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Technical Competence and Navigation Systems as Drivers of River Pilotage Performance

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ABSTRACT

Purpose – This study investigates the effects of work experience, technical competence, and navigation information systems on the safety and traffic-flow performance of ship pilotage operations in the Barito River, Indonesia, with job satisfaction examined as a mediating variable.
Methodology – A quantitative explanatory research design was employed using a cross-sectional survey of 42 active ship pilots. Data were collected through structured questionnaires and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to evaluate the measurement model, structural relationships, and mediating effects.
Findings – Technical competence had significant positive effects on job satisfaction ($\beta = 0.651$; $p = 0.015$) and pilotage performance ($\beta = 0.661$; $p = 0.016$). Navigation information systems exhibited the strongest positive relationship with pilotage performance ($\beta = 0.860$; $p < 0.001$), although their relationship with job satisfaction was not statistically significant. Work experience did not significantly influence either job satisfaction or pilotage performance, while job satisfaction itself had no significant effect on performance. Furthermore, job satisfaction did not significantly mediate the relationships between work experience ($p = 0.978$), technical competence ($p = 0.568$), or navigation information systems ($p = 0.687$) and pilotage performance.
Conclusion – The findings highlight the importance of technical competence and navigation information systems in supporting safe and efficient river pilotage operations. Rather than relying primarily on accumulated professional experience or job satisfaction, pilotage service providers should emphasize competency-based training, continuous professional development, and effective navigation information management to strengthen operational performance.

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INTRODUCTION

Indonesia's archipelagic geography makes maritime and river transport essential to territorial connectivity, logistics, energy distribution, and regional economic activity. Rivers remain particularly important in Kalimantan, where large inland waterways connect production areas with ports and coastal shipping networks. The Barito River in Banjarmasin carries merchant ships, passenger vessels, tugs, and barges serving coal, palm oil, industrial cargo, and other commodities. The continuity of these movements depends on navigation through a channel whose geometry and environmental conditions can change over time (United Nations Conference on Trade and Development [UNCTAD], 2023;

Sutopo, 2021). Ship pilotage is a primary risk-control function in such waters. A pilot contributes specialised local knowledge and navigational judgement to the master when a vessel enters, leaves, or manoeuvres within a compulsory pilotage area. River pilotage differs from open-sea navigation because the available manoeuvring space is restricted, the vessel may be affected by strong currents and shallow water, and traffic interactions develop rapidly. Sharp bends, sedimentation, fluctuating depths, tidal influence, and dense tug-and-barge movements make the Barito River a demanding socio-technical environment. Safety and smooth traffic flow are related but distinct outcomes. Safety concerns the prevention of collision, grounding, infrastructure damage, injury, and pollution. Smoothness concerns the continuity, timeliness, coordination, and efficiency of vessel movements. An action that maximises immediate safety may create delay, while pressure to maintain traffic flow can narrow safety margins. High-quality pilotage integrates both objectives by selecting decisions that control risk without creating avoidable disruption.

The legal and institutional context reinforces this responsibility. Indonesian shipping legislation and pilotage regulations require professional competence, adherence to procedures, and the use of appropriate navigational aids. The International Safety Management framework also emphasises systematic risk control, operational preparedness, and continuous improvement (International Maritime Organization [IMO], 2020, 2022). Legal compliance, however, establishes a minimum standard; actual performance depends on how human capability, technology, communication, and environmental information are combined in real time. Human-factor research has long shown that maritime casualties rarely arise from one isolated error. Decisions are shaped by workload, time pressure, communication, equipment design, organisational conditions, and the quality of available information. In pilotage, the master–pilot exchange, bridge-team coordination, vessel response, local conditions, and shore-based traffic services form an interdependent system (Hanzu-Pazara et al., 2017). A competent pilot can compensate for some weaknesses, but no individual can reliably overcome inaccurate information, poor coordination, or inadequate resources indefinitely. Work experience is commonly assumed to improve judgement because repeated exposure creates pattern recognition, local familiarity, and a repertoire of responses. Experienced pilots may detect early signs of risk, anticipate vessel behaviour, and recognise the implications of current, tide, or sedimentation. Yet tenure is only a proxy for learning. Repetition without feedback can reinforce routine rather than adaptive expertise, and long experience with older technologies does not automatically translate into effective use of modern navigation systems (Pitriyani, 2020; Suwanto & Sutrisno, 2021; Yahya, 2023).

