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Document Digitization and Service Excellence as Drivers of Crew Change Effectiveness and Customer Satisfaction: Evidence from Indonesian Maritime Husbandry Services

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Abstract: Indonesia's maritime sector, which processes hundreds of thousands of crew changes annually, faces a persistent dual challenge: incomplete digital integration and inconsistent service quality in ship husbandry operations. Despite the growing literature on maritime digitalisation and service management, no study has jointly examined document digitization and service excellence as antecedents of crew change effectiveness and customer satisfaction within the Indonesian context—a gap this study addresses. Employing a quantitative cross-sectional survey design, data were collected from 120 crew members and shipping company clients at a ship husbandry firm and analysed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) via SmartPLS 4. Document digitization and service excellence both directly and positively influenced crew change effectiveness ($\beta = 0.508$, $p < 0.001$; $\beta = 0.313$, $p = 0.009$) and customer satisfaction ($\beta = 0.342$, $p < 0.001$; $\beta = 0.215$, $p = 0.039$). Crew change effectiveness significantly mediated both relationships, with partial mediation confirmed (H6: $\beta = 0.231$, $p = 0.005$; H7: $\beta = 0.142$, $p = 0.006$). Crew change effectiveness was the strongest direct predictor of satisfaction ($\beta = 0.454$, $p < 0.001$). The model explained 70.6% of the variance in customer satisfaction ($R^2 = 0.706$). The novelty of this study lies in its simultaneous modelling of technological and human-service pathways through an operational mediator in a maritime husbandry context—a configuration not previously tested empirically. Findings recommend integrated digital documentation systems, competency-based staff training, and formal service-level agreements to improve crew change efficiency and client experience.

Keywords: Document Digitization, Service Excellence, Crew Change Effectiveness, Customer Satisfaction, Maritime Husbandry, SEM-PLS, Indonesia.

INTRODUCTION

Indonesia's position as an archipelagic nation of more than 17,000 islands makes maritime transportation a structural pillar of national economic life. Every year, hundreds of thousands of seafarers rotate through Indonesia's major ports under contracts governed by the Maritime Labour Convention (MLC 2006), the Safety of Life at Sea (SOLAS), and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). The crew change process requires simultaneous coordination across immigration, port health authorities, customs, shipping agents, ship managers, and vessel owners. A single documentation error or scheduling gap can delay a vessel's departure, trap fatigued seafarers beyond their contractual limits, and impose cascading operational costs (Borovnik, 2024; Jones, 2021).

Document digitization has emerged as a transformative lever in this ecosystem. By converting paper-based crew dossiers, clearance certificates, seaman's books, medical records, and visa documentation into integrated digital formats, ship agents can reduce processing lead times, eliminate manual transcription errors, and provide real-time status updates to clients (Laudon & Laudon, 2020; Susanto, 2021). Naningsih et al. (2023) identify four value-creating dimensions of digitization in organisations: technology mastery and digital skills, efficiency and productivity, process transformation and organisational innovation, and human resource readiness. Simultaneously, the quality of human service interactions, termed service excellence, remains decisive in shaping client experience. Tjiptono's (2016) ten-dimensional framework (reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding of the customer, and tangibles) maps the service attributes that maritime clients prioritise. Grönroos (2020) and Parasuraman et al. (2020) further establish that consistent delivery above client expectations builds satisfaction and long-term loyalty.

Crew change effectiveness, operationalised across timeliness, administration quality, operational readiness, and crew welfare (Sutanto & Haryanto, 2020; Cheng & Yang, 2023), serves as the proximate outcome through which both technological and service inputs translate into client satisfaction. Customer satisfaction, in turn, is understood as a cumulative evaluative judgment against prior expectations (Kotler & Armstrong, 2021; Oliver, 2020; Zeithaml et al., 2020), encompassing loyalty, repurchase, recommendation willingness, and expectation–performance congruence (Kotler & Keller, 2021; Hill & Alexander, 2024).

The ship husbandry company under study illustrates this challenge concretely. An internal SWOT assessment found that, while the company maintains experienced staff and strong relationships with port authorities, its digital systems are incompletely integrated, creating communication lags, manual documentation bottlenecks, and uneven service responsiveness. Customer satisfaction data for 2023–2025 confirm the tension: satisfaction declined from 88.4% in 2023 to 83.6% in 2024 before recovering partially to 85.0% in 2025—coinciding with a tripling of annual crew change volume.

