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Development of corn supply chain strategy in East Java based on logistics cost structure and marketing efficiency

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ABSTRACT

East Java has the highest corn production center, with a percentage of 26.24%. The highest production occurred in 2022, reaching 6,608,822 tons. *The market's corn supply instability occurs due to uneven harvest patterns. Price disparities between consumers and farmers occur because many supply chain actors are involved, causing losses to supply chain actors. The impact of the El Nino phenomenon can increase logistics costs, especially in procurement activities. This research aims to develop a supply chain strategy based on an analysis of logistics cost structure, marketing margin, profit margin ratio, and farmer's share. Primary data were gathered through interviews and observations. There were 98 respondents, distributed across three regencies : Kediri, Jember, and Tuban. Calculation of logistics cost structure used the ABC method with descriptive statistical analysis. The supply chain strategy was arranged through FGD with several participants. The results of the logistics cost analysis showed that the most significant proportion of logistics costs for corn supply chain actors is in procurement activities, with a percentage of 63.09% and a total cost of IDR 1,649,304 per kg of corn. Marketing is inefficient because marketing margins and profit margin ratios are not evenly spread across all tiers. The supply chain strategy at the farmer level includes standardizing fertilizer use, choosing the proper fertilization method, and using pesticides in a timely and appropriate dose. Apart from that, there is the purchase of superior corn seeds, using seed planters, and maximizing the number of laborers. The supply chain strategy at the collector trader and large trader tier in transportation activities includes maximizing vehicle loads and creating corn storage areas in each corn production center area.*

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INTRODUCTION

Corn (*Zea mays* L) is the top three food crop in the world, after rice and wheat (Dabija et al. 2021). Corn cultivation is carried out globally in tropical regions. Corn has a high protein content for animal feed and food (Zhang et al. 2021). Several factors, such as seed type and fertilization, influence corn productivity. Air humidity factors can cause a decrease in productivity (Chaplygin et al. 2020). According to Pusat Distribusi dan Cadangan Pangan (2019), 65% of domestic corn needs are used for animal feed.

East Java has the highest corn production area, with a percentage of 26.24% (Ditjen Tanaman Pangan 2023). Corn production in East Java in 2016-2022 experienced fluctuations, with the highest production occurring in 2022, 6,608,822 tons. In the first quarter, corn production reached 42.50%, so in the following month, demand for corn was more significant than supply. The impact of this condition is instability in the supply of corn.

The volume of Indonesian corn imports for 2017-2021 experienced fluctuations. The highest imports occurred in 2019, with a volume of 1,443,433 tons. Imports of corn are an indication of instability in the supply of corn in the market. Fluctuating corn prices every month can cause potential losses for supply chain actors. The price disparity between consumers and farmers causes losses to the farmer tier. The large number of supply chain actors involved causes price disparities. The impact of Climate Change and the EL NINO phenomenon has caused corn supplies to decrease. The impact of the El NINO phenomenon is increasing logistics costs, especially in procurement activities, namely on-farm costs. The percentage of corn land types in Indonesia is 71.07%, including non-rice fields. Non-rice fields are at risk of crop failure and planting delays, which affect corn supplies. This type of land can increase logistics costs at the farmer level, especially in material handling and procurement activities.

Supply chain management (SCM) involves planning and monitoring all business processes, from raw materials to the final consumer. SCM creates product value along the supply chain (Ye et al. 2022). SCM aims to efficiently integrate suppliers, manufacturers, distributors, retailers, and consumers (Guritno and Harsasi 2013). Product damage is minimized by implementing SCM (Kristanti et al. 2016). The agricultural supply chain (ASC) starts with planting and crop production, packaging, warehousing, transportation, distribution, and marketing (Routroy and Behera 2017). Implementing the supply chain is the existence of an extensive supply chain network and the development of a company network (Laari et al. 2022). A sustainable agricultural supply chain is needed for consumer satisfaction (Widodo et al. 2021). Supply chain strategies can consider costs and focus on customer service.

