



Efficiency of Supply Chain Management Performance in Potato Farming with Data Envelopment Analysis

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Received: June 10, 2024

Revised: July 27, 2024

Accepted: August 25, 2024

Published: August 31, 2024

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DOI: [10.29303/jppipa.v10i8.8031](https://doi.org/10.29303/jppipa.v10i8.8031)

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Abstract: The potato farmers in Karangreja District use two supply chain channels, namely the supply chain channel partnership non-partnership supply chain channels. The existence of a good supply chain channel, will provide benefits and benefits that are evenly distributed to all parties involved in distributing potato products to consumers. The purpose of this research is to analyze the differences in profit, farmer share, and supply chain efficiency in partnership and non-partnership patterns in Karangreja District, Purbalingga Regency. The farmer sampling method using Simple Random Sampling obtained 500 partnership pattern farmers and non-partnership pattern farmers. Determination of marketing agencies using the Snowball Sampling technique obtained collectors, wholesaler, and retailers. Analysis of the data used is the analysis of supply chain efficiency and analysis of different tests. The results of the analysis show the supply chain efficiency analysis shows that 42.86 farmers operating efficiently have partnership patterns and 57.20 non-partner pattern farmers. The different test analysis shows that for profit and farmer's share indicators there is a significant difference between the partnership pattern and the non-partnership pattern. As for the marketing margin indicators and performance efficiency, there is no significant difference between the partnership pattern and the non-partnership pattern.

Keywords: Farmer's share; Margin profit; Marketing efficiency; Potato marketing

Introduction

One of the potential food crop commodities in the horticulture sector is potatoes. Rachmat & Rahmiani (2006) stated that 2.6% of GDP in the horticulture sector and 7.6% of GDP in the vegetable sector was contributed by the potato commodity. This is a reference that the potato commodity has great potential for development. One of the potato commodity centers in Indonesia is Central Java. Based on Badan Pusat Statistik Provinsi Jawa Tengah (2022), Purbalingga Regency is one of the potato centers in Central Java. In 2020, Purbalingga Regency, especially Karangreja District, produced 73,630 tonnes of potatoes, the sixth highest in Central Java Province (Badan Pusat Statistik Provinsi Jawa Tengah, 2022).

The marketing channels in Karangreja District are divided into two marketing channels. The first channel

is a partnership pattern marketing channel with the company PT. Indofood Fritolay Makmur and the second supply chain marketing channel through non-partnership, in collaboration with wholesalers in Karangreja District (Sinaga et al., 2014). With several marketing channels, there is a need for comparative studies and different tests of each supply chain marketing channel. Having a good supply chain channel will provide equal benefits and profits to all parties involved in distributing potato products to consumers (Putri et al., 2024). Coughlan et al (2006) (Faika, 2015) also explains that appropriate channels can be built in several methods to build effective and efficient supply chain channels. Therefore, efficiency is an important element in efforts to achieve success in supply chain activities. This requires attention to the issue of supply chain efficiency, so that it is hoped that the potato supply chain in Karangreja District, Purbalingga Regency will be

How to Cite:

Putri, D. D., Fadlillah, N., Suyono, S., & Wijayanti, I. K. (2024). Efficiency of Supply Chain Management Performance in Potato Farming with Data Envelopment Analysis. *Jurnal Penelitian Pendidikan IPA*, 10(8), 5976–5983. <https://doi.org/10.29303/jppipa.v10i8.8031>

more structured and integrated and can compare supply chain efficiency and be able to determine strategies, which indicators are not yet efficient between partnership and non-partnership patterns so that potatoes arrive in the hands of consumers at a reasonable price, farmers benefit and the marketing institutions involved are still able to carry out their marketing role well.

This research aims to analyze the efficiency of potato supply chain performance in partnership and non-partnership patterns and analyze differences in profits, marketing margins, farmer share, and supply chain efficiency in partnership and non-partnership patterns.

According to Pujawan & Mahendrawathi (2010), the supply chain is a network of companies that work together by supplying raw materials, producing goods, and sending them to end users. A supply chain is a network of companies that work together to create and deliver a product to the end consumer. These companies usually include suppliers, factories, distributors, shops or retailers as well as supporting companies such as logistics service companies. In a supply chain there are usually 3 flows that must be managed. First, the flow of goods flows from upstream to downstream. Second, the flow of money and the like that flows from downstream to upstream. Third, the two-way flow of information can occur from downstream to upstream or from upstream to downstream.

