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Strategic Maritime Transportation Management and Business Performance Enhancing Operational Efficiency, Competitiveness, and Sustainability in the Indonesian Maritime Industry

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ABSTRACT

Maritime transportation management is a strategic determinant of business performance in archipelagic economies, where shipping companies, port authorities, terminal operators, and maritime service providers depend on coordinated operational and commercial capabilities. This study examines the relationships of maritime transportation management, port operational efficiency, digital technology integration, and maritime business strategy with two organizational outcomes: maritime competitiveness and maritime business performance. Maritime competitiveness is modelled as a mediating mechanism. Grounded in the resource-based view and the dynamic capabilities perspective, the study uses a synthetic dataset of 400 simulated cases and 24 five-point Likert-type indicators generated through a prespecified data-generating process. The model is assessed through indicator loadings, internal consistency reliability, average variance extracted, heterotrait–monotrait ratios, structural path estimates, explained variance, effect sizes, and 5,000 bootstrap resamples of the estimated construct scores. All indicator loadings exceed 0.80; composite reliability ranges from 0.914 to 0.929, and AVE ranges from 0.727 to 0.767. The model explains 37.4% of the variance in maritime competitiveness and 49.9% of the variance in maritime business performance. Maritime competitiveness is positively associated with business performance (β = 0.379, 95% CI [0.293, 0.462]). All four indirect effects are positive and statistically distinguishable from zero in the simulated dataset, whereas the direct effect of port operational efficiency on business performance does not reach the 5% significance threshold. These findings demonstrate the behaviour of the proposed model under a controlled synthetic-data scenario; they do not constitute evidence about actual Indonesian maritime organizations. The study provides a reproducible analytical demonstration and a framework for subsequent validation using genuine organizational data.

Keywords: *Maritime Transportation Management; Port Operational Efficiency; Digital Technology Integration; Maritime Competitiveness.*

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INTRODUCTION

Maritime transportation is a strategic infrastructure for international trade and domestic connectivity. In Indonesia, an archipelagic economy, shipping services and ports

connect production centres, consumption markets, industrial clusters, and geographically dispersed communities. Maritime businesses operate within a multi-actor system involving shipping lines, port authorities, terminal operators, cargo owners, service providers, regulators, and inland transport networks. Organizational performance is therefore shaped not only by physical assets but also by managerial decisions and the quality of coordination across organizational boundaries.

Port and maritime performance is multidimensional. Throughput, turnaround time, and capacity utilization remain important, but they do not fully capture process integration, service reliability, market access, customer value, and sustainability. Multi-stakeholder performance measurement recognizes that port users and operators evaluate service outcomes from different perspectives (Ha et al., 2017). Port competitiveness likewise reflects interrelated strategic, operational, and market drivers (Parola et al., 2017; Baştuğ et al., 2022). Sustainability-oriented research further broadens the performance agenda beyond throughput and cost efficiency (Lim et al., 2019).

Digitalization has intensified the need for integrated maritime management. Port-centric information systems and digital platforms can improve information exchange and operational coordination when embedded in business processes (Jiang et al., 2023). Smart-port research identifies technology integration, process redesign, organizational readiness, and ecosystem collaboration as connected dimensions of port transformation (Belmoukari et al., 2023). Indonesian port studies also document the strategic relevance of digital capability and management support for organizational performance (Putra et al., 2024; Utama et al., 2024).

The strategic issue is not simply whether an organization adopts technology or improves one operational process. It is how transportation management, port efficiency, digital integration, and business strategy combine to create competitive positioning and business performance. Recent work on Southeast Asian ports links digital transformation with operational efficiency and market positioning, reinforcing the need to treat digitalization as a strategic capability (Nha & Yen, 2026). Research on Indonesian container ports similarly examines digital adoption as a mechanism connecting organizational capabilities with port performance (Pramitra et al., 2026).

This study develops an integrated model with four organizational capabilities—maritime transportation management (MTM), port operational efficiency (POE), digital technology integration (DTI), and maritime business strategy (MBS)—as antecedents of maritime competitiveness (MC) and maritime business performance (MBP). MC is specified as a mediator. The contribution is an integrated management framework spanning shipping, port/terminal, and related maritime business functions. To demonstrate the analytical behaviour of the model before field validation, the study uses a fully synthetic dataset and explicitly treats all numerical results as simulation outputs.

The study addresses three questions: (1) how are the four capabilities associated with maritime competitiveness in the specified model? (2) how are these capabilities and competitiveness associated with maritime business performance? and (3) do the simulated indirect effects through competitiveness differ from zero?

