Office of Industry and Competitiveness Analysis
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Export Restrictions on Minerals and Metals: Indonesia's Export Ban of Nickel

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Abstract

This is the second paper in a series of working papers that examines the effects of export restrictions placed on minerals and metals. This paper focuses on an export ban that Indonesia placed on nickel ores and concentrates initially in 2014 and implemented again in 2020 following a brief lapse in enforcement. Indonesia, a leading global source of raw nickel products, sought to strengthen and expand its downstream nickel production capacity partially through the use of the export ban. The downstream nickel products that are made in Indonesia feed into critical applications such as stainless steel, used in construction and industrial purposes, and lithium-ion batteries for electric vehicles. The potential impact of the export ban is examined using datasets that illustrate a shift in the composition of Indonesia's exports to higher-value nickel products, increases in downstream production, and more foreign investment in Indonesia following the ban. Finally, the paper also explores areas where the increases in downstream production capacity and foreign investment intersect with a variety of issues and challenges related to this growth. The appendix provides a theoretical approach to examine the effects of Indonesia's nickel export ban on the supply chain using partial equilibrium modeling.

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Introduction

Countries are increasingly imposing export restrictions—such as licensing requirements, taxes, quotas, and bans—on upstream raw materials in a bid to protect and develop domestic downstream industries. The minerals and metals sector tends to have geographically concentrated, capital-intensive production and large firms with market power. Many countries with robust mining industries are resource-rich, developing economies that export upstream inputs to higher-value downstream applications, and view export bans as a mechanism to capture a greater portion of the downstream supply chain value domestically.

During 2009 to 2021, export taxes and licensing requirements were the most common forms of raw materials export restrictions implemented. Export bans became a proportionally higher share of global export restrictions introduced in 2020 (22.5 percent) and 2021 (21.2 percent). Three exporters introduced ten bans on various ores and concentrates during this 12-year period, including Indonesia and Zimbabwe.

The first paper in this series, *Export Restrictions on Minerals and Metals: Estimation and Analysis of Supply Chain Effects from Zimbabwe's Chromium Ore Export Ban,* proposed and applied a modeling approach to estimate economic effects of Zimbabwe's export ban of chromium ore on the domestic downstream industry. The chromium ore export bans in Zimbabwe and nickel ore export bans in Indonesia share several key characteristics. First, Zimbabwe and Indonesia are both resource-rich, lower-income countries with burgeoning industrial sectors, particularly robust in mining. Second, both chrome and nickel are important inputs to steel production and increasingly demanded in emerging technologies with high downstream value-addition in the supply chain. Finally, China—a country lacking sizable chrome and nickel reserves—is the major downstream consumer for both chromium ore from Zimbabwe and nickel ore from Indonesia. Additionally, both countries implemented their respective export bans multiple times under evolving domestic industry conditions. This paper illustrates how Indonesia's recent export ban on nickel has affected production, trade, and investment, while highlighting some of the challenges to Indonesia's nickel sector that have coincided with the trade policy. Furthermore, the paper identifies how the Zimbabwe chromium ore export ban modeling approach could be applied to estimate the economic effects of Indonesia's export ban.

Nickel is a metallic element with a silvery-white, shiny appearance. It is the fifth-most common element on earth and occurs extensively in the earth's crust and core. Nickel is a critical mineral resource that is essential in hundreds of thousands of products. Its leading use is in alloying (the mixing of metals), particularly with chromium and other metals to produce stainless steel, and it has recently emerged as a critical component in many types of lithium-ion batteries for electric vehicles.[1] Nickel was classified as a critical mineral by the United States Geological Survey in 2022, an indication of nickel's growing significance, especially as a component for producing cathodes for lithium-ion batteries.[2]

[1] Nickel Institute, "About Nickel," accessed November 14, 2023.
[2] U.S. Geological Survey, "U.S. Geological Survey Releases 2022 List of Critical Minerals," U.S. Geological Survey," accessed November 14, 2023.

While nickel is produced all over the world, the United States and many other nickel consuming economies have limited nickel mine production and lack domestic nickel processing capabilities.[3] Hence, the United States is reliant on recycled scrap and imports to satisfy its nickel consumption needs. Indonesia stands out as an emerging leading global producer and exporter of nickel and nickel products and has become a focal point of the global nickel market in the past decade.

