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Analyzing the Impact of Human Element and Human Error on Seafarer Performance, Mediated by Safety Culture: Case study Indonesian Seafarer

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ABSTRACT

This study aims to analyze how the Human Element, as recognized by the International Maritime Organization (IMO), along with human error and safety culture, influences the performance of Indonesian maritime officers. Employing a quantitative approach with the Structural Equation Modeling (SEM) method via SmartPLS 4, this causal study involved 243 Indonesian seafarers with a minimum of two years of experience, selected through purposive sampling. The research findings indicate that both the measurement and structural models possess excellent validity and reliability. Indicators demonstrate outer loading values above 0.816, Average Variance Extracted (AVE) above 0.669, and Composite Reliability (CR) above 0.919, signifying the robust quality of the measurement model. Furthermore, the Human Element and Human Error explain 61% of the variance in Safety Culture, while the combination of variables accounts for 78% of the variance in Seafarer Performance, with a Standardized Root Mean Square Residual (SRMR) of 0.067 indicating a good model fit. This research makes a significant contribution by addressing previous study gaps that focused on the quantity of seafarers, shifting instead to the qualitative aspects of the Human Element and its impact on officer performance. Consequently, these findings can be implemented by the shipping industry to enhance safety and improve seafarer performance.

Keywords: Human Element, Human Error, Safety Culture, Seafarer Performance.

INTRODUCTION

The international shipping industry serves as the backbone of the global economy (Darmawan et al., 2022; Kłopotek et al., 2024; Priyadi et al., 2021; Wadhwa & Mahadevan, 2019). This industry, at both national and global levels, is undergoing significant transformations driven by the development of increasingly effective and efficient systems and technologies ((Cicek et al., 2019; Junus et al., 2023, 2024; Sudewo, 2023). These changes encompass various aspects, including corporate management, onboard working conditions, organizational culture, and the adoption of modern technology. All these factors contribute to increased competitiveness while prioritizing operational safety and security of vessels (Islam et al., 2019; Saputra, 2021). Maritime transportation remains the primary choice due to its efficiency, which directly impacts the growing number and types of vessels, as well as the demand for seafarers at various ranks, including officers and ratings (Junus et al., 2023; Lušić et al., 2019).

In line with contemporary developments, the competency requirements for seafarers are continuously evolving (Cicek et al., 2019; Patchiappane & Rengamani, 2018). Seafarers are expected to possess diverse competencies to compete successfully for employment opportunities (Funmilayo Aribidesi Ajayi & Chioma Ann Udeh, 2024; Tsai & Liou, 2017). The International Maritime Organization (IMO) specifically regulates the criteria and standards for

competent seafarers through the STCW Convention (Standards of Training, Certification, and Watchkeeping for Seafarers) (Group, 2007; Victoria et al., 2020). The STCW Convention establishes minimum international requirements for the training, certification, and watchkeeping of seafarers worldwide. It sets competency standards for various positions on board, such as captains, deck officers, engine officers, and safety personnel. These competencies encompass the knowledge, skills, and attitudes necessary to perform duties effectively and safely at sea (Group, 2007; Priyadi et al., 2021; Tsai & Liou, 2017). The high standards of competence expected have resulted in a shortage of seafarers qualified for employment. While these competency standards are crucial for maintaining safety and efficiency in the shipping industry, the challenges in meeting them have led to a limited supply of competent seafarers. This creates a gap between demand and supply within the industry, which can affect global maritime operational stability and safety.

Many studies tend to highlight technical and operational aspects of maritime safety. However, the human element, human error, safety culture, and performance, while acknowledged as important, often don't receive sufficient practical attention (Group, 2007). According to the IMO, the Human Element is a primary factor that must be considered (Group, 2007; Nik Mat et al., 2023; Tsai & Liou, 2017), especially for Indonesian maritime officers. The low perception of Indonesian seafarers' competence leads to minimal recognition of Indonesian maritime graduates (Junus & Munandar, 2020). The human element, human error, and safety culture are complex, multidimensional issues that impact maritime safety, security, and marine environmental protection (Kumar & Subhashini, 2019). The IMO has issued various resolutions and guidelines emphasizing the importance of the Human Element in maritime safety. For instance, IMO's Human Element Vision, Principles, and Goals (MSC/Circ.878) underscore the need for a deeper understanding of how human factors affect maritime safety and performance. Nevertheless, empirical research linking these guidelines to concrete performance in the field remains scarce, particularly in the context of maritime officers.

