Strengthening Logistics and Supply Chain Management in The Archipelago in Reducing Distribution Costs: A Study on The Province of Bangka Belitung Islands

Guntur Guntur, Rival Maulana, Reniati Reniati, Darus Altin

University of Bangka Belitung, Pangkalpinang, Indonesia
gunturnaval12@gmail.com

Abstract. The purpose of this study was to analyze the influence of logistics system efficiency and to formulate a model for strengthening logistics and supply chain management that could be applied to the archipelago, especially in the Bangka Belitung Islands Province. The research used a quantitative method approach by utilizing secondary data for the 2019–2024 period obtained from the Central Statistics Agency (BPS) and the Ministry of Transportation. The analysis techniques used included descriptive analysis, simple linear regression, and multiple linear regression. The results of the study on the development of the maritime logistics system in the Bangka Belitung Islands Province during the 2019–2024 period showed fluctuating dynamics. Logistics cost indicators showed an increasing trend. The volume of goods distribution and the number of ship visits had an influence on logistics costs in the Bangka Belitung Islands Province. Ship visits had a negative and significant influence on logistics costs, which suggested that increasing the frequency of sea transportation services could improve the efficiency of logistics distribution and lower transportation costs per unit of goods. Furthermore, the volume of goods distribution and the number of ship visits were able to explain 92.1% of the variation in logistics costs. Strengthening shipping connectivity, developing port infrastructure, and integrating regional logistics systems were identified as important strategies in improving distribution efficiency and economic competitiveness in the archipelago.

Keywords: Logistics Management, Supply Chain Management, Logistics Costs.

1 Introduction

Archipelago areas have different geographical characteristics compared to continental mainland, especially in terms of limited transportation connectivity, territorial fragmentation, and dependence on sea transportation modes in the distribution of goods and services. This condition makes the logistics system in the archipelago face more complex challenges, especially related to high distribution costs, supply chain inefficiencies, and limited logistics supporting infrastructure [1]. One of the archipelago regions

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in Indonesia that has an economic structure based on natural resources, trade, and services, which is highly dependent on the smooth distribution system of logistics between islands. Goods distribution activities in this region not only involve land transportation, but also rely heavily on port connectivity and sea transportation that connect the main islands and national trade areas [2]. The dependence on the multimodal transportation system often causes the problem of relatively high logistics costs compared to the mainland. The high cost of logistics in the archipelago is one of the factors that affect the competitiveness of the regional economy. High distribution costs can increase the price of goods at the consumer level, reduce supply chain efficiency, and reduce the performance of the local trade and industrial sectors [3]. Strengthening logistics management and supply chains is one of the important strategies in improving distribution efficiency and supporting economic growth in the archipelago. From a strategic management perspective, logistics management is not only related to transportation and warehousing activities, but also includes coordination between supply chain actors, logistics information system integration, and distribution network optimization. Effective supply chain management can improve operational efficiency, reduce distribution costs, and increase the responsiveness of the logistics system to market demand dynamics [4]. Therefore, strengthening logistics management needs to be carried out systematically through improving regional connectivity, integrating distribution systems, and developing more efficient logistics infrastructure. Often, companies adopt a hybrid approach that combines elements of global and local strategies to capitalize on the benefits of both [5].

Several previous studies have shown that strengthening transportation connectivity, developing regional logistics hubs, and optimizing distribution networks can contribute significantly to reducing logistics costs in the archipelago [6]. The integration of multimodal transportation significantly improves operational efficiency, lowers logistics costs, and optimizes supply chain performance in China, especially through the application of advanced tracking technology and infrastructure integration [7]. The ideal intensity of distribution channels for a company is how to present a wide range of product types in satisfying consumer needs. The volume of goods transported between islands affects logistics costs, distance between islands, and transportation infrastructure [8].

Based on these conditions, a more comprehensive study is needed on how strengthening logistics management and supply chains can improve distribution efficiency and reduce logistics costs in the archipelago. This study aims to analyze the factors that affect the efficiency of the logistics system and formulate a model for strengthening logistics and supply chain management that can be applied to the archipelago, especially in the Bangka Belitung Islands Province. This study uses a quantitative method approach with secondary data from 2019 - 2024 obtained from the Central Statistics Agency (BPS), and the Ministry of Transportation.