In recent years, Indonesia has attempted to position itself as a global leader in the processed nickel market. Endowed with vast nickel resources and anticipating a potential surge in global demand for nickel, Indonesia implemented trade restrictions in 2014 in an attempt to take advantage of its nickel resources and boost its downstream capabilities. As a result of Indonesia's restrictions, exports of raw nickel have essentially ceased while exports of downstream processed nickel products have surged. An inflow of foreign investment in downstream nickel production capacity—predominately from China (and principally owned by Chinese firms) –boosted Indonesia's processed nickel production following the export ban.

Overview

Nickel Products

Nickel is traded and consumed in a variety of forms and products based on chemical composition and stage of processing. In its raw form, nickel is sold and traded as nickel ore and concentrates. Nickel ores are the raw (unprocessed) form of nickel, typically contain 1–4 percent nickel when extracted, and, depending on the types of ore, can be further concentrated to 10–20 percent nickel. [4]

In terms of processed nickel, there are two types of primary nickel products which are informally referred to in the industry as "Class 1" and "Class 2" nickel products. High-purity Class 1 products (containing 99.8 percent nickel or above) and lower-purity Class 2 products (containing less than 99.8 percent nickel). These product classes are used for different applications and are associated with different types of nickel deposits (e.g., sulfide and laterite, described below). Class 1 nickel, also referred to as refined nickel metal, includes electrolytic nickel (whole and cut cathodes), pellets, briquettes, granules, rondelles and powders is primarily produced from sulfide deposits. Class 2 nickel comprises lower grade nickel products such as ferronickel, nickel oxides and nickel pig iron (a lower grade type of ferronickel) is derived from nickel found in laterite deposits. [5] Class 1 nickel in its metallic form, is traded on the London Metal Exchange (LME), the global market for trade of most nonferrous metals.[6]

Along with the two classes of products, a range of intermediate nickel products, typically containing between 40–70 percent nickel, are important in nickel supply chains. Mixed hydroxide precipitate (MHP),

[3] While the United States has limited capacity to produce raw and processed nickel, Talon Metals Corp. has released plans to develop a nickel-producing mine in Tamarack, Minnesota after permitting is received and potentially develop another deposit in Michigan in the future. Talon also plans to build a plant in North Dakota that will process nickel ores and concentrates produced at the Tamarack mine for use in batteries. Talon Metals Corp., *Talon Metals Corp. Moving Forward*, January 2024, 1, 22–23.

[4] Geoscience Australia, "Australian Mineral Facts: Nickel," accessed October 20, 2023.

[5] McRae, *2018 Minerals Yearbook: Nickel*, August 2023, 1.

[6] London Metal Exchange, "LME Nickel: Contract Specifications," accessed August 8, 2023.

mixed sulfide precipitate (MSP), nickel hydroxide cake, and nickel matte are examples of such intermediate nickel products, which require further processing before use in a final product. These types of intermediate nickel have gained relevance in recent years because they are increasingly used to produce nickel sulfate, a chemical compound used in some lithium-ion batteries for electric vehicles (EVs). Over two million tons of new or primary nickel are produced and consumed each year, evenly divided between Class 1 and Class 2 units.

