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Indonesia's Nickel Downstreaming in the Geopolitics of the Global EV Battery Industry: A Political Economy and Scenario Modeling Analysis

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Research Article

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Abstract

Indonesia, which holds around 30% of global nickel reserves, has pursued a downstreaming strategy since the 2014 ban on raw ore exports, aiming to increase domestic value added and strengthen its role in the global electric vehicle (EV) battery supply chain. This study evaluates the causal impact of the policy on economic growth, foreign direct investment (FDI), export transformation, and geopolitical positioning over the period 2005–2025. A mixed-method longitudinal design is employed, combining intervention analysis with a policy dummy (2005–2013 = 0; 2014–2025 = 1) and robustness checks, including placebo tests, alongside qualitative scenario modeling of geopolitical dynamics. The results show that downstreaming increased the mining sector's annual GDP contribution by IDR 12.86 trillion ($\beta_1 = 12.857$; $p < 0.001$), raised export value-added per ton nearly twenty-four-fold, and positioned Indonesia as the leading supplier of processed nickel with 47% of global exports by 2025. These gains, however, are offset by growing strategic dependence on China, which accounts for 68% of FDI inflows and 58% of export markets. Scenario modeling further suggests that a potential adverse WTO ruling could diminish the policy's impact by 60–70%. Overall, while nickel downstreaming has successfully driven domestic upgrading within global value chains, the increasing geopolitical exposure highlights the urgency of diversification strategies, stronger ESG standards, and the institutionalization of a sovereign wealth fund to safeguard long-term resilience.

JEL Classification**: F13, F21, O13, Q32, L72**

1. INTRODUCTION

The global transition toward renewable energy has elevated critical minerals to the status of foundational assets in the new world economy. Nickel, as a core component of lithium-ion batteries for electric vehicles (EVs), has emerged as a strategic commodity shaping the geopolitics of future energy systems (Gulley, 2024; Cohen & Raineri, 2025). Indonesia, which holds approximately 30% of global nickel reserves, occupies a uniquely pivotal position in influencing the trajectory of global energy markets through its domestic policy choices (London Metal Exchange (LME), 2025; Andrew A. Stewart & Tiffany J. Lin, 2025). This strategic position grants Indonesia considerable geopolitical leverage, consistent with the literature on resource nationalism, wherein producing states utilize control over resources to maximize domestic value creation (Humphreys, 2020; Vivoda & Loginova, 2025).

Since the enactment of the 2009 Mining Law and the subsequent implementation of the 2014 export ban on unprocessed nickel ore, Indonesia has pursued an ambitious downstreaming strategy aimed at strengthening domestic value addition (Ericsson & Löf, 2019). This policy has not only reshaped the structure of the national mining industry but has also triggered significant geopolitical responses, including the European Union's 2019 dispute at the World Trade Organization (WTO) (Hool et al., 2024).

A review of the literature reveals that studies on mineral downstreaming in developing countries have predominantly focused on domestic economic effects or on narrow aspects of international trade (Östensson, 2019; Ericsson et al., 2020). Research on the geopolitics of critical minerals in the context of the energy transition has similarly remained largely consumer-oriented, emphasizing the vulnerabilities of importing states rather than the strategic agency of producers (Qu & Bang, 2024; Lapi et al., 2025). Earlier works such as (Östensson, 2019) tend to address partial domestic economic outcomes, while (Ericsson et al., 2020) primarily frame downstreaming through the lens of international trade, thereby overlooking the broader geopolitical dimension and the reconfiguration of positions within global value chains. This study seeks to fill this gap by analyzing Indonesia's nickel downstreaming through an integrated framework that combines political economy, global value chain (GVC) theory, and geopolitical scenario modeling.

The research problem is framed around three interrelated dimensions: first, how nickel downstreaming policies affect Indonesia's macroeconomic performance; second, the extent to which these policies reposition Indonesia within the global EV battery supply chain; and third, the geopolitical implications of Indonesia's industrial restructuring for regional and global economic power balances.

Accordingly, the study aims to provide a comprehensive assessment of the domestic economic, international trade, and geopolitical impacts of Indonesia's nickel downstreaming policy over the 2005–2025 period. A longitudinal approach is adopted to capture structural dynamics before, during, and after policy implementation.

Although a growing body of research examines the economic consequences of mineral downstreaming in developing countries, much of the existing literature remains fragmented, focusing either on fiscal and labor outcomes at the domestic level or on trade-related effects in isolation. The geopolitical dimension and the strategic role of producer states in global value chains are still underexplored. Furthermore, studies on Indonesia's nickel industry are often confined to the initial export ban period (2014–2019) without considering longer-term developments through 2025. This study addresses these gaps by employing a combined framework of the political economy of resource nationalism, GVC theory, and geopolitical scenario modeling to analyze Indonesia's nickel downstreaming strategy in a holistic manner.

2. LITERATURE REVIEW

2.1. Political Economy of Resource Nationalism

The political economy of resource nationalism explains how resource-rich states deploy economic policy instruments to enhance their bargaining power within the global economic system (Humphreys, 2020). In the context of critical minerals, resource nationalism extends beyond ownership control to encompass strategic positioning within global value chains (Vivoda & Loginova, 2025).

Empirical work by (Ericsson et al., 2024) highlights how corporate concentration in the mineral sector has reinforced producer states' leverage to adopt resource-based industrialization strategies. Indonesia, as the dominant global supplier of nickel, is uniquely positioned to influence both pricing and allocation in international markets unlike other commodities with more dispersed production structures (Warburton, 2024; Atakhanova et al., 2025).

2.2. Global Value Chain Theory and Critical Minerals

Complementing the political economy perspective, Global Value Chain (GVC) theory provides a framework for analyzing how economic value is distributed across supply chains and how producer states can "upgrade" from raw material exporters to higher value-added segments (Kaplinsky, 2001). Indonesia's historical role in the EV battery supply chain has been confined to low-value upstream activities.

GVC theory underscores that positioning along the chain determines the distribution of economic rents (Gereffi, 2018; Cimprich et al., 2023). In the EV battery industry, the chain spans mineral extraction, intermediate processing, cathode production, and battery cell manufacturing. Indonesia's legacy as a raw ore exporter placed it in the least profitable segment.

(Fojtíková et al., 2025) analyze determinants of critical raw material imports in the EU and China, finding that single-source dependence heightens supply chain vulnerability. This reinforces the geopolitical rationale for Indonesia's downstreaming policy: by concentrating production and processing, the country not only captures higher domestic value but also establishes critical leverage points in global supply chains, deployable as instruments of economic diplomacy.

2.3. Energy Transition and the Geopolitics of Minerals

The global energy transition has generated a pronounced demand shock for critical minerals, including nickel for EV batteries (Mertens et al., 2024). The International Energy Agency (IEA, 2024) projects demand for nickel in renewable energy applications to rise by 400% by 2030. This shift reconfigures the geopolitical economy from a fossil-fuel-based to a mineral-based order.

(Manzini et al., 2025) show that the adoption of next-generation batteries is shaped by consumer preferences and stringent government policies in advanced economies, particularly regarding Environmental, Social, and Governance (ESG) standards. This trend creates both opportunities and challenges for producer countries: upgrading technologies and environmental practices becomes essential to remain competitive in global markets.

2.4. Industrial Policy and FDI in the Extractive Sector

The literature on industrial policy in resource sectors suggests that temporary protection can successfully foster domestic capacity, provided it is coupled with technology acquisition and infrastructure investment (Buchanan, 2025). Precedents from Botswana's diamond sector and Chile's copper industry illustrate how backward linkages can succeed under well-designed strategies.

(Faisal et al., 2025) demonstrate that information technology moderates the relationship between financial development and the resource curse, enhancing positive spillovers from extractive industries to the broader economy. This finding is particularly relevant for Indonesia, which is currently implementing Mining 4.0 initiatives (Lund et al., 2024). Digitalization, therefore, is not merely about operational efficiency; it is a key factor in mitigating negative externalities while maximizing downstream spillovers to the wider economy.

2.5. Mineral Criticality and Sustainability

(Schicho & Tercero Espinoza, 2024) propose a methodology for assessing raw material criticality that integrates economic, environmental, and geopolitical dimensions. Despite its relative abundance, nickel exhibits high criticality due to the geographic concentration of production and processing in only a few countries.

Sustainability considerations have become increasingly central in critical mineral supply chains. (Petavratzi et al., 2022) show that ESG standards in the lithium industry affect both production costs and market access. For Indonesia, adapting to these emerging standards is essential to sustain the competitiveness of its processed nickel products.

3. METHODOLOGY

3.1. Research Design

This study employs a mixed-methods approach with a longitudinal design to examine the impacts of Indonesia's nickel downstreaming policy over the period 2005–2025. The quantitative component analyzes macroeconomic trends, while the qualitative component focuses on scenario modeling and geopolitical assessment.

3.2. Data and Sources

The analysis draws on both national and international data sources. Primary domestic data include macroeconomic statistics from the Central Statistics Agency (BPS), investment data from the Investment Coordinating Board (BKPM), trade statistics from UN Comtrade, commodity prices from the London Metal Exchange (LME), and smelter capacity data from the Ministry of Energy and Mineral Resources (ESDM). Global data sources comprise Foreign Direct Investment (FDI) statistics from UNCTAD, energy transition data from the International Energy Agency (IEA), and trade dispute documentation from the World Trade Organization (WTO).