2 Literature Review

2.1 Logistics Management

Logistics and supply chain management is an important aspect of today's business. The ability to manage the distribution of goods, information, and finances effectively and efficiently can provide positive value for organizations [9]. According to Christopher (2016) [4], logistics management is the process of planning, implementing, and controlling the flow of goods and information that aims to meet customer needs at a cost-efficient manner. In the context of modern business, logistics management does not only focus on transportation and warehousing activities, but also involves strategic coordination between organizational functions to improve operational performance. Bowersox, Closs, and Cooper (2019) [10] explained that the effectiveness of logistics management is greatly influenced by the integration of distribution systems, transportation network management, and the use of information technology in controlling the flow of goods. The integration allows companies and economic regions to improve operational efficiency and reduce distribution costs. Thus, logistics management is one of the key factors in increasing economic competitiveness, especially in areas that have geographical challenges such as archipelago.

2.2 Supply Chain Management

SCM is a management process that integrates production, distribution, use, and others, to provide added value for customers and the community who are interested in the company's activities [11]. According to Mentzer et al. (2001) [12], SCM is a systematic coordination of traditional business functions and cross-organizational tactics in the supply chain to improve the long-term performance of the company and the entire supply chain. Simchi-Levi, Kaminsky, and Simchi-Levi (2021) [13] state that effective supply chain management can improve operational efficiency, reduce logistics costs, and increase responsiveness to changes in market demand. Integration between supply chain players, including manufacturers, distributors, and logistics service providers, is an important element in creating an efficient and sustainable distribution system. The main objectives of SCM are the timely delivery/delivery of products, reducing time and costs in meeting needs, centralizing planning and distribution activities, and managing good inventory management between suppliers (vendors) and consumers (buyers) [14].

In the context of the archipelago, the implementation of supply chain management faces more complex challenges due to the limitations of transportation infrastructure, the relatively long distance between islands, and the dependence on sea transportation modes. Therefore, strengthening coordination between logistics actors is an important factor in improving the efficiency of the distribution system.

2.3 Archipelago Region Logistics System

Archipelago areas have different geographical characteristics than continental mainland areas, thus affecting the structure and performance of logistics systems. Rodrigue (2020) [1] explained that the logistics system in the archipelago is highly dependent on sea and port transportation connectivity as the main node for the distribution of goods. Limited transportation infrastructure and high transportation costs are often the main obstacles in the development of logistics systems in the archipelago. Maritime logistics connectivity in the archipelago still faces structural and operational obstacles, especially in terms of port infrastructure, shipping schedules, and logistics costs [15].

Notteboom and Rodrigue (2019) [6] added that the development of logistics networks in the archipelago requires an integrated approach between sea transportation, ports, and land distribution systems. The concept of *port regionalization* emphasizes the importance of developing ports as regional logistics distribution centers that can improve the efficiency of transportation networks and accelerate the flow of goods. A region that has high maritime connectivity or ship visits tends to have better economic integration, smoother flows of goods, and stronger supply resilience [16].

The state of Indonesia is an archipelagic country that has a strengthening of the regional logistics system which is one of the most important strategies in improving connectivity between regions and reducing distribution costs. The most efficient distribution of goods between islands is in areas that have the development of port networks, improved sea transportation connectivity, and the integration of the national logistics system.

2.4 Logistics Costs and Distribution Efficiency

Logistics costs are one of the operational cost structures of a distribution system. The costs in question are the costs of transportation, warehousing, packaging, and inventory management which overall affect the price of products in the market [17]. High logistics costs can reduce the competitiveness of products and increase the price of goods at the consumer level. The World Bank (2021) [3] states that the most efficient logistics system is one of the main factors in increasing the economic competitiveness of a region. Countries or archipelagic regions with efficient logistics systems tend to have lower distribution costs, thus being able to improve the performance of the trade and industrial sectors.

2.5 Strengthening Logistics Management to Reduce Distribution Costs

Strategies for strengthening logistics management can be carried out, such as improving transportation connectivity, developing regional distribution centers, and integrating logistics information systems. Christopher (2016) [4] stated that good logistics system integration can improve coordination between supply chain actors so as to reduce operational costs and increase distribution efficiency.

In addition, the use of information technology in logistics management can also increase the transparency of the flow of goods and speed up the decision-making process.

The integration of logistics information systems allows supply chain actors to monitor the movement of goods in real time, thereby reducing distribution uncertainty and improving operational efficiency.