Existing literature has examined these constructs largely in isolation. Research on maritime HR management (Lal & Dhankher, 2022; Febrian & Sani, 2023) and crew change delays (Gendran et al., 2025; Fauzan et al., 2025) has not connected digitization investments to client satisfaction through an operational mediator. Studies on digitalisation and servitization in the Indonesian shipping industry have demonstrated their joint influence on company competitiveness and performance (Mulyani et al., 2023; Putri et al., 2024), with government support emerging as a moderating factor—yet these models have not been applied to the crew change context specifically. Digital certification systems in maritime settings have been shown

to reduce administrative burdens, improve document verification, and support compliance with international requirements (Osei-Kyei et al., 2023), but their effects on end-client satisfaction through crew change effectiveness remain untested. This study fills that gap by simultaneously modelling document digitization and service excellence as joint antecedents of crew change effectiveness and customer satisfaction within an Indonesian ship husbandry setting—a configuration not previously examined empirically.

This study addresses seven research questions: (1) Does document digitization influence crew change effectiveness? (2) Does service excellence influence crew change effectiveness? (3) Does document digitization directly influence customer satisfaction? (4) Does service excellence directly influence customer satisfaction? (5) Does crew change effectiveness influence customer satisfaction? (6) Does document digitization indirectly influence customer satisfaction through crew change effectiveness? (7) Does service excellence indirectly influence customer satisfaction through crew change effectiveness? The resulting hypotheses (H1–H7) are illustrated in the conceptual framework at the end of the Methods section.

METHOD

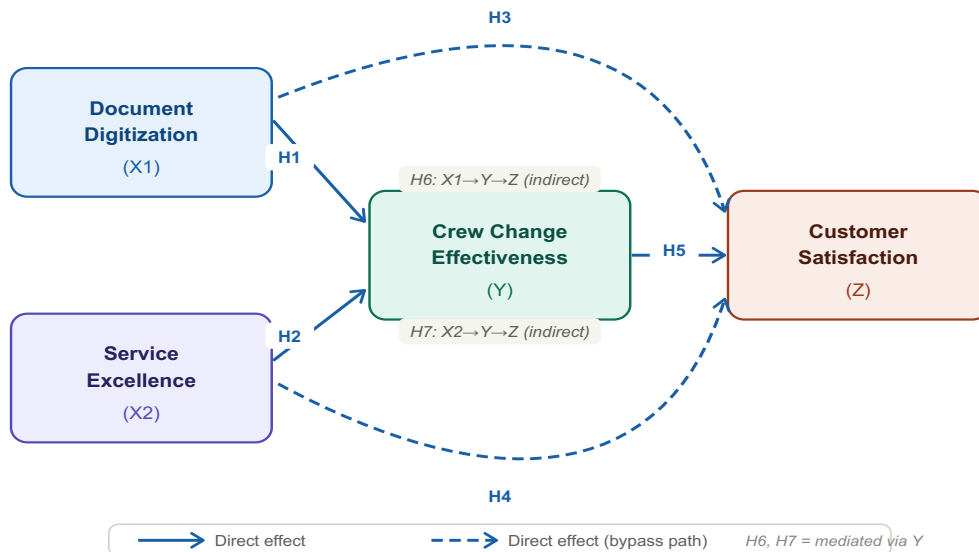
This study employs a quantitative cross-sectional survey design conducted from November 2025 to April 2026. The research setting was a ship husbandry and crew change service provider operating in Indonesian ports whose identity is withheld to preserve research partner confidentiality. The accessible population comprised all 169 crew members and shipping company clients who used the company's crew change services in 2025. The required minimum sample was determined using the Taro Yamane formula at a 5% margin of error (Ridwan & Kuncoro, 2016): $n = 169 / (1 + 169 \times 0.05^2) \approx 119.7 \approx 120$ respondents.