A review of logistics and SCM from strategic and tactical aspects has interrelated functions (Widodo et al. 2019). The focus of logistics is the coordination of materials and information flow (Anca, 2019). Logistics arrangements aim to minimize logistics time and costs (Park et al. 2012). Analyze the logistics cost structure to determine the proportion of logistics costs and the most influential cost components (Muha, 2019).

Marketing efficiency is achieved by reducing costs, thereby increasing profits. Apart from that, reducing costs while maintaining customer satisfaction (Kohls, 1955). Marketing efficiency can be based on marketing margin analysis, farmer's share, and profit margin ratio. The profit margin ratio compares profits and costs. Marketing margin analyzes price differences in each tier (Rangasamy and Dhaka 2008). Results of logistics cost structure analysis and marketing efficiency develop supply chain strategies. The preparation of supply chain strategies uses focus group discussions (FGD). The research aims to analyze the logistics cost structure in the corn commodity supply chain in East Java. Then, the marketing efficiency level will be determined, and a chain strategy for corn supply in East Java will be developed.

Several research studies have been conducted on Indonesia's corn commodity supply chain from 2013 to 2023. There were 45 journals that were collected to perform a content analysis. The analysis focuses on the topic, objectives, methods, and research location. The results of the analysis show that logistics costs, marketing efficiency, and supply chain strategy have yet to be analyzed in the corn production center area in East Java. The novelty of the author's research is that it can answer problems in the latest conditions, namely the El Nino phenomenon,

which affects logistics costs for each supply chain actor.

METHODS

The research location is in the central corn-producing area in East Java, which includes Kediri, Tuban, and Jember Regencies. The research was carried out from November 2023 to March 2024. The sampling method uses convenience and snowball sampling. Convenience sampling was used to determine the tier sample for corn farmers. Convenience sampling takes samples based on the availability of sources, ability to provide information, and ease of obtaining the sample. Snowball sampling traces the chain that distributes corn from the farmer tier to the next tier. The total number of samples used was 98 respondents. The determination of the sample size is based on the opinion of Bailey (1994), who states that research using statistical data analysis has a minimum sample size of 30. Details of research respondents are presented in Table 1. The research stages begin with conducting a preliminary survey, identifying and formulating problems, setting goals, collecting, processing, analyzing, and concluding.

Table 1 Number of research respondents

No.	Respondent	Regency		
		Kediri	Jember	Tuban
1	Farmer	22	22	28
2	Collector trader	7	6	6
3	Large trader	2	2	3
	Total	**31**	**30**	**37**

Data Collection

Primary data collection uses interviews and observations. The question focuses on activity and logistics costs for farmers, collector traders, and large traders. Apart from that, data on purchasing and selling corn prices.

Data Processing

The processing stages use calculations of logistics cost structure, marketing margin, profit margin ratio, and farmer's share.

Logistics Cost Structure Calculation

The calculation method used is the activity-based costing (ABC) method, which consists of two stages. The first stage includes activity classification, cost grouping, determining cost drivers, and determining homogeneous cost groups. The second stage is tracing and assigning costs for each cost group to the product (Kaplan and Cooper 1998). The next stage is calculating the mean, upper limit, lower limit, and proportion of logistics costs.

Marketing Margin Calculation

According to Dahl and Hammond (1977), the marketing margin calculation formula is shown by Equation (1).

$$Mm = P_{r-} P_f \quad (1)$$

Mm : Marketing margin (IDR/kg)
Pr : Price at retail level (IDR /kg)
Pf : Price at farm level (IDR /kg)

Farmer's share calculation

The farmer's share calculation formula, according to Kohls and Uhl (1990), is performed by Equation (2).

$$Fs = \frac{P_f}{P_r} \times 100\ \% \quad (2)$$

Fs : Share margin (price) with farmers (%).
Pr : Price at the consumer level (IDR/kg)
Pf : Price at farm level (IDR/kg)

Profit Margin Ratio Calculation.

Equation (3) is The formula for calculating the profit margin ratio.

$$Pm = \frac{\mu}{c} \quad (3)$$

μ: Profits of marketing agencies
c: Marketing cost

Data analysis

Data analysis on the logistics cost structure is descriptive statistical analysis. Data will be presented using tables and diagrams, and the mean will be calculated. Marketing efficiency analysis is based on operational efficiency, which is based on the results. Operational efficiency is related to product input (Mgale and Yunxian, 2020).

