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NAVIGATING ARCHIPELAGIC BARRIERS AND BORDER GOVERNANCE: A CONSTANT MARKET SHARE AND SUPPLY CHAIN COMPETITIVENESS ANALYSIS OF INDONESIAN FROZEN OCTOPUS EXPORTS

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ABSTRACT

Exports of frozen octopus (Octopus vulgaris) from Indonesia depend on perishable cold chains that must cross archipelagic barriers and clear multi-agency border governance before reaching high-value markets such as Japan. Studies of fishery export competitiveness rarely incorporate these operational and institutional constraints. We develop a Spatial-Institutional Constant Market Share (CMS) framework and apply it to Indonesian frozen octopus exports (HS 030752). The analysis combines a descriptive trade analysis for 2021 2025 with a case-based mapping of the Aceh, Jakarta, Tokyo corridor, including inter-island multimodal transfers (e.g., Aceh, Jakarta, Kupang, Surabaya), non-tariff measures (NTMs), multi-tiered licensing, and Government-to-Government (G2G) electronic Certificate of Origin (e-COO) procedures. Export volume rose from 24.50 to 33.90 thousand tons (+38.4%) and export value from USD 112.40 million to USD 164.80 million (+46.6%) between 2021 and 2025, interrupted by a 9.80% volume decline in 2022. Japan is the only destination listed every year for which destinations are itemised. The corridor mapping identifies domestic reefer transfers, sanitary and phytosanitary (SPS) and HACCP documentation, and e-COO transmission through the Indonesia National Single Window (INSW) as the principal points of friction. The trade pattern is consistent with a strong global-demand baseline in which logistics and compliance conditions shape how much of that demand Indonesia captures. This paper contributes to the literature by integrating spatial archipelagic constraints into conventional trade competitiveness models, and it specifies four testable hypotheses for the formal CMS decomposition.

Keywords: Constant Market Share; frozen octopus; archipelagic logistics; non-tariff measures; electronic Certificate of Origin; cold chain; Indonesia Japan trade

1. INTRODUCTION

Global seafood trade has undergone structural shifts, with rising demand for high-value marine species such as cephalopods (Octopus spp.) in East Asian markets, particularly Japan. For Indonesia, an archipelagic nation of thousands of islands, marine exports are a vital pillar of the maritime economy. However, exporting perishable, high-value commodities across archipelagic barriers introduces severe logistical bottlenecks.

Frozen octopus illustrates these bottlenecks clearly. Product landed at outer sites such as Aceh is moved by domestic reefer truck services (RFS) to international consolidation hubs in Jakarta (Tanjung Priok), and then by ocean reefer shipping to destination ports such as Tokyo. Each handover requires synchronised multimodal coordination. In addition, stringent border governance, Sanitary and Phytosanitary (SPS) measures, and electronic data integration (e.g., INSW and Japan's Ministry of Economy, Trade and Industry [METI] G2G frameworks) largely determine whether a consignment can be exported at all.

This study is grounded in three complementary theoretical perspectives: Constant Market Share (CMS) theory, Transaction Cost Economics (TCE) and institutional economics, and logistics

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performance and cold-chain resilience theory. Together, these perspectives provide an integrated analytical foundation for examining the international competitiveness of Indonesian frozen octopus exports, particularly in the context of archipelagic logistics constraints and increasingly stringent international trade regulations. First, Constant Market Share (CMS) theory, originally developed by Richardson (1971) and subsequently applied to international fisheries trade by Soh et al. (2021) and Aryudiawan et al. (2022), provides a framework for decomposing export growth into several underlying components, including the world trade effect, market distribution effect, and competitiveness effect. This approach enables the identification of whether changes in export performance are primarily attributable to global market expansion, the geographical distribution of export destinations, or improvements in a country's competitive position within international markets.

Second, Transaction Cost Economics (TCE), as conceptualised by Williamson (1981), offers an institutional perspective for understanding the organisational and regulatory arrangements governing export activities. In the Indonesian fisheries sector, export operations may involve multiple entities, including production units, processing facilities, and intermediary or undername exporting companies, whose activities require coordination across different administrative and institutional levels. Such arrangements necessitate the integration of tax identification, Online Single Submission (OSS) business classifications, and Hazard Analysis and Critical Control Points (HACCP) compliance to ensure regulatory consistency and operational efficiency. From a TCE perspective, coordination failures, information asymmetries, and fragmented institutional responsibilities may increase transaction costs, generate administrative delays, and expose exporters to additional regulatory risks. Consequently, effective institutional coordination is essential for reducing transaction costs and facilitating the smooth movement of frozen octopus products across domestic and international trade networks.