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Theoretical foundation: resource-based view and dynamic capabilities

The resource-based view explains differences in organizational performance through resources and capabilities that are valuable, organized, and difficult to replicate. In maritime businesses, relevant resources include vessels, terminal assets, operational expertise, customer relationships, information infrastructure, data, and interorganizational routines. The dynamic capabilities perspective extends this logic by emphasizing the ability to sense changes, seize opportunities, and reconfigure resources as markets, technologies, and regulations evolve. In port settings, digital transformation and organizational resilience are increasingly connected to performance and competitive adaptation (Zhu et al., 2026).

The two perspectives are complementary in this model. Transportation planning and port-process coordination represent operational capabilities; digital integration enables information-based coordination and adaptation; and business strategy aligns resources with market opportunities. These capabilities are expected to strengthen competitive positioning and business outcomes.

Maritime transportation management

Maritime transportation management refers to managerial planning, coordination, monitoring, and control of sea-transport activities. It encompasses route and schedule planning, capacity and resource allocation, service reliability, and operational risk management. Effective management supports predictable services and reduces avoidable disruption. It is conceptualized as an organizational capability rather than a direct measure of fleet size or cargo volume.

H1: Maritime transportation management positively influences maritime competitiveness.

H6: Maritime transportation management positively influences maritime business performance.

Port operational efficiency

Port operational efficiency concerns the ability to convert infrastructure, labour, equipment, and information into reliable services with limited avoidable time and resource loss. Relevant processes include berth and yard planning, cargo handling, equipment utilization, and coordination among operational units. Business-process management is central because port performance depends on how end-to-end processes are designed, executed, monitored, and improved (Saragiotis, 2019). Market access and hinterland connectivity also shape the operational context in which seaport efficiency is realized (Rødseth et al., 2023).

H2: Port operational efficiency positively influences maritime competitiveness.

H7: Port operational efficiency positively influences maritime business performance.

Digital technology integration

Digital technology integration refers to the extent to which digital systems are embedded in business processes and connected across organizational units and external maritime stakeholders. It includes operational information systems, vessel and cargo tracking, electronic documentation, data sharing, and decision support. Port-centric information integration has been associated with operational capability and port performance (Jiang et al., 2023). Research on smart ports emphasizes the interdependence of technology, organizational processes, and ecosystem integration (Belmoukari et al., 2023).

H3: Digital technology integration positively influences maritime competitiveness.

H8: Digital technology integration positively influences maritime business performance.

Maritime business strategy

Maritime business strategy refers to coordinated choices through which an organization defines target markets, service propositions, partnerships, innovation priorities, and long-term positioning. Strategy guides resource allocation and translates operational capabilities into customer value. Because shipping lines and terminal operators may prioritize different competitive criteria, strategic alignment must account for stakeholder-specific service expectations (Baştuğ et al., 2022).

H4: Maritime business strategy positively influences maritime competitiveness.

H9: Maritime business strategy positively influences maritime business performance.

Maritime competitiveness and business performance

Maritime competitiveness is defined as the perceived ability to offer reliable, attractive, and differentiated maritime services relative to relevant competitors. It includes responsiveness to market change, service differentiation, customer relationship quality, and relative service advantage. Port competitiveness is multidimensional and influenced by operational and market conditions (Parola et al., 2017; Yu et al., 2025). Maritime business performance is a multidimensional organizational outcome covering operational target achievement, cost efficiency, customer service, and business growth. Digital transformation studies in port settings connect organizational capabilities and information integration with performance outcomes (Putra et al., 2024; Pramitra et al., 2026).

H5: Maritime competitiveness positively influences maritime business performance.

Mediating role of maritime competitiveness

The proposed mediation mechanism reflects the argument that operational and strategic capabilities can improve business outcomes partly by strengthening an organization's competitive position. Better transportation management, port efficiency, digital integration, and business strategy may improve service reliability, responsiveness, differentiation, and customer relationships. These competitive advantages can then translate into stronger operational and commercial performance.

H10: Maritime competitiveness mediates the relationship between maritime transportation management and maritime business performance.
H11: Maritime competitiveness mediates the relationship between port operational efficiency and maritime business performance.
H12: Maritime competitiveness mediates the relationship between digital technology integration and maritime business performance.
H13: Maritime competitiveness mediates the relationship between maritime business strategy and maritime business performance.