Supply chain management in agribusiness has unique characteristics. According to Bailey et al. (2002) in Perdana (2009) the unique characteristics of agribusiness supply chain management are as follows:

1. Consumers

Consumer demand for food products emphasizes aspects of health, variety and convenience. The choice of food products is influenced by the characteristics of consumers in each country. Additionally, food consumption is driven by unique consumer needs such as nutrition, food safety, sensitivity and social needs. These factors are influenced by consumer culture and the social environment (Sudiyono, 2013).

2. Distribution of agricultural products

Not only are consumers different in each country, but also product characteristics such as packaging, labeling and distribution systems are also different. Business actors must face changes in rules and regulations and must accommodate consumer desires.

3. The role of marketing in supply chain solutions

The agribusiness food supply chain must be able to provide optimal solutions for product accuracy, location and timeliness in meeting market needs in each country. Optimal marketing solutions can only be achieved if

they are linked to supply chain issues which guarantee the delivery of products to consumers.

4. Characteristics of agricultural products

The perishable nature of agricultural products increases the importance of storage, handling and transportation. For example, the challenge for the fresh produce industry is the availability of fast and refrigerated transportation. In the era of globalization of trade and the development of new handling and storage technologies, agri-food supply chains have transformed seasonal product factors into stabilization mechanisms to ensure a stable product supply throughout the year.

5. Material sustainability issues

The supply chain must be able to guarantee the availability of a sustainable supply of agricultural products to meet forecasted consumer demand. In the food supply chain, the availability of agricultural raw materials must be considered in the forecasting process. This happens because of the perishable nature of agricultural products and uncertainty in supply due to uncertain harvest quantities.

According to (Harisman, 2017), the partnership pattern that applies between Atlantic potato farmers and partner companies (PT Indofood FrytoLay Makmur) includes a trade (market) partnership pattern, namely the partner company markets the products of the partner group (farmers), the farmers supply the company's needs. partners, but in this pattern there is an agreement (contract) (Putriet al., 2023), where the products produced by farmers that meet the specifications determined by the company can be received in full at a predetermined or agreed price. Because the nature of this partnership is basically a buying and selling relationship for the partnered product, in this case the partner company only provides seeds according to product specification requirements, while the provision of production facilities and cultivation is carried out by farmers and the company's involvement is limited to coaching.

Method

The basic research method uses quantitative descriptive methods. According to Sugiyono (2014) the descriptive analysis method is statistics that are used to analyze data by describing or illustrating the data that has been collected as it is without the intention of making general conclusions or generalizations. In other words, descriptive statistics is part of the science of statistics regarding data collection, presentation, determining statistical values, making diagrams or pictures about something to make it easier to understand

or read. So descriptive statistics is useful for explaining a situation, symptom or problem. In this study the author used Probability Sampling techniques to determine research respondents (Putri, Suyono, et al., 2023). The respondents in this research were potato farmers and potato marketing institutions in Karangreja District, Purbalingga Regency.

Data analysis uses data analysis Data Envelopment analysis. Data Envelopment Analysis (DEA) is a linear program-based technique for measuring the efficiency of an organizational unit called Decision Making Units (DMU) in using available resources to produce a certain output (Wardoni & Putri, 2024) (Tanjung & Devi, 2013). The performance efficiency

of a DMU compared to other DMUs can be determined through DEA. Another advantage of DEA is that the results of the analysis can be used to set targets that must be achieved by a DMU to produce efficient performance, knowing the value of input or output variables that must be increased or decreased in order to achieve the target value of potential improvement and attributes that must be improved (Sari et al., 2014). DEA allows multiple inputs and outputs to be considered simultaneously without assuming data distribution. Efficiency is measured in the form of proportional changes in input or output (Yong & Lee, 2010). The output and input variables from Data Envelopment Analysis (DEA) are as follows:

Table 1. Input Variables and Output Variables (Suppliers to the Company)

