Maritime Technology and Society
Vol. 5(1): 189-205, February 2026
https://doi.org/10.62012/mp.vi.47535

Conceptual Research

Ship Crew Behavior, Maritime Safety Culture, and Shipping Operational Performance

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Abstract: This study examines the influence of crew behavior on shipping operational performance, emphasizing the mediating role of maritime safety culture. A quantitative explanatory approach was applied using Partial Least Squares–Structural Equation Modeling (SEM-PLS) via SmartPLS 4. Data were collected from 343 Indonesian commercial ship crews through a five-point Likert-scale questionnaire. The measurement model demonstrated strong reliability and validity (Cronbach's $\alpha > 0.94$; AVE > 0.83; SRMR = 0.031), and the structural model showed substantial explanatory power ($R^2 = 0.877$ for safety culture and $R^2 = 0.833$ for operational performance). Results reveal that crew behavior significantly affects maritime safety culture ($\beta = 0.936$; $p < 0.001$) but has a limited direct effect on operational performance ($\beta = 0.208$; $p = 0.018$). Safety culture significantly mediates this relationship (indirect $\beta = 0.669$; $p < 0.001$), indicating that safety-oriented behavior enhances performance primarily through a strong safety culture. The findings highlight that sustainable operational excellence in shipping requires continuous training, non-punitive reporting, and safety-focused leadership. Theoretically, the study extends maritime safety management literature by confirming safety culture as a critical mechanism that transforms individual behavior into improved organizational performance.

Keywords: crew behavior; maritime safety culture; shipping operational performance; SEM-PLS

1. Introduction

The shipping industry operates in a high-risk and dynamic environment where human factors remain the dominant cause of operational failures. Although technological advancements such as smart navigation and digital monitoring have enhanced operational capabilities [1] [2], accident reports consistently indicate that human error accounts for over 80% of maritime incidents (EMSA, 2024). Previous studies have confirmed that crew behavior and safety culture are critical determinants of safety outcomes [3]. However, most of these studies examined behavioral and cultural aspects independently, without exploring how their interaction influences operational performance within the unique context of developing maritime nations such as Indonesia. It is highly dependent on the behavior of the crew as the main executors of various activities on board the ship, covering dimensions such as employment, task content, required skills, and human risk, as well as adapting the work culture to digital operations [4].

In this case, shipping operational performance is supported by technology and ship navigation systems that provide a clear view of the future direction of transportation, which is very important for the success of shipping operational performance, promoting the advancement of smart maritime transportation, where the crew plays an important role in operating this system. This behavior includes communication and teamwork. [5], [6], compliance with and

Received: 2025-10-03; Accepted: 2025-11-23

responsibility for safety procedures, and a proactive and pro-social attitude in dealing with emergency situations [7]. However, numerous reports of accidents and shipping incidents indicate that human error related to crew behavior remains the primary cause of operational disruptions. This situation indicates an urgent need for further research into how crew behavior can affect shipping operational performance, particularly in the context of shipping in Indonesia, which has its own complexities.

The increase in shipping incidents due to human error is becoming an increasingly urgent issue that must be addressed seriously. A report from the European Maritime Safety Agency shows that during the period 2014 to 2023, 80.1% of shipping accidents in the European Union were caused by human factors [8]. This explains that human factors are very important for maintaining shipping safety and operational performance, especially those related to crew behavior. At the global level, it also confirms that the dominance of human factors in accidents is caused by human error associated with safety culture [9], [10], [11]. In Indonesia, although comprehensive data remain limited, reports from the National Transportation Safety Committee (KNKT) and the Directorate General of Sea Transportation indicate that communication breakdowns, non-compliance with safety procedures, and weak teamwork are among the primary causes of operational disruptions in shipping. These behavioral deficiencies not only compromise maritime safety but also undermine the efficiency of national logistics. Consequently, this study emphasizes crew behavior and safety culture as critical systemic factors that must be strengthened to enhance operational reliability and sustainability in Indonesia's maritime sector.

The research gap lies in the limited integration of behavioral and cultural constructs within a comprehensive analytical framework that links the human element to operational outcomes. While several studies have highlighted the importance of safety behavior [6], [12], [13], and organizational culture [14], [15]. few have empirically tested safety culture as a mediating mechanism between crew behavior and shipping performance using a robust quantitative model. This limitation is particularly significant in Indonesia, where the maritime sector operates with heterogeneous crew competencies and varying compliance with international safety standards [16]. Further findings by [7] also reinforce the dominant role of human factors, highlighting that safety culture has a significant influence on three safety behaviors of crew members: compliance with procedures, prosocial behavior, and proactive behavior in preventing risks. These findings confirm that improving shipping safety does not only depend on technical equipment or sophisticated navigation systems, but also on the quality of the crew's behavior and work culture. Non-technical skills (NTS)-based approaches, such as effective communication and teamwork [17]. Although many studies have highlighted the importance of safety behavior and culture, most have been conducted separately and have not integrated these two variables into a single comprehensive analytical model to explain their impact on operational performance in shipping.