Technical competence is a more current and task-specific capability. It includes knowledge of pilotage procedures, vessel characteristics, channel conditions, navigational equipment, communication standards, risk assessment, and emergency action. Competence also requires the ability to convert knowledge into timely behaviour. In a safety-critical occupation, the quality of a decision depends not only on knowing the correct rule but on recognising when it applies, identifying conflicts among information sources, and communicating clearly under pressure (Rahman & Yusuf, 2019; Wong, 2020). Navigation information systems provide position, traffic, weather, depth, current, and route-related information through technologies such as radar, GPS, AIS, electronic charts, and monitoring systems. Their value lies in reducing uncertainty and supporting situation awareness. Nevertheless, information is useful only when it is accurate, timely, understandable, integrated, and trusted appropriately. Automation can create new forms of risk when users become over-reliant, fail to cross-check, or do not understand system limitations (Barnett, 2020; Fathurrahman & Hakim, 2021; Huda et al., 2025; United States Government, 2024). Job satisfaction was proposed as a psychological mechanism linking work resources with performance. Pilots who possess strong competence or receive effective technological support may feel more confident, secure, and satisfied. Satisfaction could then encourage commitment and sustained performance. This proposition is plausible in general organisational behaviour, but pilotage is governed by professional duty, legal accountability, and mandatory safety procedures. Performance may therefore remain high even when satisfaction varies (Putra & Nugroho, 2020).

Previous studies have examined professional pilotage, human factors, competence, navigation technology, and job satisfaction, but they rarely integrate these elements in restricted river navigation.

Research also tends to assume that experience is inherently beneficial and that job satisfaction transmits the effects of work resources to performance (Issa-Zadeh & Garay-Rondero, 2025; Nasution et al., 2025). These assumptions require empirical testing bcause modern navigation may change the relative value of tenure, competence, and information. This study develops an integrated model of pilot work experience, technical competence, navigation information systems, job satisfaction, and safety-and-flow performance in the Barito River. It tests direct effects on satisfaction and performance and three indirect paths through satisfaction. The novelty lies in distinguishing accumulated exposure from demonstrable current competence and in evaluating whether job satisfaction is an actual performance mechanism in a highly regulated, safety-critical occupation.

LITERATURE REVIEW AND HYPOTHESES

Experience, learning, and pilotage performance

Work experience represents knowledge and skill accumulated through duration, task variety, exposure to different vessels, emergency situations, training, and certification. Its potential value is grounded in experiential learning: repeated encounters allow practitioners to refine mental models and recognise patterns that novices may overlook. In river pilotage, local familiarity can improve anticipation of current, shallow-water effects, turning points, traffic conflicts, and vessel response (Pitriyani, 2020; Suwanto & Sutrisno, 2021; Yahya, 2023).

Experience is not equivalent to competence. The number of years worked does not describe the quality of cases encountered, the feedback received, or whether practice has been updated. Standardisation, simulation, and digital navigation can also reduce the unique advantage of tenure by making information more widely available. Moreover, a homogeneous group of experienced pilots may show insufficient variation for tenure to explain either satisfaction or performance. H1 proposes that experience positively affects job satisfaction, while H4 proposes that experience positively affects safety-and-flow performance.

Technical competence as a human-capital resource

Technical competence is the ability to apply task-relevant knowledge, skills, communication, and judgement to required standards. Pilotage competence includes passage planning, interpretation of hydrological and meteorological conditions, understanding vessel manoeuvrability, use of navigational equipment, compliance with procedures, bridge-resource communication, and risk control. It is observable in the quality of decisions and actions rather than inferred solely from credentials (Rahman & Yusuf, 2019; Wong, 2020).

Competence can increase job satisfaction because capable employees experience stronger person–job fit, confidence, autonomy, and perceived control. Tasks are less likely to be experienced as unmanageable when the pilot possesses the knowledge and skill to address them. Competence should also affect performance directly because the same capabilities govern hazard recognition, selection of manoeuvres, communication, and recovery from unexpected conditions. H2 proposes a positive effect on job satisfaction, and H5 proposes a positive effect on safety-and-flow performance. From a human-capital perspective, competence is valuable because it is directly linked to a role in which error costs are high. It is locally adapted yet transferable across scenarios through principles and professional judgement. In contrast with tenure, competency assessment can identify specific gaps and guide targeted development. The distinction enables management to reward and develop capability rather than assuming that time served guarantees readiness.

Navigation information systems and operational performance

A navigation information system is a configuration of sensors, databases, displays, communication links, and procedures that supports the acquisition and interpretation of operational information. In the Barito River, useful functions include reliable positioning, traffic awareness, route selection, current and depth information, weather updates, alerts, and coordination with relevant parties. System

effectiveness depends on accuracy, availability, update speed, integration, usability, and the user's ability to interpret outputs (Barnett, 2020; Fathurrahman & Hakim, 2021; Huda et al., 2025). Task–technology alignment explains why a system can improve performance. Technology contributes when its functions correspond to the information requirements and timing of a task. River pilotage requires rapid awareness of position, traffic, channel limits, and changing conditions. A reliable system can therefore reduce uncertainty and support earlier, more precise decisions. If information is delayed, inconsistent, or fragmented across devices, it can increase workload instead. Navigation systems may also influence satisfaction by reducing uncertainty, effort, and perceived risk. However, pilots may regard them as mandatory operational tools rather than sources of affective fulfilment. A system can improve task outcomes without changing satisfaction, especially when users evaluate satisfaction through recognition, organisational support, workload, and facilities. H3 proposes that navigation information systems positively affect job satisfaction, and H6 proposes that they positively affect safety-and-flow performance.

