



Analysis of the Impact of Mineral and Coal Downstreaming Policy on Global and National Economies: A GTAP Approach

Basuki Rahmad Saleh¹, Irdam Ahmad¹, Herlina Juni Risma Saragih¹, Agus Adriyanto¹,
Susanna Renna Ertanti²

¹Universitas Pertahanan RI

²Kementerian Energi dan Sumber Daya Mineral RI

*Corresponding Author: Basuki Rahmad Saleh

Email: Basuki.saleh@doktoral.idu.ac.idm



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Abstract

Indonesia's mineral and coal downstreaming policy, which imposes export bans and restrictions on raw minerals such as nickel, bauxite, copper, and coal, represents one of the most ambitious resource industrialization strategies globally. This study aims to analyze the potential and impact of the mineral and coal downstreaming policy on Indonesia's macroeconomic and sectoral economic indicators as well as its implications for global trading partners. The analysis method employs the GTAP (Global Trade Analysis Project) version 10 database model with two cooperation scenario approaches: a 50% reduction in raw mineral exports (Simulation 1) and a 95% reduction in raw mineral exports (Simulation 2). The macroeconomic indicators analyzed include welfare (equivalent variation), real Gross Domestic Product (GDP), household consumption, government expenditure, investment, exports, imports, and trade balance. The sectoral indicators include output changes and employment opportunities. The results show that Indonesia's downstreaming policy promotes an increase in real GDP, household welfare, domestic consumption, and investment, with the highest gains occurring in the nickel processing, ferronickel, and manufactured metals sectors. However, the policy creates a temporary trade balance deterioration due to increased capital goods imports for smelting infrastructure. From the sectoral perspective, downstream mineral industries particularly ferronickel, chemical fertilizers derived from coal gasification, and mineral-based manufactured goods record the highest output and employment increases. These findings underscore the strategic importance of accelerating hilirisasi policies while mitigating trade risks through market diversification.

Introduction

The mineral and coal downstreaming policy is a national strategic program that has become a key pillar of Indonesian economic policy over the past decade (Yogar et al., 2026; Rahman & Raphael, 2025; Lahadalia et al., 2024). Downstreaming, in the context of mineral resources, is defined as the domestic processing and refining of mineral raw materials before export to increase the added value of these commodities (Naryono, 2023; Ministry of Energy and Mineral Resources, 2024). This policy is formally based on Law Number 4 of 2009 concerning Mineral and Coal Mining, which was later strengthened through its amendment in Law Number 3 of 2020, which requires all mining companies to process and refine minerals domestically before export (Musafa & Muhtada, 2026; Ridwansyah & Abidin, 2026; Dewani et al., 2026). In practice, the Indonesian government has implemented a complete ban on raw nickel ore exports since January 2020, and extended the same policy to bauxite in June 2023. This move has received significant global attention, particularly after the export value of Indonesian nickel-based products surged from around USD 6 billion in 2013 to nearly USD 30 billion in

2022, driven by exports of high-value-added products such as stainless steel, ferronickel, and electric vehicle battery materials (East Asia Forum, 2023; CSIS, 2025). In line with this, President Joko Widodo emphasized that the downstreaming policy has increased the value of Indonesian nickel exports from IDR 17 trillion to IDR 510 trillion (Ministry of Energy and Mineral Resources, 2024).

The mineral and coal sectors make a significant contribution to the national economy (Nyberg et al., 2026; Umar et al., 2025; Zheng et al., 2023). According to data from the Ministry of Energy and Mineral Resources, the mining sector contributed IDR 300.3 trillion to Non-Tax State Revenue (PNBP) in 2023, with the mineral and coal sector accounting for 58% of this figure (Indonesia.go.id, 2024). Meanwhile, Indonesian coal production continues to increase, reaching a record 775.2 million tons in 2023 and 836 million tons in 2024 (APBI-ICMA, 2025). In addition to coal, Indonesia is the world's largest nickel producer, accounting for approximately 58% of total global nickel production in 2024 (CSIS, 2025).

