

ANALYSIS OF THE FACTORS AFFECTING THE COST OF SHIP REPAIRS IN THE ISLAND OF JAVA AND KALIMANTAN

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ABSTRACT

The national shipbuilding industry is primarily responsible for maintaining and repairing ships at ship repair facilities to ensure their seaworthiness. Each shipyard offers variable pricing for ship repair, mainly if the work is performed on different islands, in Java and outside of Java. By understanding the differences in ship repair costs between shipyards in Java and those outside of Java and the factors that influence these discrepancies, a ship owner can choose a repair shipyard for docking his vessel. Ship repair data were collected from shipyards in Java and Kalimantan, with data collection and direct surveys conducted at three Industries which are located in the island of Java, and three industries in Kalimantan Island, it is processed to determine the difference between the average cost of ship repairs at shipyards in Java Island and Kalimantan Island, revealing that the cost of repairing ships at shipyards in Java Island is higher than the cost of repairs at shipyards on Kalimantan Island. However, there are also increased costs associated with ship maintenance activities in shipyards in the island of Kalimantan. After processing the difference data, the identification of the factors that cause the difference in repair costs forms, and the identification results indicate that the difference in ship repair costs at the shipyards in Java and Kalimantan is influenced by differences in service costs, productivity figures, geographical location of the shipyards, supply chains. materials, as well as the completeness, quality, and capacity of repair support facilities at the shipyards.

Keyword: Ship repair cost, affecting factor, ship docking in Java and Kalimantan

Introduction

Indonesia is home to numerous shipbuilding enterprises. Because around 62% of Indonesia's land area comprises ocean and water, the shipping industry is also quite capable of ensuring the continuation of the Indonesian state in numerous sectors. With repair facilities, the national shipbuilding industry also contributes to meeting ship-worthiness requirements through maintenance and repair [1]. The shipyard's repair facilities also benefit the company's growth. Shipyards need ship repair orders to continue reviving and improving the company's economy so that shipyards may increase their productivity, service, shipyard facilities, processing time, and, of course, the quality of their ship repairs. Also, affordable prices, so that the owner's satisfaction level is always high and they trust

the shipyard to repair the ship, and so that the shipyard receives repeat orders from the ship owner so that the shipyard can always meet the needs of new ship construction and repairs, which are considered one of the strategic sectors for Indonesia's economic development [2].

Navigable vessels must be well-maintained, particularly in terms of their performance. Classification and statutory requirements must also be met to be deemed fit for sailing. Maintaining and repairing a ship are essential to demonstrate its viability for sailing.[3] The maintenance and repairs are performed at the designated shipyard at the owner's request; each shipyard offers different ship repair prices, and particular mainly pairs are performed outside Java. There must be a difference in costs due to the high cost of the materials sold, the high cost of delivery of spare parts, or the delay in the

delay in delivery process of the material, and labour costs outside of Java labour consequently, the disparity between ship repair costs in Java and outside of Java can influence the owner's consideration of the subject of inequalities in ship maintenance cost where the analysis will be conducted about the cost of the ship's repairable components. The variable utilised is the differential between ship repair costs in Java and elsewhere. By evaluating this cost difference, it is intended that the ship owner will be able to comprehend the elements that determine the cost difference and use this as a guide when selecting a shipyard for ship repair. The variable utilised is the differential between ship repair costs in Java and elsewhere. By evaluating this cost difference, it is intended that the ship owner will be able to comprehend the elements that determine the cost difference and use this as a guide when selecting a shipyard for ship repair. The variable utilised is the differential between ship repair costs in Java and elsewhere.

Literature Study

Ship Repair

Ship repair is repairing or replacing ship parts that are no longer viable and do not fulfil the minimal requirements for seaworthiness in line with statutory and classification regulations[4]. Ship Repair generally involves three things: the hull, ship machinery, and outfitting. Of the three things, repairs are typically performed on components that can still be used, while replacements are performed on components that do not fulfil the norms and regulations. A repair can also refer to repairing or replacing damaged components or materials and is part of the ship's maintenance. [5] The following categories of ship maintenance exist:

1. Corrective maintenance
2. Preventative maintenance
3. Improvement Maintenance
4. Planned maintenance
5. Run to failure maintenance

Ship Repair Activity

Based on the SWBS, or Ships Work Breakdown Structure, it is usually divided into several activities, such as docking activities, construction work, machining work, propulsion systems, piping work, electrical work, public services, cleaning and painting work, and outfitting work or ship equipment [6]. The repair activities are further divided into the following sections: [4]

