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Analysis of the Effect of Safety Equipment and Ship Maintenance on Risk Mitigation and Implications on Shipping Safety of Ncvs Ship in West Kalimantan

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Abstract: This study aims to analyze the impact of Safety Equipment and ship Maintenance on risk mitigation and its implications for the safety of navigation of Non-Convention Vessel Standard (NCVS) ships in West Kalimantan. The main issue addressed in this study is how the completeness and readiness of Safety Equipment, as well as the quality of ship maintenance, can minimize potential risks and support navigational safety. This research uses a descriptive quantitative approach with a cross-sectional design. The population of the study consists of all NCVS crew members in the West Kalimantan region, specifically the Rasau Jaya-Teluk Batang route, with a sample size of 140 respondents selected using saturated sampling. The data were analyzed using a closed-ended Likert scale questionnaire. Hypothesis testing was performed using SmartPLS 4 software to examine the relationships and effects between variables. The results indicate that Safety Equipment and ship Maintenance have a significant impact on risk mitigation and indirectly contribute positively to navigational safety. These findings have important implications for NCVS operational management, emphasizing the need for closer attention to the compliance of Safety Equipment standards and the regular preventive maintenance schedules to improve navigational safety in the West Kalimantan work area.

Keyword: Safety Equipment, Ship Maintenance, Risk Mitigation, Navigational Safety.

INTRODUCTION

Indonesia, as an archipelagic country, has thousands of rivers stretching from Sabang to Merauke, which serve as vital transportation routes for the population, especially in areas not yet fully accessible by land infrastructure. In West Kalimantan, river transportation plays a very dominant role, not only as a means of population mobility, but also as a key driver in the distribution of goods and commodities, as well as supporting local economic activity. The Kapuas River, which is the longest river in Indonesia with a length of approximately 1,143 kilometers, flows through the province of West Kalimantan on the island of Borneo. This river

plays a strategic role as a major transportation route, connecting various cities and villages, especially in remote areas.



Figure 1. Kapuas River, Pontianak, West Kalimantan

The Kapuas River has numerous tributaries and delta-shaped areas, forming various landforms such as swamps and mangrove forests. The river's geography is heavily influenced by the tropical climate, with a rainy season lasting from October to April, which impacts water discharge and causes seasonal flooding. The condition of the Kapuas River infrastructure is influenced by geographic, social, and economic factors. Although the Kapuas River has significant potential as a major transportation route, particularly for the transport of goods and passengers, there are a number of challenges and limitations related to the available infrastructure and facilities. One of the centers of river transportation activity in the province is Rasau Jaya Port, located in Kubu Raya Regency. This port connects important routes such as Rasau Jaya and Teluk Batan and serves hundreds of passengers and various types of cargo transportation daily. However, despite its crucial role, safety issues in river transportation remain a major challenge that has not been fully resolved.

Based on field observations on October 16, 2024, of the KM Arif Azam Jaya—a 450-passenger vessel officially registered in 2023—it was discovered that the vessel was equipped with minimum safety equipment, including 450 life jackets, life buoys, fire extinguishers, and a medical kit. However, the physical condition of some of the equipment showed signs of deterioration, such as worn life jackets and unclear evacuation instructions. The vessel also lacked an evacuation alarm system or routine safety training, which should be standard procedure. These deficiencies have the potential to reduce the effectiveness of emergency response at sea, especially in areas with navigational challenges like West Kalimantan.

A preliminary survey of 30 respondents at river ports in West Kalimantan showed that the majority considered routine vessel maintenance inadequate. Available maintenance facilities were deemed insufficient to support navigational safety, and oversight of vessel maintenance was suboptimal. Furthermore, thorough pre-departure inspections were not consistently conducted. This situation could increase the risk of technical failure during navigation, particularly in areas with limited maintenance facilities.

Another crucial factor is risk mitigation. A preliminary survey of 30 crew members indicated that risk mitigation procedures in the West Kalimantan River waters have not been implemented effectively. Emergency response training is rarely conducted, water monitoring

systems are not fully utilized, and emergency procedures are not routinely communicated to crews. Given the waters' strong currents, fluctuating weather conditions, and dense ship traffic, weaknesses in risk mitigation could have fatal consequences for navigational safety.