In the context of archipelagic areas such as the Bangka Belitung Islands Province, strengthening logistics management and supply chains is an important strategy to increase the efficiency of inter-island distribution of goods and reduce logistics costs. This approach is expected to be able to increase regional economic competitiveness and support the development of the trade and industrial sectors in the archipelago.

3 Methodology

This research uses a quantitative approach by utilizing secondary data for the 2019–2024 period obtained from the Central Statistics Agency (BPS) and the Ministry of Transportation which are officially published through annual reports. The data used includes the volume of goods distribution, the number of ship visits, and logistics costs that are propped through the Construction Cost Index (IKK). The research variables consisted of logistics costs as a dependent variable, as well as the volume of goods and ship visits as independent variables. Data collection was carried out through documentation studies and literature studies.

The data analysis technique used descriptive analysis, simple linear regression and multiple regression. Descriptive analysis is used to describe and explain the condition of the research data without testing the relationship between variables. This analysis presents information in the form of tables, graphs, or statistical values such as averages, trends, and growth. In this study, descriptive analysis was used to see the development of the volume of goods distribution, ship visits, and logistics costs during the 2019–2024 period. Simple linear regression is used to analyze the influence of one independent variable on one dependent variable. This model aims to determine the direction of the relationship (positive or negative) and the magnitude of the influence of independent variables on the bound variables. Multiple linear regression is used to analyze the influence of two or more independent variables on a single dependent variable simultaneously. This analysis provides a more comprehensive picture because it considers several factors at once. The equations of the management model used are as follows:

For simple linear regression:

$$Y = \alpha + \beta X + \varepsilon \quad (1)$$

For multiple linear regression:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \quad (2)$$

Where Y is projected logistics costs, indicates the volume of goods, $X_1 X_2$ indicates the arrival of ships, is constant, is the regression coefficient of each variable, and is the error component. $\alpha\beta\varepsilon$ The test was carried out using a t-test to determine the significance of each variable and the determination coefficient (R^2) with a significance level of 5%.

4 Results and Discussion

4.1 Result

Descriptive. The initial presentation provides an overview of the development of the maritime logistics system in the Bangka Belitung Islands Province during the 2019-2024 period. The data used included the volume of goods distribution, the number of ship visits, and the Construction Cost Index (IKK) which was driven by logistics costs.

Based on Table 1, the development of the maritime logistics system in the Bangka Belitung Islands Province shows quite volatile dynamics during the 2019–2024 research period. The volume of goods distribution through ports has increased significantly from 2020 to reach its peak in 2022 of 15,698,078 tons. The increase indicates the growth of trade and logistics distribution activities supported by the increasing mobility of sea transportation in regional markets [6].

Table 1. Bangka belitung logistics data (2019-2024).

Year	Goods Volume (tons)	Ship Visits (Units)	IKK / Logistics Costs
2019	10.279.522	11.938	101,27
2020	9.665.376	11.228	101,90
2021	12.440.814	12.377	101,21
2022	15.698.078	12.744	102,78
2023	5.813.829	9.000	103,94
2024	4.252.788	8.506	105,37

However, from 2023 to 2024 there will be a sharp decline in the volume of goods distribution and the number of ship visits. The volume of goods, which in 2022 reached more than 15 million tons, fell to 5,813,829 tons in 2023 and decreased again to 4,252,788 tons in 2024. This decrease was also followed by a decrease in the number of ship visits from 12,744 units in 2022 to 8,506 units in 2024. This decline illustrates the disruption of the logistics distribution system, which is influenced by economic slowdowns, changes in commodity trade patterns, as well as external factors such as transportation policies and fluctuations in global demand [18].

The Construction Cost Index (CPI) indicator used as a proxy for logistics costs shows a trend that tends to increase. The CPI value has increased from 101.27 in 2019 to 105.37 in 2024. This condition shows that although goods distribution activities have decreased in recent years, logistics costs in the archipelago still tend to increase. Overall, these dynamics show that the maritime logistics system in the Bangka Belitung Islands Province still faces challenges in terms of distribution efficiency and stability of goods flow. Therefore, efforts are needed to strengthen port infrastructure, improve sea transportation connectivity, and optimize logistics management to improve distribution efficiency and reduce logistics costs in the archipelago. This situation is in line with the characteristics of archipelago areas that have higher distribution costs due to

limited infrastructure, long distribution distances, and dependence on sea transportation [4].

To find out more clearly these dynamics, the following is presented a graph of the development of the volume of distribution of goods.