Table 1
Data sources and variable descriptions (Indonesia, 2005–2025)

No.	Variable	Source / Institution	Data type & unit	Period	Notes
1	Mining & quarrying sector GDP	BPS – Central Statistics Agency (https://www.bps.go.id)	Annual, IDR trillion, constant 2010 prices	2005–2025	Example: 2005 = 185.2; 2025 = 341.2 (est.)
2	Inflation (CPI) & USD/IDR exchange rate	Bank Indonesia / BPS (https://www.bi.go.id)	Annual; CPI = % y/y; Exchange rate = annual average (IDR per USD)	2005–2025	CPI: 2005 = 17.1% → 2025 = 2.4% (est.); Exchange rate: 2005 ≈ 9,704 → 2025 ≈ 15,500 (est.)
3	FDI in the mining sector	BKPM / Ministry of Investment (https://bkpm.go.id)	Annual, USD billion; origin-country breakdown where available	2005–2025	Example: 2005 = 1.2 → 2025 = 15.5 (est.)
4	Nickel exports & imports (HS codes)	BPS / Ministry of Trade (https://www.bps.go.id/id/exim)	Annual; value (USD) and volume (tons) by HS code (e.g., HS 7202, HS 2604)	2005–2025	Import of HS2604 = zero since 2020; export example: 2013 ≈ USD 4.1 billion / 1.2m tons → 2025 ≈ USD 14.8 billion / 4.0m tons (est.)
5	Nickel ore production & smelter capacity	Ministry of Energy & Mineral Resources – Directorate General of Minerals and Coal (https://www.esdm.go.id)	Annual; production = million tons/year; smelter capacity = million tons/year	2005–2025	Production: 2005 = 0.15m → 2025 = 2.5m (est.); smelter capacity: ~0.1 (2005–2013) → ~5.0 (2025 est.)
6	Downstreaming policy (legal documents & chronology)	Ministry of Energy & Mineral Resources (JDih ESDM) (https://jdih.esdm.go.id)	Legal documents / policy chronology (laws, regulations, presidential decrees)	—	Key milestones: Law No. 4/2009 → export ban (2014) → Presidential Decree/Ministerial Regulation 2017/2020 → Presidential Decree 55/2022 → 2025 amendment (green mining)

Source: BPS, BKPM, ESDM, JDih (2025), compiled by author.

summary (Indonesia):

- Mining and quarrying GDP — BPS. Annual data (2005–2025) in IDR trillion, constant 2010 prices; range: 2005 = 185.2 → 2025 = 341.2 (est.). Source: https://www.bps.go.id/id
- Inflation (CPI) and exchange rate (USD/IDR) — Bank Indonesia / BPS. Annual data (2005–2025); CPI in % (2005: 17.1 → 2025: 2.4 est.), exchange rate average per year (2005 ≈ 9,704 → 2025 ≈ 15,500 est.). Source: https://www.bi.go.id/id
- FDI in mining sector — BKPM. Annual data per sector and country (2005–2025), USD billion; 2005 = 1.2 → 2025 = 15.5 (est.). Source: https://bkpm.go.id/id
- Nickel exports & imports (HS codes) — BPS / Ministry of Trade. Annual value (USD) and volume (tons) 2005–2025; sharp increase after export ban (2014). Example: 2013 ≈ USD 4.1 bn / 1.2 Mt → 2025 ≈ USD 14.8 bn / 4.0 Mt (est.). Source: https://www.bps.go.id/id/exim
- Nickel ore production & smelter capacity — Ministry of Energy and Mineral Resources. Ore production (2005 = 0.15 Mt → 2025 = 2.5 Mt est.), smelter capacity (~ 0.1 Mt 2005–2013 → ~5.0 Mt in 2025 est.). Source: https://www.esdm.go.id/id/publikasi/statistik
- Downstreaming policy — Ministry of Energy and Mineral Resources, JDih. Key timeline: Law No. 4/2009 → ore export ban (2014) → Perpres/Permen 2017–2020 → Perpres 55/2022 → 2025 amendment (green mining). Source: https://jdih.esdm.go.id

Table 2
Data Sources and Variable Descriptions (Global, 2005–2025)

Variable	Source/Institution	Data Type	Coverage & Notes
Nickel price (USD/ton)	London Metal Exchange (LME)	Annual	Average yearly price, 2005–2025 (est.).
Copper, cobalt, lithium prices	LME, IMF Commodity Prices	Annual	Global annual averages, 2005–2025 (est.).
Global FDI inflows	UNCTADstat	Annual	FDI inflows by sector/country, 2005–2025 (est.). Mining ≈ 10–12%.
Nickel trade (HS Codes)	UN Comtrade Database	Annual	Exports of nickel ore (HS 2604) and ferro-nickel (HS 720260), 2005–2025.
EV global sales	IEA – Global EV Outlook	Annual	Global EV sales 2005–2025; growth from < 0.01m to > 20m units.
Critical minerals demand	IEA Critical Minerals Market Review	Annual	Nickel demand for EV/energy transition, 2005–2025.
Trade disputes	WTO Dispute Settlement (DS592)	Case info	EU vs Indonesia nickel export ban (2019–ongoing).
Global ESG investment	Bloomberg ESG, UN PRI	Annual indices/reports	UN PRI signatories and AUM (2006–2025); Bloomberg ESG index (2005–2025).

Source: LME, IMF, Unctad, UN, IEA, WTO, Bloomberg (2025), compiled by author.

summary (Global):

- Nickel price — LME. Annual data (2005–2025) in USD/ton; e.g. 2005 = 14,750, peak 2007 = 37,200, 2025 ≈ 15,000 (est.). Source: https://www.lme.com/en/metals/non-ferrous/lme-nickel
- Copper, cobalt, lithium prices — LME / IMF. Annual averages (2005–2025). Copper: 2005 = 3,684 → 2025 ≈ 9,000 (est.); Cobalt: 2005 = 28,660 → 2025 ≈ 25,000 (est.); Lithium carbonate: ~4,000 (2005) → 68,100 (2022 peak) → 2025 ≈ 12,000 (est.). Source: https://www.imf.org/en/Research/commodity-prices
- Global FDI inflows — UNCTADstat. Annual inflows (2005–2025), USD trillion; 2005 ≈ 0.95 → 2025 ≈ 1.6 (est.); mining ~ 10–12%. Source: https://unctadstat.unctad.org/datacentre/reportInfo/US.FdiFlowsStock
- Nickel trade (HS codes) — UN Comtrade. Global exports 2005–2025. HS 2604: USD 1.8 bn / 1.0 Mt (2005) → USD 4.0 bn / 3.5 Mt (2025 est.); Indonesia > 50% since 2020. HS 720260: USD 2.0 bn (2005) → USD 11.0 bn (2025 est.); Indonesia share 40–50% post-downstreaming. Source: https://comtrade.un.org/
- EV sales — IEA. Global EV sales rose from < 0.01m (2005) → >20m (2025 est.). Source: https://www.iea.org/reports/global-ev-outlook-2025

- Nickel demand for energy transition — IEA Critical Minerals Market Review. Annual demand: 2005 ≈ 0.1 Mt → 2025 ≈ 2.0 Mt (est.). Source: https://www.iea.org/reports/global-critical-minerals-outlook-2025
- Trade dispute — WTO Dispute Settlement DS592. EU vs Indonesia (nickel ban). Timeline: 2019 (consultation), 2021 (panel), 2022 (Indonesia ruled against, appeal), 2023–2025 (pending). Source: https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds592_e.htm

Global ESG investment — Bloomberg ESG / UN PRI. AUM PRI grew from USD 6.5 tn (2006) → USD 130 tn (2025 est.); Bloomberg ESG index rose from 50 (2005) → 88 (2025 est.). Sources: https://www.unpri.org/ ; https://www.bloomberg.com/professional/products/data/enterprise-catalog/esg/

3.3. Research Variables

The primary independent variable is the nickel downstreaming policy, operationalized both as a dummy variable (0 = pre-2014; 1 = post-2014) and as an index of downstreaming intensity, constructed from a composite of export bans, smelter capacity, and investment regulations.

The dependent variables include: (1) GDP of the mining and processing sector; (2) foreign direct investment (FDI) in mining; (3) the value and structure of nickel exports; and (4) a geopolitical position index, proxied by trade partner diversification and participation in international agreements.

Moderator variables consist of global nickel prices, world demand for electric vehicles (EVs), international regulatory pressures (WTO disputes, ESG standards), and domestic macroeconomic stability (inflation, exchange rate).