BIMCO, along with the ICS (International Chamber of Shipping), regularly publishes a Manpower Report that identifies workforce needs in the maritime sector, including challenges in attracting and retaining qualified maritime officers. However, these reports often emphasize workforce quantity and technical training, with less focus on how the human element, human error, and safety culture can influence officer retention and performance. Furthermore, in-depth empirical research on how fulfilling these psychological and well-being needs impacts officer performance and motivation is still limited. With recent regulations like the Maritime Labour Convention (MLC 2006), there's increased awareness of the importance of the Human Element. Yet, there are still discrepancies in understanding how these regulations are implemented in practice and how they affect the operational performance of maritime officers.

This research not only discusses how the Human Element factors recognized by the IMO affect the performance of maritime officers but also examines other factors, including human error and safety culture. This will address the needs identified by BIMCO by exploring how the fulfillment of maritime officers' needs is influenced by performance. Ultimately, this will provide deeper insights into improving retention policies and workforce management in the maritime sector.While numerous studies on seafarer supply and demand have focused on the quantity of seafarers, shortages, competencies, and year-to-year needs, they often haven't fully addressed the human element, human error, and safety culture. This research will investigate the fulfillment of maritime officers' needs by focusing on the impact of the Human Element, Human Error, and safety culture on their performance.

This approach will make the research more concrete and directly implementable by the shipping industry to enhance both safety and performance. This study can significantly contribute to developing more effective policies and guidelines for managing the Human Element in the maritime industry, with a specific focus on maritime officers. The research will analyze the influence of the Human Element, Human Error, and safety culture on seafarer performance in fulfilling maritime officers' needs, using Indonesian seafarers as a case study.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Human Element

The International Maritime Organization (IMO), through Resolution A.849(20), defines the Human Element as a complex, multifaceted issue vital to maritime safety and marine environmental protection. This encompasses every facet of human involvement, from crew members to shore-based management, regulatory bodies, organizations, shipyards, and legislators. Effective collaboration among all these stakeholders is crucial for addressing Human Element challenges. Vinagre-Ríos & Iglesias-Baniela, (2013) further highlight the Human Element as a significant risk factor in ship operations. They argue that shipowners, crew, regulators, and market demands all influence this element. Notably, Rios and Baniela observe that those involved in commercial shipping

might prioritize more profitable, riskier activities over established safety standards, which can lead to fluctuations in maritime accident rates.

Beyond normal operations, the Human Element encompasses the critical role of humans, both on board and ashore, in decision-making and regulatory adherence (Ahvenjärvi, 2016). This extends to abnormal situations, where the goal is to minimize crew errors and maximize vessel safety. Popa (2016) broadens this definition, stating that the Human Element includes any factor impacting the interaction between humans and other humans, systems, vessels, or machinery on board. He emphasizes that changes in humans, systems, vessels, and machinery necessitate a balance between regulatory compliance, operational requirements, and affordability, all while ensuring fitness for purpose.

In essence, the Human Element covers all human aspects within the maritime work system, regardless of whether they are on board or related to maritime activities ashore. Popa (2016) also noted the importance of performance management systems, crew management systems, and human contributions within shipping companies as integral to the Human Element

Ma et al.,(2023) identify six key segments of the Human Element: people factors, ship factors, external influences and environment, working and living conditions, shore-side management, and onboard organization. This categorization stems from the Human Element Analyzing Process (HEAP) adopted by the IMO. Other perspectives on the Human Element within complex safety-critical systems emphasize criteria such as trust, awareness and understanding, control, training, and work organization (Mallam et al., 2020). Furthermore, Barnett & Pekcan, (2017) highlight eight primary activities that fall under the Human Element umbrella: understanding, risk-taking, decision-making, error-making, fatigue and stress, learning and developing, working with others, and communicating with each other.

Human Error

Human error is defined as any human action, omission, or failure to meet performance limits, with these limits being determined by the system itself (Corrigan et al., 2020). It can manifest as an inappropriate or unacceptable human decision or action that negatively impacts efficiency, safety, or system performance (Sanders & McCormick, 1973). Essentially, human error is a deviation from acceptable or desired actions by an individual or a group, potentially leading to undesirable or unacceptable outcomes (IMO, n.d.). More specifically, Kim (2020) defines human error as the failure to perform a specified task or performing a forbidden activity, with consequences ranging from serious injury and property loss to near-miss incidents. Various frameworks categorize human error. G. Li et al., (2021) identify four main categories: team management errors, voyage management errors, application errors, and individual errors. Another perspective from Zhang et al., (2020) simplifies this into perception errors, decision errors, and execution errors.

