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Linkage development as industrial policy: The state and structural transformation in resource-rich countries

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Linkage development as industrial policy

The state and structural transformation
in resource-rich countries

Imaduddin Abdullah¹ and Andy Sumner^{2,*}

April 2025

Abstract: This paper examines Indonesia's upgrading within the global nickel value chain. Indonesia's transformation from a major nickel ore exporter into an integrated producer of refined nickel products offers important lessons for resource-rich developing countries seeking economic diversification. Drawing on evidence from Indonesia's strategic shift towards midstream and downstream manufacturing, this paper examines how policy choices and state intervention can reshape a country's position in global value chains. This paper shows the importance of linkage development in achieving upgrading in resource-based manufacturing. The Indonesian case demonstrates that it is possible for resource-rich countries to move up the value chain when appropriate policies are implemented. However, this industrial transformation also highlights critical challenges, including environmental concerns from coal-powered processing and the nuanced relationship between state direction and market forces. By analysing Indonesia's upgrading trajectory in nickel, this paper contributes insights to ongoing debates about industrialization pathways in resource-rich developing countries and the role of strategic state intervention in fostering industrial development.

Key words: industrialization, structural transformation, industrial policy, Indonesia

JEL classification: O14, O25, F63

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1 Introduction

This paper contributes to research on industrialization in resource-rich countries. The paper examines Indonesia's upgrading within the global nickel value chain. Historically, Indonesia participated in the lowest rung of the nickel value chain, primarily exporting raw nickel ore with limited value additions. However, recent years have witnessed a significant shift as Indonesia has entered the downstream segment of the global nickel value chain. Indonesia has shifted from a focus on upstream activities to downstream manufacturing, particularly in the production of nickel-based products like stainless steel and electric vehicle (EV) batteries.

The objective of this paper is to identify the factors driving Indonesia's new position in the global nickel value chain, and particularly the role of the state. This paper underscores the importance of linkage development in achieving upgrading in resource-based manufacturing. The paper contributes to research on industrialization in resource-rich countries by highlighting how state intervention can mitigate the limitations of market dynamics. The argument presented in this paper emphasizes that the development of linkages between segments within the nickel value chain that has been instrumental to upgrading Indonesia's nickel-based manufacturing industry. Such linkage development does not occur automatically. The paper demonstrates that the state has a central role in shaping the linkage development between the local economy and lead firms in the nickel value chain, particularly through industrial policies spanning nickel mining to the production of stainless steel and EV batteries.

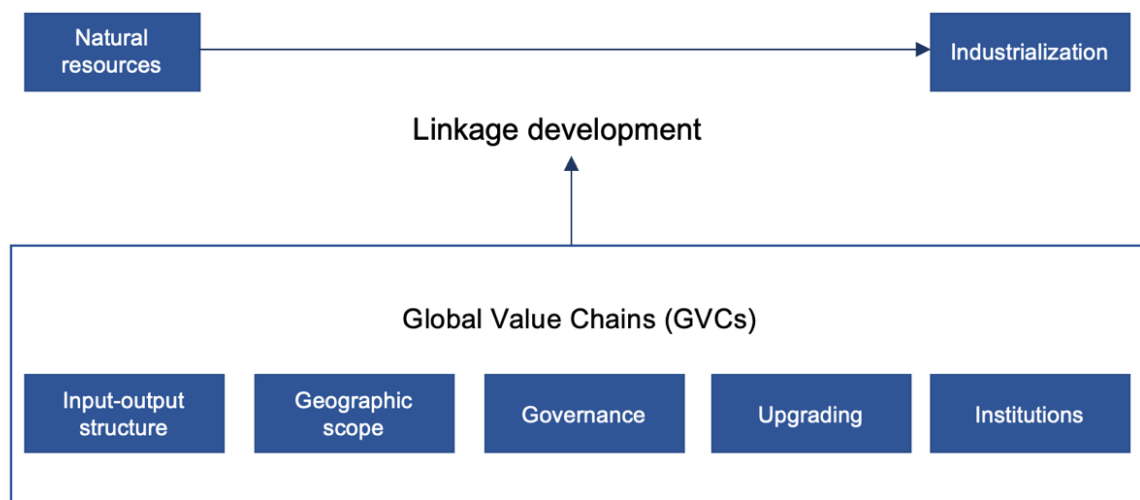
We use the case of nickel because of its central role in the global clean energy transition. Nickel is a crucial component in the rapidly growing market of EVs, which has seen substantial growth over the last decade, with the number of EVs on the road reaching 16.5 million in 2022 (IEA 2022a). The surge in EV sales has significantly increased the demand for EV batteries, which doubled year-over-year in 2021, reaching 340 gigawatt-hours (GWh). Nickel-based batteries dominate the EV battery market, underscoring nickel's importance in this sector. We focus on Indonesia because, besides its recent efforts to move up the value chain, the country holds a significant position in the global nickel reserve, being the top producer and having the largest reserves.

The paper is structured as follows: Section 2 presents an analytical framework for the analysis of resource-based industrialization in a global value chain (GVC) world. Section 3 presents the development of Indonesia's nickel-based manufacturing industry, dividing the analysis into two periods: before and after the government implemented an export ban on all mineral commodities, including nickel ore. Section 4 discusses the state's role in shaping linkage development and how collaboration with lead firms contributed to the development of nickel downstream industries in Indonesia. Section 5 concludes by synthesizing key findings on Indonesia's nickel GVC upgrading and its implications for resource-rich developing countries, while also examining challenges including environmental concerns and policy sustainability in evolving market conditions. The Appendix details the global dynamics of the nickel GVC, including input–output structure and geographic scope of nickel value chain.

2 Resource based industrialization in a GVC world: an analytical frame

To study resource-based industrialization, we propose a synthesis framework based on the survey of Abdullah (2024). This framework is used to understand how the resource sector can stimulate industrialization and economic development in resource-rich countries; specifically, the use of natural resources to promote economic diversification through linkage development. This echoes Hirschman's (1981) linkages theory, emphasizing the importance of building linkages in economies. However, promoting economic diversification is not simple. And the expansion of GVCs has added further complexity. The global economy has experienced what Baldwin (2011) called 'globalization's second unbundling', which allows production stages to be geographically dispersed rather than performed in close proximity (see also Gereffi 2014). This has significantly impacted the global economy, distinguishing today's industrialization from the experience of early industrializers. The GVC literature provides insights into how the expansion of GVCs shapes countries' industrialization. Specifically, the GVC literature introduces concepts such as upgrading and governance. Our analytical framework thus brings together linkage theory, GVC theory, and the political economy of industrialization (see Figure 1). We aim to understand the factors that determine the relationship between GVCs and industrialization in resource-rich countries.

Figure 1: Analytical frame



Source: authors' elaboration based on survey of Abdullah (2024).

As depicted in Figure 1, our paper unpacks the mechanisms through which natural resources may contribute to industrialization via linkage development. Our paper argues that the goal of industrialization in resource-rich countries is to achieve economic diversification, encompassing both vertical and horizontal diversification. Vertical diversification entails diversifying economic activities within the same value chain of commodities. In contrast, horizontal diversification entails developing new sectors beyond the value chain of those commodities. We contend that the role of the state is important in shaping and directing linkage development, in vertical and horizontal diversification. We incorporate the GVC framework proposed by Fernandez-Stark and Gereffi (2019) to analyse how natural resources can contribute to industrialization in resource-rich countries. This framework includes four key aspects: the input–output structure, which helps understand how commodities are

processed into manufactured goods; the geographic scope, illustrating global supply and demand and the distribution of production across countries; governance, which classifies value chains as buyer-driven or producer-driven and analyses the power of lead firms; and upgrading, which examines how firms and countries progress through value chains, linked to economic diversification. Upgrading involves moving from low-value to higher-value-added activities, which is essential for structural transformation (Andreoni et al. 2021a), including transitioning from raw material specialization to producing competitive downstream products. Institutions also play a crucial role in shaping a country's participation in GVCs, with local economic and social conditions, availability of key inputs, and regulations being vital for upgrading and strategic coupling. Additionally, the role of the state is important in shaping GVC participation.

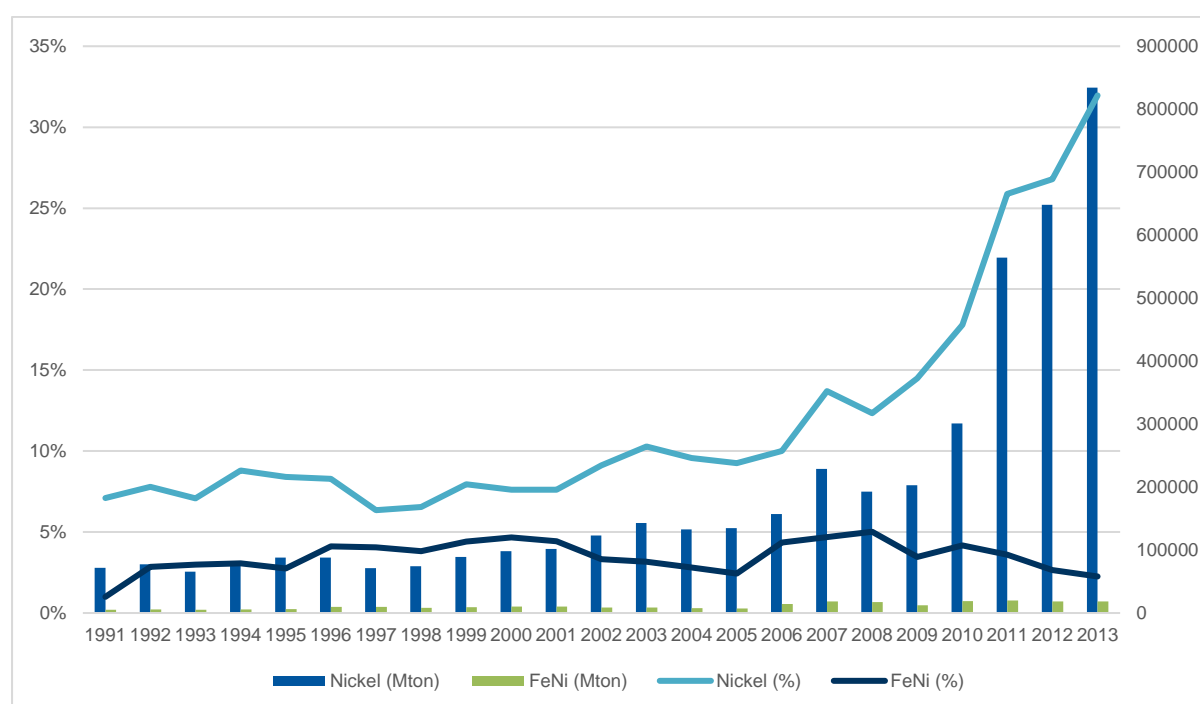
3 Moving up from the lowest rung of the value chain ladder

3.1 Indonesia's nickel sector: historical development and limited downstream processing (1970s–2013)

Nickel mining in Indonesia dates to the Dutch colonial era. Large-scale commercial operations began in Indonesia in the 1970s. Significant concessions were granted to PT Aneka Tambang (ANTAM), a state-owned enterprise (SOE), and PT International Nickel Indonesia, a subsidiary of the Canadian company INCO. ANTAM started nickel ore extraction using traditional methods, achieving a combined nickel–cobalt content of 2.4% (USGS 1977). By 1978, new estimates revealed 824 million tons of nickel-bearing laterite reserves, positioning PT INCO and PT ANTAM as key producers (USGS 1981). Significant investment from 1981 to 1990 led to annual production increases of up to 50%, making Indonesia a major player in the global market. During the commodity boom (2007–12), production peaked at 834,200 tons in 2012, driven by rising global nickel prices (ANTAM 2007). Indonesia's share of global nickel production reached 32% in 2013. In addition to nickel ore, Indonesia began ferronickel production with ANTAM's smelter in 1981, although its global contribution to ferronickel remained around 3.48%, with most nickel ore exported rather than processed domestically (see Figure 2). Indonesia's share in global ferronickel production has hardly changed. In 2013, a year when nickel ore production reached its highest level, Indonesia's ferronickel production dropped significantly to 2.3%. The limited nickel processing facilities within Indonesia were seen as the primary factor pushing the country to export nickel ore instead of processed ferronickel.¹ The lack of investment in processing facilities has resulted in minimal changes to ferronickel production capacity over the last 20 years.

¹ Author interview with an officer from the Directorate General of Mining, Ministry of Energy and Mineral Resources, Indonesia [10 June 2023, ESDM1].

Figure 2: Indonesia's nickel ore and ferronickel production (1991–2013)



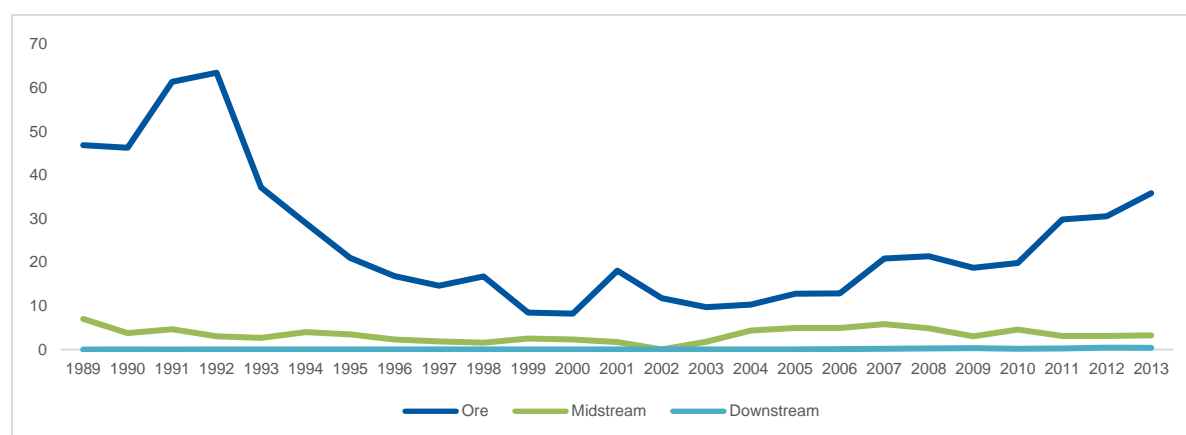
Note: FeNi, ferronickel.

Source: authors' elaboration using data from USGS (various years).

This situation was further exacerbated by the overwhelming dominance of established players in the global ferronickel market. In this case, China has been a dominant force in ferronickel production, reinforced by its superior technological capabilities in processing and refining, well-established domestic and international supply chain networks, and massive-scale operations that benefit from economies of scale. The country accounted for nearly half (375,645 tons) of global ferronickel production capacity (760,000 tons) in 2016 (USGS 2016). Furthermore, Chinese producers' extensive experience in processing, accumulated over decades of operations, combined with these competitive advantages, created significant barriers for Indonesia's attempts to move up the value chain. These advantages enabled Chinese firms to maintain their market leadership while making it challenging for new entrants like Indonesia to develop competitive downstream processing capabilities.

The limited contribution of Indonesia to global ferronickel production reflects its concentration in the upstream segment of the nickel value chain. This is supported by trade data, emphasizing Indonesia's strong competitiveness in exporting raw nickel materials. Indonesia's competitiveness in the export of semi-processed and downstream products during that period was relatively low. Figure 3 illustrates a revealed comparative advantage (RCA; i.e. measure of competitiveness) for exports of three product segments. Before 2014, Indonesia consistently maintained an RCA greater than 1 for nickel ore, indicating its strength in nickel ore exports. Indonesia's RCA for nickel ore significantly exceeded 1, reaching a peak of 48 in 1992. Although RCA declined in the following years, it remained higher than 10. After 2003, Indonesia's RCA for nickel ore experienced a resurgence, driven by the growth in nickel ore exports. Although Indonesia demonstrates some competitiveness in midstream products (as indicated by RCA greater than 1), this competitiveness is notably lower than its strength in the upstream segment.

