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A Structural Model of Maritime Logistics Collaboration: Examining the Roles of Adaptive Leadership and Trust in Driving Performance

Dothy
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
Email: dothy@pelindo.co.id, 7032201017@student.its.ac.id

Raja Oloan Saut Gurning
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
Email: sautg@its.ac.id

Imam Baihaqi
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
Email: ibaihaqi@mb.its.ac.id

Bahana Wiradanti
Pelabuhan Indonesia, Jakarta, Indonesia
Email: bahanawdanti@gmail.com

ABSTRACT

Maritime logistics collaboration research has concentrated on bilateral trust and digital integration, while the structural roles of adaptive leadership, organizational flexibility, trust, and internal capability as antecedents of collaboration remain underexplored, particularly in emerging archipelagic economies. This study develops and empirically tests a structural model using Partial Least Squares Structural Equation Modeling (PLS-SEM) with survey data from 120 Indonesian port stakeholders, situated within Indonesia's National Logistics Ecosystem (NLE), a government reform initiative integrating cargo flows from vessel arrival to warehouse delivery through a unified national digital platform. The initial conceptual model, grounded in the literature, examines adaptive leadership, organizational flexibility, trust, and internal capability as antecedents of maritime logistics collaboration and collaboration as a driver of operational, financial, and environmental performance. Following measurement model assessment, the model was empirically respecified to address construct overlap and improve statistical robustness. The final model reveals a sequential mechanism in which Adaptive Leadership significantly strengthens Trust, Trust facilitates Strategic Collaboration, and Strategic Collaboration enables Operational Collaboration. Operational Collaboration subsequently improves Operational, Financial, and Environmental Performance, with the strongest effect observed on Operational Performance. The findings extend traditional trust centered collaboration perspectives by demonstrating how leadership and relational mechanisms progress through strategic and operational collaboration to generate multidimensional performance. The study therefore advances a governance-based orchestration perspective on maritime logistics collaboration while highlighting the importance of translating strategic alignment into coordinated operational action.

Keywords: *collaboration, maritime logistics, adaptive leadership, trust, Indonesia, PLS-SEM*

1. INTRODUCTION

Approximately 80% of global trade by volume is transported by sea, positioning port-based logistics systems as critical nodes within global supply chains (Lun, Lai, and Cheng, 2010). As supply chains grow increasingly complex and geographically dispersed, ports have evolved from passive cargo handling facilities into strategic platforms coordinating multiple interdependent actors (Notteboom and Rodrigue, 2005). Supply chain collaboration, which encompasses joint planning, synchronized decision making, and incentive alignment among independent firms, has been consistently recognized as a mechanism for enhancing efficiency, responsiveness, and competitiveness (Simatupang and Sridharan, 2005; Cao and Zhang, 2011). In maritime logistics, collaboration is particularly critical due to high asset specificity, regulatory complexity, and multistakeholder operational interdependence, where coordination failures generate congestion, documentation duplication, and environmental externalities (Lam, 2011).

Despite growing scholarly interest, existing research has concentrated predominantly on technological integration and bilateral trust as drivers of maritime collaboration (Kim *et al.,* 2021; Morgan and Hunt, 1994), while structural drivers such as adaptive leadership and organizational flexibility have received limited empirical attention within port ecosystem contexts (Haezendonck and Langenus, 2019). Furthermore, evidence linking maritime collaboration to multidimensional performance outcomes across operational, financial, and environmental dimensions in emerging economies remains insufficient. Port ecosystems involve heterogeneous actors whose coordination cannot be reduced to bilateral trust or digital platform adoption, as effective collaboration requires governance mechanisms capable of translating ecosystem level leadership into adaptive operational alignment across stakeholders.

Indonesia presents a particularly relevant empirical context. As the world's largest archipelagic state, comprising more than 17,000 islands, the country depends structurally on maritime transport for domestic distribution and international trade. Persistent logistics challenges, including fragmented customs procedures, infrastructure disparities between western and eastern regions, overlapping regulatory institutions, and limited interorganizational transparency, have contributed to logistics performance rankings that consistently lag behind several ASEAN peers (Ambarwati, 2022). Cargo owners, central to supply chains as demand generators and contractual decision makers, remain largely treated as transactional participants rather than strategic collaborators within port governance structures (Song and Panayides, 2008), further constraining vertical collaboration effectiveness.

In response, the Indonesian government launched the National Logistics Ecosystem (NLE) initiative through Presidential Instruction No. 5 of 2020, integrating international cargo flows from vessel arrival to warehouse delivery via the Indonesia National Single Window (INSW). The initiative addresses business process simplification, government and private platform integration, and digital coordination across port stakeholders. Although NLE/INSW reform has standardized documentation and data flows, port collaboration performance remains variable. The structural mechanisms that translate ecosystem orchestration into operational collaboration, beyond document digitization, have not been empirically examined, making Indonesia an analytically compelling setting in which governance-based drivers of collaborative performance become particularly visible.

While prior research has examined bilateral trust and IT integration as drivers of maritime collaboration, the joint structural roles of adaptive leadership and organizational flexibility, and their empirical link to multi-dimensional performance outcomes covering operational, financial, and environmental dimensions, have not been modeled within a multistakeholder emerging archipelagic context. This study addresses these gaps by proposing and testing a structural model using Partial Least Squares Structural Equation Modeling (PLS-SEM) with survey data from 120 Indonesian port stakeholders. Specifically, the study examines: (1) how leadership, trust, internal capability, and organizational flexibility drive collaboration; (2) how collaboration influences operational, financial, and environmental performance; and (3) whether organizational flexibility mediates the effect of leadership on collaboration. By answering these questions, this study contributes to supply chain collaboration theory through the integration of leadership and flexibility which constructs within maritime contexts. This study contributes by advancing a governance-based orchestration perspective beyond traditional trust-based collaboration approaches in maritime logistics ecosystems. It also provides empirical evidence from an emerging archipelagic economy undergoing logistics reform. The findings aim to inform both academic discourse and strategic decision making in maritime logistics systems seeking enhanced competitiveness and sustainable performance. If this research gap is not addressed, maritime logistics systems particularly in emerging archipelagic contexts such as Indonesia will continue to face fragmented coordination among stakeholders, leading to persistent operational inefficiencies, sub-optimal port performance, limited effectiveness of initiatives such as the NLE, and ultimately weakened progress toward financial viability and environmental sustainability.

2. LITERATURE REVIEW

2.1 Collaboration in Port and Maritime Logistics Ecosystems

Maritime logistics systems operate as complex ecosystems of interdependent actors, including port authorities, terminal operators, shipping lines, freight forwarders, trucking companies, cargo owners, and regulatory agencies, whose collective performance depends on the quality of coordination across organizational boundaries rather than the capabilities of any single actor (Notteboom and Rodrigue, 2005). Collaboration in this context is defined as a process in which independent organizations jointly plan, coordinate, and execute logistics activities to achieve shared benefits and improved system performance (Simatupang and Sridharan, 2005; Barratt, 2004). Within port ecosystems, collaborative arrangements involving information sharing, synchronized planning, and coordinated decision making have been shown to reduce congestion and logistics costs (Tongzon, 2009), optimize cargo flow utilization (Jacobsson, Arnäs and Stefansson, 2018), improve supply chain transparency (Klumpp *et al.,* 2011), strengthen environmental monitoring (Parola *et al.* 2014), and support emission regulation compliance (Lam, 2011). Despite these benefits, port ecosystems involve heterogeneous actors with competing priorities. Shipping lines prioritize schedule reliability, terminal operators focus on cargo productivity, and government agencies emphasize regulatory compliance, creating coordination challenges that dyadic supply chain models do not adequately address. Table 1 summarizes the most relevant prior studies. This study addresses the gap shown in Table 1, including variables from existing research which are drivers and linking to multidimensional performance in emerging archipelagic context. The integration and interaction of these latent variables within a single conceptual model for the maritime logistics context becomes the uniqueness of this study.

Table 1 Most Relevant Research on Maritime Logistics Collaboration

Relevant Studies	AL	OF	IC	T	OP	FP	EP	Type of Collaboration	Findings
Song and Panayides (2008)			✓			✓		Joint digital marketing strategy between port operators and port users	Digital collaboration supports marketing and financial outcomes
Tongzon (2009)		✓			✓			Electronic based information sharing between ports and shipping lines	Integrated IT infrastructure improves coordination
Lam (2011)	✓						✓	Enforcement of emission related regulations between ports and government	Strengthens environmental monitoring and compliance
Klumpp *et al.* (2011)		✓			✓			Provision of supply chain management information between ports and customers	Improves transparency and on time logistics services
Ascencio *et al.* (2014)			✓		✓			Container terminal operations management	Integrated logistics platforms and digital coordination systems improve operational visibility, cargo flow coordination, and port logistics efficiency.
Parola *et al.* (2014)		✓					✓	Integrated waste management collaboration between port operators and users	Improves waste management performance
Parola *et al.* (2014)		✓			✓			Automation technology for terminal equipment	Increases cargo handling efficiency
Parola *et al.* (2014)		✓					✓	Adoption of green technology in port operations	Improves environmental performance
Jacobsson, Arnäs and Stefansson (2018)		✓			✓			Electronic information sharing between ports and freight forwarders	Optimizes utilization of port areas
Mlimbila and Mbamba (2018)		✓			✓	✓		Information sharing for port logistics improvement	Reduces logistics costs and improves delivery performance
Arachchige *et al.* (2019)		✓			✓			Collaboration between terminal operators and container shipping firms	Improves cargo handling and customs coordination
Jeevan *et al.* (2019)			✓		✓			Implementation of dry port management procedures	Identifies factors influencing dry port operational performance
Lai *et al.* (2020)				✓	✓			Cultural collaboration in supply chain management	Cultural factors influence collaboration behavior
Kim *et al.* (2021)				✓	✓			Inter organizational collaboration between freight forwarders and ports	Trust and transparency influence collaboration
Lasse *et al.* (2025)	✓			✓	✓			Digital collaboration (AI driven collaboration platforms)	Leadership, trust, organizational culture, communication, and digital readiness facilitate collaboration and improve port resilience and performance.
This research	✓	✓	✓	✓	✓	✓	✓	Exploring Collaboration in structural model explaining drivers and linking to multidimensional performance in emerging archipelagic context	Adaptive Leadership significantly strengthens Trust, Trust facilitates Strategic Collaboration, and Strategic Collaboration enables Operational Collaboration

Note: AL: Adaptive Leadership (P2); OF: Organizational Flexibility (P4); IC: Internal Capability (P3); T: Trust (P1); OP: Operational Performance (Y1); FP: Financial Performance (Y2); EP: Environmental Performance (Y3).

2.2 Structural and Relational Drivers of Collaboration

Scholars broadly categorize collaboration drivers into structural factors, which relate to organizational capabilities and governance mechanisms, and relational factors such as trust. As summarized in Table 1, prior maritime logistics studies have examined various forms of collaboration, including digital integration, information sharing, terminal coordination, environmental management, and inter organizational cooperation among ports, shipping lines, freight forwarders, terminal operators, and regulators. Existing studies have demonstrated that collaboration improves operational efficiency, cargo handling performance, transparency, sustainability, and financial outcomes (Song and Panayides, 2008; Tongzon, 2009; Lam, 2011). There are increasing importance of collaboration, coordination, and integration in improving supply chain performance and resilience (Dhaigude, 2026). Effective coordination mechanisms play an essential role in enhancing operational efficiency and overall supply chain performance (Partovi *et al.,* 2026). However, despite the growing body of research, the structural roles of adaptive leadership, organizational flexibility, and internal capability as antecedents of collaboration remain relatively underexplored within maritime port ecosystems, particularly in emerging archipelagic economies. Therefore, this study examines four key latent variables drawn from the literature: Adaptive Leadership, Organizational Flexibility, Internal Capability, and Trust.