Job satisfaction and the mediation proposition

Job satisfaction is an evaluative attitude towards the work itself, safety, organisational support, facilities, and the operating environment. General management theory associates satisfaction with commitment, reduced withdrawal, and better performance (Putra & Nugroho, 2020). The relationship is not automatic. In professional occupations, behaviour may be maintained through ethics, regulation, identity, and accountability even when attitudes are less favourable.

Pilotage has characteristics that may weaken the satisfaction–performance path. Pilots follow mandatory procedures, carry personal professional responsibility, and make safety decisions whose consequences are immediate. These controls can constrain performance variation. Satisfaction may remain important for retention and well-being but may not determine short-term safety behaviour. H7 proposes that job satisfaction positively affects performance (Putra & Nugroho, 2020).

Mediation requires more than significant separate relationships. Experience, competence, or technology must first influence satisfaction; satisfaction must then influence performance; and the product of these paths must be statistically distinguishable from zero. H8 proposes that satisfaction mediates the experience–performance relationship, H9 proposes mediation of the competence–performance relationship, and H10 proposes mediation of the navigation-system–performance relationship.

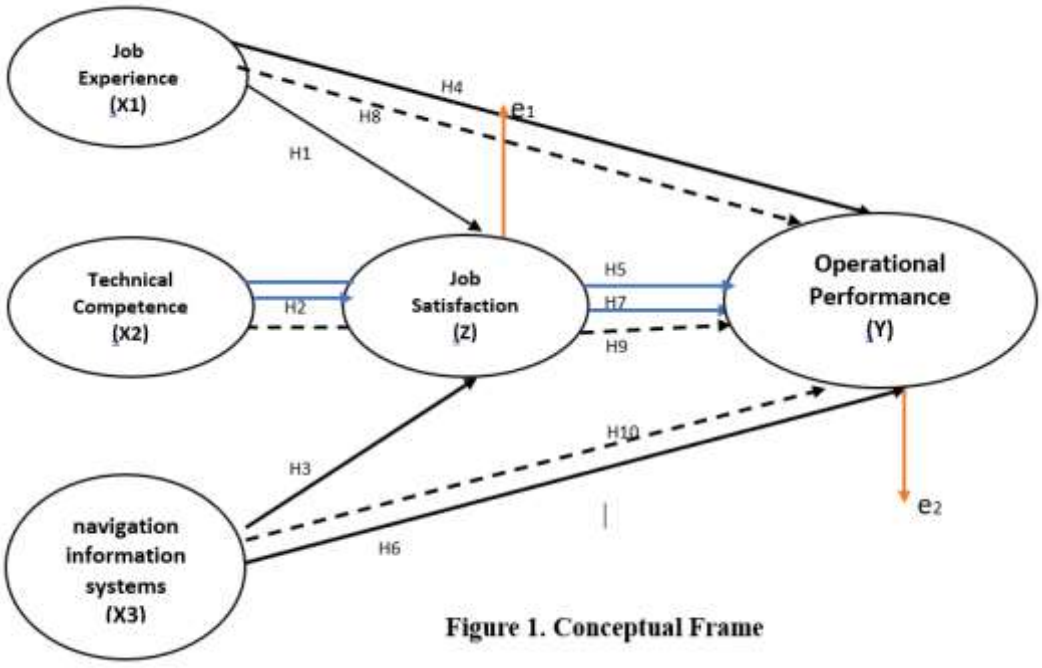


Figure 1. Conceptual Frame

METHOD

This study employed a quantitative approach with an explanatory research design using a cross-sectional survey method. The research aimed to examine the direct effects of pilot work experience, technical competence, and navigation information systems on job satisfaction and the safety-and-flow performance of ship pilotage operations, as well as the mediating role of job satisfaction. The study was conducted in the Barito River pilotage area, Banjarmasin, South Kalimantan, Indonesia, under the jurisdiction of the Class I Harbormaster and Port Authority Office (KSOP) of Banjarmasin. The study population consisted of 42 active ship pilots operating in the Barito River pilotage area. Given the relatively small and specialized population, a **total sampling technique (census approach)** was employed, involving all 42 pilots as research respondents. The unit of analysis was the individual ship pilot directly involved in navigation assistance and vessel maneuvering operations. This sampling approach ensured comprehensive coverage of the accessible population.

Primary data were collected through a structured questionnaire distributed to the respondents. The research instrument employed a five-point Likert scale to measure five latent constructs: pilot work experience, technical competence, navigation information systems, job satisfaction, and safety-and-flow performance. Work experience was measured through professional experience, decision-making capability, and exposure to operational risks. Technical competence was assessed through procedural knowledge, technical skills, equipment operation, and problem-solving ability. Navigation information systems were evaluated based on information accuracy, timeliness, accessibility, and operational support. Job satisfaction was measured through satisfaction with work responsibilities, organizational support, facilities, and professional motivation. Meanwhile, safety-and-flow performance was assessed through operational safety, risk prevention, coordination effectiveness, and compliance with maritime safety procedures. Data were analyzed using **Partial Least Squares Structural Equation Modeling (PLS-SEM)** with the assistance of SmartPLS software. The analysis consisted of two main stages: measurement model (outer model) evaluation and structural model (inner model) assessment. The measurement model was evaluated through indicator reliability (outer loadings), convergent validity using Average Variance Extracted (AVE), internal consistency reliability using Cronbach's alpha and composite reliability, and discriminant validity using Cross Loading.