Figure 3: Indonesia's RCA in export of nickel-based products (1989–2013)



Source: authors' calculation using data from UN Comtrade (2023).

Despite being a prominent player in global nickel ore production, the economic contribution of nickel to Indonesia was relatively limited compared with other commodities like oil and gas. Table 1 shows that nickel mining accounted for less than 2% of the total value added in the mining sector from 1975 to 2010. This percentage was significantly lower than that of other mineral mining products, such as copper and energy-related commodities (e.g., coal, gas, and oil). Furthermore, nickel mining demonstrated relatively lower forward linkages to other industries within the economy.

Table 1 also reports the sensitivity of the dispersion index for five mining sectors in Indonesia, measuring the extent of forward linkages of these sectors to the economy. An index value greater than 1 indicates that a sector supplies substantial output for use as inputs in other industries. As the table reveals, nickel has an index value lower than 1, indicating a relatively lower proportion of nickel ore used as inputs in other domestic industries. This is unsurprising given that Indonesia exported a significant amount of nickel ore to other countries instead of supplying it to local industries, due to the absence of downstream nickel processing. Consequently, a significant amount of nickel entered the global market in the form of unprocessed ore.

Table 1: Key figures of mining sector in Indonesia

Sector	Value added (% of mining sector)				Forward linkages (the sensitivity of the dispersion index) ^a			
	1975	1985	1995	2010	1975	1985	1995	2010
Nickel	1%	0%	2%	1%	0.54	0.70	0.62	0.57
Copper	1%	1%	8%	6%	0.63	0.51	0.62	0.53
Coal	0%	0%	6%	23%	0.74	0.92	0.89	1.07
Oil ^b	95%	93%	48%	25%	5.02	4.90	2.47	4.26
Gas			14%	21%			1.23	3.06

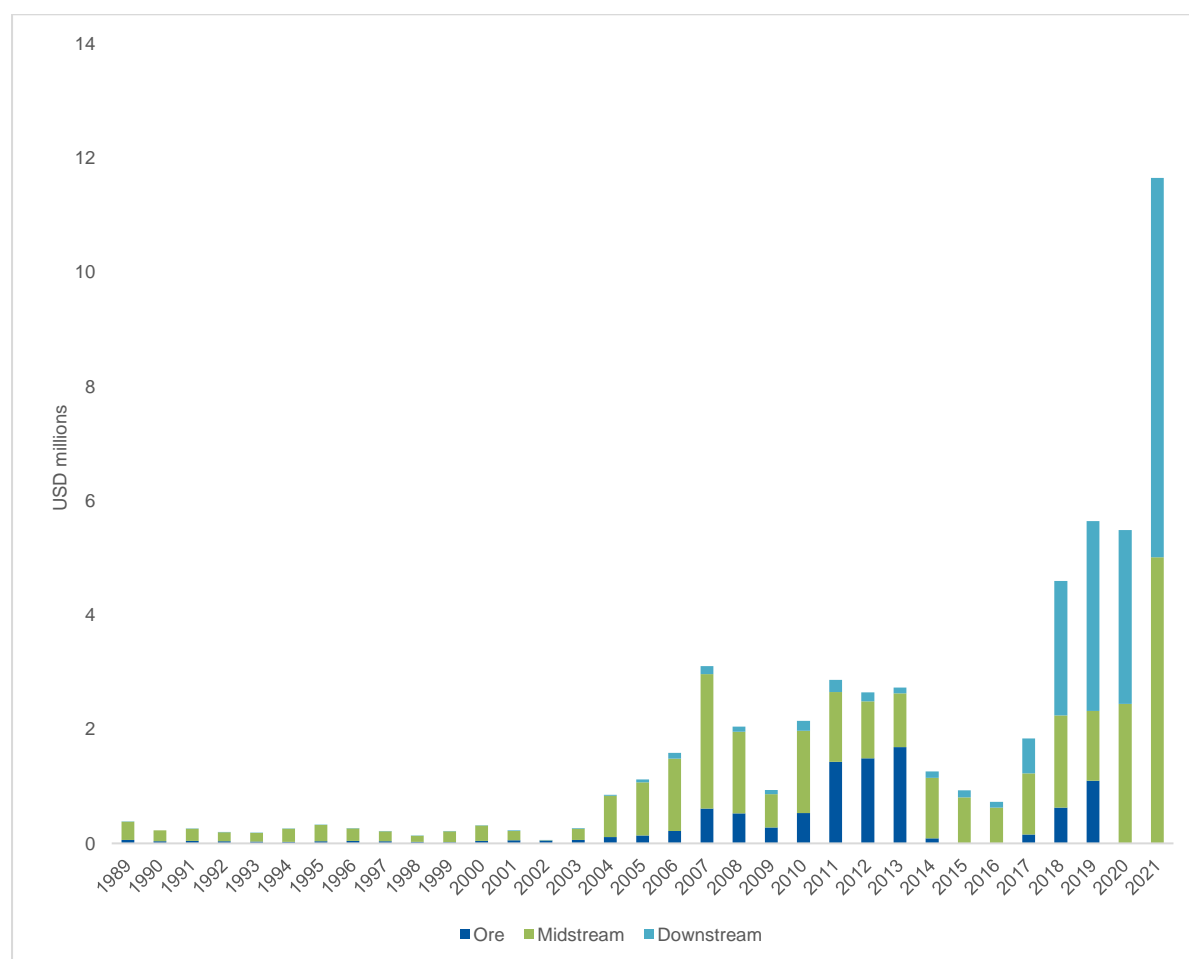
Note: ^a a sector is considered to have strong forward linkages if it is greater than 1. Greater than unity shows that a sector supplies significant amounts of outputs as an input for the production in other industries relative to other sectors in the economy. ^b Oil and gas sectors are aggregated into one sector named 'oil and gas' in the 1975 and 1985 input–output tables.

Source: authors' calculation using input–output tables (various years).

3.2 Indonesia's nickel sector: transformation to downstream processing and economic impact (2014–23)

Significant progress has been made in Indonesia's downstream nickel industry, particularly following the aftermath of the recent commodity boom. In terms of export performance, we can see that Indonesia successfully increased the export value of nickel midstream and downstream products, especially after 2014 (see Figure 4). Before 2014, the value of downstream nickel products was six times smaller than the export value of upstream products. However, in 2021, the export value of downstream nickel products reached USD 6,639 million, which is 1.3 times higher than midstream nickel, while Indonesia's export for nickel ore was virtually zero.

Figure 4: Export value of nickel-based products by segments (USD millions)



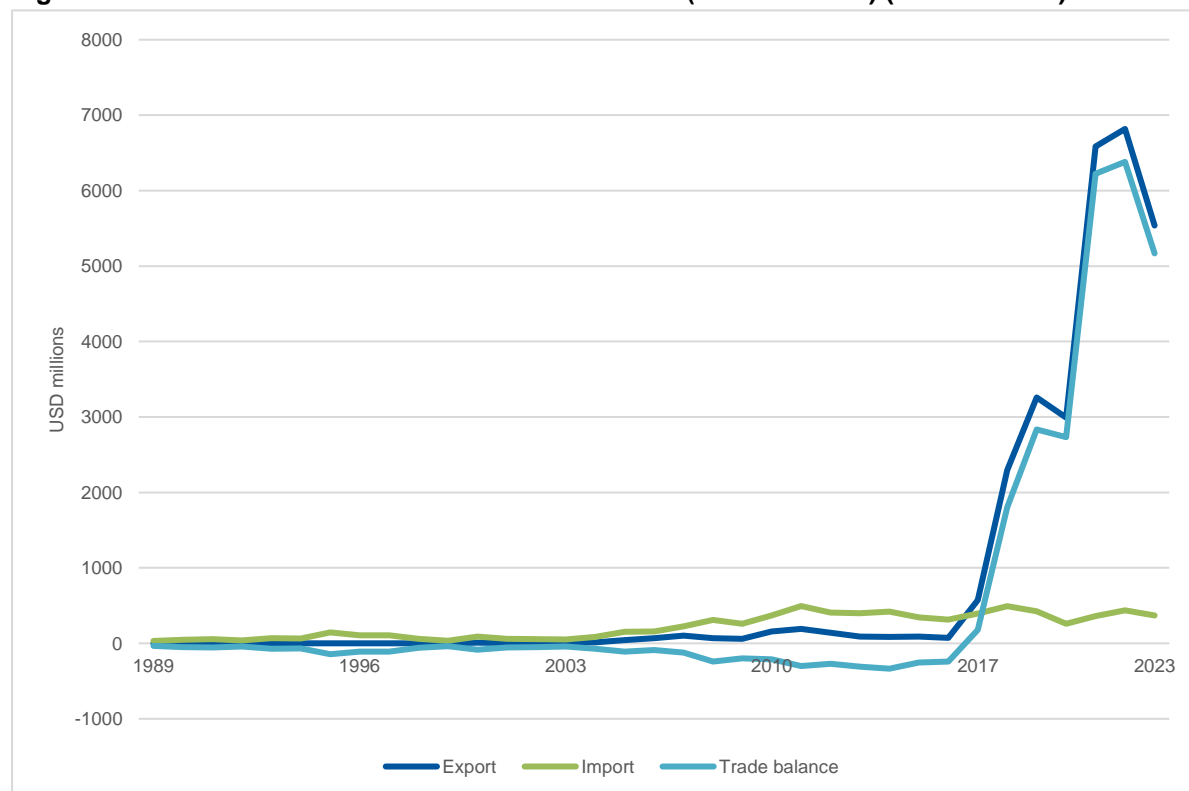
Note: see the Appendix for a list of products under each segment.

Source: authors' calculation using data from UN Comtrade (2023).

Looking at the data in more detail, it becomes evident that the export of flat-rolled products of stainless steel (HS code 7219), which is the downstream product of nickel, played a significant role in driving the growth of downstream nickel product exports. As depicted in Figure 5, Indonesia's export of stainless steel experienced a remarkable increase of over 70 times between 2016 and 2021. Historically, Indonesia exported nickel ore, a raw material for stainless steel production, only to

reimport it in the form of more sophisticated nickel products like stainless steel. Consequently, Indonesia's trade balance in stainless steel was negative before 2017. Nevertheless, the expansion of stainless steel exports after 2015 played a pivotal role in Indonesia's new status as a net exporter. As illustrated in Figure 5, Indonesia's trade balance in stainless steel has shifted from negative to positive since 2017. Exporting downstream products is a crucial element of the country's upgrading in GVCs. It illustrates how a country can shift from exporting raw materials to producing and exporting higher-value-added products. This transition meant Indonesia benefited from higher value addition from processing nickel ore into midstream and downstream products.

Figure 5: Indonesia's trade balance in stainless steel (HS code 7219) (USD millions)

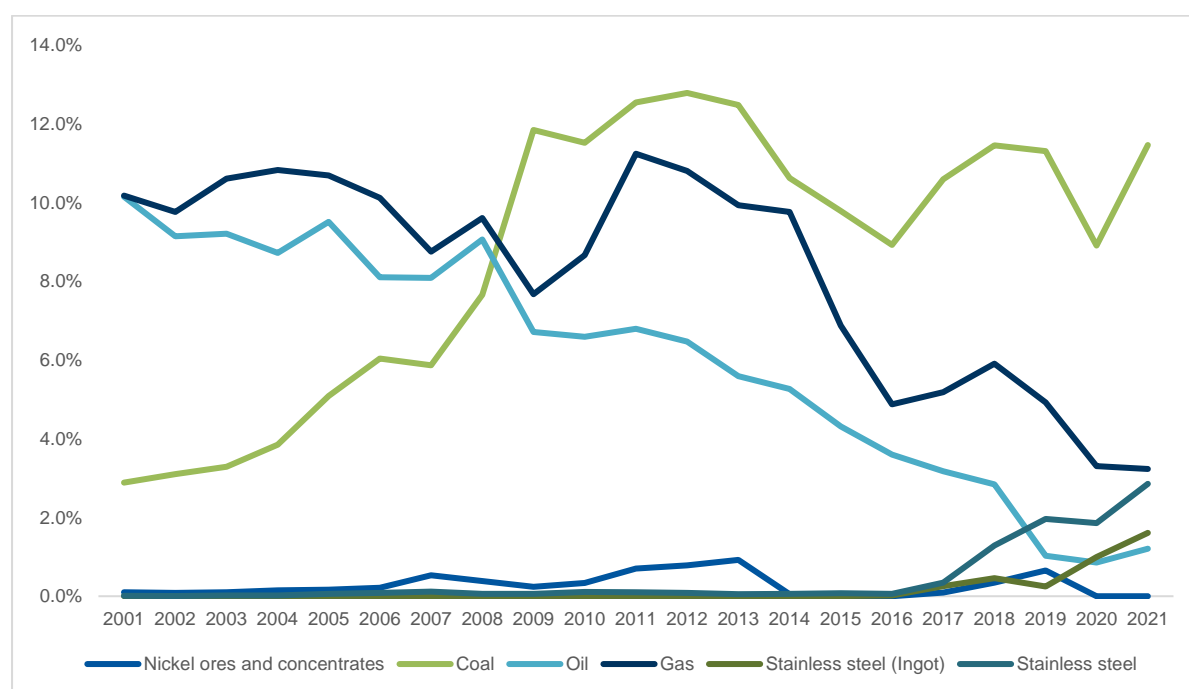


Note: see the Appendix for a list of products under each segment.

Source: authors' calculation using data from UN Comtrade (2023).

To provide additional context, one can compare the export values of stainless steel products with those of other mining commodities to assess the magnitude of nickel downstream development. Figure 6 illustrates a significant increase in the export of stainless steel, surpassing even oil, which was previously Indonesia's major commodity product. This figure implies that by developing nickel downstream industries, Indonesia reaps benefits from the export value of nickel products. Without the development of downstream industries, Indonesia would have focused solely on the upstream segment of the nickel value chain, which contributed only 1% to Indonesia's total exports even during the commodity boom.

Figure 6: Export various mining commodity in comparison to nickel downstream products (% of Indonesia's total export)

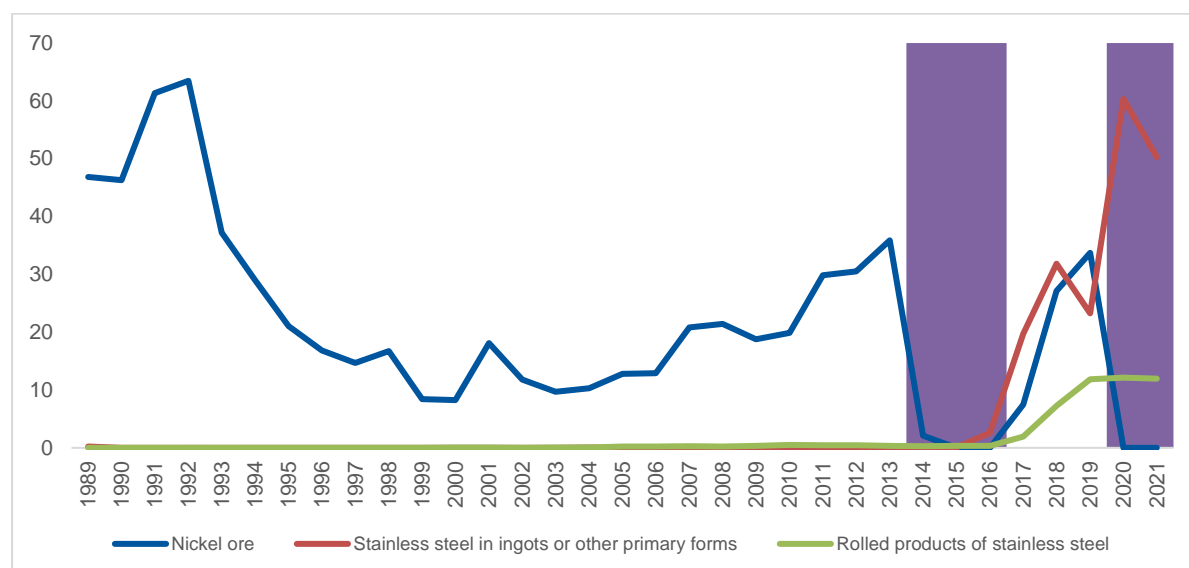


Source: authors' calculation using data from UN Comtrade (2023).