Although numerous studies have examined crew behavior and safety culture separately, few have integrated both constructs into a unified analytical framework to explain their joint influence on shipping operational performance. Recent research highlights that safety culture not only shapes safe and proactive work behavior but also moderates the relationship between individual competencies and operational safety outcomes [7], [15]. However, most studies on shipping performance remain focused on technical or managerial factors, neglecting the behavioral and cultural dimensions that critically determine safety effectiveness. In the Indonesian maritime context characterized by diverse operational environments and varying compliance levels this gap remains largely unexplored. Addressing it provides an opportunity to develop a more comprehensive model linking human factors, safety culture, and operational performance to strengthen both theoretical understanding and practical management of maritime safety.

To explain the link between crew behavior,

safety culture, and shipping operational performance, this study integrates three complementary frameworks: High Reliability Organization (HRO) Theory, Safety Culture Theory, and the Non-Technical Skills (NTS) Framework. HRO Theory highlights that high-risk organizations, such as shipping, achieve reliability through human competence, continuous learning, and adaptability [18]. Safety Culture Theory underscores the collective values and norms that shape safety perceptions and guide behavior within maritime organizations [19]. Meanwhile, the NTS Framework focuses on essential non-technical competencies communication, teamwork, leadership, and decision-making that support safety and operational readiness [20]. Together, these perspectives provide a comprehensive foundation for understanding how human factors and organizational culture interact to enhance maritime operational performance.

This study examines how crew behavior encompassing procedural compliance, proactive actions, and prosocial conduct affects shipping operational performance through the mediating role of maritime safety culture. By integrating these constructs into a structural model, the study provides a comprehensive view of the interplay between individual behavior and organizational systems in ship operations. Theoretically, it advances human element-based safety management by positioning safety culture as both a consequence and a driver of operational performance. Practically, the results offer insights for enhancing safety-oriented policies, continuous training, and non-punitive reporting systems to strengthen safety culture and improve crew effectiveness, thereby promoting greater operational reliability and reducing maritime incidents.

2. Theoretical Background & Hypothesis Development

2.1. High Reliability Organization (HRO) Theory, Safety Culture Theory, Non-Technical Skills (NTS) Framework

The High Reliability Organization (HRO) Theory, Safety Culture Theory, and Non-Technical Skills (NTS) Framework jointly underpin this study's theoretical foundation for understanding how human and organizational factors interact to influence shipping performance. HRO Theory explains that organizations in high-risk sectors such as shipping achieve reliability not merely through technology but through collective mindfulness, adaptability, and learning from failure [18], [21]. This theory positions human competence and organizational learning as dual safeguards against operational breakdowns, reinforcing that human vigilance and system feedback loops are essential for resilience ([22], [23].

Safety Culture Theory complements this by emphasizing that safety is shaped by shared values and collective practices rather than procedural compliance alone [24]. In maritime operations, safety culture serves as an integrating mechanism that translates individual safety attitudes into collective organizational performance, enabling open communication, non-punitive reporting, and a high level of situational awareness [25]. Thus, safety culture acts not only as a normative structure but as a behavioral regulator that determines how effectively crews respond to risk and uncertainty. In shipping, maritime safety culture reflects the extent to which the crew collectively values, supports, and enforces their operational safety principles by increasing safety awareness and safe behavior [26], implementing regulations with an emphasis on safety culture [27] and focusing on strengthening safety management culture and instilling appropriate safety values [7]. This culture is formed from the accumulation of individual behaviors and team interactions, which create a risk-aware work climate that is open to incident reporting and oriented towards continuous improvement. Thus, maritime safety culture becomes an important mechanism that bridges the gap between crew behavior and reliable shipping operational performance.

The NTS Framework deepens this perspective by identifying essential social and cognitive competencies communication, teamwork, leadership, and decision-making as key drivers of safe and efficient operations [28]. Unlike technical proficiency, NTS emphasizes behavioral adaptability and interpersonal

coordination as determinants of safety performance, particularly in confined, stressful maritime environments. Systematic NTS training strengthens decision quality and error prevention (Y. Kim & Lee, 2024), creating the cognitive foundation for a safety-oriented crew culture [29]. This approach is important for improving crew readiness to deal with emergency situations.