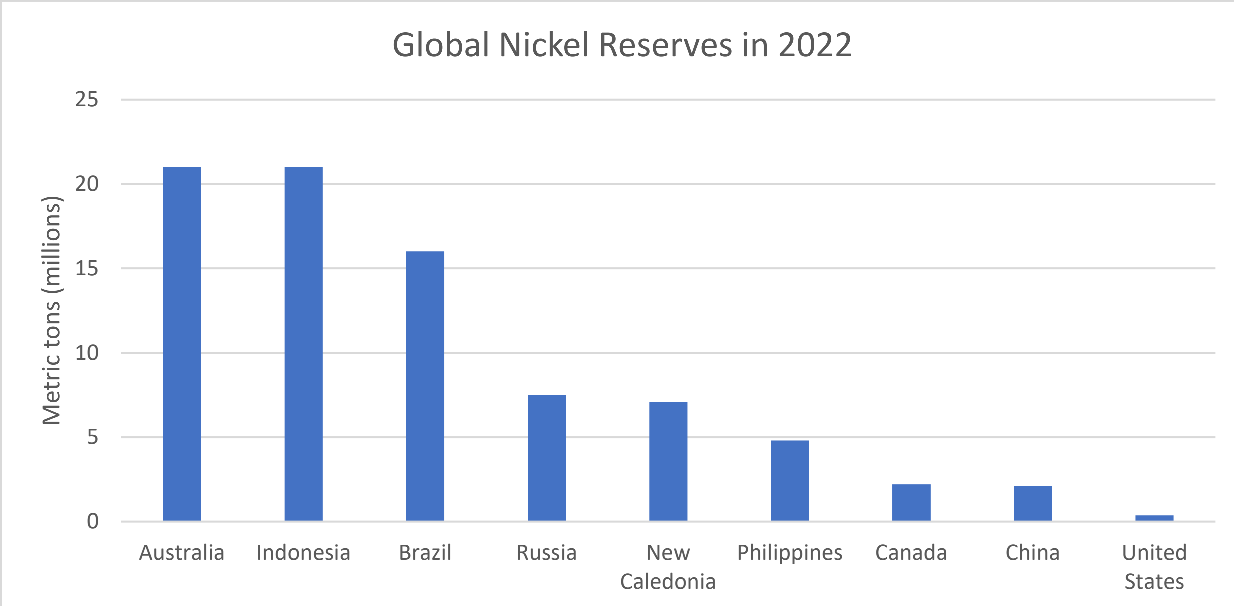
Global Nickel Resources

Two major types of deposits supply most of the nickel used today: sulfide deposits (such as those found underground in Russia, Canada, and Australia) and laterite deposits (including those found in Cuba, New Caledonia, Philippines, and Indonesia).[7] Sulfide deposits have been the main source of supply for over a century with relatively high-grade ore, typically in the range of 0.4-3.2 percent nickel.[8] Laterite resources are formed near the surface by weathering in a high temperature and humid climate. Due to differences in chemical compositions, methods of extraction and processing nickel differ by resource types.[9]

Global nickel reserves are estimated to be 90–100 million metric tons, and around 65 percent of the worldwide nickel deposits are laterite; the remaining 35 percent are sulfide.[10] Australia and Indonesia had the largest nickel reserves in the world as of 2022, accounting for about 40 percent of total nickel reserves (figure 1).[11]

[7] Boland, *Nickel—Makes Stainless Steel Strong*, accessed April 18, 2023; International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022.
[8] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022.
[9] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022.
[10] Nickel 28 Capital Corp., "Nickel 28 - About Nickel," accessed April 16, 2023; Stainless Steel World, "An Overview of World Nickel Resources," January 1, 2023.
[11] U.S. Geological Survey, *Mineral Commodity Summaries 2023: Nickel*, January 2023.

Figure 1 Global nickel reserves in 2022



Source: U.S. Geological Survey, Mineral Commodity Summaries 2023: Nickel, January 2023.

Until recently, nickel sulfide deposits provided the majority of Class 1 nickel production.[12] One of the issues facing the global nickel industry is the need to develop new high-grade sulfide nickel deposits, which have historically been the most economically viable form of nickel to process. [13] However, many of these sulfide resources have already been discovered in recent years and only a handful of new projects are expected to extract nickel from sulfide deposits in the future. As a result, over the past decade, laterite nickel deposits have emerged as the predominant source of nickel.

Nickel laterites, such as those primarily found in Indonesia, are not homogenous and are further divided into subgroups: limonites and saprolites.[14] These differences are important to note because they further divide how laterite deposits are processed and how the downstream nickel products are used. Limonite ore can be processed with a variety of methods to produce intermediate nickel products which can be used as feedstock for the production of nickel sulfate for lithium-ion batteries or Class 2 products for stainless steel.[15] Saprolite ore is generally not suitable for Class 1 products and is mainly used to produce Class 2 products for stainless steel.[16] These distinctions are important as many lateritic deposits, such as those found in Indonesia, contain both types of lateritic ore.