Adaptive leadership provides a framework for understanding leadership dynamics in complex multistakeholder environments (Heifetz, Grashow and Linsky, 2009; Mangan and Lalwani, 2016). Rather than relying solely on directive authority, adaptive leaders mobilize stakeholders, facilitate communication across institutional boundaries, and create conditions for collective problem solving in response to operational uncertainty and environmental change. In maritime logistics ecosystems involving multiple regulatory agencies, terminal operators, shipping lines, freight forwarders, and cargo owners, leadership functions as an orchestration mechanism that aligns stakeholders toward shared operational objectives (Notteboom and Rodrigue, 2005; Lam, 2011). Leadership capabilities and organizational adaptability have been recognized as important drivers of organizational performance and long-term competitiveness (Azizi *et al.,* 2025). However, as shown in Table 1, prior maritime collaboration studies have focused predominantly on technological integration and operational coordination mechanisms, such as digital marketing collaboration (Song and Panayides, 2008), electronic information sharing (Tongzon, 2009; Jacobsson, Arnäs and Stefansson, 2018), integrated logistics platforms and digital coordination systems which improves operational visibility, cargo flow coordination, and port logistics efficiency (Ascencio *et al.,* 2014; Jacobsson, Arnäs and Stefansson, 2018), while leadership driven governance mechanisms remain less empirically explored.

Organizational flexibility refers to an organization's ability to adapt operational processes, resource allocation, and decision-making structures in response to environmental uncertainty (Sanchez, 1995; Christopher and Peck, 2004). Flexibility is particularly important in maritime logistics systems, where operations are frequently affected by vessel arrival variability, congestion, weather disruptions, customs procedures, and regulatory changes. Studies summarized in Table 1 indicate that flexible coordination mechanisms support improved operational integration and responsiveness. Electronic information sharing between ports and shipping lines improves coordination efficiency (Tongzon, 2009), while collaboration between terminal operators and shipping firms enhances cargo handling and customs coordination (Arachchige, Shinohara and Takahashi, 2019). Similarly, dry port operational coordination and information sharing improve logistics efficiency and delivery performance (Jeevan *et al.,* 2019; Mlimbila and Mbamba, 2018). These studies collectively suggest that maritime collaboration requires organizations to maintain adaptive operational arrangements and responsive coordination mechanisms under dynamic conditions.

Internal capability encompasses the technological, managerial, and operational resources that enable organizations to participate effectively in collaborative logistics networks (Barney, 1991; Teece, Pisano and Shuen, 1997). Such capabilities include digital infrastructure, operational expertise, cargo tracking systems, automation technologies, and managerial competencies that support real time coordination and information exchange. Prior maritime logistics studies have emphasized the importance of technological and operational capabilities in improving coordination and port performance. For example, advanced terminal management systems improve crane, vehicle, and yard coordination, while integrated logistics management platforms enhance maritime logistics collaboration and operational visibility (Ascencio *et al.,* 2014). Klumpp *et al.* (2011) further demonstrate that supply chain management information sharing improves logistics transparency and on time delivery performance. Although these studies confirm the importance of internal capability, capability alone may not automatically generate collaboration without supporting governance structures and organizational flexibility.

Trust, grounded in commitment trust theory, reduces perceived risks associated with inter organizational cooperation and encourages long term collaborative relationships through information sharing and joint investment (Morgan and Hunt, 1994; Barratt, 2004). Within maritime logistics systems, transparency and trust have been shown to influence collaboration between ports, logistics service providers, and freight forwarders (Kim *et al.,* 2021; Baah *et al.,* 2021a). Cultural alignment and relational quality also shape collaborative behavior within logistics ecosystems (Lai *et al.,* 2020; Barratt, 2004). However, Table 1 also illustrates that many maritime logistics collaborations operate through operational necessity, shared infrastructure, and institutional coordination rather than trust alone. Environmental collaboration initiatives, such as integrated waste management systems and green port operations, require coordinated governance mechanisms among multiple actors (Parola *et al.,* 2014; Lam, 2011). In operationally intensive environments characterized by synchronized scheduling, shared infrastructure, and real time coordination, relational trust alone may therefore be insufficient to ensure effective collaboration. Consequently, collaboration in maritime logistics ecosystems may depend not only on trust, but also on adaptive governance structures, organizational flexibility, and coordinated operational mechanisms capable of integrating multiple stakeholders across the port ecosystem.

Furthermore, the following are explanation for each hypothesis in the model. First, hypothesis on Adaptive Leadership and Trust. Adaptive leadership is expected to strengthen trust by promoting communication, responsiveness, and stakeholder alignment under uncertain operational conditions. Adaptive leaders facilitate coordination across organizational boundaries and encourage collaborative problem solving, which helps build mutual confidence among stakeholders in complex logistics environments (Defee *et al.,* 2009; Heifetz *et al.,* 2009). Within maritime logistics ecosystems involving multiple actors and institutional interests, adaptive leadership may therefore support stronger inter organizational trust. Based on this rationale, the following hypothesis is proposed: H1: Adaptive Leadership has a positive effect on Trust.

Second, hypothesis on Adaptive Leadership and Organizational Flexibility. Adaptive Leadership is theorized as a critical driver for navigating complex environments. According to Heifetz *et al.* (2009), leaders who practice adaptability can foster an environment where organizational structures remain fluid yet functional. In the context of maritime logistics, this leadership style allows firms to pivot their strategies in response to digital shifts like the NLE. Uhl-Bien and Arena (2018) further argue that leadership in such ecosystems acts as a catalyst for organizational flexibility, enabling the firm to absorb external shocks. Based on this logic, it is proposed that: H1: Adaptive Leadership has a positive effect on Organizational Flexibility.

Third, hypothesis on Organizational Flexibility and Internal Capability. Organizational flexibility is expected to enhance internal capability by enabling organizations to adapt their operational processes, resource allocation, and decision-making structures in response to changing environmental conditions. Flexible organizations are better able to develop competencies, strengthen operational readiness, and reconfigure resources to support coordination and performance improvement (Sanchez, 1995; Teece *et al.,* 1997). In maritime logistics ecosystems characterized by uncertainty and operational complexity, organizational flexibility may therefore strengthen the development of internal capabilities. Based on this rationale, the following hypothesis is proposed: H3: Organizational Flexibility has a positive effect on Internal Capability.

Fourth, hypothesis on Trust and Collaboration. Relational Exchange Theory suggests that trust is a fundamental precursor to long-term partnerships. According to Morgan and Hunt (1994) and Barratt (2004), trust reduces the perceived risks of opportunistic behavior and lowers transaction costs in supply chain dyads. In the context of port operations, where multiple private and public entities interact, trust is expected to facilitate smoother information sharing and resource alignment. Therefore, H4: Trust has a positive effect on maritime logistics collaboration.

Fifth, hypothesis on Adaptive Leadership and Collaboration. While leadership often influences internal culture, its role in driving cross-organizational collaboration is increasingly vital. Heifetz *et al.* (2009) argue that adaptive leaders are capable of 'orchestrating' conflict and aligning diverse stakeholders toward a common goal. In a complex maritime ecosystem, adaptive leadership provides the strategic vision necessary to encourage independent firms to participate in collaborative platforms like the NLE. In relation to this rational therefore, H5: Adaptive Leadership has a positive effect on maritime logistics collaboration.

Sixth, hypothesis on Internal Capability and Collaboration. Based on the Resource-Based View (RBV), a firm's internal technical and managerial capabilities determine its readiness to engage in external networks. Sarkis *et al.* (2011) emphasize that without robust internal processes and digital readiness, firms cannot effectively synchronize their operations with external partners. Therefore, a high level of internal capability is theorized to be a prerequisite for effective logistics collaboration. Hence, H6: Internal Capability has a positive effect on maritime logistics collaboration.

Seventh, hypothesis on Organizational Flexibility and Collaboration. Organizational Flexibility serves as the operational 'bridge' that translates strategic intent into collaborative action. Defee and Stank (2005) emphasize that without the inherent capability to reconfigure resources, firms struggle to align their processes with external partners. In maritime supply chains, flexibility ensures that different stakeholders can synchronize their operations despite varying technical standards. This alignment is essential for the emergence of structured collaboration within a national ecosystem. Thus, in this context, the hypothesize becomes: H7: Organizational Flexibility positively influences maritime logistics collaboration. Meanwhile, while leadership sets the direction, its impact on collaboration is often indirect, mediated by the internal capabilities of the firm. Integrating the Dynamic Capabilities view (Teece, 2007), we argue that adaptive leadership builds the 'flexibility' necessary for a firm to become a viable partner in a collaborative network. Without organizational flexibility, leadership efforts may fail to manifest as actual collaborative outcomes. Therefore, this paper may propose that H2 and H7: Organizational Flexibility mediates the relationship between Adaptive Leadership and Collaboration.

Lastly, hypothesis for the relationship to Performance. The ultimate goal of maritime collaboration is the improvement of multi-dimensional performance. According to Cao and Zhang (2011), collaborative advantage arises when partners achieve synergies that could not be reached individually. H8 (Operational) explains that Collaboration leads to better synchronization of vessel schedules and cargo handling, thereby enhancing operational efficiency (H8). H9 (Financial) explains that shared resources and reduced lead times directly contribute to cost savings and improved profitability for port stakeholders (H9). H10 (Environmental) explains further that integrated logistics coordination reduces carbon footprints through optimized routing and reduced port congestion, aligning with global maritime sustainability goals (H10). Based on these arguments, it is proposed that H8: Maritime logistics collaboration has a positive effect on operational performance; H9: Maritime logistics collaboration has a positive effect on financial performance; H10: Maritime logistics collaboration has a positive effect on environmental performance.

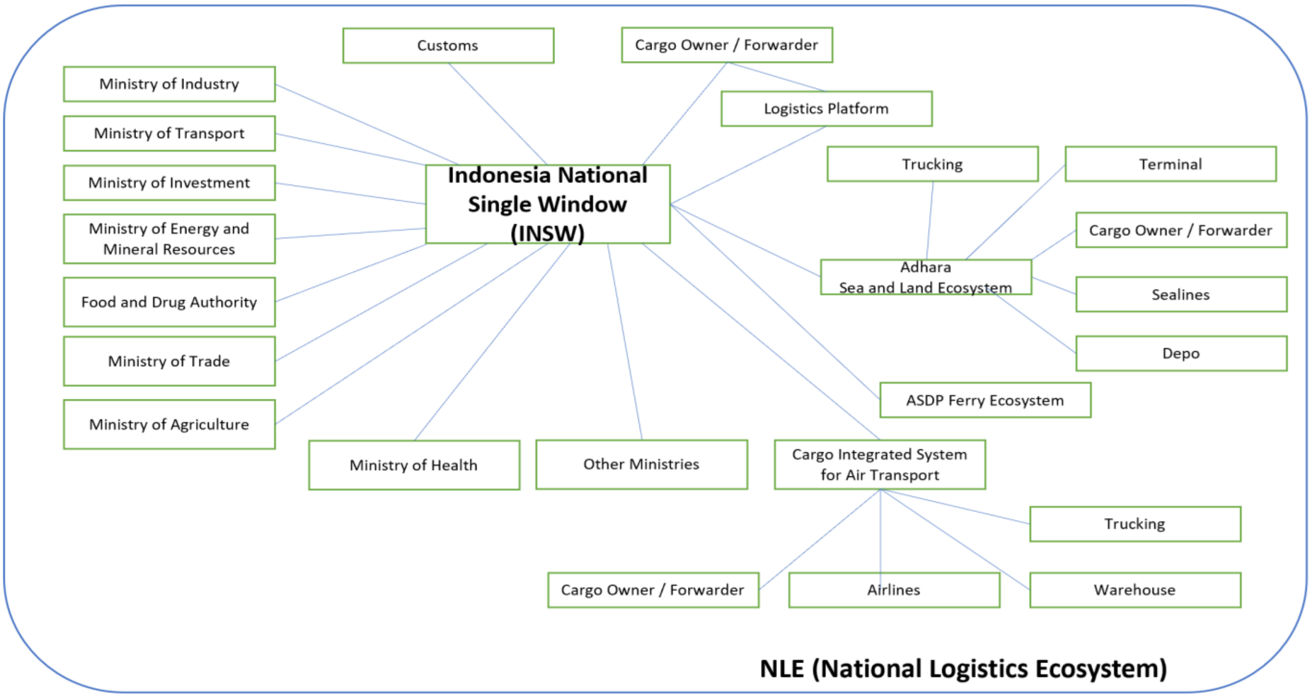

Figure 1 Indonesia National Single Window in the NLE
(Coordinating Ministry for Economic Affairs of the Republic of Indonesia, 2023)

2.3 Indonesia's Maritime Logistics Collaboration and the National Logistics Ecosystem

Indonesia presents a particularly relevant empirical context. As the world's largest archipelagic state, it depends structurally on maritime transport, yet its logistics system has historically been characterized by fragmentation across port operations, customs procedures, and regulatory institutions, contributing to high logistics costs and lagging regional competitiveness (Ambarwati, 2022). To address this, the government introduced the National Logistics Ecosystem (NLE) initiative, integrating digital platforms, harmonizing administrative procedures, and promoting collaboration among government agencies and private sector logistics actors through a unified national system (Coordinating Ministry for Economic Affairs of the Republic of Indonesia, 2023). Figure 1 illustrates Indonesia's National Single Window and the relevant stakeholders within the NLE. The NLE connects port authorities, customs agencies, and logistics providers to improve transparency and reduce administrative duplication, representing an attempt to orchestrate ecosystem level collaboration through institutional coordination and digital integration.

