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DECONSTRUCTING THE STATE-LOGISTICS PARADOX: MULTI MARGIN ELIMINATION, INTER-ENTITY CANNIBALIZATION, AND DIGITAL ALIGNMENT IN INDONESIA'S SOE SUPER-HOLDING RESTRUCTURING

MEMBEDAH PARADOKS LOGISTIK NEGARA: ELIMINASI MULTI MARGIN, KANIBALISASI ANTAR-ENTITAS, DAN PENYELARASAN DIGITAL DALAM RESTRUKTURISASI SUPERHOLDING BUMN INDONESIA

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ABSTRACT
High logistics costs and fragmented service provision are persistent coordination challenges for archipelagic economies. This study develops the State-Driven Multi-Modal Integration and Double-Marginalization Elimination (SD-MIDE) framework to explain how state-owned enterprise (SOE) restructuring may affect logistics performance through three connected mechanisms: vertical coordination and markup compression, horizontal reduction of overlapping capacity, and digital interoperability. Integrating transaction cost economics, the resource-based view, and principal–agent/public-choice perspectives, the paper specifies a panel-data research design for Indonesia's multimodal SOE logistics ecosystem. A reproducible synthetic panel of 24 entity–corridor units observed over 2017–2024 is used to demonstrate the proposed estimators and the internal coherence of the hypotheses; it is not evidence about the realised performance of any named enterprise. Unit and year fixed-effects regressions are estimated for a logistics-cost proxy, dwell time, and asset turnover, with standard errors clustered at the unit level. In the simulated results, multimodal integration and National Logistics Ecosystem (NLE) interoperability are associated with lower logistics-cost and dwell-time outcomes, while greater service and investment overlap is associated with poorer performance. The interaction between institutional inertia and digital interoperability is negative, consistent with the proposition that digital coordination can weaken the operational consequences of organizational rigidity. The integration-by-corridor interaction is directionally consistent with larger gains in archipelagic settings, although this result is treated as exploratory. The article contributes a mechanism-based framework, operational definitions, a transparent estimation workflow, and a phased policy roadmap. Because the analysis is based on constructed observations, all coefficient estimates are illustrative and must not be interpreted as causal or as estimates of Indonesia's actual logistics costs. A field application requires validated enterprise, corridor, transaction, and administrative data.
Keywords: state-owned enterprises; multimodal logistics; double marginalization; transaction cost economics; National Logistics Ecosystem; panel data; Indonesia

ABSTRAK
Biaya logistik yang tinggi dan penyediaan layanan yang terfragmentasi merupakan tantangan koordinasi yang terus-menerus dihadapi oleh negara-negara dengan karakteristik geografis kepulauan. Penelitian ini mengembangkan kerangka Integrasi Multimoda Berbasis Negara dan Eliminasi Marginalisasi Ganda (State-Driven Multi-Modal Integration and Double-Marginalization Elimination/SD-MIDE) untuk menjelaskan bagaimana restrukturisasi badan usaha milik negara (BUMN) dapat mempengaruhi kinerja logistik melalui tiga mekanisme yang saling berkaitan, yaitu koordinasi vertikal dan kompresi margin harga, pengurangan kapasitas yang tumpang tindih secara horizontal, serta interoperabilitas digital. Dengan mengintegrasikan teori ekonomi biaya transaksi, pandangan berbasis sumber daya, serta perspektif prinsipal–agen dan pilihan publik, penelitian ini merumuskan desain penelitian berbasis data panel untuk ekosistem logistik multimoda BUMN Indonesia. Panel sintetis yang dapat direproduksi, terdiri atas 24 unit entitas–koridor yang diamati selama periode 2017–2024, digunakan untuk mendemonstrasikan estimator yang diusulkan dan konsistensi internal hipotesis penelitian. Panel

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tersebut bukan merupakan bukti mengenai kinerja aktual perusahaan tertentu. Regresi efek tetap unit dan tahun diestimasi untuk mengukur proksi biaya logistik, waktu tunggu (dwell time), dan perputaran aset, dengan galat standar yang dikelompokkan pada tingkat unit. Dalam hasil simulasi, integrasi multimoda dan interoperabilitas Ekosistem Logistik Nasional (National Logistics Ecosystem/NLE) berkorelasi dengan penurunan biaya logistik dan waktu tunggu, sedangkan tumpang tindih layanan dan investasi yang lebih besar berkorelasi dengan kinerja yang lebih buruk. Interaksi antara inersia kelembagaan dan interoperabilitas digital menunjukkan hubungan negatif, yang konsisten dengan proposisi bahwa koordinasi digital dapat melemahkan dampak operasional dari kekakuan organisasi. Interaksi antara integrasi dan koridor menunjukkan arah hubungan yang konsisten dengan potensi manfaat integrasi yang lebih besar di wilayah kepulauan, meskipun hasil ini diperlakukan sebagai temuan eksploratif. Artikel ini memberikan kontribusi berupa kerangka berbasis mekanisme, definisi operasional, alur kerja estimasi yang transparan, serta peta jalan kebijakan bertahap. Karena analisis didasarkan pada observasi yang dikonstruksi secara sintetis, seluruh estimasi koefisien bersifat ilustratif dan tidak boleh ditafsirkan sebagai hubungan kausal maupun sebagai estimasi biaya logistik aktual Indonesia. Penerapan empiris di lapangan memerlukan data perusahaan, koridor, transaksi, dan administrasi yang telah divalidasi.

Kata Kunci: Badan Usaha Milik Negara; logistik multimoda; marginalisasi ganda; ekonomi biaya transaksi; Ekosistem Logistik Nasional; data panel; Indonesia

1. INTRODUCTION

Logistics performance is a system-level outcome produced by the interaction of infrastructure, service markets, regulatory processes, information systems, and organizational boundaries. For an archipelagic economy, those interactions are especially consequential: freight may cross sea, air, road, warehouse, port, and last-mile interfaces before reaching its destination. A weakness at one interface can create waiting time, duplicated handling, low asset utilization, or fragmented accountability even when each individual operator appears commercially viable. The analytical problem is therefore not simply whether a country has enough transport assets. It is whether assets, decisions, data, and incentives are coordinated across a complete logistics journey.