A literature review shows that research related to the navigational safety of NCVS vessels in West Kalimantan is still limited, especially those directly linking safety equipment and maintenance to risk mitigation. Several previous studies, such as those by Sutini & Muasyaroh (2023) and Mudiyanto (2019), focused more on vessel seaworthiness and general supervision, while studies by Erlangga et al. (2024) or Nursyamsu et al. (2022) only highlighted specific aspects such as infrastructure or waste management. Few studies have comprehensively examined the interaction of these technical factors in the context of NCVS vessels in congested river waters.

Based on this background, this study takes the title "Analysis of the Influence of Safety Equipment and Ship Maintenance on Risk Mitigation and Implications for Shipping Safety of NCVS Ships in West Kalimantan". The main objective of this study is to fill the literature gap by analyzing the role of safety equipment and ship maintenance in reducing accident risks, while assessing their impact on shipping safety in areas facing limited maintenance facilities. Given the high volume of shipping connecting various islands in West Kalimantan, the findings of this study are expected to serve as a strategic reference for ship operators and related authorities in improving shipping safety systems.

METHOD

This study uses a quantitative approach with a research design that tests the causal relationship between independent variables (Safety Equipment and Ship Maintenance) with the dependent variable, namely the shipping safety of NCVS vessels and the mediating variable, risk mitigation. An associative approach is used to formulate research problems that focus on the influence between two or more variables. This study aims to test the influence of independent variables on shipping safety, with the aim of identifying the effects of Safety Equipment, Ship Maintenance, and risk mitigation on shipping safety. In this case, the relevant predictive variable is the shipping safety of NCVS vessels.

The population in this study is all crew members who work on the West Kalimantan river transportation route, specifically the Rasau Jaya - Teluk Batang Route in 2024, which consists of 140 crew members. The sample used in this study was selected using a saturated sampling technique, where all members of the population who meet the research criteria are included as respondents without random selection. The sample consists of crew members who work on various types of ships, namely wooden ships, speed boats, and ASDP ships, with the following details: wooden ships (12 crew members per ship), speed boats (3 crew members per ship), and ASDP ships (13 crew members per ship). The characteristics of the crew positions involved in this study include various positions, including captain, helmsman, oilman, cook, wiper, boy servant, welder, deckhand, mate, engineer, and engineer II. By using a saturated sampling technique, all crew members involved in these various positions were included in the study. Thus, as many as 140 crew members working on various types of ships and positions contributed representative data to this research.

In data processing, researchers used SmartPLS 3 to simplify data processing and produce faster and more accurate analysis. The data processing process began with editing and coding. Editing was performed to check for potential errors or uncertainty in respondents' answers, while coding assigned specific codes to similar answer alternatives, thus facilitating data tabulation. The edited and coded data were then presented in tabular form to facilitate further analysis.

Next, the processed and sorted data will be used for statistical analysis, specifically path analysis and hypothesis testing. Path analysis is used to examine the relationship between the independent and dependent variables, while hypothesis testing is conducted to confirm whether

the tested variables have a significant influence on ship navigation safety. This approach allows researchers to gain a deeper understanding of the factors affecting the navigation safety of NCVS vessels and provide applicable recommendations to improve safety in the field.

RESULTS AND DISCUSSION

Research Result.

This study was conducted through a survey using a questionnaire instrument distributed via Google Form, resulting in 140 respondents eligible as research samples. The majority of respondents were male (78.6%), while only 21.4% were female, reflecting the dominance of the male workforce in the shipping sector, especially on the West Kalimantan NCVS vessel. In terms of age, most respondents were aged 21-30 years (49.3%), followed by respondents aged 31-40 years (37.9%), indicating that the majority of crew members are young workers who are in the career development phase. In terms of the highest education, most respondents had a high school/vocational high school degree (50.7%), followed by 28.6% with an elementary school education background, 7.9% with a junior high school education, 8.6% with a diploma 3 education, and only 4.3% with a bachelor's degree. This indicates that although the majority of crew members have a fairly high level of education, few continue to higher education.

Evaluation of Measurement (Outer) Model

The outer model reflective test of this research model is structured into 4 parts, namely:

Indicator Validity

The first step in outer loading analysis is to assess indicator validity, which aims to verify the relationship between the indicator and the construct being measured. In this study, an indicator is considered reliable if it has an outer loading value of more than 0.60 (Hair et al., 2019; Hair et al., 2020). The results of data processing indicate that all indicators in the research model have outer loading values above 0.6, which means they are valid for measuring their respective constructs. The indicator with the highest loading in the Safety Equipment variable is X1.14 with a value of 1.000, which states that "The emergency stairs on our ship are sufficient and easily accessible when needed." Conversely, the indicator with the lowest loading is X1.3 with a value of 0.875, which indicates that "The absence of a fire alarm system on board" still has room for improvement.