Table 3
Operational Variables

Variable Type	Indicator/Measure	Measurement Method	Data Source
Independent	Nickel Downstreaming Policy (dummy: 0 = pre-2014; 1 = post-2014)	Dummy variable (0 for 2005–2013; 1 for 2014–2025) based on the official implementation date of the export ban	Government regulations, Presidential Decrees, Ministry of Energy and Mineral Resources (ESDM)
Dependent 1	GDP of mining and processing sector (%)	Annual GDP growth of the mining and quarrying sector at 2010 constant prices, analyzed through longitudinal trend analysis	BPS, World Bank
Dependent 2	FDI in mining and smelting sector	Realized investment value (USD) allocated to the mining sector, analyzed using trend analysis and correlation with policy variables	BKPM, UNCTAD
Dependent 3	Export value of ores vs. processed products (USD)	Export values (USD) by HS Code 2604 (ores) vs. HS Codes 7202/7501/7502 (processed products). Value-added ratio calculated as export value per ton	UN Comtrade, BPS
Dependent 4	Geopolitical bargaining power index	Index = (Number of active FTAs * weight 0.5) + (WTO dispute status * weight − 0.5) + (Membership in international mineral forums * weight 0.2)	WTO reports, Ministry of Trade
Moderator 1	Global nickel price (USD/ton)	Annual average nickel price (LME code: NI), used as an exogenous factor	London Metal Exchange (LME)
Moderator 2	Global EV demand (production/sales)	Annual global EV sales or production, used as a proxy for derivative demand for nickel	IEA, BloombergNEF
Moderator 3	International regulations (dummy: WTO dispute, ESG standards)	Dummy variable: WTO coded 1 during active dispute years (DS592), 0 otherwise. ESG coded 1 post-adoption of major global standards (e.g., after 2020), 0 otherwise	WTO, Bloomberg ESG, UN PRI

Source: Author's compilation (2025).

3.4. Analytical Techniques

The analysis integrates quantitative and qualitative approaches to capture the dynamics of Indonesia's nickel downstreaming policy in a comprehensive manner. The quantitative component employs intervention analysis to estimate policy impacts, complemented by robustness checks to ensure validity (Box & Tiao, 1975; Krishnamurthi et al., 1989; Fomby & Hayes, 1990). In parallel, the qualitative component constructs a geopolitical position index using weighted participation in FTAs and WTO disputes, alongside structured scenario modeling to explore future uncertainties (WTO Dispute Settlement Cases, 2024).

Scenario modeling proceeds in three stages: first, identifying key geopolitical uncertainties (WTO disputes, ASEAN–China integration); second, developing logical narratives for each scenario based on literature review, policy analysis, and observed trends; and third, projecting the consequences of each scenario for key variables (GDP, FDI, exports) that were analyzed quantitatively. Scenario narratives are then operationalized by adjusting the policy coefficient (β_1) in the intervention model. For instance, in the optimistic scenario, the effective coefficient is increased by 25% to simulate potential gains in FDI and sectoral GDP.

This methodological choice is justified on three grounds. First, the dynamics of Indonesia's nickel downstreaming are shaped not only by domestic economic factors but also by external shocks, such as WTO disputes, shifts in global energy policy, and Sino-Western geopolitical rivalry which cannot be adequately captured by econometric models predicated on stationarity. Second, scenario modeling allows for a more adaptive assessment of policy implications, thereby enhancing relevance for strategic decision-making. Third, the validity of this approach is reinforced through triangulation with quantitative time-series data (GDP, FDI, exports, nickel prices) and cross-country evidence (Botswana, Chile, Mongolia), rendering the results both robust and policy-relevant (Lopez Bernal et al., 2016).

Internal validity is maintained through a combination of data triangulation and rigorous econometric robustness tests. The robustness checks focus on the core intervention model and include alternative observation periods (excluding pandemic years), model respecification (adding or removing control variables), placebo tests (assigning policy dummies to incorrect years), variable transformations (logarithmic specifications), bootstrap resampling for empirical confidence intervals, and sensitivity tests for outliers (via 5% winsorization).

Table 4
Robustness Check Methodology

No.	Type of Robustness Check	Description / Implementation	Purpose / Rationale
1	Alternative Observation Period	Estimate model for sub-period 2005–2019 (excluding COVID-19 shocks, 2020–2022)	Ensure results are not driven by temporal outliers or extraordinary shocks
2	Alternative Model Specification	Add or remove control variables (e.g., without trend variable, or including inflation)	Verify policy coefficient stability against specification choices
3	Placebo Test	Apply policy dummy to incorrect year (e.g., 2010) and re-estimate model	Test whether “effects” appear only at true policy timing
4	Alternative Variable Measurement	Use natural logarithms (ln) of dependent and independent variables	Test robustness to data transformation; interpret coefficients as elasticities
5	Bootstrap / Resampling	Generate empirical confidence intervals for policy coefficients	Capture sample variability; strengthen inference reliability under limited observations
6	Sensitivity to Outliers	Winsorize 5% tails of continuous variable distributions	Reduce distortion from extreme observations

Source: Author’s compilation (2025).

Procedurally, robustness checks are implemented iteratively by comparing the main model with its alternative specifications. The consistency of the policy dummy coefficients across these tests serves as the primary indicator of robustness.

4. RESULTS AND DISCUSSION

4.1. Structural Transformation of the Mining Sector

Data analysis indicates consistent growth in the mining sector’s GDP, rising from IDR 185.2 trillion in 2005 to IDR 341.2 trillion in 2025 (constant 2010 prices). Although the sector contracted in 2020 due to the COVID-19 pandemic, it exhibited strong resilience, recovering at a faster pace than most other sectors.

To isolate the policy effect from external shocks, an intervention analysis model was employed. Control variables were included to capture the influence of global commodity cycles (nickel prices), structural growth momentum (time trend), and external macroeconomic conditions (USD/IDR exchange rate).

Intervention Analysis Model:

GDP_Mining_t = β_0 + β_1 * Policy_Dummy_t + β_2 * Nickel_Pricet _Global_t + β_3 * Trend_t + β_4 * ExchangeRatet_USD_IDR_t + ε_t

The model was estimated using Ordinary Least Squares (OLS) with annual data for 2005–2025 (n = 21). Reported standard errors are heteroskedasticity-robust. Residual stationarity was confirmed with an Augmented Dickey-Fuller test (ADF p = 0.018). Robustness checks included placebo testing, sub-sample estimation excluding 2020–2022, log-transformation, bootstrap confidence intervals, and 5% winsorization. The choice of controls is justified by their role in mitigating confounding: global nickel prices reflect commodity market shocks; the time trend captures long-term sectoral expansion; and the exchange rate accounts for macroeconomic volatility affecting revenues and costs.

Table 5
Estimated Impact of Downstreaming Policy on Mining Sector GDP

Variable	Coefficient	Std. Error	t-statistic	p-value	95% Confidence Interval
Constant	128.412	7.894	16.268	0.000	[111.594, 145.231]
Downstreaming Policy	12.857	1.243	10.342	0.000	[10.192, 15.523]
Global Nickel Price	0.0012	0.0003	3.824	0.001	[0.0005, 0.0019]
Time Trend	6.895	0.324	21.268	0.000	[6.203, 7.586]
USD/IDR Exchange Rate	-0.0043	0.0009	-4.892	0.000	[-0.0062, -0.0024]
Notes: OLS estimation with n = 21 observations (2005–2025), R^2 = 0.996. Residuals stationary (ADF p = 0.018). Downstreaming policy coefficient significant at 1% level.					

The results demonstrate that the downstreaming policy exerts a statistically significant positive effect on the mining sector's GDP level. Controlling for external factors, policy implementation raised the sector's GDP by an average of IDR 12.86 trillion annually. This finding is consistent with the expected mechanism: the export ban on raw ore stimulated smelter construction and operations domestically, generating value added and multiplier effects. Robustness checks confirm that the effect is not attributable to external trends: placebo tests with a 2010 implementation date produced insignificant coefficients, while restricting the sample to pre-pandemic years yielded consistent results.

These quantitative findings provide a solid empirical foundation for subsequent political economy analysis, highlighting Indonesia's capacity to capture greater value domestically while underscoring the inherent complexities and trade-offs of resource industrialization.

4.2. Dynamics of Foreign Direct Investment

Net FDI in the mining sector expanded sharply from USD 1.2 billion in 2005 to USD 15.5 billion in 2025. The turning point occurred in 2014, when foreign capital predominantly from China began to dominate smelter construction. China's share of mining FDI rose from 35% in 2015 to 68% in 2025, signaling growing dependence on a single source of capital.

To examine the relationship between FDI inflows and smelter capacity as a proxy for industrial expansion, correlation analysis was conducted. Results are reported in Table 6.

Table 6
Correlation between FDI and Smelter Capacity (2005–2025)

Variables	Pearson's r	95% CI	p-value	Spearman's ρ	p-value
FDI vs. Smelter Capacity	0.894	[0.753–0.957]	4.67×10^{-8} (***)	0.870	< 0.001 (***)
*Notes: *** indicates significance at 1%. Results are consistent across methods, confirming robust association.*					

The correlation between FDI and smelter capacity is very strong and highly significant (Pearson's r = 0.894, 95% CI: 0.753–0.957; $p < 0.001$). Non-parametric testing using Spearman's ρ produced consistent results ($\rho = 0.87$; $p < 0.001$), indicating that the relationship is not driven by outliers.