The source draft frames Indonesia's state-owned logistics ecosystem as a setting in which port services, aviation-related logistics, postal and courier networks, warehousing, and land distribution have historically developed under separate corporate mandates. It identifies two potential distortions. The first is vertical double marginalization: sequential providers independently add markups or administrative charges, raising the end-to-end price and potentially suppressing throughput. The second is horizontal inter-entity cannibalization: entities with overlapping mandates may duplicate capital expenditure, compete for the same customers or routes, and leave capacity underused elsewhere. The draft further argues that digital alignment through the National Logistics Ecosystem (NLE) should be understood together with organizational restructuring rather than as an isolated technology intervention.

These claims motivate a question with both theoretical and policy relevance: through which mechanisms could state-directed multimodal integration improve logistics performance, and under what conditions might the expected benefits be weaker or stronger? A merger or holding-company redesign does not mechanically generate efficiency. Integration can lower contracting and coordination costs, but it can also add administrative layers, weaken competitive pressure, create common-agency problems, or centralize decisions far from operational knowledge. Digital systems can improve visibility and reduce repeated data entry, but interoperability depends on data standards, process redesign, accountability, and incentives to share information. The net effect is consequently an empirical question rather than a presumption.

Existing theory provides complementary lenses. Transaction cost economics (TCE) explains why firms internalize transactions when coordination through market contracts is costly or hazardous (Coase, 1937; Williamson, 1981). The resource-based view (RBV) explains how complementary assets and capabilities may generate value when deployed as a

coordinated system (Barney, 1991). Principal–agent and public-choice perspectives, meanwhile, highlight that state ownership introduces multiple principals, political objectives, soft budget constraints, and possible divergence between enterprise-level incentives and public welfare (Shleifer & Vishny, 1994). Combining these lenses makes it possible to distinguish the potential operational gains from the governance conditions required to realize them.

This paper develops the State-Driven Multi-Modal Integration and Double-Marginalization Elimination (SD-MIDE) framework. It links structural integration to three intermediate mechanisms: lower cumulative markups and transaction costs; reduced overlap in routes, facilities, and capital expenditure; and stronger digital interoperability across organizational boundaries. These mechanisms are expected to affect cost, dwell time, and asset turnover. The framework also specifies a moderation mechanism: digital interoperability may reduce the effect of institutional inertia on operational dwell time. Finally, the paper proposes that integration benefits may vary by corridor geography, particularly where multimodal transfers and island-to-island coordination make interface failures more costly.

The empirical section uses a reproducible synthetic panel to demonstrate how the hypotheses can be operationalized and estimated. This is a methodological simulation, not a field evaluation. The dataset is intentionally constructed to reflect plausible panel structure and relationships implied by the framework, and its estimates are therefore useful for demonstrating model specification, variable measurement, and reporting discipline only. They cannot establish the actual effect of Indonesia's SOE restructuring, provide factual estimates of national logistics costs, or validate claims about any named enterprise. Explicitly separating model demonstration from empirical evidence is important because an apparently precise regression table can otherwise create unwarranted confidence.

The study makes four contributions. First, it conceptualizes state-led logistics consolidation as a joint vertical, horizontal, and digital coordination problem rather than a merger event alone. Second, it translates this conceptualization into testable hypotheses and operational variables at the entity–corridor–year level. Third, it demonstrates a transparent fixed-effects estimation approach, including a digital moderation term and corridor heterogeneity. Fourth, it proposes a phased restructuring roadmap that treats governance, competition safeguards, data interoperability, and performance measurement as complements. The contribution is a framework and reproducible analytical template; the simulation is not presented as empirical confirmation.

The remainder of the article is organized as follows. Section 2 reviews the theoretical foundations and develops the SD-MIDE framework and hypotheses. Section 3 presents the research design, synthetic panel construction, variables, and estimators. Section 4 reports the simulated descriptive and regression results. Section 5 discusses theoretical implications, managerial and policy implications, limitations, and an agenda for empirical validation. Section 6 concludes.

2. LITERATURE REVIEW

2.1. Transaction cost economics and vertical coordination

Transaction cost economics starts from the proposition that exchange is not costless. Search, negotiation, monitoring, adaptation, and enforcement consume resources, and the appropriate governance arrangement depends on the characteristics of the transaction and the hazards that accompany it (Coase, 1937; Williamson, 1981). Logistics chains contain repeated, sequentially dependent exchanges: cargo handling may depend on terminal access, customs release, warehousing, line-haul capacity, and final distribution. If each stage is priced and managed independently, local optimization may increase total chain cost. Separate providers may also duplicate documentation, apply inconsistent service rules, or pass uncertainty to the next operator.

The double-marginalization argument provides a narrower pricing mechanism. When two or more firms with market power set markups at sequential stages, each firm does not fully internalize the effect of its price on the volume and profit of the entire chain. The combined price can exceed the integrated-chain price, reducing quantity and total surplus (Spengler, 1950). Integration may reduce this distortion if internal transfer prices, capacity decisions, and incentives are coordinated. It does not follow, however, that all markups are wasteful: charges may reflect real service costs, risk, congestion, or investment. A credible empirical design must distinguish avoidable cumulative markup from efficient cost recovery.

In the Indonesian SOE context, the relevant mechanism is not necessarily legal merger alone. Shared service standards, transparent internal transfer pricing, joint capacity planning, common shipment identifiers, and end-to-end service accountability can reduce coordination frictions even where distinct operating subsidiaries remain. Conversely, a holding structure that merely changes ownership while leaving workflows and incentives intact may have little effect. SD-MIDE therefore treats structural integration as an enabling condition and measures the mechanisms—markup compression and reduced administrative friction—separately from the organizational label.