The structural model was evaluated by examining path coefficients, coefficients of determination (R^2), effect sizes (f^2), and predictive relevance. Hypothesis testing was conducted using a bootstrapping procedure to estimate t-statistics and p-values for both direct and indirect relationships. Statistical significance was determined at the 5% level ($p < 0.05$), with a two-tailed t-statistic threshold of 1.96. Mediation analysis was performed by examining the specific indirect effects of pilot work experience, technical competence, and navigation information systems on safety-and-flow performance through job satisfaction. This analytical approach enabled a comprehensive assessment of the relationships among the research constructs within the operational context of river pilotage.

RESULT AND DISCUSSION

Respondent characteristics and measurement quality

Table 1 presents the demographic characteristics of the 42 respondents. Most respondents were aged 36–45 years (38.1%), held a bachelor's degree (57.1%), and had 11–15 years of work experience (35.7%). These findings indicate that the sample was predominantly composed of well-educated and professionally experienced individuals.

Table 1. Respondent profile

Characteristic	Category	n	%
Age	25–35 years	8	19.0
Age	36–45 years	16	38.1
Age	46–55 years	13	31.0
Age	>55 years	5	11.9
Education	Diploma	10	23.8
Education	Bachelor's	24	57.1
Education	Master's	8	19.1
Tenure	1–5 years	6	14.3
Tenure	6–10 years	12	28.6
Tenure	11–15 years	15	35.7
Tenure	>15 years	9	21.4

Source: Processed survey data (2026).

The results of the descriptive statistical analysis show that the mean scores were moderate rather than uniformly high. Experience items ranged from 3.058 to 3.385; competence from 3.192 to 3.346; navigation-system items from 3.058 to 3.231; satisfaction from 3.038 to 3.385; and performance from 3.115 to 3.327. The highest performance rating concerned the contribution of navigational technology to safety. The lowest satisfaction rating concerned the fit between work and perceived capability, indicating that competency development and role support remain relevant despite the workforce's long tenure.

Convergent Validity Assessment Based on Outer Loadings

The results of the measurement model assessment indicate that all 24 indicators have outer loading values exceeding the recommended threshold of 0.70, ranging from 0.704 to 0.945. Specifically, job satisfaction (Z) exhibits outer loading values between 0.886 and 0.935, while safety-and-flow performance (Y) ranges from 0.704 to 0.945. Technical competence (X2) demonstrates loading values between 0.788 and 0.911, whereas work experience (X1) ranges from 0.888 to 0.926. Furthermore, navigation information systems (X3) exhibit consistently high outer loadings, ranging from 0.876 to 0.934.

Table 2 Factor Loading

Indicator	Outer loading
Z.1	0.935
Z.2	0.916
Z.3	0.888
Z.4	0.931
Z.5	0.886
Y.1	0.945
Y.2	0.867
Y.3	0.903
Y.4	0.775
Y.5	0.781
Y.6	0.704
X2.1	0.897

X2.2	0.886
X2.3	0.876
X2.4	0.788
X2.5	0.911
X1.1	0.888
X1.2	0.923
X1.3	0.896
X1.4	0.926
X3.1	0.925
X3.2	0.922
X3.3	0.876
X3.4	0.934

These findings indicate that all measurement indicators demonstrate satisfactory indicator reliability and provide evidence supporting convergent validity. Therefore, all 24 indicators can be retained in the measurement model, as they adequately represent their respective latent constructs.

Table 3. Measurement and structural model summary

Construct	Composite reliability	Cronbach's α	AVE	R^2
Work experience	0.949	0.929	0.825	—
Technical competence	0.926	0.921	0.761	—
Navigation information system	0.936	0.935	0.836	—
Job satisfaction	0.949	0.949	0.831	0.915
Safety-and-flow performance	0.920	0.850	0.606	0.931

Source: Processed survey data (2026).

As shown in Table 3, all constructs demonstrated satisfactory internal consistency and convergent validity. Composite reliability values ranged from 0.920 to 0.949, Cronbach's alpha values ranged from 0.850 to 0.949, and average variance extracted (AVE) values ranged from 0.606 to 0.836. Specifically, work experience recorded a composite reliability of 0.949, Cronbach's alpha of 0.929, and AVE of 0.825. Technical competence had corresponding values of 0.926, 0.921, and 0.761, while the navigation information system had values of 0.936, 0.935, and 0.836. Job satisfaction recorded a composite reliability of 0.949, Cronbach's alpha of 0.949, and AVE of 0.831. Safety-and-flow performance had values of 0.920, 0.850, and 0.606, respectively.

All reliability values exceeded the commonly used threshold of 0.70, and all AVE values exceeded 0.50, indicating that the constructs had satisfactory internal consistency and explained more than half of the variance in their respective indicators.