Integrating these three frameworks provides a multi-layered understanding: HRO Theory explains reliability as an emergent property of human vigilance, Safety Culture Theory interprets it as a product of shared meaning systems, and the NTS Framework operationalizes it through behavioral competencies. This integration allows the current study to conceptualize crew behavior as the proximal driver, safety culture as the mediating mechanism, and operational performance as the observable outcome of aligned human and organizational systems.

2.2. Shipping Operational Performance

Shipping operational performance represents the extent to which maritime organizations achieve safe, efficient, and compliant transport outcomes through effective coordination of human, technical, and regulatory dimensions [27], [30], [31]. Good operational quality is enhanced through green technology, pilotage services, energy efficiency, renewable energy in ports, and green logistics, which together support efficiency, sustainability, and global competitiveness [32], [33], [34], [35], [36]. Rather than viewing performance solely through technical efficiency, this study conceptualizes it as an emergent outcome of cultural and behavioral alignment within the crew. Green technology, digital monitoring, and machine learning enhance real-time decision-making [37], [38].

2.3. Maritime Safety Culture

The values, beliefs, and practices that shape crew behavior toward safety are known as maritime safety culture. This concept includes procedural compliance, decision-making, and risk perception [15], [37], [39]. It functions as a socio-cognitive infrastructure that connects organizational policy to everyday operational behavior. A mature safety culture integrates technical compliance (ISM Code, Safety-I) with adaptive human learning (Safety-II), promoting proactive risk management and open reporting [40], [41]. Emergency simulations, proactive leadership, and incident reporting without sanctions have been proven effective in improving the preparedness, behavior, and safety awareness of ship crews [14], [42], [43]. One way to improve maritime safety culture is by increasing management commitment, continuous training, and procedural compliance. In addition, the use of proactive digital data-based safety indicators on ships, such as machine learning and algorithms, enables the prediction of operational risks before incidents occur [39], [44]. By fostering trust and participation, safety culture translates individual competence into collective reliability linking the micro-level of behavior to the macro-level of organizational performance.

2.4. Ship Crew Behavior

Ship crew behavior includes the attitudes, actions, and work habits of sailors when performing operational duties, both under normal and emergency conditions. Quick and accurate decision-making, teamwork, effective communication, and compliance with safety procedures are examples of this behavior [45], [46]. Competency levels, work experience, motivation, work climate, and leadership style on board are all factors that influence crew behavior [47], [48], increase openness, positive behavior reinforcement strategies can be implemented through simulation-based training, crew resource management programs, and non-punitive incident reporting systems [49], [50]. The use of technology, such as digital behavior monitoring systems, wearable devices, and machine learning-based data analysis, can provide real-time feedback and detect potential procedural violations before they pose a risk [51], [52]. Technological interventions such as digital monitoring and predictive analytics support this human dimension, but behavioral consistency remains the core determinant of operational safety. In summary, this critical synthesis positions crew behavior as the human

input, safety culture as the collective interpretive system, and operational performance as the emergent output of their interaction. This integrative view advances maritime safety research by linking micro-level behavior, meso-level culture, and macro-level performance into a coherent explanatory framework.

2.5. Hypothesis

H1: Crew behavior has a positive and significant effect on maritime safety culture.
H2: Maritime safety culture has a positive and significant effect on shipping operational performance.
H3: Crew behavior has a positive and significant effect on shipping operational performance.
H4: Maritime safety culture significantly mediates the effect of crew behavior on shipping operational performance.

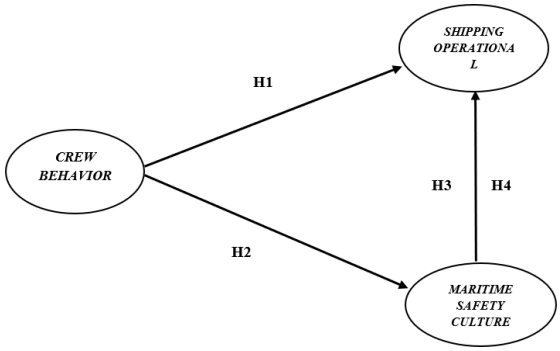

Figure 1. Conceptual Framework

3. Materials and Methods

This study employed an explanatory quantitative approach to examine the causal relationships between crew behavior, maritime safety culture, and shipping operational performance, with safety culture serving as a mediating variable. Data were collected from primary sources through a structured questionnaire using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The crew behavior measurement instrument was adapted from [20] which covers aspects of non-technical skills such as communication, teamwork, leadership, and decision making. The maritime safety culture instrument was adapted from [15], while the shipping operational performance instrument referred to the Shipping KPI Standards revised and updated in 2020 [53]. Data analysis was performed using Partial Least Squares-based Structural Equation Modeling (SEM-PLS) to test the direct effect of crew behavior on shipping operational performance and the indirect effect through maritime safety culture.