Ma et al.,(2023) further detail five segments as indicators of human error: perception errors, decision errors, execution errors, individual errors, and team management errors. Additionally, Akyuz et al., (2018) note that human errors can include deficiencies such as inadequate reporting or monitoring, delayed or insufficiesnt feedback, inadequate checks/inspections, and a lack of proper execution. Barnett (2005) highlights that human errors can stem from various factors, both individual and organizational. While some errors can be rectified through improved systems, persistent violations often originate from a workplace culture that fails to prioritize safety or compliance. The following sections will detail the classification of human error across various aspects.

Safety Culture

Safety culture, whether within a system or an organization, functions as a set of barriers or "defenses" designed to counteract potential failures. These barriers can manifest in various forms, including hardware, software, and human elements. Typically, a robust safety culture incorporates one or more of these defenses to prevent accidents (Barnett & Pekcan, 2017). A significant early contribution of safety culture models in the maritime world was their ability to explain how accidents occur. These models acknowledge failures and become active at the system's problematic end, addressing issues such as operator error onboard, as well as deficiencies in design, poor management practices, and inadequate internal system processes (Reason, 1997).

The safety culture within an organization is often intangible; it's not directly visible. While members of an organization might instinctively understand their workplace's safety culture, articulating it specifically can be challenging. This is because safety culture encompasses subconscious beliefs about appropriate behavior and unspoken assumptions regarding how work should be conducted within the organization (Barnett, 2005).

A strong safety culture goes beyond mere written rules; it embodies the attitudes, values, and tangible actions supported by all organizational members, particularly management. According to Pidgeon & O'Leary (2000), four key factors contribute to a positive safety culture: Senior management commitment to safety: This involves demonstrating genuine concern for safety, rather than just making formal statements. Shared concern for hazards and their impact on people: This cultivates a collective awareness of risks and mutual care for each other's safety.

Realistic and flexible norms and rules regarding hazards: Safety regulations should be practical, adaptable, and capable of adjusting to existing conditions. Continuous reflection through monitoring, analysis, and feedback systems (organizational learning): This involves constantly evaluating and improving safety practices based on real-world monitoring and incident analysis. Subsequently, several researchers and organizations, recognizing the crucial importance of workplace safety culture, have developed various models to guide its establishment

Seafarer Performance

Performance is generally understood as a combination of opportunity, ability, and effort (Ichsan & Nasution, 2020). It is also assessed by the outcomes of work over a specific timeframe. For any shipping company, strong seafarer performance is highly sought after due to the direct benefits it offers the organization. To achieve this, seafarers, recognized as vital assets, must be effectively managed. Research indicates that training plays a positive and significant role in seafarer performance (Nurahaju & Utami, 2020). Academic definitions of performance vary. Schmitt & Highhouse (2013) define performance as the capacity to work or an exhibited achievement. Van Scotter & Motowidlo (1996) describe it as the total expected value of an individual's behavior to an organization over a given period.

Factors Contributing to Performance

Several factors influence overall performance. Ichsan & Nasution, (2020) identify a positive work culture, peer acceptance, and job promotion as key elements that enhance performance. Another significant factor is job satisfaction, as higher satisfaction levels are associated with improved performance and, typically, lower employee turnover (Mangkunegaran, 2011).. Employee performance is commonly categorized into task performance and non-task performance (Schmitt & Highhouse, 2013).. Task performance encompasses behaviors that contribute to the core operations and maintenance activities within an organization. It can be precisely defined as an individual's proficiency in executing their work duties. In contrast, non-task performance refers to behaviors that contribute to the organizational culture and climate. This category includes interpersonal facilitation behavior and job dedication behavior. Interpersonal facilitation behavior consists of interpersonal-oriented actions that support the achievement of organizational objectives. These actions involve various interpersonal acts that help maintain the social and interpersonal context essential for effective task performance. Job dedication behavior, on the other hand, is primarily centered on self-discipline (Koopmans et al., 2011).

