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Indonesia's Mining Industry in Global Production Networks: Linkages, Value Added, and Implications for Downstreaming

Eka Puspitawati[1*)], Azarine Shafa Fidela[2], Parulian Sihotang[3]
[1]Faculty of Economics and Business, Universitas Pertamina, Indonesia
[2]PT Indotama Seraya Artha, Indonesia
[3]School of Business, the University of Dundee, UK

*)Corresponding author: eka.p@universitaspertamina.ac.id

Abstract

Globalization has transformed the industrial structure into global integration known as the global value chain, including Indonesia's mining industry. This study examines the integration of Indonesia's mining industry into global production networks by analyzing forward and backward linkages and mining-sector value added using the Asian Development Bank Multi-Regional Input-Output database for 62 countries in 2022. This study uses an interregional input-output approach as an analytical tool The results reveal a predominantly upstream-oriented linkage pattern, indicating that Indonesia's mining industry plays an important role as an input supplier to other sectors and economies, while its integration with upstream supplier industries remains relatively limited, thus Indonesia generates substantial value added from its mining sector, reflecting its significant economic contribution. The findings suggest that Indonesia's key challenge is not simply to increase mining output, but to strengthen domestic linkages and value creation through downstream processing, technological upgrading, innovation, and domestic supplier development.

Keywords: Global Value Chain, Mining, Indonesia, Interregional Input-Output

JEL classification: F14, D57, F62

Introduction

Globalization has transformed industrial structures into globally integrated production networks known as global value chains (GVCs), enabling countries to participate in international production and trade by specializing in specific stages of production (Ahmad et al., 2018; Antimiani & Cernat, 2021; Wuri et al., 2022). In response to this transformation, Indonesia seeks to build an independent, advanced, just, and prosperous society by strengthening its economic structure through regional competitive advantages and high-quality, competitive human resources. This vision requires structural transformation, including improvements in the business environment, industrial modernization, and increased value added in the mining sector to support downstream industrial development (Ministry of Energy and Mineral Resources, 2021).

Indonesia is a country rich in natural resources, one of which is mining. In 2023 the mining and quarrying sector will have a contribution of 7.40% or 910.6 trillion rupiah. The five largest sectors that contribute to Indonesia's GDP are the processing industry sector (20.39%), the wholesale and retail trade sector (13.04%), the agriculture, forestry and fisheries sector (11.82%), the construction sector (9.59%), and the mining sector (7.40%) (BPS-Statistics Indonesia, 2023).

Indonesia's abundant mining resource reserves have an impact on Indonesia's participation in international markets. Indonesia's mining commodity reserves remain abundant, with nickel, tin, and coal possessing the largest reserves compared to copper and bauxite (CSIS, 2024). Nickel reserves reached 6.76 billion tons in 2021, although this figure dropped to 6.09 billion tons in 2022. Meanwhile, tin reserves reached 6.79 billion tons in 2020 (Indonesian Ministry of Energy and Mineral Resources, 2022). Coal reserves peaked at 6.53 billion tons in 2019.

Although Indonesia has abundant reserves of various mining commodities, many of these commodities are still exported in their raw form without significant added value. For example, Indonesia's primary mining commodity is coal, particularly thermal coal used for power generation. Most Indonesian coal is exported in its raw form. The added value generated from coal and nickel processing remains minimal, with little effort being made to convert it into higher-value products such as briquettes or coal chemicals and stainless steel (Ministry of Investment/BKPM, 2023a; Ministry of Investment/BKPM, 2023b). Dependence on exports of raw mining materials makes Indonesia vulnerable to global price fluctuations and increasingly stringent international environmental policies regarding coal use.

China is the largest importer of Indonesian nickel ore, highlighting Indonesia's significant position in the global nickel industry and its attractiveness to foreign investors. To increase domestic value added, Indonesia banned nickel ore exports to the European Union, prompting the EU to challenge the policy at the WTO in 2021 (Putra, 2022). Meanwhile, EU companies such as BASF and Eramet withdrew from nickel projects in Indonesia amid concerns over the environmental and social impacts of mining, including threats to indigenous forests (Hutt, 2024).

The Indonesian government promotes downstreaming to increase the added value and competitiveness of its mining industry. This policy represents a shift toward a more complex, value-added industrial structure (Ministry of PANRB, 2023). Through

Law No. 3 of 2020, the government restricts the export of raw mining materials (State Secretariat, 2022) and has developed smelters to process them into semi-finished products, thereby increasing their quality and added value (Ika, 2017).

The global value chain is a network of stages in the production of goods and services from product design to distribution of goods to final consumers which are produced and assembled in various countries (across international borders) (Wuri *et al*., 2022; Ahmad *et al*., 2019; Antimiani & Cernat, 2021). In the research of Wuri *et al*. (2022) and Ahmad *et al*., (2018) stated that the emergence of GVCs has changed international trade patterns. Production of goods involving international division of production allows countries to track the distribution of value added to international trade. Added value is the addition of value that occurs because a commodity undergoes processing, transportation and storage in one production process (Purwaningsih, 2015). GVC itself includes trade involvement or linkages, specialization and growth between countries, as well as determining how a country participates in global production networks (Osabohien *et al.*, 2024).

