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Influencing Factors of Safety Management System Implementation on Traditional Shipping

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Abstract: Traditional shipping, often referred to as 'Pelra', displays unique characteristics in contrast with conventional ships. This study hypothesizes that the implementation of a Safety Management System (SMS) in Pelra is influenced by both technical and non-technical factors. The primary objective of this research is to ascertain the degree of influence exerted by each factor on the implementation of SMSs in Pelra. Structural Equation Modeling was utilized to analyze expert opinions gathered for this study. The findings indicate that both technical and non-technical factors have direct and interrelated impacts on the safety management of Pelra. Notably, non-technical factors, particularly the authority and responsibility of the company and the ship's crew, along with technical aspects such as the ship's construction and stability, emerge as predominant influences. These factors act as control variables, guiding the prioritization of actions in SMS implementation. The insights gained from this research can inform policymakers in developing SMS regulations for traditional ships. A detailed examination of safety issues within the most influential factors is undertaken to reshape policies and program directives, aiming to enhance traditional shipping safety. The adoption of SMSs implies increased responsibilities and associated costs for ship owners and crew, necessitating consensus and commitment among all stakeholders, including the government, ship owners, and crew, for effective SMSs policy implementation in Pelra.

Keywords: safety management; traditional shipping; technical; non-technical factors

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1. Introduction

Traditional shipping, commonly known as 'Pelra', has long been integral to trade and transport in Indonesia. Pelra, typically wooden ships, have transitioned from sail to engine propulsion (see Figure 1). These vessels play a crucial role in connecting growth centers to small and remote islands, remaining vital for the livelihood of smaller island communities. Despite their importance, Pelra ships are frequently involved in accidents.

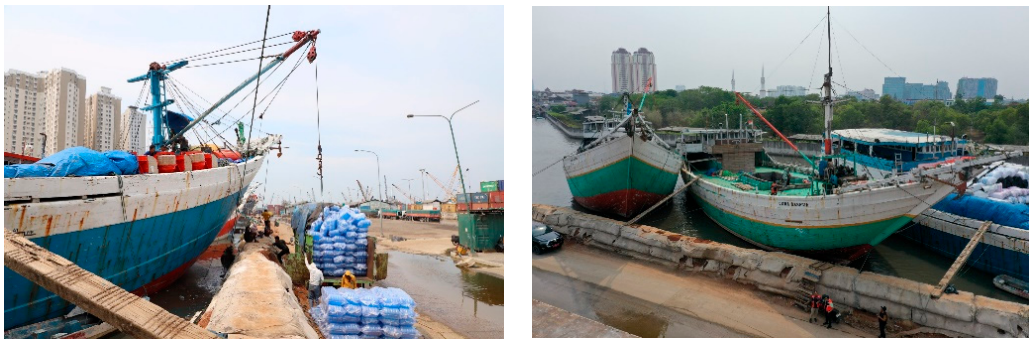


Figure 1. Traditional shipping (Pelra) in Indonesia.

In recent years, the Pelra ships has undergone significant changes, shifting from cargo transportation to tourism. This evolution marks a notable decline in its national significance compared to 20–30 years ago. Challenges such as reduced cargo demand and limited wood resources, the primary material for these ships, have led to safety concerns due to a higher incidence of accidents in traditional shipping [1].

Pelra ships, as non-conventional vessels, are mandated by government regulations to adhere to safety standards [2]. Despite this, the implementation of a Safety Management System (SMS) has been lacking. The risk of accidents and damage is particularly high in eastern Indonesian waters, which are known for their high waves. Data from 2018–2022 in Table 1 indicate that Pelra ships were involved in 10% of the 108 ship accidents investigated by the National Transportation Safety Committee (NTSC) [3]. Implementing an SMS is expected to mitigate these safety risks.

Table 1. Overview of maritime accident investigations conducted by the National Transportation Safety Committee (NTSC) in Indonesia.

No	Explanation of Causes	Year					Total
		2018	2019	2020	2021	2022	
1	Sink	10	6	3	5	5	29
2	Burns/Explodes	12	6	2	6	5	31
3	Collision	3	9	2	4	1	19
4	Run aground	7	0	4	2	2	15
5	Others	7	4	1	2	0	14
	Total	39	25	12	19	13	108

In SMS application, factors are generally categorized into technical and non-technical aspects. Human error, a non-technical factor, is often cited as a primary concern, which is usually due to crew members' lack of safety awareness and training. This aligns with theories suggesting that most maritime accidents are attributable to human error whether intentional or not. Ensuring the crew's health and physiological condition is therefore vital [4]. Consequently, SMS designs should aim to minimize human error [5,6].

Company responsibility also plays a crucial role. Companies must provide adequate resources for safety management and ensure crew members are well-versed in safety procedures [7]. This includes maintaining ships and equipment to safety standards, conducting regular maintenance, and implementing clear safety management policies. Effective risk analysis and incident reporting mechanisms are also essential [8], as is the use of early detection systems to mitigate environmental hazards [9].

From a technical standpoint, the construction and stability of ships are paramount factors in SMSs. Ships must meet regulatory standards and be built with appropriate materials and processes. Stability considerations, such as weight distribution and buoyancy, are critical for safety under various conditions [10]. The regular maintenance of construction and stability is essential, as Pelra ships often exhibit low stability due to non-standard construction, making them susceptible to high waves [11,12].

Domestic vessel SMS regulations cover a range of functions, from safety policies to company audits [13]. However, these standards cannot be directly applied to Pelra ships due to their unique characteristics. The goal of Pelra SMS should be to ensure operational safety by establishing standards and procedures to address potential risks to the ship, crew, and environment. This includes enhancing emergency preparedness for safety and environmental protection.

This paper builds on Wahid's research [14], which identified factors and indicators affecting SMS implementation, by quantifying the influence of each factor. Previous studies, such as that of Malisan et al. [15], have focused on stability, strength, and human resources. This research aims to expand on these factors and quantify their influence. Additionally, it is the first study to develop a concept for Pelra SMS policy in Indonesia.