These arguments imply that greater multimodal integration should be associated with lower end-to-end logistics cost, conditional on time effects, unit characteristics, and relevant controls. They also imply that a lower cumulative markup share should correspond to lower cost outcomes. The simulation operationalizes these ideas through an integration index and a cumulative-markup proxy; in an actual study, the latter should be constructed from invoice-level prices, transfer prices, and comparable service costs rather than inferred from the dependent variable.

2.2. Resource-based view, complementarities, and economies of scope

The resource-based view emphasizes that performance differences may arise from resources and capabilities that are valuable and difficult to replicate (Barney, 1991). Logistics assets are often location-specific and capital intensive. Ports, airports, depots, warehouses, vehicle fleets, information platforms, and customer relationships create value not only individually but also through complementarity. A port terminal with weak inland connections, for example, may fail to deliver its potential throughput; a courier network may provide a valuable last-mile capability but be unable to coordinate effectively with bulk or maritime flows without compatible data and service design.

Multimodal integration can create economies of scope when shared assets, common planning, or interoperable information reduce the incremental cost of providing a combined service. It may improve asset turnover by matching demand across facilities, smoothing peaks, consolidating loads, and avoiding duplicate procurement. Yet complementarities do not arise automatically from common ownership. Assets can be geographically mismatched, service cultures can conflict, legacy systems may be incompatible, and internal capital markets can allocate investment according to political visibility rather than productive return. Thus, the RBV predicts gains from coordinated deployment of complementary resources, while also directing attention to the capabilities needed to realize them.

The horizontal dimension is central. When state entities independently invest in similar warehouses, routes, fleets, or customer-facing services, they may create redundant capacity while leaving other nodes constrained. The overlap index in this study is intended to represent duplication in routes, facilities, and capital expenditure; a lower index should be associated with higher asset turnover and lower cost. In applied research, the index should be built from geospatial facility inventories, route networks, asset registers, and investment plans, with explicit rules for what counts as substitutable or overlapping capacity.

2.3. Principal agent problems and public-choice constraints

State-owned enterprises operate under a more complex objective structure than a firm whose mandate is limited to shareholder value. Government owners may seek financial returns, employment, regional connectivity, price stability, strategic capacity, and universal service simultaneously. Such goals can be legitimate, but they create measurement and incentive challenges when objectives are not ranked or compensated transparently. The state may also act as owner, regulator, customer, and policymaker, creating potential conflicts between commercial discipline and public objectives. Shleifer and Vishny (1994) describe how political incentives can shape firm decisions, while public-sector contracting research emphasizes the importance of information and incentive design (Laffont & Tirole, 1993).

Restructuring can clarify accountability if each operating entity has a defined mandate, comparable performance indicators, and transparent obligations for non-commercial services. A super-holding can, in principle, coordinate capital allocation across a portfolio and monitor performance using common metrics. However, it can also create an additional agency layer. If executives are rewarded for the revenue or assets of their own subsidiaries rather than total-chain cost and service reliability, internal competition may persist beneath a consolidated ownership structure. If the state absorbs losses without credible performance conditions, the soft-budget constraint may weaken the incentive to eliminate inefficiency.

In SD-MIDE, institutional inertia captures resistance to changing routines, systems, authority, and established interests. Inertia is not exclusively political: it can arise from incompatible information technology, labor arrangements, legacy contracts, safety requirements, or rational caution about operational disruption. The framework therefore does not assume that all resistance is opportunistic. Instead, it predicts that interoperability and standardized processes can reduce the operational penalty associated with inertia by making information exchange more routine and less dependent on discretionary coordination. This moderation effect should be tested rather than assumed.

2.4. Digital interoperability and the National Logistics Ecosystem

Digital logistics platforms can improve visibility by making shipment status, documents, permissions, and handoffs available across organizations. The potential value is not simply digitization of existing forms. If separate agencies require the same information in different formats or at different points in a journey, an electronic interface can reproduce the fragmentation of paper processes. Interoperability requires common data definitions, secure access, system-to-system connectivity, process ownership, and rules for resolving discrepancies. A single-window architecture may reduce repeated submissions, but it cannot by itself remove unnecessary regulatory requirements or align commercial incentives.

The draft treats NLE alignment as an institutional and technological complement to restructuring. This framing is theoretically important: ownership integration can change authority and capital allocation, while digital integration can change the cost and speed of information exchange. The two are related but not interchangeable. An organization may be legally integrated while retaining disconnected systems; independent organizations may achieve high interoperability through standards and trusted data exchange. The empirical design consequently treats multimodal structural integration and NLE interoperability as distinct variables and includes both in performance equations.

Digital alignment may also moderate the relationship between institutional inertia and dwell time. When systems are interoperable, staff can rely less on informal bilateral communication, repeated data entry, and sequential approval. The negative interaction predicted here means that the positive association between inertia and dwell time should become smaller at higher levels of interoperability. The mechanism depends on actual process redesign and adoption, not the mere presence of a platform. In a real-world application,

adoption logs, API transactions, document re-use, exception rates, and timestamps would be more informative than a self-reported binary indicator.

2.5. Research gap and the SD MIDE framework

The draft identifies two gaps. First, logistics integration research often focuses on private integrators and conventional commercial mergers, leaving less developed analytical treatment of state-orchestrated consolidation across multiple transport modes in an archipelagic emerging economy. Second, digital single-window systems are frequently discussed as technology interventions without jointly modelling ownership structure, internal competition, and governance. These gaps should be understood as motivating questions rather than proof that no related research exists; a submission-ready article should verify the boundaries of the literature through a systematic search and replace any unverified novelty claims with carefully scoped statements.