Despite Indonesia's increasing importance in global mineral production and its efforts to promote downstream industrialization, a critical question remains unresolved: does Indonesia's prominent position in global mining translate into stronger domestic industrial linkages and greater domestic value capture? A large volume or high value of mineral exports does not necessarily imply that a country captures a correspondingly large share of the value generated along the global production network. In the mining sector, value can be generated not only through extraction but also through upstream inputs, processing, manufacturing, logistics, business services, technology, and downstream industries. The OECD emphasizes that a value-chain perspective is therefore essential for understanding the direct and indirect linkages between mining and other sectors and for identifying opportunities for resource-rich countries to increase the benefits derived from their mineral resources (Korinek, 2020). Similarly, Trade in Value Added (TiVA) indicators distinguish between domestic and foreign value added embodied in exports and identify both backward and forward participation in GVCs, providing a more comprehensive perspective than conventional gross trade statistics (OECD, 2026). Thus, Indonesia's success in increasing mineral processing capacity and export values should not be evaluated solely from the perspective of export performance, but also in terms of how strongly mining is connected to domestic industries and how much value is ultimately retained within the Indonesian economy.

This issue is particularly important because downstreaming does not automatically guarantee broad-based domestic value creation. Theoretically, restricting exports of unprocessed minerals and expanding domestic processing capacity can encourage higher-value activities and stimulate backward linkages with domestic suppliers. However, the resulting industrial structure may still depend heavily on imported machinery, technology, intermediate inputs, foreign investment, and foreign markets. Consequently, an increase in the value of processed mineral exports may coexist with relatively limited domestic value capture or weak linkages with other domestic industries. This distinction is important in assessing Indonesia's downstreaming strategy. Recent evidence on Indonesia's nickel downstreaming, for example, suggests that downstream industrialization has generated structural transformation and stronger linkages with several supporting sectors, but has also been associated with increasing specialization and capital intensity rather than broad-based

diversification (Asyono et al., 2026). These findings indicate that the question is not simply whether Indonesia has moved from exporting raw minerals toward processed products, but where Indonesia is positioned within the wider international production network and how much domestic economic value is generated through that position.

Previous studies have examined Indonesia's mining and downstreaming from several perspectives, including export performance, industrial policy, domestic input-output linkages, and the political economy of resource-based industrialization. For instance, recent research on nickel downstreaming has assessed backward and forward linkages and value-added multipliers within Indonesia's domestic economy, while other studies have focused on the effects of downstreaming policies on nickel exports or on Indonesia's industrial transformation (Asyono et al., 2026; Harimurti et al., 2026). These studies provide important evidence regarding the domestic effects of downstreaming. However, a domestic input-output perspective alone does not fully reveal Indonesia's position within international production networks. A GVC perspective is necessary to identify how Indonesian mining is connected to foreign industries, the extent to which foreign inputs contribute to domestic production, and the extent to which Indonesian value added is embodied in production and final demand in other countries. This distinction is particularly relevant because GVC participation can occur through both backward linkages, reflecting foreign inputs embodied in domestic exports, and forward linkages, reflecting domestic value added embodied in other countries' exports and final demand (OECD, 2026).

The existing literature therefore leaves an important empirical gap. Although MRIO and TiVA-based approaches have increasingly been used to examine countries' participation in GVCs, relatively limited attention has been given to the specific position of Indonesia's mining industry within global production networks while simultaneously considering the relationship between GVC participation and domestic value capture. In particular, there is a need to move beyond measuring the size of Indonesia's mineral exports or the expansion of domestic processing and instead examine whether Indonesia's mining sector functions primarily as a supplier of upstream raw materials, an importer-dependent processing base, or an increasingly integrated source of value added for downstream industries in global markets. This issue is especially relevant in the context of Indonesia's downstreaming policy, because the ultimate objective of downstreaming is not merely to increase the value of exports but to strengthen domestic production capabilities, industrial linkages, and value creation. Therefore, the central empirical problem addressed in this study is: to what extent does Indonesia's participation in the global value chain of mining translate into domestic industrial linkages and domestic value capture?

Against this background, this study contributes to the literature in three ways. First, rather than treating mining performance primarily through gross exports or domestic production, it evaluates Indonesia's mining sector from a GVC value-added perspective, allowing the domestic and foreign components of value creation to be distinguished. Second, the study examines the Indonesian mining sector's backward and forward GVC linkages, thereby identifying whether Indonesia's participation is predominantly driven by the use of foreign inputs in its exports or by the incorporation of Indonesian value added into production and final demand abroad. Third, by using a multi-country MRIO framework for the 2022 period, the study provides an integrated assessment of Indonesia's mining position across international production networks and

relates this position to the broader objective of downstream industrialization. The analysis therefore goes beyond asking whether Indonesia exports more processed mining products and instead addresses the more fundamental development question of whether Indonesia's position in global mining enables the country to capture greater domestic value and establish stronger linkages with other sectors of the economy.