However, the downstreaming policy is not without challenges and controversy. On the international trade front, the World Trade Organization (WTO) ruled in 2022 that Indonesia's mineral export restrictions violated international trade rules, specifically Article XI of the GATT 1994, which prohibits export restrictions (Wau et al., 2024). Domestically, the implementation of downstreaming policies requires significant investment in smelter infrastructure, increases imports of capital goods, and relies heavily on coal energy supplies (Minerba ESDM, 2024). Furthermore, there are concerns about the dominance of foreign capital, particularly China, which controls approximately 75% of Indonesia's nickel refining capacity (CSIS, 2025).

Nevertheless, quantitative studies comprehensively measuring the impact of mineral and coal downstreaming policies on Indonesia's macroeconomic and sectoral sectors using a general equilibrium model approach are still relatively limited. Several previous studies, such as Widyastutik et al. (2023), analyzed the impact of palm oil trade liberalization between Indonesia and Pakistan using the GTAP model, while a study by the UMS Journal of Development Economics (2024) analyzed the impact of mineral export bans on welfare using the CGE framework. However, no research has specifically measured the simultaneous impact of mineral and coal downstreaming policies on Indonesia's macroeconomic and sectoral indicators in an integrated manner within a single GTAP model.

Therefore, this study aims to fill this gap by analyzing the potential and impact of Indonesia's mineral and coal downstreaming policies, represented through a simulation of a decline in raw mineral exports on macroeconomic indicators (real GDP, welfare, consumption, investment, trade balance) and sectoral indicators (output and employment) using the Global Trade Analysis Project (GTAP) version 10 database model. This study is expected to provide quantitative evidence-based policy recommendations for relevant stakeholders, particularly in the context of accelerating and deepening the implementation of Indonesia's mineral and coal downstreaming.

Literature Review

Value Added Theory and Policy Downstream

Downstreaming in resource economics refers to the process of transforming primary commodities into higher-value products through a series of processing and refining processes. Within the framework of international trade theory, this concept is closely related to the theory of dynamic comparative advantage proposed by Krugman (1987), where a country can create new comparative advantages through strategic industrial policies, including restrictions on raw material exports. A policy banning raw mineral exports theoretically operates through a market

power mechanism whereby a producing country with a significant market share in a commodity can compel foreign buyers to invest in domestic processing facilities, thereby creating technology transfer and capital accumulation (East Asia Forum, 2023).

From an industrial economic perspective, downstreaming creates a greater multiplier effect than raw mineral exports. The Ministry of Energy and Mineral Resources (2024) noted that the nickel downstreaming process creates a four-fold increase in added value when nickel ore is processed into ferronickel, and up to five-fold when processed into nickel matte. Meanwhile, data from the Ministry of Energy and Mineral Resources' Center for Data and Information Technology (2016) shows that the downstream processing of bauxite into alumina provides 5.72-fold added value to the regional economy of West Kalimantan. Hadiyanto (2015) emphasized that diversifying export products through upstream-downstream industrialization is a long-term strategy that can encourage more inclusive and sustainable economic growth.

The GTAP Model in Trade Policy Analysis

The Global Trade Analysis Project (GTAP) is a Computable General Equilibrium (CGE) model approach developed by Purdue University in 1993 and first published academically by Hertel & Tsigas (1997). This model is widely used to analyze the impact of international trade policies, tariff liberalization, and export restrictions on a country's macroeconomic and sectoral indicators simultaneously (Puspitawati & Oktaviani, 2017). The main advantage of the GTAP model is its ability to simultaneously capture complex interactions between various economic sectors and global markets, including changes in aggregate and distributional welfare (Widyastutik et al., 2023; Lu et al., 2010).

Several previous studies have utilized the GTAP model to analyze the impact of Indonesian trade policies. Widyastutik et al. (2023) used GTAP to measure the impact of One Belt One Road and the liberalization of Indonesia-Pakistan palm oil trade, finding that trade liberalization increased Indonesia's welfare and real GDP. Research by the UMS Journal of Development Economics (2024) specifically analyzed the impact of Indonesia's mineral export ban using the GTAP model and found that the policy improved Indonesia's GDP, welfare, and terms of trade. Oktaviani & Amaliah (2010) also used the GTAP model to analyze the impact of free trade agreements (FTAs) on Indonesia's macroeconomic and sectoral development, finding that trade integration generally had a positive impact on consumption and investment.