2.4 Research Gap and Conceptual Framework

Three gaps motivate this study. First, most collaboration research examines dyadic buyer supplier relationships, while port ecosystems require multistakeholder coordination across actors with different institutional mandates. Second, prior studies emphasize relational trust as the primary collaboration driver, while structural enablers such as adaptive leadership and organizational flexibility remain underexplored empirically in maritime contexts. Third, existing work focuses predominantly on operational efficiency outcomes, and the simultaneous effects of collaboration on financial and environmental performance have received limited attention despite growing sustainability pressures (Cao and Zhang, 2011; Panayides, 2006). This study addresses all three gaps by proposing a structural model linking Adaptive Leadership and Organizational Flexibility as antecedents of Maritime Logistics Collaboration, with collaboration as the driver of operational (Barratt, 2004; Haezendonck and Langenus, 2019), financial, and environmental performance outcomes (Lun, Lai, and Cheng, 2010). Figure 2 presents the conceptual model. Furthermore, Table 3 in the Appendix details all the hypotheses identified, with supporting references provided for each hypothesized relationship.

This study also extends collaboration theory by introducing a governance-based perspective, where collaboration is not solely driven by relational trust among firms, but requires orchestration by a lead entity within the ecosystem. In the Indonesian context, this role is primarily assumed by regulatory institutions through initiatives such as the National Logistics Ecosystem, which coordinate stakeholders, align incentives, and enable system level integration. This perspective highlights that effective maritime logistics collaboration depends on leadership driven governance structures that translate policy level direction into operational coordination through organizational flexibility. Unlike prior studies that primarily examine collaboration through direct relationships between relational variables such as trust and performance, this study proposes a structured model in which adaptive leadership influences collaboration indirectly through organizational

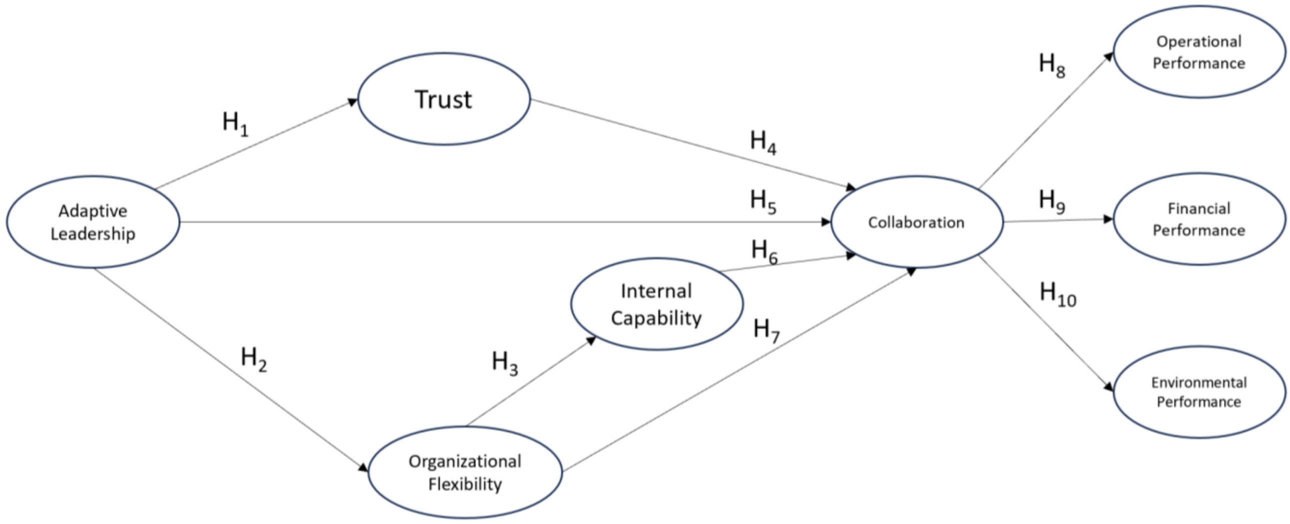

Figure 2 Conceptual Model of Collaboration in Maritime Logistics

flexibility as a mediating mechanism. This introduces a governance-based orchestration logic that extends beyond traditional dyadic or trust centric models by explicitly linking leadership, structural adaptability, and multidimensional performance outcomes within a complex port ecosystem.

Moreover, maritime logistics differs from general supply chain or ecosystem studies in that it operates within highly complex, multi stakeholder port ecosystems involving regulators, port authorities, terminal operators, and logistics service providers with divergent objectives. This creates inherently greater coordination challenges, requiring stronger governance orchestration and structural flexibility, as decisions are not only operational but also institutional and infrastructure dependent.

3. METHODOLOGY

3.1 Research Design and Data Collection

This study adopts a quantitative, cross sectional survey design to examine the relationships among adaptive leadership, trust, organizational flexibility, collaboration, and organizational performance in the Indonesian maritime logistics sector. Survey based research is appropriate for examining latent constructs that cannot be directly observed and therefore require perceptual measurement (Hair *et al.,* 2016). The unit of analysis is the organizational stakeholder involved in maritime logistics operations.

A structured questionnaire was developed based on validated measurement scales from prior supply chain and logistics research. Items measuring adaptive leadership were adapted from organizational leadership literature (Heifetz, *et al.,* 2009). Trust and collaboration items were adapted from established supply chain collaboration scales (Simatupang and Sridharan, 2005; Cao and Zhang, 2011). Organizational flexibility measures were adapted from supply chain flexibility research (Stevenson and Spring, 2007). Performance measures included operational, financial, and environmental indicators consistent with logistics performance literature (Panayides, 2006; Lam, 2011). All items were measured using a five-point Likert scale ranging from strongly disagree to strongly agree (Hair *et al.,* 2016).

Prior to full scale distribution, the questionnaire underwent expert review and pre testing involving academic experts and industry practitioners to evaluate content validity, clarity, and contextual relevance. Minor revisions were made to improve linguistic clarity and conceptual equivalence in the Indonesia language version while preserving the theoretical meaning of the original constructs. These procedures enhanced the reliability and validity of the survey instrument.

3.2 Justification for PLS-SEM in Maritime Logistics Research

Maritime logistics research increasingly employs structural modeling techniques to examine interorganizational dynamics (Panayides, 2006; Kim, Park, and Lee, 2021). This study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) rather than covariance-based SEM because the primary objective is prediction and theory development within a complex, relatively underexplored structural framework. The proposed model integrates multiple latent constructs, mediating relationships, and multidimensional performance outcomes. PLS-SEM is better suited to this configuration due to its higher statistical power for complex models and its capacity to maximize explained variance in endogenous variables (Hair *et al.,* 2016; Chin, 1998). Additionally, perceptual survey data collected from diverse maritime logistics stakeholders do not necessarily satisfy multivariate normality assumptions. As a variance-based technique robust to non-normal data, PLS-SEM is appropriate for the exploratory and predictive orientation common in supply chain and maritime research (Panayides, 2006; Hair *et al.,* 2016).

All latent constructs are modeled as reflective because the indicators are conceptualized as manifestations of underlying theoretical variables rather than components that collectively form them. Constructs such as adaptive leadership, trust, organizational flexibility, and collaboration represent behavioral and relational phenomena whose changes are expected to be reflected simultaneously across all measurement items (Hair *et al.,* 2016; Jarvis, MacKenzie, and Podsakoff, 2003). The indicators are interchangeable,

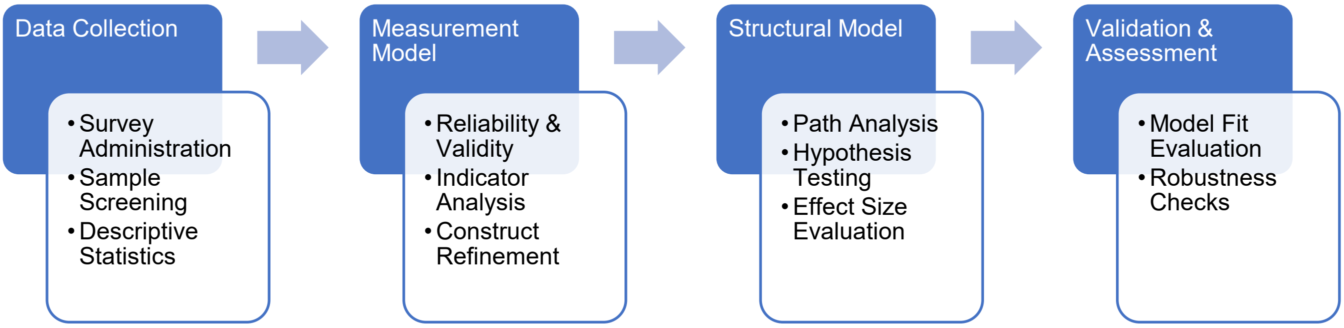

Figure 3 Research Flow Diagram

highly correlated, and derived from established literature, consistent with prior supply chain collaboration research that operationalizes similar constructs reflectively to capture stakeholder perceptions and relational quality (Cao and Zhang, 2011; Panayides, 2006).

PLS-SEM is employed in this study due to its strong suitability for prediction-oriented research, particularly in models with complex relationships and multiple latent constructs, where the primary objective is to maximize explained variance rather than confirm an established theory. Compared to CB SEM, PLS SEM is also more appropriate for exploratory model development and relatively moderate sample sizes, making it well aligned with the study's aim to examine emerging governance-based relationships within a complex maritime logistics ecosystem.

3.3 Measurement Model Development and Data Analysis Using PLS-SEM

The conceptual model includes the following latent constructs Adaptive Leadership, Trust, Internal Capability, Organizational Flexibility, Maritime Logistics Collaboration, Operational Performance, Financial Performance, and Environmental Performance. Item questions as indicators are detailed in Table 3 in the Appendix. All constructs are modeled as reflective constructs, as indicators are assumed to reflect underlying latent variables (Hair *et al.,* 2016). Reliability and validity assessments were conducted using the following criteria: 1) Indicator reliability: outer loadings above 0.70; 2) Internal consistency reliability: Cronbach's alpha and composite reliability above 0.70; 3) Convergent validity: Average Variance Extracted (AVE) above 0.50; 4) Discriminant validity: Fornell-Larcker criterion and cross-loading examination. These criteria are consistent with PLS-SEM methodological standards (Hair *et al.,* 2016; Henseler *et al.,* 2015).

Partial Least Squares Structural Equation Modeling was employed to test the proposed structural relationships. PLS-SEM is appropriate for this study for several reasons. First, PLS-SEM is prediction oriented and suitable for theory development research (Hair *et al.,* 2016). Since this study aims to examine structural relationships among leadership, flexibility, collaboration, and performance, predictive capability is essential. Second, PLS-SEM performs well with complex models and relatively moderate sample sizes (Chin, 1998). The model includes multiple constructs and paths, making covariance-based SEM less suitable due to strict distributional assumptions. Third, PLS-SEM does not require multivariate normality, which is advantageous in behavioral research settings (Hair *et al.,* 2016). The analysis followed a two-step approach:

Step 1: Measurement Model Evaluation.
The measurement model was assessed for reliability and validity. Outer loadings were examined to ensure indicator reliability. Composite reliability and Cronbach's alpha values were evaluated to confirm internal consistency. Convergent validity was assessed using AVE. Discriminant validity was examined using the Fornell-Larcker criterion and heterotrait-monotrait ratio (HTMT) (Henseler *et al.,* 2015). Indicators with loadings below acceptable thresholds were considered for removal to improve model quality while maintaining theoretical coherence.

Step 2: Structural Model Evaluation.
After confirming measurement model adequacy, the structural model was evaluated using Path coefficients, t-statistics via bootstrapping, Coefficient of determination (R^2), Effect size (f^2), Predictive relevance (Q^2), bootstrapping with 5,000 resamples was performed to assess path significance. The R^2 values indicate the explanatory power of the model for endogenous constructs. Effect sizes assess the impact magnitude of exogenous constructs on endogenous variables. Predictive relevance was assessed using blindfolding procedures to confirm out-of-sample predictive capability (Hair *et al.,* 2016).