Furthermore, it is important to assess Indonesia's competitiveness in the global market using the RCA indicator. As illustrated in Figure 7, Indonesia has demonstrated a significant increase in export competitiveness in nickel downstream products. This notable improvement became particularly evident after the implementation of the first nickel ore ban in 2014–15, which resulted in a substantial increase in Indonesia's competitiveness in stainless steel products. Meanwhile, its competitiveness in upstream products, such as nickel ore, diminished. What is particularly striking is that Indonesia's RCA for the export of stainless steel ingots reached 60 in 2019, surpassing the RCA for nickel ore during the commodity boom. This shows Indonesia's accumulation of production capabilities, enabling the country to achieve higher competitiveness in products that require sophisticated manufacturing processes compared with the export of nickel ore, where competitiveness is derived from natural advantage.

The expansion of Indonesia's stainless steel exports has played an important role in increasing the economic complexity of its export basket. Economic complexity has been considered an essential indicator for a country's structural transformation and long-term economic development (Hesse 2009; Mania and Rieber 2019).

Figure 7: Indonesia's competitiveness (RCA) in nickel ore and stainless steel products before and after the ore export ban



Note: RCA, revealed comparative advantage.

Source: authors' calculation using data from UN Comtrade (2023).

The product complexity index (PCI) is widely used as an indicator to assess a country's productive capabilities (Inoua 2023; Mealy et al. 2018; Reynolds et al. 2018). Table 2 presents Indonesia's top 10 export products in 2010 and 2020 and their respective PCI values. Notably, among the top 10 contributors to Indonesia's exports in 2020, stainless steel (both in ingot and finished product forms) is the only commodity with a positive PCI value. This change underscores that the development of downstream nickel has significantly contributed to the enhanced complexity of Indonesia's exports.

Table 2: Complexity index of top 10 exported products of Indonesia

Rank	2010		2020	
	Product name	Complexity index	Product name	Complexity index
1	Palm oil and its fractions	-2.2	Palm oil and its fractions	-2.2
2	Coconut (copra), palm kernel or babassu oil	-2.0	Copper ores and concentrates	-2.1
3	Copper ores & concentrates	-2.3	Coal	-1.7
4	Coal	-0.7	Lignite	-1.3
5	Petroleum oils (crude)	-2.4	Petroleum gases	-1.9
6	Petroleum oils (other than crude)	-0.9	Industrial monocarboxylic fatty acids	-0.3
7	Petroleum gases	-2.0	Natural rubber	-2.2
8	Natural rubber	-3.0	Ferro-alloys	-1.1
9	Uncoated paper	0.6	Stainless steel (ingots)	0.7
10	Refined copper	-1.6	Stainless steel (flat-rolled products)	1.0

Source: authors' elaboration from Harvard Growth Lab (2023).

In addition to assessing export performance, the progress of nickel upgrading can be examined through sectoral data. A notable development is the significant role played by the expansion of nickel downstream industries in driving the overall performance of the basic metal sector.² Over the last 5 years (2020–24), basic metal manufacturing has emerged as one of the most dynamic industries within Indonesia’s manufacturing sector. Table 3 presents the growth of some sub-manufacturing industries in Indonesia. The table indicates that basic metal manufacturing has experienced a remarkable surge since 2020, with an average annual growth rate of 11.9%. This growth rate surpasses that of traditional drivers like food and chemical industries within Indonesia’s resource-based manufacturing sector. Moreover, between 2020 and 2024, basic metal manufacturing expanded much faster than the overall manufacturing sector, which recorded average annual growth rates of 4.5%. A comparison of two 5-year periods (2015–19 and 2020–24) reveals that the average growth rate of basic metal manufacturing during the latter period (11.9%) surpassed that of the former period (5.0%).

Table 3: Annual growth of sub-manufacturing industries in Indonesia (%)

Sub-manufacturing industries	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average	
											2015–19	2020–24
Basic metal industry	6.2	1	5.9	9	2.8	5.9	11.5	14.8	14.2	13.3	5.0	11.9
Food and beverage industry	7.5	8.3	9.2	7.9	7.8	1.6	2.5	4.9	4.5	5.9	8.1	3.9
Chemical, pharmaceutical, and traditional medicine industry	7.6	5.8	4.5	–1.4	8.5	9.4	9.6	0.7	0.1	5.9	6.6	5.1
Machinery and equipment industry	7.6	5.1	5.6	9.5	–4.1	–10.2	11.4	11.4	0	–0.4	7.0	5.6
Total non-oil and gas manufacturing	5.1	4.4	4.9	4.8	4.3	–2.5	3.7	5	4.7	4.7	4.7	4.5

Source: authors’ elaboration based on Badan Pustat Statistik (2024).

The recent expansion of the basic metal industry marks a reversal since the Asian financial crisis in 1997. Between 2001 and 2010, the average annual growth rate of basic metal was –1.41%.³ Numerous studies have discussed factors contributing to the industry’s sluggish performance in the early twenty-first century (see Sato 2009; Wie 2000). This downturn contradicted the industry’s experience in the 1970s when basic metal was considered a pivotal force driving Indonesia’s industrial development. During that period, the government recognized basic metal as an important industry, given its strong linkages to various sectors, from upstream to downstream. In the upstream sector, the metal industry had close connections to mining, allowing Indonesia to process mining resources into metal products. In the downstream sector, metal industries were considered essential for supplying intermediate products to other sectors. As such, the development of basic metal industries has been perceived as a catalyst for the country’s structural transformation, contributing to increased production factors in downstream industries and resulting in the manufacturing of more complex and higher-value-added products. Indonesia’s focus on resource-based industrialization has

² Nickel-based manufacturing industries are classified under basic metal in the International Standard Industrial Classification.

³ Authors’ calculation based on Badan Pustat Statistik (2023).

historically centred around the basic metal industries. The government's commitment to this sector dates back to the 1970s, marked by various supports and incentives (see later discussion).

Between the 1970s and 1980s, Indonesia successfully accumulated production capacity in basic metals, leading to an increasingly significant role for this sector in the country's economy. Starting from virtually zero production and value added, the share of basic metals in the country's manufacturing value-added rose to 2.93% in 1981, reaching a peak of 11.01% in 1997.⁴ However, after the 1997 Asian financial crisis, the share of basic metals dropped to less than 4%.⁵ The recent resurgence in basic metal manufacturing, driven by the development of downstream nickel industries, has revitalized the importance of basic metals for Indonesia's economy.

The performance of basic metal over the last 5 years (2020–24) is closely related to the progress in developing linkages with the nickel value chain. As downstream industries have developed, mining companies no longer solely rely on exporting their products to the global market. Instead, they can supply nickel ore to domestic industries for subsequent processing.

The competitiveness of domestically processed nickel products in Indonesia has also strengthened against imports, driven by several strategic advantages. The country's position as one of the world's largest nickel producers provides Indonesian processors with direct access to abundant raw materials, eliminating the long-distance transportation costs that international competitors must bear. This natural cost advantage is further enhanced by Indonesia's cheap energy resources that provide the constant baseload power supply crucial for energy-intensive stainless steel production.

The implementation of export restrictions has fundamentally changed domestic market dynamics by redirecting nickel ore supply from international to domestic markets. This policy intervention has created a significant price differential between domestic and international markets, with nickel ore prices in Indonesia stabilizing at approximately 50%–60% of comparable ore prices in the Philippines, as demonstrated by the price floor set by the Ministry of Energy and Mineral Resources (Prospera 2022). The resulting lower input costs have provided Indonesian processors with a significant competitive advantage.⁶ While this transition has required structural adjustments in the industry, it has incentivized the development of domestic processing capabilities and strengthened the overall competitiveness of Indonesia's nickel processing sector.

This aligns with Hirschman's (1981) proposition that developing backward and forward linkages is central for fostering structural change, enhancing productivity growth, and ultimately facilitating long-term economic development. The next section analyses the development of linkages within the nickel value chain in more detail.

⁴ Authors' calculation using data from UNIDO (2015).

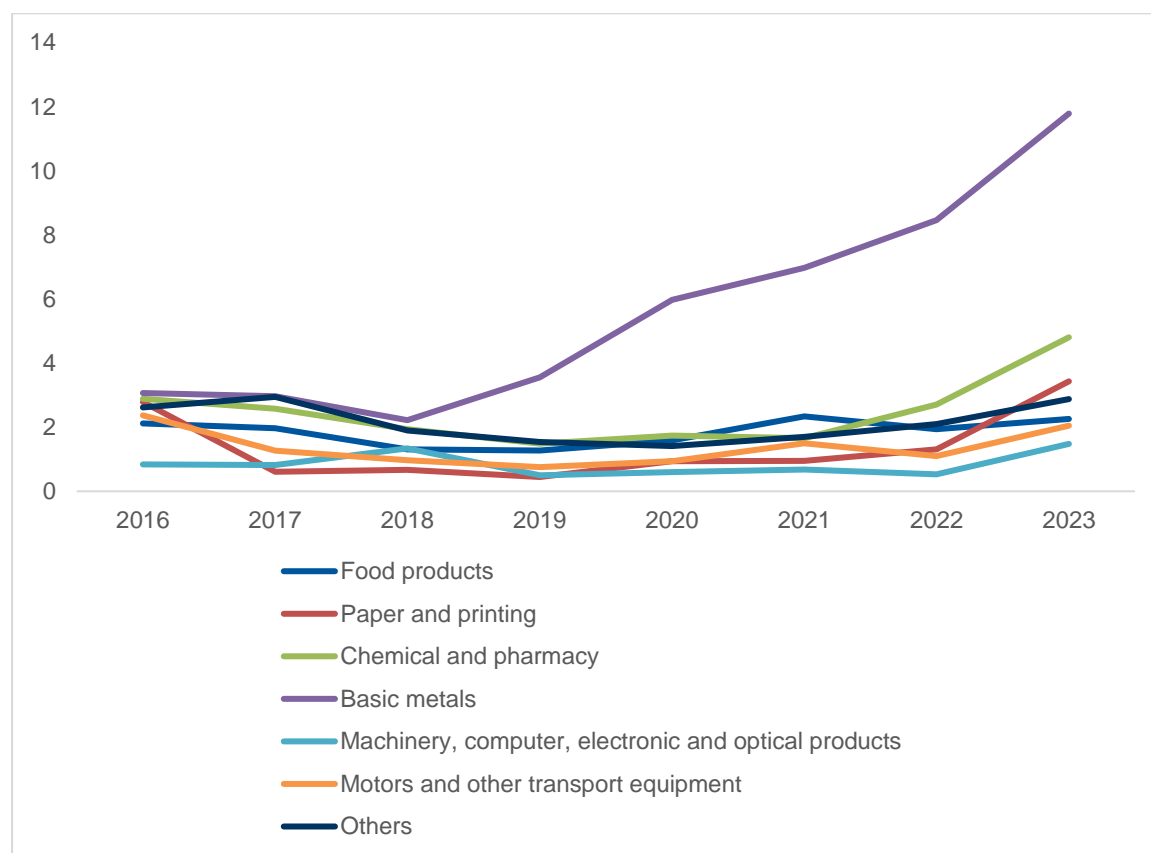
⁵ Authors' calculation using data from UNIDO (2015).

⁶ A recent study by BKPM (2024) shows that the total cash cost for smelters in Indonesia is notably lower than for smelters in China and Australia. Specifically, Chinese smelters have their highest cost components in raw material costs (44%) and transportation costs (50%), whereas Australian smelters similarly show high costs in nickel ore raw materials (22%) and other costs (60%).

3.3 Linkage development and shifts in capital

One evident development in the nickel value chain is the influx of investment towards this sector, which changed the capital structure of the economy. According to Figure 8, investment in basic steel, which encompasses the sub-sector for downstream nickel industries, significantly outpaced investments in other manufacturing sub-sectors. This sector attracted substantial investments from 2017 to 2022, with an average annual growth rate of 41.6%. A notable surge was observed in 2019, with a 60.4% increase in investment in basic metal compared with the previous year. In 2023, basic steel manufacturing received a total investment of USD 11.8 billion, accounting for 41% of the total manufacturing investment.

Figure 8: Investment influx in manufacturing by sub-sectors, USD billion



Source: authors' elaboration using data from BKPM (2023).

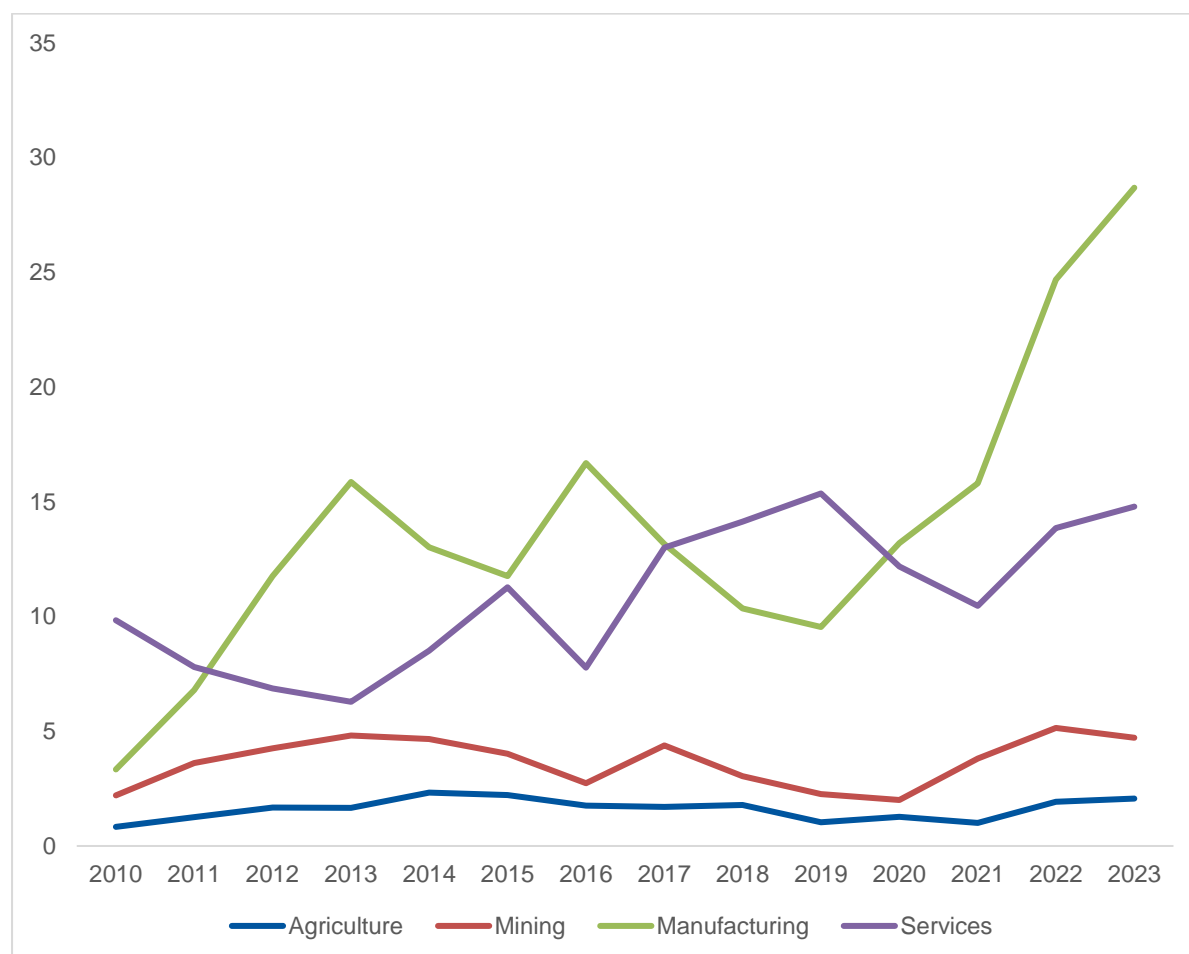
The surge in investment in the basic metal industry has significantly reshaped Indonesia's investment landscape. Despite substantial investments in manufacturing since 2010, the service sector surpassed this sector in 2017. Investments in the service sector continued to grow, constituting 54.5% of the country's total investment in 2019.⁷ Conversely, investment in the manufacturing sector experienced a declining trend between 2014 and 2019, with the exception of 2015 (see Figure 8). This raised concerns among policymakers about the potential loss of competitiveness in the domestic

⁷ Authors' calculation using data from BKPM (2023).

manufacturing sector and fuelled concerns about deindustrialization in Indonesia (Ministry of Industry 2014).

