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ECONOMIC VALUE CREATION FROM NICKEL DOWNSTREAM PROCESSING IN INDONESIA: EVIDENCE FROM INPUT–OUTPUT AND EMPIRICAL VALUE-ADDED ESTIMATION

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Abstract
Indonesia has promoted nickel downstream industrialization to enhance structural transformation and increase domestic value creation. As the world's largest nickel producer, the country aims to shift from raw ore exports toward processed products to capture greater economic benefits. However, quantitative evidence on the magnitude of value added at both sectoral and product levels remains limited. This study measures the economic value added of nickel downstream processing using a dual approach. First, an input–output analysis evaluates backward linkages, forward linkages, and value-added multipliers across nickel-related sectors. Second, empirical calculations estimate value added from processing nickel ore into Nickel Pig Iron (NPI) and nickel matte. The results show that the non-ferrous basic metal industry functions as a key sector, with linkage indices above unity and the highest value-added multiplier (2.696). At the product level, NPI generates a value added of US$ 794.40 per ton (109% increase over raw ore equivalent), while nickel matte generates US$ 868.36 per ton (11% increase). These findings confirm that downstream processing enhances economic value, although gains vary across products, underscoring the importance of strategic product prioritization.
Keywords: Downstream; Nickel; Value Added

INTRODUCTION

Indonesia is projected to become one of the world's major economic powers in the coming decades. Long-term projections based on purchasing power parity indicate that Indonesia may rank among the largest global economies by 2050 (Hawksworth et al., 2017), while earlier estimates positioned Indonesia as the seventh largest economy by 2030 (Oberman et al., 2012). Achieving this ambition requires sustained economic growth supported by structural transformation rather than continued dependence on primary commodity exports. Despite strong resource endowments, Indonesia's economic growth averaged only 5.2 percent during 2000–2019, below the level required to accelerate development (Bappenas, 2019).

Nickel has emerged as a strategically important commodity in this transformation process. Indonesia is the world's largest nickel producer, contributing approximately 37 percent of global supply in 2021 (U.S. Geological Survey, 2022). The rapid expansion of electric vehicles, renewable energy storage systems, and electronic industries has significantly increased global nickel demand (Azim et al., 2021). The transition toward clean energy systems under global net-zero emission commitments further strengthens nickel's role within future industrial supply chains (United Nations, n.d.). These developments position Indonesia as a central actor in the global battery and green technology economy.

Historically, however, Indonesia exported nickel largely in raw ore form, limiting domestic economic benefits and value creation *(Sabowo & Siswanto, 2023)*. Resource-exporting economies often face similar challenges, where reliance on raw material exports generates relatively low value added compared to downstream industrial processing. To address this issue, the Indonesian government introduced downstream industrialization policies requiring domestic processing and refining of mineral resources under Law No. 3 of 2020 concerning Mineral and Coal Mining. One key instrument of this policy was the prohibition of raw nickel ore exports, first implemented in 2014, temporarily relaxed in 2017 due to industrial readiness constraints (Ika, 2017), and fully reinstated in 2020.

While the nickel export ban has attracted considerable academic and policy debate, existing discussions primarily emphasize legal disputes, trade policy implications, or macroeconomic performance. Internationally, the policy generated tensions within global trade governance, while domestically it faced resistance from local mining stakeholders concerned about declining short-term profitability following accelerated policy implementation *(Agustinus & Azizah, 2019)*. Empirical studies generally highlight increased investment inflows and manufacturing expansion associated with downstream industrialization *(Agung & Adi, 2022; Siombo, 2023)*, as well as stronger economic contributions from manufacturing exports compared to mining exports (Asbiantari et al., 2016).

Despite this growing literature, limited research quantitatively measures the magnitude of economic value added generated by specific nickel processing products. Most analyses treat downstream industrialization outcomes at an aggregate macroeconomic level, leaving an important gap regarding how much additional value is created when nickel ore is transformed into processed products. Understanding product-level value creation is essential for evaluating whether downstream industrialization policies genuinely enhance national economic welfare.