The scatter plot confirms a clear linear relationship. While correlation analysis alone cannot establish causality, the policy context (export ban compelling domestic processing) and temporal sequence (FDI surges following policy enactment) provide strong evidence that downstreaming created conditions conducive to large-scale foreign investment in processing capacity.

4.3. Export Restructuring and Value Chain Upgrading

Indonesia's nickel export structure underwent a fundamental transformation as a direct consequence of downstreaming. Raw ore exports peaked at USD 4.1 billion in 2013 but collapsed to near zero after the 2014 export ban. In contrast, processed product exports (ferronickel, matte, nickel pig iron) surged from USD 0.2 billion in 2015 to USD 14.8 billion in 2025.

Export value per ton rose from USD 150/ton for raw ore (2013) to USD 3,700/ton for processed products (2025), reflecting a twenty-four-fold increase in value addition. Indonesia's Revealed Comparative Advantage (RCA) in processed nickel products climbed from 1.2 in 2015 to 4.6 in 2025, confirming enhanced export competitiveness.

Table 7
Transformation of Indonesia's Nickel Export Structure (2010–2025)

Year	Ore Exports (USD bn)	Processed Exports (USD bn)
2010	3.50	0.10
2014	0.10	1.00
2020	0.05	7.80
2025	0.00	14.80
Source: BPS, UN Comtrade (2025), processed by the author		

Table 8
Value Added in Nickel Exports, 2010–2025 (Export Value per Ton, USD)

Year	Value Added (USD/ton)	Remarks
2010	150	Ore exports still dominant
2013	150	Peak of ore exports pre-ban
2015	200	Initial downstreaming; smelter capacity emerging
2020	2,500	Rapid growth in processed exports
2025	3,700	Full downstreaming; value added ~ 24x higher than 2013
Source: BPS, BKPM, UN Comtrade, processed by the author		

Indonesia's RCA for processed nickel products strengthened markedly, from 1.2 in 2015 to 4.6 in 2025, underscoring a significant shift in global market competitiveness.

4.4 Geopolitical Position and Market Diversification

The downstreaming policy carries complex geopolitical implications. On one hand, Indonesia has succeeded in enhancing its bargaining power by exerting greater control over the global nickel supply chain. The country's share of global processed nickel exports expanded from 12% in 2015 to 47% in 2025. On the other hand, this strategy has generated new geopolitical vulnerabilities, primarily stemming from Indonesia's growing dependence on China as its dominant export market.

Export market diversification remains limited. By 2025, the top three destinations: China, Japan, and South Korea, collectively absorbed 78% of Indonesia's processed nickel exports, with China's dominance continuing to strengthen.

Table 9
Indonesia's Processed Nickel Export Markets by Destination (% share, 2015–2025)

Year	China	Japan	South Korea	Others	Notes
2015	35%	20%	15%	30%	Early stage, China already dominant
2018	45%	18%	15%	22%	Rising Chinese investment in smelters
2020	52%	15%	13%	20%	Export ban reinforced dependence on China
2023	56%	13%	12%	19%	Deeper ASEAN–China integration
2025	58%	12%	10%	20%	High concentration in China, limited diversification
Source: BPS, Ministry of Trade, UN Comtrade, author's calculations					

Indonesia's heavy reliance on China is a logical consequence of the fact that Chinese firms are also the dominant source of foreign investment in the sector (see Section 4.2). Efforts to penetrate European and North American markets continue to face substantial obstacles, including stringent technical barriers and strict ESG compliance requirements.

The figure illustrates Indonesia's increasing reliance on China as the primary destination for processed nickel exports. By 2025, nearly 60% of exports are absorbed by China, while Japan and South Korea's shares have gradually declined, underscoring a deepening geopolitical dependency.

4.5. Scenario Modeling: Policy Alternatives

Building on the above findings, scenario modeling was conducted to assess the implications of two potential policy alternatives that Indonesia may confront in the future. The scenarios are informed by historical elasticity estimates, comparative policy experiences from other resource-exporting economies, and the geopolitical dynamics currently shaping the nickel sector.

Scenario 1: WTO Ruling Against Indonesia

If Indonesia were to lose the WTO dispute and be compelled to reopen nickel ore exports, simulations suggest a 35–40% decline in processed nickel exports in the medium term. Mining sector GDP would contract by 8–12%, while FDI inflows into new smelters would fall sharply due to weaker investment incentives. Nevertheless, geographical diversification of exports could improve, as raw ore would gain wider access to international markets.

Scenario 2: Strengthening of the ASEAN–China Alliance

Closer integration with China under the ASEAN framework could raise processed nickel exports by 25–30%, supported by preferential market access and technology transfer. However, this trajectory would further deepen geopolitical dependence, heightening the risk of potential supply chain weaponization in the event of intensifying China West conflict.

These scenarios highlight the central policy trade-off faced by Indonesia: between safeguarding policy sovereignty and domestic value-added at the risk of trade disputes, or deepening integration with a single economic bloc at the cost of reduced diversification and greater dependency.

5. DISCUSSION

5.1. Causal Impact of the Downstreaming Policy and Theoretical Confirmation

Estimates from the intervention analysis model provide robust quantitative evidence on the causal impact of Indonesia's downstreaming policy. Controlling for global nickel prices, time trends, and exchange rate fluctuations, the policy variable's coefficient ($\beta_1 = 12.857$; $p < 0.001$) indicates that the 2014 export ban on unprocessed nickel ore significantly increased the annual average level of mining sector GDP by IDR 12.86 trillion. This causal claim is reinforced by robustness checks, particularly a placebo test assigning the intervention to 2010, which yielded insignificant results. This outcome suggests that the surge in sectoral performance was indeed triggered by the 2014 policy intervention rather than random shocks or unrelated trends (Angrist & Pischke, 2009).

These findings provide strong empirical support for the political economy of resource nationalism theory (Humphreys, 2020; Vivoda & Loginova, 2025). Indonesia has leveraged its dominant producer position to force domestic value capture, a strategy also observed in other critical commodities (Behuria, 2020; Atakhanova et al., 2025). The success of this policy evidenced by a 24-fold increase in export value-added per ton, positions Indonesia as a prominent example of a successful backward linkage strategy in the extractive sector. Comparisons can be drawn to Botswana's diamond sector, although Indonesia has adopted a more pragmatic approach by incorporating foreign capital, diverging from the full nationalization strategy pursued by Chile in the 1970s (González et al., 2024).

5.2. Transformation of Value Chains and Emerging Strategic Dependence

The downstreaming policy has reshaped Indonesia's position within the electric vehicle (EV) battery global value chain (GVC). The country has transitioned from being a mere supplier of raw materials to becoming a dominant producer of intermediate goods, accounting for 47% of global processed nickel exports in 2025. This upgrading reflects the dynamics described in GVC theory, whereby decisive state interventions can drive industrial upgrading (Cimprich et al., 2023).

Yet this transformation has produced a complex geopolitical paradox. The upgrading success is overshadowed by a new strategic dependence on China, which accounts for 68% of total FDI inflows and 58% of export destinations. Such concentration risks narrowing Indonesia's sovereign policy space in navigating international geopolitical pressures, a pattern similarly observed in China's expanding investments across other global metals sectors (Hagan Sibiri, 2023; Lapi et al., 2025). Through its strategy of vertical integration, China not only secures upstream access to raw materials but also entrenches long-term technological dependencies. Consequently, while Indonesia's bargaining power vis-à-vis other consuming nations has strengthened, its unilateral dependence on a single partner generates a distinct form of vulnerability, diverging from conventional notions of the resource curse.

5.3. Geopolitical Implications in the Energy Transition and ESG Challenges

In the context of the global energy transition, Indonesia's position as the world's largest nickel supplier has become critical. The rising demand for nickel in EV batteries renders downstreaming integral to the global green transition. However, China's dominance creates a strategic dilemma: while accelerating Indonesia's industrial upgrading, it also heightens the risk of supply chain weaponization in the event of China, West geopolitical conflict, potentially resulting in exclusion from Western markets that demand strict ESG compliance.

ESG challenges serve both as obstacles and as opportunities. The rapid expansion of smelters raises concerns about environmental sustainability and social impacts, as identified in prior research (Manhart et al., 2019). Pressure from European and North American markets regarding environmental standards is no longer a mere barrier but has become a prerequisite for accessing premium markets and attracting high-quality investment (Manzini et al., 2025). Integrating green mining initiatives and circular economy principles is therefore not only crucial for compliance but can also generate a competitive advantage, allowing Indonesian products to differentiate in the global marketplace (Clausen & Sörensen, 2022).

5.4. Comparative Lessons and Policy Implications

Indonesia's experience enriches the discourse on resource nationalism by demonstrating that downstreaming can serve a dual function: as a domestic economic instrument and as a tool of geopolitical diplomacy. Comparative lessons from other countries provide valuable insights for Indonesia's future strategy:

- **Botswana** illustrates the importance of strong fiscal governance and the establishment of a Sovereign Wealth Fund (SWF) to smooth boom bust cycles.
- **Chile** highlights the tension between state control (through Codelco) and private sector participation, and underscores the importance of channeling rents into research and development.
- **Mongolia** offers a cautionary tale of over-reliance on foreign investors combined with weak institutional capacity.