Strategies for Enhancing Seafarer Performance

Given the inherent variability in individual seafarer performance, a detailed exploration of the factors influencing it is crucial. To boost seafarers' productivity and overall performance, it is essential to focus on improving their knowledge, skills, attitudes, and behaviors, and addressing any performance deficiencies.Training is a fundamental activity aimed at enhancing an individual's work capabilities (Nurahaju & Utami, 2020). It assists employees in comprehending practical knowledge and its application, thereby elevating the skills and attitudes required by the organization to meet its goals. Training can also be defined as the process of equipping new or existing employees with the foundational skills needed to perform their job functions (Gary, 2009). Both new hires and tenured employees require continuous training due to evolving job demands, which can shift in response to changes in the work environment, organizational strategy, and other dynamic factors. Widodo (2017) proposes several strategies for improving employee performance: Providing appropriate compensation to enhance work motivation in completing tasks, particularly those related to community service. Conducting frequent meetings or briefings to evaluate employees, with the goal of delivering improved services to the community as a manifestation of strong employee performance.

Monitoring Work Challenges And Emphasizing that Past Mistakes Should Not Recur.

Encouraging management teams to adopt diverse approaches to engage subordinates, thereby fostering increased work motivation and implementing leadership styles that align with the existing organizational culture. Furthermore, job promotion offers employees opportunities for creativity and innovation, leading to beneficial impacts for the organization. This is because new positions provide employees with additional knowledge and experience, motivating them to elevate their performance (Latief et al., 2019).

H_1: Human Element (X1) is hypothesized to influence Seafarer Performance (Y).

According to IMO Resolution A.849(20), the Human Element is a complex, multidimensional issue affecting maritime safety and marine environment protection. It involves a wide range of stakeholders, both onboard and ashore (IMO, n.d.). Vinagre-Ríos & Iglesias-Baniela, (2013) assert that the Human Element is a risk factor in ship activities, influenced by various parties, including shipowners and regulations. This indicates that the Human Element impacts safety and operational efficiency onboard ships. (Ahvenjärvi, 2016) emphasizes that the Human

Element encompasses decision-making in both normal and abnormal operating conditions to minimize errors and maximize vessel security.

H2: Human Error (X2) is hypothesized to influence Seafarer Performance (Y).

Human Error as a human action that fails to meet a system's predefined performance limits. Sanders & McCormick, (1973) state that Human Error includes inappropriate decisions or actions that affect efficiency and safety. The IMO (n.d.) clarifies that Human Error is a failure to perform a specified task or engaging in a prohibited activity with serious consequences. Akyuz et al., (2018)identify several types of Human Error, such as inadequate reporting, delayed feedback, and suboptimal inspections.

H3: Human Element (X1) is hypothesized to influence Safety Culture (Z).

Pidgeon & O'Leary, (2000) states that the human element plays a critical role in establishing a robust safety culture. Decisions made by ship crew in various situations contribute to onboard operational safety. Pidgeon & O'Leary, (2000) mention that safety culture comprises beliefs and attitudes, norms and values, and collective behavior. All these are rooted in the human element, specifically how individuals think, feel, and act within an organization. Barnett & Pekcan, (2017) assert that safety culture represents a set of barriers designed to prevent failures, with the human element being a crucial component of the defense system against accidents.

H4: Human Error (X2) is hypothesized to influence Safety Culture (Z).

Safety culture encompasses various forms of "defenses" or barriers designed to address potential failures, including human failures. Its aim is to detect and mitigate human errors before they escalate into accidents (Barnett & Pekcan, 2017). Reason, (1997) explains that while human error often manifests as operator error at the frontline (e.g., on a ship), the root causes can stem from failures in design, management, or organizational systems. This implies that human error isn't merely an individual mistake but a reflection of a systematically weak safety culture. A robust safety culture directly shapes individual attitudes and behaviors, subsequently reducing the likelihood of human error. This perspective is affirmed by Barnett, (2005), who emphasizes that safety culture reflects unconscious beliefs and values that dictate employees' daily conduct.

H5: Safety Culture (Z) is hypothesized to influence Seafarer Performance (Y).