However, an important shift occurred in 2020 when the influx of investment in basic metals, mainly foreign direct investment from China, pushed the manufacturing sector to surpass the service sector, becoming the recipient of the highest investment influx. This trend persisted in subsequent years, with the manufacturing sector attracting a total investment of USD 28.7 billion in 2023, accounting for 57.1% of the country's total investment influx (Figure 9).⁸

Figure 9: Investment influx by sectors, USD billion



Source: authors' elaboration using data from BKPM (2023).

To provide context for how investment in nickel-based manufacturing changes a total investment in the basic metal sector, it is useful to examine investments in basic metals in three nickel-rich regions: Morowali, Central Halmahera, and South Halmahera. Focusing on these regions is important because the government has designated these three regions as the centre of nickel downstream industries. Analysing the investment flow in these regions can shed light on how the availability of nickel

⁸ Authors' calculation using data from BKPM (2023).

resources in the upstream segment (mining) attracts investments in the midstream and downstream industries.

One notable investment initiative involved the establishment of an industrial park in Morowali, attracting investments across various sectors, from mining to downstream segments like stainless steel production. The region has attracted approximately USD 12 billion in investments for basic metal manufacturing to produce several downstream nickel products such as nickel pig iron, ferronickel, and stainless steel (see Table 4). Beyond basic metal, substantial investments have been directed towards chemical manufacturing, constituting 10.8% of the total investment in Morowali. The industrial park has also attracted investments in complementary sectors like power, hospitality, and transportation/logistics, with a combined investment of USD 1.9 billion, representing 11.2% of the total investment in the region. This influx of investments from leading firms has reshaped Morowali's capital structure. Once primarily identified as a mining-centric region, the mining sector contributed only 0.9% to the total investment between 2009 and 2022. This transformation underscores the region's shift from an extractive economy to a diversified one through resource-based industrialization.

Table 4: Total investment influx in three regions between 2009 and 2022, based on sector

Sector-wise investment	Total investment (USD million)	Share of total region's investment (%)
Morowali (Indonesia Morowali Industrial Park)		
Basic metal manufacturing	12,650	76.6
Chemical manufacturing	1,781	10.8
Housing, industrial parks, and office	797	4.8
Electricity, gas, and water	700	4.2
Transport, storage, and telecommunication	369	2.2
Mining	149	0.9
Central Halmahera (Indonesia Weda Bay Industrial Park)		
Basic metal manufacturing	6,073	77
Mining	773	10
Housing, industrial parks, and office	736	9
Electricity, gas, and water	276	4
South Halmahera (Halmahera Persada Lygend)		
Basic metal manufacturing	3,517	95
Mining	160	4
Others	40	1

Source: authors' elaboration using data from BKPM (2022a).

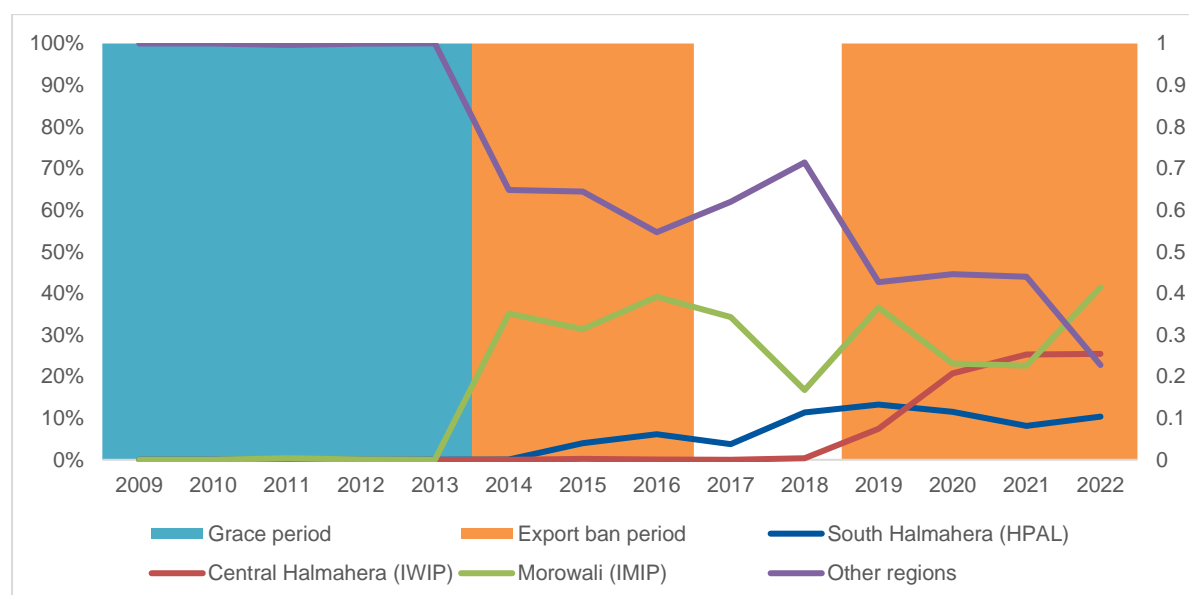
In addition to Morowali, there has been a massive influx of investment to Central Halmahera to establish Weda Bay Industrial Park. Similar to Morowali, basic metal manufacturing emerged as the sector that experienced the most pronounced influx of investment in the region. In total, basic metal manufacturing received USD 607 billion in investment, constituting 77% of the total investment in the region. In addition to basic manufacturing, other sectors supporting the operation of Weda Bay Industrial Park, such as housing, industrial park, office, and power sector, received substantial investment over the same period. These two sector groups comprised around 13% of total investment in the region.

South Halmahera has emerged as another focal point for significant investment. The investment influx for basic metal manufacturing accounts for the largest share of investment in South Halmahera

(95%). This is unsurprising, considering that the area was designated to accommodate high-pressure acid leach (HPAL) plants, necessitating substantial financial commitments. From 2014 to 2022, various investments have been directed towards establishing HPAL plants in the region. One example is PT Halmahera Persada Lygend, the first company in Indonesia to build HPAL plants to produce nickel–cobalt mixed hydroxide precipitate (MHP) and nickel sulphate. These outputs serve as crucial raw materials for the manufacturing of EV batteries, contributing to the broader development of the EV industry.

An examination of the investment landscape in the three designated industrial parks—Morowali, South Halmahera, and Central Halmahera—reveals a transformative trend since 2014 (Figure 10).⁹ Prior to this period, there was virtually no investment in basic metals within these three regions, constituting a mere 0% of the total national investment in this sector. However, in the year preceding the grace period, Morowali witnessed a significant influx of investments, constituting 35% of the total national investment in basic metal. This momentum continued in subsequent years, with Morowali consistently contributing around 40% of the national investment in basic metals. Additionally, investments in other industrial parks, particularly those in South Halmahera and Central Halmahera, further increased the share of downstream nickel industries in these three regions, collectively accounting for approximately 77% of the total national investment in basic metals in Indonesia in 2022. This highlights the magnitude of investments in nickel-based manufacturing industries in these specific regions.

Figure 10: Share of investment in basic metal manufacturing in three regions in Indonesia's total basic manufacturing investment



Note: HPAL, Halmahera Persada Lygend; IWIP, Indonesia Weda Bay Industrial Park; IMIP, Indonesia Morowali Industrial Park.

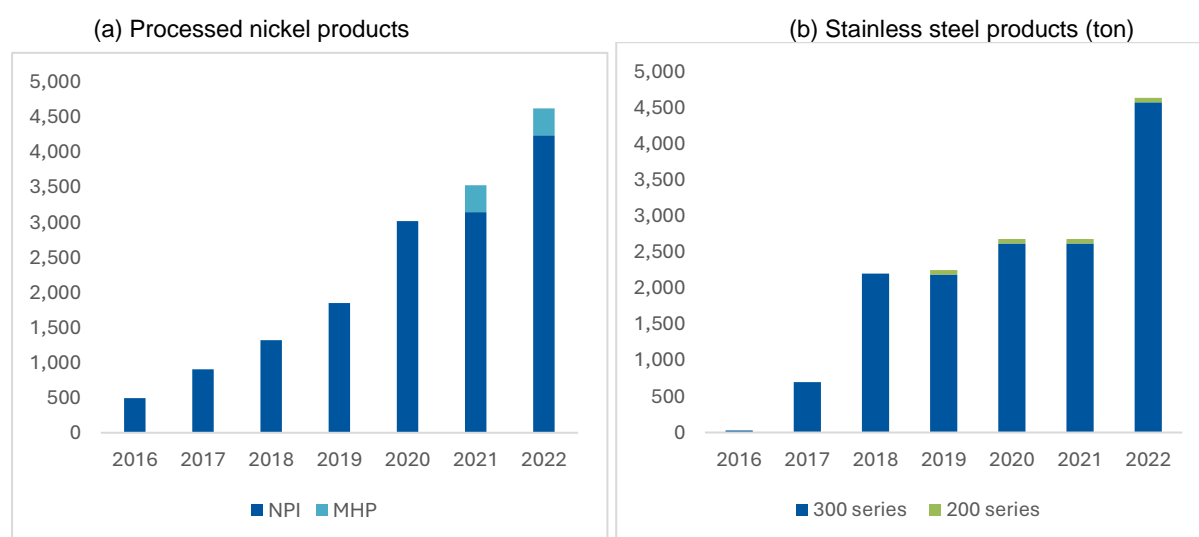
Source: authors' elaboration using data from BKPM (2022a).

The significant investment in the basic steel sector bought new technologies, expertise, and capital, thereby increasing production capacity in the nickel midstream and downstream industries. Figure 11

⁹ The mining law stipulates a grace period of 5 years before the export ban is implemented.

demonstrates the growth in the production capacity of products, including nickel pig iron and ferronickel, which are important materials for stainless steel production, as well as MHP for EV battery production. The figure reveals a clear rise in production capacity for nickel pig iron and ferronickel between 2016 and 2020, with average annual growth rates exceeding 45% and 16%, respectively. The two largest producers of these products are PT Obsidian Stainless steel and PT Virtue Dragon Nickel Industry, bringing a combined total production capacity of 3 million tons and 1 million ton, respectively (MEMR 2022).

Figure 11: Production capacity of nickel-based manufacturers



Note: NPI, nickel pig iron; MHP, mixed hydroxide precipitate.

Source: authors' elaboration using data from BKPM (2022b).

In contrast to nickel pig iron and ferronickel, Indonesia had virtually no production capacity for MHP in the past. However, to meet the ambition to develop an EV battery value chain, the government attracted a number of foreign firms to invest in MHP production. One significant company is Ningbo Lygend, which formed a joint venture with a local firm, Harita Group, creating PT Halmahera Persada Lygend. In 2021, an HPAL plant was constructed to produce MHP. The plant has a total production capacity of 37,000 tons per year for nickel-in-MHP (Ribeiro et al. 2021). This further paved Indonesia towards the development of the EV battery value chain, given the important role of MHP as a material for EV battery production. According to reports from the Ministry of Energy and Mineral Resources, three additional plants are currently in the construction stage, which will contribute an additional production capacity of 343,664 tons for MHP (MEMR 2022).

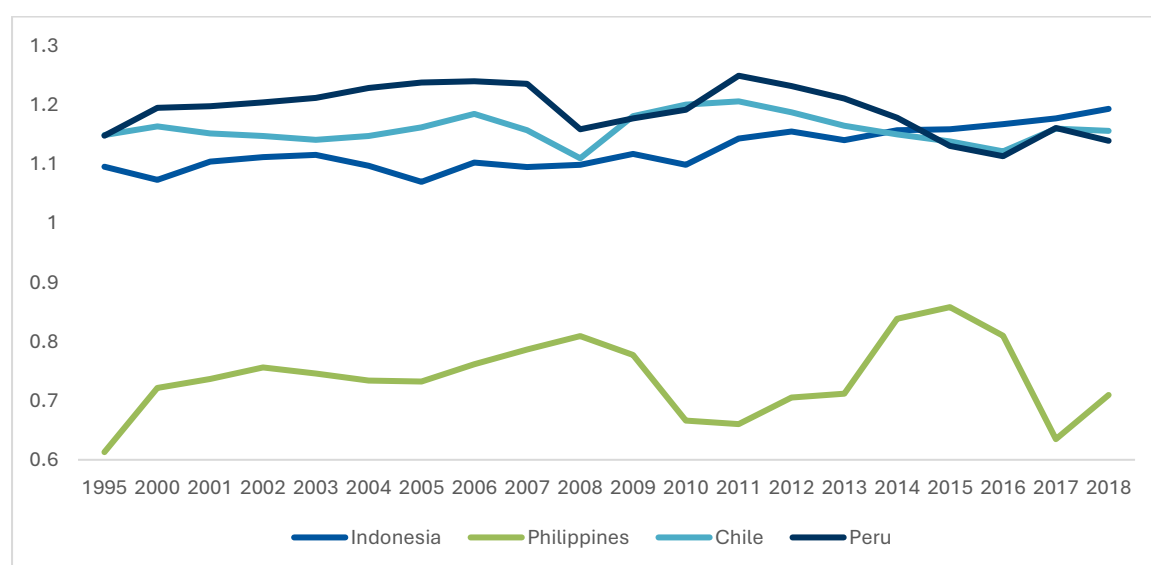
In the downstream sector, a wave of investments has spurred the establishment of stainless steel plants, resulting in a significant expansion of Indonesia's production capacity. Historically, Indonesia predominantly exported upstream products, particularly to China, where further processing into stainless steel took place. This trend translated into limited stainless steel production capacity in Indonesia before 2016, characterized by small-scale and fragmented producers.¹⁰ However, as numerous leading firms relocated their plants from China to Indonesia, Indonesia's stainless steel

¹⁰ Author interview with an officer from Directorate General of Metal, Machinery, Transportation Equipment, and Electronics Industry, Ministry of Industry, Indonesia [15 June 2023, LMTE].

production capacity began to surge. Between 2016 and 2022, the production capacity of stainless steel (series 300) reached 152.5 times higher. The substantial boost in production capacity was predominantly driven by the operationalization of PT Obsidian Stainless steel, which installed a production capacity of 1 ton per year (Ministry of Industry 2021).

The notable increase in production capacity within the midstream and downstream sectors of the nickel value chain has facilitated the development of stronger linkages between various sectors of the economy. Subsequently, the development of linkages within the nickel value chain enabled the midstream and downstream industries to use intermediate inputs/services provided domestically. Consequently, it is reasonable to predict that there would be an increasing share of domestic value added in the country's product export. In the context of the GVC world, the increasing share of domestic value added is important as it indicates the rising competitiveness of a country in a particular sector (Andreoni et al. 2021b; Lee et al. 2021). We can analyse the database for trade-in value added to assess the competitiveness of Indonesia's basic metal industry in the GVC world. Figure 12 depicts the competitiveness of basic metals of selected mining-rich countries.¹¹ An index higher than unity suggests that the country has competitiveness compared with other countries. The figure shows that Indonesia's competitiveness in the basic metal industry has consistently increased, surpassing countries like Chile and Peru. In particular, Indonesia's competitiveness in the basic metal industry has continued to increase and reached a record high of 1.2 in 2018.

Figure 12: Domestic competitiveness in basic metal of selected mining-rich countries



Source: authors' calculation using OECD's (2023) TiVA database.