Table 2 in the Appendix explains the latent variable in this study, including its definition, item measurements and sources. The relationships between constructs in this study are not measured through direct survey questions but are theoretically specified and tested through hypotheses. These hypotheses are empirically examined using structural model analysis, allowing the study to assess causal relationships between latent variables. Regarding the measurement instrument, all measurement items adopted for each construct were retained in the survey instrument as adapted from their respective original sources; therefore, no questionnaire items were removed during survey administration. Furthermore, the following Figure 3 describes the research steps in a flowchart diagram. Research methodology using PLS-SEM begins with Data Collection, which includes survey administration, respondent screening, and descriptive statistical analysis. The second stage is the Measurement Model, where the reliability and validity of indicators and constructs are evaluated. Next, the Structural Model assesses the relationships between variables through path analysis and hypothesis testing. Finally, Validation and Assessment are conducted to evaluate model fit and the robustness of the research findings.

3.4 Ethical Considerations and Survey Dissemination

Participation in the survey was voluntary, and respondents were informed of the academic purpose of the study. No personally identifiable information was collected, and all responses were analyzed in aggregate form to ensure confidentiality. The survey was disseminated through professional networks, institutional contacts, and organizations within the Indonesian maritime logistics sector to reach respondents with direct experience in port, terminal, and logistics operations. Follow up communications were conducted throughout the data collection period to encourage participation and improve the response rate. Respondents were selected based on their professional involvement in maritime logistics and their managerial, supervisory, or operational decision-making responsibilities. Following data screening, only valid and complete questionnaires were retained for subsequent analysis.

4. FINDINGS

4.1 Sample Profile

A total of 120 questionnaires was collected, of which 104 were deemed valid and included in the final analysis. Prior to the full survey deployment, a pre-test involving 30 respondents were conducted to evaluate the clarity, reliability, and relevance of the measurement items. The minimum required sample size was calculated as 100 based on a statistical power target of 0.80 and a significance level of 0.05. The final sample size of 120 respondents therefore exceeded the minimum threshold, supporting the adequacy of the dataset for PLS-SEM analysis.

The survey involved respondents representing various stakeholders within the Indonesian maritime logistics ecosystem, with detailed demographic information provided in Figure 5 in the Appendix. Terminal and port operators constituted the largest stakeholder group, accounting for 33% of the respondents (n = 41), followed by shipping line representatives at 19% (n = 24). Regulators contributed 13% of the sample (n = 16), while freight forwarders represented 10% (n = 13). Cargo owners and trucking companies each accounted for 9% of respondents (n = 11), and depot operators represented the remaining 6% (n = 8). This distribution indicates that the study successfully captured perspectives from a broad range of actors involved in maritime logistics activities, with particularly strong representation from organizations directly engaged in port and shipping operations. This diverse respondent profile reflects the multi stakeholder nature of maritime logistics and supports the applicability of the findings across different port ecosystem contexts (Notteboom and Rodrigue, 2005).

Overall, the respondent profile indicates that terminal and port operators, followed by shipping line representatives, constituted the largest stakeholder groups. In terms of age, respondents above 39 years old represented the dominant category, while managerial and executive level personnel formed the majority of participants. This distribution indicates that the survey successfully captured perspectives from experienced professionals directly involved in strategic and operational decision-making processes across the maritime logistics sector. In addition, comparisons between early and late respondents revealed no significant differences, suggesting that non response bias is unlikely to affect the validity of the findings.

4.2 Measurement Model Assessment

The initial conceptual model presented in Figure 2 was developed based on the theoretical relationships established in the literature review and incorporated Adaptive Leadership, Trust, Organizational Flexibility, Internal Capability, Maritime Logistics Collaboration, Operational Performance, Financial Performance, and Environmental Performance. The initial model was first subjected to measurement model assessment following established PLS-SEM guidelines (Hair *et al.,* 2016; Hair *et al.,* 2022). Indicator reliability, internal consistency reliability, convergent validity, and discriminant validity were evaluated using outer loadings, Cronbach's alpha, composite reliability, Average Variance Extracted (AVE), the Fornell Larcker criterion, cross loadings, and the Heterotrait Monotrait ratio (HTMT).

The initial assessment indicated satisfactory internal consistency reliability for the constructs. However, several measurement issues were identified, particularly regarding convergent and discriminant validity. Three constructs, Adaptive Leadership, Trust, and Operational Performance, exhibited AVE values marginally below the recommended threshold of 0.50, despite demonstrating satisfactory composite reliability. More importantly, the discriminant validity assessment revealed substantial empirical overlap among several constructs. The Fornell Larcker criterion and cross loading assessment indicated that some constructs were not sufficiently distinguishable from one another, while several structural relationships in the initial model also produced unusually high coefficients.

These findings suggested that although the initial conceptual model remained theoretically grounded in the literature, its empirical specification required further refinement. In particular, the substantial overlap involving Organizational Flexibility, Internal Capability, Maritime Logistics Collaboration, and Operational Performance raised concerns regarding construct distinctiveness and potential redundancy. Rather than interpreting these overlaps as theoretically acceptable, the measurement results were used as the basis for reassessing the empirical specification of the model.

Accordingly, model respecification was undertaken following the measurement model assessment. The purpose of this procedure was not to replace the theoretical foundation established in the literature review, but to develop a more parsimonious empirical representation in which the retained constructs could be more clearly distinguished statistically. Table 4 in the Appendix summarizes the reliability and validity assessment of the measurement model. The detailed statistical results supporting this assessment, including indicator loadings, composite reliability, AVE, Fornell–Larcker criterion, cross loadings, and HTMT values, are provided in Tables 5 to Table 9 in the Appendix. These results provide the basis for the subsequent model respecification discussed in Section 4.3.

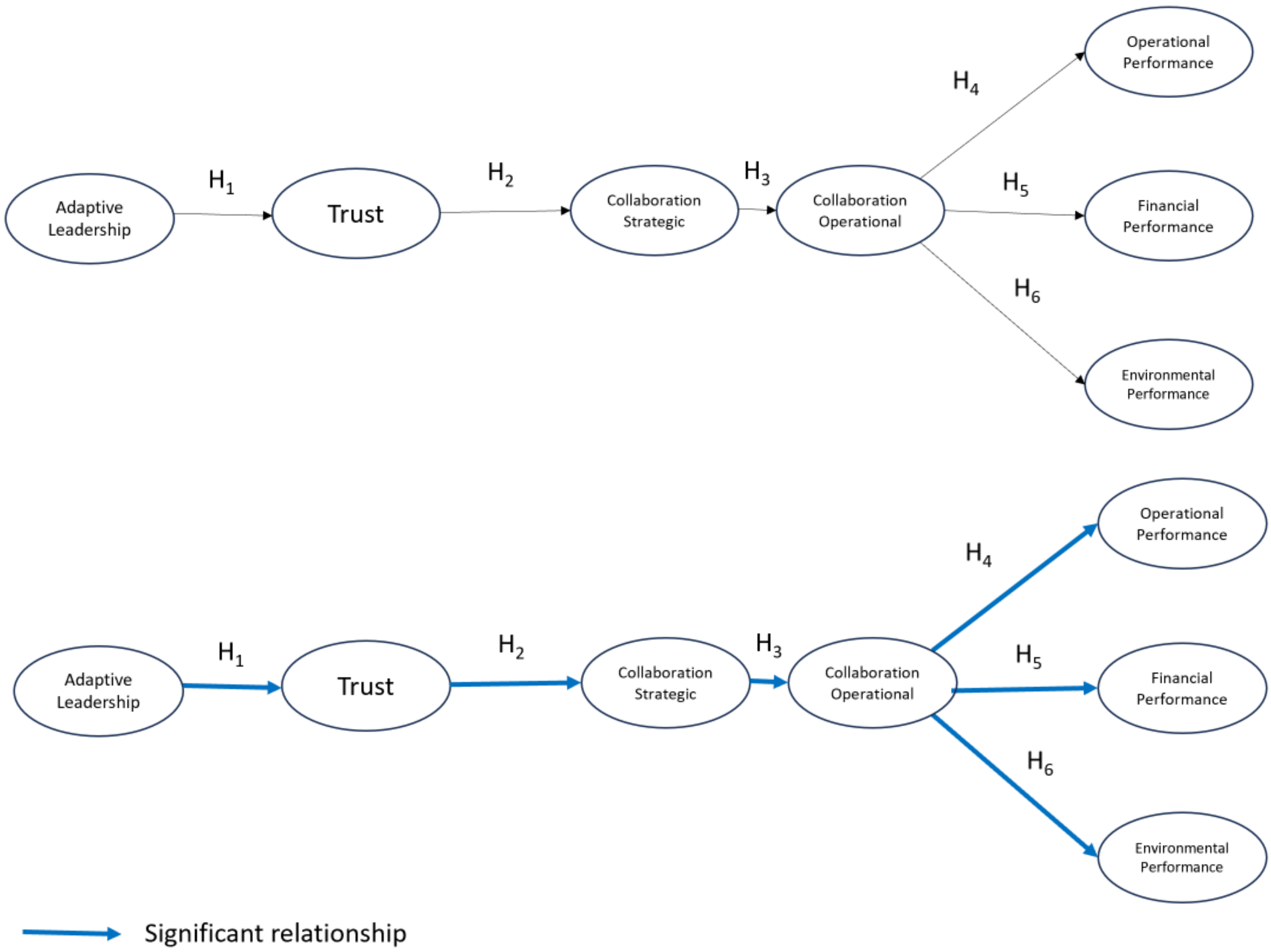

Figure 4 Revised Conceptual Model (Respecification) Following Measurement Model Assessment and Final PLS-SEM Model with Significant Relationships

4.3 Model Respecification and Structural Model Assessment

Based on the measurement model assessment, further model refinement was undertaken to address the empirical overlap identified among several latent constructs. Following the evaluation of indicator loadings and cross loadings and the elimination of problematic indicators, discriminant validity concerns remained due to substantial overlap among several constructs. Alternative specifications, including the potential combination of overlapping constructs, were subsequently examined but did not provide adequate empirical distinctiveness. Henseler *et al.* (2015) recommend that discriminant validity problems be addressed through systematic reassessment of problematic indicators and, where theoretically justified, the splitting, reassignment, or merging of constructs, followed by renewed assessment of discriminant validity. Accordingly, the empirical specification was further refined while maintaining consistency with the theoretical foundations of the study. Organizational Flexibility and Internal Capability, which continued to exhibit substantial empirical overlap with other constructs, were excluded from the respecified structural model, while Maritime Logistics Collaboration was represented through two empirically distinguishable dimensions: Strategic Collaboration and Operational Collaboration.

The resulting structure provides a more parsimonious sequential mechanism in which Adaptive Leadership influences Trust, Trust influences Strategic Collaboration, Strategic Collaboration influences Operational Collaboration, and Operational Collaboration subsequently contributes to Operational, Financial, and Environmental Performance. The revised conceptual model is presented in Figure 4. Importantly, Figure 4 represents an empirical respecification of the initial theory derived conceptual model presented in Figure 2 rather than a replacement of its theoretical foundation.

Following model respecification, the measurement properties of the retained constructs were reassessed. The hypotheses were renumbered to correspond to the retained structural relationships in the revised empirical model. All constructs demonstrated satisfactory internal consistency reliability, with Cronbach's alpha values ranging from 0.839 to 0.927 and composite reliability values ranging from 0.860 to 0.931. These values exceeded the recommended minimum threshold of 0.70, supporting the reliability of the revised measurement model.

Convergent validity was assessed using AVE. Strategic Collaboration (AVE = 0.573), Operational Collaboration (AVE = 0.608), Financial Performance (AVE = 0.685), and Environmental Performance (AVE = 0.709) exceeded the recommended threshold of 0.50. Adaptive Leadership (AVE = 0.473), Operational Performance (AVE = 0.480), and Trust

(AVE = 0.479) remained marginally below the conventional threshold. However, these constructs demonstrated satisfactory composite reliability of 0.909, 0.885, and 0.853, respectively. They were therefore retained, while their marginal AVE values are acknowledged when interpreting the measurement model.