Developing a Supply Chain Strategy Using Focus Group Discussion (FGD)

The supply chain strategy is formulated based on a comprehensive analysis of the logistics cost structure, marketing margin, profit margin ratio, and farmer's share. Our approach to an

efficient supply chain strategy is strategic, focusing on reducing logistics activities and enhancing cost efficiency at the highest costs. The supply chain strategy was prepared through FGD with several parties, namely the regional government (Department of Agriculture and Food Security, East Java Province) and corn supply chain actors. FGD provides various kinds of data presented in one forum (Hamzah et al. 2024). The FGD stages are divided into two: searching for FGD informants and carrying out the FGD.

RESULTS AND DISCUSSION

Logistics Cost Structure Analysis.

There are six logistics activities based on observations: procurement, material handling maintenance, transportation, and customer communication. These logistics activities are supported by research conducted by Ongkunaruk and Piyakarn (2011), which shows the same type of activity. The correct application of the ABC method is achieved by clearly identifying activities (Berry, 2014). ABC considers resource-consuming activities (Quesado and Silva 2021); (Bichou and Gray 2004). The calculation stages using the ABC method are as follows.

Classification Activity

Activity classification is based on its hierarchy.

Determination of cost pool

The stages are carried out by grouping activities and costs according to the main logistics activities.

Determination of a homogeneous cost pool

A homogeneous cost pool is meticulously controlled by a cost driver, ensuring the efficient management of cost pools. Homogeneous cost pools are found in procurement activities: planting, fertilizing, pest and disease control, and irrigation. Apart from that, there is a homogeneous cost pool for material handling activities: harvesting, drying, and loading and unloading. Maintenance activities, namely maintenance of equipment and vehicles, are also controlled by the same cost driver. Cost drivers and cost pools of homogeneous logistics activities are presented in Appendix 1.

The next stage is tracking the product by dividing logistics costs by units produced. The unit produced in this research is the corn harvest (pipil) or the amount of corn purchased. A recapitulation of the logistics cost structure for corn in East Java according to logistics activities is presented in Appendix 2. Figure 1 shows the proportion of corn logistics costs in East Java for all supply chain actors. The highest proportion of logistics costs is for procurement activities, with a percentage of 63.09%. The farmer tier dominates high logistics costs for purchasing several raw materials such as fertilizer, seeds, and pesticides. Calculation of logistics costs provides essential information that influences the policies taken (Trenouth et al. 2023).

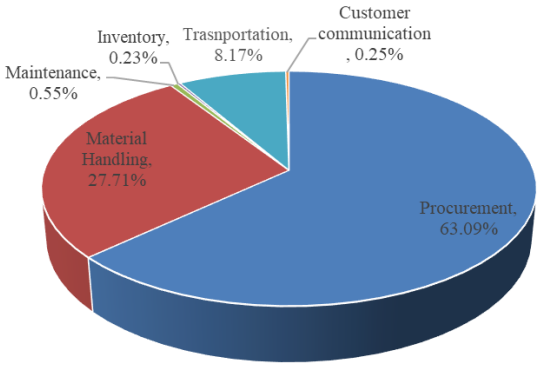

Figure 1 Proportion of corn logistics costs in East Java.

Table 2 Proportion of logistics costs for each tier

Tier	Procurement (%)	Material Handling (%)	Maintenance (%)	Inventory (%)	Transportation (%)	Customer communication (%)	Total
Farmer	**69.73**	28.65	0.47	0.11	0.79	0.25	**100**
Collector Trader	15.53	27.17	1.76	2.79	**52.31**	0.44	**100**
Large Trader	0.59	14.98	1.02	0.34	**83.01**	0.06	**100**

Table 3 Results of marketing margin calculations, farmer's share, and profit margin ratio