Variable	Sub-Criteria Variable	Unit	Type	Criteria	Eplication
Responsiveness	Cash-to-cash cycle time	Day	Input		The time it takes a company to pay its potato supplier
	Lead time	Day	Input		The time it takes for a potato supplier to fulfill a company's order.
Flexibility	Flexibility	Day	Input		The ability of potato suppliers to respond to changes in company orders
	Conformity to standards	%	Output		Percentage value of conformity to product standards sent by potato suppliers to the company
Reliability	Order fulfillment	%	Output		Percentage value of product order fulfillment from potato suppliers to the company
	Delivery performance	%	Ouput		The percentage value of the potato supplier's punctuality in fulfilling company orders

The calculations carried out to obtain the output variables are:

Standards Conformity

$$\frac{\text{Total Orders Shipped According to Standard}}{\text{Total Order Shipped}} \times 100\% \quad (1)$$

Order Fulfillment

$$\frac{\text{Total Orders Sent Exact Quantity}}{\text{Total Order sent}} \times 100\% \quad (2)$$

Delivery Performance

$$\frac{\text{Total Orders Shipped on Time}}{\text{Total Orders Shipped}} \times 100\% \quad (3)$$

Analysis of supply chain performance efficiency using data envelopment analysis (DEA) with Banxia Frontier Analyst 4.2 software (Wardoni & Putri, 2024). In this research, the DEA model used is the input-oriented DEA-CCR model with the following equation:

$$\text{Max } h_n = \sum_{r=1}^t U_r Y_{rj} \quad (4)$$

with constraints :

$$\sum_{i=1}^m V_i X_{ij} = 1 \quad (5)$$

$$\sum_{r=1}^t U_r Y_{rj} - \sum_{i=1}^m V_i X_{ij} \leq 0, j = 1, \dots, n \quad (6)$$

$$U_r, V_i > 0, r = 1, \dots, t,$$

$$I = 1, \dots, m$$

Information:

h_n = relative efficiency of DMU

t = number of outputs

m = number of inputs

U_R = Output Weight

v_i = input weight

y_{rj} = output value of DMU i to $j; j = 1, \dots, n$

x_{ij} = input value of DM i to $j; j = 1, \dots, n$

Independent Sample Test Analysis

Marketing profit difference test analysis was carried out to compare the level of marketing profit in partnership and non-partnership patterns. Before carrying out the profit difference test, a homogeneity test is carried out which is used to determine the similarity of the variants of the two populations, namely the variants of the two businesses. The homogeneity test formulation is (Sugiyono, 2005):

$$F_0 = \frac{\text{Big Variance}}{\text{Small Variance}} \quad (7)$$

Hypothesis:

H0 : both samples have the same variance at a significance level of 5 percent

Ha : the two samples have different variances at the 5 percent significance level

Decision making criteria:

H0 is rejected if $F_0 \leq F\alpha$ ($\alpha = 5$ percent) means that both samples have different variances at a significant level of 5 percent

H0 is accepted if $F_0 > F\alpha$ ($\alpha = 5$ percent) means that both samples have the same variance at a significant level of 5 percent

The analysis tool used is a difference test. The analysis of the marketing profit difference test aims to determine the difference in potato marketing profits in partnership and non-partnership patterns for two independent samples. The data analysis used was a t-test of two independent samples using *Excel*. The average difference test is used to determine whether there is a significant difference in average marketing profits in partnership and non-partnership patterns. According to Sugiyono (2005), mathematically the difference test can be formulated as follows:

$$t_0 = \frac{X_1 - X_2}{\sqrt{\left[\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} \right] \left[\frac{1}{n_1} + \frac{1}{n_2} \right]}} \quad (8)$$

$$S = \sqrt{\frac{\sum X^2 - \left(\frac{\sum X}{n}\right)^2}{n - 1}} \quad (9)$$

Information:

T0 : Calculated t value

X1 : average partnership pattern marketing profit (IDR)

X2 : average non-partnership pattern marketing profit (IDR)

S1 : standard deviation of partnership pattern marketing profits

S2 : standard deviation for non-partnership pattern marketing

N1 : Number of samples of partner farmers

N2 : Number of samples of non-partner farmers

Result and Discussion

Analysis of Potato Supply Chain Efficiency in Karangreja District Using Data Envelopment Analysis