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[12] Nickel 28 Capital Corp., "Nickel 28 - About Nickel," accessed April 16, 2023.
[13] Nickel 28 Capital Corp., "Nickel 28 - About Nickel," accessed April 16, 2023.
[14] Laterite deposits can be further classified into subtypes with different ore types that contain different nickel-bearing minerals and occur at different zones of the laterite deposit. In the laterite deposit, the ore weathered upper soil is called limonite, and less weathered lower soil is called saprolite. Nickel is mainly absorbed in clay in the ore rather than in minerals. Saprolite has a relatively higher grade (1.8-3.0 percent) than limonite (0.8-1.8 percent). Marsh, Anderson, and Gray, *Nickel-Cobalt Laterites: A Deposit Model*, 2013, 17, 22–23, USGS Publications Warehouse.
[15] Nickel 28 Capital Corp., "Nickel 28 - About Nickel," accessed April 16, 2023.
[16] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022.

Nickel supply has historically been adequate for global consumption, but the need for battery-grade products is changing the market. Supply of Class 1 nickel is relatively tight and the rapid rise in demand for lithium-ion batteries is expected to create more demand for this type of nickel. In general, sulfide resources are a good fit for producing battery-grade Class 1 nickel. However, most of the production growth in the coming years is expected to come from the regions with vast amounts of laterite resources, such as Indonesia, the Philippines, and New Caledonia, which are generally more suitable for Class 2 products.[17]

Global Nickel Production

As mentioned above, there are two types of primary nickel products: high-purity Class 1 products (containing 99.8% nickel or above) and lower-purity Class 2 products (containing less than 99.8% nickel). Relationships between different nickel resource types (sulfide and laterite) and product types (Class 1 and Class 2) are complex, requiring various nickel production methods by resource type.

The different types of nickel deposits and their production process flows, along with the leading producers associated with each, are illustrated in figure 2. Sulfide ore is suitable for pyrometallurgical [18] processes, as ore grades are relatively high and easily concentrated. Currently, underground sulfide ore is the main source of high-purity Class 1 products--such as nickel metal and nickel sulfate--used in all nickel applications, including stainless steel and battery cathodes. The two main types of lateritic ore (limonite and saprolite) follow different processing streams. Saprolite ore is typically processed with pyrometallurgical methods into Class 2 primary nickel products (e.g., ferronickel and nickel pig iron) used in stainless steel but not suitable for battery cathodes. Low-grade limonite ore is usually processed via hydrometallurgical[19] methods such as high-pressure acid leaching (HPAL), as it is easy to leach the absorbed nickel from the clay in the ore or pyrometallurgically.[20] Ultimately, limonite ore can be used to produce intermediate products (which are then further processed into nickel sulfate for lithium-ion batteries) or Class 2 products.[21]

[17] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022.