The development of backward and forward linkages plays a crucial role, especially for countries rich in natural resources, where concerns often arise regarding the potential enclave nature of this sector. Therefore, a country can harness the advantages of its natural resources for structural transformation by fostering linkages from the mining sector to other industries, particularly those involved in

¹¹ Competitiveness in the GVC world follows Wang et al. (2013). Instead of using gross exports (as 'traditional revealed comparative advantage'), GVC-RCA uses value-added contributions to exports. Using value-added contribution would provide a better picture of competitiveness in the GVC world than using gross export the latter included overlook the fact that the export value still carries value added from other countries.

producing complex and high-value-added goods. Linkage development plays an important role in the context of natural resource products, which tends towards additive value chains instead of vertically specialized value chains (Kaplinsky and Morris 2016). However, such linkages do not occur automatically. We argue in the next section that state activism drove linkage development (in keeping with Kaplinsky and Morris 2016; Lebdioui 2020; Morris et al. 2012). We argue that this theory is supported in the case of nickel in Indonesia since 2014, following a series of government interventions that the linkages began to develop.

4 Role of the state in resource-based industrialization in Indonesia

In this section we discuss state activism in the nickel value chain through the promotion of nickel downstream activities. This has been facilitated through the implementation of various government regulations in Indonesia and aligns with the broader trend observed in other resource-rich countries, where there has been a resurgence of interest in state activism following the end of the 2000s commodity boom (see Dargent et al. 2017; Nem Singh and Ovadia 2018; North and Grinspun 2016).

Various policies have been implemented in resource-rich countries, encompassing downstream policies, beneficiation, and efforts to increase value added, based on the belief that processing raw materials will facilitate forward linkages to other sectors and foster economic growth (Bam and De Bruyne 2017). However, as Hausmann et al. (2008) argue, these approaches have not always achieved the desired outcomes. This highlights the complexities of such policies, indicating that achieving their goals is not always straightforward.

In the case of nickel downstreaming in Indonesia, the government has used both regulations and SOEs to foster the development of the downstream segment of nickel. Furthermore, the policy in the nickel value chain is extensive, encompassing various segments of the nickel value chain, from the upstream segments to downstream segments, including the EV industry. Moreover, this strategy is overt in its aim to foster linkage development within the entire value chain.

One significant regulation is the new mining law. The introduction of the mining law reflected a significant shift in the management of mining resources in Indonesia. The mining law, while initially intended to replace the mining licensing system, also incorporated elements of resource nationalism. It mandates mining companies to engage in domestic processing and refining of raw commodities, encompassing metals, non-metals, and stones, before exporting them to the global market (as stipulated in Article 130). The decline in global commodity prices, leading to an expanding trade deficit for Indonesia, led the government to introduce additional value requirements for mining companies, as mandated by the mining law. Most notably, in 2014, the government officially implemented export bans on unprocessed mineral products, including nickel, intending to force mining companies to refine and add value to mineral commodities before exporting the raw materials. The execution of this policy encountered challenges and opposition from various groups. Notably, mining companies objected to the export ban, asserting that it would adversely affect their operations, primarily due to the limited availability of smelter facilities for processing nickel ore. Insufficient domestic smelter facilities were viewed as a major obstacle preventing mining companies from refining nickel ore. In 2014, only a limited number of smelters were operational, falling significantly short of the government's initial targets. Reports indicated that only 14% of the total smelter facilities were in the production stages (MEMR 2015), raising concerns among policymakers (Sudoyo 2013).

Despite granting a 5-year grace period for mining companies to meet smelting requirements, the mining law posed challenges for many companies in constructing smelter facilities. High construction costs, estimated at USD 5–7 million (Dinata et al. 2020: 16), were a major barrier. The export ban significantly impacted the cash flow of these companies, limiting their ability to invest in smelter facilities (Dinata et al. 2020: 1). Given the prevailing conditions, the government opted to relax the export ban on nickel and other mineral commodities in 2017. The revised regulation permitted the export of certain metal mineral concentrates until January 2022, subject to compliance with specific requirements. These included divestiture obligations, smelter construction plans, and payment of the applicable export tax. Nickel-producing companies were also mandated to supply 30% of low-metal content nickel ore to domestic smelters. However, the government accelerated the nickel ore export ban in 2019 while allowing the export of other mineral commodities. This decision was influenced by demands from foreign investors who had made significant investments in constructing smelting facilities in Indonesia.

The decision to reintroduce the export ban on nickel highlights the government's acknowledgement of nickel's crucial role in the country's resource-based industrialization, particularly within the context of the green energy transition. Before 2019, the industrial strategy outlined by the government did not emphasize EV batteries as a primary downstream product for nickel. However, given the advancements in EV technology and the increasing global trend towards EVs, nickel gained strategic importance in the EV industry. Consequently, the government expanded its downstreaming objectives from stainless steel to encompass EV batteries. In doing so, the government aimed to seize the opportunity presented by the global EV boom to leverage Indonesia's position as the world's largest nickel producer. The goal was to attract investments in the EV battery supply chain and establish a fully integrated value chain, spanning from the extraction of nickel ore to the production of EV batteries and the manufacturing of electric cars and motorcycles.¹²

Developing a fully integrated supply chain for the EV battery industry in Indonesia is not simple. First, the existing supply chain for stainless steel cannot be directly used for EV batteries, as they have different production processes and different supply chains. Specifically, EV batteries require Class 1 nickel, whereas the stainless steel industry primarily uses Class 2 nickel. In this case, Indonesia's nickel ore deposits mostly contain Class 2 nickel. Although Class 2 nickel can be refined to Class 1 nickel through hydrometallurgical processes such as HPAL, the process is very costly (Ribeiro et al. 2021). Furthermore, other countries' experiences with HPAL projects have highlighted the complexity of the projects and the risk of failure (Home 2014). Second, the EV battery supply chain consists of several segments, each with different companies specializing in specific niches. This contrasts with stainless steel, where a single company typically integrates vertically. In the global EV battery value chain, multinational companies collaborate with domestic companies across various segments, including component, battery, and EV manufacturers. Consequently, this demanded a different approach to attract lead firms to invest in Indonesia.

Given these challenges, the government's approach to developing EV battery manufacturing involves a higher level of active support than the stainless steel manufacturing approach. Industrial policy in EV batteries covers both the upstream and downstream segments of the industry. In the upstream segment, the government continues to leverage the export ban on unprocessed nickel ore to attract companies to invest in this sector. Additionally, recognizing the need for substantial investment in

¹² Author interview with the Deputy Coordinating Minister of Maritime and Investment Affairs [26 June 2023, MAR1].

HPAL projects, the government is actively promoting collaboration between Chinese firms and local companies through joint ventures to construct these projects.

Since 2021, multiple HPAL pipeline projects, such as PT Halmahera Persada Lygend, Huayue Nickel & Cobalt, and PT QMB New Materials, have been initiated (Durrant 2023). On completion of these HPAL projects, it is estimated that Indonesia will contribute to 70% of the global nickel Class 1 supply, further enhancing its position in resource-based industrialization within the nickel value chain.¹³ In addition to regulatory measures, the government has proactively involved SOEs in playing a significant role in the nickel mining value chain. The government facilitates its active participation in downstream activities such as refining and processing mining ore commodities. Recognizing that establishing refining facilities demands substantial investment, the government has employed diverse strategies, including capital injections into mining SOEs. This aligns with the broader government approach, especially during the Joko Widodo (Jokowi) administration, where capital injections to SOEs for development projects were actively pursued (Kim 2020). Over the years, there has been a notable increase in the proportion of annual average state capital injection in overall government expenditure, rising from 1.7% (2010–14) to 5.3% (2015–19) (Kim 2020: 2). Notably, ANTAM, a recipient of state capital injection, has utilized an additional capital of 3.5 trillion Indonesian rupiahs to fund the construction of a ferronickel smelter in North Maluku (ANTAM 2020). This smelter, scheduled for full operation in 2023, is considered a significant milestone in advancing the region's nickel industry.

Beyond capital injections, the government took a further step by establishing a holding company to expand the size of mining SOEs. Four mining SOEs—Inalum, ANTAM, Timah, and Bukit Tambang—were consolidated into one holding company, with Inalum designated as the parent company because it is wholly owned by the government. This consolidation resulted in the total corporate assets of the holding company reaching USD 20.83 billion, surpassing the individual worth of each company, which ranged from USD 4–6 billion before their integration into the holding company (Winati 2016). The establishment of the holding company is anticipated to enhance the financial capacity of mining SOEs, enabling active participation in acquiring shares of foreign mining firms and facilitating access to international financing (Kim 2018). This move is particularly crucial given that mining SOEs face limitations in internal resources to fund substantial corporate initiatives, including the construction of smelting facilities.

The government then strategically employs SOEs to participate in the upstream sector and downstream industries, aligning with Indonesia's aim to control the entire supply chain. The Indonesia Battery Corporation (IBC) was established to advance the development of the EV battery industry, with four key mining and energy SOEs (PLN, Pertamina, ANTAM, and Inalum) each holding a 25% stake in IBC (Inalum 2022). IBC serves as a central entity ensuring the active involvement of domestic firms in the EV battery value chain.¹⁴ Foreign companies investing in EV battery manufacturing in Indonesia are mandated to collaborate and partner with IBC, fostering technology transfer between

¹³ With HPAL technology, battery-grade nickel sulphates can be produced from lower-grade laterite ores. Of the 220,000 metric tons of the world's HPAL project production capacity being developed, 70% are located in Indonesia (Bloomberg NEF 2021).

¹⁴ Author interview with an officer at the Deputy for State-Owned Enterprises Business Development, Research, and Innovation, the Coordinating Ministry of Economic Affairs, Indonesia [30 June 2023, COR1].

foreign firms and IBC and facilitating Indonesia's progression in the EV battery value chain in the long term (Huber 2022).

Although Indonesia has an abundant reserve of nickel, the government acknowledges that it is important for the country to link up with the lead firms to develop nickel downstream industries. Indonesia's limited financial and technical capabilities to process nickel ore make such a link-up more crucial (Pandyaswargo et al. 2021). Linking up with lead firms is also crucial to gain access to the necessary technical expertise and financial resources. In this case, Chinese firms were considered potential partners for developing nickel processing facilities in Indonesia for several reasons. First, China possesses competitive technology in smelting facilities.¹⁵ Over the years, China has developed the capability to process nickel ore into midstream and downstream products. China accounted for 29.7% of the global export of nickel downstream products.¹⁶ At the company level, several Chinese firms have emerged as major players in the nickel value chain. In the upstream segment, three Chinese companies—Tsinghan Group, Delong, and Jichuan—contribute 17%, 9%, and 7% of global nickel production, respectively (Norilsk Nickel 2022). These companies also dominate the downstream segment because of the integrated nature of the stainless steel value chain. Four Chinese companies in the stainless steel market, namely Tsinghan, Delong, Baosteel, and TISCO, account for over 54% of global stainless steel production.¹⁷

The partnership between China and Indonesia within the nickel value chain has been an important development. In 2013, before the Indonesian government banned nickel ore exports, a substantial portion of Indonesia's nickel ore was shipped to China (86.0%). Simultaneously, Indonesia ranked as the major nickel ore supplier for China, contributing to 58.4% of total nickel ore imports in China. This reliance on the Indonesian nickel ore supply gave Indonesia an advantage to attract Chinese firms to invest in the country. Indonesia offered access to the nickel resources needed by Chinese domestic industries. Moreover, the long-standing nickel trade between Indonesia and China has given Chinese investors valuable knowledge about the Indonesian nickel sector. This familiarity with Indonesian nickel reserves has proven beneficial for Chinese firms as they began investing in and establishing downstream nickel industries in Indonesia (Dinata et al. 2020).

The strong political relationship between the Indonesian and Chinese governments further contributes to the attractiveness of Chinese firms as potential partners for Indonesia's nickel downstream industries. This close connection dates back to 2005, when both governments established a comprehensive partnership. In 2013, there was a mutual commitment to develop a nickel-based industrial park during a high-level summit between China's President Xi Jinping and Indonesia's then-president, Susilo Bambang Yudhoyono (Yean and Negara 2020). The relationship between the two nations deepened during Jokowi's administration, particularly in terms of economic issues. President Jokowi recognized China's increasing role in the global political economy and saw it as a potential source of investment to support his infrastructure development goals (Mursitama and Ying 2021).

At the same time, China has expressed its ambition to play a significant role in the geopolitical landscape through initiatives like the Belt and Road Initiative. This aligns with Jokowi's aspirations to

¹⁵ Author interview with Deputy Minister of Investment/Head of Indonesia Investment Coordinating Board [22 June 2023, BKP1].

¹⁶ Authors' calculation using data from UN Comtrade.

¹⁷ Authors' calculation using data from Thyssenkrupp (2023).

develop infrastructure in Indonesia. This made China a favoured funding source for Jokowi's infrastructure projects (Anwar 2019). China has actively participated in numerous infrastructure projects in Indonesia, with investments totalling USD 1.3 billion in 763 projects (Damuri et al. 2019). Notably, Chinese investments in the nickel value chain, spanning smelting facilities, stainless steel production plants, and nickel industrial parks, represent the most substantial Chinese investments in Indonesia. Despite operating on a business-to-business (B2B) scheme without government guarantees, these projects received endorsement from government elites in both countries (Negara and Leo 2018). Some have argued that China's investment in Indonesia's nickel value chain serves as a potential model for future Belt and Road Initiative investments in the country (Damuri et al. 2019).

Although the initial plan was to attract investment to develop smelting facilities, the government saw greater economic benefits if investors opted to construct industrial parks.¹⁸ Consequently, the government adjusted its strategy to encourage investors to focus on building industrial parks instead. Industrial parks foster the integration of all industries within the nickel value chain due to proximity. This approach aligns with the integrated nature of the nickel value chain, characterized by vertical integration from upstream to downstream activities. The construction of industrial parks provides additional linkages to various sectors. It accommodates refining facilities for processing nickel ore into intermediate goods like ferronickel and supports the establishment of production facilities for downstream products such as stainless steel. In addition to fostering vertical linkages (i.e. connecting nickel to industries like stainless steel and EV battery manufacturing), the industrial park also facilitates the development of horizontal linkages. This involves establishing supporting infrastructure within the industrial park, such as electricity, power, water supply, and other amenities like hotels and transportation facilities (roads, seaports, and airports), thereby enhancing both backward and forward linkages within the industrial park.

Although the mining law did not mandate the construction of an industrial park, many mining firms opted to invest in such facilities. A notable example is Tsingshan Group, the largest ferronickel producer and the second-largest stainless steel producer globally. Initially lacking plans for an industrial park, the company eventually decided to expand its investment beyond smelting facilities by establishing a nickel industrial park (Yean and Negara 2020). The construction of this industrial park ensures Tsingshan Group a secure supply of raw materials and intermediate products crucial for stainless steel production, mitigating uncertainties associated with the mining sector, such as price fluctuations and policy uncertainties from export bans (Camba et al. 2022). The industrial park provides access to cost-effective Indonesian labour and streamlines bureaucratic procedures in the country. These factors influence Tsingshan Group's decision to undertake its construction (Tritto and Camba 2022).

In 2013, the Tsingshan Group, in collaboration with the Bintang Delapan Group, established the Indonesia Morowali Industrial Park (IMIP). Operating under a joint venture agreement, the Tsingshan Group held a controlling stake of 66.25% in IMIP and the Bintang Delapan Group owned the remaining 33.75% (Damuri et al. 2019). The construction of IMIP was facilitated by the Bintang Delapan Group acquiring a 47,000-hectare concession in Morowali, Central Sulawesi, as early as

¹⁸ Author interview with Deputy Minister of Investment/Head of Indonesia Investment Coordinating Board [22 June 2023, BKP1].

2007. Furthermore, these two companies had previously formed partnerships in the nickel mining sector well before the government's imposition of added value requirements (Camba et al. 2020).