For Indonesia, the policy implications are clear: aggressive diversification of both investment sources and export markets is necessary to mitigate over-dependence on China. At the same time, strengthening ESG standards and advancing further downstream industries, such as battery precursor production are essential for moving higher up the value ladder and consolidating Indonesia's bargaining power within global energy geopolitics.

Table 10
Comparative Summary

Country	Resource & Policy Focus	Successes	Challenges / Risks	Lessons for Indonesia
Botswana	Diamonds – State-led revenue management (De Beers partnership, Sovereign Wealth Fund)	High revenue capture; stable fiscal system; long-term savings	Overdependence on diamonds; limited diversification	Strong revenue governance & SWF design to manage boom-bust cycles
Chile	Copper – Codelco + private sector mix; downstream semi-processing	Sustained copper production; strong fiscal contribution; tech upgrading	Limited full industrial upgrading; exposure to global price volatility	Balance between SOE and FDI, use rents for R&D and social investment
Mongolia	Copper & coal – foreign-led mining projects; weak regulatory capacity	Surge in FDI inflows; rapid GDP growth during boom years	Dutch disease; macro instability; vulnerability to foreign investors	Strengthen institutional capacity, avoid over-reliance on foreign-led mining
Source: Author's analysis (2025)				

5.5 Scenario Modeling: Projecting the Impact of Alternative Policy Pathways

The quantitative results of the intervention analysis, particularly the baseline policy impact coefficient (β_1 = 12.857), provide an empirical foundation for projecting the implications of alternative policy scenarios.

In **Scenario 1 (WTO Dispute Ruling Against Indonesia)**, a simulated reopening of nickel ore exports would weaken incentives for smelter investment and operations. As a result, the downstreaming impact is projected to shrink by 60–70%, implying that the annual GDP contribution of the policy would fall to approximately IDR 5.14–7.71 trillion (from the baseline of IDR 12.86 trillion). This contraction would slow GDP growth in the mining sector and reduce processed nickel exports by 35–40% in the medium term, as domestic processing activities decline. Foreign direct investment (FDI) for new smelter projects would also contract sharply. Nonetheless, short-term geographical diversification of exports could increase, given wider access to international markets for unprocessed ore.

In contrast, **Scenario 2 (Deepening the ASEAN–China Alliance)** projects a 20% increase in the policy impact coefficient (to ~ IDR 15.43 trillion per year), driven by improved access to technology and markets through tighter integration with this economic bloc. Such alignment could boost processed nickel exports by 25–30%. However, this strategy risks reinforcing Indonesia's geopolitical dependence on China, with the potential weaponization of supply chains in the event of China and West conflict.

Together, these scenarios highlight a fundamental policy trade-off: maintaining policy sovereignty and domestic value-added at the risk of trade disputes, versus deepening integration with a specific economic bloc at the cost of diversification and strategic autonomy. The modeling underscores that the future of Indonesia's nickel downstreaming is shaped not only by domestic policy design but also by highly dynamic global geopolitical forces.

6. CONCLUSION AND POLICY IMPLICATIONS

- ## 6.1. Main Findings

  This study provides robust empirical confirmation that Indonesia's nickel downstreaming policy has generated significant causal effects on the national economy. Based on the intervention analysis model, the nickel ore export ban introduced in 2014 directly contributed to an average annual increase of IDR 12.86 trillion in mining sector GDP, after controlling for external factors such as global commodity prices and macroeconomic conditions. This success is reflected not only in output growth but also in a fundamental structural transformation: the value added per ton of nickel exports increased twenty-fourfold, while Indonesia's share of global processed nickel exports rose from 12% (2015) to 47% (2025).

  Yet these economic achievements are shadowed by a complex geopolitical paradox. A policy originally designed to reinforce economic sovereignty has simultaneously generated new strategic dependence on China, which accounts for 68% of inward FDI and 58% of processed nickel exports. Such dominance risks constraining Indonesia's policy space in navigating global geopolitical dynamics, particularly amid intensifying technological rivalry and increasingly stringent ESG standards.

These findings reinforce the political economy of resource nationalism by showing that producer states can leverage control over strategic resources to enforce value capture and industrial upgrading. At the same time, the results extend the theory by highlighting that such successes may engender novel forms of vulnerability distinct from the traditional resource curse.

Drawing on the empirical evidence and comparative lessons from Botswana, Chile, and Mongolia, this study formulates five strategic policy pillars to consolidate achievements and mitigate emerging risks, summarized in Table 11.

Table 11
Strategic Policy Recommendations for Indonesia's Nickel Downstreaming

Policy Area	Core Recommendation	Rationale	Expected Impact
Investment & Market Diversification	Attract FDI beyond China (Japan, South Korea, EU, US) through technology-linked incentive schemes.	Reduce geopolitical risk and mitigate overdependence on a single partner.	Greater resilience and more balanced bargaining power.
ESG Standards Enhancement	Implement strict environmental and social governance (waste, energy use, local communities).	Comply with global ESG scrutiny and access green finance.	Improved export competitiveness and entry to premium markets.
Downstream Industry Development	Expand into mid-downstream (battery precursors, EV components).	Move beyond ferronickel/matte exports toward higher value chains.	Enhanced value-added capture and industrial upgrading.
Economic Diplomacy	Strengthen ASEAN-based alliances and selective cooperation with China/West.	Leverage nickel as a strategic resource in the global EV supply chain.	Greater geopolitical influence and diversified export markets.
Fiscal Governance & SWF	Establish a Sovereign Wealth Fund (SWF) for resource rents.	Shield the economy from price volatility and build intergenerational savings.	Fiscal stability and sustainable development financing.

Source: Author's synthesis from empirical analysis and comparative literature (Botswana, Chile, Mongolia).

6.2 Detailed Policy Implications

1. **Investment and Market Diversification**: The government should actively attract investors from Japan, South Korea, the European Union, and the United States through differentiated incentive schemes tied to technology content and commitments to technology transfer. This approach is essential to reduce reliance on China and strengthen strategic resilience.
2. **Strengthening ESG Standards and Sustainable Mining Practices**: Implementing rigorous environmental, social, and governance (ESG) standards is no longer merely a compliance requirement but a competitive advantage for accessing premium markets and global green finance. Indonesia can reposition itself as a responsible supplier within the global EV battery value chain.

3. **Advancing Downstream Industrial Development**: Downstreaming must be deepened into higher value-added stages, including the production of battery precursors, cathodes, and ultimately cell manufacturing. This requires substantial investment in research and development (R&D) and sustained human capital formation.
4. **Proactive and Multilateral Economic Diplomacy**: Indonesia should leverage its dominant position in global nickel supply to strengthen bargaining power in international forums and build strategic alliances with other mineral-producing states, thereby creating collective negotiation leverage.
5. **Enhanced Fiscal Governance and Sovereign Wealth Fund**: Establishing a Sovereign Wealth Fund (SWF) dedicated to managing revenues from natural resources is critical to mitigating boom-and-bust cycles, ensuring intergenerational savings, and financing sustainable development beyond the extractive sector.

6.3. Academic Contributions

This study makes three principal academic contributions.

First, it extends the discourse on the political economy of resource nationalism by providing robust quantitative evidence of the downstreaming policy's causal effects, while also introducing the paradox of economic success accompanied by deepened geopolitical dependence.

Second, it enriches global value chain theory by demonstrating that industrial upgrading through assertive policy intervention is indeed feasible, yet may simultaneously generate new forms of dependency on technology and markets controlled by dominant partners.

Third, it offers a methodological contribution by integrating a parsimonious yet robust intervention analysis with qualitative scenario modeling, thereby providing an analytical framework that can be applied to assess extractive-sector policies in other developing economies.

6.4. Limitations and Future Research Agenda

This study is subject to several limitations. Most importantly, the analysis remains macro-level and does not capture distributional impacts on local communities and regional economies. Future research should explore how downstreaming influences income inequality, labor market conditions, and socio-environmental dynamics in mining regions.

Moreover, the rapid evolution of battery technologies, particularly the potential substitution of nickel with alternative materials or the adoption of next-generation battery chemistries represents a major disruptive factor. Continuous monitoring and adaptive policy responses will be essential. The long-term sustainability of Indonesia's nickel industry ultimately depends on its capacity to anticipate and adjust to these technological disruptions.

Declarations

Author Contribution

S.B.S. conceived and designed the study, collected and analyzed the data, developed the models, interpreted the results, and wrote the manuscript. S.B.S. is solely responsible for all aspects of the work.

Data Availability

All data used in this study are publicly available through BPS, BI, BKPM, ESDM, UN Comtrade, UNCTADstat, LME, IEA, and WTO, as referenced in the manuscript.