Therefore, this study focuses on measuring the economic value added generated through downstream nickel processing in Indonesia. By comparing raw nickel ore with processed products, particularly Nickel Pig Iron (NPI) and nickel matte, this research evaluates how industrial processing contributes to value creation and structural economic upgrading.

LITERATURE REVIEW

Nickel Resources and Types of Nickel Ore

Nickel is a strategic mineral resource widely used in stainless steel production, rechargeable batteries, and various advanced manufacturing industries. Global nickel resources are estimated at approximately 300 million tons, consisting of two main geological types: laterite nickel ore and sulfide nickel ore (U.S. Geological Survey, 2022). These two ore types differ significantly in formation processes, mineral characteristics, extraction methods, and processing technologies.

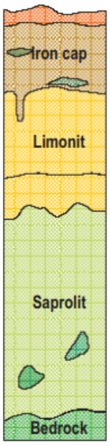
Table 1. Comparative Characteristics of Sulfide and Laterite Nickel Deposits

Nickel Sulfide	Nickel Laterite
1. Formed through mineral precipitation and segregation processes occurring in magma chambers or lava flows. 2. Classified as high-grade nickel, with nickel content ranging from 0.15–8%. 3. Found at depths of hundreds of meters below the ground surface; therefore, the mining cost of this type of nickel is relatively higher.	1. Formed through the weathering process of ultramafic rocks in tropical and subtropical regions. 2. Classified as low-grade nickel, with nickel content ranging from approximately 1–1.6%. 3. Found at relatively shallow depths, around 15–20 meters below the ground surface; therefore, mining costs are relatively lower. 4. Requires higher energy in production and processing.

Source : Siregar (2017) and Mudd (2009)

Indonesia's nickel resources are dominated by laterite-type deposits distributed across Sulawesi, Halmahera, and Papua. These deposits occur in stratified profiles, as illustrated in Figure 1.

Figure 1. Illustration of Laterite Nickel Deposits and Their Processing Pathways



Komposisi – %brt.					Metode Ekstrasi
Ni	Co	Fe	Cr_2O_3	MgO	
<0,8	<0,1	>50	>1	<0,5	*Overburden*
0,8 s/d 1,5	0,1 s/d 0,2	40 s/d 50	2 s/d 5	0,5 s/d 5	Hidrometalurgi
1,5 s/d 1,7		25 s/d 40		5 s/d 15	Hidrometalurgi / Pirometalurgi
1,7 s/d 3	0,02 s/d 0,1	10 s/d 25	1 s/d 2	15 s/d 35	Pirometalurgi
0,25	<0,02	5	<1	>35	Tidak diproses

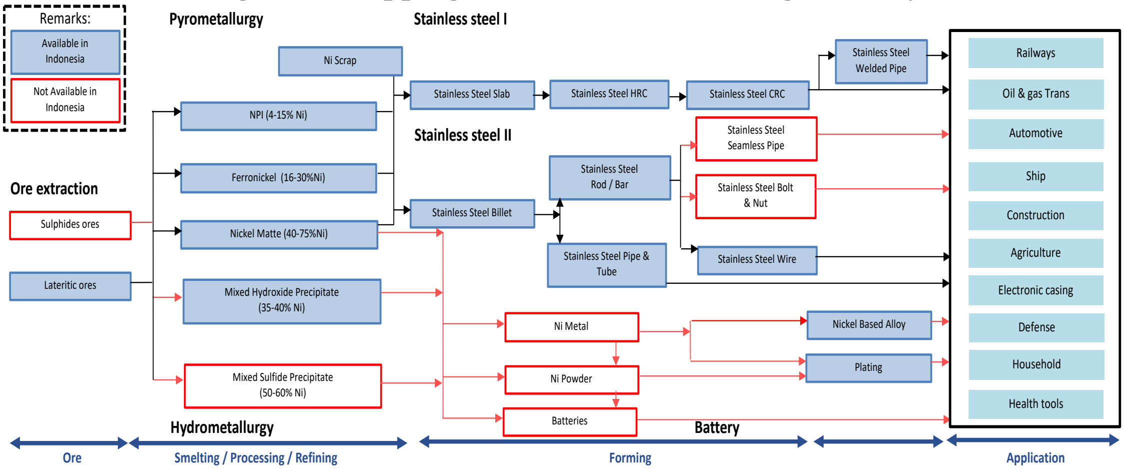
Source: Direktorat Jenderal Mineral dan Batubara (2021)