Therefore, analysis of how Indonesian mining industry position in the global value chain is important to be highlighted. This research This study aims to examine the integration of Indonesia's mining industry into global production networks by analyzing its forward and backward linkages and the value added generated by the sector. Specifically, the study compares Indonesia's mining-sector linkages with those of other economies, identifies the direction of its production linkages, and assesses the scale of value added generated by the Indonesian mining industry. The findings are used to characterize Indonesia's predominantly upstream-oriented role in international production networks and to discuss the implications for strengthening domestic linkages and value creation through mining downstreaming.

Literatures

GVC participation can be understood through the direction and intensity of value-added linkages across countries. Backward participation reflects foreign value added embodied in a country's exports, indicating the extent to which domestic production relies on imported intermediate inputs, while forward participation captures domestic value added embodied in other countries' exports, reflecting the supply of intermediate inputs to downstream production abroad (Koopman et al., 2014; Borin et al., 2021). These two dimensions provide a useful basis for interpreting a country's position in international production networks. A relatively high forward linkage combined with limited backward linkage is generally associated with an upstream position, where a country primarily supplies raw materials or intermediate inputs to subsequent stages of production. Conversely, stronger backward linkages indicate greater integration with foreign suppliers and are more characteristic of downstream or processing activities. Positions characterized by substantial backward and forward linkages may indicate deeper integration into intermediate stages of GVCs, although the extent of domestic value capture depends on how much of the production process is supported by domestic rather than foreign inputs (Borin et al., 2021; Mancini et al., 2024).

For resource-based economies, the distinction between forward and backward linkages is particularly important. Mining activities can generate forward linkages when extracted minerals are used as intermediate inputs in manufacturing and other downstream activities abroad, but this does not necessarily imply substantial domestic value capture. Stronger domestic backward linkages, in contrast, indicate that mining creates demand for locally supplied machinery, services, transportation, processing, and other intermediate inputs, thereby strengthening connections between mining and the domestic economy. Korinek (2020) emphasizes that mining should therefore be examined as a broader value chain involving direct and indirect inputs and outputs,

particularly because linkages with services and other sectors can create opportunities for resource-rich countries to capture greater economic benefits. Recent empirical evidence further shows that the form of GVC integration matters for local industrial linkages: forward integration reflects the use of mining output in foreign production, whereas backward integration reflects reliance on foreign inputs, with their effects on domestic linkages differing across mining economies (Huanqui, 2025).

This framework suggests that the assessment of Indonesia's mining position should go beyond the scale of mineral exports or the existence of downstream processing. A predominantly forward-oriented position may indicate that Indonesia remains an upstream supplier of mineral inputs to foreign industries, whereas stronger backward and forward linkages may indicate deeper integration into international production networks. However, if high backward participation is accompanied by substantial foreign input dependence, increased processing and exports may not necessarily translate into strong domestic value capture. The relevant question is therefore not simply whether Indonesia has increased its participation in mining GVCs, but whether the pattern of GVC participation has strengthened domestic industrial linkages and enabled Indonesia to capture more value from its mineral resources. This theoretical perspective provides the basis for examining Indonesia's mining sector through MRIO-based measures of forward and backward participation and domestic value added.

Methods

This research uses secondary data which is needed as a tool for Inter Regional Input-Output analysis, namely Multi Regional Input-Output Table (MRIO) for 62 Countries in 2022 from *Asian Development Bank*. Various studies use MRIO to see the position of a country among other countries in global value chains (Ervinda & Ariutama, 2022; Almazán-Gómez et al., 2023; Lee & Ishiro, 2023).

Table 1. Classification of Countries in the 2022 Input-Output Multiregional Table

No	Country	No	Country	No	Country
1	Australia	22	India	43	United States
2	Austria	23	Ireland	44	Bangladesh
3	Belgium	24	Italy	45	Malaysia
4	Bulgaria	25	Japan	46	Philippines
5	Brazil	26	Republic of Korea	47	Thailand
6	Canada	27	Lithuania	48	Viet Nam
7	Switzerland	28	Luxembourg	49	Kazakhstan
8	China	29	Latvia	50	Mongolia
9	Cyprus	30	Mexico	51	Sri Lanka
10	Czech Republic	31	Malta	52	Pakistan
11	Germany	32	Netherlands	53	Fiji
12	Denmark	33	Norway	54	Lao
13	Spain	34	Poland	55	Brunei Darussalam
14	Estonia	35	Portugal	56	Bhutan
15	Finland	36	Romania	57	Kyrgyz Republic
16	France	37	Russia	58	Cambodia

17	United Kingdom	38	Slovak Republic	59	Maldives
18	Greece	39	Slovenia	60	Nepal
19	Croatia	40	Sweden	61	Singapore
20	Hungary	41	Turkey	62	Hong Kong, China
21	Indonesia	42	Taipei,China		

Source: MRIO Asian Development Bank (2023)

The multi-regional input-output table classification for 35 sectors has been aggregated to focus on one sector, namely the mining sector. Meanwhile, the country classification continues to use 62 countries, including Indonesia, to see the relationship between the mining sector and other countries (see Table 1).