The measurement instruments were designed to capture the constructs of crew behavior, maritime safety culture, and shipping operational performance, each operationalized into 18 indicators comprising 54 measurement items. These items were adapted and modified to fit the maritime context of Indonesian commercial and passenger vessels, ensuring alignment with international standards such as the ISM Code and STCW. The instrument covered key aspects of non-technical skills (communication, teamwork, leadership, and decision-making), organizational safety practices (management commitment, training participation, and non-punitive reporting), and operational performance (punctuality, efficiency, and incident rate).

The measurement indicators of the study are shown in Table 1. The research data came from questionnaires given to sailors on commercial and passenger ships. The research method was adapted to the contextual needs of maritime research. This method considered international shipping safety standards (ISM Code, STCW) and the dynamics of work culture in the Indonesian shipping industry.

Table 1. Measurement Scale Indicators

Variable	Indicator	Reference Source	Scale
	1. Compliance with safety procedures and work discipline on board	[20]	Likert 1-5
	2. Effective communication and teamwork among crew members		

Variable	Indicator	Reference Source	Scale
	3. Quick decision-making in emergency situations		
Crew Ship Behaviour	4. Concern for the well-being of coworkers		
	1. Management commitment to safety	[15], [37], [39]	Likert 1-5
	2. Crew participation in safety training		
	3. Non-punitive incident reporting		
	4. Awareness of operational risks		
Maritime Safety Culture	5. Compliance with international safety regulations		
	6. Use of standard operating procedures (SOPs)		
	1. Punctuality and compliance with shipping schedules	[53]	Likert 1-5
	2. Fuel efficiency		
	3. Work accident rates on ships		
	4. Technical disruption rates during ship operations		
Shipping Operational Performance	5. Loading and unloading productivity at ports		

Ship crew members working for shipping companies affiliated with the Transportation Human Resources Development Agency (BPSDM) in Indonesia were the subjects of this study. This study uses a quantitative approach with a descriptive design and non-probability purposive sampling method because the researcher needs respondents who meet the criteria relevant to the research objectives [54].

The target population consisted of Indonesian-flagged ship crews working in domestic and international waters**.** Respondents were selected using a non-probability purposive sampling technique**,** as participation required specific qualifications: (a) active seafarers with at least two years of sea service, (b) holders of valid Basic Safety Training certificates, and (c) direct involvement in deck, engine, or navigation operations. A total of 343 valid responses were obtained from crew members representing various ranks (captains, officers, engineers, and ratings). The sample size exceeded the minimum requirement of 180, calculated based on which recommends at least 5–10 times the number of indicators in PLS-SEM analysis. With a total of 18 indicators, the minimum sample size was 85-180 respondents. This study took 343 respondents consisting of captains, officers, and crew members from various types of commercial ships.

Table 2. Respondent Demographics

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	310	90.4
	Female	33	9.6
Age	< 25	72	21.0
	25–30	128	37.3
	31–40	97	28.3
	> 40	46	13.4
Job Level	Captain	18	5.2
	Second Officer	28	8.2
	Third Officer	32	9.3
	Second Engineer	25	7.3

Characteristics	Category	Frequency (n)	Percentage (%)
	Third Engineer	26	7.6
	Fourth Engineer	19	5.5
	Deck Ratings (AB/OS)	87	25.4
	Engine Ratings (Motorman)	61	17.8
	Cook/Steward	27	7.9
Sailing Experience	< 2 years	66	19.2
	2–5 years	102	29.7
	6–10 years	93	27.1
	> 10 years	82	23.9
Total		343	100

Data for exogenous and endogenous variables are often collected from the same respondents at the same time, which causes general method bias in survey-based research [55]. For this reason, the Full Collinearity Test (Variance Inflation Factor/VIF), developed by [56], is a test that combines collinearity between constructs to identify common method bias. The general rule is that data is considered free from common method bias if all VIF values are less than 3.3 or, more conservatively, less than 3.0. This indicates that the data did not experience common method bias. The test results showed Cronbach's Alpha values for crew behavior of 1.879, maritime safety culture of 1.923, and ship operational performance of 1.856. As a result, all metrics were retained in the official survey. Overall, the trial showed that respondents understood the questionnaire questions; the questions were clear and correctly understood, and the format and time required to complete them were reasonable.