Docking Activities

The docking activity is one of the repair activities related to the process of ascending and descending the ship from the dock. This activity is further divided into several things including:

1. Tugboat activity
2. Take the ship to the dock
3. Lowering the ship from the dock
4. Mooring and rigging

Construction Works

Construction work on repair activities is one of the activities related to maintaining the condition of the ship's hull construction so that it remains good during sailing. The construction work itself consists of several things including:

1. Replacement and repair of hull plates
2. Plate fabrication and preparation process
3. Fairing plate, plate cutting and plate fixing
4. Installation of double plates and stiffeners
5. Manual cleaning, blasting and plate sweeping
6. Gouging plate
7. Welding

Machinery Works and Propulsion System

Mechanical work is one of the activities in ship repair related to engines, pumps, and propulsion systems such as propellers and rudders that work on ships. This work itself is divided into several activities including:

1. Generator disassembly or overhaul
2. Shaft bearing repair
3. Disassembly and installation of rope guard
4. Propeller polishing and repair
5. Steering disassembly, measuring, testing
6. Steering Repair
7. Drilling and machining

Piping Works

Piping work is one of the activities in ship repair related to pipes and valves on the ship. This work is further divided into several activities including:

1. Removal and installation of pipes, valves, pumps, coolants, and blowers
2. Pipe bending
3. Pipe Insulation
4. Valve work or valve

Electric Work

Electrical work is one of the repair activities related to electrical work on the ship. This work is divided into several activities including:

1. Electric motor repair and disassembly

2. Installation or replacement of electric power cables
3. Removal and installation of electrical installations on board

Public Service

Public service is an activity in ship repair related to the provision of facilities needed by ships and crew or crew while the ship is on the dock. This public service is divided into several activities including:

1. Cleaning and waste removal
2. Periodic services such as providing electricity supply, telephone, lighting, ventilation, fresh water, fire fighting and others
3. Security services
4. Crane service
5. Cleaning the tanks on the ship
6. Implementation of free gas
7. Inspection and testing

Cleaning and Painting Works

Cleaning and painting work on the hull is an activity in ship repair related to the surface treatment of the hull visually. This work is divided into several activities including:

1. Blasting and cleaning of hull from fouling
2. Cathodic protection (anode mount)
3. Primary and final hull painting
4. Painting signs on ships such as bulbous bows, draft marks, ship names, port names, strait marks, plimsol marks, and other signs on the ship
5. Installation of scaffolding

Outfitting Job

Outfitting work is an activity in the ship repair process related to the maintenance of equipment on the main ship on the main deck. The scope of the outfitting work itself includes:

1. Dropping and unraveling of anchors and anchor chains
2. Open and close the tank on the ship
3. Cleaning the stomach cupboard or searest and filter or strainer
4. Deck equipment repair
5. Handrail repair or replacement

Ship Repair Cost Component

In the repair process at dock businesses and shipyards, there are three crucial cost factors[7]:

Direct Material Costs (Direct Materials)

Direct material costs are the costs of materials used in the production/repair process to produce a product ready to be delivered to the ship owner/consumer.

Labor Costs (Direct Labor)

Labour expenses are the costs associated with the placement and employment of labour to handle repair process activities, which are essential to managing any repair equipment/facilities [7]. Modern management-adhering shipbuilding businesses do not perform the complete process/repair work with their employees. Now that the shipyard company has completed a restoration process, ties to other industries are visible. These industries, which may generate materials, completed or semi-finished items, services, or labour, are called maritime industry supporting sectors.

Indirect Costs (Overhead)

Indirect or overhead costs consist of indirect material costs, indirect labour costs, and other charges required to successfully complete the production/repair process. Classification of Operating Expenses According to Behavior, the Department is split into two categories: direct departmental overhead expenses (producing department) and indirect departmental overhead costs.

Methodology

Problem Identification Stage

The first step in this research is to determine the problems. At this stage of the research process, the issues that led to this research will be found and written down as a problem formulation. Also, the problem is put into words by showing the shipyards that are the focus of the study and the results of figuring out what the problem is. So that the authors can find and confirm the problem, they use the problem formulation and problem boundaries as research materials.