Laterite nickel deposits typically consist of several stratigraphic layers, namely the iron cap, limonite, saprolite, and bedrock. Among these layers, only limonite and saprolite ores are economically viable for further processing. Saprolite ore generally contains higher nickel concentrations, ranging from approximately 1.7% to 3%. In contrast, limonite ore contains relatively lower nickel grades, typically between 0.8% and 1.7%. Variations in nickel grade and mineralogical composition significantly influence the selection of extraction and processing methods. Specifically, limonite ores are commonly processed using hydrometallurgical methods, whereas saprolite ores are more frequently treated through pyrometallurgical routes. Consequently, differences in ore characteristics play a critical role in determining the technological pathway, energy requirements, and overall value-added potential within the nickel processing industry.

Nickel Processing Industry and Industrial Structure

The nickel value chain consists of sequential stages beginning with mining extraction, followed by smelting or refining, intermediate product formation, and final industrial applications. The development of downstream industries depends largely on available processing technologies and industrial investment capacity.

Figure 2. Mapping of the Nickel Processing Industry



Source: Direktorat Jenderal Mineral dan Batubara (2021)

As illustrated in Figure 2, the processing of nickel ore is carried out through two principal methods, namely pyrometallurgy and hydrometallurgy. Pyrometallurgical processing, which dominates Indonesia's current industrial structure, produces intermediate products such as Nickel Pig Iron (NPI), ferronickel, and nickel matte. These products are primarily used as inputs for stainless steel manufacturing. Hydrometallurgical processing, on the other hand, produces Mixed Hydroxide Precipitate (MHP) and Mixed Sulphide Precipitate (MSP), which serve as key raw materials for electric vehicle battery production.

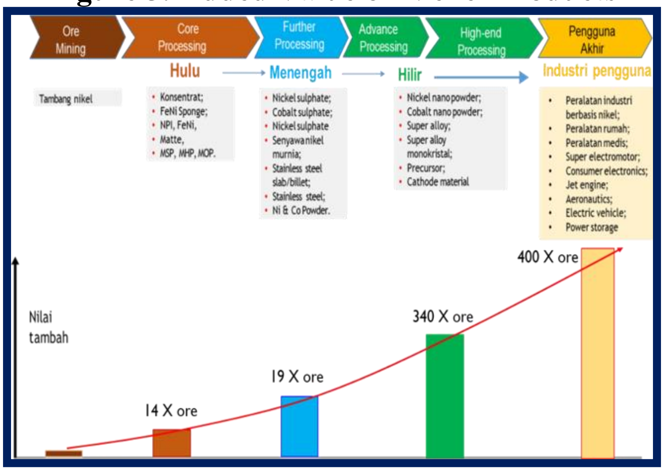
The industrial map of nickel processing in Indonesia demonstrates rapid expansion following downstream industrialization policies. By 2021, Indonesia's total nickel processing capacity reached approximately 90 million tons of ore input annually, supported by the development of multiple smelting facilities (Direktorat Jenderal Mineral dan Batubara, 2021). Despite this expansion, industrial activities remain heavily concentrated in stainless steel-oriented production using pyrometallurgical technology, while battery-related processing industries are still in a developmental phase.

Global nickel demand remains dominated by stainless steel production, accounting for the majority of consumption. However, demand from battery industries is projected to grow significantly alongside the global transition toward electric mobility and renewable energy systems. This structural shift increases the importance of downstream processing capabilities in determining future economic value creation.