Specifically, for export restriction policies, Aragie et al. (2016) used a CGE model to analyze the impact of Ethiopia's cereal export ban and found a negative impact on the short-term trade balance but a positive impact on long-term domestic value added. Meanwhile, Kutlina-Dimitrova (2017) analyzed the impact of Russia's import ban using CGE analysis and found that trade restriction policies create welfare losses in partner countries but can increase domestic production in import substitution sectors. These previous research results provide a strong theoretical and methodological foundation for this study to analyze the impact of Indonesia's mineral and coal downstreaming policy through GTAP simulations.

Methods

GTAP Model Framework

This study employed a quantitative simulation approach using the Global Trade Analysis Project (GTAP) version 10 database. The GTAP model is a multi-region and multi-sector Computable General Equilibrium (CGE) model that allows the analysis of policy shocks on macroeconomic performance, sectoral output, trade flows, welfare, and factor allocation across countries and regions. In this study, the GTAP model was used to estimate the potential impact

of Indonesia’s mineral and coal downstreaming policy on both the national economy and major global trading partners.

The GTAP version 10 database contains data from 160 countries/regions and 65 commodity sectors, with a baseline data year of 2014. The model is built on national accounting data, input-output tables, bilateral trade flows, and protection data, including tariffs and subsidies. The standard GTAP model assumes perfectly competitive markets, constant returns to scale, and factor mobility across sectors within each region. These assumptions allow the model to capture how a policy shock in one sector, such as export restrictions on raw minerals, affects production, consumption, investment, trade, and welfare through intersectoral and international linkages.

In this research, the downstreaming policy was represented as a reduction in Indonesia’s raw mineral and coal exports. The simulation was designed to reflect the policy mechanism through which restrictions on raw mineral exports encourage the reallocation of mineral resources from direct export activities toward domestic processing and value-added industries. The main macroeconomic indicators analyzed include welfare or Equivalent Variation (EV), real GDP, household consumption, government expenditure, investment, exports, imports, trade balance, and terms of trade. Meanwhile, sectoral indicators include changes in output and employment opportunities for skilled and unskilled labor.

Regional and Commodity Aggregation

To align the model with the research objectives, regional and commodity aggregation was conducted using the GTAP version 10 database. The selected regional aggregation reflects Indonesia’s major trading partners in mineral, coal, metal, and downstream industrial products. These regions were selected because they represent economies that are directly connected to Indonesia’s raw mineral exports, downstream metal industries, and global supply chains for manufacturing, steel, and electric vehicle-related industries.

China, Japan, South Korea, India, the European Union, and the United States were included because of their important roles as major importers, industrial users, or strategic partners in mineral-based manufacturing. The Rest of World (ROW) category was used to capture the remaining global economic interactions outside the selected regions. Table 1 presents the regional aggregation used in this study.

Table 1. Regional Aggregation in GTAP Approach

No.	Code	Country / Region
1	IDN	Indonesia
2	CHN	China
3	Japan	Japan
4	KOR	South Korea
5	IND	India
6	EU	European Union
7	USA	United States of America
8	ROW	Rest of World (Australia, other ASEAN, Africa, etc.)

Source: GTAP version 10 Database, processed.

Commodity aggregation was focused on sectors directly related to mineral and coal downstreaming. The selected sectors include upstream raw mineral and coal commodities, intermediate processing sectors, and downstream manufacturing sectors. This aggregation enables the model to capture the transformation from raw mineral exports into higher-value

products, such as ferronickel, alumina, stainless steel, nickel sulfate, mixed hydroxide precipitate (MHP), DME, battery cells, and other metal-based products.

Table 2. Aggregation Main Commodities Based on GTAP Sectoral Approach

No.	GTAP Code	Description (Upstream)	Product Downstream
1	oxt	Minerals nec (Nickel, Bauxite, Copper)	Ferronickel, Alumina, Cathode Copper
2	coa	Coal	Coal, Coke, Briquette Gasification
3	i s	Ferrous Metals (Iron-Steel)	Stainless Steel, Alloy Steel
4	nfm	Non-Ferrous Metals	Aluminum, Nickel Sulfate, MHP
5	fmp	Metal Products	Component EV Battery, Products Downstream Metals
6	p c	Petroleum & Coal Products	DME (Dimethyl Ether), Premium Coke
7	crp	Chemical, Rubber & Plastic Products	Fertilizer from Coal Gasification
8	ele	Computers, Electronics & Optical	Battery Cell, Cathode Material

Source: GTAP version 10 Database, processed.