Understanding both technical and non-technical influencing factors is vital for developing Pelra SMS policy. Recognizing the interplay among these factors will aid in comprehensive risk analysis, effective policy formulation, resource optimization, stakeholder engagement, and adaptation to environmental changes. This approach will enable the creation of more contextual, adaptive, and effective safety management policies for future ship safety.

2. Research Methods

2.1. Population Type and Sample

This study is a cross-sectional analysis focusing on the elements of the Safety Management System (SMS) when applied to traditional maritime transportation. The primary method used is Structural Equation Modeling (SEM), which is a multivariate statistical technique that integrates regression, factor analysis, and path analysis. SEM's application in transportation research is well documented, including in areas such as sea transportation network integration [16], accessibility and connectivity [17], public bus transportation [18], aviation service quality [19], and quality of goods distribution services [20].

The data for this study were collected through an online questionnaire distributed via Google Docs. The questionnaire targeted respondents with experience in marine transportation safety and included items related to research variables. Responses were measured using a Likert scale, with 5 indicating 'strongly agree', 4 indicating 'agree', 3 indicating 'moderately agree', 2 indicating 'disagree', and 1 indicating 'strongly disagree'. Both reliability and validity tests were conducted on all variables.

A total of 265 respondents participated in this study, meeting the minimum SEM requirement of 200 participants [21]. The selection of informants was conducted using a purposive sampling technique. The demographic breakdown of participants was as follows: 90% male and 10% female, with educational backgrounds of 32.4% high school, 39.7% Bachelor's or Diploma, and 27.9% postgraduate. Age distribution included 38.9% aged 30-40 years, 45.3% aged 41–50 years, and 15.8% over 51 years. Regarding work experience, 45.7% had 5–10 years, 31% had 11–15 years, and 23.3% had over 15 years in the field. Additional details on informant characteristics are provided in Table 2.

Table 2. Distribution of respondents by occupation.

	Characteristics	*n*	%
-	Academics	30	11.3
-	National Search and Rescue Agency	44	16.6
-	Indonesian Classification Bureau (ICB)	7	2.6
-	Shipping Directorate, Ministry of Transportation	6	2.3
-	Shipping Court	12	4.5
-	Marine Inspector	29	10.9
-	Ship Owner/Ship Crew	78	29.4
-	Harbormaster	59	22.3

2.2. Research Variables

This study involves the identification of both latent and manifest variables, which are critical in assessing the performance improvement of Pelra's Safety Management System (SMS). These variables were identified through a comprehensive review of relevant literature and in-depth interviews conducted using the Delphi method. The detailed list and descriptions of these variables, including their sources and potential impacts on Pelra's SMS performance, are presented in Table 3.

Table 3. Research variables.

Variable Latent	Variable Manifest		References	Factor Type
Corporate responsibility and authority (X1)	X1.1	Establish rules and procedures for ship safety and environmental protection	[13,15,22–24]	Non-Technical
	X1.2	Regularly monitor crew compliance with vessel safety requirements		
	X1.3	Ensure safety rules are implemented by all crew		
	X1.4	Ensure the availability of crew resources in accordance with manning regulations		
	X1.5	Prepare operation checklist for vessel operations related to safety and personnel		
	X1.6	Consistent implementation of SMS regulations		
	X1.7	Implementation of ongoing safety management training for crew members		
	X1.8	Consistently conduct regular meetings to find solutions to safety management issues		
	X1.9	Appoint crew members who understand the safety aspects of the vessel (skipper and shore personnel)		
	X1.10	Program and internally evaluate safety activities		
	X1.11	Evaluate the effectiveness of SMS and review in accordance with established procedures		
Crew responsibility and authority (X2)	X2.1	Routinely check the completeness requirements of safety systems on board	[13,15,23,25–32]	Non-Technical
	X2.2	Understand the duties and responsibilities related to ship safety management system		
	X2.3	Obtain precise, clear and easy clarity of instruction in the implementation of safety systems		
	X2.4	The skipper motivates the crew to implement the safety policy		
	X2.5	Routine strengthening of leadership to captains		
	X2.6	Able to operate navigational equipment		
Resources and personnel (X3)	X3.1	Receive regular vessel safety training (skipper and shore personnel)	[13,30,33]	Non-Technical
	X3.2	Psychological examination of crew members before sailing		
	X3.3	Checking the physical condition of the crew before sailing		
	X3.4	Crew health check before sailing		
Emergency readiness (X4)	X4.1	Identify potential emergency situations on board	[13,22,23,27,28]	Non-Technical
	X4.2	Establish procedures for responding to emergency situations		
	X4.3	The crew must be able to respond quickly when conditions occur that jeopardize safety		

Table 3. *Cont.*

Variable Latent		Variable Manifest	References	Factor Type
Administration and Documentation (X5)	X5.1	Establish procedures for controlling documents and data related to the safety management system	[13]	Non-Technical
	X5.2	Organizing document and data control procedures related to the safety management system		
	X5.3	Establish and document authority, responsibility, and coordination patterns among crew members in the implementation of the safety management system		
Ship maintenance (X6)	X6.1	The ship owner establishes regular ship maintenance procedures	[13,15,22]	Technical
	X6.2	The crew understands maintenance operation manuals and routine maintenance systems		
	X6.3	The crew performs routine ship maintenance		
Ship Construction (X7)	X7.1	Connection system	[14]	Technical
	X7.2	Ship body impermeability		
	X7.3	Transverse watertight bulkhead		
	X7.4	Reinforcement of machine foundation		
	X7.5	Reinforcement of deck and deck house construction		
	X7.6	Reinforcement of hatch area		
Ship stability (X8)	X8.1	Cargo layout	[14]	Technical
	X8.2	Type of cargo transported		
	X8.3	Ship shape and size		
	X8.4	Wind, waves, currents and storms		
Safety and navigation equipment (X9)	X9.1	Checklist the condition and quantity of safety and navigation equipment	[14]	Technical
	X9.2	Guidelines for the use of safety and navigation equipment		
	X9.3	Placement of safety equipment in an easily accessible location		
	X9.4	Crew skills using safety and navigation equipment		

2.3. Conceptual Framework and Hypothesis

Drawing from the work of Ofori et al. [34], it is posited that a safety culture is established through knowledge and consistent safety training. However, these elements are only effective when there is adherence to safety regulations and standards. Additionally, the enhancement of safety performance is contingent upon the support of robust policies and institutional frameworks [35].