The purpose of this study was to evaluate the effectiveness of the questionnaire as a communication tool between researchers and respondents and the validity of the measurement scale for each construct [57]. Prior to the main survey, a pilot test involving 40 participants was conducted to ensure clarity, readability, and relevance of the items. The results indicated strong internal consistency, with Cronbach's Alpha values of 0.964 (crew behavior), 0.975 (safety culture), and 0.951 (operational performance). In the full dataset, the outer model confirmed convergent and discriminant validity, with indicator loadings above 0.70, AVE values above 0.80, and composite reliability (ρc) exceeding 0.95. The Full Collinearity Test (VIF < 3.0) also confirmed that common method bias was not present.

3. Results

3.1 Outer Model

Each indicator used to evaluate the three research constructs, namely Maritime Safety Culture (MSC), Operational Performance of Shipping (OPS), and Crew Behavior (CB), has a value above 0.70, indicating that they meet the criteria for convergent validity very well. The external loadings of the BKM1–BKM6 indicators ranged from 0.941 to 0.974, indicating that each indicator consistently describes the construct of maritime safety culture. Similarly, the KOP1–KOP5 indicators produced values between 0.867 and 0.937, indicating that the operational shipping performance variables were measured using a robust and appropriate instrument. The PAK1–PAK4 indicators, on the other hand, showed very high values, namely 0.923–0.977, indicating excellent crew behavior. Overall, this shows that the research instrument has strong convergent validity. This means that each construct used could accurately explain empirical phenomena in accordance with the underlying theory and also provides a solid methodological basis for proceeding to the structural analysis phase. The outer loading values can be seen in Table 2.

Table 2. Outer Loading

	Maritime Safety Culture	Shipping Operational Performance	Crew Behavior
BKM 1	0.945		
BKM 2	0.941		
BKM 3	0.974		
BKM 4	0.942		
BKM 5	0.951		
BKM 6	0.950		
KOP 1		0.895	
KOP 2		0.867	
KOP 3		0.929	
KOP 4		0.937	
KOP 5		0.931	
PAK 1			0.951
PAK 2			0.963
PAK 3			0.977
PAK 4			0.923

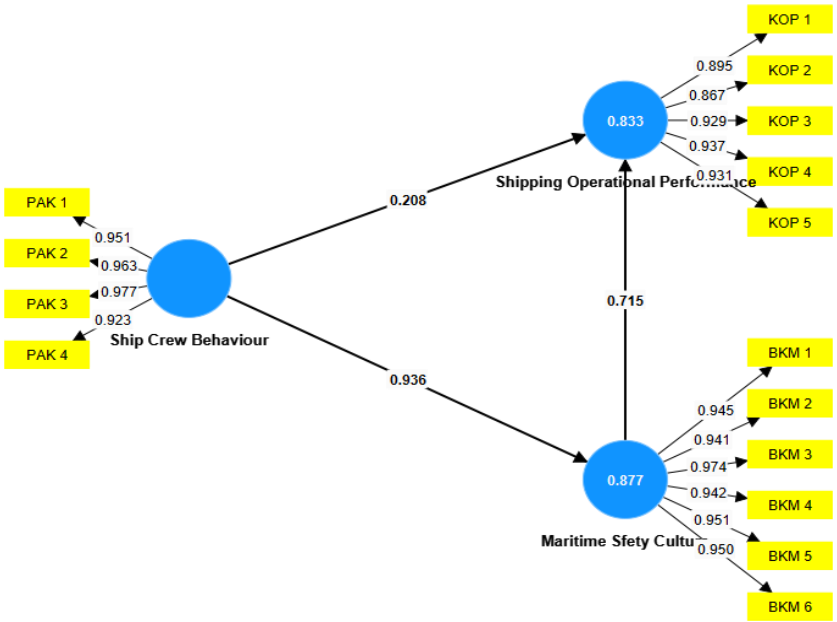

Figure 2. Research Model

The results of the reliability and construct validity tests show that all research variables, namely Maritime Safety Culture, Operational Performance of Shipping, and Crew Behavior, meet excellent criteria. The three constructs have Cronbach's Alpha values above 0.90 (0.949–0.979), indicating very high and stable internal consistency among indicators. In addition, the reliability values show very satisfactory results, with values above 0.96 for each construct, far exceeding the minimum threshold of 0.70. This shows that the indicators used are truly consistent in explaining each latent construct. In addition, the Average Variance Extracted (AVE) values are also at a very good level, with Maritime Safety Culture at 0.904, Shipping Operational Performance at 0.832, and Crew Behavior at 0.909. The results can be seen in Table 3.