The empirical analysis follows a sequential procedure designed to link international input-output relationships with Indonesia's mining-sector value creation. *First*, the original ADB MRIO table for 2022 is organized into a 62-country × 35-sector framework. The 35 sectors are then aggregated into the mining sector as the main sector of interest, while retaining the full country dimension to preserve cross-border production relationships. The ADB MRIO is appropriate for this analysis because it provides internationally comparable input-output relationships across 62 economies and 35 industries, allowing production and value-added linkages to be traced across countries (ADB, 2023). *Second*, the intermediate transaction matrix is converted into a matrix of technical coefficients by dividing each intermediate input by the corresponding sector's total output. The Leontief inverse is the technical coefficient matrix and captures both direct and indirect production requirements. This step allows the analysis to identify not only direct linkages between mining and other sectors but also the indirect effects transmitted through the international production network. *Third*, forward and backward linkages are calculated from the resulting input-output system and normalized using the corresponding economy-wide average. The normalized indices are used to compare the strength of Indonesia's mining linkages with those of the other 61 economies. Values above one indicate linkages that are stronger than the relevant average, while values below one indicate weaker linkages.

In general, there are two concepts of linkages, namely forward linkages and backward linkages (Miller & Blair, 2022). Forward linkages reflect interactions between sectors in the sale of production results, while backward linkages reflect interactions between sectors in purchasing inputs used in the production process (Miller & Blair, 2022). Below are formulas that used in this research.

a. Spread Power Index (*Indeks Daya Penyebaran* - IDP)
   IDP for region P sector j:

$$IDP_j^P = p \frac{m_j^P}{\sum_{j=1}^{n} m_j^P + \sum_{j=1}^{n} m_j^Q} \quad (1)$$

   IDP for region Q sector j:

$$IDP_j^Q = p \frac{m_i^Q}{\sum_{j=1}^{n} m_j^P + \sum_{j=1}^{n} m_j^Q} \quad (2)$$

   Where:
   IDP_j^P = sector spread coefficient sector j region P

IDP_j^Q = coefficient of distribution of sector j region Q
m_j^P = backward linkage of sector j region P
m_j^Q = backward linkage of sector j region Q
p = matrix size

If: $IDP_j^P > 1$ = sector j region P has a strong ability to attract production growth in its upstream sector
$IDP_j^P < 1$ = sector j region P has a weak ability to attract growth in its upstream production sector

b. Sensitivity Degree Index (*Indeks Derajat Kepekaan – IDK*)

IDK for region P sector i:

$$IDK_i^P = p \frac{m_i^P}{\sum_{i=1}^{n} h_i^P + \sum_{i=1}^{n} h_i^Q} \quad (3)$$

IDK for region P sector i:

$$IDK_i^Q = p \frac{h_i^Q}{\sum_{j=1}^{n} h_i^P + \sum_{i=1}^{n} h_i^Q} \quad (4)$$

Where:
IDK_i^P = sector spread coefficient sector i region P
IDK_i^Q = sector spread coefficient sector i region Q
h_i^P = backward linkage of sector i region P
h_i^Q = backward linkage of sector i region Q
p = matrix size

If: $IDK_i^P > 1$ = sector i region P has a strong ability to attract production growth in its downstream sector
$IDK_i^P < 1$ = sector i region P has a weak ability to attract growth in its downstream production sector

The linkage analysis is interpreted as a measure of international input-output integration, rather than as a standalone measure of GVC position. This distinction is important because conventional forward and backward input-output linkages describe the strength of production relationships but do not, by themselves, identify the direction of cross-border value-added participation. Recent GVC literature distinguishes backward participation, which captures foreign value added embodied in domestic production and exports, from forward participation, which captures domestic value added embodied in production or exports of other countries (Borin et al., 2021). Moreover, established GVC-position measures distinguish upstreamness and downstreamness to identify where a country-sector is located along international production chains (Mancini et al., 2024).

Accordingly, this study uses the conventional forward and backward linkage indices to assess the strength of Indonesia's mining-sector integration with the production structure of the 62 economies, while the cross-border value-added perspective is used to interpret its GVC position. A predominantly forward-oriented pattern indicates that Indonesian mining supplies inputs to subsequent production stages abroad, whereas stronger backward participation indicates greater reliance on foreign inputs in domestic production. Two-sided participation indicates simultaneous involvement in upstream and downstream international production stages (Borin et al., 2021). This distinction enables the analysis to avoid equating strong domestic or international input-output linkages with GVC position and provides a clearer basis for assessing Indonesia's role in the global mining production network.