In this research, the conceptual framework encompasses safety knowledge, safety training, safety policy, and institutional support as key latent variables. These variables comprise nine factors and are further delineated into manifest variables, which include both technical/environmental and non-technical factors. The structural model (Y) is conceptualized as follows: $Y = f\ (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9)$, where the measurement model is $X_1 = f\ (X_{1.1}, X_{1.2}, X_{1.3}, X_{1.4}, X_{1.5}, X_{1.6}, X_{1.7}, X_{1.8}, X_{1.9}, X_{1.10}, X_{1.11})$; $X_2 = f\ (X_{2.1}, X_{2.2}, X_{2.3}, X_{2.4}, X_{2.5}, X_{2.6})$; $X_3 = f\ (X_{3.1}, X_{3.2}, X_{3.3}, X_{3.4})$; $X_4 = f\ (X_{4.1}, X_{4.2}, X_{4.3})$; $X_5 = f\ (X_{5.1}, X_{5.2}, X_{5.3})$; $X_6 = f\ (X_{6.1}, X_{6.2}, X_{6.3})$; $X_7 = f\ (X_{7.1}, X_{7.2}, X_{7.3}, X_{7.4}, X_{7.5}, X_{7.6})$; $X_8 = f\ (X_{8.1}, X_{8.2}, X_{8.3}, X_{8.4})$; and *dan* $X_9 = f\ (X_{9.1}, X_{9.2}, X_{9.3}, X_{9.4})$. The interplay between technical and non-technical variables is elucidated through both the structural and measurement models,

as depicted in the conceptual framework presented in Figure 2. This framework forms the basis for understanding how these variables interact within the context of the study.

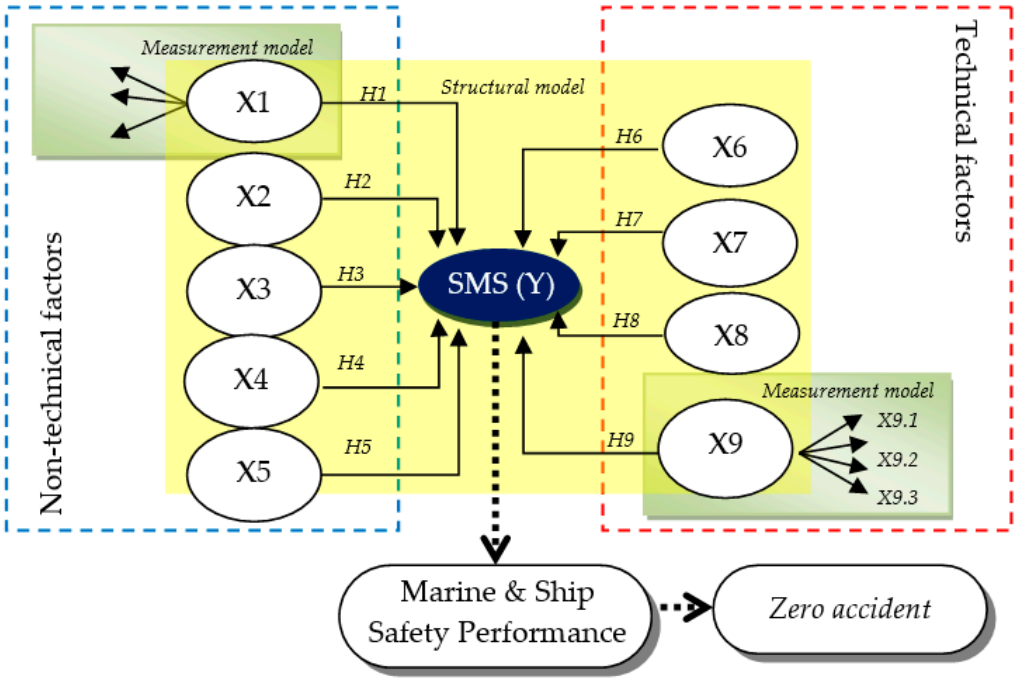


Figure 2. SEM conceptual framework.

Based on the delineated relationships in the SEM conceptual framework, it is hypothesized that each variable (H_1 to H_9) exerts a direct and positive influence on the overall improvement of transportation safety performance, which is represented by hypothesis H_0. Therefore, the research hypotheses are formulated to reflect this direct positive relationship, which is denoted as [(H_1 to H_9) = (H_0)].

3. Results and Discussion

3.1. Statistical Test of Data and Measurement Model

The reliability of the questionnaire was assessed using Cronbach's alpha (CA), yielding values between 0.73 and 0.86. This indicates a high level of reliability for the measurement tool. Validity testing on 44 indicators, with a 95% confidence level, resulted in a count value of r = 0.232, confirming the validity of all indicators. A normality test, using the critical ratio skewness value criterion of ±1.98 at a significance level of 0.03, showed that the data are normally distributed, with skewness and kurtosis values ranging between −2 and +2 [36]. The outliers test indicated a significant value of $p < 0.001$, suggesting an absence of outlier observations. Additionally, the multicollinearity test, with a determinant of the sample covariance matrix value of 4.438, indicated no issues of multicollinearity or singularity in the data.