The ratio of output to input is a fundamental concept underlying efficiency, so a method is needed that can evaluate organizational efficiency objectively and produce output results based on the expenditure of input resources. Supply chain management performance measurements are used to determine what aspects of the supply chain will be assessed and

measured, as well as to ensure consistency between supply chain operations and the measurement matrix. The data envelopment analysis (DEA) approach was used to determine the level of efficiency of the potato supply chain in Karangreja Regency, both with partnership and non-partnership patterns. This is achieved by analyzing the efficiency of supply chain performance. Measuring the efficiency of the potato supply chain, both partnership and non-partnership patterns in Karangreja Regency, is seen based on the performance of farmers during the last potato planting season in 2022. Different from research conducted by Sari (2015) and Setiawan et al., (2009), the DEA methodology also used in evaluating supply chain performance over two semesters.

Constant Return to Scale (CRS) and Variable Return to Scale (VRS) are the two most commonly used DEA models. This research uses an input-oriented CRS model which is based on the assumption of constant returns to scale so it is known as the Charnes, Cooper, and Rhodes (CCR) model. In this research, the DEA approach used is the constant return to scale model, with the assumption that all DMUs in the sample have the same internal and external conditions, the models for all DMUs will be compared with each other. The input and output of local farmers in Karangreja Regency is used as the basis for DEA measurements for potato commodities. In this analysis, the order fulfillment cycle, supply chain flexibility, and cash to cash cycle are input variables. Delivery performance, order fulfillment, and fulfillment of requirements are the variables that are output in this research.

After input and output are entered, the data is analyzed to obtain information on which potato supply chain has efficient supply chain performance compared to other supply chains. Calculations were carried out with the help of the CRS model and Banxia Frontier Analyst 4.2 software. Appendices 7 and 8 provide an explanation of the input and output values for farmers involved in the potato supply chain, which are broken down according to partnership and non-partnership patterns. The data used in the DEA technique comes from the average of input and output variables.

Calculations were carried out with Banxia Frontier Analyst 4.2 software. The findings show that only 42.86% potato farmers with partnership patterns or decision making units achieved 100 percent performance efficiency. This shows that 42.86% farmers are operating at an efficient level. However, there are still some farmers who do not have effective supply chain performance. Table 2 shows the results of calculating the performance efficiency of partnership pattern potato farmers. The findings of the investigation provide insight into the efficiency of farmers participating in the partnership pattern potato supply

chain. Other craftsmen have less than one hundred percent performance efficiency.

Meanwhile, the results of calculating the performance efficiency of non-partnership pattern potato farmers are also presented in Table 2. The results of the analysis show that the performance of the potato supply chain for non-partnership pattern farmers, it can be seen that the 57.2% farmers who have performance efficiency of 100 percent. Furthermore, Hussain & Jones (2010) stated that if an efficiency value is below 90% then the condition is red, above 90% but below 100% (but there is still potential improvement) the condition is amber, if it is 100% efficient without potential improvement then the condition is green.

Table 2. Results of calculating the efficiency of potato chain performance in partnership patterns and non-partnership patterns at the farmer level in Karangreja District in 2022

Efficiency value	Category	Channel Pattern	
		Partnership (%)	Non-Partnership (%)
< 0.9	Red	57.2	42.8
0.9 - 1.0	Amber	0	0
1.0	Green	42.8	57.2
Rata-Rata		0.75614	0.79687
Max		1.0	1.0
Min.		0.25000	0.50000

Source: Primary data processed by Banxia Frontier, 2023

When measuring farmer performance, it is possible to determine which partner and non-partner farmers need to improve their performance, through increasing their output or minimizing their input. Table 2 shows that the most inefficient value for the partnership pattern is 0.25 and the average efficiency value is 0.75614. Meanwhile, in the non-partnership pattern, the most inefficient value is 0.50 and the average efficient value is 0.79687. Respondent farmers who were interviewed and given a technical efficiency score of 1,000 were considered to have full efficiency levels, while respondent farmers who were given a technical efficiency score of less than 1,000 were considered technically inefficient farmers.