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Figures

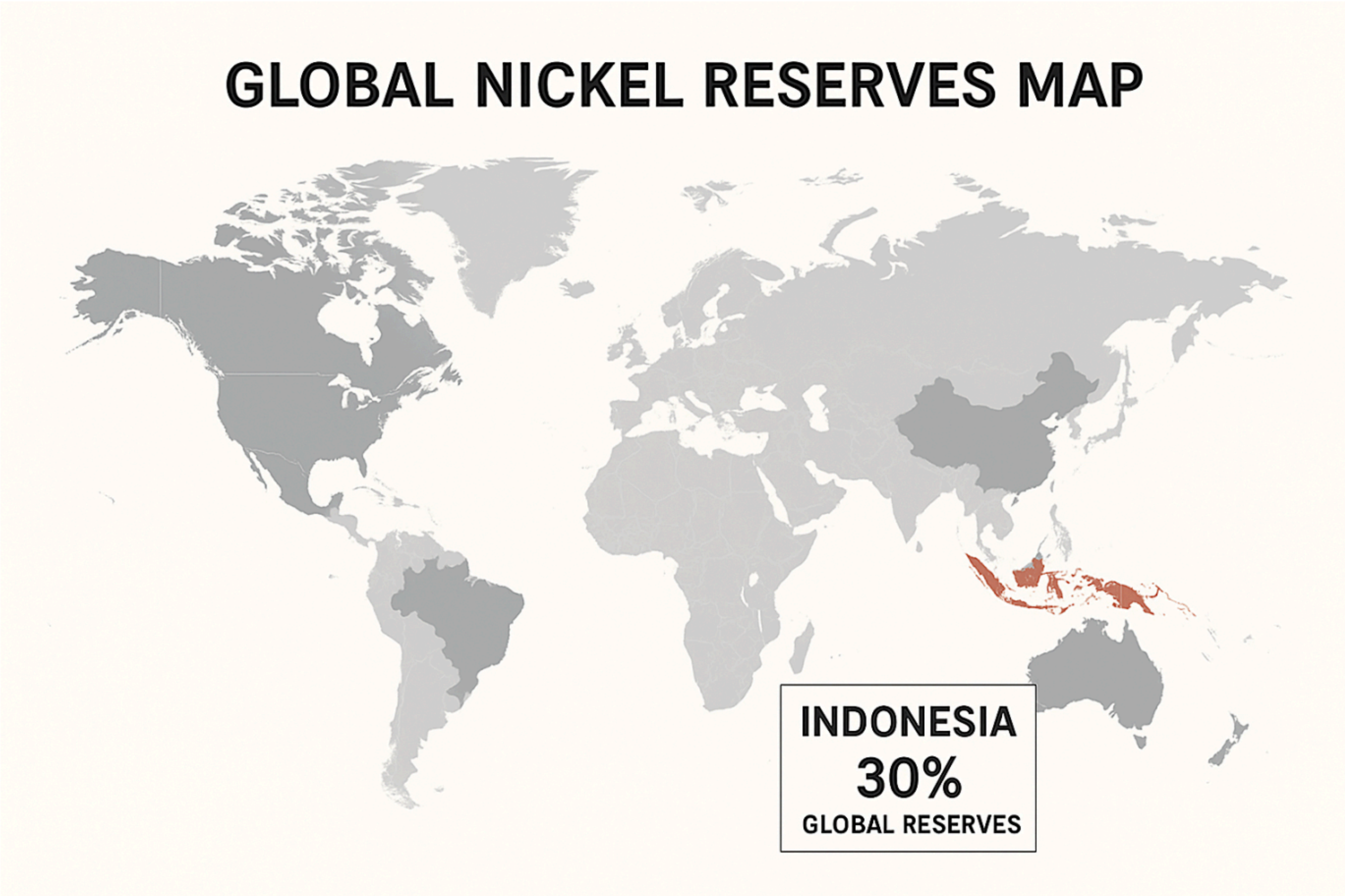

Figure 1

Global Nickel Reserve Map

Figure 2

Mining Sector GDP Trend and Policy Implementation (2005–2025)