Table 4. Dicriminant Validity with Cross Loading

	Z	Y	X2	X1	X3
Z.1	0.935	0.826	0.859	0.847	0.839
Z.2	0.916	0.810	0.895	0.861	0.866
Z.3	0.888	0.855	0.915	0.879	0.891

Z.4	0.931	0.807	0.864	0.779	0.808
Z.5	0.886	0.838	0.799	0.805	0.838
Y.1	0.886	0.945	0.910	0.902	0.938
Y.2	0.817	0.867	0.767	0.733	0.828
Y.3	0.880	0.903	0.899	0.895	0.937
Y.4	0.656	0.775	0.706	0.719	0.720
Y.5	0.633	0.704	0.665	0.660	0.793
X2.1	0.816	0.822	0.897	0.848	0.862
X2.2	0.858	0.859	0.886	0.876	0.867
X2.3	0.907	0.776	0.876	0.778	0.811
X2.4	0.722	0.733	0.788	0.756	0.721
X2.5	0.834	0.832	0.911	0.885	0.869
X1.1	0.757	0.796	0.825	0.888	0.813
X1.2	0.837	0.838	0.841	0.923	0.877
X1.3	0.839	0.838	0.891	0.896	0.846
X1.4	0.890	0.840	0.892	0.926	0.864
X3.1	0.847	0.873	0.882	0.848	0.925
X3.2	0.852	0.894	0.891	0.887	0.922
X3.3	0.790	0.848	0.818	0.794	0.876
X3.4	0.916	0.910	0.877	0.892	0.934

The results of the discriminant validity assessment using the cross-loading approach indicate that most indicators exhibit higher loading values on their respective constructs than on other latent constructs. However, several indicators, demonstrate relatively high loadings on other constructs. Nevertheless, the majority of indicators exhibit higher loadings on their intended constructs than on other constructs, suggesting that the measurement model generally demonstrates discriminant validity. However, the identified cross-loading issues indicate that discriminant validity has not been fully established based on this criterion alone.

Iner Model

1) Coefficient of determination

Table 4 presents the R-square values reported in the structural-model document. Job satisfaction had an R-square of 0.915, meaning that its predictors accounted for 91.5% of its variance in the analysed sample. The remaining 8.5% was unexplained by this equation. Pilotage performance had an R-square of 0.931, corresponding to 93.1% explained and 6.9% unexplained variance. Unexplained variance can include omitted influences and measurement or random error; it should not be attributed exclusively to unmeasured variables.

Table 4 Coefficients of determination

Endogenous construct	R-square	Explained variance	Unexplained variance
Job satisfaction (Z)	0.915	91.5%	8.5%
Pilotage performance (Y)	0.931	93.1%	6.9%

2) Effect Size (f^2) Assessment

The effect size (f^2) results show that technical competence had a large effect on job satisfaction (f^2 = 0.356). In contrast, work experience had a negligible effect on job satisfaction (f^2 = 0.001), while the navigation information system had a small effect (f^2 = 0.083).

For safety-and-flow performance in ship pilotage, the navigation information system had a large effect (f^2 = 0.958). Job satisfaction and work experience each had a negligible effect on this outcome (f^2 =

0.005). Among the effects reported in the table, the navigation information system had the largest effect on safety-and-flow performance. This finding indicates its substantial contribution to the model's explanatory power for pilotage performance on the Barito River in Banjarmasin.

3) Predictive Test

The predictive relevance of the structural model was assessed using the Q^2 calculation based on the coefficient of determination (R^2) values for the two endogenous constructs, namely job satisfaction ($R^2 = 0.915$) and safety-and-flow performance ($R^2 = 0.931$). The calculation was performed as follows:

$$Q^2 = 1 - [(1 - 0.915)(1 - 0.931)]$$

$$Q^2 = 1 - (0.085 \times 0.069)$$

$$Q^2 = 1 - 0.005865 = 0.994$$

Based on the above calculation, the Q^2 value of 0.994 indicates that the model exhibits very strong predictive relevance. This suggests that the model is capable of explaining approximately 99.4% of the variance in the research data, while the remaining 0.6% is attributable to other factors not included in the research model.

4) Effect Size

The results of the effect size (f^2) analysis indicate that technical competence has a large effect on job satisfaction, with an f^2 value of 0.356. In contrast, work experience exhibits a negligible effect on job satisfaction ($f^2 = 0.001$), while navigation information systems demonstrate a small effect ($f^2 = 0.083$). Regarding the safety-and-flow performance of ship pilotage operations, navigation information systems exhibit a substantially large effect, with an f^2 value of 0.958. Meanwhile, job satisfaction and work experience contribute only negligible effects, each with an f^2 value of 0.005. These findings suggest that navigation information systems represent the most influential factor in explaining variations in the safety-and-flow performance of ship pilotage operations in the Barito River, Banjarmasin.

Table 5. Effect Size

	Z	Y	X2	X1	X3
Z		0.005			
Y					
X2	0.356				
X1	0.001	0.005			
X3	0.083	0.958			

5) Direct and indirect effects

Based on the Specific Indirect Effects obtained through bootstrapping, the mediation effects were evaluated using a T-statistic threshold of 1.96 and a significance level of 0.05. The results are interpreted as follows.