Economic Value Added and Nickel Product Transformation

Value added represents a fundamental concept in evaluating industrial economic performance. In production economics, value added is defined as the difference between the value of output produced and the value of intermediate inputs used in the production process (Krugman et al., 2022; Mankiw, 2018). Furthermore, (Sorga et al., 2014) define value added as the incremental value of a product resulting from processing, transportation, or storage activities within a production system. Value added can be examined from two perspectives: value added in processing and value added in marketing. The determinants of processing value added can be categorized into technical factors and market factors. Technical factors include production capacity and the quantity of raw materials utilized. Market factors, on the other hand, comprise the output price, raw material price, and the cost of other inputs. The magnitude of processing value added is calculated by subtracting the cost of raw materials and other non-labor inputs from the value of the final product generated.

Figure 3. Added Value of Nickel Products



Source: Direktorat Jenderal Industri Logam Mesin Alat Transportasi dan Elektronika (2023)

Nickel downstream industrialization is expected to generate value added through processing activities. According to the Directorate General of Metal, Machinery, Transportation Equipment, and Electronics Industries of the Ministry of Industry, the value added generated from processing nickel ore into intermediate products, such as Nickel Pig Iron (NPI), ferronickel, nickel matte, Mixed Hydroxide Precipitate (MHP), and Mixed Sulfide Precipitate (MSP), is estimated to reach up to fourteen times the value of the raw nickel ore. These products are generally classified as upstream processed products, commonly referred to as core processing (see Figure 3).

METHODS

This study employs a two-stage analytical framework combining macro-level input–output analysis and micro-level empirical value-added estimation to assess the economic impact of nickel downstream industrialization. The first approach utilizes Indonesia's national input–output table to evaluate the structural linkages of nickel-related sectors.

Intersectoral relationships are measured using backward and forward linkage indices based on the Hirschman–Rasmussen method. Backward linkage reflects the degree to which a sector relies on inputs from upstream industries, while forward linkage measures the extent to which a sector supplies outputs to downstream sectors (Sukma et al., 2018). A sector is categorized as a key or leading sector when both linkage indices exceed unity, indicating above-average intersectoral integration *(Miller & Blair, 2009)* .

To capture broader economic effects, output and value-added multipliers are estimated using the Leontief Inverse Matrix. This matrix illustrates the total direct and indirect output required from each industry to produce one monetary unit of goods or services for final demand (Claus, 2009). Linkage analysis identifies structural interdependence between sectors, whereas multiplier analysis quantifies the cumulative magnitude of economic effects generated across the entire production system. This distinction allows the study to evaluate not only structural positioning but also the intensity of economic spillovers from nickel-related industries.

To complement the macro-structural analysis, the study conducts product-level value-added calculations for Nickel Pig Iron (NPI) and nickel matte. Value added is estimated by comparing the export value of processed products with the cost of raw nickel ore required in their production. Gross processing value added is calculated as:

$$Value\ Added = P_{product} - (Q_{ore} \times P_{ore})$$

Where $P_{product}$ represents the export price per ton of processed nickel product, Q_{ore} denotes the quantity of nickel ore required to produce one ton of output, and P_{ore} refers to the official benchmark price of nickel ore. Percentage value-added growth is further calculated by comparing processed export value with the hypothetical export value of equivalent raw ore inputs. This approach captures direct transformation value added from industrial processing. Although it does not incorporate additional production costs such as energy, labor, capital, or logistics, it provides a clear and comparable measure of economic upgrading resulting from downstream processing activities.

RESULT AND DISCUSSION

Backward and Forward Linkages and the Value-Added Multiplier Effects in the Nickel Industry

Using Indonesia's national input–output framework, this study evaluates the intersectoral linkage effects of nickel-related industries. The analysis focuses on three key indicators: the Backward Linkage Index (BLI), the Forward Linkage Index (FLI), and the Value-Added Multiplier (VAM).