SD-MIDE combines three layers. The structural layer comprises multimodal integration and portfolio coordination. The mechanism layer comprises cumulative-markup reduction, lower administrative and transaction costs, lower intra-SOE overlap, and digital interoperability. The outcome layer comprises end-to-end cost, dwell time, and asset turnover. Governance conditions—including clear mandates, performance contracts, transparent capital allocation, competition safeguards, and service obligations—shape whether the first layer produces the second and third. This structure avoids treating merger status as a sufficient statistic for efficiency.

The conceptual model is deliberately falsifiable. If integration does not predict lower costs after accounting for unit and year effects, the expected vertical or coordination mechanism may be absent, poorly measured, or offset by integration costs. If overlap reduction is not related to asset turnover, the asset complementarities assumed by the RBV may not be realized. If the interaction between inertia and NLE interoperability is not negative, digital alignment may not offset institutional rigidity or the chosen measures may fail to capture effective use. If corridor heterogeneity is absent, the claim that archipelagic settings necessarily benefit more should be narrowed.

2.6. Hypotheses

H1. Greater multimodal structural integration is associated with lower logistics costs, partly through lower cumulative markups and coordination frictions.

H2. Lower intra-SOE service and investment overlap is associated with higher asset turnover and lower logistics costs.

H3. NLE interoperability is associated with shorter administrative and operational dwell time.

H4. NLE interoperability negatively moderates the relationship between institutional inertia and dwell time.

H5. The association between multimodal integration and logistics-cost reduction is stronger in archipelagic corridors than in land-connected corridors.

H1 and H2 express distinct but potentially linked mechanisms. H3 focuses on the direct association between digital interoperability and time performance, whereas H4 tests whether interoperability changes the relationship between inertia and dwell time. H5 is a heterogeneity proposition, not a claim that all archipelagic corridors are alike. The corridor classification should be refined in applied work using route-level transfer counts, distance, modal mix, and island connectivity rather than a single binary indicator alone.

3. METHODS

3.1. Research design and inferential boundary

The design is a quantitative panel-data demonstration organized around entity–corridor units observed annually. The source draft does not contain a firm-level dataset,

administrative records, or measured outcomes. To meet the request for a coherent and reproducible analysis, this manuscript constructs a synthetic panel with 24 units over eight years (2017–2024), yielding 192 unit-year observations. The data-generating process is seeded and documented in the accompanying CSV. It encodes plausible associations consistent with the conceptual model and includes unit heterogeneity, year variation, and stochastic disturbance.

The synthetic observations are not real observations from Indonesian SOEs, ports, airports, warehouses, or freight corridors. They are not estimates of Indonesia's logistics-cost-to-GDP ratio, and they do not identify the impact of Danantara, any holding structure, or a particular restructuring event. Regression coefficients and significance levels are properties of the chosen simulation process. Their purpose is to demonstrate the proposed estimators, variable relationships, and reporting format. Any interpretation of coefficient signs is conditional on that artificial process.

The panel is described as entity–corridor data to illustrate the intended empirical unit, but unit identifiers are anonymized simulation labels rather than actual corporate identities. The entity-type labels are broad analytical categories, not assertions about the observed behavior of specific companies. The eight-year window is selected to provide a manageable demonstration of temporal and unit variation; it should not be interpreted as a claim that the relevant reform took place at a particular date or that the years are sufficient to identify a reform effect.

3.2. Sample structure and reproducibility

The simulation contains 24 units, each observed in every year from 2017 to 2024. Six broad operator categories are represented, and 16 units are assigned to archipelagic corridors while eight are assigned to land-connected corridors. A fixed random seed (20261009) is used to reproduce the dataset. The unit identifier absorbs time-invariant differences in a fixed-effects specification; year indicators absorb common annual shocks. The sample is balanced by construction. This balance is a modelling convenience, not a description of the availability or completeness of actual SOE data.

Table 1. Structure and Reproducibility

Design element	Specification
Unit of analysis	Synthetic entity–corridor unit-year
Units	24
Years	2017–2024 (8 annual periods)
Observations	192
Panel structure	Balanced by construction
Corridor groups	16 archipelagic; 8 land-connected
Random seed	20261009
Inference	OLS with unit and year fixed effects; standard errors clustered by unit
Files	CSV dataset accompanying this manuscript

3.3. Variables and operational definitions

Table 2. Variables and Operational Definition

Construct	Variable	Operational definition
Logistics cost proxy	logistics_cost_pct_gdp_proxy	Continuous simulated index labelled in percentage-point-like units; lower is better. Not a national statistic.
Dwell time	dwell_time_days	Simulated days from a defined arrival/entry point to release or onward movement; lower is better.
Asset turnover	asset_turnover	Simulated throughput/revenue proxy per unit of asset base; higher is better.
Multimodal integration	multimodal_integration	Continuous index from 0 to 1 representing process, asset, and planning integration.
NLE interoperability	nle_interoperability	Continuous index from 0 to 1 representing cross-system data and process interoperability.
Overlap index	overlap_index	Continuous index from 0 to 1; higher indicates more route, service, or investment overlap.
Cumulative markup share	cumulative_markup_share	Simulated share representing cumulative sequential markups; higher indicates greater layered markup.
Institutional inertia	institutional_inertia	Continuous index from 0 to 1; higher indicates greater resistance or delay in changing routines.
Fuel price index	fuel_price_index	Synthetic common input-cost proxy, indexed around 100 in the first year.
Infrastructure index	infrastructure_index	Synthetic index of corridor infrastructure availability/quality.
GDP growth	gdp_growth_pct	Synthetic macroeconomic control, in percentage points.
Archipelagic corridor	archipelagic	Indicator equal to 1 for archipelagic units and 0 for land-connected units.

All continuous indices are generated within bounded ranges where appropriate. The cost and dwell-time outcomes are generated from integration, interoperability, overlap, markup, fuel, infrastructure, macroeconomic controls, unit heterogeneity, and random disturbances. Because several regressors are components of the same data-generating process, the simulation is designed for demonstration rather than for independent validation of causal mechanisms. In actual research, construct validity should be assessed through documented data provenance, inter-rater procedures where coding is involved, and sensitivity tests using alternative definitions.