Confirmatory Factor Analysis (CFA) was conducted to further ensure the reliability and validity of the model. The results, as shown in Table 3, demonstrate that the composite reliability (CR) for each construct exceeded the threshold of >0.7 [37], factor loadings were above >0.5 [38], and all average variance extracted (AVE) values surpassed the threshold of >0.5 [39], confirming the model's high reliability. Discriminant validity was also established, as the square root of AVE values (Table 3) was greater than the correlation coefficients between the constructs [40], indicating a significant effect of all manifest variables on their respective latent variables. The CFA validation for the measurement model is detailed in Appendix A.

3.2. Structural Model Analysis

The model's quality was evaluated using various goodness of fit (GOF) tests, including sig-probability, RMSEA, GFI, AGFI, CMIN/DF, TLI, and CFI, with the standardized criteria values listed in Table 4. The initial hypothesis posited that all latent variables (X1 to X9) significantly influence the application of SMSs in Pelra sea transportation, as depicted in Figure 3. However, the initial model test indicated that the GOF values did not meet the requisite criteria, necessitating modifications to the structural model. Subsequent tests and estimations involved altering paths between latent variables and manifest variables to optimize the model [16].

Table 4. Full structural model test results.

Test Criteria	Standardized Cutoff Criteria	GOF Test Results	Description
Sig-Probability	≥0.05	0.083	Good fit
RMSEA	≤0.08	0.047	Good fit
GFI	≥0.90	1.484	Good fit
AGFI	≥0.90	0.915	Good fit
CMIN/DF	≤2.00	1.720	Good fit
TLI	≥0.95	0.945	Marginal fit
CFI	≥0.95	0.921	Marginal fit

Description: GOF = goodness of fit; RMSEA= root mean square error of approximation; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; CMIN/DF = the minimum sample discrepancy function; TLI = Tucker–Lewis index, CFI = goodness-of-fit-index.

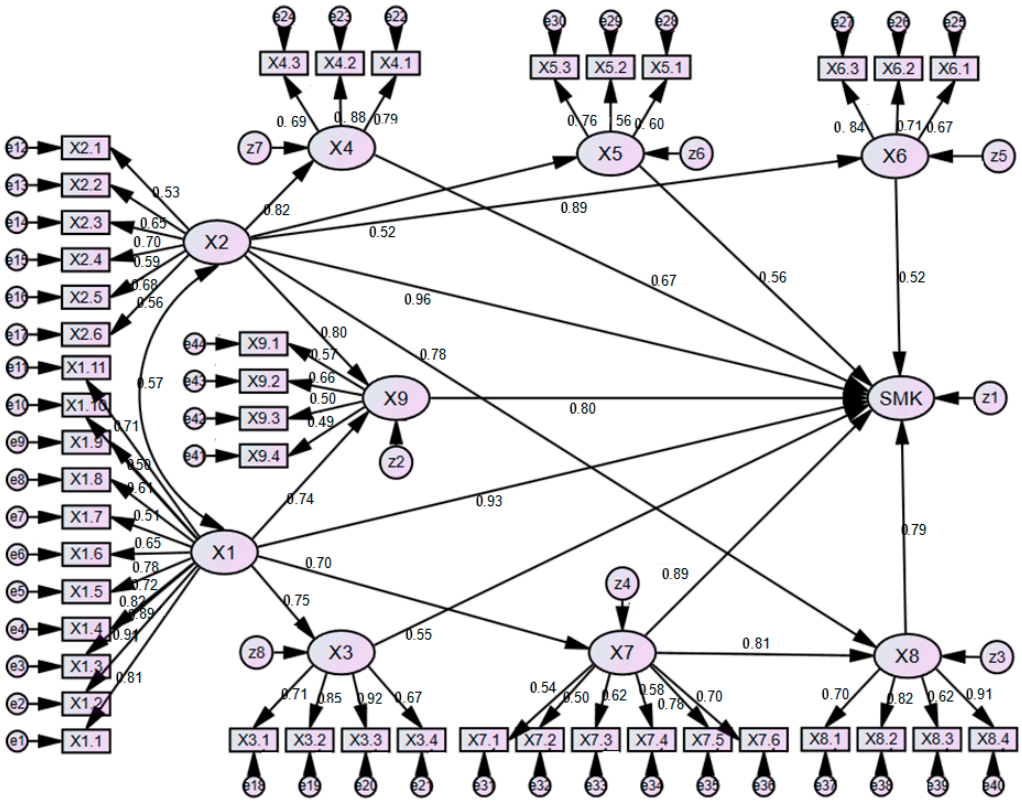


Figure 3. Optimized full structural model depicting enhanced results after modifications.

After several modifications, the optimal structural model was identified, as shown in Figure 3. These modifications involved adjusting the paths so that latent variables not only exert direct effects on the implementation of SMSs but also have indirect effects. Specifically, the safety and navigation equipment variable (X9) is influenced by both the company's responsibility and authority variable (X1) and the crew's responsibility and

authority variable (X2), subsequently affecting SMS implementation. Variable X1 directly impacts variables X3, X7, and X9, while X2 directly influences variables X4, X5, X6, X8, and X9. Additionally, there is a reciprocal influence between variables X1 and X2. In this final model, the SMS is directly influenced by all latent variables from X1 to X9. The comprehensive structural model diagram is presented in Figure 3, and the goodness of fit (GOF) values of the model are detailed in Table 4.

The model fit test results, as shown in Table 4, indicate that the modified model (Figure 3) performs well since most test criteria, including sig-probability, RMSEA, GFI, AGFI, and CMIN/DF, meet the specified standards. Despite TLI and CFI values being slightly below the cutoff threshold, the model is considered acceptable due to the marginal fit acceptance and the proximity of these values to the cutoff limit [40]. Ghozali [36] suggests that if two or more test criteria indicate a good fit with the data, the model can be deemed satisfactory.

