Siber Journal of Transportation and Logistic (SJTL)
E-ISSN: 2987-1050
P-ISSN: 2987-1026
+62 822 1012 3600 https://research.e-siber.org siberpublisher.info@gmail.com

DOI: https://doi.org/10.38035/sjtl.v4i1.850

Optimizing Chemical Tanker Performance: The Role of Cargo Control Operations and Crew Discipline

David Pandapotan Sirait[1], Esterlinus Edwin Lermatan[2], Marthaleina Ruminda[3]
[1]Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia, david.fmbitltrisakti@gmail.com
[2]Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia, edwinlemartan@gmail.com
[3]Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia, marthaleina.rs@gmail.com

Corresponding Author: david.fmbitltrisakti@gmail.com[1]

Abstract: This study analyzes the impact of cargo control operations during Caustic Soda (CCS) loading/unloading and crew discipline on Motor Tanker operational performance at a South Korean shipping company. A quantitative survey approach was utilized, involving 35 crew members directly responsible for cargo handling. Data were analyzed through multiple linear regression and hypothesis testing via SPSS. Cargo control operations and crew discipline partially and simultaneously exert a positive, significant effect on operational performance, explaining 86.5% of the variance. Optimizing cargo control technology and enforcing strict crew discipline are crucial synergies for ensuring the smooth, safe, and efficient operation of vessels transporting hazardous chemical cargoes. The small sample size and specific focus on CCS cargo within one company may restrict the generalizability of these findings to other vessel types or cargo scales. This research provides strategic insights into maritime operational management, contributing empirical evidence on high-risk handling procedures for hazardous liquid chemicals.

Keyword: Cargo Control Operation, Crew Discipline, Operational Performance, Chemical Tanker, Maritime Logistics.

INTRODUCTION

Amidst the current dynamics of international trade and economic globalization, the logistics and transportation sector plays a vital role as the fundamental backbone of global supply chains (Notteboom & Haralambides, 2025; Sianturi et al., 2024). Operations management represents a set of activities that generate value in the form of goods and services by transforming inputs into outputs (Helmold, 2022). In the context of maritime transport, operations management focuses on the efficiency of vessel movement and cargo handling (Edih et al., 2023; Sirait et al., 2026). Rapid global economic growth demands increasingly complex, responsive, and efficient exchanges of goods, particularly through maritime transport, which currently facilitates more than 80% of international trade volume (Canbay, 2024). This phenomenon is prominently observed in the Asian region, including South Korea as a leading maritime and economic hub, and Indonesia, which continuously

advances its modern port infrastructure to support seamless regional logistics flows (Lee et al., 2023; Yudhantara & Achmadi, 2026).

Vessel operations, particularly on chemical tankers, constitute a complex system that requires the integration of technology, safety procedures, and human competence. A highly crucial and strictly regulated segment within maritime transportation is the carriage of hazardous liquid cargo, such as Caustic Soda (Sodium Hydroxide / CCS). The handling of this specific chemical cargo necessitates not only stringent time efficiency to prevent port congestion and demurrage costs but also absolute compliance with international safety standards (Sezer et al., 2023). Modern chemical tankers rely heavily on the Cargo Control Room (CCR) as the central nervous system for cargo management. For hazardous cargoes such as Caustic Soda (CCS), cargo control operations extend beyond mere cargo transfer to encompass the management of chemical risks, including corrosivity and temperature stability. Optimizing operations in the Cargo Control Room through the utilization of real-time monitoring technology and automation can significantly reduce cargo handling time and minimize the risk of cargo spillage (Latifah et al., 2025; Ruminda, 2026). Nevertheless, in practical maritime operations, exclusive dependency on this technology presents distinct operational challenges; procedural failures within these operations can result in operational delays and the risk of fatal occupational accidents (Aboud & M. Attia, 2025; Gulen et al., 2026).

On the other hand, technological sophistication in maritime operations is inextricably linked to the human resources operating it. Discipline is defined as an individual's behavior that aligns with established rules and work procedures; it encompasses the attitudes, conduct, and actions that comply with organizational regulations, both written and unwritten. As isolated and high-risk working environments, chemical tanker vessels demand an exemplary level of crew discipline. Crew discipline is defined as consistent compliance with Standard Operating Procedures (SOPs) and safety regulations (Ntounias et al., 2026). Unfortunately, the phenomenon of declining crew discipline frequently surfaces as a latent issue in maritime management, often reflecting underlying issues of fatigue, low work motivation, or weak supervisory control (Bouzón Otero et al., 2026). Human error, which frequently stems from a lack of discipline, fatigue, or procedural violations, accounts for 75% to 96% of total maritime accidents (Dimitrakiev & Milev, 2025).