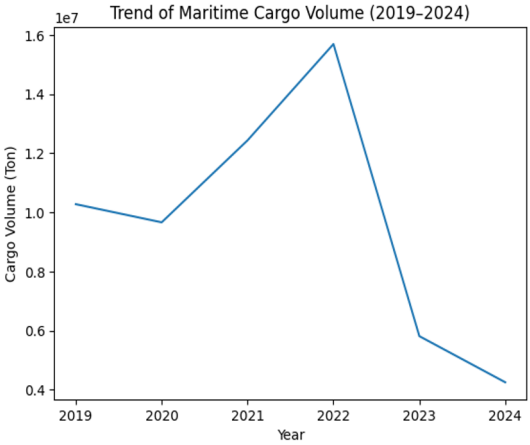

Fig. 1. Trend chart shows the development of the distribution volume of goods.

The graph shows that maritime logistics activities in the Bangka Belitung Islands Province have increased significantly in the 2020–2022 period, which is shown by an increase in the volume of goods distribution to reach 15.69 million tons in 2022. However, after 2022, there will be a sharp decline in distribution volume to 4.25 million tons in 2024. On the other hand, the Construction Cost Index (CPI) which represents logistics costs shows an increasing trend from 101.27 in 2019 to 105.37 in 2024, which indicates that distribution costs in the archipelago tend to increase despite the decline in goods distribution activities. In the context of logistics theory, this condition can occur when there is a decrease in distribution capacity utilization so that fixed costs cannot be optimally reduced [1].

Simple Linear Regression Analysis. To analyze the influence of the volume of distribution of goods on logistics costs, the following simple linear regression model equation is used:

$$Y = 105.34 - 2.68 \times 10^{-7} X$$

Coefficient of determination:

$$R^2 = 0.47$$

This means that about 47% of the variation in logistics costs can be explained by changes in the volume of distribution of goods. The regression coefficient shows a negative relationship between the volume of goods and logistics costs. This indicates that an increase in the volume of distribution of goods has the potential to reduce logistics

costs through increasing the efficiency of distribution scale. Theoretically, the larger the distribution volume, the lower the average cost per unit because the fixed cost can be distributed to a larger number of outputs [19]. However, a p-value (0.133) indicates that the relationship is not statistically significant at a significance level of 5%. This indicates that the volume factor alone is not strong enough to explain the partial variation in logistics costs, so additional variables are needed in the model [20] (see Fig. 2 and Table 2).

Table 2. Table of regression results.

Variable	Coefficient	t-stat	p-value
Intercept	105.344	–	–
Volume of Goods	-2.68E-07	-1.883	0.133

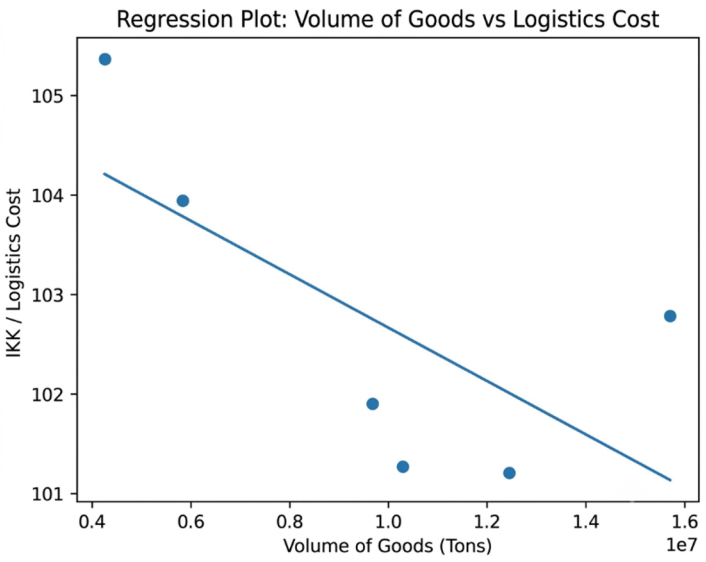

Fig. 2. Plot regression: volume of goods vs logistics costs.

The graph shows the tendency of a negative relationship between the volume of distribution of goods and logistics costs. When the volume of distribution increases, the logistics costs are relatively lower. This can be explained through the concept of economies of scale in logistics systems, where increasing distribution capacity can reduce the average operational cost [19].