Literature Study Stage

To complete this research, further references that are beneficial and support all possible facts and data are required. The reference sources include literary works, journals, and prior research. The author's literature review covers the following themes:

- a. Variable Costing and its application to ship repair cost estimation
- b. Ship repair operations
- c. Definition and classification of costs

Field Observation Stage

This is the stage to examine the shipyard's repair activities and the elements that influence the cost of repairs. This stage also involves examining the current state of the disparity in repair costs between the

shipyards of Java Island and Kalimantan Island and their contributing elements.

Data collection process

This phase collects the data required for the completion of this final project. In this phase, the authors collect data in the form of:

- a. Activities performed during the ship repair process;
- b. Ship repair costs at the shipyard;
- b. Productivity of ship repair work;
- c. Supply of materials for ship repair work; and
- d. Facilities supporting ship repair activities.

Data Processing Procedure

After completing the data collection phase, the author gathered and analysed the data by comparing the average ship repair costs between shipyards in the island of Java and shipyards in the island of Kalimantan based on the details of the evaluated repair activities. This comparison will be obtained of ship repair costs at Java Island and Kalimantan Island shipyards.

After comparing ship repair costs at shipyards in Java Island and in Kalimantan Island, the causes for the differences in repair costs between the two islands will be determined.

Data Analysis Stages

From the data processing, an analysis of the current state of the disparity between ship maintenance costs in Java Island and Kalimantan Island was conducted. This step is required to identify the elements contributing to these cost discrepancies' emergence.

Conclusion Phase

At this level, conclusions are reached based on existing research and suggestions for further research are made. In this section, we will summarise the current situation regarding the difference in ship repair costs between shipyards in Java Island and shipyards in Kalimantan Island, as well as the results of identifying factors that influence the differences in ship repair costs between shipyards on Java Island and Kalimantan Island.

Result and Discussion

Comparison of Average Amount of Repair Costs

In terms of the overall average number of repair charges, the statistics are depicted in Figure 1.

This graph is comprised of the averaged total cost of all repair items in each island, both for shipyards in the island of Java and the island of Borneo. Based on this calculation, the difference between the average cost of repairs at the shipyards of Java Island and

Kalimantan Island is Rp. 12,260,903.00, and it is determined that the average cost of repairing ships at the shipyards of Java Island is higher, amounting to Rp. 1,052,827.825.00, compared to shipyards in Kalimantan Island, which have an average ship repair cost of Rp.1,040,566,922.00.

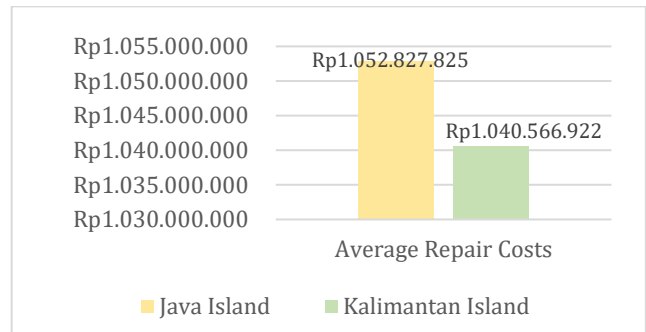


Figure 1. Comparative Graph of Average Repair Costs
Cost Difference Factors in Dockage Activities

The average cost of docking and undocking ships in the island of Java is more than double the average cost on the island of Kalimantan. In Java Island, the docking-undocking cost for a 3001–5000 GRT ship is IDR 37,397,800.00, while in Kalimantan Island, it is IDR 19,344,400. This is owing to the lack of facilities facilitating docking activities. The shipyards in the island of Java use more advanced docking facilities than those in the island of Kalimantan; hence the cost of maintenance and repair is likewise higher. This significantly impacts the cost of repairs, particularly in this Dockage operation.

Factors of Cost Differences in General Service Activities

The average cost of public services in shipyards in Kalimantan Island is greater than on Java Island, which costs Rp. 39,530,000.00 per year. In this repair job, it is evident that the cost of escorting the ship to the shipyard location with a tug boat or scout boat is much different. PT. MNO and PT. The PQR's location along the river makes it more difficult to access. In contrast to most of the island of Java shipyards, which are located by the river, access for ships to dock is easier. It does not require significant operational expenditures since the scouting route to the island of Java shipyards is closer and quick.

Referring to IPERINDO [2], which states that the cost of scouting ships to dock at a shipyard is based on the amount of time a tug boat or scout ship operations while conducting the scouting, it can be deduced that the location of this shipyard is a consideration.