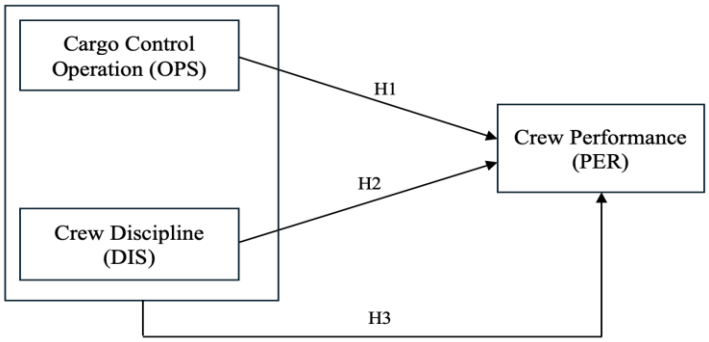
Vessel operational performance constitutes a multidimensional construct that reflects the overall effectiveness, safety, and efficiency of a ship's daily functions. The operational management issue becomes considerably more complex when these two variables—technical constraints in cargo control operations and a low level of crew discipline—occur simultaneously. The ultimate achievement of optimal vessel operational performance is contingent upon a holistic sociotechnical synergy. While previous studies in maritime logistics have widely investigated general vessel performance, the majority of existing literature tends to evaluate technical reliability and human resources as separate, isolated entities, often focusing on dry bulk or general oil cargoes (Theotokas et al., 2024). There is a notable scarcity of empirical research that quantitatively integrates both the technical dimensions (Cargo Control Operations) and behavioral dimensions (Crew Discipline) within the specific, high-risk context of Caustic Soda handling on chemical tankers.

Ultimately, the objective of this research is to provide robust empirical contributions and formulate strategic recommendations for the operational management of Motor Tanker vessels, specifically within South Korea-based shipping operations, thereby enhancing both logistics efficiency and maritime safety. Based on the theoretical integration of operational systems and sociotechnical behavior, this study proposes the following hypotheses (Figure 1):

H1: Cargo control operations during the loading and unloading of Caustic Soda (CCS) are hypothesized to have a positive impact on the operations of Motor Tanker vessels.

H2: Crew discipline is hypothesized to have a positive impact on the operations of Motor Tanker vessels.

H3: Cargo control operations during the loading and unloading of Caustic Soda (CCS) cargo and crew discipline simultaneously exert a positive impact on the operations of Motor Tanker vessels.



Source: Research Results

Figure 1. Research Framework

METHOD

This associative-causal quantitative study utilizes a survey method to examine the impact of Cargo Control Operations (OPS) and Crew Discipline (DIS) on Vessel Operational Performance (PER) (Kilian et al., 2023). Employing a saturated sampling technique, the sample comprised all 35 crew members directly involved in Caustic Soda handling aboard a South Korea-based chemical Motor Tanker.

The independent variables were operationalized through specific indicators: Cargo Control (procedural understanding, equipment utilization, and temperature/pressure monitoring) and Crew Discipline (schedule adherence, SOP compliance, PPE usage, and work responsibility). The dependent variable, Operational Performance, was assessed based on loading/unloading time efficiency, occupational safety, and schedule seamlessness.

Primary data were collected via a five-point Likert scale closed-ended questionnaire. Following validity (Product Moment correlation) and reliability (Cronbach's Alpha > 0.60) verifications, data were analyzed using SPSS software. The analytical procedure encompassed Classical Assumption Tests, Multiple Linear Regression, hypothesis testing (partial t-test and simultaneous F-test), and the Coefficient of Determination (Bansal & Singh, 2023; Guo et al., 2024).

RESULTS AND DISCUSSION

Based on demographic data, all respondents on a shipping (100%) are male seafarers, predominantly within the productive age group of 20-30 years (82.85%). The majority of the crew is also in the early stages of their careers, with less than 5 years of service (62.86%). This composition reflects the reality of the tanker industry, which demands prime physical condition and stamina (Islam et al., 2026). In the context of maritime operations, this relatively young crew profile underscores the importance of supervision from senior officers and the enforcement of a strict disciplinary culture by company management to mitigate the risk of human error when handling hazardous cargo (Radzi et al., 2026).

The test results demonstrate that all research instruments are highly valid and possess a very high level of reliability (Cronbach’s Alpha above 0.900). The observational data have also fulfilled all classical assumption test criteria (normally distributed, free from multicollinearity, heteroscedasticity, and autocorrelation), thereby rendering the regression model highly robust and unbiased. Through descriptive statistical analysis, it was found that

the *Crew Discipline* variable obtained the highest mean score (42.40), indicating that the shipping company's management has successfully cultivated a proactive safety culture as the primary foundation for vessel operations (Parlindungan, 2026; Xi et al., 2025).

The data processing results for the *Cargo Control Operation* (OPS) variable, comprising indicators OPS01 through OPS10, yielded r-calculated values ranging from 0.637 to 0.884. The strongest indicator for this variable was OPS04 (0.884). Since all r-calculated values (0.637–0.884) exceeded the critical value of 0.514, all ten statement items for the *Cargo Control Operation* variable were declared valid. The *Crew Discipline* (DIS) variable, consisting of 10 indicators (DIS01 through DIS10), exhibited r-calculated values ranging from 0.647 to 0.882. The results indicate that the strongest indicator for measuring discipline was DIS04 (0.882). As all r-calculated values (0.647–0.882) exceeded 0.514, all ten statement items for the *Crew Discipline* variable were declared valid. Regarding the *Crew Performance* (PER) variable, which consists of 12 indicators (PER01 through PER12), the r-calculated values ranged from 0.612 to 0.923. The strongest indicators for measuring performance were PER05 and PER09 (both sharing the highest value of 0.923). Since all r-calculated values (0.612–0.923) exceeded 0.514, all twelve statement items for the *Crew Performance* variable were declared valid.