Table 6. Specific Indirect Effects (Bootstrapping)

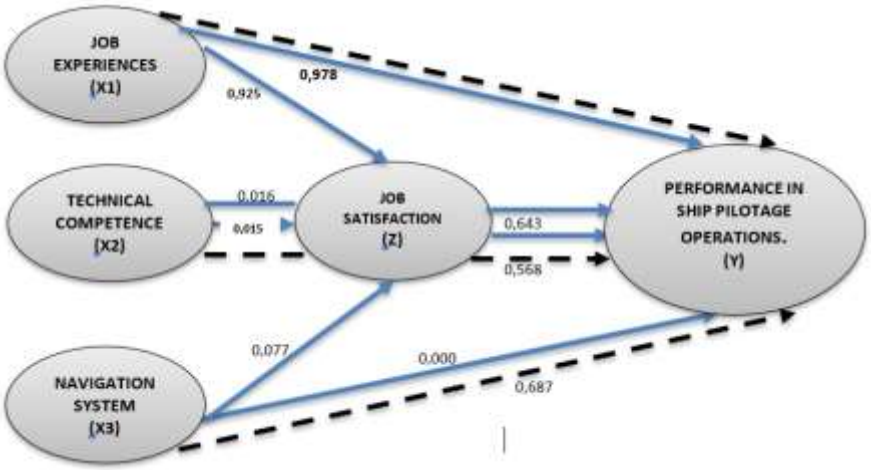
Indirect Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics	P-Values
X2 → Z → Y	0.035	0.043	0.062	0.572	0.568
X1 → Z → Y	0.001	0.015	0.045	0.028	0.978
X3→ Z → Y	0.015	0.017	0.038	0.403	0.687

Source: SEM-PLS 4 statistical output (2026).

1. The Indirect Effect of Technical Competence on Safety-and-Flow Performance through Job Satisfaction
The indirect effect coefficient of 0.035 indicates a positive relationship. However, the T-statistic of 0.572 is below the critical value of 1.96, and the p-value of 0.568 exceeds 0.05. These findings indicate that job satisfaction does not significantly mediate the relationship between technical competence and safety-and-flow performance in ship pilotage operations. Therefore, the mediation hypothesis is not supported.

2. The Indirect Effect of Work Experience on Safety-and-Flow Performance through Job Satisfaction
The indirect effect coefficient of 0.001 indicates a negligible mediation effect. Furthermore, the T-statistic of 0.028 and p-value of 0.978 demonstrate that the indirect effect is statistically insignificant. These results suggest that job satisfaction does not significantly mediate the relationship between work experience and safety-and-flow performance in ship pilotage operations. Therefore, the mediation hypothesis is not supported.

3. The Indirect Effect of Navigation Information Systems on Safety-and-Flow Performance through Job Satisfaction
The indirect effect coefficient of 0.015 indicates a positive relationship. However, the effect is statistically insignificant, as indicated by the T-statistic of 0.403, which is below 1.96, and the p-value of 0.687, which exceeds 0.05. Thus, job satisfaction does not significantly mediate the relationship between navigation information systems and safety-and-flow performance in ship pilotage operations. Therefore, the mediation hypothesis is not supported.



Path analysis figure
Table 7. Hypothesis testing

Relationship	β	t	p-value	Decision
H1: Experience → satisfaction	0.024	0.094	0.925	Rejected
H2: Competence → satisfaction	0.651	3.442	0.015	Supported
H3: Navigation system → satisfaction	0.283	1.769	0.077	Rejected
H4: Experience → performance	0.058	0.385	0.700	Rejected
H5: Competence → performance	0.661	2.421	0.016	Supported
H6: Navigation system → performance	0.860	5.503	0.000	Supported
H7: Satisfaction → performance	0.054	0.464	0.643	Rejected
H8: Experience → satisfaction → performance	0.001	0.028	0.978	Rejected
H9: Competence → satisfaction → performance	0.035	0.572	0.568	Rejected
H10: Navigation system → satisfaction → performance	0.015	0.403	0.687	Rejected

Source: Processed survey data (2026).

As shown in Table 3, work experience was not significantly associated with job satisfaction (H1: β = 0.024, t = 0.094, p = 0.925). Technical competence was positively and significantly associated with job satisfaction (H2: β = 0.651, t = 3.442, p = 0.015), whereas the navigation information system was not significantly associated with job satisfaction (H3: β = 0.283, t = 1.769, p = 0.077).
Work experience was not significantly associated with safety-and-flow performance (H4: β = 0.058, t = 0.385, p = 0.700). Technical competence (H5: β = 0.661, t = 2.421, p = 0.016) and the navigation information system (H6: β = 0.860, t = 5.503, p = 0.001) were positively and significantly associated with performance. Job satisfaction was not significantly associated with performance (H7: β = 0.054, t = 0.464, p = 0.643).
The indirect effects through job satisfaction were not statistically significant for work experience (H8: β = 0.001, t = 0.028, p = 0.978), technical competence (H9: β = 0.035, t = 0.572, p = 0.568), or the navigation information system (H10: β = 0.015, t = 0.403, p = 0.687). At the 0.05 significance level, H2, H5, and H6 were supported; H1, H3, H4, H7, H8, H9, and H10 were not supported.