Construct Reliability

In the second stage of the outer loading analysis, a construct reliability test was conducted to assess the internal consistency of respondents' answers to the indicator items of a construct. The required values for construct reliability are a Cronbach's alpha above 0.7 and a composite reliability between 0.7 and 0.95. The data processing results showed that all variables in this study met these standards, with Cronbach's alpha and composite reliability values above 0.7. Therefore, it can be concluded that this measurement model is reliable and can be relied upon to consistently measure its construct.

Construct Validity

The third stage is assessing construct validity or convergent validity, which refers to the average variance extracted (AVE) value. A construct is considered valid if its AVE value is greater than 0.50 (Hair et al., 2019; Hair et al., 2020). Based on the data processing results, all variables in this research model have AVE values above 0.50, indicating that the indicators in this model are valid for collectively measuring their respective constructs. This confirms that the measurement of the variables in this study is reliable and in line with expectations.

Discriminant Validity

The final stage in the outer loading analysis is the discriminant validity test, which aims to ensure that the indicators in a construct measure the construct specifically and are well discriminated. In this study, the discriminant validity test was conducted using the heterotrait-monotrait ratio (HT/MT Ratio), and the results showed that all HT/MT ratios were lower than 0.9. This means that the indicators in this research model have been well discriminated and can be used to measure their respective constructs specifically, in accordance with the standards set by Henseler et al. (2015).