Table 1. Reliability Test

Variable	Alpha Cronbach	Remark
OPS	0.939	Reliable
DIS	0.935	Reliable
PER	0.954	Reliable

Cronbach's Alpha > 0.600

Source: Research data

The measurement instruments employed for the three variables (*Cargo Control Operation*, *Crew Discipline*, and *Vessel Operational Performance*) have successfully passed the consistency test (Table 1.). This indicates that the respondents' answers are stable and consistent, thereby rendering the resulting data valid and suitable for further analysis using regression.

For the *Cargo Control Operation* (OPS) variable, the mean score was 39.629, with a range between 31 and 47. This result indicates that, in general, respondents perceive the *Cargo Control* systems and operational procedures during the loading and unloading of Caustic Soda to be effectively implemented. A standard deviation of 4.194 suggests that the respondents' evaluations were relatively uniform, implying no extreme variance in opinion among the crew regarding the reliability of the vessel's cargo systems.

Table 2. Descriptive Statistics Test

Variable	N	Range	Min.	Max.	Sum	Mean	Std. Dev.
OPS	35	16	31	47	1,387	39.629	4.194
DIS	35	18	32	50	1,484	42.400	4.053
PER	35	18	30	48	1,428	40.800	4.431

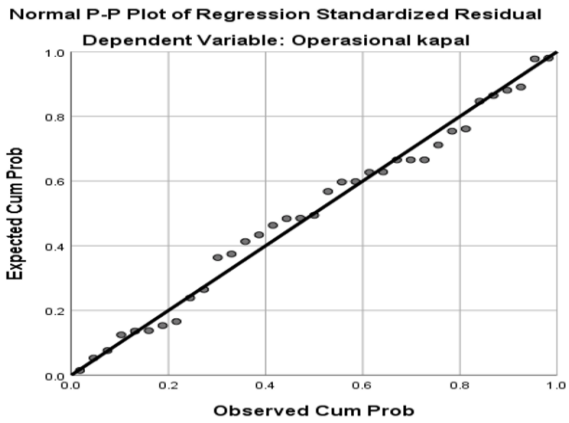
Source: Research data

The test results for the *Crew Discipline* (DIS) variable yielded the highest mean score of 42.400, with scores ranging from 32 to a maximum of 50. The maximum value of 50 indicates that some respondents provided perfect scores across all discipline indicators. This high mean, combined with the lowest standard deviation (4.053), demonstrates that the level of discipline among the crew is robust and consistent. The entire crew shares a similarly high

level of awareness and consensus regarding the importance of adhering to working hours, Standard Operating Procedures (SOPs), and safety regulations.

Finally, *Vessel Operational Performance* (PER) exhibited a mean score of 40.800, with a minimum score of 30 and a maximum of 48. The overall operational performance of the vessel was rated very highly by the crew members. However, this variable displayed the highest standard deviation (4.431) compared to the other two variables. This is a common occurrence in field research, indicating a slight variation in perspectives—such as those between deck officers and engine crew—when evaluating aspects of operational efficiency, work quality, or daily operational supervision.

Based on Figure 2, the P-P Plot graph for the dependent variable Vessel Operational Performance, it can be observed that the residual points are densely distributed and consistently align along the diagonal line (from the bottom-left to the top-right). There is no evidence of extreme outliers or the formation of wave-like patterns deviating from the cumulative probability reference line.



Source: Research data

Figure 2. P-Plot Normality Graphic

The residual data in this study is normally distributed, thereby satisfying the normality assumption requirement. Consequently, the multiple regression model predicting the impact of Cargo Control Operations and Crew Discipline on Operational Performance is deemed valid.

Table 3. Normality Test One Sample T-test KS

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		35
Normal Parameters[a,b]	Mean	0
	Std. Deviation	1.63029775
Most Extreme Differences	Absolute	.074
	Positive	.073
	Negative	-.074
Test Statistic		.074
Asymp. Sig. (2-tailed)		.200[c,d]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

Source: Research data

Based on Table 3, the One-Sample Kolmogorov-Smirnov test utilizing the unstandardized residuals from the 35 respondents reveals that the Test Statistic, which represents the most extreme absolute differences, is recorded at 0.074. The resulting significance value, or Asymp. Sig. (2-tailed), is 0.200. The obtained significance probability value of 0.200 is well above the significance level of $\alpha = 0.05$ (0.200 > 0.05). This indicates that the instrument and the sample in this study have successfully passed the normality test, demonstrating that the sample is normally distributed.

These findings confirm that the questionnaire responses provided by the Motor Tanker crew regarding the *Cargo Control Operation* and *Crew Discipline* variables are evenly distributed around their mean, without the presence of extreme responses (outliers) that could compromise the model. With the fulfillment of this fundamental assumption, the regression model is deemed highly ideal, ensuring that the conclusions drawn from both the t-test (partial) and F-test (simultaneous) are statistically valid and scientifically accountable."