Table 2. Estimated Backward and Forward Linkage Indices and Value-Added Multiplier Results

No	Sector	BLI	FLI	VAM
044	Nickel Ore Mining	0,945	0,726	1,525
114	Basic Iron and Steel Industry	1,127	0,880	2,199
115	Non-Ferrous Basic Metal Industry	1,193	1,078	2,696

116	Metal Casting Products Industry	1,175	0,781	2,437
120	Other Fabricated Metal Products Industry	1,052	1.005	1,963
125	Battery and Accumulator Manufacturing Industry	1,058	0,922	1,968

Source: Author's Processed Results

Based on the input–output calculations across nickel-related sectors, the non-ferrous basic metal industry emerges as a leading or driving sector within Indonesia's industrial structure (see Table 2). This classification is supported by both the Backward Linkage Index (BLI) and the Forward Linkage Index (FLI) exceeding unity. An index value above one indicates that the sector has stronger-than-average intersectoral linkages, both in terms of absorbing intermediate inputs from upstream industries and supplying outputs to downstream sectors. In other words, the non-ferrous basic metal sector demonstrates a substantial capacity to stimulate economic activity across the production network.

Similarly, the other fabricated metal products sector can also be categorized as a driving sector due to its relatively strong linkage performance. In contrast, the nickel ore mining sector records both BLI and FLI values below one, indicating limited intersectoral integration. This suggests that upstream nickel extraction activities have relatively weak capability to generate spillover effects, either through upstream input demand or downstream industrial utilization.

Several other downstream sectors such as basic iron and steel, metal casting products, and battery manufacturing display BLI values above one but FLI values below one. This pattern indicates strong demand for intermediate inputs from upstream industries, although their outputs are less intensively utilized by other sectors. These sectors remain economically promising, particularly due to their capacity to stimulate supplier industries. Their expansion has the potential to strengthen upstream production networks and increase domestic industrial depth.

Overall, the results confirm that downstream nickel processing industries, particularly the non-ferrous basic metal sector, possess stronger structural economic influence compared to upstream nickel mining. This finding supports the economic rationale for downstream industrialization, as expanding processing activities is more likely to generate broader production linkages and enhance domestic value creation.

Beyond linkage indicators, sectoral value-added multipliers provide additional insight into economy-wide effects. The non-ferrous basic metal sector records the highest value-added multiplier at 2.696. This implies that a one-million rupiah increase in final demand for this sector generates an additional 2.696 million rupiah in total value added across the economy. In comparison, the nickel ore sector exhibits the lowest multiplier value at approximately 1,5, reflecting its relatively limited contribution to aggregate value creation. Other downstream sectors, including metal casting products and basic iron and steel industries, also demonstrate relatively high multiplier values (at least 2), further reinforcing the conclusion that processed metal industries yield stronger economic spillovers than raw mineral extraction.

Taken together, these findings indicate that downstream industrial development, particularly within the non-ferrous basic metal sector, serves as a key mechanism for enhancing national value added. The structural superiority of processing industries over upstream mining activities provides empirical support for policies aimed at promoting nickel downstream industrialization. In line with Pratama (2025), who shows that the government's nickel downstream policy is a sound strategy. Since the output multiplier of the manufacturing sector is higher than that of mining and quarrying, downstream industrialization is likely to generate greater domestic output than relying solely on upstream extraction.

Value Added of Nickel Pig Iron

Behre Dolbear Australia, acting as an independent technical expert for PT Merdeka Battery Materials Tbk, reported the production performance results of the Nickel Pig Iron (NPI) plant as presented in Table 3.

Table 3. NPI Production Performance at PT. Merdeka Battery Materials Tbk

Parameters	Unit	Plant A	Plant B
Saprolite Nickel Ore Ni 1,8% ; Moisture Content 35%	kt (wet)	1.927	1.837,8
Nickel Pig Iron (NPI) Output	kt	154	139,4
Wet Nickel Ore Input Requirement per Ton of NPI (13% Ni)	ton	12,51	13,18
Average Wet Nickel Ore Input per Ton of NPI	ton	12,8	

Source: Behre Dolbear Australia (2023)

Based on the data, the average consumption of raw material in the form of wet nickel ore required to produce one ton of Nickel Pig Iron (NPI) is estimated at 12.8 tons.