Simulation Scenarios

This study developed two policy simulation scenarios to represent different levels of Indonesia's mineral and coal downstreaming policy. The scenarios were constructed based on the assumption that downstreaming policies reduce the availability of raw mineral exports from Indonesia to the global market and encourage domestic processing activities. The policy shock was applied to raw mineral and coal-related sectors, namely oxt, coa, i_s, and nfm.

Simulation 1 represents a partial downstreaming scenario, in which raw mineral exports are restricted by 50%. This scenario reflects a more moderate or pessimistic policy implementation, where downstreaming is applied gradually and some raw commodity exports remain possible under certain policy arrangements. Simulation 2 represents a stronger or more optimistic downstreaming scenario, in which raw mineral exports are restricted by 95%. This scenario reflects a near-full implementation of the downstreaming policy, where most raw mineral exports are redirected toward domestic processing industries.

The two levels of export restriction were used to compare the economic effects of partial and more comprehensive downstreaming implementation. The comparison between the two simulations allows the study to evaluate whether stronger downstreaming policies generate larger macroeconomic and sectoral benefits, as well as whether they create greater trade-related adjustment costs.

Table 3. Scenarios Simulation Policy Downstreaming of Indonesian Minerals and Coal

Simulation	Restriction Level Raw Mineral Exports	Sectors Covered	Interpretation Policy
Sim 01	50%	All raw mineral commodities (oxt, coa, i_s, nfm), except commodities sensitive	Scenario pessimistic: Implementation downstreaming Partial (Preferential Treatment Agreement)

Sim 02	95%	All raw mineral commodities (oxt, coa, i_s, nfm), except commodities sensitive	Scenario optimistic: Implementation downstreaming Full Downstreaming Policy
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Source: Compiled by the author based on GTAP framework.

Sensitive commodities were excluded from the export restriction scenario to avoid excessive short-term disruption to domestic economic stability. These excluded commodities include crude oil, natural gas, and rice (pdr). The exclusion was based on the consideration that these commodities are closely related to national food security, energy security, and domestic price stability. Therefore, restricting these commodities could create substantial short-term risks for household welfare, production costs, and macroeconomic stability.

Data Analysis

The results of the GTAP simulations were analyzed by comparing the baseline condition with the two policy scenarios. The analysis focused on three main aspects. First, the macroeconomic impact was assessed through changes in welfare, real GDP, household consumption, government expenditure, investment, exports, imports, trade balance, and terms of trade. Second, the sectoral impact was evaluated through changes in output across mineral, metal, manufacturing, and supporting sectors. Third, the labor market impact was assessed by examining changes in employment opportunities for skilled and unskilled labor in the sectors most affected by downstreaming.

In addition, the study analyzed the welfare effects on Indonesia's major trading partners to identify the global redistribution effects of Indonesia's downstreaming policy. This analysis is important because export restrictions on raw minerals may generate welfare gains for Indonesia while creating adjustment costs for countries that depend on Indonesian mineral and coal supplies. Therefore, the GTAP approach provides a comprehensive framework for evaluating both the domestic and international implications of Indonesia's mineral and coal downstreaming policy.

Results and Discussion

Impact Policy Downstream on the Indonesian Macro Economy

Based on results GTAP model simulation, policy downstreaming of Indonesian minerals and coal is predicted give diverse impacts to various indicator economy Indonesia's macroeconomics. Table 4 presents summary results simulation For second analyzed scenarios.

Table 4. Impact Policy Downstreaming of Minerals and Coal to Indicator Indonesian Macroeconomics

Indicator Macroeconomics	Sim 01 (50%)	Sim 02 (95%)
Welfare (EV, USD Million)	+1,842.50	+4,763.20
Real GDP (%)	+0.2150	+0.5312
Expenditure Private / Household Consumption (%)	+0.3271	+0.7843
Investment (%)	+0.5640	+1.2380
Expenditure Government (%)	+0.1982	+0.4715
Exports (%)	-0.1230	-0.2940
Imports (%)	+0.4810	+0.9720
Balance Sheet Trade (USD Million)	-423.80	-1,024.60
Terms of Trade (%)	+0.3840	+0.8920

Sim 01 = Restrictions raw mineral exports 50%; Sim 02 = Restriction raw mineral exports 95%.

Source: GTAP version 10 Database, processed.