Based on Table 4 regarding the Collinearity Statistics parameters, the test results demonstrate that the *Cargo Control Operation* variable during the loading and unloading of Caustic Soda (CCS) cargo possesses a Tolerance value of 0.528 and a Variance Inflation Factor (VIF) of 1.895. Furthermore, the *Crew Discipline* variable exhibits a Tolerance value of 0.528 and a VIF value of 1.895.

Table 4. Multicollinearity Test

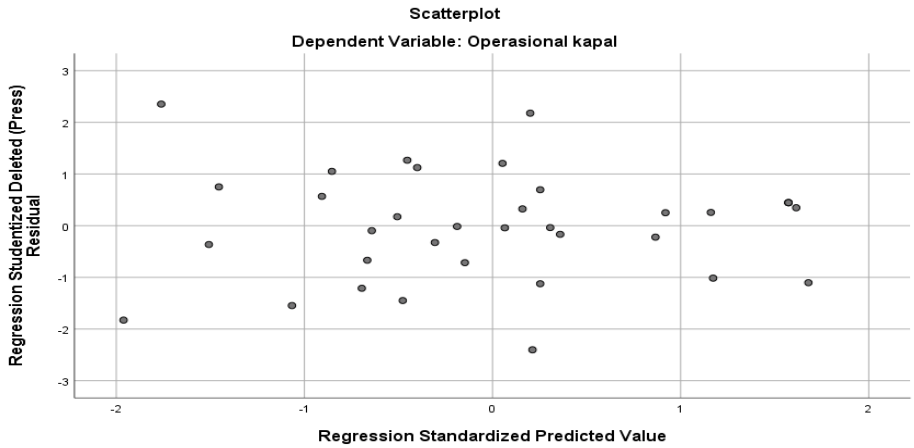
Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Cargo Control Operation	.528	1.895
	Crew Discipline	.528	1.895

a. Dependent Variable: Crew Performance

Source: Research data

These results clearly indicate that the Tolerance values for all predictor variables exceed the established threshold of 0.10 (0.528 > 0.10). In alignment with this, the VIF values for both variables are considerably low and remain well below the maximum acceptable limit of 10 (1.895 < 10). Consequently, it can be concluded that the regression model in this study is free from multicollinearity issues. The reliability aspect of the technical systems (*Cargo Control Operation*) does not conceptually overlap in the respondents' perception with the behavioral aspect of the crew (*Crew Discipline*). Each variable is capable of providing a unique and distinct contribution in predicting *Vessel Operational Performance*. Ultimately, this distinct predictive capacity facilitates vessel management in formulating targeted improvement strategies.

Referring to Figure 3, the data points (residual observations) appear to scatter randomly and do not cluster in any single specific area. The dispersion of these points is even, positioned both above and below the zero (0) mark on the vertical (Y) axis. Visually, the cluster of data points does not form a regular geometric pattern, such as a wavy or funnel-like shape. Based on this visual analysis, it can be concluded that there is no indication of heteroscedasticity within the regression model of this study.



Source: Research data

Figure 3. Heteroscedasticity Graphic

The predictive capability of the *Cargo Control Operation* and *Crew Discipline* variables concerning *Vessel Operational Performance* will remain consistent and accurate, regardless of whether the operational and disciplinary scores are at high, moderate, or low levels. The data collected from the vessel's crew are proportionally distributed. The conclusion of this statistical test asserts that no specific group of respondents exerts an extreme dominance over the variance bias."

Based on Table 5, the Coefficient of Determination (R^2) is 0.865, with a resulting Durbin-Watson value of 1.977. This DW value legitimately falls within the zone indicating an absence of autocorrelation. Consequently, it can be definitively concluded that no autocorrelation issues exist within the regression model of this study.

Table 5. Autocorrelation Test with Durbin-Watson Test

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.930[a]	.865	.856	1.680	1.977

a. Predictors: (Constant), Crew Discipline, Cargo Control Operation
b. Dependent Variable: Crew Performance

Source: Research data

The crew's responses regarding *Cargo Control Operation* and *Crew Discipline* were not systematically influenced by the answers of other crew members or by the sequence of questionnaire completion. Given that the model is proven to be free from multicollinearity, heteroscedasticity, and autocorrelation, this multiple regression model fully satisfies the criteria for statistical viability. This guarantees that the finding—asserting that *Vessel Operational Performance* is critically determined by the operational synergy of Caustic Soda cargo handling and crew discipline is valid, objective, and can confidently serve as an empirical basis for policy formulation by shipping company management without any academic reservation.

H1: The Impact of Cargo Control Operations on Vessel Operational Performance

The testing of the H1 (partial t-test) definitively proves that Cargo Control operations during the loading and unloading of Caustic Soda (CCS) exert a positive and highly significant impact on vessel operational performance (Assilbekova & Konakbay, 2026; Bimarso et al., 2024). Statistical analysis reveals a calculated t-value of 13.339, which substantially exceeds the t-table threshold of 1.692, accompanied by a significance level of

0.000 ($p < 0.05$). Notably, this technical factor contributes a dominant 84.4% to the variance in the vessel's overall performance.