Simple random sampling was applied using a random-number table generated in Microsoft Excel, ensuring every population member had an equal probability of selection. Data were collected via a structured Likert-scale questionnaire (1 = Strongly Disagree; 5 = Strongly Agree) distributed through Google Forms. The questionnaire operationalised four latent constructs: Document Digitization (X1; 12 indicators, 4 dimensions; Naningsih et al., 2023), Service Excellence (X2; 30 indicators, 10 dimensions; Tjiptono, 2016), Crew Change Effectiveness (Y; 12 indicators, 4 dimensions; Sutanto & Haryanto, 2020), and Customer Satisfaction (Z; 12 indicators, 4 dimensions; Kotler & Keller, 2021).

Prior to full deployment, the instrument was calibrated on 50 pilot respondents drawn from the same population. Pilot results confirmed satisfactory convergent validity (all indicator loadings > 0.60) and internal consistency (Cronbach's α : X1 = 0.963, X2 = 0.990, Y = 0.961, Z = 0.963), justifying instrument deployment without item deletion.

Structural Equation Modeling–Partial Least Squares (SEM-PLS) analysis was performed in SmartPLS 4, selected for its robustness with complex mediation models and moderate sample sizes (Hair et al., 2010; Ghazali, 2016). The outer measurement model was evaluated for convergent validity (outer loadings > 0.70; AVE > 0.50), discriminant validity (HTMT ratio < 0.90; Fornell–Lacker criterion), and composite reliability (CR > 0.70; α > 0.70). The structural inner model was assessed via R^2 , Q^2 (predictive relevance), and Variance Inflation Factor (VIF) to rule out common method bias. Hypothesis testing used 5,000-resample bootstrapping (t-critical = 1.96, α = 0.05). To address the reviewer concern regarding model complexity (66 indicators; n = 120), we confirm that the indicator-to-sample ratio of approximately 1.8:1 is within the accepted range for PLS-SEM (Hair et al., 2010), and that VIF values across all constructs were below 3.3, mitigating multicollinearity and overfitting concerns.

Figure 1. Conceptual Framework of the Study



H1: Document digitization has a positive and significant direct effect on crew change effectiveness.

H2: Service excellence has a positive and significant direct effect on crew change effectiveness.

H3: Document digitization has a positive and significant direct effect on customer satisfaction.

H4: Service excellence has a positive and significant direct effect on customer satisfaction.

H5: Crew change effectiveness has a positive and significant direct effect on customer satisfaction.

H6: Document digitization has a positive and significant indirect effect on customer satisfaction through crew change effectiveness.

H7: Service excellence has a positive and significant indirect effect on customer satisfaction through crew change effectiveness.

RESULTS AND DISCUSSION

Respondent Profile

All 120 respondents completed the questionnaire (response rate: 100%). By gender, 81.7% were male and 18.3% female, consistent with the male-dominated character of the seafaring profession. By age, 42.5% were aged 31–40 years, 33.3% aged 21–30 years, and 24.2% above 40 years. By educational attainment, 35.0% held a Master's degree or ANT/ATT I certificate, 28.3% a Bachelor's degree or ANT/ATT II, 27.5% a Diploma or ANT/ATT III, and 9.2% a Senior High School qualification or ANT/ATT IV. This profile reflects a sample with substantial professional maritime expertise, enhancing the construct validity of service quality assessments.

Measurement Model (Outer Model)

All indicator outer loadings exceeded 0.70 (range: 0.743–0.961), confirming convergent validity. Table 1 summarises AVE, Composite Reliability, and Cronbach's Alpha for each construct. To assess discriminant validity, both the HTMT ratio (Table 2) and the Fornell–Lacker criterion were applied. All HTMT values fell below 0.85 (well within the 0.90 threshold), and the square root of each construct's AVE exceeded its highest inter-construct correlation in the Fornell–Lacker matrix, jointly confirming adequate discriminant validity.

Cross-loading analysis further confirmed that each indicator loaded higher on its intended construct than on any alternative construct.