Safety culture encompasses the values, norms, and attitudes deeply embedded within an organization, serving as a reference for behavior (Pidgeon & O'Leary, 2000). When seafarers operate within a system that prioritizes safety, they become more risk-aware, work more meticulously, and exhibit greater discipline. This directly contributes to improved task performance and job dedication (Koopmans et al., 2011). Safety culture has been empirically shown to have a positive and significant influence on performance Syardiansah et al., (2020); Hasibuan, (2013). Seafarers who feel valued and protected tend to work with greater enthusiasm and efficiency. Reason, (1997) emphasizes that a strong safety culture can reduce human error and system failures. When the risks of errors and accidents are minimized, seafarers can work with enhanced focus, directly impacting the achievement of optimal work outcomes (Ichsan & Nasution, 2020);(Van Scotter & Motowidlo, 1996).

RESEARCH METHODS

Research Design

This study employs a quantitative approach with a causal research design. Its primary objective is to examine the causal relationship between Human Element and Human Error on Seafarer Performance, with Safety Culture acting as an intervening variable. The chosen analytical method is Structural Equation Modeling (SEM), utilizing SmartPLS 4 software. This method is preferred due to its capability to analyze complex relationships among latent variables and its robustness in handling non-normally distributed data.

Population and Sample

The research population consists of Indonesian seafarers actively working on merchant vessels or international shipping lines. Inclusion criteria for participants include: a minimum of two years of seafaring experience, understanding of safety management systems, and willingness to complete the questionnaire. Purposive sampling was used as the sampling technique. The sample size was determined based on the recommendation by (J. Hair et al., 2022), which suggests a minimum of 10 times the number of indicators. With a total of 23 indicators in this study, a minimum of 230 respondents was required. Data was successfully collected from 243 seafarers.

Data Collection Techniques and Instrument Development

Data were gathered through the distribution of online questionnaires via Google Forms and direct distribution at several shipping companies. The research instrument was a structured questionnaire employing a 5-point Likert

scale (1 = Strongly Disagree, 2 = Disagree, 3 = Moderately Agree, 4 = Agree, 5 = Strongly Agree). The instrument was developed from various previously validated studies:

Human Element (X1): Adapted Ma et al., (2023), Mallam et al., (2020), Ahvenjärvi, (2016), Vinagre-Ríos & Iglesias-Baniela, (2013), Popa, (2016), this variable includes 6 indicators: People factor, Ship factor, External influences and environment, Working and living conditions, Shore-side management, Organization on board. Human Error (X2): Adapted from Ma et al., (2023), Zhang et al., (2020), Kim, (2020), Akyuz et al., (2018), Y. Li & Li, (2024), this variable comprises 5 indicators: Perception error, Decision error, Execution error, Individual error, Team management error, Safety Culture (Z): Adapted from Barnett & Pekcan, (2017), Halaj, (2017), Pidgeon & O'Leary, (2000), Cooper Ph.D., (2000), this variable consists of 6 indicators: Values, attitudes, and beliefs, Behavior and competence, Safety systems and regulations, Management commitment and employee involvement, Training and communication, Risk factors and accident causes, Seafarer Performance (Y): Adapted Ichsan & Nasution, (2020), Widodo, (2017), Nurahaju & Utami, (2020), Syardiansah et al., (2020), Latief et al., (2019), this variable includes 6 indicators: Individual factors, Organizational factors, Social and relational factors, Career and development factors, Working environment and welfare, Instrument Validation, Prior to the main data collection, content validity testing was conducted through expert judgment. Additionally, a limited pilot test involving 30 seafarers was performed to ensure the instrument's initial reliability, with all measures demonstrating a Cronbach's Alpha > 0.7.

Data Analysis Techniques

The data analysis for this study will follow a structured approach, encompassing descriptive analysis, data quality assessment, Structural Equation Modeling (SEM), and mediation analysis.

Descriptive Analysis

Descriptive statistics will be utilized to summarize the demographic characteristics of the respondents and to present the mean scores for each variable.

Data Quality Assessment

Data quality will be rigorously assessed through the following tests: Convergent Validity: This will be evaluated by ensuring outer loadings are greater than 0.70 and the Average Variance Extracted (AVE) is greater than 0.50. Discriminant Validity: This will be assessed using the Fornell-Larcker Criterion and cross-loading analysis.Reliability: Both Composite Reliability (CR > 0.70) and Cronbach's Alpha will be used to establish instrument reliability.