Discriminant validity of the respecified model was reassessed using the Fornell Larcker criterion, cross loadings, and HTMT. The Fornell Larcker assessment continued to indicate relatively close relationships among several constructs, particularly Strategic Collaboration, Operational Collaboration, Adaptive Leadership, and Operational Performance. Cross loading assessment similarly demonstrated some empirical proximity among these constructs. Therefore, HTMT was additionally examined as a more sensitive criterion for discriminant validity (Henseler *et al.,* 2015).

HTMT values ranged from 0.513 to 0.894, with all values remaining below the threshold of 0.90. The highest values were observed between Operational Performance and Strategic Collaboration (0.894), Adaptive Leadership and Strategic Collaboration (0.890), Operational Performance and Operational Collaboration (0.870), and Adaptive Leadership and Operational Collaboration (0.865). Although these values indicate close relationships among several constructs, the HTMT results provide additional support for their empirical distinctiveness. Nevertheless, the remaining proximity indicated by the Fornell Larcker and cross loading assessments is considered when interpreting the structural results.

Following reassessment of the revised measurement model, the structural relationships were evaluated through bootstrapping. All six hypothesized relationships in the respecified model were statistically significant. Adaptive Leadership positively influenced Trust (H1: $\beta = 0.780$, $t = 8.118$, $p < 0.001$), while Trust positively influenced Strategic Collaboration (H2: $\beta = 0.814$, $t = 8.783$, $p < 0.001$). Strategic Collaboration subsequently exerted a significant positive effect on Operational Collaboration (H3: $\beta = 0.843$, $t = 24.468$, $p < 0.001$).

Operational Collaboration significantly influenced all three performance dimensions. The strongest relationship was observed with Operational Performance (H4: $\beta = 0.874$, $t = 20.521$, $p < 0.001$), followed by Environmental Performance (H6: $\beta = 0.679$, $t = 9.557$, $p < 0.001$) and Financial Performance (H5: $\beta = 0.597$, $t = 4.191$, $p < 0.001$). Thus, all six hypotheses specified in the respecified model were supported.

The explanatory power of the structural model was evaluated using the coefficient of determination (R^2). The model explained 60.9% of the variance in Trust ($R^2 = 0.609$), 66.2% in Strategic Collaboration ($R^2 = 0.662$), and 71.1% in Operational Collaboration ($R^2 = 0.711$). For the performance dimensions, Operational Collaboration explained 76.5% of the variance in Operational Performance ($R^2 = 0.765$), 35.6% in Financial Performance ($R^2 = 0.356$), and 46.1% in Environmental Performance ($R^2 = 0.461$). These findings indicate particularly strong explanatory power for Operational Performance, while financial and environmental outcomes are likely to be additionally influenced by factors outside the model.

Effect size analysis further demonstrated the substantive importance of the structural relationships. Large effects were observed for Adaptive Leadership on Trust ($f^2 = 1.560$), Trust on Strategic Collaboration ($f^2 = 1.960$), Strategic Collaboration on Operational Collaboration ($f^2 = 2.463$), and Operational Collaboration on Operational Performance ($f^2 = 3.255$). Operational Collaboration also demonstrated substantial effects on Financial Performance ($f^2 = 0.553$) and Environmental Performance ($f^2 = 0.855$).

Structural collinearity was also assessed for the respecified model. All inner VIF values were 1.000. These values reflect the sequential specification of the model, in which each endogenous construct has a single direct predictor, and therefore indicate no structural collinearity concerns among predictor constructs. Importantly, these VIF values are interpreted specifically as structural collinearity diagnostics and are not independently interpreted as evidence that common method bias is absent. Overall, the final model demonstrates a sequential mechanism through which Adaptive Leadership strengthens Trust, Trust facilitates Strategic Collaboration, Strategic Collaboration enables Operational Collaboration, and Operational Collaboration subsequently contributes to Operational, Financial, and Environmental Performance. The theoretical and contextual meaning of these relationships is examined further in Section 4.4.

4.4 Interpretation of Findings

The findings reveal a sequential mechanism through which adaptive leadership contributes to collaboration and multidimensional performance within maritime logistics ecosystems. Rather than demonstrating isolated direct relationships among organizational factors, the final model indicates a progressive pathway from Adaptive Leadership to Trust, from Trust to Strategic Collaboration, from Strategic Collaboration to Operational Collaboration, and subsequently from Operational Collaboration to Operational, Financial, and Environmental Performance. This suggests that collaboration in maritime logistics develops through interconnected relational, strategic, and operational stages.

First, Adaptive Leadership has a significant positive effect on Trust (H1: $\beta = 0.780$). This finding indicates that adaptive leadership provides an important relational foundation for collaboration by strengthening confidence among stakeholders operating within complex maritime logistics environments. Adaptive leaders facilitate communication, responsiveness, stakeholder alignment, and collective problem solving under uncertain conditions, thereby creating conditions in which inter organizational trust can develop. This finding is consistent with Defee *et al.* (2009) and Heifetz *et al.* (2009), who emphasize the role of adaptive leadership in mobilizing actors and strengthening relationships under changing organizational conditions. Within port ecosystems involving regulators, port operators, shipping lines, logistics providers, and cargo owners, such leadership becomes particularly relevant because coordination frequently occurs across organizational and institutional boundaries.

Second, Trust significantly influences Strategic Collaboration (H2: $\beta = 0.814$). This finding supports the relational perspective of collaboration represented by commitment trust theory (Morgan and Hunt, 1994), suggesting that trust facilitates stakeholders' willingness to engage in higher level collaborative arrangements. Trust reduces perceived relational risks and supports information sharing, joint planning, and alignment of objectives among independent organizations. Within maritime logistics ecosystems, where participating organizations may have different commercial and institutional priorities, trust therefore appears particularly important for establishing collaboration at the strategic level. Rather than directly producing operational outcomes, trust creates the relational conditions through which stakeholders become willing to coordinate their objectives and collaborative strategies.

Third, Strategic Collaboration has a strong positive effect on Operational Collaboration (H3: $\beta = 0.843$). This relationship demonstrates that strategic alignment must subsequently be translated into coordinated operational practices. Strategic collaboration may establish shared objectives, planning arrangements, information exchange mechanisms, and institutional commitments, but their value ultimately depends on implementation through day-to-day operational coordination. In maritime logistics, this translation is particularly important because port activities require synchronization among vessel operations, terminal activities, cargo movements, customs procedures, inland transportation, and other logistics processes. The finding therefore distinguishes collaborative intention and strategic alignment from collaborative execution, indicating that strategic collaboration provides the foundation for operational collaboration.

Fourth, Operational Collaboration demonstrates its strongest effect on Operational Performance (H4: $\beta = 0.874$). This represents the strongest performance relationship in the final model and indicates that coordinated operational activities substantially contribute to efficiency and effectiveness within maritime logistics systems. Operational collaboration enables stakeholders to synchronize activities, exchange operational information, coordinate resource utilization, and respond jointly to disruptions. Such coordination can reduce process duplication, delays, congestion, and other inefficiencies arising from fragmented logistics operations. This finding reinforces previous maritime logistics research emphasizing the importance of inter organizational coordination for improving cargo flows and operational efficiency (Tongzon, 2009; Jacobsson *et al.,* 2018).

Fifth, Operational Collaboration also has a significant positive effect on Financial Performance (H5: $\beta = 0.597$), although the relationship is comparatively weaker than its effect on operational performance. This indicates that operational collaboration can generate economic benefits through improved resource utilization, reduced inefficiencies, shorter processing times, and better coordination among logistics stakeholders. However, the comparatively lower coefficient and R^2 for Financial Performance ($R^2 = 0.356$) suggest that financial outcomes are influenced by a wider range of factors beyond collaboration, including market conditions, trade volumes, pricing structures, investment requirements, and macroeconomic conditions. Collaboration therefore contributes to financial performance, but does not independently determine financial outcomes.

Finally, Operational Collaboration significantly improves Environmental Performance (H6: $\beta = 0.679$). The relationship is stronger than the financial performance effect but lower than the operational performance effect. This finding indicates that environmental improvements in maritime logistics can also emerge through coordinated operational practices. Collaboration can facilitate more efficient cargo movements, reduced waiting and idle times, coordinated resource utilization, environmental information sharing, and collective implementation of sustainability initiatives. The result is consistent with maritime sustainability literature emphasizing that environmental performance often requires coordinated action among multiple stakeholders rather than isolated initiatives undertaken by individual organizations (Lam, 2011; Parola *et al.,* 2014).

Additional analyses of indirect effects, total effects, and predictive relevance (Q^2) were conducted to further examine the proposed sequential mechanism. The results indicate that leadership influences organizational performance through trust, strategic collaboration, and operational collaboration, thereby supporting the proposed serial mediation mechanism. Among the relationships examined, operational collaboration exhibited the strongest influence on operational performance, while all endogenous constructs demonstrated Q^2 values greater than zero, confirming the model's predictive relevance. Detailed results are presented in Table 10 in the Appendix.

Compared with the previous studies summarized in Table 1, this study contributes to the literature in several ways. First, it examines collaboration within a broader port ecosystem by incorporating multiple stakeholder groups rather than focusing on individual organizations or bilateral relationships. Second, the findings suggest that strategic collaboration serves as an important mechanism linking leadership, trust, and operational capabilities to multiple performance outcomes. Third, the study provides empirical evidence from the Indonesian maritime sector, a context that remains relatively underrepresented in the existing literature. Collectively, these findings indicate that collaboration functions as an integrated capability that simultaneously influences operational, environmental, and financial performance.

Overall findings indicate that the effects of leadership on maritime logistics performance unfold through a sequential collaborative process rather than through a single direct relationship. Adaptive Leadership establishes Trust; Trust enables Strategic Collaboration; Strategic Collaboration is translated into Operational Collaboration; and Operational Collaboration generates multidimensional performance outcomes. The progressively differentiated effects on Operational ($\beta = 0.874$), Environmental ($\beta = 0.679$), and Financial Performance ($\beta = 0.597$) further demonstrate that collaboration produces its most immediate benefits at the operational level, while its financial and environmental consequences represent broader organizational and ecosystem outcomes. This sequential mechanism provides the empirical basis for the theoretical and managerial implications discussed in Section 5.

5. DISCUSSION

5.1 Beyond Traditional Trust-Based Collaboration

The findings provide a revised understanding of how collaboration develops within complex maritime logistics ecosystems. Traditional supply chain collaboration literature has frequently emphasized trust as a central antecedent of inter organizational cooperation, arguing that trust reduces perceived relational risk, facilitates information sharing, and strengthens commitment between collaborating organizations (Morgan and Hunt, 1994; Barratt, 2004; Fawcett *et al.,* 2012). The present findings support the importance of trust but indicate that its role should be understood as part of a broader sequential collaborative mechanism rather than as an isolated determinant of collaboration.

Adaptive Leadership demonstrated a strong positive relationship with Trust ($\beta = 0.780$), indicating that leadership provides an important foundation for building relational confidence among maritime logistics stakeholders. This finding is particularly relevant in port ecosystems, where collaboration involves heterogeneous organizations including regulators, port authorities, terminal operators, shipping lines, freight forwarders, trucking companies, and cargo owners. Unlike collaboration within a single organization or conventional buyer supplier dyads, these actors operate under different institutional mandates, commercial objectives, and operational responsibilities. Adaptive leadership can therefore function as an orchestration mechanism that facilitates communication, stakeholder alignment, and collective responses to operational uncertainty (Heifetz *et al.,* 2009).

Trust subsequently demonstrated a strong relationship with Strategic Collaboration ($\beta = 0.814$). This result is consistent with commitment trust theory because organizations are more likely to engage in information sharing, joint planning, and strategic alignment when they have confidence in their collaborative partners (Morgan and Hunt, 1994). However, the final model extends this perspective by showing that trust does not represent the end point of the collaborative mechanism. Rather, trust creates the relational conditions through which strategic collaboration can develop.

This distinction is particularly important within the Indonesian maritime logistics context. The National Logistics Ecosystem (NLE) involves collaboration among public and private organizations whose relationships are shaped not only by voluntary relational arrangements but also by institutional responsibilities, regulatory requirements, operational interdependencies, and national logistics reform. Collaboration within such an ecosystem therefore cannot be explained solely through interpersonal or inter organizational trust. Trust facilitates willingness to collaborate, but effective ecosystem coordination requires this relational foundation to be translated into strategic and subsequently operational forms of collaboration.