Factors Affecting Cost Variations in Hull Maintenance

Compared to the average cost of hull maintenance operations in ship repair, the average cost of hull maintenance at a shipyard in Kalimantan Island is more than double that of Java Island. This is due to the cost of painting, which is affected by the cost of providing paint vendors, which is higher in Java, and the cost of services.

Cost Difference Factors in Replating Activities

The average cost of replating activities in shipyards in Java Island was somewhat higher than in Kalimantan Island, at Rp 30,339,950.00 versus Rp 28,087,000.00. Compared to the average cost of replating activities, the cost difference is not too significant, but replating operations in Java are nevertheless more costly. This is because the servicing charges at the shipyards in Java Island are more expensive than those in Kalimantan Island.

The average cost of replating activities at shipyards in the island of Java is higher. Still, the plate material required on a large scale and a great deal of it is less expensive (the amount is uncertain because it adjusts the stock available at the supplier). Therefore, shipyard replating operations on Borneo will be more expensive than on Java. This is because the supply of plates accessible from plate material suppliers in the island of Kalimantan is highly restricted, requiring shipyards to purchase plate material from outside the island of Kalimantan and incurring taxes or expenditures. includes for shipping.

Cost Difference Considerations for Tank Cleaning and Maintenance

The average cost of cleaning and maintaining a ship's tank at a shipyard in Java Island is Rp. 2,567,500.00, compared to Rp. 1,346,700.00 on Kalimantan Island. Several interrelated variables determine the variance in the average cost of cleaning and maintaining this tank. The primary element affecting the difference in the average cost of cleaning and maintaining these tanks is the cost of services, which is greater in Java Island shipyards than in Kalimantan Island shipyards. The second and third components, namely production and facilities, are associated.

Cost Variation Considerations for Anchor, Cable, and Chain Locker Repair

The average cost of public services in shipyards in Java Island is greater than on Kalimantan Island, which costs Rp. 56,584,670.00 per year. The variance in the

average cost of fixing anchors, cables, and chain lockers is influenced by several interrelated variables.

The first factor influencing the difference in the average cost of this activity is the cost of services, which is higher on Java Island than in Kalimantan Island. Productivity and facilities are associated as the second and third factors.

The fourth aspect is the cost of supply chain anchor materials at each shipyard; the anchor chain is more expensive in the shipyard in Java Island, in addition to the expense of changing the anchor chain.

Cost Variation Considerations for Sea Chest, Sea Valves, and Valves Repair

The average cost of fixing sea chests, sea valves, and valves differs by as little as Rp1,339,117.00, which is not significant. However, the average cost of this activity is higher in Java Island's shipyards. The cost of services influences the variance in the average cost of this activity, with the cost of services in the shipyards of Java Island being more significant than that of Kalimantan Island.

Cost Variation Considerations for Tail Shaft Repair

The average cost of tail shaft repair activities in the island of Kalimantan is 38.6% higher than in the shipyards of Java, according to the statistics on average cost differences. This is due to various circumstances, as not all tail shaft repair work in the island of Kalimantan is more expensive if one examines the task's specifics. There is a significant cost difference between the propeller axle centring repair and the propeller axle bearing replacement.

The data indicates that the Java Island shipyard is more expensive for propeller work involving centring. This is due to the larger capacity of the facilities owned by shipyards in Java, particularly the lathes required to centre the propeller. Therefore, product excellence is excellent.

According to the statistics, the replacement of propeller axle bearings is more expensive at the shipyard in Kalimantan Island. This is due to the material supply. In the appendix's cost statistics, the greater the propeller's diameter, the higher the cost percentage difference. This is because the stock of materials in the island of Borneo is limited, necessitating shipyards in the island of Borneo to order materials from outside the island of Kalimantan in the cost of transporting materials.

Cost Difference Considerations for Propeller and Rudder Repair

According to the data about the difference in the average cost of propeller and rudder repairs, shipyards in the island of Kalimantan are Rp. 28,633,042 is more expensive than shipyards in the island of Java. Due to the restricted availability of materials in the island of Kalimantan, shipyards in the island Kalimantan must order from outside the island, increasing the cost of shipping materials.

Variables Influencing Electrical Repair Cost Differences

In the data results of the difference in the average cost of electricity-related activities, the difference in prices is not overly significant, where the difference in prices is only Rp 1,359,133.00, and differences influence this difference in service costs, where the cost of services in shipyards in Java is higher than with a service fee in the island of Borneo.