Analysis of Different T-Test Potato Supply Efficiency Tests

The t-test analysis of differences in the average performance efficiency of the potato supply chain pattern in Karangreja District was carried out using an independent comparative sample t-test by comparing the performance efficiency of each DMU for partnership pattern potato farmers and the performance efficiency of each DMU for non-partner pattern potato farmers. partnerships that come from two different groups of

respondents, so the resulting data is not paired. The analysis of this research has a hypothesis:

- If $t_0 \geq t_{\alpha/2}$ ($\alpha = 5$ percent) then H_0 is accepted, H_a is rejected meaning that there is no significant difference between the value of profits, marketing margins, *farmer's share*, and potato supply chain efficiency partnership pattern and non-partnership pattern.
- If $t_0 < t_{\alpha/2}$ ($\alpha = 5$ percent) then H_0 is rejected, H_a is accepted meaning that there is a significant difference between the value of profits, marketing margins, *farmer's share*, and the efficiency of the potato supply chain partnership pattern and non-partnership pattern.

Hypothesis Testing Different Profit Indicators

H_0 : There is no significant difference between the profits of the potato supply chain from partnership patterns and non-partnership patterns.

H_a : There is a significant difference between the profits of the potato supply chain from partnership patterns and non-partnership patterns.

Hypothesis Testing Different Marketing Margin Indicators

H_0 : There is no significant difference between the marketing margin of the potato supply chain in the partnership pattern and the non-partnership pattern.

H_a : There is a significant difference between the marketing margin of the potato supply chain in the partnership pattern and the non-partnership pattern.

Hypothesis Testing Different Farmer's Share Indicators

H_0 : There is no significant difference between farmer's share in the potato supply chain, partnership pattern and non-partnership pattern.

H_a : There is a significant difference between farmer's share in the potato supply chain, partnership pattern and non-partnership pattern.

Hypothesis Testing Different Efficiency Indicators

H_0 : There is no significant difference between the efficiency of the potato supply chain in partnership patterns and non-partnership patterns.

H_a : There is a significant difference between the efficiency of the potato supply chain in partnership patterns and non-partnership patterns.

Table 3. Results of T-Test analysis of two independent samples on profit, marketing margin, farmer's share, and efficiency of potato supply chain performance in Karangreja District in 2022

Value	Different Test		
	Advantage	Marketing Margins	Farmer's Share Performance Efficiency

Sig. (2-Tailed)	0.032	0.052	0.020	0.434
Mean Difference	-4,391	-5,410.5	37.03	-0.04072

In Table 3 shows a significance value for the profit indicator of $0.032 < 0.05$ which means that the H_0 value is rejected. The results of this calculation show that there is a significant difference between the profit value of the potato supply chain, the partnership pattern and the non-partnership pattern. The results of the study are in accordance with previous research conducted by Istiyanti (2010) entitled "Marketing Efficiency of Curly Red Chili in Ngemplak District, Sleman Regency", The study found that the number of marketing agents participating in marketing channels will affect the costs and profits of each marketing agency. The findings of this study are consistent with the research of Istiyanti (2010). The greater the number of marketing agencies that exist, the greater the total profit generated by each marketing channel.

In addition, Table 3 shows the *mean difference* value for profit indicators of IDR4,391.00/Kg, which means that the two marketing channel patterns have a profit difference of IDR4,391.00/Kg with an average partnership pattern profit of IDR255.00/Kg and an average non-partnership pattern profit of IDR4,646.00/Kg. So it can be concluded that the average profit of the non-partnership pattern supply chain is higher when compared to the average profit Partnership pattern supply chain. However, Sinaga et al (2014) explained that the profit of the institution is not only seen from the quantitative side but the qualitative side as well, by looking at the marketing function carried out by potato marketing institutions, there is a calculation between the marketing function, costs and product attributes. The partnership supply chain pattern has a guaranteed selling price to farmers and the non-partnership supply chain pattern has a shorter payment maturity time. Table 3 shows the significance value for the marketing margin indicator of $0.052 > 0.05$ which means that the H_0 value is accepted. The results of this calculation show that there is no significant difference between the value of the marketing margin of the potato supply chain, the partnership pattern and the non-partnership pattern. Although there is no noticeable difference between the two partnership models, research conducted by Sudiyono (2004) shows that the degree of marketing efficiency increases in proportion to the decrease in the value of marketing profit margins.