Research contribution

The model integrates four complementary management capabilities and positions maritime competitiveness as a mechanism connecting those capabilities with business performance. The contribution is integrative and contextual: it extends port-level discussions of efficiency and digitalization into a broader maritime-business framework spanning shipping, port/terminal, and related service organizations. The synthetic-data design is used to demonstrate the estimation workflow and expected reporting structure; it does not establish population-level relationships.

Conceptual Framework

Figure 1 presents the proposed structural model. MTM, POE, DTI, and MBS are specified as exogenous constructs. Each capability is connected to MC and to MBP through a direct path. MC is also connected to MBP and functions as the mediator. The model therefore allows partial mediation: capability effects may operate directly and indirectly through competitiveness.

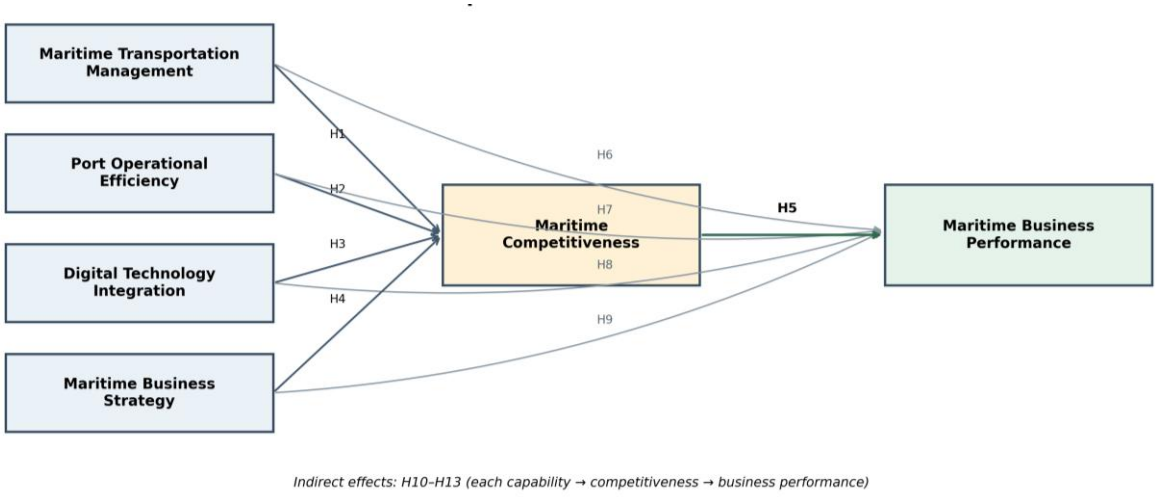


Figure 1. Conceptual framework of strategic maritime transportation management and business performance.

The model includes nine direct hypotheses (H1–H9) and four specific indirect hypotheses (H10–H13). The direct paths are retained to distinguish the mediating contribution of competitiveness from the independent contribution of each organizational capability.

RESEARCH METHODOLOGY

Research design and analytical purpose

The study uses a quantitative simulation design. A synthetic dataset was generated to demonstrate the measurement and structural assessment of the proposed reflective model using a PLS path-modelling procedure. The dataset is not derived from questionnaires, organizational records, or human participants. Accordingly, the analysis is a controlled methodological demonstration and must not be interpreted as an empirical survey of Indonesian maritime organizations.

Data generation

The dataset contains 400 simulated cases and 24 indicators, with four indicators assigned to each of the six latent constructs. Each indicator is recorded on a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree). Latent exogenous variables were generated from a multivariate normal distribution with prespecified moderate correlations. Maritime competitiveness was generated as a function of the four capability constructs plus an error term; maritime business performance was generated as a function of the four capabilities and competitiveness plus an error term. Reflective indicators were generated using construct-specific loadings and indicator-level error, then discretized into five response categories. The random seed and generation rules are retained to support reproducibility.

The simulated profile fields (organization type, role, experience, and market orientation) are also randomly generated for demonstration. They do not represent actual respondent characteristics and are not used to make claims about the Indonesian maritime workforce.

Constructs and measurement

All six constructs are specified as reflective and measured using four indicators each. The indicators were developed from the construct definitions and the maritime management literature. The resulting instrument provides a structured basis for expert assessment and field pretesting before administration in a future survey, as summarized in Table 1. To clarify the operationalization of the proposed model, Table 1 presents the six latent constructs, their indicator codes, and the principal domains covered by each measurement scale.

Table 1. Constructs, measurement codes, and operational domains.