Third, logistics performance and cold-chain resilience theory emphasise the importance of maintaining product quality and temperature integrity throughout the transportation and distribution process. This perspective is particularly relevant to Indonesia's archipelagic geography, where frozen octopus exports frequently require multimodal transportation involving inter-island transfers, domestic reefer truck services, port handling, and international refrigerated shipping. Maintaining a continuous temperature of approximately −20 °C in 20-foot refrigerated containers is essential for preserving product quality, minimising post-harvest deterioration, and reducing the risk of shipment rejection or additional costs associated with delays at destination ports. Disruptions in cold-chain continuity, extended domestic transit times, and inefficient coordination between transportation modes may therefore undermine export cost efficiency and international competitiveness. In this context, logistics resilience represents not merely an operational requirement but also a strategic determinant of export performance in geographically fragmented supply-chain systems.

Previous empirical studies have examined several dimensions of Indonesia's fisheries export performance, although their analytical focus has remained largely concentrated on specific commodities and aggregated trade relationships. Rindayati et al. (2018), for instance, investigated the effects of non-tariff measures (NTMs) on Indonesian tuna exports to major destination markets, highlighting the relevance of regulatory requirements in shaping international market access. Similarly, Rostwentivaivi et al. (2025) examined the determinants and export potential of Indonesian frozen shrimp, contributing to the understanding of the economic factors influencing fisheries export performance. In addition, CMS-based studies by Soh et al. (2021) and Aryudiawan et al. (2022) demonstrate the applicability of market-share decomposition techniques for assessing fisheries export competitiveness. Nevertheless, the integration of international trade competitiveness,

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institutional transaction costs, and archipelagic cold-chain logistics within a single analytical framework remains relatively underexplored, particularly for Indonesian frozen octopus exports. This study addresses this gap by developing an integrated theoretical perspective that links global market dynamics and export competitiveness with domestic logistical constraints and institutional compliance mechanisms.

Despite the growing body of literature on international fisheries trade, several important research gaps remain in understanding the export competitiveness of perishable marine products originating from archipelagic economies. Previous studies have predominantly employed macroeconomic gravity models or Constant Market Share (CMS) approaches to examine export performance at an aggregated national or commodity level, particularly for fisheries products such as fish, shrimp, and tuna. Although these approaches provide valuable insights into international market dynamics and export competitiveness, they offer limited explanations of the operational and institutional constraints that influence the actual movement of perishable commodities across geographically fragmented supply chains. In particular, the effects of archipelagic transportation barriers, multimodal cold-chain disruptions, and multi-tiered undername exporting arrangements remain insufficiently incorporated into conventional fisheries trade competitiveness models. These limitations highlight the need for an analytical framework that connects aggregate export performance with the underlying spatial and institutional conditions governing international market access.

To address these limitations, this study introduces a Spatial-Institutional Constant Market Share (CMS) Framework specifically designed to analyse the export competitiveness of Indonesian frozen octopus. The proposed framework extends conventional CMS analysis by incorporating spatial logistics constraints and institutional compliance mechanisms as additional dimensions influencing export performance. Specifically, it examines how domestic multimodal transportation friction, particularly inter-island reefer truck services (RFS), cargo consolidation, and port-stuffing processes, interacts with international cold-chain requirements to influence export efficiency and market competitiveness. Furthermore, the framework incorporates digital customs integration through the Indonesia National Single Window (INSW) and the Government-to-Government (G2G) electronic Certificate of Origin (e-COO) mechanism, including its alignment with Japan's regulatory information system. By integrating these dimensions, the framework provides a more comprehensive perspective on how logistical efficiency and institutional coordination may influence Indonesia's ability to capture international market opportunities. Its principal contribution lies in linking the competitiveness residual generated by CMS decomposition with observable operational and regulatory factors that are often overlooked in conventional aggregate trade analyses.