Tier	(IDR/kg)	Marketing Margin (%)		Margin Distribution (%)	Profit Margin Ratio	Farmer's Share (%)
		Rp	**%**			
Farmer					1.52	
a. Total Cost	2,340,313					
b. Selling Price	5,898,611					94.5
c. Profit	3,558,298					
Collector Trader		135.6	39.39		0.284	
a. Buying Price	5,898,611					
b. Total Cost	105,585			30.67		
c. Selling Price	6,034,21					
d. Profit	30,014			8.72		
Large Trader		208,65	60.61		0.239	
a. Buying Price	6,034,21					
b. Total Cost	168,451			49.93		
c. Selling Price	6,242,857					
d. Profit	40,196			11.67		
Total		344,25	100 %	100 %		

Proportion of Logistics Costs for Each Tier

The proportion of logistics costs in each tier is presented in Table 2. The activity with the most significant proportion in the farmer tier is procurement activities, with a percentage of 69.73%. Transportation activities are the activities with the most significant proportion of costs in the collector trader and large trader tiers, with respective percentages of 52.31% and 83.01%

Marketing Efficiency Analysis

The data required for the calculation are the buying price, total costs, selling price, and profit. The total cost component is obtained by calculating the logistics costs for each tier. Buying prices and selling prices are obtained through interviews at each tier. The selling price for each tier will be the buying price for the next tier. The average selling price calculation is used as a representation of each tier. The selling price at the farmer tier is IDR 5,898,611/kg. The selling price at the collector trader and large trader tiers is IDR 6,034,210/kg and IDR 6,242,857/kg. The price determination is based on the prices during the harvest season, namely November 2023 to March 2024. The calculation of marketing margin, farmer's share, and profit margin ratio is presented in Table 3 below.

The collecting trader tier has an IDR marketing margin. 135,6/kg or 39.39 %, which consists of costs of 30.67 % and profits of 8.72 %. The large trader tier has a marketing margin of Rp. 208,65/kg or 60.61 %, which consists of costs of 49.93 % and profits of 11.67 %. The most significant marketing margin in the large trader tier is due to the significant price difference between collectors and large traders. Table 3 shows that marketing margins are not spread

evenly, and there are quite significant differences in margins, so marketing is not yet efficient.

An even profit margin ratio indicates an efficient marketing system. The profit margin ratio at the farmer level is 1.52. Then, the level of collectors and large traders is 0.284 and 0.239. The calculation results show that the ratio of each level is not spread evenly, so marketing still needs to be more efficient. Table 3 shows that the farmer share value is 94.5%, indicating efficient marketing.

Developing a Supply Chain Strategy

The supply chain strategy is based on analyzing logistics cost structure, marketing margin, profit margin, and farmer's share. Implementing a supply chain strategy considers several factors: the environment and resources (Kim et al. 2023). The right supply chain strategy can accelerate business performance and improve financial performance (Ariadi et al. 2021); (Shah et al. 2018). The supply chain strategy used is efficient because corn demand tends to be stable and easy to predict. This strategy focuses on cost considerations so that the strategy is carried out by reducing logistics activities or cost efficiency (Chopra and Meindl, 2016). The supply chain strategy at the farmer tier is presented in Table 4.

The logistics activity at the farmer tier that has the highest logistics costs is procurement activity. Reducing the use of pesticides can save costs. Pesticide use must be done in a timely manner and at the correct dose. Purchasing seeds considers aspects of seed quality and certification. Superior seeds can reduce costs because the seeds are resistant to pest and disease attacks. Flat-shaped corn seeds perform better in the early growth phase (Dubal et al. 2020). Apart from that, using a seed planter tool for planting corn allows the distribution of seeds precisely in each row with uniform spacing (Sharaby et al. 2019). The use of these tools can reduce labor costs. Standardizing appropriate fertilizer, including the type of fertilizer and fertilization method, can provide cost efficiency. Farmer respondents need to use fertilizer appropriately according to government recommendations. Maximizing the number of laborers can provide cost efficiency. Planting on a land area of 0.14 ha requires two laborers. Productivity analysis of agricultural labor refers to the agricultural products produced (Balezentis et al. 2021). Irrigation of corn plants according to plant needs can provide cost efficiency. The irrigation time for corn plants is five times in phases: early growth, vegetative phase, phase flowering, seed filling phase, and ripening phase.