Construct	Code	Operational domain
Maritime Transportation Management	MTM1–MTM4	Planning, route/schedule management, resource allocation, operational risk management
Port Operational Efficiency	POE1–POE4	Delay management, cargo handling, equipment utilization, unit coordination
Digital Technology Integration	DTI1–DTI4	Process integration, decision support, stakeholder information exchange, information quality
Maritime Business Strategy	MBS1–MBS4	Strategic clarity, market responsiveness, business development, sustainability orientation
Maritime Competitiveness	MC1–MC4	Service competitiveness, market responsiveness, customer relationships, relative service advantage
Maritime Business Performance	MBP1–MBP4	Operational targets, cost efficiency, customer service, business growth

Table 1 summarizes the six constructs included in the research model, their corresponding indicator codes, and the operational domains represented by each construct. Each construct is measured by four reflective indicators. The operational domains provide the conceptual basis for interpreting the indicators and clarify how the broad management concepts are represented in the measurement model.

PLS path modelling and evaluation

The model was estimated using a Mode A reflective measurement specification and a path-weighting approach to obtain construct scores. Structural paths were estimated for MC from MTM, POE, DTI, and MBS, and for MBP from those four constructs plus MC. The measurement model was evaluated through standardized indicator loadings, Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), and the heterotrait–monotrait ratio (HTMT). Structural assessment included variance inflation factors (VIF), standardized path coefficients, R^2, f^2, and specific indirect effects.

Uncertainty intervals for structural paths and indirect effects were estimated using 5,000 nonparametric bootstrap resamples of the estimated construct scores. The bootstrap resampling was conditional on the full-sample outer-weight solution; therefore, intervals quantify structural-path uncertainty conditional on those estimated scores rather than full outer-model re-estimation in every resample. This implementation detail is reported to make the simulation workflow reproducible and to distinguish it from software implementations that re-estimate the complete PLS algorithm in each bootstrap sample.

Data governance and research ethics

Because all records are computer-generated, no human participants were recruited and no personal or organizational data were collected. The simulation does not require participant consent. Any subsequent field study using the questionnaire must obtain the applicable institutional ethics approval or exemption, secure informed consent, and report the approving body and reference number accurately.

RESULTS AND DISCUSSION

Sample and measurement assessment

The simulation produced 400 cases with complete values for all 24 indicators. Synthetic profile fields were generated to illustrate the structure of a potential multi-stakeholder dataset; they are not observed respondent characteristics and are not used to make claims about the composition of the Indonesian maritime workforce. The measurement model was first examined to assess the reliability of the indicators and the internal consistency and convergent validity of each construct. Table 2 reports the indicator loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) for the six constructs.

Table 2. Measurement-model assessment for the synthetic dataset.

Construct	Indicator loadings	Cronbach's α	CR	AVE
MTM	0.812, 0.844, 0.863, 0.890	0.875	0.914	0.727
POE	0.852, 0.865, 0.853, 0.881	0.886	0.921	0.745
DTI	0.854, 0.859, 0.876, 0.890	0.892	0.925	0.756
MBS	0.839, 0.859, 0.898, 0.899	0.897	0.928	0.764
MC	0.826, 0.872, 0.874, 0.879	0.886	0.921	0.745
MBP	0.854, 0.853, 0.890, 0.905	0.899	0.929	0.767

As reported in Table 2, all indicator loadings exceeded 0.80. Cronbach's alpha values ranged from 0.875 to 0.899, composite reliability values ranged from 0.914 to 0.929, and AVE values ranged from 0.727 to 0.767. These values exceed commonly applied guidelines for internal consistency and convergent validity, indicating satisfactory measurement properties within the simulated dataset.

Discriminant validity was assessed using the heterotrait–monotrait ratio (HTMT). The pairwise HTMT values are presented in Table 3 to evaluate whether the six constructs are empirically distinguishable within the simulated measurement model.

Table 3. Heterotrait–monotrait ratio (HTMT) matrix.

Construct	MTM	POE	DTI	MBS	MC	MBP
MTM	—	0.314	0.310	0.318	0.467	0.458
POE	0.314	—	0.330	0.332	0.443	0.416
DTI	0.310	0.330	—	0.374	0.459	0.552
MBS	0.318	0.332	0.374	—	0.501	0.502

MC	0.467	0.443	0.459	0.501	—	0.697
MBP	0.458	0.416	0.552	0.502	0.697	—

The HTMT values ranged from 0.310 to 0.697, remaining below the conservative threshold of 0.85. The highest value was observed between maritime competitiveness and maritime business performance (0.697). This pattern supports discriminant validity among the constructs in the simulated dataset.