These empirical findings assert that the reliability of operating procedures and mechanical systems within the Cargo Control Room (CCR) serves as the primary operational backbone in chemical tanker logistics. Unlike standard liquid bulk, Caustic Soda is a high-density, highly corrosive, and temperature-sensitive hazardous cargo (Uflaz et al., 2026). Consequently, optimization within the control room extends far beyond the mere mechanical transfer of fluids; it dictates the precise, real-time regulation of pump pressures, flow rates, and thermodynamic stability required to prevent cargo crystallization, contamination, or catastrophic structural damage to the vessel's tanks (Olayinka & Kaka, 2025; Sirait et al., 2023).

Furthermore, the results indicate that high procedural comprehension and the precise utilization of CCR equipment by the operators are directly correlated with time and cost efficiency. By maintaining optimal loading and unloading flow rates and preventing mechanical anomalies, the vessel significantly minimizes port berthing time (turnaround time), thereby shielding the company from the risk of exorbitant demurrage claims and operational delays (Hlaing & Aung, 2025; Ruminda, 2022). In the context of high-risk maritime operations, the CCR acts as the ultimate line of defense (Shamsah & Al-Dashti, 2026). The ability to flawlessly execute the cargo transfer sequence not only accelerates logistical workflows but also acts as a robust risk mitigation strategy against fatal occupational hazards and severe marine environmental pollution. Ultimately, this technical mastery guarantees that the shipping company can achieve its dual mandate: maximizing logistical efficiency while strictly maintaining a zero-accident safety record (Table 6).

Table 6. Simple Linear Regression Analysis Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.349	2.898		.810	.424
	Cargo Control Operation	.970	.073	.918	13.339	0

a. Dependent Variable: Crew Performance

Source: Research data

H2: The Impact of Crew Discipline on Vessel Operational Performance

The H2 is robustly confirmed by the proven positive and significant partial impact of crew discipline on the vessel's operational performance. Statistical evaluations yielded a calculated t-value of 6.258, which comfortably exceeds the t-table threshold of 1.692, alongside a significance level of 0.000 ($p < 0.05$). Notably, crew discipline accounts for a substantial 54.3% contribution to the variance in overall vessel performance. The positive regression coefficient derived from this analysis provides a crucial managerial implication: targeted investments in the continuous enforcement of maritime discipline—such as rigorous safety training, continuous supervisory oversight by senior officers, and stringent fatigue management—will yield immediate, direct returns in operational improvement (Ginting et al., 2025; Sheriff et al., 2025) (Table 7).

Table 7. Simple Linear Regression Analysis Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.646	5.482		1.212	.234
	Crew Discipline	.806	.129	.737	6.258	0

a. Dependent Variable: Crew Performance

Source: Research data

Empirically, this finding serves as a critical reminder that regardless of the increasing sophistication of onboard automation and mechanical control systems, operational success remains fundamentally anchored to the human element. In the high-stakes environment of chemical tankers transporting reactive and hazardous substances like Caustic Soda, the human element is confirmed to play a central, irreplaceable role in bridging the gap between theoretical mechanical capacity and actual maritime safety. A crew that demonstrates a high level of discipline regarding strict adherence to working hours and navigational watches is significantly less prone to fatigue-induced errors, which are historically recognized as the leading cause of maritime casualties (Crestelo Moreno et al., 2026).

Furthermore, operational discipline extends into absolute, non-negotiable compliance with Standard Operating Procedures (SOPs) and the mandatory utilization of Personal Protective Equipment (PPE). Highly disciplined crews cultivate a proactive safety culture rather than a merely reactive one. They execute pre-transfer checklists with greater meticulousness, monitor critical cargo parameters without negligence, and possess the operational readiness to respond to potential chemical emergencies or mechanical alarms with rapid precision (Imandiya et al., 2024). Consequently, this behavioral reliability effectively neutralizes the risk of catastrophic human error, ensures strict compliance with international maritime safety protocols (such as the IMDG Code), and directly guarantees the seamless, uninterrupted execution of the vessel's daily logistical operations.

H3: The Simultaneous Impact of Cargo Control Operations and Crew Discipline on Vessel Operational Performance

Simultaneous testing (F-test) decisively proves that Cargo Control operations and crew discipline collectively exert a positive and highly significant impact on the operational performance of Motor Tanker vessels. The robust calculated F-value of 102.202 substantially exceeds the F-table threshold of 3.295 ($p < 0.05$). (Table 8)

Table 8. ANOVA Test Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	577.232	2	288.616	102.202	.000[b]
	Residual	90.368	32	2.824		
	Total	667.600	34			

a. Dependent Variable: Crew Performance

b. Predictors: (Constant), Crew Discipline, Cargo Control Operation

Source: Research data

Furthermore, the coefficient of determination reveals that the synergy between these two independent variables accounts for a formidable 86.5% of the variance in vessel performance. This extraordinarily high explanatory power—indicating an excellent Goodness of Fit—suggests that operational success on chemical tankers is almost entirely dictated by

the flawless interplay between mechanical systems and human behavior, leaving only a marginal 13.5% fraction to external or uncontrollable variables (Arici et al., 2026) (Table 9. Figure 4.)