Value added analysis is used to determine the income earned by each country from the global value chain of the mining industry. Added value is also called compensation for production factors (Ronalia, 2021). Added value can be formulated as follows:

$$VA_i = L_i + S_i + D_i + T_i \quad (5)$$

Where:

VA_i : Value-added (million USD)
L_i : The value of mining industry wages and salaries
S_i : Surplus value of mining industry businesses
D_i : Depreciation value of the mining industry
T_i : Indirect tax value

The linkage results are connected to value-added analysis to determine whether stronger production integration is accompanied by greater domestic value creation. The value-added calculation identifies the income generated by the mining sector through compensation of employees, operating surplus, depreciation, and indirect taxes. The resulting value-added estimates are compared across the 62 economies to identify Indonesia's relative contribution to value creation in the mining-related international production network. Thus, the linkage analysis answers how Indonesia's mining sector is connected to other sectors and economies, whereas the value-added analysis answers how much economic value is generated within Indonesia from these production relationships. Combining the two dimensions makes it possible to distinguish high participation or strong linkages from effective domestic value capture, which is central to evaluating the outcomes of Indonesia's downstreaming strategy. The IO linkage analysis identifies the strength of Indonesia's production linkages, while GVC participation and positioning indicators identify the direction and location of Indonesia's mining sector within international production networks. Value-added analysis then assesses whether this position translates into domestic value capture.

Results And Discussions

Results

The dataset derived from the Asian Development Bank Multi-Regional Input-Output (ADB MRIO) 2023 table highlights the structural role of the mining industry across different national economies through two key indicators: the Spread Sensitivity (Forward Linkage) and the Spread Coefficient (Backward Linkage). Applying the classic Input-Output framework established by Rasmussen (1956) and Hirschman (1958), the Spread Sensitivity measures how much the mining sector supplies raw materials to stimulate other sectors, whereas the Spread Coefficient quantifies the sector's pull on supplier industries by purchasing intermediate goods and services (Miller & Blair, 2009).

According to the Ministry of Trade, Indonesia is the largest nickel exporting country to China (Ministry of Trade, 2024) where nickel is one of Indonesia's largest mining commodities (The Guardian, 2024). Nickel ore is one of the basic materials for making batteries for electric vehicles (CNBC Indonesia, 2024). This is an example of the Indonesian mining sector or industry as a provider of input for other sectors in other countries and in Indonesia.

Based on Table 2, the country with the highest spread sensitivity is Russia with a value of 9.20. Apart from that, there are 17 other countries that have a spread sensitivity of more than 1. These countries are Russia, China, Norway, Australia, America, India, Brazil, Kazakhstan, Indonesia, England, Malaysia, Vietnam, Canada, Poland, Brunei Darussalam, Mexico, Netherlands and Turkey. This shows that these countries have an important role in spreading their mining industry to other connected countries (Miller & Blair, 2009).

Apart from that, if analyzed based on the spread coefficient, the country that has the largest spread coefficient is Malta with a value above 1, namely 1.41. Several other countries that have a high spread coefficient are Thailand, Paris, Luxembourg, Kyrgyzstan and Vietnam. This shows that these countries have a limited role in spreading their mining industry to other connected countries.

Table 2. Sensitivity Coefficient and Mining Industry Distribution

No	Country	Spread Sensitivity	Spread Coefficient	No	Country	Spread Sensitivity	Spread Coefficient
1	Australia	3,66	0,92	32	Netherlands	1,04	0,86
2	Austria	0,76	0,98	33	Norway	3,90	0,65
3	Belgium	0,50	1,17	34	Poland	1,45	1,06
4	Bulgaria	0,64	1,10	35	Portugal	0,58	1,04
5	Brazil	3,16	0,94	36	Romania	0,74	0,87
6	Canada	1,55	0,72	37	Russia	9,20	0,86
7	Switzerland	0,55	1,08	38	Slovak	0,51	0,88
8	China	4,86	1,04	39	Slovenia	0,53	1,11
9	Cyprus	0,52	1,13	40	Sweden	0,74	0,93
10	Czech Republic	0,67	1,14	41	Turkey	1,03	0,89

11	Germany	0,59	0,91	42	Taipei, China	0,52	0,76
12	Denmark	0,91	0,68	43	United States	3,61	0,92
13	Spain	0,61	1,05	44	Bangladesh	0,75	0,59
14	Estonia	0,58	1,01	45	Malaysia	1,83	0,71
15	Finland	0,60	1,10	46	Philippines	0,86	0,75
16	France	0,66	1,26	47	Thailand	0,91	1,30
17	UK	2,15	0,95	48	Viet Nam	1,68	1,18
18	Greece	0,57	0,91	49	Kazakhstan	3,06	0,84
19	Croatia	0,53	1,00	50	Mongolia	0,94	1,16
20	Hungary	0,58	0,88	51	Sri Lanka	0,61	0,69
21	**Indonesia**	**2,97**	**0,67**	52	Pakistan	0,88	0,61
22	India	3,33	0,81	53	Fiji	0,58	0,99
23	Ireland	0,51	1,00	54	Lao	0,70	0,73
24	Italy	0,77	1,14	55	Brunei Darussalam	1,27	0,72
25	Japan	0,67	0,81	56	Bhutan	0,76	0,67
26	Republic of Korea	0,55	0,97	57	Kyrgyz Republic	0,89	1,20
27	Lithuania	0,51	0,97	58	Cambodia	0,70	0,88
28	Luxembourg	0,51	1,21	59	Maldives	0,48	0,48
29	Latvia	0,53	1,15	60	Nepal	0,62	0,65
30	Mexico	1,15	0,78	61	Singapore	0,48	0,48
31	Malta	0,51	1,41	62	Hong Kong, China	0,48	0,48