Following the establishment of IMIP, significant efforts were made to construct large-scale refining facilities within the industrial park. The company established a number of smelting facilities with a total capacity amounting to 40% of Indonesia's total smelting capacity (Camba et al. 2022). The development of the industrial park also involved a substantial investment of USD 4 billion, which encompassed various facilities such as transportation networks (including an airport, seaport, and major roads), a 1,830-megawatt steam power plant for electricity generation, and additional supportive amenities like hotels and schools (Camba et al. 2022: 2382). This massive investment in the construction of IMIP has attracted several companies to also invest in IMIP, including 18 nickel mining companies and producers of stainless steel and other steel products (IMIP 2023).

In sum, the significant investment in the nickel value chain in Indonesia has been driven by state activism and the industrial policies of the Indonesian government. The result has been the development of linkages within the industry, enabling the growth of downstream sectors. As a result, Indonesia has successfully developed its downstream industry, allowing it to export higher-value-added products and move up the value chain.

5 Challenges and future considerations

Indonesia's downstream nickel sector tells a complex story. The country has achieved remarkable success in stainless steel production, capturing two-thirds of global exports. Yet this headline figure masks significant challenges. Local communities have seen limited economic benefits from this rapid industrial expansion. Environmental impacts raise serious concerns. Furthermore, despite the country's nickel abundance, its progress in developing EV battery production—a key growth market—remains constrained. These challenges offer important lessons for other resource-rich countries seeking to transform their economies through downstream processing. Let us examine each of these issues in turn.

The development of Indonesia's nickel processing sector has undoubtedly driven dramatic economic expansion in the country's key production regions. Industrial hubs have emerged in Konawe, Morowali, and the Halmahera districts, marked by new processing plants, smelters, and integrated industrial parks. Yet a closer examination of the data reveals a disconnect between headline growth figures and local living standards.

This disconnect is evident in the divergence between regional gross domestic product (GDP) growth and household consumption patterns. Take Morowali, for instance. Despite posting remarkable GDP growth of 28.74% in 2020 and 28.4% in 2022, household consumption grew by just 1.26% and 3.62%, respectively—a fraction of the headline economic expansion. The pattern repeats across other nickel-producing regions. In Halmahera Selatan, substantial GDP growth of 21.38% in 2022 corresponded with modest household consumption growth of only 4.95%. Perhaps most striking is Halmahera Timur, where a GDP surge of 26.56% in 2023 yielded household consumption growth of merely 3.18%. Even Konawe's impressive GDP expansion of 22.52% in 2023 translated into household consumption growth of just 5.56%. These figures tell a clear story: the economic gains from nickel processing are not effectively reaching local communities. While industrial development

has dramatically boosted regional output, the benefits remain highly concentrated, failing to materially improve living standards for most households in these regions (Figure 5).

Table 5: Growth by expenditure in nickel-producing regions (%)

Regions	2019	2020	2021	2022	2023
Morowali					
Household consumption	4.13	1.26	0.9	3.62	3.73
Government consumption	4.69	5.6	2.62	2.21	3.36
GRDP	20.26	28.74	25.28	28.4	20.34
Konawe					
Household consumption	5.64	-0.61	1.89	2.48	5.56
Government consumption	6.01	-8.95	-2.94	1.08	6.23
GRDP	11.84	6.89	7.78	15.38	22.52
Halmahera Timur					
Household consumption	5.86	1.33	0.51	4.43	3.18
Government consumption	29.87	-3.51	0.86	4.08	9.68
GRDP	5.14	0.24	8.93	1.18	26.56
Halmahera Selatan					
Household consumption	3.73	-0.63	4.57	4.95	3.32
Government consumption	7.45	-8.77	2.6	2.78	4.66
GRDP	12.15	17.64	14.22	21.38	27.78

Source: authors' elaboration based on data from BPS Morowali Regency (2024), BPS Konawe Regency (2024), BPS Halmahera Timur Regency (2024), and BPS Halmahera Selatan Regency (2024).

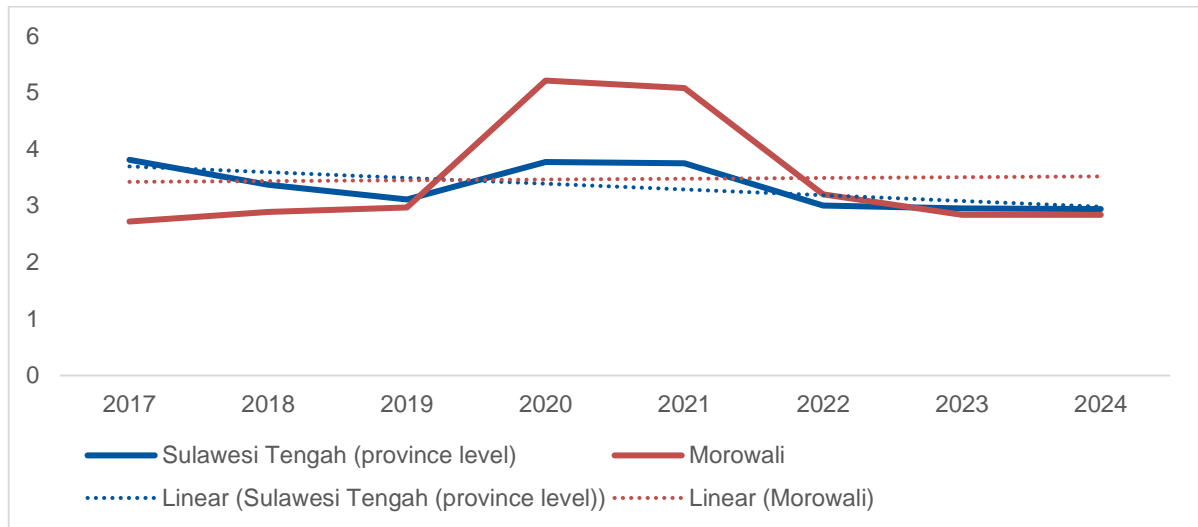
Why have local communities captured so little benefit from this industrial expansion? The answer lies in the structural characteristics of Indonesia's nickel processing sector. The industry has developed as a classic economic 'enclave'—physically present in these regions but largely disconnected from the local economy.

Technical expertise comes predominantly from outside, with skilled positions filled by workers from other regions or countries. This pattern has created a troubling two-tier labour market. Local workers, constrained by skills gaps, remain largely confined to lower-paying positions. More lucrative technical and managerial roles go to outsiders. Low wages in the positions accessible to local workers further limit the diffusion of economic benefits. The result is a modern version of the resource enclave that has historically plagued many resource-rich regions, where extractive industries generate impressive output figures but fail to catalyse broader local development.

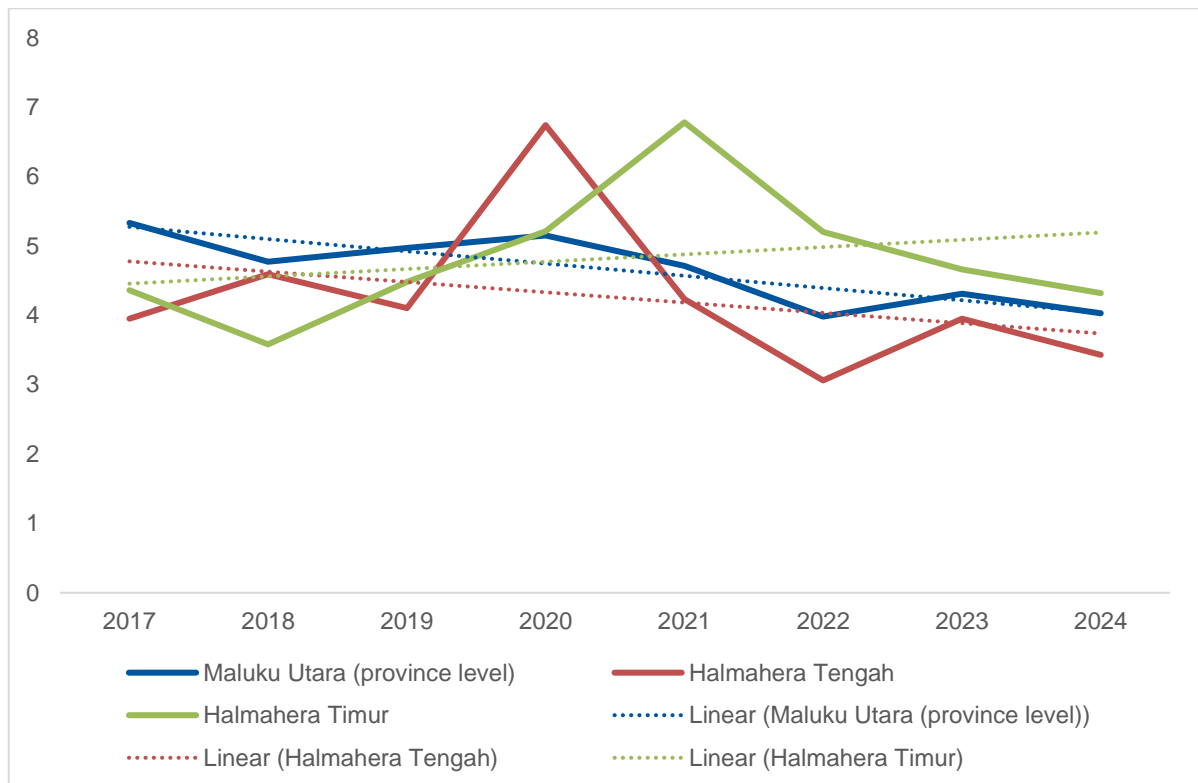
The employment data paint a picture of the nickel industry's economic impact. At first glance, the falling unemployment rates in nickel-producing regions since 2020 might suggest positive industry effects. However, deeper analysis reveals this improvement stems primarily from post-pandemic economic recovery rather than any substantial job creation by the nickel sector (see Figure 13). Consider the evidence from major nickel-producing regions: Konawe's sharp decline in unemployment from its 2020 peak of 5.5% merely represents a return to pre-pandemic levels, closely mirroring the broader provincial trends of Sulawesi Tenggara. The major nickel processing centres of Halmahera Tengah and Halmahera Timur show unemployment rates converging with the Maluku Utara provincial average by 2024—a pattern that suggests minimal industry impact on local employment. Most striking is the case of Morowali, where post-pandemic unemployment rates have settled back to match the Sulawesi Tengah provincial average, indicating that general economic recovery, rather than nickel industry expansion, drives the improvement.

Figure 13: Unemployment rate in nickel-rich regions compared with that at province level (%)

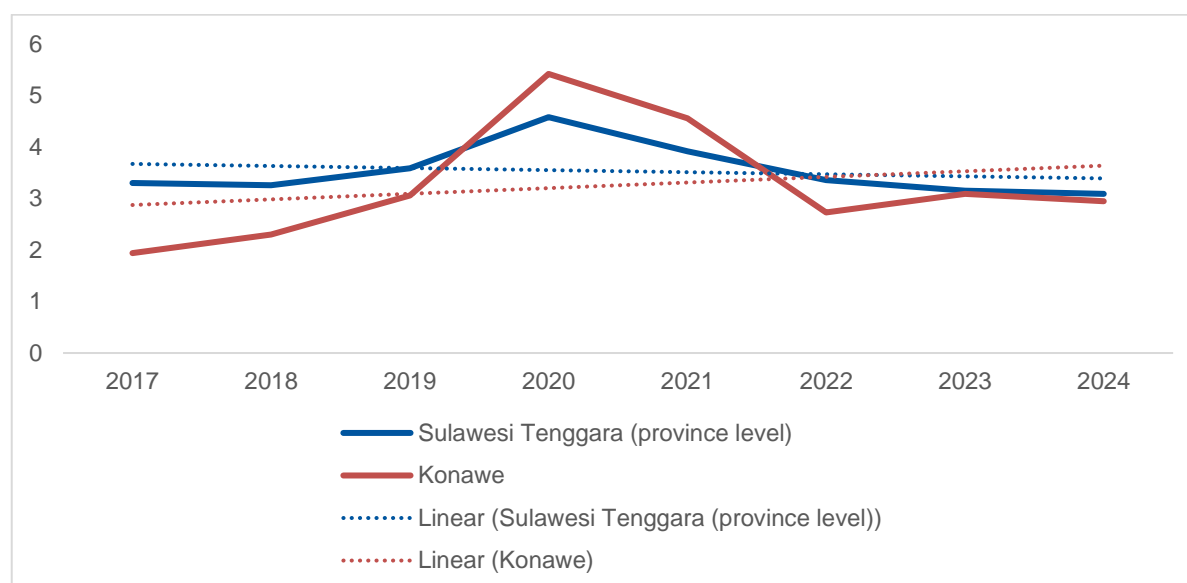
(a) Morowali and Sulawesi Tengah



(b) Halmahera Timur, Halmahera Tengah, and Sulawesi Tengah



(c) Konawe and Sulawesi Tenggara



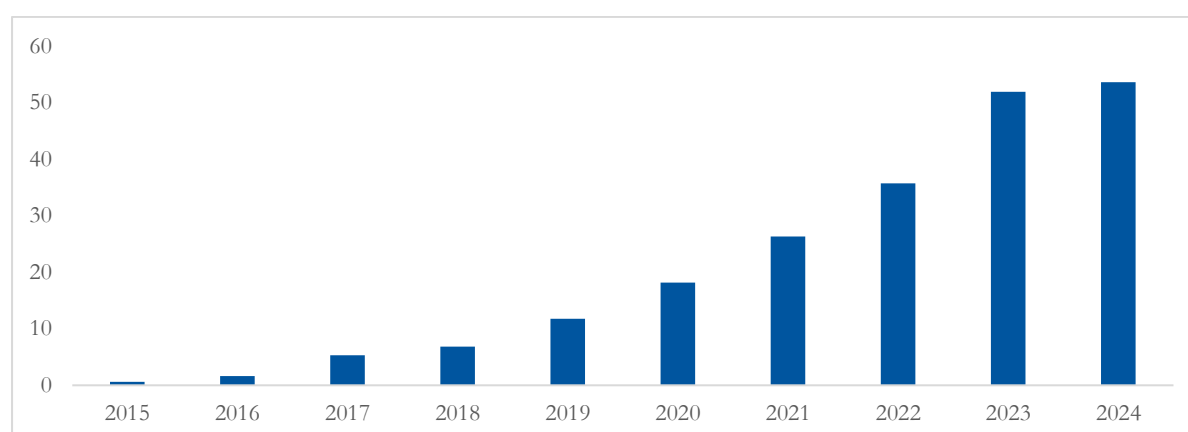
Source: authors' elaboration based on data from BPS Morowali Regency (2024), BPS Konawe Regency (2024), and BPS Halmahera Timur Regency (2024).

There also appears to be a mismatch between the nickel industry's requirements and local workforce capabilities. The sector's operations, which rely on advanced technology and substantial capital investment, generate relatively fewer employment opportunities compared with traditional industries—particularly for local communities. This situation is further complicated by a skills gap, as local workers often lack the specialized technical expertise required for these operations.

The case of Morowali, a key nickel processing hub, provides insights into this challenge. As of February 2024, 40.06% of Morowali's working population has only primary school education or lower (including those with no formal education or incomplete primary education). Higher education attainment remains limited, with 1.80% holding diploma qualifications and 11.40% with university degrees (BPS Morowali Regency 2024). This educational profile is not unique to Morowali but reflects a broader pattern across Indonesia's nickel-producing regions, suggesting a persistent gap between industry requirements and local workforce capabilities.

In addition to limited local economic benefits, the environmental footprint of Indonesia's nickel industry reveals a profound transformation with far-reaching implications. What began as a strategic push for industrial expansion has evolved into an environmental challenge. The challenge is striking: between 2015 and 2024, the industry's growth necessitated the construction of more than 66 new power plants to support smelting operations. The industry's reliance on coal-fired power plants has triggered a dramatic surge in carbon emissions. From negligible levels in 2015, emissions from coal-fired power plants in nickel-producing regions have soared to approximately 50 million tons annually by 2023. This increase has been particularly sharp since 2019, with emissions more than tripling from about 15 million tons in 2020 to nearly 50 million tons by 2023 (see Figure 14).