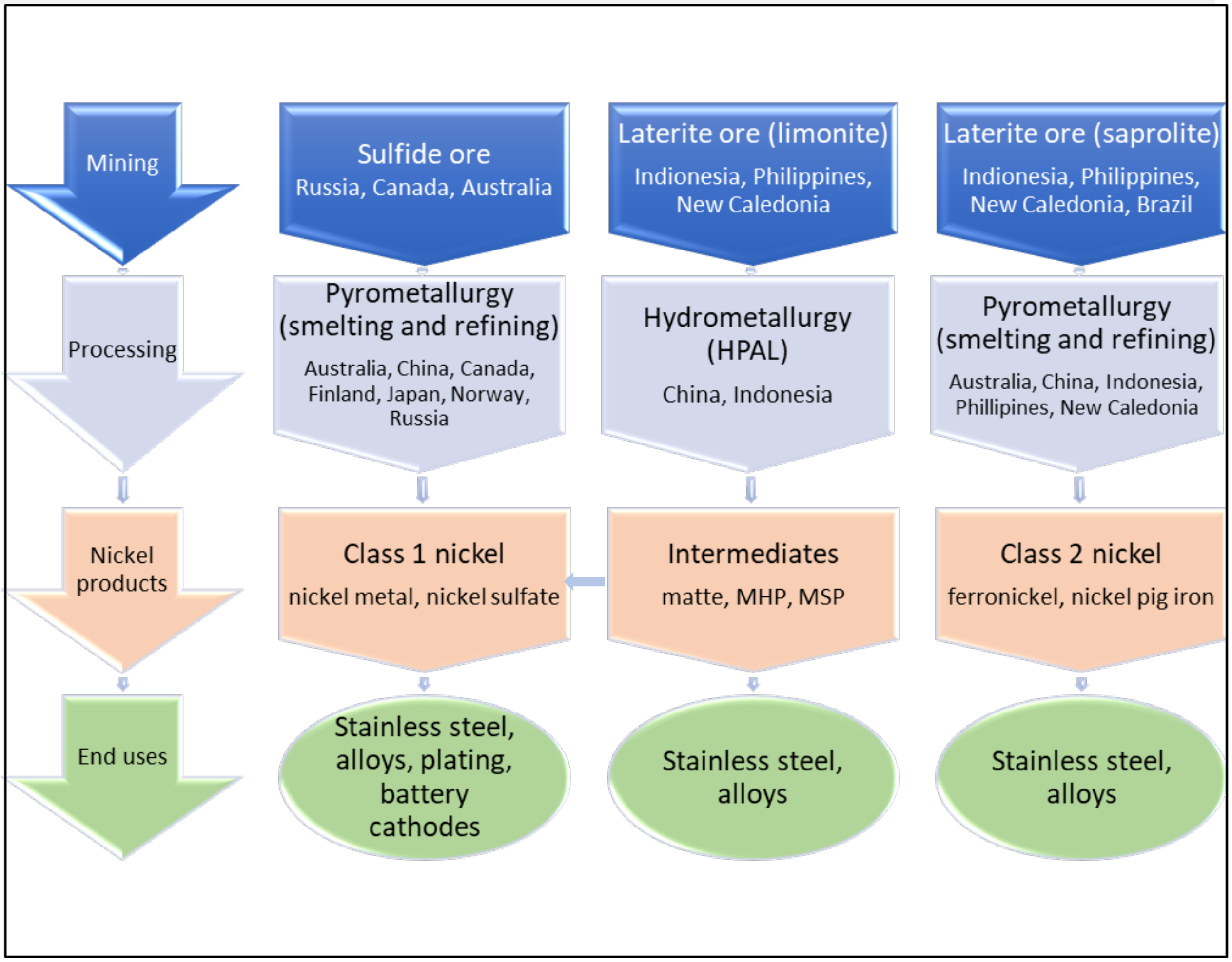
[18] Most sulfide ores then undergo a series of pyrometallurgical processes consisting of roasting, smelting, and converting the ore to intermediate products that are further refined into primary nickel products. Tundermann et al., "Nickel and Nickel Alloys," in *Kirk-Othmer Encyclopedia of Chemical Technology*, 2013, 4.

[19] Hydrometallurgical processing of laterite ores involves leaching with ammonia or with sulfuric acid. High-Pressure Acid Leaching (HPAL) is a type of hydrometallurgical processing low-grade nickel ore by combining it with sulfuric acid under high pressure and heat, producing a slurry that allows for the extraction of nickel. The technique was pioneered in the 1960s in Cuba. Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023; Tundermann et al., "Nickel and Nickel Alloys," in *Kirk-Othmer Encyclopedia of Chemical Technology*, 2013, 5.

[20] Pyrometallurgical processing typically includes a series of processes consisting of roasting, smelting, and converting. Tundermann et al., "Nickel and Nickel Alloys," in *Kirk-Othmer Encyclopedia of Chemical Technology*, 2013, 4.

[21] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022, 143–44.

Figure 2 Simplified nickel production process flows by product type with leading producers



Source: IEA, The Role of Critical Minerals in Clean Energy Transitions, May 2021, 143; Azevedo, Goffaux, and Hoffman, "How Clean Can the Nickel Industry Become?," September 11, 2020.; staff research.
Note: Not illustrated in the simplified figure, a relatively new production process upgrades nickel pig iron to nickel matte which then can be refined to Class 1 nickel.

Global mine production of nickel in 2022 was estimated at 3.16 million tons--an increase of almost 18 percent from 2021. Indonesia was the largest nickel producer at 1.54 million tons, or 49 percent of global mine production. The Philippines, Canada, and New Caledonia were the other top nickel mine producers, but collectively produced considerably less than Indonesia (table 1).