DISCUSSION

The findings presented in Table 7 demonstrate that technical competence and navigation information systems are significantly associated with safety-and-flow performance in ship pilotage operations along the Barito River, whereas work experience and job satisfaction do not exhibit statistically significant direct relationships with operational performance. Among the ten hypotheses examined, three were supported, while seven were not supported. These results suggest that operational performance in river pilotage is more closely associated with the application of technical expertise and navigation information systems than with accumulated experience or individual job satisfaction. Given the safety-critical nature of pilotage operations, these findings emphasize the importance of examining the technical and technological dimensions of maritime performance.
The nonsignificant relationship between work experience and job satisfaction (β = 0.024, p = 0.925), as reported in Table 7, indicates that accumulated professional experience does not necessarily correspond to greater satisfaction among ship pilots. Similarly, work experience does not significantly predict safety-and-flow performance (β = 0.058, p = 0.700). These findings contrast with the meta-analysis conducted by Quiñones et al. (1995), which identified a positive relationship between work experience and job performance across occupational settings. Their analysis also demonstrated that task-specific experience was more strongly associated with performance than broader measures of experience. This

distinction may help explain the present findings, as the operational effectiveness of ship pilots may depend not only on the duration of professional service but also on the relevance of accumulated experience to specific navigational challenges. Consequently, the present study contributes to the literature by demonstrating that experience alone may be insufficient to explain variations in performance within a specialized maritime occupation.

Technical competence exhibits a significant positive relationship with job satisfaction ($\beta = 0.651$, $p = 0.015$) and safety-and-flow performance ($\beta = 0.661$, $p = 0.016$), as shown in Table 7. These findings suggest that technical competence is an important factor associated with both occupational satisfaction and operational effectiveness. In river pilotage, technical competence encompasses the ability to interpret navigational conditions, apply operational procedures, respond to potential hazards, and make appropriate decisions in complex maritime environments. The positive association between technical competence and performance is consistent with the broader evidence reported by Quiñones et al. (1995), which emphasizes the importance of task-specific expertise in explaining job performance. Although their research focused on work experience rather than technical competence directly, it supports the interpretation that occupation-specific capabilities are particularly relevant to performance outcomes. The present findings therefore highlight the potential importance of continuous technical training, competency assessment, and professional development in maintaining safe and efficient pilotage operations.

Navigation information systems demonstrate the strongest reported direct relationship with safety-and-flow performance ($\beta = 0.860$, $p < 0.001$), as presented in Table 7. This finding indicates that effective navigation information systems are strongly associated with the operational performance of ship pilots. The result is consistent with research published in the Information Resources Management Journal (2026), which examined the optimization of electronic chart display and information systems (ECDIS) and reported improvements in situational awareness and navigational decision support through better information management. While that study examined ocean navigation rather than river pilotage, both findings emphasize the operational importance of accurate, accessible, and appropriately presented navigational information. In the Barito River context, such systems may be particularly valuable for supporting decisions under changing navigational conditions. Nevertheless, navigation information systems do not demonstrate a statistically significant relationship with job satisfaction ($\beta = 0.283$, $p = 0.077$). This distinction suggests that technological support may be more closely associated with operational effectiveness than with pilots' subjective satisfaction with their work.

The relationship between job satisfaction and safety-and-flow performance is positive but statistically insignificant ($\beta = 0.054$, $p = 0.643$), as indicated in Table 7. This finding differs from the meta-analysis conducted by Judge et al. (2001), which examined 312 samples involving 54,417 participants and reported an estimated mean true correlation of 0.30 between job satisfaction and job performance. The difference suggests that the satisfaction–performance relationship may vary across occupational and organizational contexts. In safety-critical maritime operations, performance may be more directly associated with technical proficiency, procedural compliance, and navigational support than with subjective job satisfaction. However, the present result should not be interpreted as evidence that job satisfaction is unimportant; rather, the study did not identify a statistically significant relationship between satisfaction and the particular performance construct examined.

The importance of technical competence is further supported by Shi et al. (2024), who investigated seafarer competencies in restricted waters using Bayesian networks and identified maneuvering, decision-making, situational awareness, communication, and procedural operations as critical competencies associated with maritime accident prevention. Their findings are consistent with the positive relationship between technical competence and pilotage performance identified in Table 7. Similarly, Fan and Yang (2023) emphasized the importance of interactions between seafarer competencies and increasingly automated shipboard systems. These studies provide a broader explanation for the present findings: effective maritime operations require both human technical capabilities and the ability to use technological systems appropriately.