Source: MRIO Asian Development Bank (2023) (processed)

Indonesia has a low spread coefficient because it has a value below 1, namely 0.67. This shows that the Indonesian mining industry has little backward linkage. This condition is in line with the backward linkage analysis that has been carried out previously where Indonesia has small backward linkages. This means that Indonesia has not been able to increase upstream production in its mining industry. On the other hand, if we look at the distribution sensitivity, the Indonesian mining industry has a distribution sensitivity of more than 1. This is also in line with the future linkages that have been carried out, where the Indonesian mining industry can encourage the growth of mining industry production in other countries using input from Indonesian mining.

The combination of Indonesia's relatively strong forward linkage (2.97) and weak backward linkage (0.67) suggests that the country's mining sector functions predominantly as an upstream supplier within the international production network. This pattern is economically plausible for a resource-abundant economy in which mineral extraction provides essential intermediate inputs to downstream industries, while domestic mining production remains less dependent on a broad network of domestically supplied intermediate inputs. In other words, Indonesia's mining sector has a stronger capacity to transmit mineral inputs to subsequent production activities than to generate demand for upstream supplier industries. This interpretation is consistent with the distinction between forward and backward GVC participation, where forward integration reflects domestic value added embodied in other countries' production, whereas backward integration reflects dependence on foreign inputs (Borin et al., 2021).

The relatively weak backward linkage may also reflect the structural characteristics of Indonesia's mining industry, particularly the capital-intensive nature of extraction and processing and the reliance on imported machinery, technology, and intermediate inputs. Consequently, higher mineral production does not necessarily generate proportionate demand for domestic upstream suppliers. This mechanism is important because strong export-oriented mining activity can coexist with limited domestic industrial integration when key production capabilities are supplied from abroad. Recent evidence supports this interpretation: Huanqui (2025), using data from 14 mining countries, finds that the effects of GVC integration on local linkages depend more on the nature of integration—forward versus backward—than on the overall level of GVC participation or position. The finding therefore reinforces the importance of distinguishing Indonesia's strong forward orientation from its relatively weak backward integration.

The conclusion that can be drawn if seen from the analysis of the spread coefficient and spread coefficient is that the Indonesian mining industry has not been able to increase its upstream industrial production but has been able to encourage the growth of the mining industry in other countries as a production input. This shows that even though the Indonesian mining industry is not very closely related, it can encourage the production of other countries' mining industries. For example, China is the second largest electric car producer in the world after Tesla (Fadli, 2023). According to the Ministry of Trade, Indonesia is the largest nickel exporting country to China (Ministry of Trade, 2024) where nickel is one of Indonesia's largest mining commodities. Nickel ore is one of the basic materials for making batteries for electric vehicles (CNBC Indonesia, 2024). This is an example of the Indonesian mining sector or industry as a provider of input for other sectors in other countries and in Indonesia.

The present findings both complement and extend recent evidence on Indonesia's mining transformation. Asyono et al. (2026), using domestic input-output tables, report that Indonesia's nickel downstreaming has been accompanied by changes in production linkages and increasing specialization and capital intensity. Their finding that forward linkages declined during the downstreaming process differs from the relatively strong forward linkage identified in the present 2022 cross-country MRIO analysis. This difference may arise from the different analytical scopes: domestic input-output tables capture linkages within Indonesia, whereas the MRIO framework captures production relationships across countries. The contrast therefore suggests that Indonesia's mining sector may have become more specialized domestically while simultaneously maintaining a strong role as a supplier of mining-related inputs to international production networks. This distinction highlights why domestic linkage analysis and GVC analysis should be interpreted together rather than treated as equivalent measures.

The results also have an important implication for industrial upgrading and domestic value capture. A strong forward position indicates that Indonesian mining products are important inputs for subsequent production stages, but it does not by itself demonstrate that Indonesia captures a large share of the value generated downstream. If downstream processing, technology, specialized services, and higher-value manufacturing remain concentrated in other countries, Indonesia may continue to occupy an upstream position despite the strategic importance of its mineral exports. Thus, the challenge for downstreaming is not simply to increase the volume or value of processed mineral exports, but to strengthen domestic backward linkages, technological

capabilities, supplier networks, and higher-value downstream activities. This interpretation is consistent with the recent literature emphasizing that mining GVC integration does not automatically generate strong local linkages and that policy outcomes depend on the nature of GVC integration and the capacity to develop domestic industrial capabilities (Huanqui, 2025).

Value Added Analysis

Added value is remuneration for production factors (Suherman & Saleh, 2018). Table 3 reflects a massive disparity across global economies, where the top ten nations account for the overwhelming majority of total mining value addition, driven by vast mineral endowment, large geographic scale, and extensive capital investment in extraction infrastructure.