Against this background, the primary objective of this study is to examine the international trade competitiveness, cross-border customs governance, and multimodal supply-chain resilience of Indonesian frozen octopus exports, with particular emphasis on export corridors serving the Japanese market. More specifically, the study seeks to assess the contribution of global market growth, destination-market distribution, and export competitiveness to changes in Indonesian frozen octopus export performance; investigate the implications of pricing competitiveness and product-grading consistency for market-share retention; evaluate the effects of archipelagic transportation constraints on export volume and logistics cost efficiency; and analyse the role of electronic customs integration and sanitary compliance in reducing non-tariff barriers, clearance delays, and destination-port detention risks. Through these objectives, the study aims to provide an integrated analytical basis for understanding the relationship between international market dynamics and the spatial-institutional determinants of fisheries export competitiveness in an archipelagic economy.

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Drawing upon the theoretical framework and research gaps discussed in the preceding sections, this study develops four research hypotheses to examine the determinants of Indonesian frozen octopus export performance. The hypotheses are formulated by integrating international trade competitiveness, export pricing, archipelagic logistics performance, and institutional compliance within the proposed Spatial-Institutional Constant Market Share (CMS) Framework. First, the study proposes that global import demand growth for frozen cephalopods has a positive and statistically significant effect on the expansion of Indonesian frozen octopus export volumes (H1). An increase in international demand is expected to create greater export opportunities and provide a favourable external market environment for Indonesian exporters. Second, export pricing competitiveness and consistency in product grading are hypothesised to positively and significantly influence Indonesia's market-share retention in international destination markets, particularly Japan (H2). Competitive export prices, supported by consistent product quality and standardised size classifications ranging from AA to E, are expected to strengthen buyer confidence, improve market positioning, and enhance the sustainability of export relationships. Third, multimodal transportation disruptions and prolonged transit times across Indonesia's archipelagic supply chains are hypothesised to negatively affect export volumes and logistics cost efficiency (H3). Delays associated with domestic reefer truck services (RFS), inter-island transportation, cargo consolidation, and port-stuffing operations may increase transportation costs, disrupt cold-chain continuity, and consequently weaken the international competitiveness of Indonesian frozen octopus.

Finally, effective electronic regulatory integration through the Government-to-Government (G2G) electronic Certificate of Origin (e-COO) mechanism facilitated by the Indonesia National Single Window (INSW), together with compliance with Sanitary and Phytosanitary (SPS) and Hazard Analysis and Critical Control Points (HACCP) requirements, is hypothesised to significantly reduce non-tariff-related administrative barriers (H4). Improved digital integration and institutional coordination are expected to minimise documentary discrepancies, accelerate customs clearance procedures, and reduce the likelihood of shipment detention and associated costs at destination ports. Collectively, these four hypotheses establish the empirical foundation for examining how global market dynamics, pricing competitiveness, geographical constraints, and institutional governance interact to shape the export performance of Indonesian frozen octopus.

2. METHODS

2.1 Research Design

The study uses a case-based, mixed design with three components: (i) a descriptive analysis of Indonesian frozen octopus exports over the past five years; (ii) a CMS decomposition of export growth, extended with spatial and institutional indicators; and (iii) a process mapping of the operational, documentary, and cold-chain requirements of the Aceh, Jakarta, Tokyo corridor, with the Kupang Surabaya inter-island segment as a secondary reference.

2.2 Data

Trade data cover annual export volume (thousand tons) and export value (USD million) for HS 030752 (frozen octopus) for 2021 2025, with the 2025 figures treated as an estimate. Data are organised in line with the reporting structure of Indonesian official trade sources: the Ministry of Trade, Statistics Indonesia (BPS), and customs traffic recorded through INSW. Operational and documentary information on the export corridor is drawn from the industry case study by Primindra (2026), which covers export documentation, e-G2G transmission through INSW, and multimodal reefer logistics for the Jakarta Tokyo corridor.

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2.3 Constant Market Share Decomposition

Following Richardson (1971), the change in Indonesia's frozen octopus export value between a base period (0) and a final period (1) is decomposed as:

$$\Delta V = V_0 \cdot r + \Sigma_j V_{j0}(r_j - r) + \Sigma_j [V_{j1} - V_{j0}(1 + r_j)] \quad (1)$$

where V_0 and V_1 are Indonesia's total export values of the product in the base and final periods; V_{j0} and V_{j1} are the corresponding exports to destination market j; r is the growth rate of world imports of frozen octopus; and r_j is the growth rate of total frozen octopus imports of market j. The three terms are, respectively, the world trade (growth) effect, the market distribution effect, and the competitiveness (residual) effect. Because the analysis is confined to a single product, the commodity composition effect of the four-term CMS identity vanishes.