SEM Analysis with SmartPLS

The analysis will proceed in two main stages:

Evaluation of the Measurement Model (Outer Model): This step focuses on testing the validity and reliability of the latent constructs. Evaluation of the Structural Model (Inner Model): This involves assessing the relationships between constructs, specifically through path coefficients and their p-values. Bootstrapping with 5,000 subsamples will be employed to test for statistical significance. Finally, the Goodness of Fit of the model will be evaluated using key metrics such as SRMR (< 0.08), R^2 (model adequacy), and Q^2 (predictive relevance).

Mediation Analysis

Mediation will be tested using the bootstrapping method for indirect effects. A p-value of less than 0.05 will indicate significant mediation (J. F. Hair et al., 2021).

RESULTS AND DISCUSSION

Respondent Characteristics

A total of 243 seafarers participated in this study. The majority of respondents were between 31-40 years old (39.8%), had over 5 years of work experience (81.38%), and originated from various types of merchant vessels. These included cargo ships, tankers, offshore support vessels (OSV), container ships, tugboats, and passenger vessels.

Descriptive Analysis of Research Variables

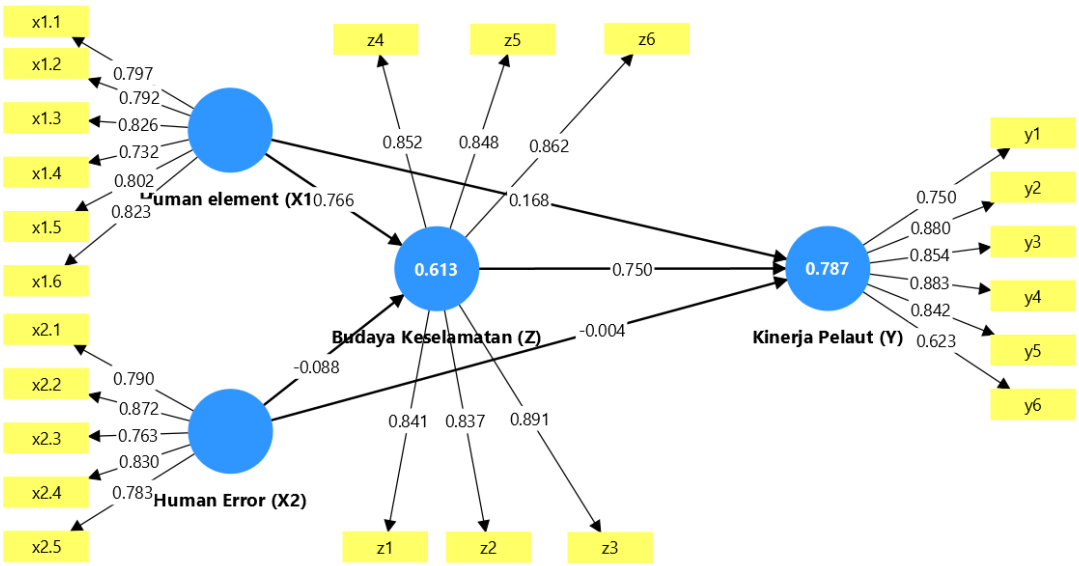

Figure 1. SEM Path Relationship Diagram.

Human Element (X1) and Seafarer Performance (Y)

The Human Element has a direct, positive, but relatively weak influence on Seafarer Performance. A coefficient of 0.168 indicates that while factors like seafarer competence and psychological state contribute to performance, this direct effect is less pronounced compared to its indirect influence, likely channeled through safety culture.

Human Error (X2) and Seafarer Performance (Y)

The direct effect of Human Error on Seafarer Performance is almost negligible, with a coefficient close to zero. This suggests that any substantial impact of human error on performance is primarily indirect, likely mediated by other factors such as safety culture.

Human Element (X1) and Safety Culture (Z)

The Human Element positively and strongly influences Safety Culture. A significant coefficient of 0.766 demonstrates a very robust relationship. This finding underscores that aspects such as seafarers' competence, experience, and psychological conditions are major contributors to establishing a strong safety culture.

Human Error (X2) and Safety Culture (Z)

Human Error has a negative impact on Safety Culture. Although the coefficient is small and negative, it supports the premise that an increase in human errors tends to diminish the perception or reality of a robust safety culture.

Safety Culture (Z) and Seafarer Performance (Y)

Safety Culture exhibits a very strong and positive influence on Seafarer Performance. A substantial coefficient of 0.750 indicates that a stronger safety culture directly and significantly leads to improved seafarer performance. This represents the strongest relationship observed within the model.