3.3. Model Interpretation

The analysis of the SEM model's suitability demonstrates the significance of both direct and indirect relationships among variables, offering insights into the extent of their influence on the implementation of Pelra's Safety Management System (SMS). The estimated values, as presented in Table 5, provide a quantified understanding of the correlations between these variables.

Table 5. SEM model fit test results for the implementation of SMS in Pelra shipping.

Variables	Estimate	S.E	C.R	Description	Influence Rating
X1 → X9	0.590	0.187	7.452	significant	-
X1 → X3	0.506	0.023	8.704	significant	-
X1 → X7	0.691	0.095	10.450	significant	-
X2 → X4	0.703	0.150	8.054	significant	-
X2 → X5	0.609	0.034	8.334	significant	-
X2 → X6	0.534	0.090	3.903	significant	-
X2 → X8	0.804	0.056	6.034	significant	-
X2 → X9	0.690	0.056	12.434	significant	-
X1 → SMS	0.810	0.138	10.034	significant	2
X2 → SMS	0.842	0.084	6.430	significant	1
X3 → SMS	0.585	0.041	4.899	significant	7
X4 → SMS	0.555	0.039	6.346	significant	8
X5 → SMS	0.503	0.040	13.441	significant	9
X6 → SMS	0.618	0.042	14.434	significant	6
X7 → SMS	0.803	0.023	8.233	significant	3
X8 → SMS	0.785	0.076	7.034	significant	4
X9 → SMS	0.704	0.092	8.438	significant	5

Based on the estimated values in Table 5, which reflect the extent of positive and significant influences on SMS implementation in Pelra vessels, these values range from 50.3% to 84.2%. Accordingly, the hypothesis [(H_1 to H_9) = (H_0)]—based on the SEM model fit test—suggests that the latent variables (X1 to X9) have a direct impact on SMS application. Notably, the variable representing crew responsibility and authority (X2) emerges as the most influential, which is followed closely by the employer responsibility and authority variable (X1). Subsequent variables, including construction, ship stability, safety and navigation equipment, ship maintenance, administration and documentation, emergency preparedness, and resources and personnel, also exhibit significant effects. Specifically, variable X2, elucidated through manifest variables indicated by X2.1 to X2.6, shows an influence of 84.2%. Similarly, the administration and documentation variable (X5) demonstrates a positive and significant effect on SMS application in Pelra vessels (H5 = accepted), with its influence explained by indicators X5.1 to X5.3, accounting for 50.3%.

Furthermore, the estimated values indicate a hierarchy of influence among the factors affecting SMS application, ranked from the most to the least influential: crew responsi-

bility and authority (X2), company responsibility and authority (X1), ship construction (X7), ship stability (X8), safety and navigation equipment (X9), ship maintenance (X6), resources and personnel (X3), emergency preparedness (X4), and finally, administration and documentation (X5). This order of influence is visually depicted in Figure 4.

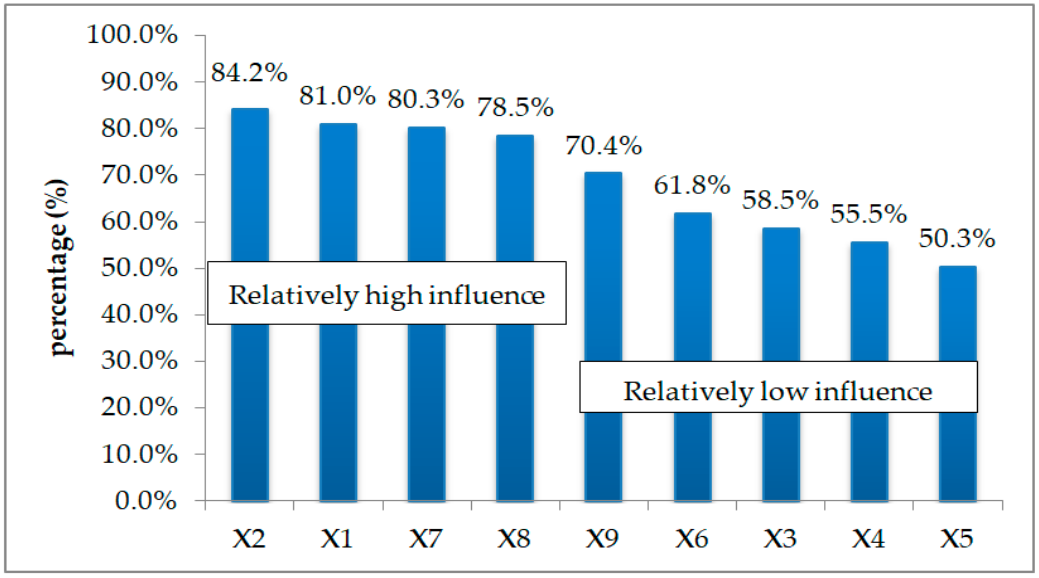


Figure 4. Hierarchical ranking of factors influencing the implementation of SMS in Pelra.

Figure 4 illustrates the varying levels of influence exerted by each factor on the implementation of the Safety Management System (SMS) in Pelra shipping. It is crucial to note, however, that the lower influence of certain factors does not diminish their importance in maritime safety. In the context of safety, every factor, regardless of its perceived magnitude, has the potential to contribute to maritime accidents. Therefore, when implementing SMS on Pelra vessels, it is essential to conduct a thorough analysis of each factor. This comprehensive approach allows for the identification of potential issues and the development of targeted strategies and program plans, ensuring a robust and effective safety management system.

3.4. Implications of Non-Technical and Technical Aspects of SMS Implementation

The most influential non-technical aspect in the implementation of Pelra's Safety Management System (SMS) is crew responsibility and authority (X2). This significance stems from the captain's critical role in coordinating sea activities, ensuring the safety of both the crew and the ship, and making key technical decisions, especially in emergency situations [22]. The crew's responsibilities extend to regular maintenance and understanding safety and navigation aspects, which are vital for keeping the ship seaworthy. Similarly, land-based personnel play a significant role in organizing and coordinating safety activities before departure. However, the initial competence of Pelra crews is currently deemed inadequate, lagging in technology mastery and correlating strongly with accident occurrences [15,23].