Simulation results show that Indonesia's mineral and coal downstreaming policy consistently drives welfare improvements, as measured by Equivalent Variation (EV). In Simulation 1, Indonesia's welfare increased by USD 1,842.50 million, and in Simulation 2, it significantly increased to USD 4,763.20 million. This welfare increase aligns with research findings from the UMS Journal of Development Economics (2024), which used the GTAP framework and found that the mineral export ban significantly improved Indonesia's welfare, primarily due to the more efficient allocation of raw minerals to domestic downstream industrial activities.

From a real GDP perspective, the downstreaming policy drove significant increases of 0.2150% in Simulation 1 and 0.5312% in Simulation 2. This real GDP increase aligns with findings from the East Asia Forum (2023), which noted that the value of Indonesia's nickel-based product exports jumped nearly fivefold between 2013 and 2022 as a result of the downstreaming policy. The transmission mechanism for GDP growth occurs through the multiplier effect of downstream industrial activities, which are more technology-intensive and create significantly greater added value than raw material exports. Oktaviani & Puspitawati (2008) state that increased domestic industrial activity directly increases household consumption and investment, the main components of GDP.

Investment is the macro indicator that shows the most significant increase in this simulation, increasing by 0.5640% in Simulation 1 and 1.2380% in Simulation 2. This is consistent with empirical evidence, where Indonesia's nickel export ban in 2020 drove a 44.2% surge in foreign direct investment (FDI) between 2021 and 2022, reaching USD 45.6 billion (CSIS, 2025). This investment transmission mechanism operates through incentives provided to foreign investors, particularly from China, to build refining and smelter facilities domestically to maintain access to Indonesia's mineral resources. Gastanaga et al. (1998) and Philippa & Gali (2003) emphasized that policies promoting economic integration and reducing trade barriers generally increase investor confidence and encourage investment inflows.

However, contrary to the indicators above, Indonesia's trade balance is predicted to experience a deficit in both simulation scenarios. The trade balance deficit of USD 423.80 million in Simulation 1 and USD 1,024.60 million in Simulation 2 occurred due to a surge in imports of capital goods and raw materials for smelter infrastructure development, exceeding the increase in the value of downstream product exports in the short term. This is consistent with empirical conditions, where Indonesia imported approximately 70% of its heavy mining machinery (HS-Code 8474) from China in 2024, valued at over USD 750 million (CSIS, 2025). However, in the long term, exports of high-value-added products are expected to exceed imports of capital goods, as indicated by an increase in Indonesia's terms of trade of 0.3840% to 0.8920% in both scenarios.

The Impact of Downstreaming Policies on Indonesia's Sectoral Performance

From a sectoral perspective, downstreaming policies encourage a significant reallocation of output and labor from the raw mining sector to mineral processing and downstream industries. Table 5 displays the ten Indonesian commodities that experienced the highest output increases in both downstreaming simulation scenarios.

Table 5. Ten Commodity with Largest Output Increase consequence Policy Downstream Mineral and Coal Processing in Indonesia (Percent)

No.	GTAP Code (Sim 01)	Sim 01 Output Change (%)	No.	GTAP Code (Sim 02)	Sim 02 Output Change (%)
1	nfm (Non-Ferrous Metals)	+4,823	1	nfm (Non-Ferrous Metals)	+11.742
2	i_s (Ferrous Metals)	+3.741	2	i_s (Ferrous Metals)	+8.934
3	fmp (Metal Products)	+2.652	3	fmp (Metal Products)	+6.418
4	ele (Electronics & Optical)	+1.934	4	ele (Electronics & Optical)	+4.721
5	p_c (Petroleum & Coal Prod.)	+1.623	5	p_c (Petroleum & Coal Prod.)	+3.984
6	crp (Chemical, Rubber, Plastic)	+1.218	6	crp (Chemical, Rubber, Plastic)	+2.913
7	ome (Machinery & Equipment)	+0.987	7	ome (Machinery & Equipment)	+2.341
8	cns (Construction)	+0.842	8	cns (Construction)	+1.873
9	wtr (Water Transport)	+0.531	9	wtr (Water Transport)	+1,234
10	ofi (Financial Services)	+0.412	10	ofi (Financial Services)	+0.987

Sim 01 = Restrictions raw mineral exports 50%; Sim 02 = Restriction raw mineral exports 95%.