Source: BPS (2025), processed by the author

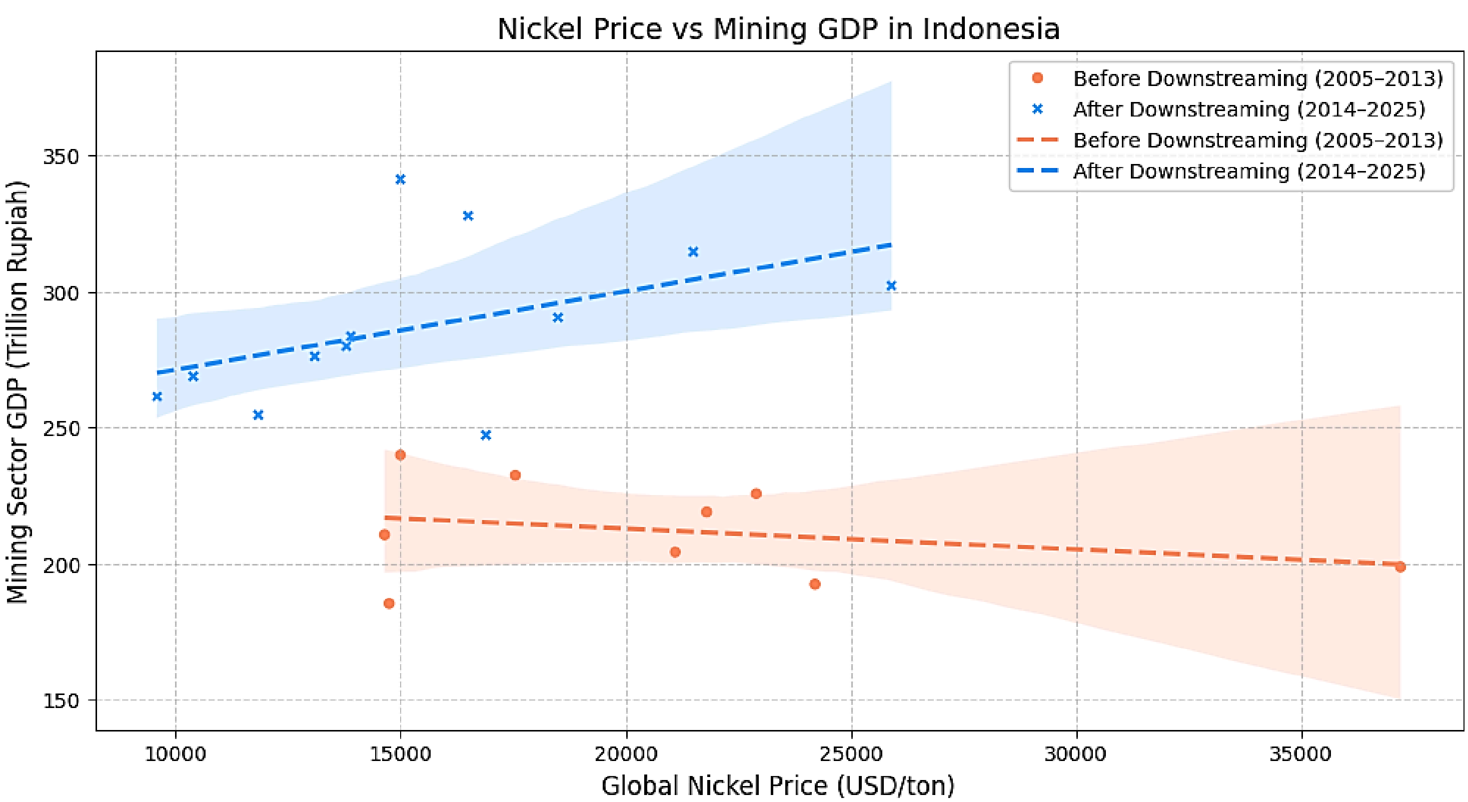

Figure 3

Global Nickel Prices and Mining GDP Before and After Downstreaming

Source: BPS, LME (2025), processed by the author

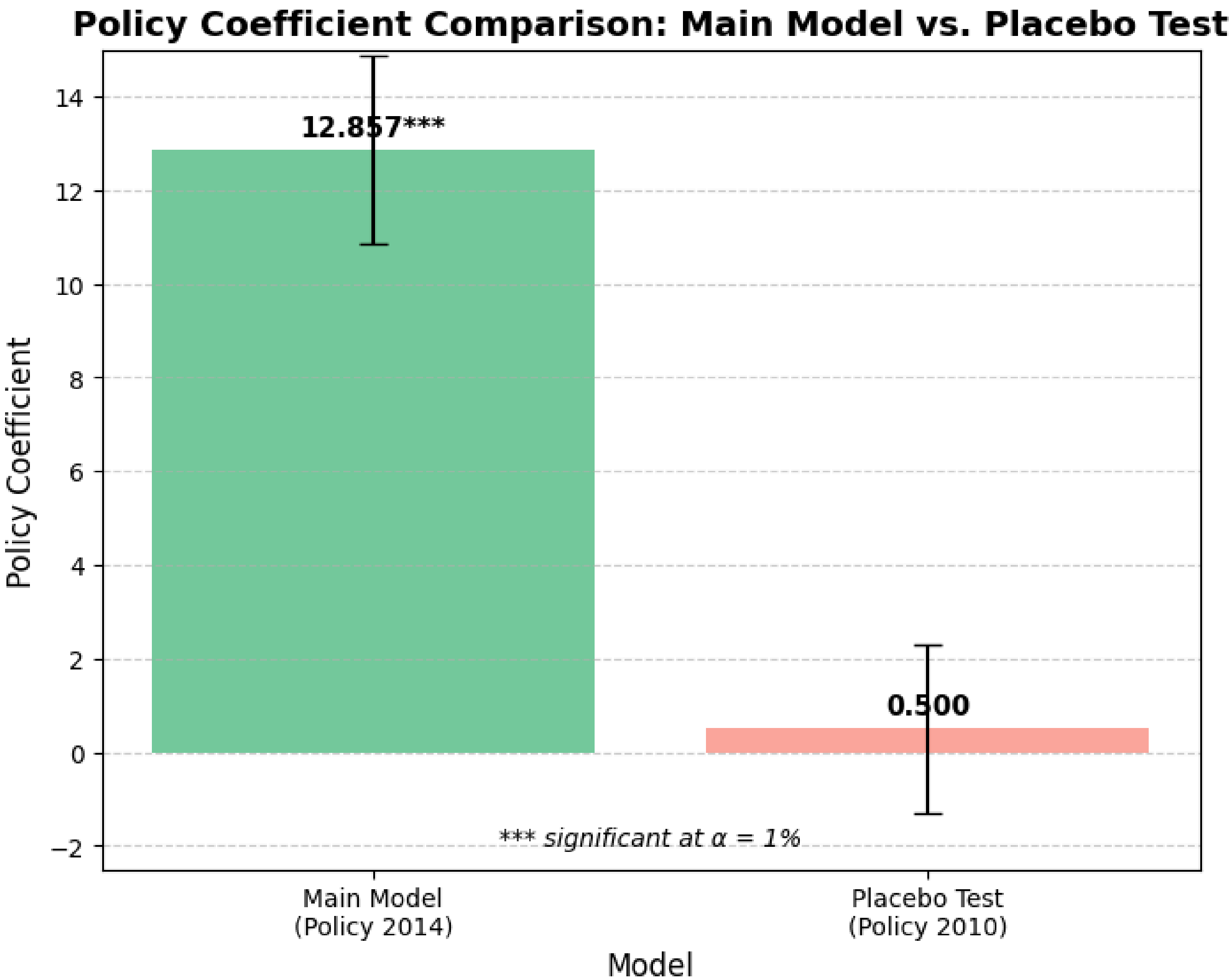

Figure 4

Policy Coefficients: Main Model vs. Placebo Test

Source: Author's calculations (2025)

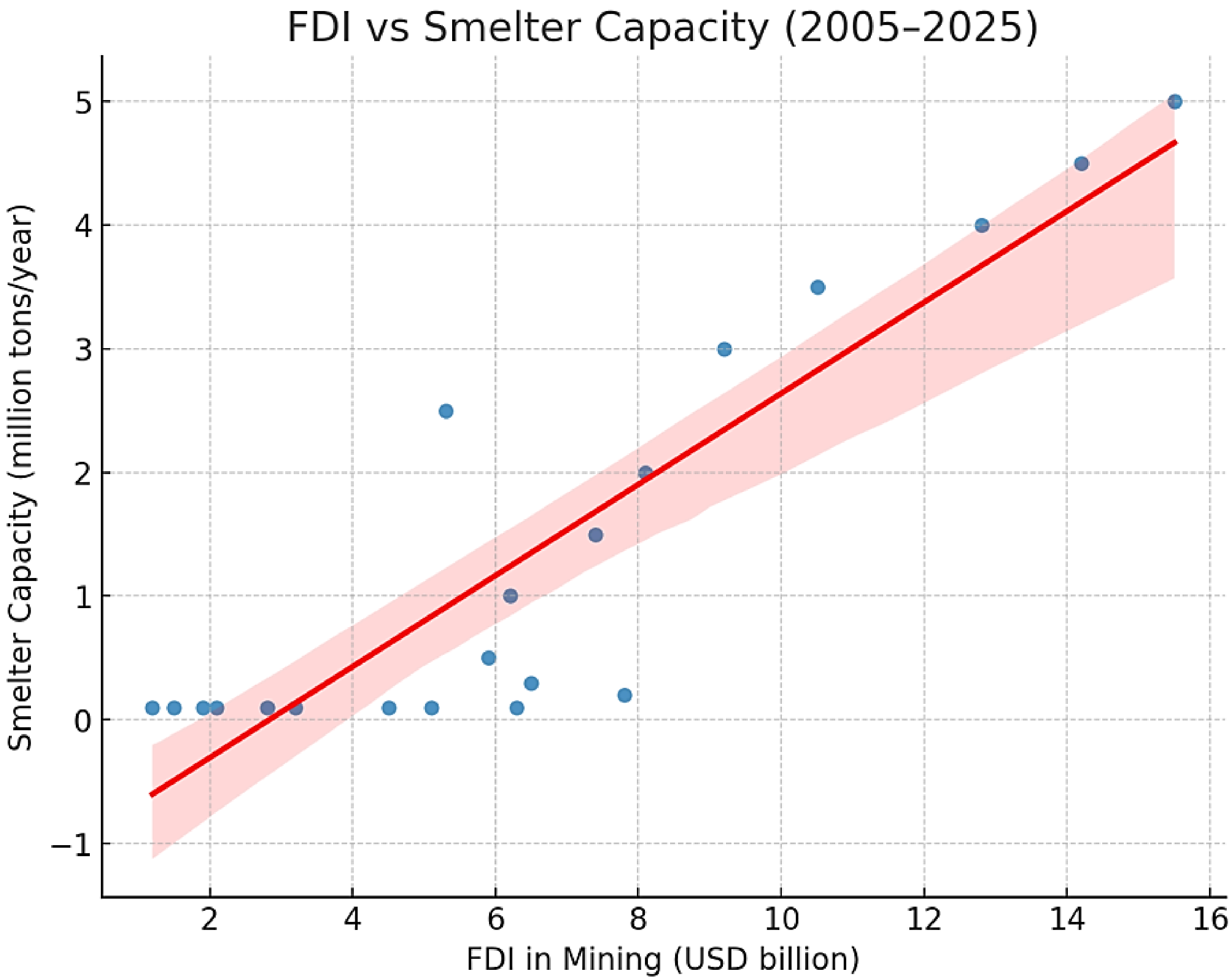

Figure 5

Relationship between FDI and Nickel Smelter Capacity (2005–2025)

Source: Author's calculations (2025)

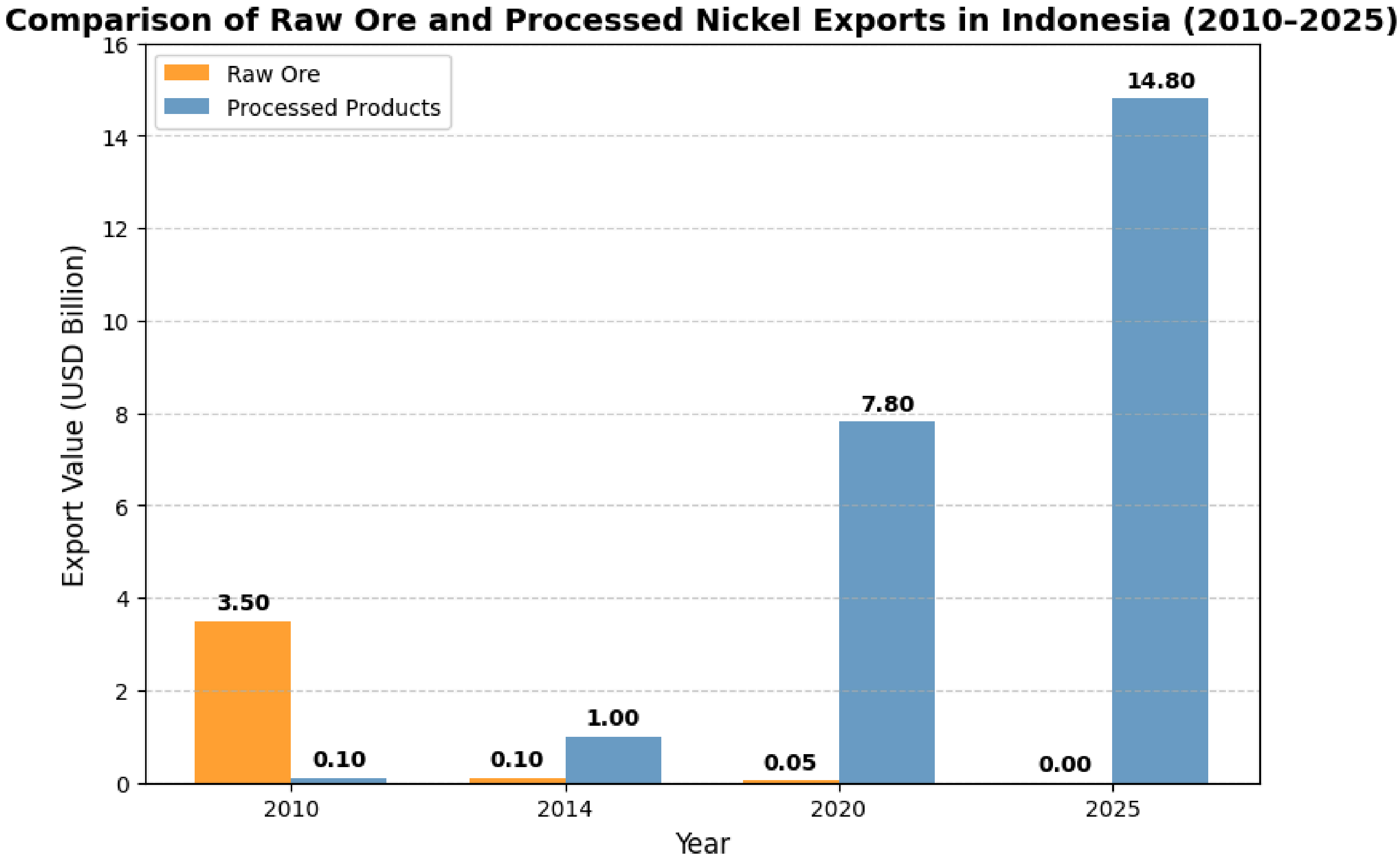

Figure 6

Ore vs. Processed Nickel Exports (2010–2025)