The final model therefore moves beyond a purely trust based explanation by positioning trust within a broader chain of collaborative development. Adaptive leadership establishes the conditions for trust, trust supports strategic alignment, and strategic alignment subsequently enables operational coordination. The contribution is consequently not to challenge the importance of trust, but to reposition trust as an enabling stage within a wider governance and collaboration process. This perspective provides a more comprehensive explanation of collaboration in multi stakeholder maritime ecosystems than models that consider trust as a direct and sufficient predictor of collaborative performance.

5.2 Strategic and Operational Collaboration

The findings from model respecification suggest that, within the Indonesian maritime logistics context, collaboration is more appropriately understood as comprising distinct but interrelated strategic and operational dimensions. In the respecified model, these dimensions provide a more empirically distinct representation of interorganizational collaborative mechanisms, whereas organizational flexibility and internal capability were excluded due to their empirical overlap with other constructs. This distinction is consistent with the broader collaboration concepts established by Myhr and Spekman (2005) and Baah *et al.* (2021), while providing a more context-specific interpretation of how interorganizational collaboration operates. Strategic collaboration reflects the long-term orientation of collaborative relationships, including shared objectives, service integration, customer orientation, competitiveness, and organizational capability development. Operational collaboration, in contrast, represents the mechanisms through which these strategic intentions are translated into day-to-day coordinated action, including information and knowledge sharing, teamwork, joint planning, resource sharing, and operational system integration. This distinction is particularly relevant to Indonesia's maritime logistics ecosystem, where service delivery requires coordination among multiple interdependent actors. Thus, the differentiation between strategic and operational collaboration does not depart from previous literature but rather refines the broader collaboration construct by demonstrating how long-term strategic alignment can be translated into operational coordination and, ultimately, performance outcomes.

Furthermore, the revised model describes the empirical distinction between Strategic Collaboration and Operational Collaboration. Strategic Collaboration significantly influences Operational Collaboration ($\beta = 0.843$), demonstrating that collaboration should not necessarily be treated as a single homogeneous organizational phenomenon. Instead, the results suggest that collaborative relationships develop from strategic alignment into operational execution. Strategic Collaboration represents higher level coordination among stakeholders through shared objectives, information exchange, joint planning, and alignment of organizational priorities. Such collaboration establishes the institutional and strategic basis for organizations to work collectively rather than independently. This is consistent with established supply chain collaboration literature emphasizing joint planning, synchronized decision making, information sharing, and alignment of incentives as important components of collaborative relationships (Simatupang and Sridharan, 2005; Cao and Zhang, 2011).

However, strategic agreement alone does not guarantee coordinated logistics operations. Maritime logistics systems are characterized by highly interconnected physical activities, including vessel scheduling, berth allocation, terminal operations, cargo handling, customs processes, trucking movements, and hinterland distribution. Strategic collaboration must therefore be translated into day-to-day coordination among the participating organizations. The strong relationship between Strategic and Operational Collaboration demonstrates this translation from collaborative alignment to collaborative execution.

This distinction is especially relevant to port ecosystems because operational performance depends on synchronization across organizational boundaries. A strategic agreement to share information, for example, produces limited operational value unless the information is integrated into scheduling, cargo handling, resource allocation, or disruption management. Similarly, digital integration initiatives generate their intended benefits only when stakeholders adapt their operational processes around shared information and coordinated decision making. The findings therefore reinforce the view that collaboration creates value when strategic arrangements become embedded within actual logistics operations.

The importance of this transition is further demonstrated by the effects of Operational Collaboration on the three performance dimensions. Operational Collaboration has its strongest effect on Operational Performance ($\beta = 0.874$), followed by Environmental Performance ($\beta = 0.679$) and Financial Performance ($\beta = 0.597$). The particularly strong operational effect is consistent with previous research demonstrating that coordinated information sharing and logistics integration can improve cargo flows, transparency, resource utilization, and operational efficiency in port systems (Tongzon, 2009; Klumpp *et al.,* 2011; Jacobsson *et al.,* 2018).

The positive relationship with Financial Performance indicates that operational collaboration also generates economic benefits. Better synchronization can reduce delays, duplication, inefficient resource utilization, and logistics costs. Nevertheless, the comparatively lower coefficient and explained variance for Financial Performance indicate that collaborative efficiency does not automatically translate proportionally into financial outcomes. Financial performance remains influenced by external determinants such as cargo volumes, market conditions, pricing structures, capital expenditure, and macroeconomic conditions.

The significant effect on Environmental Performance is also theoretically important. Environmental outcomes in maritime logistics frequently require coordination among multiple actors because emissions, congestion, waste management, energy consumption, and cargo movements extend across organizational boundaries. The findings therefore support the argument that environmental sustainability in port ecosystems cannot be achieved solely through isolated firm level initiatives. Operational collaboration enables coordinated environmental practices and more efficient utilization of shared infrastructure and resources, consistent with the collaborative environmental governance perspective discussed by Lam (2011) and Parola *et al.* (2014).

The distinction between Strategic and Operational Collaboration provides a more nuanced explanation of how collaborative value is created. Strategic Collaboration establishes alignment, whereas Operational Collaboration converts that alignment into measurable performance outcomes. The findings therefore suggest that the effectiveness of collaboration should be assessed not only by whether organizations establish collaborative relationships, but also by whether those relationships become embedded within operational processes.

5.3 Theoretical, Managerial and Policy Implications

The findings generate several theoretical implications for maritime logistics and supply chain collaboration research. First, the study extends traditional trust-based collaboration perspectives by demonstrating a sequential mechanism connecting Adaptive Leadership → Trust → Strategic Collaboration → Operational Collaboration → Performance. Rather than treating leadership, trust, and collaboration as parallel determinants of performance, the final model suggests that their contributions occur through successive stages. Adaptive Leadership establishes relational conditions through Trust; Trust enables Strategic Collaboration; Strategic Collaboration facilitates Operational Collaboration; and Operational Collaboration generates performance outcomes. This sequential perspective provides a governance-based explanation of how collaboration develops within complex multi stakeholder ecosystems.

Second, the distinction between Strategic and Operational Collaboration provides an additional conceptual contribution. Existing collaboration research frequently conceptualizes collaboration as an aggregate construct encompassing information sharing, joint planning, coordination, and collaborative decision making. The findings suggest that distinguishing strategic alignment from operational execution can provide greater explanatory clarity in maritime logistics. This distinction is particularly relevant in asset intensive and operationally interdependent systems, where formal strategic collaboration does not necessarily produce performance improvements unless it is translated into coordinated operational practices.

Third, the findings strengthen the multidimensional perspective on collaborative performance. Operational Collaboration contributes significantly to operational, financial, and environmental outcomes, but the magnitude of these relationships differs considerably. Its strongest contribution occurs through Operational Performance, followed by Environmental and Financial Performance. This suggests that the benefits of collaboration emerge most immediately through operational coordination, while broader economic and sustainability outcomes depend on collaboration together with other organizational and external conditions. The findings therefore connect collaboration research with the growing emphasis on simultaneous competitiveness and sustainability within maritime logistics.

From a managerial perspective, the results suggest that port and logistics managers should approach collaboration as a progressive management process rather than a single organizational initiative. Leadership development should emphasize stakeholder communication, responsiveness, and cross organizational alignment because these behaviors contribute to trust formation. However, building trust alone is insufficient. Managers should establish mechanisms that convert relational confidence into strategic collaboration through shared objectives, joint planning arrangements, transparent information exchange, and common performance priorities.

The subsequent managerial priority is to ensure that strategic collaboration becomes operationally embedded. Port authorities, terminal operators, shipping lines, freight forwarders, trucking companies, cargo owners, and government agencies should develop coordinated operational mechanisms involving integrated scheduling, shared information systems, synchronized cargo processes, joint disruption management, and cross organizational performance monitoring. The findings indicate that this operational integration represents the stage at which collaboration produces its strongest measurable performance benefits.

The results also have direct policy relevance for Indonesia's National Logistics Ecosystem (NLE) and Indonesia National Single Window. These initiatives seek to integrate government and private sector logistics processes through digital and institutional coordination. The findings suggest that digital integration should not be viewed as sufficient by itself. Technology provides the infrastructure for information exchange, but collaborative performance depends on whether stakeholders develop strategic alignment and translate this alignment into coordinated operational processes. Policy interventions should therefore combine digital platform development with governance mechanisms that strengthen stakeholder trust, joint planning, interoperability, and operational coordination.

The findings are also consistent with practitioner perspectives in Indonesia's port sector, where coordination across multiple stakeholders requires strong leadership, institutional alignment, and effective operational arrangements rather than reliance on trust alone. While trust remains an important relational foundation, the final model demonstrates that its contribution is realized through Strategic Collaboration and subsequently translated into Operational Collaboration. This reinforces the practical relevance of the model, as port operators in Indonesia increasingly adopt governance driven orchestration approaches to strengthen coordination, operational efficiency, and sustainability outcomes within the NLE. The findings therefore suggest that effective port ecosystem governance should combine trust building with mechanisms that translate strategic alignment into coordinated operational action across public and private stakeholders.

Finally, the significant relationship between Operational Collaboration and Environmental Performance indicates that sustainability objectives should be incorporated into collaborative logistics governance rather than managed separately from operational coordination. Port decarbonization, congestion reduction, efficient resource utilization, environmental monitoring, and other sustainability initiatives frequently require collective action across multiple organizations. Policymakers and port authorities should therefore integrate environmental targets into shared operational frameworks and collaborative performance measures. In this way, maritime logistics collaboration can function not only as a mechanism for improving efficiency and financial outcomes, but also as an institutional pathway toward more sustainable port ecosystems. The final model suggests that effective maritime logistics collaboration is produced through the progressive transformation of leadership into trust, trust into strategic alignment, and strategic alignment into coordinated operational action. This mechanism provides a theoretical explanation of collaborative development while offering managers and policymakers a practical sequence for strengthening performance across complex maritime logistics ecosystems.

6. CONCLUSION

This study developed and empirically tested a structural model of maritime logistics collaboration within Indonesia's port ecosystem using PLS-SEM and survey data from 120 maritime logistics stakeholders. Building on an initial conceptual framework derived from the literature, the model was subsequently respecified following measurement model assessment to improve construct distinctiveness and statistical robustness. The final model identifies a sequential mechanism through which Adaptive Leadership strengthens Trust, Trust facilitates Strategic Collaboration, Strategic Collaboration enables Operational Collaboration, and Operational Collaboration subsequently contributes to Operational, Financial, and Environmental Performance. Overall, the final model provides a more parsimonious explanation of how collaborative relationships develop and generate multidimensional performance outcomes within a complex multi-stakeholder maritime logistics ecosystem.

The model respecification also illustrates the iterative nature of PLS-SEM based model development. Although Organizational Flexibility and Internal Capability were initially included in the conceptual framework based on the literature, empirical assessment indicated considerable overlap with other constructs. Consequently, these constructs were excluded from the respecified model, while the broader construct of Maritime Logistics Collaboration was empirically represented through two distinct but interrelated dimensions: Strategic Collaboration and Operational Collaboration. This refinement preserves the theoretical foundations of the initial model while providing greater empirical distinctiveness among the constructs retained in the final model.

The findings further demonstrate that Adaptive Leadership provides an important foundation for collaborative development through its strong positive effect on Trust. Trust, in turn, facilitates Strategic Collaboration, indicating that relational confidence supports stakeholders' willingness to establish shared objectives, exchange information, and engage in joint planning. Importantly, however, strategic alignment must be translated into Operational Collaboration before measurable performance benefits can be realized. The strong relationship between Strategic and Operational Collaboration therefore highlights the importance of moving beyond collaborative intention toward coordinated execution across organizational boundaries.

Operational Collaboration significantly improves all three performance dimensions, with its strongest contribution occurring through Operational Performance, followed by Environmental and Financial Performance. This pattern indicates that the most immediate benefits of maritime logistics collaboration arise from improved synchronization, information exchange, resource utilization, and operational coordination. At the same time, the significant environmental and financial effects demonstrate that collaborative operations can generate broader sustainability and economic benefits. The comparatively lower effect on Financial Performance suggests that financial outcomes remain influenced by market, investment, and macroeconomic factors beyond inter organizational collaboration.