Multiple Linear Regression Analysis. To obtain more comprehensive results, this study uses a multiple regression model equation that adds the variable of ship visits.

$$Y = 120.26 + 5.99 \times 10^{-7} X_1 - 0.00213 X_2$$

Coefficient of determination:

$$R^2 = 0.921$$

Adjusted R^2:

$$0.868$$

Approximately 92.1% of the variation in logistics costs can be explained by the volume of goods distribution and ship visits in the research model (see Tables 3-4).

Table 3. Multiple regression results.

Variable	Coefficient	t-statistic	p-value
Constant	120.261	32.741	0.000
Volume of Goods	5.99E-07	2.729	0.072
Ship Visits	-0.00213	4.129	0.026

Table 4. Model summary.

Statistics	Value
R^2	0.921
Adjusted R^2	0.868
Observations	6

The regression results showed that the volume of goods had a positive coefficient of logistics costs, while ship visits had a negative coefficient. The change in the direction of the coefficient of the volume of goods compared to the simple model shows the interaction between variables in a more complex logistics system. Partially, the vessel visit variable was significant at a significance level of 5% (p-value = 0.026). This shows that the frequency of ship visits is an important factor in improving logistics efficiency. The higher the frequency of ships, the smoother the distribution of goods and the waiting time can be reduced, thus decreasing logistics costs [6].

Meanwhile, the variable of the volume of goods was not statistically significant (p-value = 0.072), although it had a positive influence. This shows that an increase in distribution volume is not always followed by cost efficiency, especially if it is not supported by adequate infrastructure capacity and distribution systems [4].

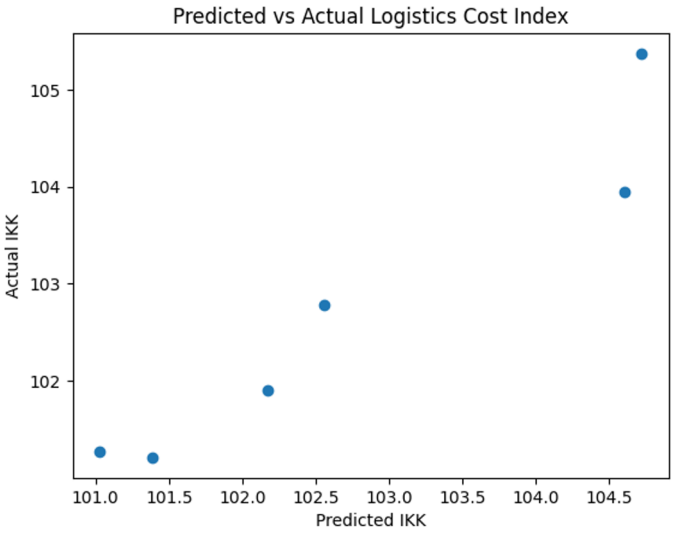

Fig. 3. Predicted VS actual logistics cost index validation chart

This graph shows the relationship between the predicted value of the regression model and the actual value of logistics costs (IKK). Most of the observation points are relatively close to the diagonal line, which suggests that the regression model has quite good predictive capabilities. This is in line with the R^2 value of 0.921, so the regression model used can be said to be quite representative in explaining the variation in logistics costs in the study area [20].

5 Conclusion and Recommendation

The development of the maritime logistics system in the Bangka Belitung Islands Province during the 2019–2024 period shows fluctuating dynamics. Logistics cost indicators show an increasing trend during the research period and the cost of logistics distribution in the archipelago is still relatively high influenced by geographical factors, limited infrastructure, and dependence on sea transportation. The volume of goods distribution and the number of ship visits have an influence on logistics costs in the Bangka Belitung Islands Province. Ship visits have a negative and significant influence on logistics costs, which suggests that increasing the frequency of sea transportation services can improve the efficiency of logistics distribution and lower transportation costs per unit of goods.

Local and central governments need to increase the frequency and regularity of inter-island shipping schedules. This is important because the results of the study show that increasing ship visits has a significant effect on lowering logistics costs. Optimization of the shipping network will increase the efficiency of goods distribution and reduce transportation costs. Investment is needed in the development of port infrastructure, such as increasing dock capacity, deepening shipping channels or moving ports, loading and unloading facilities, and port logistics systems. Port efficiency will maximize the

acceleration of the flow of goods and minimize ship waiting time (dwelling time), so that it can reduce overall logistics costs.

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