Source: GTAP version 10 Database, processed.

Commodity *Non-Ferrous Metals* (nfm), which includes product processed nickel (ferronickel, *nickel matte*, *nickel sulfate*, MHP), into sector with highest output increase in second scenario. In Simulation 1, the output of the sector This increase by 4.823%, while in Simulation 2 the increase was reached 11.742%. This is consistent with empirical data showing that export product based Indonesia's nickel production increased by 367% year - *on-year* in 2022 as impact from implementation prohibition export ore nickel raw (BPS via IISD, 2025). Incentives production in the sector processing nickel happen Because policy downstreaming in a way effective lower raw mineral prices domestic relatively to global prices encourage domestic smelters get supply material more standard cheap at a time sell product the processing to the global market with premium prices (East Asia Forum, 2023).

Ferrous Metals (i_s) sector which includes stainless steel and alloy steel based nickel also experienced significant increase in output: 3.741% in Simulation 1 and 8.934% in Simulation 2. Industry data show that Indonesia's stainless steel output is increasing from 4 million tons to 7.5 million tons between 2020 and 2024, some of which big driven by policy downstreaming nickel (CSIS, 2025). Increased output in the sectors downstream This push effect positive multiples in the sectors supporters like *Metal Products* (fmp), *Construction* (cns), and *Financial Services* (ofi), which also experienced significant increase in output.

On the side sector mining raw (oxt and coa), policy downstreaming precisely cause a significant decline in export output, however offset by an increase request strong domestic from sector industry downstream. Conditions This confirm East Asia Forum (2023) argument that restrictions raw mineral exports of course sacrificing producer surplus in the sector mining

upstream, however benefits obtained by the sector downstream and economy in a way overall Far beyond losses in the sector upstream.

Impact to Chance Work Sectoral

Table 6 presents the five sectors with improvement chance Work highest as impact from policy downstreaming of Indonesian minerals and coal. In accordance with classification in the GTAP model, power Work differentiated become power Work skilled *labor* and manpower Work No unskilled *labor*.

Table 6. Five Sectors with Improvement Chance Work Highest consequence Policy Downstream (Percent)

Commodity	Sim 01 Unskilled (%)	Sim 01 Skilled (%)	Sim 02 Unskilled (%)	Sim 02 Skilled (%)
nfm (Non-Ferrous Metals)	4,791	4,863	11,682	11,795
i_s (Ferrous Metals)	3,712	3,798	8.871	8.982
fmp (Metal Products)	2.621	2.694	6.383	6.467
p_c (Petroleum & Coal Prod.)	1.601	1.648	3.943	4.021
cns (Construction)	0.819	0.843	1.849	1.896

Source: GTAP version 10 Database, processed.

Simulation results show that policy downstreaming in a way consistent push improvement chance work in sectors industry downstream minerals, especially in the sector *Non-Ferrous Metals* and *Ferrous Metals*. In the Non-Ferrous Metals sector, the workforce Work No unskilled *labor* increases of 4.791% in Simulation 1 and 11.682% in Simulation 2, while power Work skilled *labor* increases by 4.863% and 11.795% respectively. This pattern show that industrialization downstream minerals not only create field Work in amount big, but also encouraging improvement quality power Work through more requests tall to *skilled labor*.

In a way Empirically, data from the Ministry of Energy and Mineral Resources (2024) shows that realization power work in the sector Indonesia's mining sector in 2023 reached 308,107 Indonesian migrant workers, which is number highest throughout history, driven by expansion investment in the sector mineral downstreaming. Surge investment foreign direct investment (FDI) which is partly big aimed at the construction of an estimated smelter create around 47,000 fields Work new from projects *greenfield* that has been announced (Lowy Institute, 2025). In GTAP model framework, increasing output in a sector in a way direct push improvement request power work in the sector mentioned, as stated by Stephan & Ademayowa (2015) that the more tall products produced so the more Lots chance work required.

Impact Policy Downstream towards Indonesia's Main Trading Partners

Policy downstreaming of Indonesian minerals and coal is not only impact on the economy domestic, but also deliver significant impact to partners trade the main thing that has been This import raw minerals from Indonesia. Table 7 presents change partner welfare trade Indonesia's main impact policy downstreaming.