Table 3. Validity Convergent

	Cronbach's Alpha	Composite Reliability (Rho_C)	Average Variance Extracted (AVE)
Maritime Safety Culture	0.979	0.983	0.904
Shipping Operational Performance	0.949	0.961	0.832
Crew Behavior	0.967	0.976	0.909

Furthermore, the results of the discriminant validity test using the Fornell-Larcker criteria show that the different research constructs meet the requirements. The AVE square root values for Maritime Safety Culture (0.951), Operational Performance of Shipping (0.912), and Crew Behavior (0.954) are all higher than the correlation values between constructs in the same row and column. For example, the AVE root value for Maritime Safety Culture (0.951) is higher than the correlation value between constructs in the same row and column. Similarly, Shipping Operational Performance has an AVE root value of 0.912, which is higher than its correlation with Maritime Safety Culture (0.910) and Crew Behavior (0.877). The same is seen in Crew Behavior, with an AVE root value of 0.954 that exceeds the correlation with the other two constructs. Thus, it can be concluded that each construct has adequate discriminant validity, because each variable is better able to explain its own indicators than the indicators belonging to other constructs. These findings confirm that the measurement model in this study has good conceptual clarity and that there is no overlap between constructs, see Table 4.

Table 4. Fornell-Larcker Criterion

	Maritime Safety Culture	Shipping Operational Performance	Crew Behavior
Maritime Safety Culture	0.951		
Shipping Operational Performance	0.910	0.912	
Crew Behavior	0.936	0.877	0.954

3.2 Inner Model

The structural model demonstrates strong explanatory power, with $R^2 = 0.877$ for maritime safety culture and $R^2 = 0.833$ for shipping operational performance, indicating that both constructs are substantially explained by crew behavior. All model fit indices meet the recommended criteria (SRMR = 0.031), confirming that the model fits the observed data well, indicating that 83.3% of the variance in shipping operational performance can be explained by the predictor variables in the model. Considering the criteria proposed by (Hair et al., 2019), it can be concluded that the structural model used has excellent predictive power. An R-square value above 0.75 is classified as substantial. Therefore, these results indicate that the relationship between variables in the study is not only statistically significant but also useful for explaining cultural phenomena related to maritime safety and shipping operational performance. The table can be seen below.

Table 5. R-Square

	R-square	R-square adjusted
Maritime Safety Culture	0.877	0.876
Shipping Operational Performance	0.833	0.832

The Goodness of Fit (GoF) evaluation results in Table 6 show that the research model fits the data very well. The SRMR (Standardized Root Mean Square Residual) value of 0.031 is well below the threshold of 0.10 [58], indicating that the difference between the observed covariance matrix and the model-predicted

covariance matrix is very small, so the model can be considered a good fit. This can be seen in Table 6.

Table 6. Goodness of Fit (GoF)

	Saturated model	Estimated model
SRMR	0.031	0.031
d_ULS	0.119	0.119
d_G	0.290	0.290
Chi-square	558.960	558.960
NFI	0.934	0.934

Then, the f-square test results in Table 7 provide an overview of the contribution of each exogenous variable to the endogenous variable in the research model. Referring to Cohen's (1988) guidelines, which are also widely used in PLS-SEM analysis [58], f^2 values can be categorized as small (0.02), medium (0.15), and large (0.35). The path analysis shows that crew behavior has a significant positive influence on maritime safety culture ($\beta = 0.936$; $p < 0.001$), while its direct effect on operational performance is relatively small ($\beta = 0.208$; $p = 0.018$). Conversely, maritime safety culture has a strong direct impact on operational performance ($\beta = 0.715$; $p < 0.001$). The indirect effect of crew behavior through safety culture ($\beta = 0.669$; $p < 0.001$) demonstrates that safety culture fully mediates this relationship. The effect size ($f^2 = 7.112$) further underscores that crew behavior is a dominant predictor in shaping safety culture, whereas safety culture itself contributes a large effect ($f^2 = 0.377$) on operational performance.