Table 1 Global nickel mine production (thousand metric tons)

	2020	2021	2022	2023 (forecasted)	2024 (forecasted)
Indonesia	781	1,043	1,605	1,959	1,994
Philippines	329	394	308	340	370
New Caledonia	200	186	200	233	236
Canada	233	190	221	210	230
Russia	169	151	156	219	228
Australia	158	117	95	158	169
Others	576	603	642	626	641
World total	2,444	2,683	3,161	3,398	3,868

Sources: Economist Intelligence Unit (EIU), "Nickel," in Commodity forecast: World, September 1, 2023.

Global Nickel Consumption

China consumes most of the world's nickel (accounting for 57 percent of global consumption in 2022), followed by the European Union (EU) and Japan (table 8). Globally, nickel is used in stainless steel (69 percent), followed by batteries (11 percent), nonferrous alloys (7 percent), plating (6 percent), and other applications.[22] In the United States, stainless steel and other alloys account for more than 85 percent of domestic nickel consumption.[23] Market observers expect that nickel will continue to be widely used in stainless steel and alloys but will also emerge as a primary component in lithium-ion batteries for EVs.[24] Global demand for nickel is projected to continue to record robust growth at an annual average rate of 5.3 percent in the 2023-24 forecast period, after rising by an estimated 1.5 percent in 2022 (table 2). These increases are expected to be driven by both the stainless steel and the EV battery sectors.[25]

Table 2 Global nickel consumption (thousand metric tons)

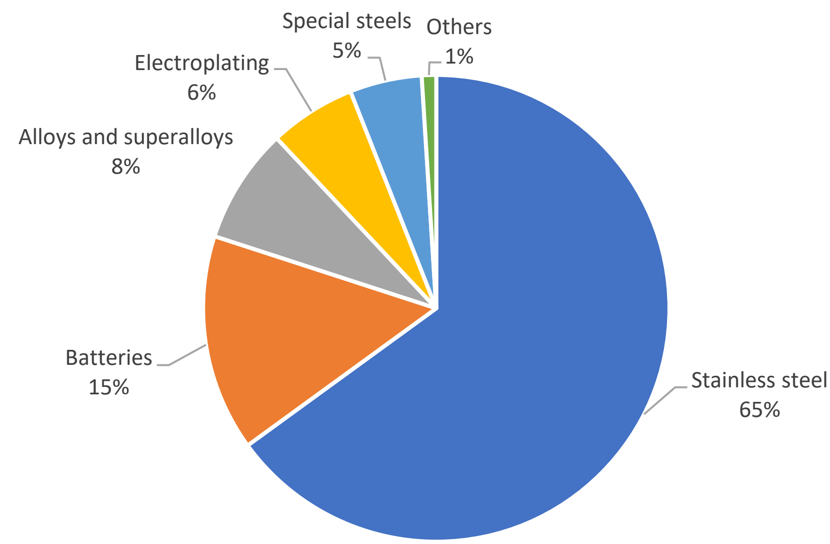
	2020	2021	2022	2023 (forecasted)	2024 (forecasted)
China	1,416	1,651	1,746	1,825	1,883
EU	267	270	264	248	255
Japan	149	168	182	181	184
US	98	99	116	117	115
South Korea	84	111	97	95	96
Taiwan	40	73	47	40	65
Others	393	590	556	604	724
World total	2,446	2,962	3,008	3,109	3,323

Sources: Economist Intelligence Unit (EIU), "Nickel," in Commodity forecast: World, September 1, 2023.

In 2022, the stainless steel industry accounted for 65 percent of primary nickel consumption worldwide. Batteries of all types accounted for the second largest share of primary nickel consumption that year (figure 3).[26]

[22] Nickel Institute, "About Nickel," accessed November 14, 2023.
[23] U.S. Geological Survey, *Mineral Commodity Summaries 2023: Nickel*, January 2023.
[24] Meng, "An Overview of World Nickel Usage," September 2021.
[25] Economist Intelligence Unit (EIU), "Nickel," in *Commodity forecast: World*, September 1, 2023.
[26] Statista, "Primary Nickel Consumption by Industry Share 2022," June 2023.