The study contributes theoretically by moving beyond conventional explanations that position trust as the primary or direct determinant of collaboration. Rather than diminishing the importance of trust, the findings reposition it within a broader sequential process connecting leadership, relational confidence, strategic alignment, operational execution, and performance. The distinction between Strategic and Operational Collaboration further contributes to collaboration research by demonstrating that strategic alignment and operational implementation represent related but distinct stages of collaborative development. From a managerial and policy perspective, the findings indicate that port authorities, logistics organizations, and policymakers should complement digital integration initiatives with mechanisms that strengthen stakeholder trust, joint planning, strategic alignment, and coordinated operational implementation. This is particularly relevant for initiatives such as Indonesia's National Logistics Ecosystem and Indonesia National Single Window, where technological integration must ultimately translate into effective coordination among public and private logistics stakeholders.

Despite these contributions, several limitations provide opportunities for future research. The cross-sectional design limits the ability to examine how trust, strategic collaboration, and operational collaboration evolve over time, while reliance on perceptual survey data may introduce common method bias. The study is also situated within Indonesia's emerging archipelagic maritime logistics context, which may limit the generalizability of the findings to other institutional and geographic environments. Future research may incorporate longitudinal analysis, objective operational indicators, and comparative cross-country studies to examine whether the sequential mechanism identified in this study from Adaptive Leadership and Trust through Strategic and Operational Collaboration to multidimensional performance. This is specific to emerging archipelagic economies or represents a broader pattern across global maritime logistics systems. Future studies may also further examine the role of Organizational Flexibility and Internal Capability within alternative model specifications and larger independent samples to determine how these theoretically relevant capabilities interact with trust and different forms of collaboration across diverse port governance contexts.

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Dothy is a doctoral researcher at Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia, specializing in maritime logistics, port collaboration, and sustainable logistics systems. Her research focuses on digital collaboration, adaptive leadership, and organizational capabilities in port ecosystems, with particular relevance to emerging archipelagic economies. She is actively involved in academic and industry-based research projects related to port performance, resilience, and National Logistics Ecosystem development.

Raja Oloan Saut Gurning is a Professor at Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia, with extensive expertise in shipping economics, port management, and maritime logistics systems. His research interests include maritime supply chain integration, port performance, and logistics policy, and he has published widely in international journals and conferences. He has also contributed to various national and international research collaborations in the field of maritime transport and logistics.

Imam Baihaqi is a faculty member at Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia, specializing in operations and supply chain management. His research focuses on supply chain integration, digital transformation, and performance measurement in logistics and manufacturing systems. He has published in reputable international journals and is actively engaged in research and academic development in the field of operations and supply chain management.

Bahana Wiradanti is an employee in Pelabuhan Indonesia (Indonesian Ports), also researcher and consultant specializing in port economics, maritime logistics, and sustainable port development. Her research focuses on port governance, sustainability, resilience, and operational efficiency in maritime and logistics systems, particularly in developing and archipelagic regions. She is actively involved in academic research, consulting projects, and international collaborations related to maritime transport, ESG, and logistics development.

APPENDIX

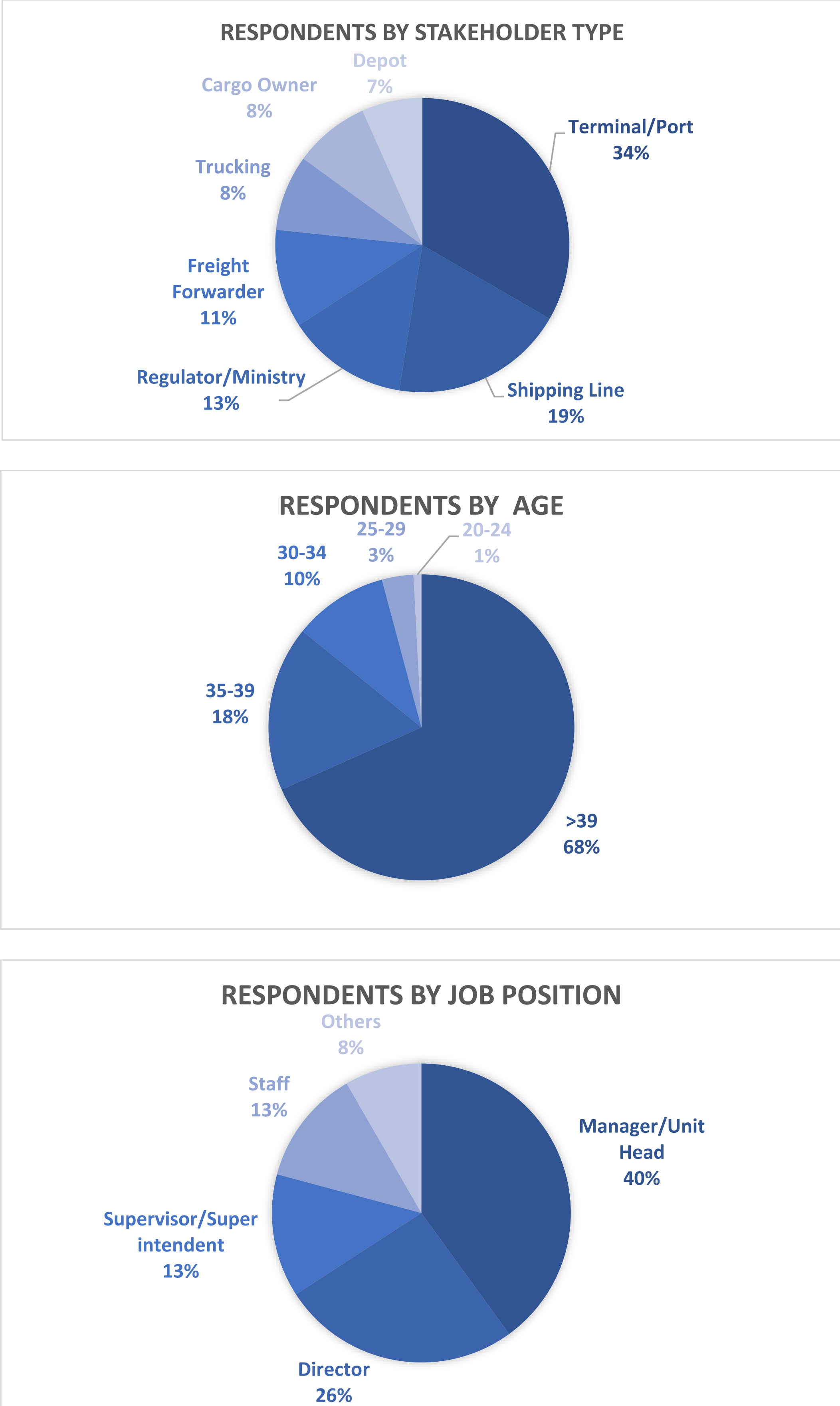

Figure 5 Profile of Survey Respondents

Table 2 Latent Variables, Definition and Indicator Variables

Latent Variable	Definition	Indicator Variables (Item Measurements)	Sources
Adaptive Leadership (P_2)	The ability of leaders to respond to complex, dynamic, and uncertain environments by aligning stakeholders and facilitating change	• Gets my company to look at problems from many different angles. • Encourages my company to express ideas and opinions. • Asks my company to contribute ideas for improving supply chain problems • Promotes creativity from my company. • Helps my company develop more creative solutions to supply chain problems. • Does not want me to change processes that work effective in mentoring my company to become a better contributor to supply chain success. • Understands my company's capabilities are different from others. • Encourages my company to continually improve it supply chain skills. • Assumes all supply chain members have the same abilities.	Defee (2007); Heifetz, Grashow, and Linsky (2009); Mangan and Lalwani (2016); Teece (2007)
Trust (P_1)	The willingness of parties to rely on each other based on confidence in reliability and integrity	• Each party believes the information provided by the other. • We both find each other trustworthy. • Our company considers stakeholders' interest in making decisions. • Our company creates skills for effective coordination in execution of plans. • Our company implements strategies to ensure quality relationships. • Our company involves stakeholders in the tasks needed to produce and deliver products and services to customers.	Baah et al (2021a); Myhr *et al.* (2019); Morgan and Hunt (1994); Panayides (2006); Lai et al (2020)
Collaboration (X)	The process of organizations working together through information sharing, coordination, joint decision making, and mutual cooperation to achieve shared goals and improve collective performance.	• We are achieving our long-term goals together. • In this supplier relationship. • We work together with this supplier as a team. • People from both companies work together informally. • Our firm and supply chain partners share benefits and costs. • Our firm and supply chain partners jointly search. • Our firm and supply chain partners have agreements on the relevance of improvements that benefit the whole supply network. • Our firm and supply chain partners collaboratively manage inventory and demand forecasts. • SCC (Supply Chain Council) has led the organization to choses their suppliers on the basis of high quality. • SC integration has assisted in improving the quality of goods. • Internal collaboration leads to an increased quality information sharing in order to enhance operational efficiency. • Customer collaboration leads to improved services quality. • The company has a computerized system for ordering customer. • Customer needs and satisfactions are our competitive strategies. • The company makes use of different internet platform to engage with customer.	Baah et al (2021a); Myhr *et al.* (2019); Simatupang and Sridharan (2005)

Table 2 Latent Variables, Definition and Indicator Variables (cont'd)

Latent Variable	Definition	Indicator Variables (Item Measurements)	Sources
Operational Performance (Y_1)	An organization's ability to efficiently manage its operations through improvements in productivity, service quality, flexibility, reliability, and resource utilization.	• Delivery according to due date. • Flexibility of supply goods. • Productivity of the supply goods. • Lead-time of fulfillment. • The perfect number of invoices. • The company decreased partner complement. • The company continues to change mechanism and method.	Omoush (2020)
Financial Performance (Y_2)	Organization's achievement of economic and financial objectives, including profitability, cost efficiency, revenue growth, and overall financial sustainability.	• Return on sales. • Return on investment. • Profit margin. • Net profit.	Baah et al (2021)
Environmental Performance(Y_3)	The extent to which an organization reduces its negative environmental impacts through efficient resource use, waste reduction, pollution control, and environmentally sustainable practices.	• Encourage stakeholders' involvement in planning and executing environmental practices. • Allow environmental audits. • Adoption of cleaner production methods. • Our firm reuses and recycles materials.	Baah et al (2021b)

Table 3 Summary of Findings by Hypothesis (After Model Respecification)

Hypothesis	Path	Key Theoretical Support	β	t-stat	p-value	Decision	Summary
H1	Adaptive Leadership→ Trust	Heifetz *et al.* (2009); Defee *et al.* (2009)	0.780	8.118	<0.001	Supported	Adaptive leadership significantly strengthens trust among maritime logistics stakeholders.
H2	Trust → Strategic Collaboration	Morgan and Hunt (1994); Barratt (2004); Fawcett *et al.* (2012)	0.814	8.783	<0.001	Supported	Trust provides the relational foundation for strategic alignment and collaboration.
H3	Strategic Collaboration → Operational Collaboration	Simatupang and Sridharan (2005); Cao and Zhang (2011)	0.843	24.468	<0.001	Supported	Strategic alignment is strongly translated into coordinated operational collaboration.
H4	Operational Collaboration → Operational Performance	Tongzon (2009); Klumpp *et al.* (2011); Jacobsson *et al.* (2018)	0.874	20.521	<0.001	Supported	Operational collaboration strongly improves coordination, efficiency, and operational performance.
H5	Operational Collaboration → Financial Performance	Cao and Zhang (2011); Panayides and Song (2009)	0.597	4.191	<0.001	Supported	Operational collaboration contributes to financial performance through improved efficiency and resource utilization.
H6	Operational Collaboration → Environmental Performance	Lam (2011); Parola *et al.* (2014)	0.679	9.557	<0.001	Supported	Operational collaboration improves environmental performance through coordinated and more efficient logistics practices.

Table 4 Model Reliability and Validity Summary

Findings	Reliability & Validity	Summary
Variable Loadings	>0.7	Most indicators demonstrate adequate loadings on their respective constructs, supporting indicator reliability. Indicators with relatively lower loadings were retained where overall construct reliability remained satisfactory.
Composite Reliability (CR)	>0.7	CR values range from 0.853 to 0.957, exceeding the recommended threshold and demonstrating satisfactory internal consistency across the constructs.
Average Variance Extracted (AVE)	>0.5	Most constructs meet the recommended AVE threshold. Adaptive Leadership (0.473), Trust (0.479), and Operational Performance (0.480) are slightly below 0.50; however, their satisfactory composite reliability provides additional support for construct retention.
Fornell–Larcker Criterion	Square root of AVE should be greater than inter construct correlations	The criterion is met for several construct comparisons, while some closely related constructs show remaining empirical overlap. These relationships are therefore interpreted together with the HTMT assessment.
Cross Loadings	Indicators should load higher on their own construct than on other constructs	Most indicators load highest on their intended constructs. Some relatively close cross loadings remain among conceptually related constructs, particularly Strategic Collaboration, Operational Collaboration, Adaptive Leadership, and Operational Performance.
HTMT	<0.90	All HTMT values are below 0.90 (0.513–0.894), providing additional support for discriminant validity among the constructs in the revised model.