Source: BPS, UN Comtrade (2025), processed by the author

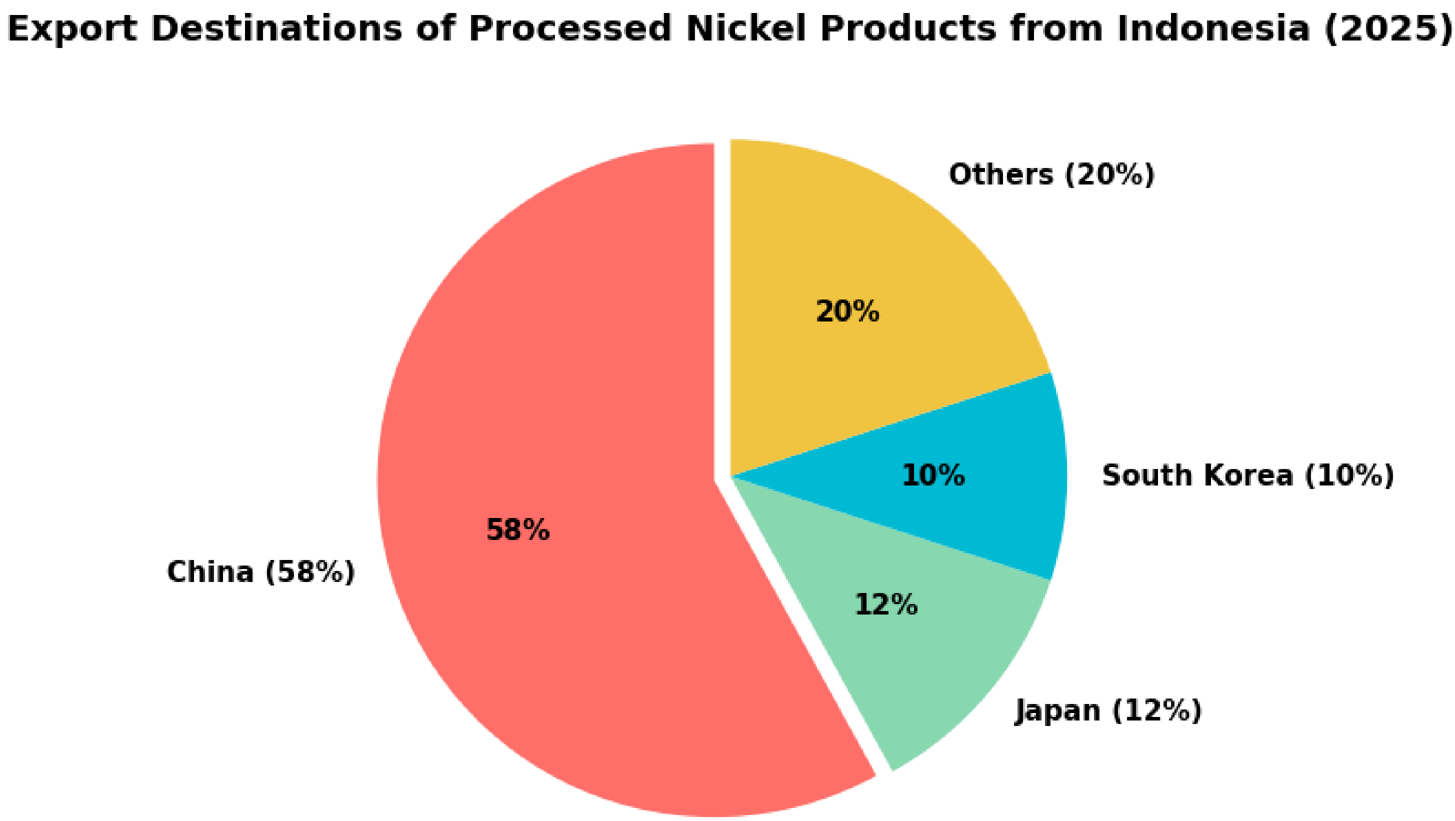

Figure 7

Composition of Indonesia’s Processed Nickel Export Markets (2025)

Source: BPS, Ministry of Trade, UN Comtrade (2025), processed by the author

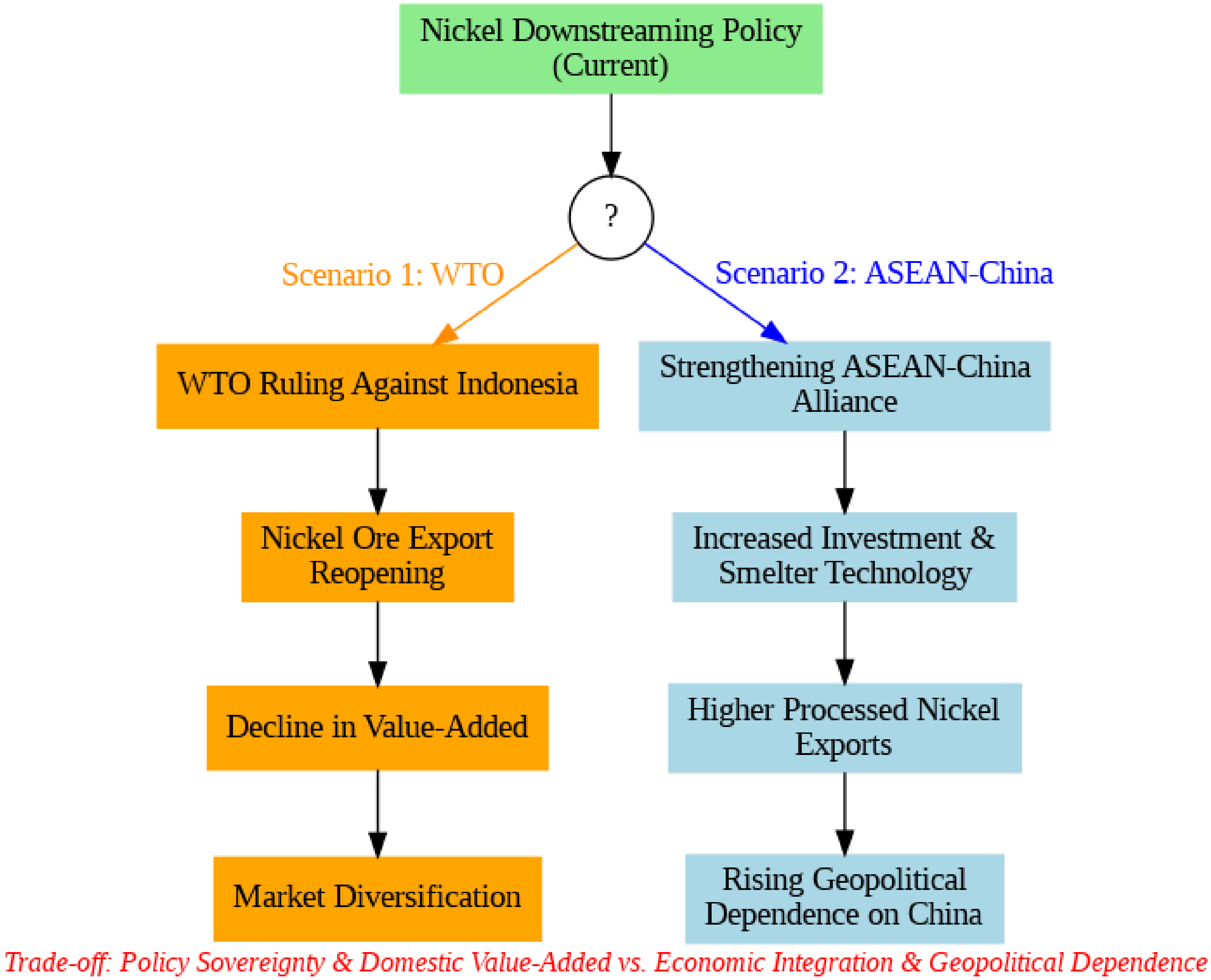

Figure 8

Scenario Modeling of Policy Alternatives (WTO Ruling vs. ASEAN–China Alliance)

Source: Author's analysis (2025)