The competitiveness residual is then examined against the spatial and institutional factors described in Section 2.4, which is what distinguishes the proposed Spatial-Institutional CMS Framework from the conventional specification.

2.4 Institutional and Logistics Analysis

The corridor analysis traces four dimensions: (i) domestic multimodal transfer (inter-island reefer truck services and port stuffing); (ii) cold-chain integrity (−20 °C in 20-foot reefer containers); (iii) regulatory and documentary compliance (health certification, catch documentation, e-COO, customs processing); and (iv) the governance of multi-tiered "undername" exporting entities. Product grading (size grades AA to E) is recorded as a quality and pricing attribute.

2.5 Hypothesis Testing Strategy

Table 1. Hypotheses and analytical mapping

Hypothesis	Focus	Analytical component	Expected relationship
H_1	World trade effect	CMS world trade (growth) effect	Positive
H_2	Pricing competitiveness and grading consistency	CMS competitiveness effect; unit value and grade structure	Positive
H_3	Archipelagic logistical friction	SEM / econometric moderation of volume and cost efficiency	Negative
H_4	Electronic compliance integration (INSW, e-COO, SPS/HACCP)	SEM / econometric effect on clearance delay and detention cost	Negative on delays and costs

Note. SEM = structural equation modelling; CMS = Constant Market Share.

Source: Processed Data, 2026

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Table 1 presents the hypothesis-testing framework developed to examine the determinants of export performance and competitiveness within the Indonesian seafood export corridor. The framework integrates the Constant Market Share (CMS) analysis with Structural Equation Modelling (SEM) and econometric approaches to capture the interactions between international market dynamics, product-level competitiveness, logistical constraints, and institutional facilitation. Each hypothesis is operationalised through specific analytical components, with the expected direction of the relationships established on the basis of the underlying theoretical arguments.

Hypothesis H1 examines the effect of global trade dynamics on export performance through the CMS world trade growth effect. This component identifies the extent to which changes in Indonesia's export performance are attributable to the expansion or contraction of international demand for seafood products. A positive relationship is expected, indicating that growth in global seafood trade creates favourable market conditions and contributes positively to export expansion. This hypothesis provides an assessment of whether Indonesia's export performance is supported by favourable external market conditions rather than being driven exclusively by country-specific competitive advantages.

Hypothesis H2 focuses on pricing competitiveness and product grading consistency, which are assessed through the CMS competitiveness effect, export unit values, and the distribution of product grades. The analysis considers whether Indonesia's competitive position is strengthened by its ability to maintain internationally competitive prices while ensuring consistent product quality across grading categories, ranging from AA to E. A positive relationship is expected, suggesting that improvements in price competitiveness and grading consistency contribute to stronger export performance. The combined assessment of unit values and grade composition also enables the distinction between price-driven competitiveness and quality-related value creation, thereby providing a more comprehensive understanding of product-level export advantages.

Hypothesis H3 investigates the influence of archipelagic logistical friction on export performance, particularly in relation to inter-island transportation, multimodal connectivity, and cold-chain management. The hypothesis is examined using SEM and/or econometric modelling to assess how logistical constraints moderate the relationship between export volume and cost efficiency. Particular attention is given to inter-island reefer truck services, port stuffing operations, and the maintenance of −20 °C temperatures in 20-foot refrigerated containers. A negative relationship is anticipated, indicating that increasing logistical friction reduces operational efficiency, raises transportation and handling costs, and potentially constrains the ability of exporters to fulfil international market requirements. This hypothesis therefore captures the structural implications of Indonesia's archipelagic geography for the reliability and cost competitiveness of seafood export supply chains.

Hypothesis H4 evaluates the effect of electronic regulatory compliance integration on export clearance efficiency, with particular reference to the Indonesia National Single Window (INSW), electronic Certificates of Origin (e-COO), and sanitary and phytosanitary (SPS) and Hazard Analysis and Critical Control Points (HACCP) requirements. The analytical framework employs SEM and/or econometric estimation to examine the relationship between the integration of electronic compliance systems and two operational outcomes: customs clearance delays and container detention costs. A negative relationship is expected, implying that greater integration, interoperability, and consistency in electronic documentation and regulatory procedures reduce administrative processing time and associated logistics costs. The analysis also considers the institutional implications of multi-tiered undername exporting arrangements, particularly their potential effects on documentary accountability, coordination among exporting entities, and regulatory traceability.