The calculation of raw material costs and product value is based on reference prices obtained from several sources. According to the 2022 Mineral Reference Price (Harga Patokan Mineral/HPM) issued by the Ministry of Energy and Mineral Resources and cited by (Media Nikel Indonesia, 2022), the average price of nickel ore with a grade of 1.8% Ni and 35% moisture content was US$ 56.43 per ton. Furthermore, based on Indonesia's NPI export data reported by ITC Trade Map (2023), the average export price of NPI was US$ 1,516.70 per ton.

Table 4. Calculation of Value Added in Nickel Pig Iron (NPI) Production

Product	Quantity (tons)	Price (US$/ton)	Total (US$)
Ni 1,8 % (*Moisture Content* 35%)	1	56,43	56,43
NPI (13-20% Ni)	1	1.516,70	1.516,70
Nickel Input Cost per Ton of NPI	12,8	56,43	722,30
Value Added			794,40
Percentage Growth in Value Added			109%

Source: Author's Processed Results

The simulation results indicate that the value added generated from producing one ton of NPI from its original raw material amounts to US$ 794.40 (see Table 4). This figure is obtained by subtracting the raw material cost of US$ 722.30 from the NPI product value of US$ 1,516.70. In other words, if the material were exported in its original form as nickel ore, it would generate foreign exchange earnings of only US$ 722,30 per ton. However, when exported in the form of NPI, it would generate US$ 1.516,70 per ton, representing an increase of approximately 109%.

Value Added of Nickel Matte

Based on the input–output production capacity of nickel matte at PT Vale Indonesia, it is estimated that 137,54 tons of nickel ore are required to produce one ton of nickel matte (Direktorat Jenderal Mineral dan Batubara, 2021). Furthermore, the highest product value of nickel matte, based on historical export data, was recorded at US$ 8.630,53 per ton (ITC Trade Map, n.d.).

Table 5. Calculation of Value Added in Nickel Matte Production

Product	Quantity (ton)	Price (US$/ton)	Total (US$)
Ni 1,8 % (*Moisture Content* 35%)	1	56,43	56,43
Nickel Matte	1	8.630,53	8.630,53
Nickel Input Cost per Ton of Nickel Matte	137,54	56,43	7.762,17
Value Added			868,36
Percentage Growth in Value Added			11%

Source: Author's Processed Results

The simulation results indicate that the value added generated from producing one ton of nickel matte from its original raw material amounts to US$ 868.36 (see Table 5). This figure is obtained by subtracting the raw material cost of US$ 7,762.17 from the nickel matte product value of US$ 8,630.53. In other words, if the material were exported in its original form as nickel ore, it would generate foreign exchange earnings of only US$ 7,762.17 per ton. However, when exported in the form of nickel matte, it would generate US$ 8,630.53 per ton, representing an increase of approximately 11%.

The estimated value-added calculations for downstream nickel products namely Nickel Pig Iron (NPI) and nickel matte indicate that both products generate higher value added compared to their primary raw material, nickel ore. The estimated value-added increases amount to approximately 109% for NPI and 11% for nickel matte, respectively. These findings provide a more moderate estimate compared to the claim made by the Direktorat Jenderal Industri Logam Mesin Alat Transportasi dan Elektronika (2023), which suggested that NPI and nickel matte could generate value added up to fourteen times the value of nickel ore. The present calculation indicates that while downstream processing does generate additional value, the magnitude of the increase is considerably lower than previously asserted. Nevertheless, even this level of value addition may contribute to broader macroeconomic effects, including employment creation, capital inflows, and foreign exchange earnings. Such effects are not fully captured by the direct value-added calculation but may materialize through intersectoral linkages and multiplier mechanisms.

An important additional finding is that, in relative terms, NPI exhibits a higher percentage increase in value added compared to nickel matte. Although nickel matte commands a higher unit price in international markets, its production requires substantially larger quantities of nickel ore. The increase in output value does not proportionally compensate for the significantly higher raw material input requirement. These results suggest that downstream industrialization policies should be accompanied by careful economic assessments of product-level profitability and input–output efficiency. Accordingly, nickel downstream strategies may yield greater economic benefits when directed toward processed or final products that demonstrate stronger value-added performance relative to their raw material base.