Structural model assessment

The structural model explained 37.4% of the variance in maritime competitiveness and 49.9% of the variance in maritime business performance. Predictor VIF values ranged from 1.170 to 1.598, indicating no material collinearity concern in the simulated model. The direct structural relationships are reported in Table 4.

After evaluating the measurement model, the structural relationships were examined. Table 4 presents the standardized path coefficients, bootstrap confidence intervals, p-values, and decisions for the nine hypothesized direct relationships.

Table 4. Direct structural paths in the synthetic-data model.

Hypothesis	Path	β	95% bootstrap CI	p-value	Decision
H1	MTM → MC	0.227	[0.141, 0.313]	<0.001	Supported
H2	POE → MC	0.198	[0.112, 0.279]	<0.001	Supported
H3	DTI → MC	0.202	[0.124, 0.282]	<0.001	Supported
H4	MBS → MC	0.261	[0.178, 0.346]	<0.001	Supported
H5	MC → MBP	0.379	[0.293, 0.462]	<0.001	Supported
H6	MTM → MBP	0.127	[0.044, 0.206]	0.002	Supported
H7	POE → MBP	0.077	[-0.002, 0.157]	0.059	Not supported
H8	DTI → MBP	0.234	[0.155, 0.315]	<0.001	Supported
H9	MBS → MBP	0.145	[0.062, 0.226]	<0.001	Supported

As shown in Table 4, maritime transportation management, port operational efficiency, digital technology integration, and maritime business strategy were all positively associated with maritime competitiveness. Maritime competitiveness was also positively associated with maritime business performance ($\beta = 0.379$, 95% CI [0.293, 0.462], $p < 0.001$). Among the direct capability-to-performance relationships, the paths from MTM, DTI, and MBS were statistically distinguishable from zero. The POE-to-MBP path was positive, but its confidence interval included zero and its p-value exceeded the 0.05 significance threshold.

Mediation analysis

The analysis next examined whether maritime competitiveness transmits the effects of the four organizational capabilities to maritime business performance. The specific indirect effects and their bootstrap confidence intervals are reported in Table 5.

Table 5. Specific indirect effects through maritime competitiveness.

Hypothesis	Specific indirect path	Indirect β	95% bootstrap CI	p-value	Decision
H10	MTM → MC → MBP	0.086	[0.050, 0.127]	<0.001	Supported
H11	POE → MC → MBP	0.075	[0.041, 0.112]	<0.001	Supported
H12	DTI → MC → MBP	0.077	[0.043, 0.114]	<0.001	Supported
H13	MBS → MC → MBP	0.099	[0.063, 0.138]	<0.001	Supported

As reported in Table 5, all four indirect effects were positive, and their 95% bootstrap confidence intervals excluded zero. This indicates that each capability had a positive indirect association with business performance through maritime competitiveness in the generated dataset. For port operational efficiency, the indirect effect was statistically distinguishable from zero while the direct effect on business performance was not. This pattern is consistent with an indirect-only mediation pattern in this particular simulation.

Effect sizes

To assess the relative contribution of each predictor to the explained variance of the endogenous constructs, effect sizes (f^2) were calculated. Table 6 reports the change in explained variance associated with omitting each predictor from the relevant structural equation.

Table 6. Effect sizes (f^2) for the structural model.

Endogenous construct	Predictor	f^2
MC	MTM	0.071
MC	POE	0.053
MC	DTI	0.054
MC	MBS	0.089
MBP	MTM	0.026
MBP	POE	0.009
MBP	DTI	0.085
MBP	MBS	0.031
MBP	MC	0.179

As shown in Table 6, maritime competitiveness had the largest effect on maritime business performance ($f^2 = 0.179$), followed by digital technology integration ($f^2 = 0.085$). The effects of the individual capability constructs on maritime competitiveness were smaller in magnitude. These effect sizes reflect the parameterization of the simulation and should not be generalized to actual maritime organizations.

Discussion

The simulation demonstrates the internal coherence of the proposed capability–competitiveness–performance model under a controlled data-generating process. The four

organizational capabilities were positively related to maritime competitiveness, while competitiveness had the strongest direct association with business performance in the structural equation. This pattern is consistent with the theoretical argument that operational and strategic resources create value partly by improving service differentiation, market responsiveness, and customer relationships.