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Taken together, the four hypotheses establish an integrated analytical framework linking external market conditions, product-level competitiveness, geographical and logistical constraints, and institutional governance to seafood export performance. The framework distinguishes between external determinants of trade growth (H1), firm- and product-level competitive attributes (H2), structural supply-chain constraints (H3), and institutional and regulatory facilitation (H4). This distinction is important because export performance cannot be adequately explained by international demand or price competitiveness alone. Rather, the capacity to translate favourable market opportunities into sustained export growth also depends on the efficiency of domestic logistics, the integrity of cold-chain operations, and the effectiveness of regulatory and documentary coordination. Accordingly, the combined CMS, SEM, and econometric approaches provide complementary analytical perspectives for identifying both the sources of export competitiveness and the institutional and operational constraints affecting the performance of Indonesia's seafood export corridor.

3. RESULTS

3.1 Export Performance, 2021 2025

Volume fell by 9.80% in 2022, then recovered with growth of 21.27% in 2023, 17.16% in 2024, and 7.96% in 2025. Over the full period, volume rose by 38.4% (a compound annual growth rate of 8.5%) and value by 46.6% (10.0% per year). Because value grew faster than volume, implied unit value increased from USD 4.59 per kg in 2021 to USD 4.86 per kg in 2025 (+6.0%).

Table 2. Indonesian frozen octopus exports (HS 030752), 2021 2025

Year	Volume (thousand tons)	Value (USD million)	Volume growth (YoY)	Value growth (YoY)	Unit value (USD/kg)
2021	24.50	112.40	Baseline	Baseline	4.59
2022	22.10	104.50	−9.80%	−7.03%	4.73
2023	26.80	128.60	+21.27%	+23.06%	4.80
2024	31.40	152.20	+17.16%	+18.35%	4.85
2025*	33.90	164.80	+7.96%	+8.28%	4.86

Source: Processed Data, 2026

3.2 Destination Corridors

Table 3 summarises the primary destinations recorded for each year. Japan appears every year for which destinations are itemised (2021 2024). The United States appears in 2021 and 2023, South Korea in 2021 and 2024, and China and Vietnam in 2024, while the European Union (Italy and Spain) appears in 2023. For 2025, the source data identify the gateway corridors (Jakarta, Surabaya, and Makassar, processed through the integrated INSW) rather than destination markets.

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Table 3. Primary destination markets and corridor notes, 2021 2025

Year	Primary destination markets	Corridor / compliance note
2021	Japan, USA, South Korea	Managed via INSW / CEISA e-LO
2022	Japan, Taiwan, ASEAN	Post-pandemic cold-chain adjustments
2023	Japan, USA, European Union (Italy, Spain)	—
2024	Japan, China, South Korea, Vietnam	—
2025	Not itemised in the source data	Jakarta, Surabaya, and Makassar corridors via integrated INSW

Source: Processed Data, 2026

3.3 Corridor Structure and Compliance Requirements

The case corridor runs from outer landing sites (Aceh) by domestic reefer truck to the consolidation hub at Jakarta (Tanjung Priok), where product is stuffed into 20-foot reefer containers held at −20 °C, and then by ocean reefer shipping to Tokyo (Primindra, 2026). Export clearance for HS 030752 relies on the INSW portal linked with CEISA 4.0 (the Customs-Excise Information System and Automation). Compliance involves automated checks of three document sets: health certificates (HC) issued by the Fish Quarantine Agency (BKIPM); the e-COO issued under the applicable preferential framework (Form D, Form E, or EPA); and catch documentation, which supports the strict standards of destination markets in the European Union, the United States, and Japan. For Japan, the e-COO is transmitted through the INSW METI G2G link.

The production base is concentrated in Eastern Indonesia (Sulawesi, Maluku, and Nusa Tenggara Timur) with processing centres in Java (Jakarta and East Java). Every consignment therefore combines at least one inter-island domestic leg with an international leg, and both legs are subject to the temperature and documentary requirements above.

3.4 CMS Decomposition and Hypothesis Tests

3.4.1 Constant Market Share decomposition

The CMS decomposition compares the 2021 base year with the 2025 endpoint. National export value increased from USD 112.40 million to USD 164.80 million, giving a change (ΔV) of USD 52.40 million. For this illustration, the national totals were distributed across eight destination groups and paired with illustrative destination-specific growth rates in world imports of frozen octopus. The global benchmark import growth rate was set at 18.0%.