The second most influential variable is the responsibility and authority of the company or ship owner (X1). Traditional management structures in Pelra (kinship relations) place significant responsibilities on the ship owner for financing operations and ensuring crew safety [22]. However, challenges persist, including providing competent personnel and modern safety and navigation equipment as well as ensuring ship construction meets the standards of the Indonesian Classification Bureau (ICB).

Financial constraints are a major challenge for Pelra companies with a significant decrease in market share leading to imbalances between revenue and operational costs [41]. The responsibility for providing adequately educated and experienced personnel, despite

the implication of higher salaries, falls on the company [23]. Furthermore, the cost of safety and navigation equipment, along with the necessity of regular maintenance for the predominantly old Pelra fleet, adds to the financial burden.

These findings underscore the high impact of human error (crew) and company management in implementing Pelra's SMS. The alignment of crew ability with company safety management capabilities, particularly in fostering a safety culture, is crucial. Yet practical challenges, including the cost implications for companies amid competition with conventional ships, present significant hurdles in SMS implementation [42].

In terms of technical aspects, the SEM analysis indicates that ship construction (X7) directly and positively influences SMS implementation, also affecting ship stability (X8). Ship construction is crucial for SMS effectiveness, with dynamic stability being dependent on the ship's design and dimensions. The longitudinal and transverse strength, which are critical for wave resistance, are significantly influenced by loading practices on Pelra ships. Research by Malisan et al. [15] confirms that most ships under 150 GT meet and often exceed regulatory strength standards. However, despite these strengths, traditional design elements in construction still pose safety risks, with vulnerabilities in areas such as the hull, bulkheads, engine foundation, and deck construction [22].

Malisan et al. [15] also found issues in watertight integrity, particularly in the bulkhead separating different ship sections. Inadequate engine foundation reinforcement, especially in ships under 150 GT, and insufficient deck house reinforcement for external loads are prevalent issues. Damage often occurs due to collisions, which is exacerbated by the lack of robust construction in these areas [22].

Stability studies on various Pelra cargo vessels indicate compliance with technical seaworthiness criteria based on stability measures like righting arm and metacenter height, as required by the International Maritime Organization (IMO). This includes stability in Beaufort wind conditions 4, 5, and 6 as well as for converted tourist pinisi ships in wave heights up to 3.12 m [43,44]. Despite this, challenges remain, especially in coastal and inter-island shipping in underdeveloped and border areas, which often face natural sea conditions ranging from Beaufort 4 to 6. Important factors include a reliable weather information system, careful cargo supervision, especially of hazardous materials, and adherence to safety protocols in cargo preparation. Crew understanding of ship hydrodynamics, proper loading arrangements, and avoiding overloading are essential to prevent loss of stability and potential sinking in adverse weather [15].

4. Conclusions

Traditional shipping, known as Pelra, plays a pivotal role in enhancing connectivity and the distribution of goods across inland regions in Indonesia. Pelra, being non-conventional ships, have yet to fully implement Safety Management Systems (SMSs), resulting in recurrent accidents each year, particularly in vessels under 150 GT. This study reveals that both technical and non-technical factors significantly impact the application of SMSs, thereby influencing Pelra ships' seaworthiness and safety.

Our analysis identifies the most influential factors in SMS implementation as the authority and responsibility of the ship's crew (84.2%) and the company (81.0%), which are followed by ship construction (80.3%). Other notable factors include ship stability (78.5%), safety and navigation equipment (70.4%), ship maintenance (61.8%), personnel resources (58.5%), emergency preparedness (55.5%), and administration and documentation (50.3%).

These findings imply an increased responsibility for ship owners, encompassing the provision of competent crew, ensuring technical feasibility (construction and stability), risk identification to minimize emergencies, compliance with international regulations for safety and navigation equipment, and regular ship maintenance. Future research should focus on developing comprehensive SMS policies that integrate all these influential variables.

However, this research has limitations. (1) The indicators used could be further refined to strengthen the factors and indicators applicable to Pelra's safety management system. (2) The study's focus on ships operating in Indonesia's outermost, remote, and border areas

may require validation for different regional characteristics. (3) The analysis's reliance on respondent inputs introduces a degree of subjectivity, necessitating cautious interpretation of the results.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in the current study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A Overall Measurement Model Convergent Validation Results

Latent and Manifest Variables	FL	SE	CR	AVE	CA
Corporate responsibility and authority (X1)			0.91	0.69	0.77
X1.1	0.67	0.033			
X1.2	0.76	0.021			
X1.3	0.82	0.024			
X1.4	0.65	0.019			
X1.5	0.85	0.042			
X1.6	0.66	0.040			
X1.7	0.84	0.032			
X1.8	0.70	0.081			
X1.9	0.67	0.022			
X1.10	0.72	0.041			
X1.11	0.78	0.039			
Crew responsibilities and authority (X2)			0.89	0.65	0.81
X2.1	0.81	0.018			
X2.2	0.89	0.021			
X2.3	0.91	0.023			
X2.4	0.71	0.041			
X2.5	0.83	0.025			
X2.6	0.74	0.038			
Resources and personnel (X3)			0.85	0.75	0.73
X3.1	0.69	0.051			
X3.2	0.89	0.049			
X3.3	0.74	0.043			
X3.4	0.65	0.030			
Emergency readiness (X4)			0.84	0.77	0.79
X4.1	0.82	0.017			
X4.2	0.77	0.029			
X4.3	0.67	0.024			