Table 9. Regression Coefficients Test

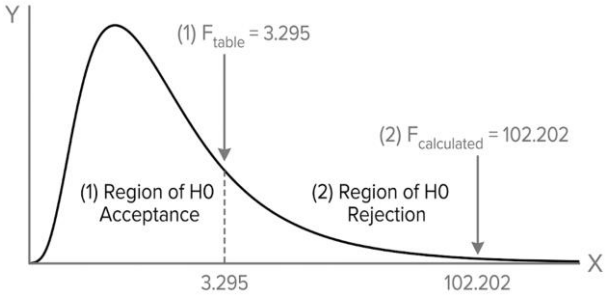
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.167	3.158		-.370	.714
	Cargo Control Operation	.825	.095	.781	8.724	0
	Crew Discipline	.219	.098	.200	2.233	.033

a. Dependent Variable: Crew Performance

Source: Research data

The multiple regression model empirically validates the premise that vessel operational performance cannot function as a set of isolated components; rather, it demands a cohesive amalgamation of compliant human operators and highly reliable technical infrastructure. These results strongly reinforce the application of Sociotechnical Systems (STS) theory within modern maritime logistics management. In the enclosed, high-risk micro-environment of a chemical tanker, the sophisticated automation of Cargo Control systems designed for handling highly reactive hazardous materials (such as Caustic Soda) will fundamentally fail to yield optimal performance if it is not supported by a crew rigorously disciplined in executing standard procedures (Kemp et al., 2024). Conversely, even the most disciplined and motivated crew will inevitably face critical operational delays and safety compromises if the mechanical systems they govern are obsolete, uncalibrated, or poorly maintained (Katinić et al., 2025). Consequently, the seamless integration of these technical and behavioral dimensions is proven to be the absolute primary determinant in achieving the ultimate dual objectives of maritime operations: maximizing port berthing time efficiency and preventing fatal operational failures (the 'zero accidents' mandate).



Source: Research data

Figure 4. F-test Curve

The synergy between an acute technical monitoring system in the CCR and an alert, rule-abiding crew actively prevents minor technical anomalies from escalating into catastrophic chemical spills, cargo contamination, or severe structural damage (Lee et al., 2023). Maximizing performance improvement, therefore, demands a paradigm shift towards a holistic managerial approach. Shipping company management must avoid siloed operational strategies; they are required to concurrently finance the routine, rigorous maintenance of Cargo Control technologies while continuously cultivating an uncompromising, top-down culture of strict work discipline and safety compliance among all seafarers (Holovan, 2025).

CONCLUSION

This study demonstrates that cargo control operations and crew discipline significantly and positively impact Motor Tanker operational performance. The safe and efficient handling of high-risk hazardous cargoes, specifically Caustic Soda (CCS), requires a holistic synergy between reliable technical control systems and strict crew compliance.

The generalizability of these findings is limited by a small sample size and a specific focus on a single cargo type (CCS) within one South Korean shipping company.

Shipping management must prioritize regular equipment maintenance in the Cargo Control Room and enforce strict crew discipline to achieve port time efficiency and zero-accident targets. Future studies should utilize larger, multi-company samples, explore alternative hazardous cargoes, and incorporate exogenous variables such as environmental conditions or port infrastructure.

REFERENSI

Aboud, L. M., & M. Attia, M. (2025). Enhancing the fire safety onboard container ship cargo area: A barrier analysis method. *Safety and Reliability*. Scopus. https://doi.org/10.1080/09617353.2025.2584445

Arici, S. S., Sezer, S. I., & Akyuz, E. (2026). Prediction of Human Error in Chemical Tanker Ship's Tank Heating Process to Enhance Operational Safety. *Journal of Marine Science and Application*, *25*(2), 523–535. Scopus. https://doi.org/10.1007/s11804-025-00628-1

Assilbekova, I., & Konakbay, Z. (2026). The Business Model of an Automated Warehouse with the Integration of the Cargo World Application. In *Sustain. Aviat.: Part F1097* (pp. 399–404). Springer Nature. Scopus. https://doi.org/10.1007/978-3-032-07678-6_71

Bansal, S., & Singh, G. (2023). Multiple Linear Regression Based Analysis of Weather Data: Assumptions and Limitations. In Shaw R.N., Ghosh A., & Paprzycki M. (Eds), *Commun. Comput. Info. Sci.* (Vol. 1920, pp. 221–238). Springer Science and Business Media Deutschland GmbH. Scopus. https://doi.org/10.1007/978-3-031-45121-8_19

Bimarso, W., Idris, M. K., Herianto, B., & Sirait, D. P. (2024). *Perencanaan dan pengoperasian terminal roro dan curah, cruise dan penumpang*. Institut Transportasi dan Logistik Trisakti Press.

Bouzón Otero, R., Crestelo Moreno, F., Amado Sánchez, Y., & Díaz-Secades, L. A. (2026). Noise exposure, circadian misalignment, and fatigue in maritime operations: A case study on a Ro-Pax vessel. *Reliability Engineering and System Safety*, *272*. Scopus. https://doi.org/10.1016/j.ress.2026.112483

Canbay, S. (2024). The analysis of relationships between global shipping networks and foreign trade volumes in developing countries. *Case Studies on Transport Policy*, *17*. Scopus. https://doi.org/10.1016/j.cstp.2024.101242

Crestelo Moreno, F., Soto-López, V., García Maza, J. A., & Sernaglia, M. (2026). Fatigue as a latent risk factor in maritime safety systems: A systematic review and implications for reliability analysis. *Reliability Engineering and System Safety*, *267*. Scopus. https://doi.org/10.1016/j.ress.2025.111930