Table 5 Validity and Reliability

Latent Variable	Indicator	T_{value}	P-values	Latent Variable	Indicator	T_{value}	P-values
Trust(P_1)	λ_1	5.763	<0.001	**Collaboration Strategic (X1)**	λ_1	8.885	<0.001
	λ_2	5.544	<0.001		λ_{10}	12.998	<0.001
	λ_3	15.492	<0.001		λ_{11}	19.904	<0.001
	λ_4	10.539	<0.001		λ_{12}	11.671	<0.001
	λ_5	11.112	<0.001		λ_{13}	14.04	<0.001
	λ_6	6.01	<0.001		λ_{14}	9.173	<0.001
	λ_7	5.712	<0.001		λ_{15}	18.734	<0.001
Leadership (P_2)	λ_1	18.566	<0.001	**Collaboration Operational (X2)**	λ_2	12.817	<0.001
	λ_2	6.319	<0.001		λ_3	18.11	<0.001
	λ_3	10.869	<0.001		λ_4	15.273	<0.001
	λ_4	15.707	<0.001		λ_5	13.603	<0.001
	λ_5	4.173	<0.001		λ_6	12.973	<0.001
	λ_6	10.235	<0.001		λ_7	11.684	<0.001
	λ_7	17.848	<0.001		λ_8	6.986	<0.001
	λ_8	8.025	<0.001		λ_9	6.678	<0.001
	λ_9	5.826	<0.001	**Operational Performance (Y1)**	λ_1	9.622	<0.001
	λ_{10}	18.44	<0.001		λ_2	7.219	<0.001
	λ_{11}	10.367	<0.001		λ_3	9.489	<0.001
					λ_4	5.657	<0.001
					λ_5	8.318	<0.001
					λ_6	13.921	<0.001
					λ_7	11.867	<0.001
					λ_8	8.472	<0.001
				Financial Performance (Y2)	λ_1	9.781	<0.001
					λ_2	9.677	<0.001
					λ_3	10.948	<0.001
					λ_4	12.5	<0.001
					λ_5	19.987	<0.001
				Environmental Performance (Y3)	λ_1	15.087	<0.001
					λ_2	8.489	<0.001
					λ_3	5.763	<0.001
					λ_4	5.544	<0.001

Table 6 Composite Reliability and Average Variance Extracted (AVE)

	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
Coll Ops	0.927	0.931	0.925	0.608
Coll Strategic	0.889	0.895	0.889	0.573
Environmental Perf	0.905	0.913	0.906	0.709
Financial Perf	0.915	0.925	0.915	0.685
Leadership	0.898	0.910	0.897	0.473
Operational Perf	0.878	0.885	0.879	0.480
Trust	0.839	0.860	0.843	0.479

Table 7 Fornell Larcker Criterion

	Coll Ops	Coll Strategic	Environmental Perf	Financial Perf	Leadership	Operational Perf	Trust
Coll Ops	0.780						
Coll Strategic	0.843	0.757					
Environmental Perf	0.679	0.789	0.842				
Financial Perf	0.597	0.644	0.681	0.828			
Leadership	0.866	0.903	0.690	0.602	0.687		
Operational Perf	0.874	0.895	0.762	0.799	0.784	0.692	
Trust	0.712	0.814	0.693	0.516	0.780	0.770	0.692

Table 8 Cross Loading

	Coll Ops	Coll Strategic	Environmental Perf	Financial Perf	Leadership	Operational Perf	Trust
A1	0.445	0.434	0.322	0.316	0.499	0.428	0.585
A2	0.360	0.394	0.359	0.193	0.435	0.448	0.519
A3	0.620	0.624	0.525	0.444	0.621	0.594	0.781
A4	0.434	0.647	0.568	0.420	0.571	0.597	0.765
A5	0.595	0.732	0.633	0.405	0.596	0.566	0.834
A6	0.469	0.473	0.403	0.319	0.502	0.554	0.611
B1	0.470	0.448	0.384	0.360	0.594	0.469	0.463
B10	0.457	0.420	0.378	0.222	0.538	0.311	0.420
B2	0.649	0.632	0.399	0.472	0.675	0.574	0.526
B3	0.681	0.749	0.656	0.479	0.815	0.562	0.636
B4	0.599	0.609	0.554	0.408	0.590	0.516	0.460
B5	0.578	0.617	0.410	0.336	0.680	0.525	0.530
B6	0.679	0.753	0.567	0.510	0.810	0.663	0.632
B7	0.617	0.605	0.392	0.361	0.574	0.529	0.448
B8	0.518	0.540	0.340	0.369	0.601	0.484	0.469
B9	0.681	0.755	0.590	0.547	0.898	0.690	0.700
E1	0.790	0.891	0.596	0.565	0.846	0.806	0.682
E11	0.586	0.705	0.468	0.363	0.604	0.589	0.583
E12	0.560	0.656	0.592	0.470	0.573	0.656	0.525
E13	0.649	0.766	0.658	0.508	0.700	0.693	0.620
E14	0.644	0.772	0.614	0.570	0.686	0.707	0.636
E15	0.575	0.731	0.662	0.434	0.660	0.596	0.641
E2	0.787	0.647	0.543	0.438	0.614	0.721	0.516
E3	0.815	0.668	0.526	0.503	0.690	0.741	0.578
E4	0.645	0.560	0.398	0.365	0.699	0.595	0.503
E5	0.621	0.496	0.417	0.346	0.563	0.592	0.389

Table 8 Cross Loading (cont'd)

	Coll Ops	Coll Strategic	Environmental Perf	Financial Perf	Leadership	Operational Perf	Trust
E6	0.828	0.689	0.491	0.555	0.767	0.747	0.595
E7	0.890	0.775	0.640	0.542	0.742	0.718	0.626
E8	0.778	0.654	0.539	0.480	0.738	0.663	0.613
E9	0.835	0.730	0.644	0.459	0.595	0.671	0.589
F1	0.565	0.682	0.500	0.554	0.546	0.646	0.606
F2	0.735	0.769	0.623	0.451	0.596	0.840	0.660
F3	0.626	0.575	0.433	0.534	0.575	0.716	0.503
F4	0.590	0.527	0.375	0.560	0.531	0.675	0.449
F5	0.641	0.620	0.627	0.661	0.558	0.733	0.550
F6	0.526	0.502	0.465	0.578	0.371	0.601	0.383
F7	0.577	0.508	0.514	0.496	0.522	0.660	0.414
F8	0.560	0.761	0.678	0.639	0.636	0.641	0.683
G1	0.563	0.531	0.585	0.944	0.511	0.708	0.482
G2	0.505	0.443	0.467	0.847	0.492	0.580	0.338
G3	0.540	0.644	0.645	0.905	0.587	0.691	0.499
G4	0.434	0.540	0.648	0.728	0.453	0.671	0.413
G5	0.409	0.518	0.481	0.685	0.443	0.680	0.403
H1	0.504	0.662	0.742	0.593	0.523	0.625	0.582
H2	0.609	0.694	0.896	0.613	0.636	0.685	0.616
H3	0.627	0.694	0.924	0.563	0.632	0.684	0.617
H4	0.539	0.609	0.793	0.529	0.524	0.569	0.520

Note: Table 8 presents cross-loading values used in the assessment of discriminant validity rather than outer loading values. Therefore, the results were interpreted within the broader context of the overall measurement model assessment. Although several indicators exhibited relatively low outer loadings and some indicators (B4, B7, F1, and F8) showed relatively high cross-loadings on other constructs, these indicators were retained based on their theoretical relevance and the overall adequacy of the measurement model. Their retention was further supported by acceptable construct-level reliability and convergent validity, as indicated by Cronbach's alpha, composite reliability, and average variance extracted (AVE).

Table 9 Heterotrait-Monotrait Ratio (HTMT)

	Heterotrait-monotrait ratio (HTMT)
Trust <-> Financial Perf	0.513
Financial Perf <-> Coll Ops	0.586
Leadership <-> Financial Perf	0.594
Financial Perf <-> Coll Strategic	0.645
Environmental Perf <-> Coll Ops	0.669
Leadership <-> Environmental Perf	0.682
Financial Perf <-> Environmental Perf	0.689
Trust <-> Environmental Perf	0.689
Trust <-> Coll Ops	0.708
Operational Perf <-> Environmental Perf	0.767
Trust <-> Operational Perf	0.780
Operational Perf <-> Leadership	0.781
Trust <-> Leadership	0.781
Environmental Perf <-> Coll Strategic	0.794
Trust <-> Coll Strategic	0.806
Operational Perf <-> Financial Perf	0.820
Coll Strategic <-> Coll Ops	0.828
Leadership <-> Coll Ops	0.865
Operational Perf <-> Coll Ops	0.870
Leadership <-> Coll Strategic	0.890
Operational Perf <-> Coll Strategic	0.894

Table 10 Total Indirect Effect, Total Effect and Q^2 (Predictive Relevance)

Indirect Effect	Original sample (O)	T statistics (|O/STDEV|)	P values	Interpretation
Col Strategic -> Env Perf	0.574	8.252	0.000	1) Trust mediates the effect of Leadership on Strategic Collaboration. 2) Trust and Strategic Collaboration mediate the effect of Leadership on Operational Collaboration. 3) Operational Collaboration mediates the effect of Strategic Collaboration on the three performance dimensions, namely operational, financial, and environmental performance. 4) A serial mediation mechanism exists in which Leadership influences Trust, which subsequently enhances Strategic Collaboration and Operational Collaboration, ultimately leading to improved organizational performance.
Col Strategic -> Fin Perf	0.505	4.030	0.000	
Col Strategic -> Ops Perf	0.740	12.619	0.000	
Lead -> Col Strategic	0.648	4.234	0.000	
Lead -> Coll Ops	0.548	4.134	0.000	
Lead -> Env Perf	0.372	3.611	0.000	
Lead -> Fin Perf	0.327	2.731	0.006	
Lead -> Ops Perf	0.479	3.918	0.000	
Trust -> Coll Ops	0.701	8.290	0.000	
Trust -> Env Perf	0.476	5.861	0.000	
Trust -> Fin Perf	0.418	3.550	0.000	
Trust -> Ops Perf	0.613	7.112	0.000	

	Total effects	Interpretation
Col Strategic -> Coll Ops	0.846	1) The strongest relationship in the model was observed between Operational Collaboration and Operational Performance (β = 0.875). 2) Strategic Collaboration → Operational Collaboration (β = 0.846) and Trust → Strategic Collaboration (β = 0.829) also demonstrated very strong effects. 3) Leadership served as the antecedent construct that fostered Trust, which subsequently promoted Strategic Collaboration and Operational Collaboration, ultimately enhancing operational, financial, and environmental performance. 4) Accordingly, Trust, Strategic Collaboration, and Operational Collaboration represent the principal mechanisms through which Leadership contributes to improved organizational performance. 0.846
Col Strategic -> Env Perf	0.574	
Col Strategic -> Fin Perf	0.505	
Col Strategic -> Ops Perf	0.740	
Coll Ops -> Env Perf	0.679	
Coll Ops -> Fin Perf	0.597	
Coll Ops -> Ops Perf	0.875	
Lead -> Col Strategic	0.648	
Lead -> Coll Ops	0.548	
Lead -> Env Perf	0.372	
Lead -> Fin Perf	0.327	
Lead -> Ops Perf	0.479	
Lead -> Trust	0.781	
Trust -> Col Strategic	0.829	
Trust -> Coll Ops	0.701	
Trust -> Env Perf	0.476	
Trust -> Fin Perf	0.418	
Trust -> Ops Perf	0.613	

	Q^2	Interpretation
Trust	0.426	Q^2 is used to assess the predictive capability of the model with respect to its endogenous constructs. According to Hair *et al.* (2022), a Q^2 value greater than zero indicates that the model possesses predictive relevance. The results of the predictive relevance analysis showed that all endogenous constructs exhibited Q^2 values greater than zero, indicating that the proposed model has good predictive capability.
Col Strategic	0.557	
Coll Ops	0.459	
Env Perf	0.233	
Fin Perf	0.163	
Ops Perf	0.326	