3.4. Model specification

The baseline logistics-cost equation is specified as:

$$Cost_{it} = \beta_0 + \beta_1 Integration_{it} + \beta_2 Markup_{it} + \beta_3 Overlap_{it} + \beta_4 NLE_{it} + \beta_5 Fuel_{it} + \beta_6 Infrastructure_{it} + \beta_7 GDPGrowth_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

where i denotes the entity–corridor unit and t denotes year; α_i represents unit fixed effects, λ_t represents year fixed effects, and ε_{it} is the idiosyncratic error. The coefficient of interest for H1 is β_1, while β_2 and β_3 correspond to the markup and overlap mechanisms. A negative β_1 is consistent with lower costs associated with higher integration, conditional on the included regressors. Because integration and mechanism variables may be jointly determined in real settings, this association alone would not establish causality.

The dwell-time equation includes the interaction between institutional inertia and NLE interoperability:

$$Dwell_{it} = \gamma_0 + \gamma_1 Integration_{it} + \gamma_2 Inertia_{it} + \gamma_3 NLE_{it} + \gamma_4(Inertia_{it} \times NLE_{it}) + \gamma_5 Overlap_{it} + \gamma_6 Fuel_{it} + \gamma_7 Infrastructure_{it} + \alpha_i + \lambda_t + \upsilon_{it}$$

H4 predicts $\gamma_4 < 0$. The marginal association between inertia and dwell time is $\gamma_2 + \gamma_4 NLE_{it}$. A negative interaction means that the inertia–dwell-time slope declines as interoperability rises. Main effects should be interpreted at the zero point of the interacting variable; centering variables around their means would often improve interpretability in a substantive application. The demonstration retains the original 0–1 scale for reproducibility.

The asset-turnover equation is:

$$Turnover_{it} = \delta_0 + \delta_1 Integration_{it} + \delta_2 Overlap_{it} + \delta_3 Infrastructure_{it} + \delta_4 GDPGrowth_{it} + \alpha_i + \lambda_t + \omega_{it}$$

H2 anticipates $\delta_2 < 0$ because the overlap index increases with duplication. A positive integration coefficient would be consistent with better use of complementary assets. Asset turnover is only one proxy for capital allocation efficiency; it should be supplemented by utilization, throughput per asset, maintenance cost, and service quality to avoid rewarding high utilization that comes at the expense of resilience or reliability.

To explore H5, the cost equation adds an interaction between multimodal integration and the archipelagic indicator. The main effect of a time-invariant corridor classification is absorbed by unit fixed effects; the interaction remains estimable because integration changes over time. The interaction coefficient tests whether the integration–cost slope differs between corridor types. This specification is exploratory because corridor types may differ along many dimensions, and the simulated sample is not designed to support a definitive policy comparison.

3.5. Estimation and statistical inference

All reported models are estimated by ordinary least squares with unit and year indicators. Standard errors are clustered at the unit level to allow heteroskedasticity and serial dependence within a unit. With only 24 clusters, conventional cluster-robust inference may still be unreliable; a field study should consider small-sample corrections, wild-cluster bootstrap procedures, and sensitivity to alternative clustering levels. The estimates reported here are presented to three decimal places, with conventional significance markers used only as descriptive output from the simulation.

Fixed effects are appropriate when unobserved time-invariant unit characteristics may be correlated with the regressors. They do not eliminate bias from time-varying confounders, reverse causality, measurement error, or anticipatory behavior. Nor do they by themselves identify a restructuring effect. A causal evaluation would need a credible source of treatment variation and a defensible counterfactual, such as a carefully designed event study or difference-in-differences strategy if parallel-trend assumptions and treatment timing can be substantiated.

The original conceptual draft refers to mediation through transaction-cost reduction and administrative dwell time. A formal mediation analysis would require explicit temporal ordering and assumptions about mediator–outcome confounding. The synthetic demonstration reports mechanism-aligned regressions and an interaction model but does not claim a fully identified causal mediation effect. In a real study, researchers could estimate indirect effects using a pre-specified causal mediation framework, bootstrap uncertainty at the unit level, and sensitivity analysis for unmeasured mediator–outcome confounding. This distinction prevents a collection of correlated regressions from being overstated as a causal pathway.

3.6. Robustness and validity plan for an empirical application

First, outcome definitions should be varied. Logistics cost may be measured as a firm-level cost per shipment, cost per ton-kilometre, or a carefully documented national cost ratio. These outcomes are not interchangeable. Dwell time should be defined consistently by start and end timestamps and separated into port, customs, warehouse, and intermodal transfer components. Asset turnover should be adjusted for differences in asset valuation, outsourcing, and accounting policy.

Second, integration and interoperability should be measured independently of performance outcomes. Integration may be coded from shared planning, internal transfer agreements, joint procurement, common service-level agreements, and cross-modal coordination. Interoperability should use observable evidence such as the proportion of transactions exchanged electronically, successful system-to-system messages, duplicate-document rates, and exception-resolution times. Using an outcome such as reduced dwell time to construct the interoperability score would create mechanical correlation.

Third, the analysis should test alternative lag structures because capital investment and organizational integration may take time to affect operations. Lagged integration, distributed lags, and event-time coefficients can help reveal adjustment patterns, though lagging alone does not solve endogeneity. Fourth, models should include demand intensity, commodity mix, weather disruptions, congestion, route distance, shipment size, and service obligations when such data are available. Fifth, inference should be tested under alternative standard-error estimators and with influential units removed according to pre-specified criteria.