On the other hand, the f2 value of 0.032, found in the relationship between crew behavior and operational performance, falls into the category of small effects. This indicates that crew behavior does not contribute significantly to improving operational performance. However, crew behavior is still very important because its influence is transmitted more through safety culture as a mediating factor. Overall, these results show that maritime safety culture plays an important role in linking crew behavior with shipping operational performance. In reality, shipping companies must prioritize building a strong safety culture through policies, training, reporting systems, and leadership. They must also encourage supportive behavior individually through habit reinforcement and incentives. In the maritime context, it is emphasized that although the implementation of the ISM Code is important, it is often the case that the human element and crew participation are neglected, so that real improvement requires an approach that better integrates technical and cultural aspects. These statistical results indicate that while good individual behavior is important, it only translates into improved operational outcomes when embedded within a strong safety culture. Crews who act safely, communicate effectively, and report incidents transparently strengthen collective norms, which in turn enhance the organization's ability to operate efficiently and safely.

Table 7. Effect Size (f-square)

	f-square
Maritime Safety Culture - Shipping Operational Performance	0.377
Crew Behavior - Maritime Safety Culture	7.112
Crew Behavior - Shipping Operational Performance	0.032

3.3 Hypothesis Testing

The t-statistics generated by the internal model were examined to test the direct effect of hypothesis. The results of the direct effect hypothesis test are shown in Table 8. The results indicate that the research hypothesis can be accepted if the t-statistic is greater than 1.96. Simulations were used in PLS research to evaluate hypothetical relationships. The bootstrap method was applied to the research sample to reduce unusual research data problems.

Table 8. Direct Effect

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Maritime Safety Culture -> Shipping Operational Performance	0.715	0.716	0.087	8.239	0.000
Crew Behavior-> Maritime Safety Culture	0.936	0.935	0.011	84.305	0.000
Crew Behavior-> Shipping Operational Performance	0.208	0.207	0.088	2.363	0.018

The results of the analysis in Table 8 show that maritime safety culture has a positive and significant effect on shipping operational performance (O = 0.715; T = 8.239; p < 0.000). This confirms that the stronger the implementation of safety culture, the better the operational performance achieved. A safety culture that includes compliance with SOPs, ongoing training, and an incident reporting system has been proven to improve the effectiveness and efficiency of ship operations. These findings are consistent with recent literature, which states that strengthening the safety culture in the maritime sector can reduce human error and improve operational effectiveness [59].

Furthermore, the behavior of the crew has been proven to have a very strong influence on maritime safety culture (O = 0.936; T = 84.305; p < 0.000). The results show that individual behavior that is consistent in implementing safety procedures, actively participating in training, and reporting incidents without worrying about the consequences will have an impact on safety culture. Thus, crew behavior is the main foundation that ensures a safety culture runs effectively on board. Meanwhile, the direct influence of crew behavior on operational performance is insignificant and relatively small (O = 0.208; T = 2.363; p = 0.018). This indicates that a safety culture enhances the contribution of crew behavior to performance [60] found in their study that perceptions of safety climate influence individual safety behavior, but situational and contextual factors can be moderators or inhibitors, so the influence of individual behavior on operational outcomes is not always directly significant. In other words, good crew behavior will enhance safety culture and enable significant improvements in operational performance. These results indicate that management strategies should focus on developing crew behavior and enhancing safety culture as the primary means of achieving operational excellence [40].

Table 9. Indirect Effect

	Original sample (O)	Sample means (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Crew Behavior -> Maritime Safety Culture -> Shipping Operational Performance	0.669	0.669	0.083	8.098	0.000

Based on the results in Table 9, the path from Crew Behavior → Maritime Safety Culture → Operational Performance shows a coefficient of O = 0.669, with T statistics = 8.098 and p < 0.000. This value confirms that there is a strong and significant mediating effect, whereby crew behavior affects operational performance mainly through the strengthening of safety culture. This means that safe crew behavior (e.g., compliance with SOPs, participation in training, and incident reporting) will strengthen the safety culture, and it is this solid safety

culture that ultimately improves the effectiveness and reliability of shipping performance. Maritime organizations with a mature safety culture tend to be able to reduce incidents and improve operational performance because this culture functions as a collective system that mediates individual actions into measurable results. In the shipping industry, the influence of behavior on performance is not always direct, but rather stronger when mediated by an effective safety culture. Thus, these results confirm that maritime safety culture is a critical bridge that ensures crew behavior can be translated into tangible improvements in operational performance.