Latent and Manifest Variables	FL	SE	CR	AVE	CA
Administration and documentation (X5)			0.79	0.68	0.74
X5.1	0.61	0.043			
X5.2	0.72	0.053			
X5.3	0.76	0.033			
Ship maintenance (X6)			0.81	0.64	0.75
X6.1	0.68	0.041			
X6.2	0.77	0.047			
X6.3	0.79	0.028			
Ship construction (X7)			0.70	0.61	0.82
X7.1	0.81	0.021			
X7.2	0.59	0.037			
X7.3	0.63	0.035			
X7.4	0.73	0.019			
X7.5	0.80	0.023			
X7.6	0.65	0.042			
Ship stability (X8)			0.69	0.70	0.86
X8.1	0.91	0.022			
X8.2	0.77	0.049			
X8.3	0.82	0.037			
X8.4	0.67	0.029			
Safety and navigation equipment (X9)			0.73	0.64	0.82
X9.1	0.78	0.021			
X9.2	0.89	0.047			
X9.3	0.76	0.046			
X9.4	0.66	0.033			

Description: FL = factor loading; SE = standard error; CR = construct reliability; AVE = average variance extracted; CA = Cronbach's alpha.

References

1. Jinca, M.Y.; Humang, W.P. *Transport Planning and Development of Islands*; Nas Media Pustaka: Makassar, Indonesia, 2023. (In Indonesian)
2. Minister of Transportation Regulation. No. KM 65 Year 2009 on Indonesian-flagged Non Convention Vessel Standard. Available online: https://jdih.dephub.go.id/peraturan/detail?data=Gci9J7qtAOSFj8baZuvflQ4JId5wFQ5dG8X4t68HXV3Z8WAPCQBfvVY8MMyaLlUPNE4Tsa31ZpHJX4ZA1OtPXB3g8gmxCZOTH5o8QjhQeHT3CSBHVPR7Hmvxp9AufdPxodJK1XK0m460tCrJQICgyZpZgz (accessed on 15 June 2022).
3. National Transportation Safety Committee. Transportation Accident Investigation Statistics Book. 2022. Available online: www.knkt.go.id (accessed on 12 April 2023). (In Indonesian)
4. Wróbel, K.; Gil, M.; Chae, C.J. On the influence of human factors on safety of remotely-controlled merchant vessels. *Appl. Sci.* **2021**, *11*, 1145. [CrossRef]
5. Dominguez-Péry, C.; Vuddaraju, L.N.R.; Corbett-Etchevers, I.; Tassabehji, R. Reducing maritime accidents in ships by tackling human error: A bibliometric review and research agenda. *J. Shipp. Trade* **2021**, *6*, 20. [CrossRef]
6. Zhang, Y.; Zhan, Y.; Tan, Q. Studies on human factors in marine engine accident. In Proceedings of the 2009 Second International Symposium on Knowledge Acquisition and Modeling, Wuhan, China, 30 November–1 December 2009; Volume 1, pp. 134–137.
7. Theotokas, I. *Management of Shipping Companies*; Routledge: London, UK, 2018.
8. Håvold, J.I. Safety-culture in a Norwegian shipping company. *J. Saf. Res.* **2005**, *36*, 441–458. [CrossRef]
9. Gil, M.; Kozioł, P.; Wróbel, K.; Montewka, J. Know your safety indicator—A determination of merchant vessels Bow Crossing Range based on big data analytics. *Reliab. Eng. Syst. Saf.* **2022**, *220*, 108311. [CrossRef]
10. Bertram, V. *Practical Ship Hydrodynamics*; Elsevier: Amsterdam, The Netherlands, 2011.
11. Mata-Álvarez-Santullano, F.; Souto-Iglesias, A. Stability, safety and operability of small fishing vessels. *Ocean Eng.* **2014**, *79*, 81–91. [CrossRef]
12. Kurniawan, A.; Hutapea, G.; Hardianto, S.; Suhartana, I.K.; Yuliani, A.; Putra, T.P.; Siahaan, W.J.; Hidayat, K.; Humang, W.P.; Paotonan, C.; et al. Finding a New Home: Rerouting of Ferry Ships from Merak–Bakauheni to East Indonesian Trajectories. *Sustainability* **2022**, *15*, 630. [CrossRef]
13. Minister of Transport Regulation. No. PM 45 Year 2012 on Ship Safety Management. Available online: https://jdih.dephub.go.id/peraturan/detail?data=3Z22dQSRZRM0iXpBsxqejJ4vQiLYYJ8FS4DyNtQNaLpq8LUr7XaqCcz4aCjLJk0S6I4ZJ4OZg7P864vRymHq0Q2k4uYY8bCe31D4jqdcpZ4f8VAYKjTrYWZdsFBw4s5ehA565io8l12PkHPFnxUftH22uT (accessed on 15 June 2022).