Sixth, an applied design should examine heterogeneous effects by corridor geography, cargo type, firm function, and baseline digital maturity. A binary archipelagic indicator may conceal important variation in transfer intensity and remoteness. Seventh, placebo outcomes or placebo reform dates can reveal whether estimated patterns are spuriously associated with time. Finally, all variable construction rules, exclusions, code, and data limitations should be documented. These procedures are not reported as completed empirical tests in this simulation; they constitute a validation protocol for subsequent field research.

4. RESULTS

4.1. Descriptive profile of the synthetic panel

Table 3. Descriptive profile

Statistic	Synthetic panel
Observations	192
Units	24
Years	8
Integration index, mean (SD)	0.430 (0.175)
NLE interoperability, mean (SD)	0.409 (0.195)
Overlap index, mean (SD)	0.574 (0.148)
Cumulative markup share, mean (SD)	0.129 (0.058)

Statistic	Synthetic panel
Cost proxy, mean (SD)	17.054 (0.975)
Dwell time, days, mean (SD)	7.441 (0.867)
Asset turnover, mean (SD)	0.991 (0.131)

The panel contains 192 observations from 24 units over eight years. As designed, integration and interoperability vary across units and years, while overlap and markup measures vary over time. The outcome distributions are generated by the stated data-generating process and include unit heterogeneity and random error. The descriptive values are included to make the example auditable; they should not be compared with published Indonesian macroeconomic estimates because the cost outcome is a simulated proxy rather than an observed national ratio.

4.2. Fixed effects estimates for the logistics-cost proxy

Table 4. Fixed-effects estimates

Predictor	Coefficient	Clustered SE	p-value	
multimodal integration	-1.839	0.522	0.000	***
cumulative markup share	0.706	1.636	0.666	
overlap index	0.658	0.481	0.171	
nle interoperability	-2.376	0.774	0.002	***
fuel price index	0.016	0.009	0.073	*
infrastructure index	-1.238	1.231	0.315	
gdp growth pct	-0.203	0.030	0.000	***

The cost model has R-squared 0.769 and adjusted R-squared 0.714. In the simulated regression, multimodal integration has a coefficient of -1.839 (clustered SE 0.522; p=0.000). The sign is consistent with H1: higher integration is associated with a lower cost proxy after conditioning on markup, overlap, interoperability, controls, and unit and year fixed effects. This is a property of the simulation, not an empirical estimate of the effect of restructuring.

The cumulative-markup coefficient is 0.706 (p=0.666), while the overlap coefficient is 0.658 (p=0.171). Their simulated signs are consistent with the proposition that layered markups and duplicated activity are associated with higher cost. The NLE coefficient is -2.376 (p=0.002), consistent with lower costs at higher interoperability. The simultaneous inclusion of integration and mechanism variables means the integration coefficient is a conditional association, not the total effect of integration through all pathways.

4.3. Dwell-time model and digital moderation

Table 5. Dwell-time model and digital moderation

Predictor	Coefficient	Clustered SE	p-value	
multimodal integration	-2.194	0.443	0.000	***
institutional inertia	2.362	0.888	0.008	***
nle interoperability	0.302	1.414	0.831	

institutional inertia × nle interoperability	-4.353	2.046	0.033	**
overlap index	1.459	0.605	0.016	**
fuel price index	0.027	0.006	0.000	***
infrastructure index	-1.258	1.365	0.357	

The dwell-time model has R-squared 0.765. The interaction between institutional inertia and interoperability is -4.353 (clustered SE 2.046; p=0.033). A negative interaction is consistent with H4 because the simulated inertia–dwell-time slope becomes less positive as interoperability increases. The direct NLE coefficient is interpreted at an inertia value of zero; it should not be treated as the average digital effect without computing marginal effects at substantively relevant values.

The institutional-inertia main effect is 2.362 (p=0.008), while the NLE main effect is 0.302 (p=0.831). The integration coefficient is -2.194 (p=0.000). These associations follow the simulation's assumed mechanism, which gives digital interoperability a role in reducing both direct process friction and the operational penalty associated with inertia.

4.4. Asset turnover and overlap

Table 6. Asset turnover and overlap

Predictor	Coefficient	Clustered SE	p-value	
multimodal integration	0.212	0.074	0.004	***
overlap index	-0.042	0.049	0.394	
infrastructure index	0.205	0.148	0.165	
gdp growth pct	0.034	0.006	0.000	***

The asset-turnover model has R-squared 0.760. The coefficient on multimodal integration is 0.212 (p=0.004), while the overlap coefficient is -0.042 (p=0.394). The expected positive integration and negative overlap pattern would be consistent with H2. These results illustrate how an asset-use outcome can complement cost and dwell-time measures; they do not demonstrate that a real consolidation has improved asset utilization.

4.5. Corridor heterogeneity

Table 7. Heterogeneity

Predictor	Coefficient	Clustered SE	p-value	
multimodal integration	-1.825	0.653	0.005	***
multimodal integration × archipelagic	-0.022	0.458	0.962	
cumulative markup share	0.699	1.641	0.670	
overlap index	0.659	0.486	0.175	
nle interoperability	-2.374	0.781	0.002	***

The integration-by-archipelagic interaction is -0.022 (p=0.962). Its sign indicates whether the integration cost slope differs across the two simulated corridor classes. H5 is supported in direction only if the interaction is negative; statistical significance and magnitude must be evaluated from the displayed estimate. Even where the simulated interaction is significant, it cannot substantiate a real-world claim that archipelagic corridors obtain larger benefits. The corridor composition and interaction were generated for illustration.

4.6. Hypothesis Assessment

Hypothesis	Simulation result	Interpretive note
H1: integration and cost reduction	Directionally consistent; p<0.05 in simulation	Cost regression; conditional association only.
H2: overlap and asset turnover	Directionally consistent; p≥0.05 in simulation	Asset-turnover regression.
H3: NLE and dwell time	Not directionally consistent; p≥0.05 in simulation	Direct NLE coefficient is conditional on inertia=0.
H4: NLE moderates inertia	Directionally consistent; p<0.05 in simulation	Interaction model.
H5: stronger integration association in archipelagic corridors	Directionally consistent; p≥0.05 in simulation	Exploratory interaction model.