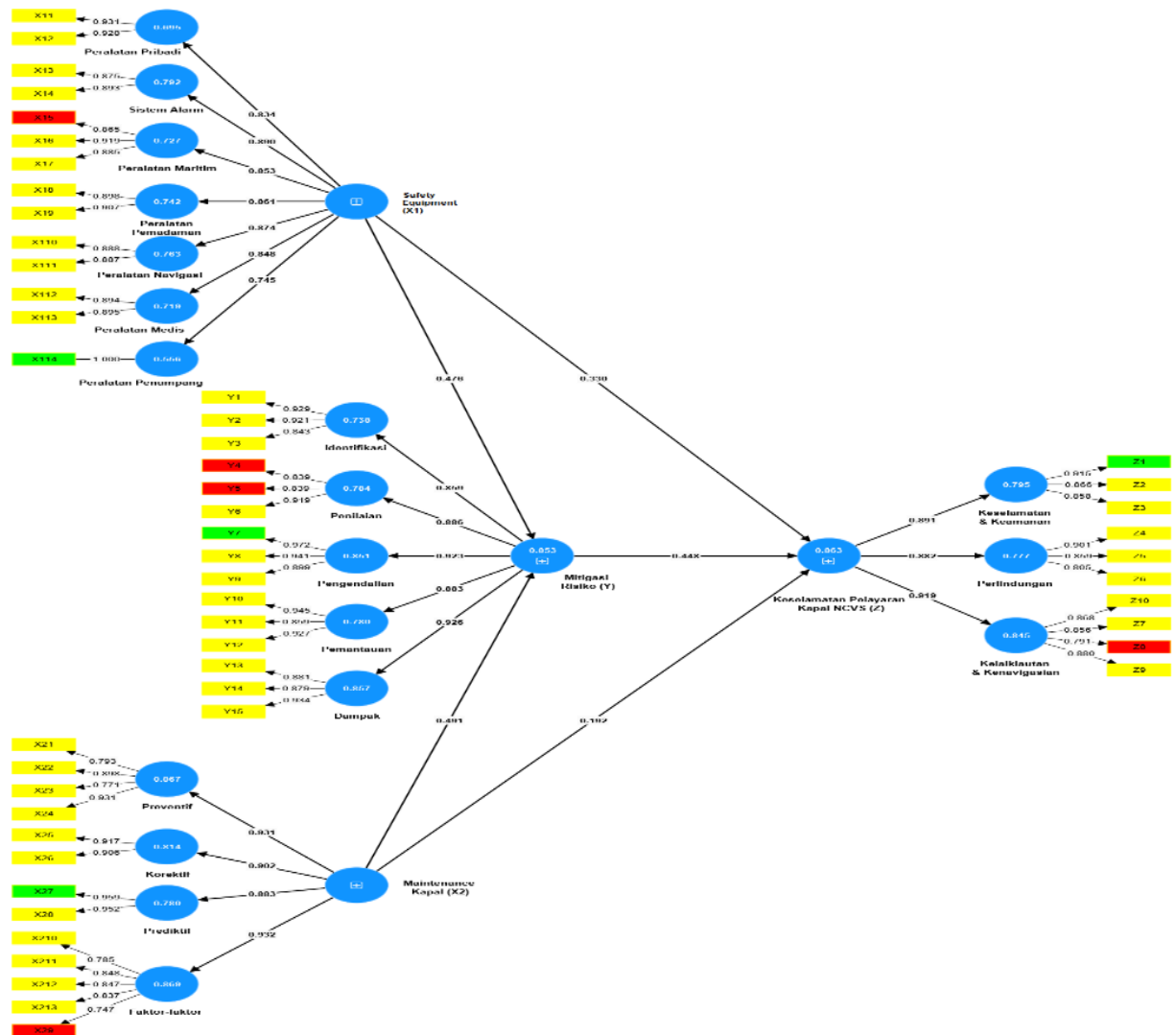


Figure 2 Outer Model Results

Overall, the results of the reliability and validity tests on the outer model indicate that all indicators in this research model have been declared reliable and valid for measuring their respective constructs specifically. Therefore, this measurement model is suitable for proceeding to the next stage of analysis, namely the inner model (structural model) test, to examine the relationships between constructs within the research model.

Inner Model Results

In the data analysis stage using PLS-SEM, after evaluating the outer model, the next step is to assess the inner model, or structural model. Below is a graphical representation of the inner model from PLS-SEM bootstrapping, along with a description:

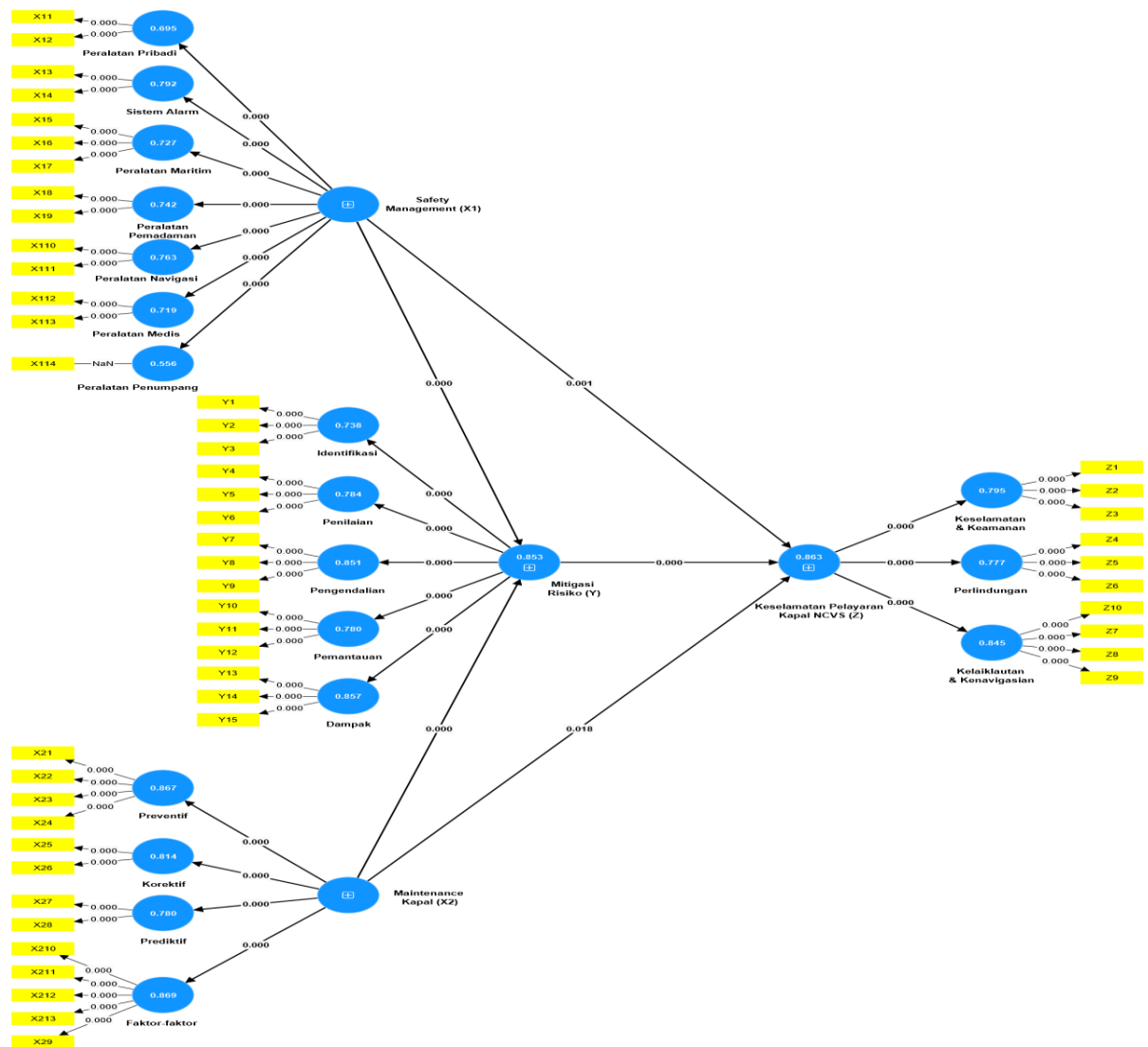


Figure 3 Inner Model Results

Multicollinearity

Based on the results of the Variance Inflation Factor (VIF) test, the VIF values for all variables in the research model are below 5. This indicates that there is no multicollinearity problem between the variables in this model. Low multicollinearity indicates that there is no very strong relationship between the independent variables that can cause distortion in the estimation of the regression coefficients, so this research model can be considered to be of good quality and is not affected by multicollinearity.

Coefficient of Determinant (R-Squared)

In the second stage of the inner model analysis, an R-squared value was assessed to assess the quality of the research model. The R-squared value for the Risk Mitigation variable was 0.853, meaning that 85.3% of the variation in Risk Mitigation can be explained by the Safety Equipment and Ship Maintenance variables. Meanwhile, the R-squared value for the NCVS Ship Navigation Safety was 0.863, indicating that 86.3% of the variation in navigation safety can be explained by the three independent variables (Safety Equipment, Ship Maintenance, and Risk Mitigation). These values indicate that this model has excellent explanatory power, and the ability to significantly explain the dependent variable.

Effect Size (f-Squared)

In the effect size test, it was found that the Ship Maintenance variable has a strong influence on risk mitigation with an f-squared value of 0.522, indicating that Ship Maintenance has a significant impact on risk mitigation. Meanwhile, the Safety Equipment variable has a strong influence on risk mitigation (f-squared 0.492), but its influence on NCVS Ship Navigation Safety is relatively lower (f-squared 0.170). This indicates that the Ship Maintenance and Safety Equipment variables play an important role in risk mitigation, while the influence on ship navigation safety is more moderate.

Predictive Relevance Value (Q²)

The Q² value calculated using the blindfolding method shows that the Risk Mitigation variable has a high predictive ability with a Q² value of 0.539, indicating strong predictive relevance. Meanwhile, the NCVS Ship Navigation Safety variable has a Q² value of 0.500, which is classified as medium predictive relevance. This indicates that this model has a fairly good ability to predict outcomes and shows significant predictive relevance to the dependent variable.

Research Hypothesis Test Results

In the hypothesis testing stage, a bootstrapping test was used to evaluate the significance of the relationships between variables in the research model. The test results showed that all paths in the research model had T-statistics greater than 1.96 (with a significance level of 0.05), indicating that all hypotheses in the model were supported and significant. This indicates that the relationships between the independent and dependent variables in this model can be generalized to a wider population, making this model valid for use in further analysis

Table 1 Hypothesis Test Results

Hypothesis	Influence	Original sample (O)	T statistics (O/STDEV)	P values	Note
H1	<i>Safety Equipment</i> (X1) -> Risk Mitigation (Y)	0.476	8,550	0.000	Significant
H2	<i>Maintenance_Ship</i> (X2) -> Risk Mitigation (Y)	0.491	9,627	0.000	Significant
H3	<i>Safety Equipment</i> (X1) -> Navigation Safety _NCVS Ships (Z)	0.330	3,282	0.001	Significant
H4	<i>Maintenance_Ship</i> (X2) -> Safety of Navigation _Ship NCVS (Z)	0.192	2,360	0.018	Significant
H5	Risk Mitigation (Y) -> NCVS Vessel Navigation Safety (Z)	0.448	4,310	0.000	Significant
H6	<i>Safety Equipment</i> (X1) -> Risk Mitigation (Y) -> Shipping Safety of NCVS Ships (Z)	0.213	3,892	0.000	Significant
H7	<i>Maintenance_Ship</i> (X2) -> Risk Mitigation (Y) -> Shipping Safety _Ship NCVS (Z)	0.220	3,878	0.000	Significant