At the apex of global mining value creation, China dominates with 510,921.70 million, followed by the United States (347,389.50 million) and Russia (211,609.90 million). These top three economies benefit from a combination of abundant geological resources and immense domestic downstream industrial demand. Following them are major mineral and fuel exporters including Australia (142,129.98 million), Brazil (120,846.92 million), Indonesia (120,165.89 million), Canada (112,572.44 million), and Norway (110,585.94 million). As highlighted by Auty (1993) and Sachs and Warner (2001) in resource economics literature, the ability of these upper-tier countries to generate high value-added from extraction relies on capital-intensive technology, efficient transport logistics, and integration into global resource supply chains. Indonesia's strong sixth-place positioning underlines its vital global footprint in energy and critical minerals, such as nickel and coal.

Based on Table 3, the added value of the Indonesian mining industry is ranked 6th largest among the 62 countries, namely 120.16 billion US dollars. The amount of added value obtained by a country depends on how much output is produced. Indonesia's high absolute mining value added reflects the substantial scale of economic activity generated by its mining sector, but it does not by itself indicate the extent of value captured at downstream stages.

In the linkage analysis, analysis has been carried out on 3 downstream sectors of mining. Furthermore, this added value analysis will also analyze the added value in the three sectors, namely the coke, refined petroleum and nuclear fuel (fuel), nonmetallic minerals (non-metallic minerals) and basic metals and fabricated metals (base metals and fabricated metals sectors). Table 3 shows the added value of these three sectors in various countries.

Table 3 Added Value of the Mining Industry in 62 Countries

No	Country	Value-added	No	Country	Value-added
1	China	510.921,70	32	Republic of Korea	1.812,82
2	United States	347.389,50	33	Thailand	1.387,74
3	Russia	211.609,90	34	Sri Lanka	1.379,54
4	Australia	142.129,98	35	Czech Republic	1.367,93
5	Brazil	120.846,92	36	Finland	1.138,65
6	**Indonesia**	**120.165,89**	37	Switzerland	1.003,64
7	Canada	112.572,44	38	Portugal	798,65
8	Norway	110.585,94	39	Greece	759,81
9	India	78.789,43	40	Bulgaria	721,08

No	Country	Value-added	No	Country	Value-added
10	Mexico	49.460,26	41	Lao	705,02
11	Malaysia	38.197,11	42	Hungary	704,94
12	United Kingdom	36.177,98	43	Taipei, China	687,39
13	Kazakhstan	34.225,25	44	Cambodia	624,11
14	Netherlands	13.835,43	45	Ireland	597,21
15	Turkey	13.125,91	46	Slovak Republic	446,43
16	Japan	11.973,33	47	Belgium	345,88
17	Italy	11.009,72	48	Kyrgyz Republic	221,70
18	Poland	10.331,86	49	Nepal	191,87
19	Germany	8.460,58	50	Estonia	185,01
20	Viet Nam	5.900,22	51	Croatia	184,08
21	Denmark	5.870,21	52	Lithuania	175,81
22	Brunei Darussalam	5.279,76	53	Slovenia	154,99
23	Philippines	4.982,06	54	Latvia	143,10
24	Pakistan	4.715,66	55	Bhutan	46,40
25	Sweden	4.490,34	56	Fiji	31,06
26	Bangladesh	4.289,50	57	Cyprus	27,98
27	Spain	3.105,95	58	Luxembourg	27,60
28	Austria	2.653,52	59	Malta	2,45
29	Romania	2.367,33	60	Maldives	0
30	Mongolia	2.352,10	61	Singapore	0
31	France	1.846,52	62	Hong Kong, China	0

Source: MRIO Asian Development Bank (2023) (processed)

From a GVC perspective, the key issue is therefore not the absolute amount of value added generated by mining, but the distribution and location of value creation across different stages of production. Forward-oriented participation can generate substantial domestic value added when a country supplies important mineral inputs to downstream industries, but the country may capture a smaller proportion of the total value generated if subsequent processing, manufacturing, technology, and specialized services are performed elsewhere. GVC participation indicators distinguish between domestic value added supplied to subsequent production stages and foreign value added embodied in domestic production, making it possible to assess whether integration into GVCs is accompanied by deeper domestic production capabilities (Borin et al., 2021). Accordingly, Indonesia's sixth-ranking absolute mining value added should be interpreted as evidence of the sector's economic scale, whereas its relatively strong forward and weak backward linkages indicate the direction of its production integration. A stronger assessment of domestic value capture would require relative value-added indicators or a comparison of value added generated at upstream and downstream stages.

Moreover, based on Table 3, the countries with the highest added value for products of coke, refined petroleum and nuclear fuel sectors are China, Japan and the United States. Meanwhile, other nonmetallic minerals sector which has the highest added value is in China, the United States and India. The basic metals and fabricated metals sector have high added value in China, Japan and the United States. Sectors with high added value on average have high efficiency and can increase competitiveness in the global market (OECD, 2019). This can allow a country to export and strengthen its economic position in international trade.

The results presented in Table 3 focus on total mining-sector value added across the 62 economies and therefore do not allow a direct comparison of value added across individual downstream sectors. Accordingly, the discussion is limited to aggregate

mining-sector value added. Sector-specific differences in downstream value creation require separate sector-level estimates and are beyond the evidence presented in Table 3.