CONCLUSION

Based on the results and discussion of this study, several conclusions can be drawn. First, the downstream segment of the nickel industry demonstrates strong potential as a key driving sector within the economy and generates higher value added compared to the upstream sector. This is evidenced by the Backward Linkage Index (BLI) and Forward Linkage Index (FLI) of the non-ferrous basic metals sector, both of which exceed unity. Moreover, among sectors associated with the nickel industry, this sector exhibits the largest value-added multiplier effect, with a coefficient of 2.696. These findings indicate that downstream nickel processing activities possess significant capacity to stimulate broader economic activity through intersectoral linkages.

Second, at the product level, processed nickel products such as Nickel Pig Iron (NPI) and nickel matte also generate positive value-added effects relative to raw nickel ore exports. NPI production yields a value added of US$ 794.40 per ton, representing a 109% increase compared to exporting an equivalent quantity of nickel ore required to produce one ton of NPI. Meanwhile, nickel matte production generates a value added of US$ 868.36 per ton, corresponding to an 11% increase relative to exporting the equivalent quantity of nickel ore required to produce one ton of nickel matte.

REFERENCES

Agung, M., & Adi, E. A. W. (2022). Peningkatan Investasi Dan Hilirisasi Nikel Di Indonesia. JISIP (Jurnal Ilmu Sosial Dan Pendidikan), 6(2). https://doi.org/10.58258/jisip.v6i2.3085

Agustinus, M., & Azizah, N. N. (2019, August 11). Larangan Ekspor Nikel: Penambang Menolak, Pengusaha Smelter Mendukung. https://kumparan.com/kumparanbisnis/larangan-ekspor-nikel-penambang-menolak-pengusaha-smelter-mendukung-1riifHijpnz/full

Asbiantari, D. R., Parulian Hutagaol, M., & Asmara, A. (2016). Pengaruh Ekspor Terhadap Pertumbuhan Ekonomi Indonesia (Effect of Export on Indonesian's Economic Growth). Jurnal Ekonomi Dan Kebijakan Pembangunan, 5(2), 10–31. https://doi.org/https://doi.org/10.29244/jekp.5.2.2016.10-31

Azim, F., Lionardo, A., & Rivai, F. (2021). UPAYA PENINGKATAN NILAI KOMPETITIF PRODUK NIKEL INDONESIA MELALUI PERATURAN MENTERI ENERGI DAN SUMBER DAYA MINERAL NO 11 TAHUN 2019 [Sriwijaya University]. https://repository.unsri.ac.id/51992/59/RAMA_84201_07041281722076_0001057901_0011048903_01_front_ref.pdf

Bappenas. (2019). Indonesia 2045 : Berdaulat, Maju, Adil, dan Makmur. https://perpustakaan.bappenas.go.id/e-library/file_upload/koleksi/migrasi-data-publikasi/file/Policy_Paper/Ringkasan%20Eksekutif%20Visi%20Indonesia%202045_Final.pdf

Behre Dolbear Australia. (2023). KAJIAN TEKNIS INDEPENDEN ASET NIKEL MERDEKA BATTERY MATERIALS – SULAWESI TENGGARA, INDONESIA. https://assets.merdekabattery.com/dist/documents/Initial%20Public%20Offering%20Prospectus%20MBMA%202023%20-%20Final.pdf

Claus, I. (2009). New Zealand's economic reforms and changes in production structure. Journal of Economic Policy Reform, 12(2), 133–143. https://doi.org/10.1080/17487870902872938

Direktorat Jenderal Industri Logam Mesin Alat Transportasi dan Elektronika. (2023). FGD - Strategi dan Progress Hilirisasi Industri Berbasis SDA [PowerPoint slides].