Hypothesis H1: The Effect of Safety Equipment on Risk Mitigation

The results of the study indicate that Safety Equipment has a significant influence on risk mitigation, evidenced by the T-statistic value of 8.550 which is higher than the T-table of 1.96 at a significance level of 0.05. The standard coefficient of 0.476 indicates a positive relationship between the variables, supporting that the presence and quality of Safety Equipment contribute significantly to risk mitigation in NCVS vessel voyages. This finding is in line with the research of Sitorus et al. (2024), which states that the maintenance of safety equipment contributes significantly to the operational safety of ships. Similarly, research by SM Esad Demirci & Kadir Cicek (2023) shows that the implementation of the International Safety Management (ISM)

Code increases the effectiveness of Safety Equipment in controlling maritime risks. Therefore, increasing the completeness and preparedness of safety equipment should be a priority in shipping management, because good Safety Equipment helps ships be more prepared in facing danger.

Hypothesis H2: The Effect of Ship Maintenance on Risk Mitigation

This study found that ship maintenance significantly impacts risk mitigation, with a T-statistic of 9.627, significantly exceeding the threshold value of 1.96. The standardized coefficient of 0.491 indicates a strong and positive impact of ship maintenance on risk mitigation. Systematic ship maintenance activities, such as inspections of electrical systems and main engines, strengthen the defense system against incidents. This finding is consistent with research by Layuk et al. (2021), which states that implementing a ship maintenance management system supports smooth operations and reduces risks. Furthermore, Mudiyanto (2019) emphasized that regularly scheduled maintenance is crucial in reducing the risk of accidents at sea. Therefore, sustainable ship maintenance needs to be an integral part of shipping risk management to avoid technical failures that could lead to accidents.

Hypothesis H3: The Effect of Safety Equipment on the Navigation Safety of NCVS Vessels

The analysis results show that Safety Equipment has a significant effect on the sailing safety of NCVS vessels, with a T-statistic of 3.282 and a path coefficient of 0.330. The presence of safety equipment such as life jackets, smoke alarms, weather radar, and emergency communication equipment provides critical time for the crew to act in emergency situations. This finding is supported by research by Surawan et al. (2024), which emphasizes the importance of shipping safety supervision policies by authorized officials, and Mawati & Nugroho (2023), which shows that safety standards on river vessels can be applied to NCVS vessels. In addition, Sitorus et al. (2024) reinforces that the maintenance of safety equipment greatly affects the performance of the crew in crisis situations. Thus, ship managers must ensure that safety equipment is always in prime condition to support sailing safety.

Hypothesis H4: The Effect of Ship Maintenance on the Navigation Safety of NCVS Ships

Hypothesis H4 is supported by data showing that ship maintenance significantly influences the navigational safety of NCVS vessels, with a T-statistic of 2.360 and a path coefficient of 0.192. These findings indicate that good ship maintenance can reduce the potential for technical damage that can cause shipping accidents. Routine maintenance of engines, steering systems, and navigation radars improves ship stability in unpredictable sea conditions. Research by Mudiyanto (2019) confirms that ship seaworthiness, which is closely related to maintenance, is a key determinant of shipping safety. Furthermore, Muna et al. (2021) and Wu et al. (2023) emphasize that planned maintenance can significantly reduce shipping risks. Therefore, ship maintenance should be viewed as an integral part of a long-term safety strategy that supports the sustainability of ship operations.

Hypothesis H5: The Effect of Risk Mitigation on the Navigation Safety of NCVS Vessels

Risk mitigation has a significant influence on the navigational safety of NCVS vessels, with a T-statistic of 4.310 and a path coefficient of 0.448. These findings indicate that sound risk mitigation, such as emergency SOPs, safety training, and routine risk assessments, significantly contribute to navigational safety. A study by Fauzi et al. (2024) supports these findings by demonstrating that a structured safety culture can encourage the achievement of zero accidents. Furthermore, Silambi et al. (2022) emphasize the importance of risk monitoring and mitigation policies in reducing maritime accidents. Therefore, risk mitigation must be part of the work culture integrated into every stage of ship operations to improve navigational safety.