The hypothesis table uses a deliberately restrained reporting convention. “Directionally consistent” means that the estimated sign matches the pre-specified expectation; the p-value label describes only the simulated regression. It does not mean the hypothesis has been empirically established for Indonesia. Because the data-generating process was constructed around the theoretical relationships, conventional significance in this setting should not be treated as an independent test of the theory.

4.7. Interpretation of the simulated pattern

Taken together, the illustrative models show how the SD-MIDE framework can be translated into an estimable panel structure. The cost equation separates integration from cumulative markup, overlap, and digital interoperability; the dwell-time equation evaluates an interaction; the asset-turnover equation tests a capital-use implication; and the corridor model probes geographic heterogeneity. The set of outcomes matters because an apparent cost reduction could arise from underinvestment or lower service quality, while asset utilization could increase at the expense of resilience. A field study should therefore estimate multiple outcomes jointly and report service-quality guardrails.

The synthetic design also demonstrates a key interpretive issue: when a regression includes variables that are conceptually downstream of integration, the coefficient on integration does not represent the total association that would be observed without conditioning on those mediators. In a real analysis, researchers should decide whether the estimand is the total effect of integration, a direct effect holding mechanisms constant, or a mediated effect through markup and transaction-cost reduction. These estimands answer different questions and require different assumptions.

Finally, a panel with a modest number of units may produce apparently precise estimates when the data-generating process is smooth and variables are designed to co-move. Actual logistics data are likely to contain measurement error, policy discontinuities, commodity-specific shocks, missing records, and heterogeneous adoption. Replication with

genuine operational data may yield smaller, larger, or opposite estimates. The value of this section is procedural transparency rather than numerical generalization.

5. DISCUSSIONS

5.1. Theoretical implications

The first theoretical implication is that vertical integration should be treated as a bundle of governance and operational changes. TCE predicts that integration may reduce transaction costs when sequential exchanges are difficult to coordinate through separate contracts. Yet organizational boundaries are only one component of governance. A super-holding that centralizes ownership but leaves transfer pricing, service-level agreements, and exception management unchanged may preserve the very frictions it was designed to remove. The SD-MIDE framework therefore emphasizes the operational pathways through which governance redesign is expected to matter.

Second, the RBV broadens the analysis beyond price markups. Ports, aviation assets, warehouses, postal networks, and land distribution systems may have complementary capabilities, but their value depends on how they are combined. Shared forecasting, compatible data, synchronized schedules, and coordinated capital planning can improve the productive use of a portfolio. The negative relationship between overlap and asset turnover encoded in the simulation illustrates an estimable prediction; actual evidence would need to show that overlap was reduced and that utilization improved without weakening coverage or redundancy needed for resilience.

Third, the principal–agent perspective explains why a technically coherent consolidation may fail institutionally. A holding company can lower some coordination costs while increasing monitoring distance between the central owner and operational units. The reform must specify who is accountable for end-to-end performance, how internal prices are set, how public-service obligations are funded, and how capital projects are evaluated. If subsidiaries continue to be rewarded for local revenue, they may have incentives to retain customers, duplicate facilities, or shift costs to another node. Governance design is therefore a moderator of the integration–performance relationship, even though the present simulation does not estimate a separate governance interaction.

Fourth, the digital moderation mechanism suggests that digital infrastructure and organizational integration should not be viewed as substitutes. Digital systems can reduce the cost of sharing information across legal boundaries, while integration can align incentives and decision rights. Either may operate without the other, but the strongest results may require both. This proposition is especially relevant where many agencies and service providers handle the same shipment. A digital single window that merely transmits forms more quickly may improve local processing but fail to address duplicated procedures, incompatible incentives, or sequential pricing.

Fifth, the framework helps avoid a simplistic presumption that state ownership is either inherently inefficient or inherently capable of coordination. State ownership may enable portfolio-level planning across infrastructure that private firms would not integrate because of contracting barriers, network externalities, or public-service requirements. It may also create political allocation, soft-budget constraints, and weak exit discipline. The relevant question is institutional: whether the ownership model, performance contracts, competition policy, and public-service compensation together create incentives for total-chain efficiency.

5.2. Implications for restructuring policy

A first policy implication is to distinguish ownership consolidation from functional integration. A merger announcement or share transfer should not be used as a performance indicator. Authorities should track whether end-to-end service standards exist, whether internal transfer prices are transparent, whether route and asset planning is coordinated, and

whether customers experience fewer handoffs. Integration milestones should be tied to operational evidence, not only to legal milestones.

A second implication is to map overlap before rationalizing assets. Duplication can occur in routes, terminals, warehouses, vehicle fleets, customer accounts, IT platforms, and planned capital expenditure. A common asset register and geospatial route map can identify where capacity is substitutable and where apparent redundancy provides resilience. Removing duplicated capacity indiscriminately may create single points of failure, weaken regional access, or increase congestion. Portfolio optimization should therefore consider cost, utilization, service coverage, reliability, and contingency capacity together.

A third implication is to redesign internal pricing and performance measurement. End-to-end cost-to-serve should be visible across the chain, while internal transfer prices should reflect real costs and avoid incentive structures that reward each node for maximizing its own markup. Common performance dashboards could include cost per shipment or ton-kilometre, dwell time at each interface, on-time delivery, claims, utilization, emissions intensity, and service obligations. Metrics should be disaggregated by corridor and cargo type to prevent aggregate improvement from concealing deterioration in remote areas.

A fourth implication is that NLE implementation should be evaluated by interoperability and process outcomes rather than system availability alone. Relevant indicators include the share of shipment records reused across agencies, the number of duplicate submissions, the percentage of transactions completed without manual re-entry, error and exception rates, and elapsed time between handoffs. Data governance must address access rights, cybersecurity, auditability, retention, and responsibility for correcting inaccurate records. Digital systems are not a substitute for simplifying unnecessary procedures.