Figure 14: Annual carbon dioxide emissions (million tons/annum) from nickel-related projects



Source: authors' calculation using data from Global Coal Tracker (2024).

Beyond these, the environmental impact manifests in multiple ways, with particularly concerning implications for Indonesia's nickel sector. The energy-intensive processes of nickel smelting and refining generate significant air and water pollution, threatening both local ecosystems and community health. The challenges are especially acute given that Indonesia's nickel production generates two to five times more emissions than operations using high-grade nickel sulphide ore in other countries (Adhiguna 2024). The environmental challenges extend well beyond emissions. The industry's growing reliance on HPAL technology for battery-grade materials presents significant risks in managing tailings, particularly given Indonesia's high rainfall and seismic activity. This concern is compounded by the industry's poor environmental monitoring practices—as of early 2023, only a quarter of refiners had implemented water pollution monitoring systems (Adhiguna 2024). Environmental non-governmental organizations have been particularly vocal in their criticism, documenting extensive cases of environmental degradation and deforestation threats to Indonesia's rich biodiversity, and demanding stricter oversight of the industry's rapid expansion (CREA and CELIOS 2024). These mounting environmental concerns raise fundamental questions about the industry's alignment with global climate objectives and sustainable development goals.

An apparent contradiction emerges in Indonesia's strategic position: while the country seeks to establish itself as a significant participant in the EV battery supply chain—a sector integral to global decarbonization efforts—its production processes contribute substantially to carbon emissions. This presents a complex dynamic for Indonesia's nickel processing industry. The country's aspirations in the EV battery sector appear to be potentially constrained by its increasing environmental impact, particularly regarding carbon emissions. This situation warrants attention given that participants in the global EV market increasingly emphasize environmental sustainability in their supply chains, suggesting potential implications for Indonesia's competitive position in this sector. As Addison and Roe (2024) argue, countries maintaining high-emissions pathways risk losing investment and market share to competitors who can achieve lower emissions, particularly as environmental, social, and governance concerns increasingly influence commercial decisions. This suggests that Indonesia's high-emission nickel processing approach might affect its future competitiveness in the global EV supply chain.

However, greening the nickel value chain is not straightforward. The inherent characteristics of mining and processing operations present environmental challenges across multiple production stages. At the upstream level, emissions emerge from mining equipment and processing energy requirements, while downstream processing introduces additional complexities through pyrometallurgical smelting and hydrometallurgical processes, which risk air, water, and soil contamination. Although technical solutions exist—such as renewable energy integration and waste recycling—their implementation faces significant economic barriers. Many Indonesian mining companies limit their environmental initiatives to basic compliance measures due to high costs, suggesting that effective environmental transformation may require governmental incentive structures for emission reduction (Lubis and Maqoma 2024).

The trajectory of Indonesia's EV battery production development presents multiple technical and market-related constraints that extend beyond environmental considerations. While Indonesia has achieved significant expansion in nickel production, demonstrating an eightfold increase since 2015, this growth has primarily manifested in stainless steel production rather than EV battery manufacturing. The figure indicates limited market penetration in the global battery sector: Indonesia's battery production capacity of 10 GWh represents approximately 0.4% of global capacity, which exceeds 2,800 GWh (Adhiguna 2024).

The challenges in Indonesia's nickel sector appear to be rooted in both specific technical constraints and the organization of supply chains. In relation to the former, the predominance of Class 2 nickel ore in Indonesia's reserves necessitates the implementation of HPAL processing to achieve the Class 1 grade specifications required for EV batteries. The adoption of HPAL technology presents significant technical complexity and operational uncertainties, as evidenced by implementation challenges observed in global contexts (Ribeiro et al. 2021). Furthermore, in relation to the latter, while Indonesia has demonstrated capabilities in developing vertical integration within its stainless steel production chain, the EV battery supply chain introduces distinct organizational challenges. This sector is characterized by a high degree of fragmentation across specialized segments, each requiring specific technical competencies and coordinated industrial approaches—capabilities that remain under development in the Indonesian context. The complexity of market entry is particularly evident in battery cell production, where three dominant companies—CATL, LG, and Panasonic—control more than 65% of global production capacity, accounting for 32.5%, 21.5%, and 14.7%, respectively (IEA 2022a).

Therefore, despite significant policy initiatives and investments to develop EV battery production capabilities, Indonesia's position in this high-value segment remains limited. The divergence between this outcome and Indonesia's documented success in stainless steel production underscores the complex technical, organizational, and environmental challenges that need to be addressed to establish a competitive position in the global EV battery market.

6 Conclusion

This paper has examined how Indonesia achieved upgrading in the global nickel value chain. What is particularly notable from Indonesia's case is how the country moved from being one that concentrated on the upstream segment towards one with strong downstream manufacturing of nickel-based products such as stainless steel. Over the last 5 years (2020–24), Indonesia experienced the diversification of nickel downstream with the stainless steel segment increasing its contribution to

Indonesia's total export. The export of stainless steel increased significantly and has overtaken oil, which was Indonesia's major commodity product. Indonesia's export of stainless steel also contributes to the increasing economic complexities in the country's export basket. Furthermore, Indonesia also emerged as a global player in stainless steel, accounting for 67% of total global export. Indonesia has also pursued the development of a domestic EV battery value chain to compete in the global EV market.

This paper reaffirms the significance of state activism in linkage development and upgrading in resource-based manufacturing. This is particularly important due to the additive nature of the value chain of resource-based manufacturing, where value addition occurs sequentially. In the case of nickel, the process begins with the extraction of nickel ore, followed by processing and refining to produce midstream products such as nickel pig iron, ferronickel, nickel mattes, MHP, mixed sulphide precipitate, and sulphide concentrate. Finally, the downstream manufacturing process involves the production of stainless steel, nickel alloys, nickel plating, and batteries. In short, in contrast to non-resource products that undergo vertical production processes, nickel's value addition process is carried out sequentially. Consequently, achieving upgrading requires a distinct understanding of how countries can effectively manage this process.

We argue that such upgrading can be accomplished by fostering linkage development in the nickel value chain. These linkages do not occur automatically. Instead, such linkages are driven by a myriad of factors, most notably state activism. In the context of nickel in Indonesia, state activism can be observed. A significant policy shift in the mining sector came with the introduction of the new mining law, signifying a fundamental change in Indonesia's approach to managing mining resources. This law mandates the domestic processing of mining commodities before being exported to the global market. To enforce this law, a series of trade policies were enacted, including a 2014 export ban on all mining ore. Although the policy was temporarily lifted in 2017, it was later reinstated in 2019, specifically for nickel ore. Beyond the upstream segment, the government has actively stimulated investment and production capabilities in the downstream sector by providing incentives on both the supply and demand sides. The state has also played an active role in the nickel mining value chain by encouraging participation of SOEs in the nickel value chain efforts.

In a GVC world where lead firms shape the countries' upgrading and participation, the state needs to ensure the local economy has a link-up with lead firms. We examined how the state promotes an ecosystem with the aim of creating such an environment to enable the link-up with lead firms. The Indonesian government leveraged the abundance of nickel to attract investment and build links with the leading firms in the nickel value chain. Since nickel constituted a significant portion of production costs, this policy effectively attracted lead firms to relocate their production capacity to Indonesia. The link-up with lead firms materialized through joint ventures, which has been recognized as one important step for the local firms to participate in the GVC. As shown in several cases, local firms can also foster improvements in technological capabilities and research and development through joint ventures. In the case of nickel in Indonesia, the link between local and lead firms is also supported by horizontal collaboration in the form of the industrial park. From 2020 to 2024), several industrial parks devoted to the nickel downstream industries have been built to further support the linkage between firms within the nickel value chain. Several nickel-based industrial clusters located close to a number of firms would facilitate a continuous learning process between local firms and lead firms, which would be an important factor for the long-term upgrading of Indonesia in the nickel value chain.

This further underlines the crucial role of the state in facilitating upgrading in the GVC world. Although Indonesia has had extracted nickel ore since the 1970s, traditionally, the country's participation in the

nickel value chain was relatively at the lowest rung. Indonesia exported its nickel in the form of ore, contributing limited economic value. This lack of value addition was attributed to limited downstream industries, hindering linkages within the nickel value chain. However, the government's intervention in the nickel industry after 2014 managed to address the relatively underdeveloped downstream industries.

The case of the nickel value chain in Indonesia that we present shows one possible trajectory for resource-rich countries to pursue industrialization by capitalizing on their natural resource endowment. The case study of Indonesia offers insight into how resource-rich countries navigate the complexities of GVCs and promote industrial development. That said, it is crucial to acknowledge that some questions remain. These include the issue of ensuring equitable local economic benefits, addressing environmental sustainability, and overcoming technical and structural barriers to move up the value chain.

Although Indonesia has achieved remarkable growth in nickel processing, particularly in stainless steel production, the benefits have not effectively translated into improved local household welfare. Additionally, the environmental impacts, such as significant carbon emissions and pollution from nickel smelting activities, pose challenges to the industry's alignment with global sustainability goals. Furthermore, the transition to higher-value segments, such as the EV battery supply chain, is constrained by the predominance of Class 2 nickel ores, high-cost processing technologies like HPAL, and a fragmented supply chain requiring greater coordination and investment. These unresolved issues highlight the need for a more inclusive, sustainable, and strategic approach to maximize the developmental potential of resource-driven industrialization. This includes promoting green industrial policies that integrate environmental sustainability into industrial policy by addressing ecological challenges like climate change, accelerating the transition to a low-carbon, resource-efficient economy, steering investments towards sustainable technologies, enhancing coordination to manage policy complexities, and aligning national efforts with global sustainability goals.

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Appendix: the global market for nickel

Nickel, one of the most common elements on Earth, has a long history since its discovery in 1751 (Nickel Institute 2023a). It gained significant attention in the twentieth century with the unveiling of its role in stainless steel (Nickel Institute 2023b). Nickel is considered to have properties that make nickel alloys resistant to corrosion and high temperatures. As such, the demand for nickel has increased substantially and has been an important component in modern technologies and engineering. The International Nickel Study Group documents that nickel is used in more than 300,000 products in a wide range of sectors such as industry, transport/aerospace, and marine (see INSG 2021).

The value chain of nickel, akin to other minerals, comprises three main segments. In the upstream segment (i.e. mining), nickel is extracted from two types of deposits—laterite (near-surface) and sulphide (underground) deposits. The type of the ore influences its application in midstream and downstream products. Nickel from laterite deposits is primarily used in the production of stainless steel, while that from sulphide deposits is used in the creation of cathodes, crucial components for electric vehicle (EV) batteries. The midstream segment encompasses activities to process and refine nickel ore, resulting in midstream products such as nickel pig iron, ferronickel, nickel mattes, nickel–cobalt mixed hydroxide precipitate, mixed sulphide precipitate, and sulphide concentrate. Downstream nickel products encompass stainless steel, nickel alloy, nickel plating, and batteries. Among these, stainless steel holds paramount importance, constituting 69% of total nickel consumption. Despite batteries accounting for only 11% of nickel usage (Nickel Institute 2023a), recent technological advancements emphasize the growing significance of nickel in batteries, particularly for EVs, as it enhances energy density and extends vehicle range (Chen and Yarham 2021).

Nickel exhibits a broad geographical distribution worldwide. Nickel deposits are found in diverse locations, ranging from northern regions like Russia and Finland to tropical countries such as Indonesia, the Philippines, and Zimbabwe. Nickel mining sites are also spread across various income levels. Notably, some leading producers are classified as high-income countries, including Australia, Finland, and Canada, whereas others, like Zimbabwe, fall within the category of lower-middle-income countries.

As of 2021, Indonesia and Australia are the top two countries with the largest nickel reserves globally. Both nations boast around 21 million tons of reserves each (refer to Appendix Table A1). Other countries, such as Brazil and Russia, also hold substantial nickel reserves, with proven reserves reaching 16 million tons and 7.5 million tons, respectively. In terms of production, Indonesia is the world's largest nickel producer, contributing approximately 1 million tons in 2021, representing 30.4% of the global nickel production. Meanwhile, the Philippines and Russia came second and third where they produced 370,000 and 250,000 tons of nickel, respectively, in the same year.

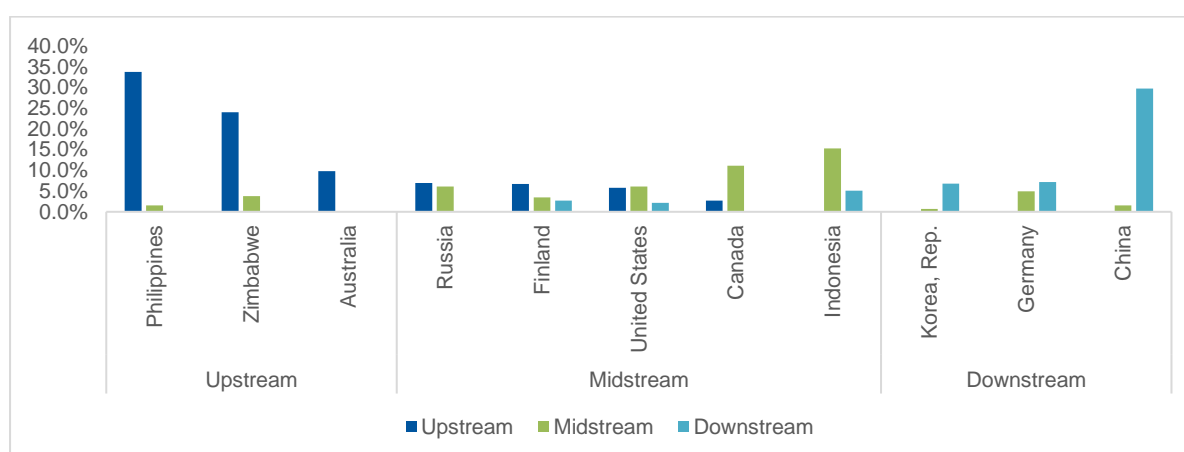
Table A1: Overview of nickel-rich countries

No	Country	Reserve		Production		Export	
		Value	Share	Value	Share	Value	Share
1	Australia	21,000	22%	170	7%	425	9.8%
2	Brazil	16,000	17%	73	3%	237	5.5%
3	Canada	2,800	3%	150	6%	118	2.7%
4	China	2,800	3%	120	5%	0	0.0%
5	Cuba	5,500	6%	49	2%	NA	NA
6	Dominican Republic	NA	NA	47	2%	NA	NA
7	Indonesia	21,000	22%	760	30%	0	0.0%
8	New Caledonia	NA	NA	200	8%	NA	NA
9	Philippines	4,800	5%	320	13%	1,456	33.7%
10	Russia	6,900	7%	280	11%	300	6.9%

Note: data for reserve and production are extracted from USGS (2023) whereas export data are gathered from UN Comtrade (2022).

Source: authors' elaboration from various sources.

Countries' positions in the nickel global value chain (GVC) are determined by their contributions to the export of nickel-based products on the global market. Appendix Figure A1 illustrates the roles of selected countries in three nickel product categories: upstream, midstream, and downstream. To understand countries' participation in the nickel value chain, it is important to create a group of products that represent respective segments (i.e. upstream, midstream, and downstream). Appendix Figure A1 summarizes nickel products by segment and harmonized system (HS) code. This section uses the global HS four-digit subheading level to discuss the GVCs for nickel products. Notably, the Philippines, Zambia, and Australia emerged as leading exporters of nickel, collectively accounting for over 60% of nickel ore exports. These countries predominantly operate in the upstream segment of the nickel value chain, with relatively limited exports of midstream and downstream nickel products. In contrast, countries like Russia, Finland, and the United States are positioned in the upstream and midstream segments, maintaining a balanced contribution to global exports in these categories.

Figure A1: Select countries' share in the global export nickel-based products (%)

Source: authors' calculation using data from UN Comtrade (2023).