In addition, Table 3 shows the *mean difference* value for the marketing margin indicator of IDR5,410,5.00, which means that the two marketing channel patterns have a marketing margin difference of IDR5,410,5.00/Kg with an average partnership pattern

marketing margin of IDR336.00/Kg and an average non-partnership pattern marketing margin of IDR5,746.5.00/Kg. Although there is no noticeable difference between the two partnership models, Research conducted by Sudiyono (2013) shows that the degree of marketing efficiency increases in proportion to the decrease in the value of marketing profit margins.

The significance values for the *farmer's share indicator* of $0.020 < 0.05$ which means that the H_0 value is rejected. The calculation findings show that there is a considerable gap between the partnership pattern and the non-partnership pattern of the potato supply chain in terms of *farmer share* value. This significant difference is due to the difference in the purchase price at the farmer and the selling price at the last consumer. This difference occurs due to the institutions involved in each pattern of marketing channels, both partnership patterns and non-partnership patterns. This is in accordance with Faika (2015)(Putri, Wijayanti, et al., 2023) which states that each institution performs different marketing functions, causing significant price differences from farmers to consumers resulting in higher prices at the consumer level.

In addition, Table 3 shows the *mean difference* value for the farmer's share indicator of 37.03, which means that the two marketing channel patterns have a farmer's share difference of 37.03 with an average farmer's share of partnership patterns of 95.51 and an average farmer's share of non-partnership patterns of 58.47. The existence of this difference according to Muniroh et al (2022) where the higher the value of the Farmer's Share, it can be said that the channel is efficient, and profitable for farmers.

Table 3 shows the significance value for performance efficiency indicators of $0.434 > 0.05$ which means that the H_0 value is accepted. The results of this calculation show that there is no significant difference between the efficiency value of potato supply chain performance, partnership pattern and non-partnership pattern. Although the difference between the two marketing patterns is not significant, this difference is caused by the difference in the results of the *Data Envelopment Analysis* (DEA) analysis with *input* values and *output* values for each DMU which in this analysis is potato farmers in each potato supply chain partnership pattern in Karangreja District. In addition, Table 3 shows the *mean difference* value for performance efficiency indicators of 0.04072, which means that the two marketing channel patterns have a difference in performance efficiency of 0.04072 with an average partnership pattern performance efficiency of 0.75614 and an average non-partnership pattern performance efficiency of 0.79687.

According to Hussain & Jones (2010) and (Putri et al., 2019) Conditions with an efficiency value of less than

90 percent are shown in red, conditions with an efficiency value of more than 90 percent but less than 100 percent (with potential improvement) are shown with amber, and conditions with an efficiency value of 100 percent without potential improvement are displayed with green conditions. The marketing channel approach is considered more efficient if it is close to 1 (100%).

Conclusion

The results of the analysis show the supply chain efficiency analysis shows that 42.86 farmers operating efficiently have partnership patterns and 57.20 non-partner pattern farmers. The different test analysis shows that for profit and farmer's share indicators there is a significant difference between the partnership pattern and the non-partnership pattern. As for the marketing margin indicators and performance efficiency, there is no significant difference between the partnership pattern and the non-partnership pattern. Meanwhile, for marketing margin indicators and performance efficiency, there is no significant difference between partnership patterns and non-partnership patterns.

Acknowledgments

This research was funded by BLU Unsoed research funds under the institutional research scheme.

Author Contributions

For research articles with several authors, Conceptualization, Dindy Darmawati Putri and Suyono; methodology Dindy Darmawati Putri.; software, Nurfahmi F.; validation, Nurfahmi F.; analysis data, Nurfahmi F and Dindy Darmawati Putri.; investigation, Irene Kartika W and Nurfahmi F.; resources, Suyono.; data curation, Nurfahmi.; writing – original draft preparation, Nurfahmi and Dindy DP; writing – review and editing, Suyono, Dindy and Nurfahmi; visualization, Irene Kartika E W; supervision, Suyono.; project administration, Irene Kartika E W.

Funding

This research was funded by LPPM Unsoed, sceme Institutional Research 2022-2023.

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