Table 7. Impact Policy Indonesia's downstreaming of Major Trading Partners' Welfare (EV, USD Million)

Country / Region	Sim 01 – EV (USD Million)	Sim 02 – EV (USD Million)
Indonesia	+1,842.50	+4,763.20
China (CHN)	-812.40	-1,984.70
Japan (JPN)	-321.90	-763.20
South Korea (KOR)	-218.60	-512.40
India (IND)	-143.20	-341.80
European Union (EU)	-98.40	-231.60
United States of America (USA)	-76.10	-183.40
Rest of World (ROW)	-172.30	-414.70

Source: GTAP version 10 Database, processed.

Simulation results show that Indonesia's downstreaming policy creates a global welfare redistribution effect: Indonesia experiences significant welfare gains, while trading partners that have historically relied on raw mineral imports from Indonesia experience welfare losses. China is the most impacted country, with a welfare loss of USD 812.40 million in Simulation 1 and USD 1,984.70 million in Simulation 2. This is consistent with the fact that prior to the 2014 nickel export ban, Indonesia supplied approximately 50% of China's nickel ore import needs (Ember Energy, 2025). Chinese firms, major players in the downstream nickel industry, had no choice but to establish or expand their operations in Indonesia to secure access to nickel resources (East Asia Forum, 2023).

Japan and South Korea also experienced significant welfare losses, as both countries are major importers of nickel-based metal products and coal from Indonesia for their steel and manufacturing industries. Meanwhile, the European Union and the United States experienced smaller, but still negative, impacts, reflecting the dependence of their automotive and manufacturing industries on critical mineral supplies from Indonesia. This situation places Indonesia in a strong strategic position in international trade negotiations related to critical minerals, which are increasingly important as the global energy transition accelerates and demand for minerals supporting electric vehicles increases.

Conclusion

Based on the analysis using the GTAP version 10 database model, it can be concluded that Indonesia's mineral and coal downstreaming policy has had a significant positive impact on the country's macroeconomic and sectoral economy. Macroeconomic variables predicted to increase include: real GDP (0.2150% in Sim 01 and 0.5312% in Sim 02), aggregate welfare (USD 1,842.50 million and USD 4,763.20 million), household consumption, government spending, investment, and terms of trade. The largest increase occurred in the investment variable, reflecting the tangible effect of the raw mineral export ban policy on attracting foreign direct investment to Indonesia's downstream industrial sector.

From a sectoral perspective, the downstreaming policy has driven a significant increase in output in the Non-Ferrous Metals (NFM) and Ferrous Metals (ISM) sectors, which include processed nickel, ferronickel, and stainless steel products, followed by Metal Products, Electronics, and Petroleum & Coal Products. This sectoral output increase directly drives employment opportunities, for both skilled and unskilled workers. The Non-Ferrous Metals

sector recorded the highest employment increase, reaching 11.795% for skilled labor in Simulation 2.

However, the downstreaming policy also poses several challenges that must be anticipated. Indonesia's trade balance is predicted to experience a short-term deficit due to a surge in imports of capital goods for smelter infrastructure development. Furthermore, Indonesia's major trading partners, particularly China, Japan, and South Korea, are experiencing substantial welfare losses, which could trigger diplomatic pressure and trade disputes. Therefore, accelerating downstreaming needs to be balanced with a proactive economic diplomacy strategy, diversifying downstream product export markets, and strengthening domestic industrial capacity to maximize the domestic benefits of this policy.

Policy Rekomendations

Based on findings research, some recommendation policy can formulated as following. First, the government need speed up implementation policy downstreaming in a way comprehensive (95% scenario) because impact the positive on GDP, well-being, and opportunities Work Far more big compared to scenario partial (50%). Acceleration This need provision infrastructure adequate energy specifically energy renewable For avoid dependence excess on coal as source smelter energy that can increase cost carbon term long.

Second, to overcome deficit balance sheet trading term short consequence surge import capital goods, government need push substitution import machinery and equipment mining through development industry manufacturing machine domestic. Third, Indonesia needs in a way active do diversification of export markets product downstream minerals from dependence excess in China towards markets in Europe, the United States, and industrial countries others who have critical mineral needs For transition energy they. Fourth, the government need strengthen governance framework downstreaming through structured technology transfer, mastery industry by entity domestic in a way gradual, and implementation standard strict environmental and social regulations to avoid risk downstreaming which only benefit foreign investors.

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