Table 4 Supply chain strategy at the farmer tier

Logistic Activity		Activity Details	Supply Chain Strategy
Procurement		Purchase of fertilizer.	The use of fertilizer is based on standards set by the government to reduce excessive use of fertilizer.
		Purchase of pesticides.	a. Use pesticides on time and in the correct dosage b. Use corn seed varieties resistant to pests and disease
		Purchase of corn seed	a. Purchase seeds based on quality, namely superior and certified seeds b. Use the correct planting pattern according to the recommended planting distance c. Use the seed planter as a corn-planting tool to reduce labor cost
	On-farm cost	Planting	Maximizing the number of laborers, namely an estimated land area of 0.14 ha, requires two planting laborers.
		Irrigation and maintenance of crop	Corn irrigation is carried out according to plant conditions to reduce labor costs.

Table 5 Supply chain strategy at the collector trader and large trader

Logistic Activity		Supply Chain Strategy
Transportation	Transportation of shipping	a. Maximizing truck vehicle loads up to 8-8.5 tons of corn b. Construction of corn warehouses for the animal feed industry in each corn production center area c. Establishing cooperation with farmer groups and collector traders in supplying corn to ensure full vehicle loads.
	Loss during delivery	Checking corn quality before delivery

Table 6 Supply chain strategy linked to government policy

No	Problems	Supply Chain Strategy
1	Costs for procurement activities are high	a. Socialization about corn seeds, using fertilizers and pesticides, and corn cultivation to farmers b. Subsidies or assistance with superior corn seeds are needed to reduce procurement costs. c. Additional fertilizer subsidies are needed to reduce procurement costs.
2	Costs for transportation activities are high.	Distribution cost assistance subsidies for collectors and large traders are needed to reduce shipping costs.
3	Market guarantees are not yet available.	Collaborating in partnership with the animal feed industry and chicken breeders to obtain production facilities, supervision from the industry, and definite market guarantees

Table 5 presents the supply chain strategy of the collectors and large traders. The logistics activity at the collector and large trader tier that has the highest logistics costs is transportation activity. Maximizing vehicle loads can provide cost efficiency. Namely, pickup vehicles can load 3-3.5 tons of corn, while truck-type vehicles can load around 8-8.5 tons of corn. Create small warehouses from the animal feed industry in each region's corn production centers to reduce transportation and loss costs. The vehicle load does not affect shipping costs and must be completed to provide efficiency.

Table 6 explains several corn supply chain strategies based on government policy. There are several main problems: high costs for procurement activities, high costs for transportation activities, and uncertain market guarantees. The policy plan was prepared based on the results of the FGD with the East Java Province Department of Agriculture and Food Security and the corn supply chain actor.

CONCLUSION

The most significant proportion of logistics costs is in procurement activities, with a percentage of 63.09%. The farmer tier is dominated by procurement activities, with a percentage of 69.73%. Then, in the collector traders and large traders tier, transportation activities are dominated by 52.31% and 83.01% percentages. Marketing margins and profit margin ratios are not evenly spread across all tiers, so marketing is inefficient. The supply chain strategy at the farmer level includes standardization of fertilizer use, selection of fertilization methods, use of pesticides in a timely and appropriate dose, purchasing superior corn seeds, and using seed planters. Then, the supply chain strategy at the collector trader and large trader tier in transportation activities includes maximizing vehicle loads, creating corn storage warehouses in each corn production center area, and checking the quality of corn before delivery

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Appendix 1. Classification of activities and grouping of homogeneous costs

Table 7 Classification of activities and grouping of homogeneous costs.