The mediation results presented in Table 7 reveal that job satisfaction does not significantly mediate the relationships between work experience and safety-and-flow performance (β = 0.001, p = 0.978), technical competence and performance (β = 0.035, p = 0.568), or navigation information systems and performance (β = 0.015, p = 0.687). These findings indicate that the indirect pathways through job satisfaction are not statistically supported. The results can be interpreted alongside the findings of Judge et al. (2001), who established a positive average association between job satisfaction and performance but also highlighted the complexity of this relationship. In the present study, the absence of a significant satisfaction–performance relationship may help explain why the proposed indirect effects were not supported. This suggests that technical competence and navigation information systems are more directly associated with pilotage performance than through the psychological mechanism of job satisfaction. Nevertheless, the absence of significant mediation should not be interpreted as proof that psychological factors have no relevance to maritime safety.

These findings also provide an opportunity to reconsider the mechanisms underlying safety-critical performance. Fan et al. (2023) examined the incorporation of seafarers' psychological factors into maritime safety assessment, highlighting the relevance of human psychological processes in maritime risk analysis. Meanwhile, research on seafarer training in the autonomous shipping era found that behavioral training could improve navigation-fault recognition and diagnosis, even among experienced personnel. Compared with these studies, the present research suggests that job satisfaction may not be the most immediate psychological mechanism linking technical and technological resources with operational performance. Future research could therefore examine situational awareness, decision-making confidence, safety behavior, or adaptive performance as alternative mediating variables. These possibilities require further empirical testing rather than being treated as established explanations of the current results.

Overall, the findings presented in Table 7 contribute to maritime human resource management and operational safety research by identifying technical competence and navigation information systems as important correlates of safety-and-flow performance in river pilotage operations. The results are consistent with recent international maritime studies emphasizing technical proficiency, effective navigation technology, and human–machine interaction. At the same time, the nonsignificant relationships involving work experience and job satisfaction demonstrate that findings from general organizational research cannot necessarily be transferred directly to specialized maritime occupations. From a practical perspective, the results support prioritizing competency-based training, navigation information system reliability, and integrated operational assessments. However, the cross-sectional research design and the relatively small sample of 42 pilots limit causal interpretation and the generalizability of the findings.

CONCLUSION

This study examined the effects of work experience, technical competence, and navigation information systems on safety-and-flow performance, with job satisfaction serving as a mediating variable in ship pilotage operations along the Barito River, Banjarmasin. Based on the PLS-SEM analysis involving 42 ship pilots, the findings indicate that three of the ten proposed hypotheses were supported, while seven were not supported. Technical competence demonstrated significant positive relationships with both job satisfaction (β = 0.651, p = 0.015) and safety-and-flow performance (β = 0.661, p = 0.016). Navigation information systems also exhibited a significant positive relationship with safety-and-flow performance (β = 0.860, p < 0.001), representing the strongest reported direct relationship in the research model. These findings suggest that technical proficiency and effective navigation information systems are important factors associated with safe and efficient pilotage operations.

In contrast, work experience did not significantly influence either job satisfaction or safety-and-flow performance. Navigation information systems also showed no statistically significant relationship with

job satisfaction, while job satisfaction itself did not significantly predict operational performance. Furthermore, the mediation analysis demonstrated that job satisfaction did not significantly mediate the relationships between work experience, technical competence, or navigation information systems and safety-and-flow performance. Consequently, all three mediation hypotheses were not supported. These findings indicate that technical and technological capabilities are more directly associated with pilotage performance than through the proposed psychological mechanism of job satisfaction.

The findings are broadly consistent with Shi et al. (2024), who emphasized the importance of seafarer competencies, situational awareness, and decision-making in maritime safety, as well as Fan and Yang (2023), who highlighted the interaction between human competencies and technological systems in maritime operations. However, the insignificant relationship between work experience and operational performance differs from Quiñones et al. (1995), who reported a positive association between work experience and job performance. Similarly, the nonsignificant relationship between job satisfaction and performance contrasts with Judge et al. (2001), whose meta-analysis identified a positive relationship between these constructs. These differences suggest that performance determinants may vary across occupational contexts, particularly in specialized and safety-critical maritime operations where technical competence, procedural compliance, and navigational support play essential roles.

From a practical perspective, the findings suggest that maritime authorities and pilotage service providers should prioritize continuous technical competency development, simulation-based training, regular competency assessments, and improvements in navigation information systems. Strengthening the integration of human expertise and technological support may contribute to safer and more efficient vessel movements in restricted waterways. Nevertheless, the study's cross-sectional design and relatively small sample of 42 ship pilots limit the generalizability of the findings and do not establish causal relationships.

Future research should involve larger samples across multiple ports and pilotage areas to improve the generalizability of the results. Longitudinal or mixed-methods approaches could also provide a deeper understanding of how technical competence and navigation technologies influence operational performance over time. Additionally, future studies are encouraged to examine alternative mediating or moderating variables, such as situational awareness, safety behavior, decision-making confidence, organizational safety culture, and work adaptability. Incorporating objective operational indicators, including navigational incidents, vessel movement efficiency, and compliance with safety procedures, would further strengthen the empirical assessment of safety-and-flow performance in maritime pilotage operations.

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