Dimitrakiev, D., & Milev, D. (2025). Performance Influencing Factors and Evaluation Onboard Ships. In Alzoubi H.M., Cheng Ling T., & El Khatib M. (Eds), *Adv. Sci. Tech. Inno.* (Vol. 29, pp. 325–330). Springer Nature. Scopus. https://doi.org/10.1007/978-3-031-90131-7_37

Edih, U. O., Nwafili, K. A., & Faghawari, N. D. (2023). The Nexus and Implications of Top-level Management Policy, Programme and Strategic Planning Model on Human

Resource Performance in the Maritime Industry in Nigeria. *Journal of Maritime Research*, *20*(3), 152–162. Scopus.

Ginting, N., Trisno, R. J., & Ruminda, M. (2025). The Effect of Ship Maintenance Management, Crew Competence and Supervision On The Smooth Distribution of Oil and Gas Mediated by Ship Reliability. *R2J*, *7*(4). https://doi.org/10.38035/rrj.v7i4

Gulen, M. F., Guedes Soares, C., & Arslan, O. (2026). A comprehensive risk assessment of enclosed space operations on ships. *Reliability Engineering and System Safety*, *265*. Scopus. https://doi.org/10.1016/j.ress.2025.111543

Guo, X., Liu, X., & Song, G. (2024). Multiple linear regression analysis. In *Textb. Of Med. Statistics: For Med. Students* (pp. 171–180). Springer. Scopus. https://doi.org/10.1007/978-981-99-7390-3_12

Helmold, M. (2022). Performance Management in Operations Management. In *Manag. Prof.: Part F369* (pp. 57–70). Springer Nature. Scopus. https://doi.org/10.1007/978-3-030-98725-1_3

Hlaing, S. W., & Aung, M. M. (2025). Managerial Competencies and Performance of Small and Medium Enterprises in Yangon, Myanmar. *International Journal of Financial, Accounting, and Management*, *7*(1), 105–124. https://doi.org/10.35912/ijfam.v7i1.2669

Holovan, A. (2025). Digital strategies for enhancing the efficiency of cargo ships maintenance. In *Some issues of increasing the energy eff. Of ships by improv. Navig. Methods* (pp. 178–196). Scientific Route OU. Scopus. https://doi.org/10.21303/978-9908-9706-4-6.ch10

Imandiya, K., Zulkarnain, M., & Noviadi, P. (2024). Employees' Perceptions in Occupational Health and Safety Culture: A Case Study in the High-Risk Industry: Literature Review. *Media Publikasi Promosi Kesehatan Indonesia*, *7*(1), 65–72. Scopus. https://doi.org/10.56338/mppki.v7i1.4287

Islam, M. R., Suhrab, M. I. R., Fuad, A. F. A., & Sani, R. M. (2026). Assessment and Mitigation of Seafarer's Fatigue Among Singapore Bunker Tanker Crews. In *SpringerBriefs Appl. Sci. Technol.: Part F1138* (pp. 129–137). Springer Science and Business Media Deutschland GmbH. Scopus. https://doi.org/10.1007/978-3-031-97931-6_15

Katinić, M., Konjatić, P., Glavaš, D., & Marinković, B. (2025). Maintenance of Mechanical Equipment in Potentially Explosive Atmospheres. In Glavaš H., Hadzima-Nyarko M., Ademović N., & Hanák T. (Eds), *Lect. Notes Networks Syst.: 1242 LNNS* (pp. 201–213). Springer Science and Business Media Deutschland GmbH. Scopus. https://doi.org/10.1007/978-3-031-80597-4_16

Kemp, T., Ayton, J., Butler-Henderson, K., & Lam, M. (2024). Using socio-technical systems theory to study the health information management workforce in Australian acute hospitals. *Social Theory and Health*, *22*(4), 285–300. Scopus. https://doi.org/10.1057/s41285-024-00214-5

Kilian, S., Meisenbacher, K., & Bischoff, M. S. (2023). Linear and logistic regression analysis: Interpret correlations and make predictions. *Gefasschirurgie*, *28*(6), 462–472. Scopus. https://doi.org/10.1007/s00772-023-01021-4

Latifah, A., Sitorus, M. R., Thamrin, M., Agusinta, L., & Sugiyanto, S. (2025). Kompetensi Kerja dan Kinerja Pemeriksaan Kapal: Bukti Empiris Kelaiklautan Kapal di Indonesia. *Jurnal Manajemen Bisnis Transportasi Dan Logistik*, *10*(1), 58. https://doi.org/10.54324/j.mbtl.v10i1.1470

Lee, S. G., Kim, E. H., & Ma, B. C. (2023). Monitoring Chemical Accidents in Industrial Complexes Using Tower-Installed Infrared System for Remote Chemical Detection and Long-Range Video Surveillance System. *Applied Sciences (Switzerland)*, *13*(3). Scopus. https://doi.org/10.3390/app13031544

Notteboom, T., & Haralambides, H. (2025). Seaports in a tense geopolitical environment: Key agents or sitting ducks? *Maritime Economics & Logistics*, *27*(1), 1–24. https://doi.org/10.1057/s41278-025-00313-8