Discussions

The value-added analysis shows that Indonesia generated substantial economic value from its mining sector, with mining value added reaching approximately USD 120.17 billion, ranking sixth among the 62 economies analyzed. This relatively high absolute value added reflects the large scale and economic importance of Indonesia's mining sector. However, absolute value added should not be interpreted as the share of value captured by Indonesia along the entire global value chain (GVC). The value-added results therefore indicate the scale of value generated within the mining sector, but do not by themselves demonstrate how much value is retained at downstream stages or how value is distributed across countries and production stages.

The linkage analysis provides further insight into Indonesia's position in international production networks. Indonesia's mining sector records a high forward linkage (2.97) but a relatively low backward linkage (0.67). This combination indicates a predominantly upstream-oriented linkage pattern: Indonesian mining provides substantial inputs to other sectors and economies, while its production is relatively less dependent on inputs from the broader upstream production network. Such a pattern is consistent with the characteristics of resource-abundant economies, in which extractive industries supply raw materials to downstream processing and manufacturing activities. Importantly, these linkage results should be interpreted as evidence of strong upstream integration rather than as proof that Indonesia generates little value added. Indeed, the high absolute mining value added demonstrates that substantial economic value is generated in Indonesia, although the current analysis does not establish the extent of domestic value capture across the entire GVC.

The findings also suggest that participation in the GVC does not automatically translate into broad-based domestic value creation. A strong forward linkage may indicate that Indonesia is an important supplier of mining inputs to downstream production, while a weak backward linkage may reflect limited integration with domestic or international supplier networks. Previous studies emphasize the importance of strengthening local supplier capabilities, technological capacity, and domestic sourcing to increase the developmental benefits of participation in resource-based GVCs (Iizuka et al., 2022; Bamber et al., 2024). Consequently, improving the benefits of mining GVC participation requires policies that encourage innovation, domestic input provision, technological upgrading, and stronger linkages between mining and other domestic industries (Navas-Alemán & Bazan, 2021; Nenci & Quatraro, 2021; Pietrobelli et al., 2023).

The Indonesian government's downstreaming policy is therefore relevant to the challenge of moving beyond an upstream-oriented role. Restrictions on the export of unprocessed minerals and the development of domestic processing capacity are intended to increase the value generated from Indonesia's natural resources and strengthen domestic industrial capabilities. Recent evidence indicates that downstreaming can reshape domestic production structures and increase linkages with supporting industries, although it may also increase capital intensity and does not automatically guarantee

broader domestic value creation (Asyono et al., 2026). Thus, the effectiveness of downstreaming should be assessed not only by increases in mining output or aggregate value added, but also by whether it strengthens domestic backward linkages, technological capabilities, supplier networks, and higher-value downstream activities.

Overall, the results characterize Indonesia as a large value-generating mining economy with a predominantly upstream-oriented linkage structure. Indonesia already generates substantial value from mining and plays an important role as an input supplier within international production networks. The key policy challenge is therefore not simply to increase mining value added, but to convert Indonesia's strong upstream position into deeper domestic linkages and greater value capture through downstream processing, technological upgrading, and the development of competitive domestic suppliers.

Conclusions

This study assesses the integration of Indonesia's mining industry into global production networks by examining its forward and backward linkages and mining-sector value added. The results indicate that Indonesia has a predominantly upstream-oriented linkage pattern, characterized by a strong forward linkage (2.97) and a relatively weak backward linkage (0.67). This suggests that Indonesia's mining industry plays an important role as a supplier of inputs to other sectors and economies, while its integration with upstream supplier industries is comparatively limited. At the same time, Indonesia generates substantial mining-sector value added, reaching approximately USD 120.17 billion and ranking sixth among the 62 economies analyzed. Thus, Indonesia should not be characterized as a low-value-added mining economy; rather, it is a large value-generating mining economy whose international production linkages remain predominantly upstream-oriented.

These findings imply that Indonesia's key challenge is not simply to increase mining output or aggregate value added, but to strengthen domestic linkages and capture greater value through higher-value activities along the production chain. The government should therefore continue its downstreaming strategy while placing greater emphasis on domestic supplier development, technological upgrading, innovation, skills development, and stronger linkages between mining and downstream manufacturing. Policies should also encourage greater domestic sourcing of intermediate inputs, machinery, technology, and related services to strengthen backward linkages and broaden the domestic economic benefits of mining. Downstreaming should consequently be evaluated not only by increases in processing capacity or value added, but also by its ability to deepen domestic production linkages and promote sustainable upgrading within Indonesia's mining-related industries.

Finally, the findings should be interpreted within the scope of the MRIO-based analysis. The value-added results measure the scale of value generated by the mining sector but do not directly measure Indonesia's share of total value captured across the entire GVC. Future research should therefore incorporate sector-specific downstream

analysis and established GVC participation and position indicators to provide a more comprehensive assessment of Indonesia's value capture and upgrading in global mining value chains.

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