A fifth implication concerns governance and public accountability. The owner should define the commercial objectives of each subsidiary, the public-service obligations it must meet, and the mechanism through which those obligations are compensated. Performance contracts should separate controllable operational outcomes from macroeconomic shocks and should avoid rewarding cost reduction that comes at the expense of safety, labor standards, environmental performance, or universal service. Independent benchmarking and transparent reporting can reduce the risk that consolidation simply relocates inefficiency within a larger corporate group.

A sixth implication is to preserve contestability where feasible. Integration may reduce double marginalization, but it can also create market power or discriminate against third-party logistics providers. Access rules, transparent tariffs, nondiscriminatory use of essential facilities, and competition oversight can help ensure that internal coordination gains are not achieved by foreclosing efficient competitors. The public interest should be assessed in terms of total logistics cost, service quality, reliability, and market access rather than the profitability of the consolidated group alone.

5.4. Research implications and empirical validation agenda

The most important next step is to replace the synthetic panel with linked administrative and enterprise data. Potential sources include audited financial statements, shipment-level invoices, port and airport timestamps, warehouse management systems, fleet and route records, procurement plans, and NLE transaction logs. These sources need not be merged at the individual level if privacy and commercial confidentiality prevent it; secure data environments and aggregated corridor-level measures may be sufficient for many questions. The unit of analysis should match the mechanism being studied: firm-year for financial performance, shipment for dwell time, and route or facility-year for overlap and utilization.

Treatment timing and exposure require careful definition. A formal change in ownership may occur on a different date from operational integration, shared procurement, or digital adoption. An event study should therefore distinguish legal consolidation from

implementation milestones. If a comparison group can be defended, difference-in-differences may estimate a reform effect under a parallel-trends assumption. If treatment is staggered, estimators should accommodate heterogeneous treatment timing and effects. If no credible comparison exists, the study should present descriptive longitudinal evidence and avoid causal language.

Mechanism tests should be pre-registered or otherwise specified before outcome analysis. For double marginalization, researchers could estimate changes in cumulative price components, internal transfer prices, and total cost for comparable service bundles. For cannibalization, they could track overlapping routes, duplicate investments, utilization, and entry or exit of facilities. For digital alignment, transaction-level data could identify whether document reuse and interoperability precede shorter dwell time. Mechanism evidence is stronger when the mediator changes after the intervention and before the final outcome, and when alternative explanations are addressed.

External validity is another priority. Indonesia's geography, regulatory arrangements, and public-service obligations may differ from those of continental markets or other state-led logistics systems. Rather than generalizing from a single country, future research could compare corridor types within Indonesia and then compare institutional settings across countries. Such comparisons should not treat a state-owned operator in one country as equivalent to another without examining ownership mandates, competition conditions, subsidy arrangements, and market structure.

5.5. Limitations

The central limitation is the constructed nature of the data. The regression estimates are not empirical evidence and cannot support claims about the actual effects of restructuring. The simulation encodes the expected relationships and thus cannot serve as an independent test of the hypotheses. It is included solely to show how a transparent dataset, model, and results section can be organized before genuine data become available.

Second, the panel is small and balanced by construction. Real administrative panels are likely to be unbalanced and may contain missingness related to performance, organizational changes, or reporting capacity. The small number of units also limits the reliability of cluster-robust inference. Third, the cost proxy is not a measured national logistics-cost-to-GDP ratio and should not be interpreted as one. Dwell time and asset turnover are likewise synthetic outcomes.

Fourth, the current models do not identify causal mediation. Including markup, overlap, and interoperability alongside integration estimates conditional relationships, but does not establish that these variables mediate a causal effect. Fifth, the binary corridor classification is simplified, and the simulation does not model network spillovers, congestion externalities, strategic behavior by private competitors, or service-quality trade-offs. Sixth, the model does not explicitly estimate governance quality, competition intensity, labor adjustment, emissions, safety, or regional equity.

Seventh, the literature review is theory-driven and based on the references listed in the source draft plus foundational works. Several references in the supplied draft require bibliographic verification before journal submission. The article does not assume that every source-listed title, page range, or publication detail is correct. A submission-ready version should verify each reference against publisher or bibliographic records, add recent empirical work directly relevant to state-owned logistics restructuring and digital trade facilitation, and ensure that all in-text citations match the final reference list.

6. CONCLUSION

This article develops the SD-MIDE framework to explain how state-directed multimodal logistics integration may influence performance through vertical markup compression,

horizontal overlap reduction, and digital interoperability. The framework integrates TCE, RBV, and principal–agent/public-choice perspectives and distinguishes organizational restructuring from the mechanisms through which restructuring might create value. It proposes testable relationships for cost, dwell time, asset turnover, digital moderation, and corridor heterogeneity.

The synthetic panel demonstrates a reproducible approach to operationalizing the constructs and estimating unit and year fixed-effects models with unit-clustered standard errors. The illustrative coefficients are consistent with the relationships built into the simulation, but they are not findings about actual Indonesian logistics operations. No policy conclusion about the realised impact of SOE consolidation can be drawn from these estimates. The article's empirical value is methodological: it supplies a variable dictionary, model specifications, a reporting template, and a clear boundary between simulated and observed evidence.

For policy and research, the core proposition is that ownership consolidation is neither a sufficient condition nor a reliable proxy for logistics efficiency. Performance gains require operational coordination, transparent capital allocation, compatible data, incentives tied to end-to-end outcomes, and safeguards against market power and service deterioration. A rigorous field evaluation should use validated shipment, financial, asset, and platform data; establish a defensible counterfactual where possible; test mechanisms separately; and report cost and service-quality outcomes together. Only then can the SD-MIDE framework be assessed as an explanation of Indonesia's restructuring experience rather than as a theoretically motivated research agenda.

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