4. Discussion

The findings confirm that maritime safety culture serves as a strategic bridge between human behavior and operational reliability. A crew's adherence to procedures, proactive engagement, and teamwork are not sufficient unless reinforced by shared organizational values and structured safety systems. In line with the High Reliability Organization (HRO) Theory, reliability in high-risk environments depends on collective mindfulness and institutional learning. Within this framework, safety culture transforms individual competencies into systemic reliability through open communication, constructive feedback, and effective error management, enabling maritime organizations to operate safely and efficiently under complex conditions.

These results are in line with research [61], which emphasizes that safety culture is very important for increasing productivity in high-risk industries and reducing the risk of workplace accidents. However, even though crew behavior has a small direct impact on operational performance, safety culture can be very important. This explains that individual behavior, collective values, and resulting operational outcomes are connected in a more complex systemic manner. Therefore, this study shows that safety culture is a mechanism that improves crew behavior towards operational efficiency. From a maritime safety and policy perspective, the results emphasize that safety culture is not merely supportive but a key performance driver. The strong mediating role of safety culture indicates that interventions must move beyond compliance-based approaches toward values-driven leadership and behavioral reinforcement mechanisms. Continuous simulation training, peer feedback systems, and non-punitive reporting channels can cultivate trust and proactive safety behavior. At the institutional level, the findings suggest integrating behavioral and cultural dimensions into national maritime safety programs, revising training curricula to emphasize non-technical skills alongside technical competencies, and aligning company-level safety initiatives with ISM Code Sections 6 and 12 on resources and continuous improvement.

The hypothesis test results also support the conclusion that crew behavior influences safety culture, which in turn influences shipping operational performance. Safety culture helps connect an individual's actions with operational outcomes, according to the mediation pathway. This is in line with the findings [7] that emphasize the importance of creating a safety climate for maritime organizations. In other words, individual behaviors such as complying with standard operating procedures (SOPs), participating in training, and reporting incidents will not result in significant operational improvements. This will not happen without a strong safety culture system [59]. Conceptually, this research model shows that safety culture is the foundation of an organization that has the ability to transform individual behavior into operational advantages. Therefore, performance improvement strategies in the shipping industry must incorporate elements of safety culture into management, cultural, and structural strategies.

Theoretically, this study enriches maritime safety literature by providing empirical evidence that safety culture mediates the relationship between crew behavior and operational performance, validating the integration of HRO and NTS perspectives in maritime organizational analysis. Practically, it offers actionable insights for enhancing safety leadership, transparency, and continuous behavioral training initiatives

that reduce accident rates and strengthen operational resilience. Overall, the findings underscore that sustainable maritime performance depends on behavioral consistency supported by a strong safety culture and institutional commitment to learning and improvement.

5. Conclusions

As this study shows, maritime safety culture is a key factor influencing how well shipping operations run. Although crew behavior has a relatively small influence on performance, the results show that when safety culture mediates, this influence becomes significant. This indicates that individual behavior correlates with organizational principles, and a strong safety culture can lead to improved operational performance as measured by compliance and personal commitment. The results of this study indicate that incorporating a safety culture into the management system will make shipping operations more efficient and accurate. This study concludes that maritime safety culture plays a pivotal mediating role in linking crew behavior with shipping operational performance. While individual behavior such as compliance, teamwork, and proactive engagement contributes positively to safety, its direct effect on operational performance remains limited unless embedded within a strong organizational culture. The integration of behavioral consistency and cultural reinforcement significantly enhances reliability, operational efficiency, and risk mitigation in maritime operations. These findings validate the theoretical linkage between human factors and organizational systems proposed by the High Reliability Organization (HRO) and Non-Technical Skills (NTS) frameworks.

From a managerial standpoint, the results highlight that sustainable safety and performance improvement cannot be achieved through technical compliance alone. Shipping companies and maritime authorities should prioritize leadership that models safety values, develop continuous behavioral training programs, and establish non-punitive reporting mechanisms that encourage transparency and learning. Embedding safety culture indicators into performance management systems alongside compliance metrics will strengthen accountability and align individual behavior with organizational safety goals. In addition, integrating these cultural dimensions into crew assessment, promotion, and reward structures can cultivate a long-term safety mindset across all operational levels.

For future research, this study opens several promising directions. Scholars may extend this model by examining the moderating roles of leadership style, safety climate, or regulatory enforcement to capture the broader dynamics of maritime safety performance. Longitudinal or cross-national studies could further validate the temporal and contextual stability of the relationships identified here. Qualitative investigations exploring narratives of crew experiences and safety decision-making may also enrich understanding of how safety culture is internalized in real operational contexts. Ultimately, future work should continue to integrate behavioral, cultural, and technological dimensions to build more resilient and adaptive maritime organizations.

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