The positive MTM-to-competitiveness path illustrates the strategic role of route and schedule planning, resource allocation, and operational risk management. Port operational efficiency also contributed positively to competitiveness. This aligns with multi-stakeholder approaches to port performance and with research emphasizing process management and market access as important features of port efficiency (Ha et al., 2017; Saragiotis, 2019; Rødseth et al., 2023).

Digital technology integration displayed positive relationships with both competitiveness and business performance in the simulated model. This is theoretically consistent with research showing that port-centric information integration can support port-community operational capability and performance (Jiang et al., 2023), and with Indonesian port research linking digital capability and management support to organizational performance (Putra et al., 2024; Utama et al., 2024). The implication is not that technology adoption automatically produces performance gains; rather, digital systems must be integrated into operating routines, decision processes, and stakeholder interfaces.

Maritime business strategy was positively associated with competitiveness and performance. This supports the resource-based and dynamic-capabilities interpretation that strategic clarity, market responsiveness, and business development help organizations align their resources with changing market conditions. The finding is also compatible with literature emphasizing that port competitiveness is shaped by a portfolio of strategic and operational drivers (Parola et al., 2017; Başтuğ et al., 2022).

The mediation results show positive indirect paths from all four capabilities to business performance through competitiveness. In the synthetic model, the direct effect of port operational efficiency on performance was not significant while its indirect effect was significant. This pattern highlights why direct and indirect pathways should be examined together. However, these outcomes are a consequence of the simulation design and are not empirical evidence that the same mediation pattern exists in Indonesian maritime organizations.

The results should be interpreted as a methodological demonstration. The generated sample was constructed from known latent relationships and measurement assumptions; consequently, the analysis assesses whether the estimation and reporting workflow recovers patterns embedded in the simulation. It does not test the prevalence, strength, or causal direction of relationships in the real maritime industry.

Managerial and Policy Implications

The framework offers a structured diagnostic lens for maritime organizations. Shipping companies can assess route and schedule management, capacity allocation,

operational risk, and service reliability. Port and terminal organizations can review cargo-handling coordination, equipment utilization, process integration, and information exchange. Maritime service businesses can evaluate the extent to which digital systems support core workflows and customer interfaces.

At the ecosystem level, policymakers and industry institutions can prioritize interoperability, consistent data standards, workforce development, and coordination between shipping and port stakeholders. Competitive positioning should be treated as an explicit management outcome: operational efficiency and digital investments should be linked to service reliability, responsiveness, differentiation, and customer value. These implications are derived from the theoretical model and the simulated relationships; their operational prioritization requires validation with actual organizational evidence.

CONCLUSION

This study develops and demonstrates an integrated model linking maritime transportation management, port operational efficiency, digital technology integration, and maritime business strategy with maritime competitiveness and maritime business performance. In a synthetic dataset of 400 cases, the reflective measurement model met the selected reliability and validity criteria. The structural model explained 37.4% of the variance in competitiveness and 49.9% of the variance in business performance. Competitiveness was positively associated with business performance, and all four specific indirect effects were positive in the simulation. The direct effect of port operational efficiency on business performance was not statistically significant at the 5% level.

The principal contribution is the demonstration of an integrated PLS path model and a transparent analysis workflow for maritime management research. The results are simulation outputs, not empirical findings about Indonesian maritime organizations. A field study using genuine responses is required before substantive conclusions can be drawn about the industry.

Limitations and Future Research

The principal limitation is the synthetic origin of the dataset. The data-generating process embeds prespecified relationships and therefore cannot substitute for field observations. The bootstrap intervals are conditional on the estimated full-sample outer weights, rather than based on complete outer-model re-estimation in every resample. Future research should administer the questionnaire to eligible managers and professionals, document sampling and response rates, conduct expert content validation and pilot testing, and re-estimate the full measurement and structural models using the collected data. Subsequent studies may incorporate objective operational and financial indicators, environmental performance, safety, resilience, regulatory quality, and supply-chain integration.

Data Availability Statement

The 400-case synthetic dataset generated for this simulation is provided as a supplementary CSV file. It contains no actual respondent records. The generation seed is 20261103. The dataset may be used to reproduce the illustrative analyses reported in this manuscript.

Ethics Statement

No human participants were involved. All observations were computer-generated for methodological demonstration; therefore, participant consent and human-subject ethics approval were not applicable to this simulation.

Conflict of Interest

The authors declare no conflict of interest.

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