The decomposition follows Equation (1): $\Delta V = V_o r + \Sigma_j V_{j0}(r_j - r) + \Sigma_j[V_{j1} - V_{j0}(1 + r_j)]$. The three components are the world trade effect, market distribution effect, and competitiveness (residual) effect. Because the product category is held constant (HS 030752), no separate commodity-composition effect is estimated.

Table 4. Synthetic destination allocation and destination-market import growth

Destination market	2021 exports	2025 exports	Illustrative import

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	(USD million)	(USD million)	growth (rj)
Japan	42.00	62.00	22.0%
United States	18.00	24.00	15.0%
South Korea	12.00	16.00	18.0%
Taiwan	10.00	12.00	12.0%
ASEAN	12.00	18.00	20.0%
China	8.00	15.00	30.0%
European Union	5.00	9.00	10.0%
Other markets	5.40	8.80	16.0%
Total	112.40	164.80	—

Source: Processed Data, 2026

Table 5. CMS decomposition of Indonesian frozen octopus export-value growth, 2021 2025.

CMS component	Contribution (USD million)	Share of ΔV	Calculation
World trade (growth) effect	20.232	38.61%	$V_o \times r$
Market distribution effect	1.232	2.35%	$\Sigma V_{j0}(r_j - r)$
Competitiveness (residual) effect	30.936	59.04%	$\Sigma [V_{j1} - V_{j0}(1+r_j)]$
Total export-value change	52.400	100.00%	$\Delta V = V_1 - V_o$

Source: Processed Data, 2026

The decomposition attributes USD 20.232 million (38.61%) of the USD 52.40 million increase to growth in world imports. The market distribution effect is positive but comparatively small at USD 1.232 million (2.35%), indicating that the illustrative destination portfolio grew marginally faster than the global benchmark. The residual competitiveness effect is USD 30.936 million (59.04%), accounting for the largest share of export-value growth. This residual is not a direct causal estimate of logistics or institutional performance; it also captures omitted price, quality, supply, exchange-rate, and destination-specific influences.

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The synthetic allocation shows the largest absolute increase in exports to Japan, from USD 42.00 million to USD 62.00 million, followed by China and ASEAN. These values are calibration inputs rather than measured bilateral exports. The destination pattern therefore demonstrates the CMS arithmetic but cannot substantiate actual market-share changes.

3.4. 2 Hypothesis-test results

A second synthetic dataset was constructed to demonstrate the proposed hypothesis-testing logic. It represents 60 hypothetical export consignments and uses standardized coefficients for comparison. The estimates below are model outputs. H1 and H2 are interpreted alongside the CMS and pricing indicators; H3 and H4 are represented by hypothetical shipment-level relationships.

Table 6. Synthetic hypothesis-test results (illustrative only; n = 60 hypothetical consignments).

Hypothesis / explanatory construct	Expected sign	Standardized β	p-value	Illustrative decision
H1: World import-demand growth	Positive	0.42	0.003	Supported in simulation
H2: Pricing competitiveness and grading consistency	Positive	0.31	0.012	Supported in simulation
H3: Archipelagic logistical friction	Negative	−0.36	0.006	Supported in simulation
H4: Electronic compliance integration	Negative on delay/cost	−0.29	0.018	Supported in simulation

Source: Processed Data, 2026

For H1, the positive coefficient (β = 0.42, p = 0.003) illustrates the expected association between world import-demand growth and Indonesian export-volume expansion. This direction is consistent with the positive world trade effect in the CMS demonstration. For H2, the positive coefficient (β = 0.31, p = 0.012) illustrates a positive relationship between pricing competitiveness/grading consistency and export performance. The manuscript's increase in national unit value from USD 4.59/kg in 2021 to USD 4.86/kg in 2025 is a descriptive context; by itself, it does not establish improved price competitiveness or a grading effect.

For H3, the negative coefficient (β = −0.36, p = 0.006) illustrates the hypothesised adverse relationship between multimodal disruption/transit friction and shipment performance. In an empirical model, this construct should be operationalised using measurable indicators such as door-to-port transit time, missed vessel connections, temperature excursions, and domestic reefer cost. For H4, the negative coefficient (β = −0.29, p = 0.018) illustrates the expected reduction in clearance delay and detention cost associated with more seamless e-COO/INSW and SPS/HACCP compliance. The compliance construct should be measured through document-processing time, correction/rejection frequency, clearance duration, and detention charges.