Cost Difference Considerations for Pipe Repair

Shipyards in the island of Java have a higher average cost of repair activities connected to piping work than shipyards in the island of Kalimantan. This difference is caused by the difference in service costs that the cost of services at the shipyards in Java Island is greater than the cost of services in Kalimantan Island.

Cost Variation Considerations for Other Activities

Shipyards in Java Island have a higher average cost of Rp.2,733,950.00 than shipyards in Kalimantan Island, which have an average cost of Rp.1,699,900.00. There are two reasons for this. The first factor is the cost of services, where the cost of services in the shipyards of Java Island is greater than that of Kalimantan Island.

The second factor is the material supply factor. If we look at the data on the difference in the average cost of checkered plates, there is a significant difference in costs. This happens because the stock of materials available in the island of Kalimantan is very limited. Therefore, shipyards in the island of Kalimantan often have to order materials from outside the island of Kalimantan which results in swelling of the cost or shipping costs of these materials.

Recapitulation of factor comparisons

Based on studies, numerous factors influence the difference in shipyard repair costs between Java Island and Kalimantan Island, both overall and per activity. This table summarises researchers' factor-identification results.

Table 1. Recapitulation of factors influencing the price difference

Factor	Java Island	Borneo Island
Service Cost	The average cost of repair services at the shipyards in Java Island is higher than the service costs at the shipyards in Kalimantan Island, which is Rp. 3,861,993.00.	The average cost of repair services at the shipyards in Kalimantan Island is lower than the service costs at the shipyards in Java, which is Rp. 3,079,168.00.
Productivity	the average plate replacement productivity is 0.021 Ton/man hour, and the average docking time is 38.7 GT/Day	the average plate replacement productivity is 0.018 Ton/man hour, and the average docking time is 17.6 GT/Day
Facility	have better completeness, quality, and capacity	completeness, quality, and capacity, supporting facilities for ship repair in shipyards in Kalimantan Island are still worse
Supply chain material	the distance of material delivery is not too far, and the operational costs are lower	Plate supply is limited, need to order from outside the island. From the data obtained, shipyards on the island of Kalimantan order plate materials from Java and even import them from Singapore.
Geographical location	The majority are located by the sea. The shorter duration while piloting a repaired ship	the majority of shipyards are located on the banks of rivers. And have an impact on a longer time when guiding the vessel to be repaired using a tug boat to the shipyard.

Conclusion

Based on the findings of the research, the following conclusion may be drawn:

1. The difference in ship repair prices at the shipyards of Java Island and Kalimantan Island suggests that the cost of repairing ships at Java Island shipyards is greater than that of Kalimantan Island shipyards. Detailed examination reveals that the costs of ship maintenance equipment in Kalimantan are higher than in Java.
2. The results of data collecting on the current factors that influence the formation of differences in repair costs at the shipyards of Java Island and Kalimantan Island, including differences in service costs, productivity figures, geographical location of shipyards, material supply chains, as well as the completeness, quality, and capacity of repair support facilities at the shipyard, have been identified through both general and per-activity factor identification.

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References

- [1] M. S. Arief, Komputerisasi Estimasi Biaya Reparasi Kapal Berdasarkan Historical Data untuk Meningkatkan Efisiensi Activity Based Costing Berbasis Web, ITS, 2012.
- [2] R. Nurwanti, Pribadi T.W., Analisa Peningkatan Kualitas Layanan Jasa Reparasi Kapal Di Galangan Kapal Jawa Timur, *Jurnal Teknik ITS*. (2015). DOI: 10.12962/j23373539.v5i1.15945
- [3] C. Jahn and T. Bussow, Best practice ship management, *Germanishce Lloyd SE*. (2013).
- [4] A Guide to Ship Repair Estimates in Man-hours. DOI: 10.1016/c2011-0-07776-1, 2012.
- [5] I. Lazakis, K. Dikis, A. L. Michala, and G. Theotokatos, Advanced Ship Systems Condition Monitoring for Enhanced Inspection, Maintenance and Decision Making in Ship Operations, *Transp. Res. Procedia*. **14** (2016) 1679–1688. DOI: 10.1016/j.trpro.2016.05.133.
- [6] B. D. Smith Jr, Ship repair cost model, *Nav. Eng. J.* **Vol. 106, No. 3** (1994) 264–278.
- [7] M. S. Karim and others, Modeling and Analysis of Labour Cost Estimation for Ship Repairing: A Case Study in Chittagong Dry Dock Limited, *Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh*. (2019).