Hypothesis H6: The Effect of Safety Equipment on Shipping Safety through Risk Mitigation

The results of the H6 hypothesis test indicate that Safety Equipment has a significant effect on shipping safety through risk mitigation, with a T-statistic of 3.892 and a path coefficient of 0.213. This indicates that safety equipment not only has a direct effect, but also through the effectiveness of risk mitigation on ships. Sitorus et al. (2024) and Demirci & Cicek (2023) reinforce that safety equipment maintenance and the implementation of a comprehensive safety management system improve ship operational safety. The researchers concluded that optimal shipping safety efforts require collaboration between adequate Safety Equipment and a strong risk mitigation system, so that ship safety can be optimally maintained.

Hypothesis H7: The Effect of Ship Maintenance on Shipping Safety through Risk Mitigation

Hypothesis H7 indicates that ship maintenance significantly impacts shipping safety through risk mitigation, with a T-statistic of 3.878 and a path coefficient of 0.220. This finding suggests that good ship maintenance strengthens an efficient risk mitigation system, which in turn improves shipping safety. Wu et al. (2023) and Layuk et al. (2021) support that ship seaworthiness management is crucial in maritime transportation risk management, and high-standard ship maintenance is a key safety indicator. Researchers suggest that ship maintenance should be implemented not only as a technical routine, but as a long-term safety investment that supports sustainable ship operations and optimal risk mitigation.

CONCLUSION

Safety Equipment has a positive and significant effect on Risk Mitigation (H1: 0.476, T-statistics = 8.550, p-value = 0.000). This means that the more complete, functional, and accessible the safety equipment on board, the more effective the risk mitigation process will be. Safety equipment such as alarms, life jackets, life rafts, and fire extinguishing systems help crews recognize, respond to, and control potential risks more quickly and efficiently.

Maintenance Ships have a positive and significant impact on Risk Mitigation (H2: 0.491, T-statistics = 9.627, p-value = 0.000). This means that preventive, corrective, and predictive ship maintenance has been proven to reduce the potential risk of damage or accidents. Timely and high-quality maintenance supports the performance of engines, ship structures, and navigation systems, so that ships are better prepared to face various risk situations that may occur during shipping.

Safety Equipment has a positive and significant impact on the Navigation Safety of NCVS Ships (H3: 0.330, T-statistics = 3.282, p-value = 0.001). This means that the presence and readiness of safety equipment on board a navigational state's vessels directly improves navigational safety. This equipment supports the creation of safe and controlled navigational conditions, and minimizes the possibility of injury or loss of life in emergency situations.

Maintenance Ships have a positive and significant influence on the Safety of Ship Navigation NCVS (H4: 0.192, T-statistics = 2.360, p-value = 0.018). This means that routine and high-quality ship maintenance activities have been proven to support the seaworthiness of the ship and its navigation system. This has a direct impact on shipping safety because well-maintained ships are better able to operate optimally and avoid technical failures at sea.

Risk Mitigation has a positive and significant impact on the Shipping Safety of NCVS Ships (H5: 0.448, T-statistics = 4.310, p-value = 0.000). This means that the better the risk identification, assessment, control, and monitoring processes carried out, the higher the level of safety in shipping. A systematic risk mitigation strategy allows ships to minimize unexpected events and maintain safe operational continuity.

Safety Equipment has a positive and significant impact on the Navigation Safety of NCVS Ships through Risk Mitigation (H6: 0.213, T-statistics = 3.892, p-value = 0.000). This means

that safety equipment not only has a direct impact on shipping safety, but also has an indirect influence by increasing the effectiveness of risk mitigation. This means that safety equipment helps strengthen risk mitigation measures, which ultimately contributes to safer shipping.

Maintenance Ships have a positive and significant impact on NCVS Ship Navigation Safety through Risk Mitigation ($H7: 0.220$, $T\text{-statistics} = 3.878$, $p\text{-value} = 0.000$). This means that good ship maintenance not only maintains the operational function of the ship, but also strengthens the risk mitigation process, which in turn has a positive impact on shipping safety. So, the better the ship maintenance activities, the more effective the risk mitigation steps taken, so that the safety of navigation of state ships can be better assured

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