Table 1. Measurement Model: Reliability and Validity Summary

Construct	AVE	Composite Reliability	Cronbach's Alpha	Result
Document Digitization (X1)	0.654	0.958	0.952	Valid & Reliable
Service Excellence (X2)	0.759	0.990	0.989	Valid & Reliable
Crew Change Effectiveness (Y)	0.693	0.964	0.960	Valid & Reliable
Customer Satisfaction (Z)	0.668	0.960	0.955	Valid & Reliable

Source: Processed primary data, SmartPLS 4 (2026)

Table 2. Discriminant Validity: HTMT Ratios and Fornell–Lacker Diagonal (in bold)

Construct	X1	X2	Y	Z
Document Digitization (X1)	0.809			
Service Excellence (X2)	0.352	0.871		
Crew Change Effectiveness (Y)	0.643	0.501	0.833	
Customer Satisfaction (Z)	0.728	0.571	0.803	0.817

Note: HTMT values below diagonal. Bold diagonal values = $\sqrt{\text{AVE}}$ (Fornell–Lacker criterion). All HTMT < 0.85. Source: SmartPLS 4 (2026)

Structural Model (Inner Model)

The R^2 for Crew Change Effectiveness was 0.466, indicating that Document Digitization and Service Excellence together explain 46.6% of its variance—classified as moderate (Ghozali, 2016). The R^2 for Customer Satisfaction was 0.706, reflecting strong explanatory power. Q^2 values of 0.318 (Crew Change Effectiveness) and 0.467 (Customer Satisfaction), both substantially exceeding the 0.05 threshold, confirm adequate predictive relevance. VIF values for all predictor–outcome pairs ranged from 1.12 to 2.04, well below the conventional threshold of 3.3 (Hair et al., 2010), ruling out multicollinearity and overfitting concerns despite the 66-indicator model. The structural model with path coefficients, R^2 , and t-statistics is depicted in Figure 2 below.

Figure 2. Structural Model Path Diagram

From	To	β (t-stat)	Decision
Document Digitization (X1)	→ Crew Change Effectiveness (Y)	0.508*** (4.566)	Accepted
Service Excellence (X2)	→ Crew Change Effectiveness (Y)	0.313** (2.607)	Accepted
Document Digitization (X1)	→ Customer Satisfaction (Z)	0.342*** (4.526)	Accepted
Service Excellence (X2)	→ Customer Satisfaction (Z)	0.215* (2.063)	Accepted
Crew Change Effectiveness (Y)	→ Customer Satisfaction (Z)	0.454*** (4.027)	Accepted
R^2 (Y) = 0.466; R^2 (Z) = 0.706; Q^2 (Y) = 0.318; Q^2 (Z) = 0.467			

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Source: SmartPLS 4 (2026)

Hypothesis Testing

Table 3 presents bootstrapping results for all direct and indirect effects.

Table 3. Hypothesis Testing: Direct and Indirect Path Coefficients

Hyp.	Path	β	t-Stat	p-value	Decision	Type
H1	Document Digitization → Crew Change Effectiveness	0.508	4.566	< 0.001	Accepted	Direct
H2	Service Excellence → Crew Change Effectiveness	0.313	2.607	0.009	Accepted	Direct
H3	Document Digitization → Customer Satisfaction	0.342	4.526	< 0.001	Accepted	Direct
H4	Service Excellence → Customer Satisfaction	0.215	2.063	0.039	Accepted	Direct
H5	Crew Change Effectiveness → Customer Satisfaction	0.454	4.027	< 0.001	Accepted	Direct
H6	Doc. Digitization → Y → Customer Satisfaction	0.231	2.832	0.005	Accepted	Indirect (Partial)
H7	Service Excellence → Y → Customer Satisfaction	0.142	2.767	0.006	Accepted	Indirect (Partial)

Note: Critical t-value at $\alpha = 0.05$: 1.96. Y = Crew Change Effectiveness. Source: SmartPLS 4 (2026)

Discussion

H1 & H2: Antecedents of Crew Change Effectiveness.