14. Wahid, A.; Jinca, M.Y.; Rachman, T.; Malisan, J. Determination of Indicators of Implementation of Sea Transportation Safety Management System for Traditional Shipping Based on Delphi Approach. *Sustainability* **2023**, *15*, 10080. [CrossRef]
15. Malisan, J.; Jinca, M.Y.; Herman, P.; Abrar, S. Traditional shipping transport safety case study: Phinisi fleet (A study on stability, strength and human resources). *Int. Ref. J. Eng. Sci. IRJES* **2013**, *2*, 1821–2319.
16. Humang, W.P.; Hadiwardoyo, S.P. Factors influencing the integration of freight distribution networks in the Indonesian archipelago: A structural equation modeling approach. *Adv. Sci. Technol. Eng. Syst.* **2019**, *4*, 278–286. [CrossRef]
17. Papaioannou, D.; Martinez, L.M. The role of accessibility and connectivity in mode choice. A structural equation modeling approach. *Transp. Res. Procedia* **2015**, *10*, 831–839. [CrossRef]
18. Mokarami, H.; Alizadeh, S.S.; Pordanjani, T.R.; Varmazyar, S. The relationship between organizational safety culture and unsafe behaviors, and accidents among public transport bus drivers using structural equation modeling. *Transp. Res. Part F Traffic Psychol. Behav.* **2019**, *65*, 46–55. [CrossRef]
19. Rahman, F.; Rahman, M.M. Analyzing service quality of domestic airlines in an emerging country-Bangladesh by structural equation models. *J. Air Transp. Manag.* **2023**, *107*, 102346. [CrossRef]
20. Chao, S.L.; Yu, M.M.; Sun, Y.H. Ascertaining the effects of service quality on customer loyalty in the context of ocean freight forwarders: An integration of structural equation modeling and network data envelopment analysis. *Res. Transp. Bus. Manag.* **2023**, *47*, 100955. [CrossRef]
21. Lei, P.W.; Wu, Q. Introduction to structural equation modeling: Issues and practical considerations. *Educ. Meas. Issues Pract.* **2007**, *26*, 33–43. [CrossRef]
22. Jinca, M.Y. *Sea Transport of Pinisi Motorised Sailboats, Makassar*; Hasanuddin University Research Institute: Makassar, Indonesia, 2002.
23. Widarbowo, D. *Competency Analysis of People's Shipping Ship Crew Officers*; Hasanuddin University: Makassar, Indonesia, 2006.
24. Nurwahida. *Perceptions of Decision Making towards the Implementation of Safety Management Standards for People's Shipping Vessels*; Postgraduate UNHAS: Makassar, Indonesia, 2013.
25. Łosiewicz, Z.; Nikończuk, P.; Pielka, D. Application of artificial intelligence in the process of supporting the ship owner's decision in the management of ship machinery crew in the aspect of shipping safety. *Procedia Comput. Sci.* **2019**, *159*, 2197–2205. [CrossRef]
26. Bowo, L.P.; Furusho, M.; Mutmainnah, W. A New HEART–4M Method for Human Error Assessment in Maritime Collision Accidents. *Trans. Navig.* **2020**, *5*, 39–46.
27. Antão, P.; Soares, C.G. Analysis of the influence of human errors on the occurrence of coastal ship accidents in different wave conditions using Bayesian Belief Networks. *Accid. Anal. Prev.* **2019**, *133*, 105262. [CrossRef] [PubMed]
28. Qiao, W.; Liu, Y.; Ma, X.; Liu, Y. A methodology to evaluate human factors contributed to maritime accident by mapping fuzzy FT into ANN based on HFACS. *Ocean Eng.* **2020**, *197*, 106892. [CrossRef]
29. Chen, D.; Pei, Y.; Xia, Q. Research on human factors cause chain of ship accidents based on multidimensional association rules. *Ocean Eng.* **2020**, *218*, 107717. [CrossRef]
30. Beşikçi, E.B. Strategic leadership styles on maritime safety. *Ocean Eng.* **2019**, *185*, 1–11. [CrossRef]
31. Wróbel, K. Searching for the origins of the myth: 80% human error impact on maritime safety. *Reliab. Eng. Syst. Saf.* **2021**, *216*, 107942. [CrossRef]
32. Galieriková, A. The human factor and maritime safety. *Transp. Res. Procedia* **2019**, *40*, 1319–1326. [CrossRef]
33. Kim, T.E.; Gausdal, A.H. Leading for safety: A weighted safety leadership model in shipping. *Reliab. Eng. Syst. Saf.* **2017**, *165*, 458–466. [CrossRef]
34. Ofori, E.K.; Aram, S.A.; Saalidong, B.M.; Gyimah, J.; Niyonzima, P.; Mintah, C.; Ahakwa, I. Exploring new antecedent metrics for safety performance in Ghana's oil and gas industry using partial least squares structural equation modelling (PLS-SEM). *Resour. Policy* **2023**, *81*, 103368. [CrossRef]
35. Machfudiyanto, R.A.; Latief, Y.; Suraji, A.; Soeharso, S.Y. Improvement of policies and institutional in developing safety culture in the construction industry to improve the maturity level, safety performance and project performance in Indonesia. *Int. J. Civ. Eng. Technol.* **2018**, *9*, 1022–1032.
36. Ghozali, I. *Structural Equation Models: Concepts and Applications with the Amos 16.0 Programme*; Diponegoro University Publishing Agency: Semarang, Indonesia, 2013.
37. Hair, J.F., Jr.; Hult, G.T.M.; Ringle, C.M.; Sarstedt, M.; Danks, N.P.; Ray, S. *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook*; Springer Nature Switzerland AG: Cham, Switzerland, 2021.
38. Hair, J.F.; Black, W.C.; Babin, B.J.; Anderson, R.E. *Multivariate Data Analysis*, 7th ed.; Pearson Education Limited: Harlow, UK, 2014.
39. Fornell, C.; Larcker, D.F. Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* **1981**, *18*, 39–50. [CrossRef]
40. Bae, B.R. Structural equation modeling with Amos 24. In *Seoul: Chenngram Books*; Routledge: New York, NY, USA, 2017; pp. 76–309.
41. Humang, W.P. Demand Model and Role of Stakeholders to Increase General Cargo Load of People's Shipping Transport. *Transp. Res. J.* **2021**, *33*, 47–56.

42. Humang, W.P.; Aspar, W.A.N.; Upahita, D.P.; Muharam, A.; Bowo, P.B.; Puriningsih, F.S. Competitiveness of Traditional Shipping in Sea Transportation Systems Based on Transport Costs: Evidence from Indonesia. *Int. J. Sustain. Dev. Plan.* **2023**, *18*, 627–634. [CrossRef]
43. Magfiroh, L.I. Conversion of General Cargo Pinisi Ship into Liveaboard Tourism Pinisi Ship with Manggarai Cultural Concept. Bachelor's Thesis, Surabaya State Shipbuilding Polytechnic, Surabaya, Indonesia, 2022.
44. Santoso, D.B.B. Technical Analysis of Pinisi Ship Conversion as Tourism Ship in Ambon-Kep. Banda Shipping Area. Bachelor's Thesis, Ten November Institute of Technology, Surabaya, Indonesia, 2007.

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