Countries positioned towards the right end of the figure exhibit strong competitiveness in the downstream segment, constituting a significant share of nickel downstream exports. For example, China's downstream product exports contribute approximately 30% to the global downstream product

export market. The case of Indonesia is particularly intriguing within the nickel GVC. Unlike other nickel-rich developing countries that tend to specialize in the upstream segment, Indonesia manages to participate in both midstream and downstream segments.

Stainless steel is a major player in the nickel value chain, consuming approximately 69% of the world's total nickel ore. On the other hand, EV batteries, while currently constituting a smaller share of global nickel consumption, are gaining prominence because of the growing demand for clean energy. A thorough analysis of each downstream industry will provide the context for understanding Indonesia's upgrading efforts within the nickel value chain.

Stainless steel is a major product for nickel, with 69% of nickel ore supplied for its production. Despite its long history dating back 100 years, recent technological advancements have led to a wider use of stainless steel in various applications. Its advantages, such as formability, weldability, ductility, and sustainability, as well as its ability to enhance corrosion resistance, have made it a key component in numerous products such as kitchenware, construction, automotive, medical, architecture, defence, and energy (World Stainless 2023). In recent years, the clean energy transition agenda has also boosted demand for stainless steel in renewable energy products, such as solar photovoltaic power, hydro turbines, and wind turbines (ISSF 2023). As a result, the demand for stainless steel has risen in recent years, outpacing the growth in demand for other forms of iron and steel. Between 1980 and 2021, stainless steel production growth reached 5.35%, surpassing the growth of other metals such as aluminium (3.66%), copper (2.54%), and carbon steel (2.42%).*

China dominates stainless steel production, accounting for approximately 56% of the world's total output at 32 million tons (Statista 2023). This dominance is attributed to factors influencing the sourcing and supply of production plant locations. Raw material availability, including nickel, iron, and energy, is crucial as it constitutes a significant share of production costs (Aperam 2020). Proximity to customers also plays a pivotal role in determining industry location. As a result, stainless steel production is concentrated in Asia, with China being the primary producer, contributing to 69% of the total global stainless steel production. In contrast, Europe and America only contributed 17.5% and 5%, respectively.

Although currently dominating the global stainless steel market, China can be considered a newcomer. Traditionally, China heavily relied on importing stainless steel. Between 1992 and 2000, the country spent USD 7.7 billion on importing stainless steel. From 2001 to 2009, this figure rose to USD 36.1 billion.† However, the situation began to shift in 2010 when China achieved a trade surplus of USD 224 million in the stainless steel market. Since then, the country has sustained a surplus in this product, averaging USD 3,367 million annually. In 2021, the country exported USD 10,334 million, accounting for 16.8% of the global stainless steel export. Conversely, several European countries lost their dominance in the stainless steel trade. Germany, which accounted for 11.2% of the global exports in 2000, only contributed 5.6% to the total stainless steel exports in 2021. Similarly, in the

* Authors' calculation using data from Statista (2023).

† Authors' calculation using data from UN Comtrade (2023).

same period, the share of Belgium's stainless steel export in the global market dropped from 8.2% to 6.5%.[‡]

The shift in the key players in the stainless steel industry is also reflected at the firm level. Historically, companies from developed countries such as Acerinox (Spain), Aperam (Luxembourg), and Thyssenkrupp (Germany) dominated the market share for stainless steel, accounting for 23%, 21%, and 20% of global production in 2010, respectively (see Appendix Table A2). However, the landscape has gradually changed with the emergence of several Chinese companies as the leading stainless steel producers. By 2015, three Chinese companies had secured a place among the biggest players in the stainless steel industry. The domination of Chinese firms in the stainless steel market became even more pronounced in 2022 when the four largest stainless steel producers were from China.

Table A2: Leading producers in stainless steel value chain

Number	2010		2015		2022	
	Company	Production share (%)	Company	Production share (%)	Company	Production share (%)
1	Acerinox (ESP)	3.28	Tsingshan (CHN)	5.6	Tsingshan (CHN)	13.8
2	Aperam (LUX)	3	TISCO (CHN)	4.5	Delong (CHN)	5.9
3	Thyssenkrupp (DEU)	2.9	POSCO (KOR)	3.9	Baosteel (CHN)	5.2
4	POSCO (KOR)	2.8	Outokumpu (FIN)	3.6	TISCO (CHN)	4.5
5	TISCO (CHN)	2.6	Baosteel (CHN)	3.4	POSCO (KOR)	3.3
6	Outokumpu (FIN)	2.55	Acerinox (ESP)	2.9	Acerinox (ESP)	3.3
7	Yusco (TWN)	1.98	Aperam (LUX)	2	Outokumpu (FIN)	3.2

Note: ESP, Spain; CHN, China; LUX, Luxembourg; DEU, Germany; KOR, Republic of Korea; FIN, Finland; TWN, Taiwan.

Source: authors' compilation from Thyssenkrupp (2011, 2016, 2023).

In line with general patterns in the GVC world, a handful of transnational corporations have managed to consolidate their dominance in the industry. The production share of the five largest producers of stainless steel has steadily increased over the years. In 2010, these firms accounted for only 19% of global stainless steel production. Fast forward to 2022, and the top five companies contributed to over 39% of global stainless steel production. Notably, Chinese firms have emerged as leaders in the stainless steel industry, commanding more than 29.4% of worldwide stainless steel production.

These firms also have accumulated power by expanding their business line to the upstream segment. Notably, the Tsingshan Group oversees mining operations in Indonesia and Zimbabwe (Tsinghan 2023). This expansion solidified its position as the world's largest nickel producer, contributing 17% of global nickel production (Statista 2023). Major Chinese companies like Delong and Baosteel have similarly extended their upstream operations. Delong's acquisition of nickel mines across multiple countries positions it prominently in global nickel production. The company has an operation in Indonesia (Hewson 2016) and also Zimbabwe (Kazunga 2022) and now accounts for 9% of global nickel production (Statista 2023). Baosteel has diversified its production lines by gaining control of mines in Australia, Indonesia, and Africa through strategic partnerships, subsidiaries, and joint investments.

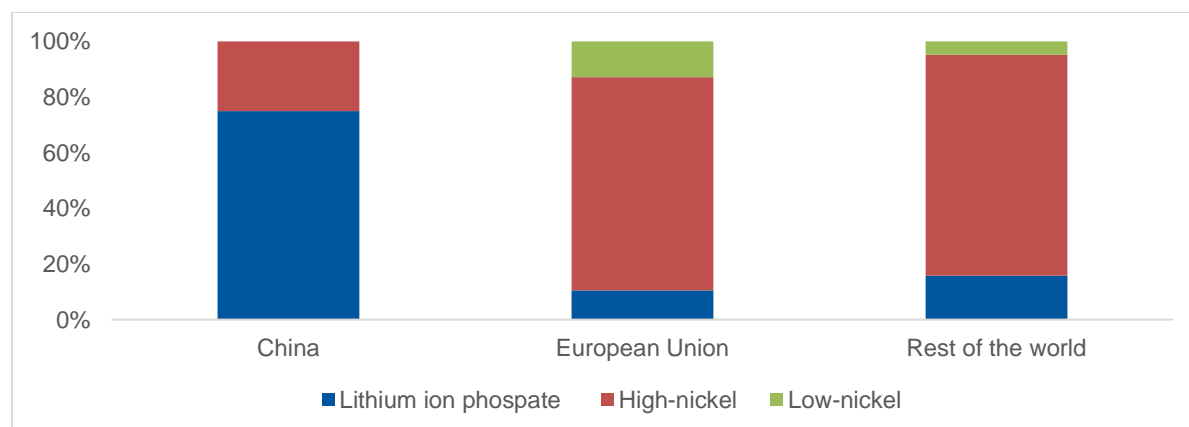
[‡] Authors' calculation using data from UN Comtrade (2023).

Directly controlling the upstream segment highlights the distinctive nature of the stainless steel GVC compared with other products, which often involve outsourcing various production tasks to different firms. Firms in the stainless steel industry have strategically invested in the upstream sector to address technical complexities and physical constraints (Mattera et al. 2017). This move is particularly advantageous given the upward trend in metal prices and the volatility in the global commodity market (McKinsey & Company 2013). Companies have invested in metal ore extraction to secure a cost-effective and stable supply of raw materials (McKinsey & Company 2013).

In addition to stainless steel, the EV battery industry plays a crucial role within the nickel GVC. Although batteries currently account for only 11% of global nickel consumption, their significance is expected to grow. This growth is driven by the rapid expansion of the EV market in recent years. According to data from IEA (2022a), the number of EVs on the road has reached 16.5 million. Interestingly, the surge in EV demand is not limited to developed countries, with China emerging as a leader in the EV market. This is attributed to a combination of subsidies and extensive EV infrastructure development (IEA 2021). In 2020, China recorded the sale of more than 3.3 million EVs, constituting over 50% of global EV sales. The increase in EV sales has, in turn, led to a surge in demand for EV batteries. IEA (2022b) reported a twofold increase in demand for EV batteries in 2021, reaching 340 GWh. Given the significance of nickel-based batteries in the EV market, the rising demand for EVs is expected to correspondingly increase the demand for EV batteries and, consequently, nickel.

Despite the variety of batteries available for EVs, nickel-based batteries still dominate the EV battery market. However, market preferences vary significantly by region, as shown in Appendix Figure A2, which categorizes batteries into lithium iron phosphate (LFP), high-nickel, and low-nickel batteries. China predominantly favors LFP batteries (74.6% of its market), with high-nickel batteries accounting for only 24.9%, largely due to Chinese producers prioritizing LFP as a cheaper battery chemistry that, through extensive research and development, now offers competitive ranges while being approximately 30% less expensive than nickel manganese cobalt battery alternatives; this cost advantage is further amplified by fierce competition among nearly 100 Chinese battery producers cutting profit margins to maintain market share (IEA 2024). In contrast, the European Union and rest of the world heavily rely on high-nickel batteries (76.7% and 79.5%, respectively) despite manufacturing costs being nearly 20% higher than in China, even before considering China's advantages in material sourcing and supply chain integration.

Figure A2: Market share of battery types by region



Source: authors' calculation using data from IEA (2024).

Similar to other complex and high-technology products, the production of EV batteries involves multiple stages, with different firms specializing in each stage. Broadly, the GVC of EV batteries can be segmented into three stages: mining/extraction, processing and refining, and cell components production. In the initial stage, several key metals are extracted. As discussed earlier in this paper, nickel is mined from two deposits—laterite (near-surface) and sulphide (underground) deposits. The two main nickel producers, Indonesia and the Philippines, account for 43% of global nickel production. Despite this, Chinese companies dominate the list of the largest firms in nickel mining. Notably, three Chinese firms—Tsinghan Group, Delong, and Jichuan—supply 17%, 9%, and 7% of global nickel production, respectively (Norilsk Nickel 2022).

The second segment of the EV batteries value chain is processing and refining, particularly crucial for nickel mined from Indonesia and the Philippines, where lower-grade nickel dominates the countries' reserves. This type of nickel necessitates a refined process to achieve battery-grade quality. Nickel grade 1, which can be used to produce battery-grade nickel easily, is mainly extracted from mining pits in Russia. The nickel refining and processing are concentrated in a handful of firms, with estimates suggesting that five major companies hold more than 70% of the refining capacity (IEA 2022b).

The subsequent stage involves the production of cell components such as cathodes, anodes, electrolytes, and separators. Similar to the nickel mining segment, the production of cell components is also dominated by Chinese companies. As shown in Appendix Table A3, only Sumitomo (Japan) and SK IE Technology (South Korea) made it into the list of the three largest companies in the production of battery components. Several companies control the largest share of battery cell components, with Jiangxi Tinci Central responsible for 35% of global electrolyte salt. Furthermore, in some segments, the market structure is even more concentrated. For example, four companies accounted for over 50% of the global production capacity in anode production (IEA 2022b). Despite significant investment in the production of cell components outside China to diversify the supply chain. For example, BASF (2022) with a planned cathode material production plant in Canada. Chinese companies are expected to continue dominating this segment. The IEA (2022b) projected that by 2025, the United States and Europe would contribute only 4% and 2% to global cathode production, respectively.

The last segment in EV battery production is battery cell production. This segment tends to be more diverse, with the three largest companies coming from three different countries. Nevertheless, it can also be argued that this segment is highly concentrated, with these three companies holding more than 65% of global production capacity. CATL is the leading producer of EV batteries worldwide, contributing 32.5% of global EV batteries, while LG and Panasonic account for 21.5% and 14.7% of world battery production, respectively.

The EV industry is marked by an active role of the state through various supports and policies (for existing support provided by authorities across the world, see IEA 2022b). Many governments have identified the EV industry as an important and emerging sector in the age of clean energy transition. Not only does it support carbon emission reduction, but also the EV industry is considered an emerging sector to boost the country's domestic economy (The White House 2022).

Table A3: Leading producers in EV batteries value chain

Segment	Company	Country	Market share
Nickel	Tsinghan Group	China	17%
	Delong	China	9%
	Jinchuan	China	7%
Cathode production	Sumitomo	Japan	N/A
	Tianjin B&M Science and Technology	China	N/A
	Shenzhen Dynanonic	China	N/A
	Ningbo Shanshan	China	N/A
Anode production	Ningbo Shanshan	China	N/A
	BTR New Energy Materials	China	N/A
	Shanghai Putailai New Energy Technology	China	N/A
Separators production	Zhuhai Enjie New Material Technology	China	N/A
	Shanghai Putailai New Energy Technology	China	N/A
	SK IE Technology	South Korea	N/A
Electrolytes production	Jiangxi Tinci Central Advanced Materials	China	35%
	Zhangjiagang Guotai-Huarong New Chemical Materials	China	N/A
	Shenzhen Capchem Technology	China	N/A
	Ningbo Shanshan	China	N/A
Battery cell production	CATL	China	32.5%
	LG Energy Solution	South Korea	21.5%
	Panasonic	Japan	14.7%

Source: authors' summary from IEA (2022b).

Additionally, authorities in many developed countries have implemented industrial policies to build alternative supply chains to reduce its dependence from the existing EV battery value chain that is dominated by Chinese companies. Many governments perceive the high dependence on the Chinese EV battery value chain as risky for the EV industry (Halligan 2023). As such, it is not surprising to see various industrial policies implemented in many developed countries. For example, the United States enacted the Infrastructure Investment and Jobs Act (bipartisan infrastructure law), allocating USD 3.16 billion to enhance the production capacity of the advanced battery supply chain in the United States. The funds cover upstream battery materials, refining, production plants, battery cells, pack manufacturing, and recycling facilities (US Department of Energy 2022). Likewise, the European Union is also investing in advancing battery technology, with EuBatIn allocating funding amounting to EUR 2.9 billion (USD 3.4 billion) for 2031 to develop battery supply chains (European Commission 2021).

State activism to develop the EV industry, including EV batteries, is not limited to developed countries that already have a significant demand for EVs. Several developing countries have outlined their target to participate in the global EV value chains (Ghoshal 2022). To achieve this goal, authorities in developing countries also provide financial incentives (e.g., tax credits and subsidies), support research and development to promote new technologies in EV batteries, and set targets for EV battery production (IEA 2022b; Appendix Table A4).

Table A4: Recent developments in nickel downstream industries and implications for Indonesia

	Stainless steel	EV batteries
Major development	<ul style="list-style-type: none"> • China as the emerging and leading player • Indonesia has already established strong relations with China 	<ul style="list-style-type: none"> • Increasing demand driven by clean energy transition • Indonesia gained an important role because of its natural advantage in the nickel industry
GVCs	<ul style="list-style-type: none"> • Vertically integrated • Fits with Indonesia's ambitions to build a vertically integrated value chain 	<ul style="list-style-type: none"> • Vertically specialized • Indonesia focuses on the downstream end of the EV battery value chain
Industrial policy in other countries	<ul style="list-style-type: none"> • N/A • Limited policy space (trade dispute with European Union) 	<ul style="list-style-type: none"> • Governments across the world provide support for EV battery and EV industries • Indonesia has more policy space to implement industrial policy in EV battery

Source: authors' elaboration.