	Logistic Activity	Resource	Cost driver	Cost Level	Cost pool
Procurement	Purchase of fertilizer.	Urea Fertilizer and Phonska	The number (kg) of fertilizer.	Unit	1
	Purchase of pesticides.	Insecticides, herbicides and fungicides	The number of bottles or packs of pesticides	Unit	2
	Purchase of corn seeds	Hybrid seeds	The number (kg) of seeds.	Unit	3
	Procurement communications	Communication tools and credits	The number of credit purchased and the frequency of communication.	Batch	4
	Transportation for procurement of goods	Type of vehicle and vehicle fuel	The number (liters) of fuel purchased and the intensity of the purchase	Batch	5
	Planting, Fertilization, Pest and disease control, Irrigation and maintenance of crops	Labor	The number of labor and hours worked.	Batch	6
	Land cultivation	Land	Land area	Batch	7
Material Handling	Corn harvesting, Drying, packaging, and loading and unloading,	Labor	The number of labor and hours worked.	Batch	8
	Corn picking	Rent a machine	The number (kg) of corn	Unit	9
	Transportation of corn shipments from the field to the farmer's homes.	Type of vehicle and vehicle fuel	Delivery distance	Batch	10
	Depreciation of agricultural equipment	Depreciation of agricultural equipment	Frequency of use	Facility	11
	Loss during handling	Reduction in the number of corn	The number (kg) of damaged corn, sprawling, and shrinkage.	Batch	12
Maintenance	Maintenance of agricultural equipment and vehicles	Maintenance cost of agricultural equipment and vehicles	The number of agricultural equipment and vehicles	Batch	13
Inventory	Storage	Building rental and electricity cost	The number of electricity bills	Facility	14
Transportastion	Transportation of shipping	Type of vehicle and vehicle fuel	Delivery distance	Batch	15
	Vehicle depreciation	Vehicle depreciation	Frequency of use	Facility	16
	Loss during delivery	Reduction in the number of corn	The number (kg) of corn.	Batch	17
Costumer communications	Sales communications	Communication tools and credits	The number of credit purchased and the frequency of communication	Customer	18

Appendix 2. Recapitulation of corn logistics cost structure in East Java

Table Recapitulation of corn logistics cost structure in East Java.

Activity	Cost Component	Farmer	Collector Trader	Large Trader	Total Cost	Logistic Cost (IDR/kg)			Cost Proportion (%)
						Mean	Maximum	Minimum	
Procurement	Cost of Purchasing goods	1031,703	0	0	1031,703	343,901	1031,703	0	39,463
	Procurement communications cost	2,266	0,463	0,102	2,831	0,944	2,266	0,463	0,108
	Procurement transportation cost	5,443	15,935	0,893	22,271	7,423	15,935	0,893	0,853
	On-farm cost	592,499	0	0	592,499	197,50	592,499	0	22,663
Total		**1631,911**	**16,398**	**0,995**	**1649,304**	**549,768**	**1642,403**	**1,356**	**63,087**
Material Handling	Post-harvest cost	509,213	27,009	23,977	560,199	186,733	509,213	23,977	21,428
	Cost of depreciation of agricultural equipment	151,752	1,125	0,985	153,862	51,287	151,752	0,985	5,885
	Cost of loss during handling	9,619	0,56	0,278	10,457	3,486	9,619	0,278	0,4
Total		**670,584**	**28,694**	**25,24**	**724,518**	**241,506**	**670,584**	**25,24**	**27,713**
Maintenance	Maintenance cost of agricultural equipment and vehicles	10,87	1,857	1,715	14,442	4,814	10,87	1,715	0,552
Total		**10,87**	**1,857**	**1,715**	**14,442**	**4,814**	**10,87**	**1,715**	**0,552**
Inventory	Holding cost	2,596	2,943	0,572	6,111	2,037	2,943	0,572	0,234
Total		**2,596**	**2,943**	**0,572**	**6,111**	**2,037**	**2,943**	**0,572**	**0,234**
Trasnportation	Shipping cost	18,466	28,108	120,094	166,668	55,556	120,094	18,466	6,375
	Vehicle depreciation cost	0	27,066	19,427	46,493	15,498	27,066	0	1,778
	Cost of loss during shipping	0	0,057	0,306	0,363	0,121	0,306	0	0,014
Total		**18,466**	**55,231**	**139,827**	**213,524**	**71,175**	**147,466**	**18,466**	**8,167**
Customer communication	Cost of sales communication	5,886	0,462	0,102	6,45	2,15	5,886	0,102	0,247
Total		**5,886**	**0,462**	**0,102**	**6,45**	**2,15**	**5,886**	**0,102**	**0,247**
Total		**2340,313**	**105,585**	**168,451**	**2614,349**	**871,450**	**2480,152**	**47,451**	**100**