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The p-values are included only to show how a results table could be reported. They have no inferential meaning because the underlying observations were generated for demonstration and do not represent a probability sample or verified administrative dataset. The phrase “supported in simulation” must not be shortened to “supported” in a submission based on this data.

3.4.3 Summary of the simulated evidence

Taken together, the synthetic CMS exercise demonstrates how export growth can be separated into global-demand, destination-structure, and residual components, while the synthetic hypothesis table demonstrates the expected signs for H1 H4. The numerical illustration is internally calibrated to the national export-value totals reported in Table 2, but the destination allocation, destination import-growth rates, and shipment-level coefficients remain hypothetical. Empirical confirmation requires bilateral import data for Indonesia’s destination markets and shipment-level logistics and clearance observations. Until those data are obtained and the models are re-estimated, the numerical findings in this section should be treated as a worked example rather than evidence of causal effects or statistically validated hypotheses.

4. DISCUSSION

4.1 Interpretation of the Trade Pattern

The trade data are consistent with the proposition that global and East Asian demand sets a strong baseline for Indonesian frozen octopus exports (H_1). Growth recovered each year after 2022 and was strongest in 2023 2024, when Japan and China featured prominently among destinations. The steady increase in unit value, with value growing faster than volume in every year except the 2022 contraction, is also compatible with a quality- and grading-based pricing position (H_2), although the descriptive data cannot separate price competitiveness from general price movements in the world market.

The 2022 contraction coincided with post-pandemic supply-chain adjustments and domestic reefer transport constraints, which is the pattern expected under archipelagic logistical friction (H_3). The subsequent rebound coincided with the use of integrated digital export licensing platforms (INSW and G2G e-COO), which are expected to reduce cargo rejection risk at destination ports (H_4). These coincidences are suggestive only. Establishing that logistics friction and electronic compliance integration explain the movements requires the formal CMS decomposition and hypothesis tests described in Section 2.

4.2 Theoretical Contribution

The study extends trade competitiveness models by incorporating spatial archipelagic friction and multi-tier institutional governance into the conventional CMS and export performance framework. The CMS residual, usually interpreted as undifferentiated “competitiveness”, is here linked to specific, observable mechanisms: inter-island cold-chain transfers (logistics performance theory), the governance of “undername” exporting entities (TCE), and digital border compliance. This responds to the gap noted in Section 1.3, where CMS and gravity applications have remained at the aggregated level (Soh et al., 2021; Aryudiawan et al., 2022).

4.3 Empirical, Managerial, and Policy Implications

Empirically, the study provides granular insight into the frozen octopus supply chain corridor (Aceh, Jakarta, Tokyo), mapping grading structures, customs valuation purposes, and reefer container logistics. For exporters and policymakers, the findings point to three priorities: optimising digital customs integration through INSW; streamlining inter-island cold-chain infrastructure so that temperature integrity is preserved between landing sites and gateway ports; and strengthening compliance with the SPS, HACCP, and documentary standards of destination markets. The relevance of NTMs to Indonesian fishery exports is consistent with earlier evidence on tuna (Rindayati et al., 2018).

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4.4 Limitations and Future Research

Several limitations apply. First, the trade series is aggregated at the national level, covers only five years, and treats 2025 as an estimate. Second, destinations are recorded qualitatively, without import-market shares, so the market distribution and competitiveness effects in Equation 1 cannot yet be quantified. Third, the corridor analysis rests on a single industry case study (Primindra, 2026), which limits generalisation to other commodities and routes. Future research should (i) obtain destination-level import data to estimate Equation 1 for Japan and competing markets, (ii) collect corridor-level data on transit time, temperature excursions, clearance delay, and detention cost to test H_3 and H_4, and (iii) compare the Aceh Jakarta and Kupang Surabaya segments.

5. CONCLUSION

Indonesian frozen octopus exports grew substantially between 2021 and 2025, with Japan as the anchor market, while moving through a corridor that combines inter-island multimodal transfer with demanding electronic and sanitary compliance. This paper proposes a Spatial-Institutional CMS Framework that links the competitiveness residual to those logistics and governance conditions, and it specifies four hypotheses for testing. By integrating spatial archipelagic constraints into trade competitiveness analysis, the framework offers a basis for exporters and policymakers to improve cold-chain infrastructure and digital customs integration for perishable seafood exports.

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