The obtained results require continuous improvement to boost efficiency. Lumbung Stroberi can enhance cooperation with suppliers, fostering strong relationships and communication to streamline supply chain activities. Effective planning and management of supply chain activities are crucial for ensuring timely and efficient operations (Maulidya et al., 2020; Ross, 2015).

Several steps can be taken to improve efficiency in both input and output variables to meet the agreed-upon performance target. Among the five strawberry suppliers, two have been identified as inefficient, necessitating managerial strategies for improvement. Suppliers 3 and 4 deliver strawberries to Lumbung Stroberi every three days instead of the required frequency every two days, leading to inefficiencies in the supply chain. To address this, Suppliers 3 and 4 can improve by enhancing control of the strawberry plants' land, such as using greenhouses and regularly monitoring the plants and strawberries. This improvement is necessary to increase strawberry production and ensure that the quality of the strawberries meets the sales standard. With the abundance of strawberries produced, they can easily meet sales demand as per planned schedule. Therefore, sustaining Lumbung Stroberi's supply chain management requires appropriate strategies and policies for all stakeholders to implement. The involvement of various stakeholders (i.e., , suppliers, consumers, employees, and businesses) could foster cooperation, coordination, connectivity, and information flow (Villegas, 2019; Maulidah et al., 2023). This must be done to ensure the agrotourism has policies and strategies to support its improvement, overcome future challenges, and achieve supply chain management sustainability.

Conclusions

The evaluation of the strawberry supply chain efficiency level was carried out from suppliers to Lumbung Stroberi. Supply chain activities involved the flow of goods, money, and information. Utilizing the DEA model approach, the evaluation identified three suppliers with efficient performance and two with inefficient performance. Efficient suppliers need to be maintained, while inefficient ones require improvement, particularly in increasing supply. One strategy for enhancing the performance of inefficient suppliers involves implementing better control over strawberry cultivation, such as utilizing greenhouses and regularly monitoring the plants and strawberries. Based on the research results, it is expected that Lumbung Stroberi can improve each input and output variable provided by its suppliers to better align with its objectives. In future studies, utilizing a broader range of input and output variables is desirable to ensure a more comprehensive assessment of supply chain efficiency.

Declarations

Conflict of interests The authors declare no competing interests.

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