Ntounias, C., Farantos, G., Papoutsidakis, M., Sgouropoulou, C., & Damikouka, I. (2026). Analysis of maritime accident dynamics and risk factors: A focus on vessel age, human element, and safety trends in the Greek Merchant Fleet (2019–2023). *International Journal of Occupational Safety and Health*, *16*(1), 139–159. Scopus. https://doi.org/10.3126/ijosh.v16i1.88206

Olayinka, A. A., & Kaka, E. J. (2025). A panel regression analysis of corporate governance mechanism and financial performance of listed cement industries in Nigeria. *International Journal of Financial, Accounting, and Management*, *7*(2), 245–259. https://doi.org/10.35912/ijfam.v7i2.2812

Parlindungan, P. (2026). Operasi & Rantai Pasok Yang Berkelanjutan. In *Pengantar Bisnis dan Inovasi* (Vol. 1, p. 12). Damera Press.

Radzi, Z. M., Yolhamid, M. N. A. G., Appan, N. S., & Azis, M. A. A. (2026). Maritime Leadership Module Using a Ship Navigation Simulator. In *SpringerBriefs Appl. Sci. Technol.: Part F1833* (pp. 9–15). Springer Science and Business Media Deutschland GmbH. Scopus. https://doi.org/10.1007/978-3-032-18181-7_2

Ruminda, M. (2022). Sistem Informasi Kualitas Jasa. In A. Sudirman (Ed.), *Service Marketing: Pendekatan Teori dan Praktik* (I, Vol. 1, pp. 183–198). Media Sains Indonesia.

Ruminda, M. (2026). Inovasi Sosial & Bisnis Hijau [Ebook]. In *Pengantar Bisnis dan Inovasi* (1st edn, p. 11). Damera Press. https://damerapress.co.id/product/pengantar-bisnis-dan-inovasi-librita-arifiani-gratia-atanka-barus-siti-krisnawati-dkk/

Sezer, S. I., Elidolu, G., Akyuz, E., & Arslan, O. (2023). An integrated risk assessment modelling for cargo manifold process on tanker ships under FMECA extended Dempster–Shafer theory and rule-based Bayesian network approach. *Process Safety and Environmental Protection*, *174*, 340–352. Scopus. https://doi.org/10.1016/j.psep.2023.04.024

Shamsah, B., & Al-Dashti, A. (2026). Mirroring from Control Room DCS to WKO DCS. *Soc. Pet. Eng. - Kuwait Oil Gas Show, KOGS*. Scopus. Society of Petroleum Engineers - Kuwait Oil and Gas Show, KOGS 2026. https://doi.org/10.2118/230968-MS

Sheriff, A. M., Anantharaman, M., Islam, R., & Nguyen, H.-O. (2025). A review of port state control inspections: Critical issues and emerging trends in maritime oversight. *Australian Journal of Maritime and Ocean Affairs*. Scopus. https://doi.org/10.1080/18366503.2025.2554348

Sianturi, T. F. D., Djati, S. P., Ruminda, M., & Arifiani, L. (2024). Blockchain Technology's Impact on Port Logistic Operational Enhancement at Pontianak Port. *Dinasti International Journal of Education Management & Social Science*, *5*(6). https://doi.org/https://doi.org/10.38035/dijemss.v5i6.3030

Sirait, D. P., Ayutia, Y., Hamdi, A., Krisnawati, S., Shiela, M., & Ramdhani, R. (2023). *Managing the Congestion for Delivering and Receiving Truck Container at the Tanjung Priok Terminal by Analyzing the Congestion at Koja Container Terminal*.

Sirait, D. P., Sitorus, M. R., Lermatan, E. E., Pratiwi, S. W., & Parlindungan, P. (2026). The Mediating Role of Online Tracking in the Relationship Between Delivery Timeliness and Customer Satisfaction in E-Commerce. *Dinasti International Journal of Management Science*, *7*(3), 684–694. https://doi.org/10.38035/dijms.v7i3.6239

Theotokas, I. N., Lagoudis, I. N., & Raftopoulou, K. (2024). Challenges of maritime human resource management for the transition to shipping digitalization. *Journal of Shipping and Trade*, *9*(1). Scopus. https://doi.org/10.1186/s41072-024-00165-0

Uflaz, E., Orhan, M., Gulen, M. F., Gumus, F., & Arslan, O. (2026). Assessing human reliability in reactive cargo handling for chemical tanker ships. *Ocean Engineering*, *353*. Scopus. https://doi.org/10.1016/j.oceaneng.2026.124780

Xi, Y., Wang, Z., Hu, S., Han, B., & Yin, J. (2025). The effect of safety culture on the safety behavior of ship deck officers- empirical evidence from shipping industry. *Frontiers in Marine Science*, *12*. Scopus. https://doi.org/10.3389/fmars.2025.1599455

Yudhantara, A., & Achmadi, T. (2026). The Impact of Infrastructure Development on Improving Indonesia's Logistics Performance. In *SpringerBriefs Appl. Sci. Technol.: Part F1144* (pp. 85–93). Springer Science and Business Media Deutschland GmbH. Scopus. https://doi.org/10.1007/978-3-032-05613-9_11