Direktorat Jenderal Mineral dan Batubara. (2021). Grand Strategy Mineral dan Batubara : Arah Pengembangan Hulu Hilir Mineral Utama dan Batubara Menuju Indonesia Maju. https://www.esdm.go.id/assets/media/content/content-buku-grand-strategy-komoditas-minerba.pdf

Hawksworth, J., Clarry, R., & Audino, H. (2017). The Long View How will the global economic order change by 2050? https://www.pwc.com/gx/en/world-2050/assets/pwc-the-world-in-2050-full-report-feb-2017.pdf

Ika, S. (2017). Kebijakan Hilirisasi Mineral : Policy Reform untuk Meningkatkan Penerimaan Negara. Kajian Ekonomi Dan Keuangan, 1(1), 42–67. https://doi.org/10.31685/kek.v1i1.259

ITC Trade Map. (n.d.). Trade statistics for international business development Monthly, quarterly and yearly trade data. Import & export values, volumes, growth rates, market shares, etc. Retrieved May 19, 2023, from https://www.trademap.org

Krugman, P. R., Obstfeld, M., & Melitz, M. J. (2022). International Economics Theory and Policy (12th ed.). Pearson Education.

Mankiw, N. G. (2018). Macroeconomics (C. Woods, Ed.; 9th ed., Vol. 10). Worth Publishers.

Media Nikel Indonesia. (2022, December 27). Refleksi HPM Nikel 2022: Dari Tragedi Big Short hingga Perhitungan Normal | Media Nikel Indonesia. https://nikel.co.id/2022/12/27/refleksi-hpm-nikel-2022-dari-tragedi-big-short-hingga-perhitungan-normal/

Miller, R. E., & Blair, P. D. (2009). Input-Output Analysis. Cambridge University Press. https://doi.org/10.1017/CBO9780511626982

Mudd, G. M. (2009). Nickel sulfide versus laterite: the hard sustainability challenge remains. Proceedings of the 48th Conference of Metallurgists, 23–26.

Oberman, R., Richard, D., Arief, B., Fraser, T., & Rossé, M. (2012). The archipelago economy: Unleashing Indonesia's potential. www.mckinsey.com/mgi.

Pratama, K. A. (2025). ANALYSIS OF THE IMPACT OF INCREASING THE VALUE OF FERRONICKEL EXPORTS ON DOMESTIC INDUSTRY AND IMPORTS USING THE 2016 INDONESIAN INPUT-OUTPUT TABLE. Journal of Economic, Bussines and Accounting (COSTING), 8(2), 1193–1200. https://doi.org/10.31539/costing.v8i2.14007

Sabowo, H. K., & Siswanto, B. (2023). Legal Aspects of the Export Prohibition of Raw Nickel Related to Increasing Hilirization in Indonesia. In International Conference On Law, Economics, and Health (ICLEH 2022) (pp. 733–743). https://doi.org/10.2991/978-2-38476-024-4_74

Siombo, M. R. (2023). Kajian Hukum Hilirisasi dan Penghentian Ekspor Mineral Logam. JISIP (Jurnal Ilmu Sosial Dan Pendidikan), 7(2). https://doi.org/http://dx.doi.org/10.58258/jisip.v7i2.4915

Siregar, N. K. (2017). Ekstraksi nikel laterit soroako menggunakan asam sulfat. https://dspace.uii.ac.id/bitstream/handle/123456789/27728/13612041%20Nida%20Khoirina%20Siregar.pdf?sequence=1&isAllowed=y

Sorga, S., Darus, H. M. M. B., & Ayu, S. F. (2014). Analisis Komparasi Nilai Tambah dalam Berbagai Produk Olahan Kedelai pada Industri Rumah Tangga Di Kota Medan. JOURNAL ON SOCIAL ECONOMIC OF AGRICULTURE AND AGRIBUSINESS, 2(12). https://www.neliti.com/publications/15171/analisis-komparasi-nilai-tambah-dalam-berbagai-produk-olahan-kedelai-pada-indust#cite

Sukma, M., Hartono, D., & Prihawantoro, S. (2018). The Impacts Analysis of Creative-Products Export on the Economy. JEJAK, 11(1), 92–107. https://doi.org/10.15294/jejak.v11i1.11337

United Nations. (n.d.). For a livable climate: Net-zero commitments must be backed by credible action. Retrieved June 6, 2023, from https://www.un.org/en/climatechange/net-zero-coalition

U.S. Geological Survey. (2022). Mineral commodity summaries 2022. https://doi.org/10.3133/mcs2022