Evaluation of the Measurement Model (Outer Model)

The evaluation of the measurement model confirmed its robustness and reliability. All indicators demonstrated excellent convergent validity, with outer loading values consistently above 0.70 (specifically, 0.816). This indicates that each indicator effectively measures its respective latent construct (human element, human error, safety culture, and seafarer performance).

Furthermore, the Average Variance Extracted (AVE) for all constructs was 0.669, exceeding the 0.50 threshold, which confirms the achievement of convergent validity. Composite Reliability (CR) values for all constructs were 0.919, well above the 0.80 benchmark. This high CR value signifies that all latent variables are measured by strong instruments, thereby reinforcing the quality of the measurement model and lending confidence to the structural model path coefficients. The Cronbach's Alpha of 0.894 (greater than 0.7) further confirms the exceptional reliability of the instrument. Finally, both the Fornell-Larcker Criterion and Heterotrait-Monotrait Ratio (HTMT) analyses indicated that discriminant validity was successfully achieved.

Evaluation of the Structural Model (Inner Model)

The structural model also demonstrated strong explanatory power and good fit:

R^2 for Safety Culture (Z): A value of 0.613 indicates that the Human Element and Human Error variables collectively explain 61% of the variance in Safety Culture. R^2 for Seafarer Performance (Y): A value of 0.787

signifies that the combination of all explanatory variables in the model accounts for 78% of the variance in Seafarer Performance. Standardized Root Mean Square Residual (SRMR): A value of 0.067 (below the 0.08 threshold) suggests that the model exhibits a good fit with the observed data.

Hypothesis Testing Results

Table 1. Hypothesis Testing

Hipotesis	Relation	Path Coeficien	p-value	result
H1	Human Element (X1) → Seafarer Performance (Y).	0.168	0.000	Accepted
H2	Human Error (X2) → Seafarer Performance (Y).	-0.004	0.000	Accepted
H3	Human Element (X1) → Safety Culture (Z).	0.766	0.000	Accepted
H4	Human Error (X2) → Safety Culture (Z).	-0.088	0.002	Accepted
H5	Safety Culture (Z) → Seafarer Performance (Y).	0.750	0.000	Accepted

DISCUSSION

H1: Human Element (X1) Positively Influences Seafarer Performance (Y)

This hypothesis is supported by numerous studies, oleh Ma et al., (2023), Mallam et al., (2020), Ahvenjärvi, (2016), Vinagre-Ríos & Iglesias-Baniela, (2013), Popa, (2016). These works consistently demonstrate that factors such as technical competence, experience, and psychological well-being significantly influence seafarer productivity and effectiveness.

H2: Human Error (X2) Negatively Influences Seafarer Performance (Y)

This assertion aligns with findings from Ma et al., (2023), Zhang et al., (2020), Kim, (2020), Akyuz et al., (2018), Y. Li & Li, (2024). Their research indicates that workplace errors directly lead to a reduction in maritime work efficiency and output.

H3: Human Element (X1) Positively Influences Safety Culture (Z)

This result is consistent with existing literature suggesting that seafarers with sound physical, mental, and practical skills tend to foster a safe and controlled working environment. Supporting references include Ma et al., (2023), Mallam et al., (2020), Ahvenjärvi, (2016), Vinagre-Ríos & Iglesias-Baniela, (2013), Popa, (2016).

H4: Human Error (X2) Negatively Influences Safety Culture (Z)

Studies by Ma et al., (2023), Zhang et al., (2020), Kim, (2020), Akyuz et al., (2018) consistently show that a high incidence of workplace errors leads to a decline in trust in safety systems and a deterioration of the overall work climate.

H5: Safety Culture (Z) Positively Influences Seafarer Performance (Y)

This finding is supported by the work of (Barnett & Pekcan, (2017), Halaj, (2017), Pidgeon & O'Leary, (2000), Cooper Ph.D., (2000). Their research indicates that a robust safety climate fosters a sense of security and strengthens work collaboration, ultimately enhancing performance.

CONCLUSION

This research highlights that safety culture is the most significant variable influencing seafarer performance. The human element plays a substantial role, contributing strongly to both safety culture and, directly and indirectly, to seafarer performance. Conversely, human error, while having a negative impact, does not directly influence seafarer performance significantly. Therefore, mitigation strategies should primarily focus on improving safety culture to enhance overall seafarer effectiveness and safety outcomes.

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