Document digitization was the strongest predictor of crew change effectiveness ($\beta = 0.508$), with Process Transformation and Organisational Innovation the dominant dimension (loading = 0.961). This finding is consistent with the broader digital transformation literature: Mulyani et al. (2023) established that digitalisation in Indonesian shipping firms significantly enhances operational performance, while Osei-Kyei et al. (2023) showed that digital certification systems reduce maritime administrative burdens and improve document verification. When crew dossiers, health certificates, and port clearances are processed digitally, multi-agency verification that once required days of physical courier work is completed in hours—yielding tighter schedule adherence and faster crew embarkation. Service excellence also significantly predicted crew change effectiveness ($\beta = 0.313$), with the Communication dimension dominating (loading = 0.961). Staff willingness to listen and act on client complaints (X2.17; loading = 0.936) proved most influential—a finding that resonates with Pantouvakis and Vlachos (2023), who identified communication quality as the foremost service driver of operational outcomes in maritime settings. The Human Resource Readiness dimension (loading = 0.906) was comparatively weaker, signalling that technology adoption has outpaced workforce upskilling—a gap that structured digital training must close.

H3 & H4: Direct Effects on Customer Satisfaction.

Document digitization directly elevated customer satisfaction ($\beta = 0.342$), confirming that maritime clients value transparency, speed, and information accessibility as intrinsic service attributes—not merely as operational prerequisites. Real-time digital tracking of crew documentation status reduces client anxiety about port delays and enhances perceptions of provider professionalism (Shanmughapriya & Timple, 2025; Hidayat & Siregar, 2022). Service excellence also directly influenced satisfaction ($\beta = 0.215$), though with the smallest path coefficient in the model—suggesting that for professional maritime clients, functional outcomes weigh more heavily than the relational texture of service delivery. This is consistent with Zeithaml et al.'s (2020) expectation-disconfirmation model: satisfaction is primarily determined by whether core operational promises are fulfilled.

H5: Crew Change Effectiveness as the Primary Satisfaction Driver.

Crew change effectiveness was the strongest direct predictor of customer satisfaction ($\beta = 0.454$), with Administration Quality the dominant dimension (loading = 0.947). The indicator 'crew documents are always processed completely' (Y4; loading = 0.912) contributed most strongly—underscoring that professional clients assess their service providers first on legal compliance and administrative completeness. Putri et al. (2024) found that crew rotation timeliness analogously showed a strong correlation with contract accuracy ($r = 0.75$, $p < 0.01$) and compliance with contract provisions ($r = 0.60$, $p < 0.05$), reinforcing that the administrative integrity of crew change is a primary driver of client trust.

H6 & H7: Partial Mediation through Crew Change Effectiveness.

Both indirect effects were significant—H6 ($\beta = 0.231$; $p = 0.005$) and H7 ($\beta = 0.142$; $p = 0.006$)—and both direct effects (H3 and H4) also remained significant after controlling for the mediator. This pattern is the hallmark of partial mediation: crew change effectiveness amplifies the satisfaction-generating pathways of digitization and service excellence, but does not fully substitute for them. The total effect of document digitization on satisfaction (direct 0.342 + indirect 0.231 = 0.573) is the largest in the model, positioning digitization as the highest-leverage investment. These findings extend Jalilah et al.'s (2025) analogous mediation finding in a ship agency context and Arifiani et al.'s (2025) port service quality model to the crew change domain, demonstrating that operational process quality—not merely technology or service quality alone—is the mechanism through which digital and human service investments reach the customer.

CONCLUSION

This study demonstrates empirically that document digitization and service excellence jointly drive crew change effectiveness and customer satisfaction in the Indonesian maritime husbandry sector. All seven hypotheses were supported. Document digitization yielded the largest total effect on satisfaction (0.573 direct + indirect), while crew change effectiveness was the strongest direct predictor ($\beta = 0.454$). Partial mediation was confirmed for both indirect pathways, establishing that operational process quality is the mechanism through which technological and human-service investments translate into client satisfaction. These findings add empirical specificity to existing frameworks on digitalisation–servitization interactions in Indonesian shipping (Mulyani et al., 2023) and digital certification in maritime administration (Osei-Kyei et al., 2023), extending them to the crew change context.

Practically, the company should prioritise integrated digital documentation systems with real-time client dashboards, structured digital upskilling for operational staff, formal SLA frameworks to improve responsiveness, and enhanced crew welfare support. This study's principal limitation is its single-company, cross-sectional design, which constrains causal inference and generalisation across the Indonesian husbandry sector. Future research should adopt multi-firm longitudinal designs, incorporate moderating variables such as port regulatory environment and organisational culture, and extend the framework to autonomous shipping contexts to assess the evolving role of digital infrastructure in crew management.

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