Figure 3 Distribution of global primary nickel consumption in 2022, by application



Source: Nornickel, "*Annual Report 2022*", page 29.

Market observers forecast that by 2040 stainless steel production will still be the leading use for nickel, but account for a smaller share than in 2022. Meanwhile, batteries are projected to represent as much as 41 percent of nickel demand by 2040, up from 15 percent in 2022.[27]

Stainless Steel

Nickel is added to stainless steel to increase formability, weldability, and malleability, while increasing corrosion resistance in certain applications. Nickel-containing stainless steels account for 75 percent of all production and typically contain between 8–11 percent nickel.[28] Ferronickel is the more widely used ferroalloy and typically contains between 20–40 percent nickel.[29] Nickel Pig Iron (NPI) is a much lower-grade form of ferronickel used in stainless steel production that was originally created in China as a cheaper alternative to higher-grade, more costly nickel products.[30] China and Indonesia were the only countries that produced NPI, which typically contains 4–13 percent nickel.[31]

Lithium-Ion Batteries

When used in the cathode of lithium-ion batteries, nickel helps deliver higher energy density and greater storage capacity at a lower cost. Two of the commonly used types of lithium-ion batteries, Nickel Cobalt Aluminum (NCA) and Nickel Manganese Cobalt (NMC), use 80 percent and 33 percent nickel respectively; newer formulations of NMC are also approaching 80 percent nickel. Overall, most lithium-

[27] Statista, "Nickel Global Demand Share by End Use 2040," April 2022.
[28] Nickel Institute, "Stainless Steel," accessed September 25, 2023.
[29] Crundwell et al., "Chapter 6 - Smelting of Laterite Ores to Ferronickel," in *Extractive Metallurgy of Nickel, Cobalt and Platinum Group Metals*, January 1, 2011.
[30] Mackay, "Nickel Pig Iron Market Contributes to Indonesian Nickel Mining Growth," accessed September 25, 2023.
[31] Schulte, *2018 Minerals Yearbook: Ferroalloys [Advance Release]*, June 2023, 25.3.

ion batteries rely on nickel-based chemistries albeit other non-nickel-based chemistries, such as lithium-ion phosphate, are available and growing in popularity.[32]

Owing to price spikes and concerns over ethical mining practices in the 2010s, EV producers have been working to reduce the amount of cobalt in batteries over the past several years. This implies, in many cases, an increase in the quantity of nickel used in batteries.[33] NCA batteries transitioned to NCA+, a nickel-rich variant of NCA, and NMC 111 batteries have moved increasingly towards NMC 532, NMC 622 and NMC 811, and could move to even more nickel-rich chemistries. This trend of moving away from cobalt could have major implications for global demand for nickel.[34]

Nickel sulfate, the form of nickel typically used in lithium-ion batteries, can be produced directly from nickel intermediates such as mixed hydroxide precipitate (MHP), mixed sulfide precipitate (MSP), and nickel matte, by dissolving Class 1 nickel (as nickel briquettes or powder), or from recycled materials.[35] Nickel sulfate is then used with other materials to make precursors for battery cathodes. The significant rise in the availability of low-cost nickel intermediates such MHP, MSP, and nickel matte has led producers in China to pivot to these feedstocks, but outside of China, nickel metal dissolution remains dominant feed for producing nickel sulfate. [36]

Indonesia's Nickel Sector

The history of mining for minerals in Indonesia began in the 16th century, originating with gold mining in Sambas, and Mandai, and West Kalimantan and tin mining in Bangka Belitung. At the time, mining was primarily carried out by immigrants from China. In 1915, nickel ore was discovered around Sorowako by the Dutch Government.[37] While Indonesia has diverse mineral resources, including copper, gold, tin, silver, bauxite, and iron, nickel is the largest in terms of reserves and production and a leading exporter of in different forms. [38] Nickel mining in Indonesia has been tracked back to 1941.[39]

Indonesia has prioritized the development of the nickel processing and refining industry in Indonesia's National Industry Development Master Plan (RIPIN) 2015-2035. Certain RIPIN targets for the 2020-2024 period, including for nickel unwrought metal production, have not yet been realized. RIPIN targets also include producing more intermediate nickel products from 2020-24 and moving along the value chain to nickel sulfate for batteries during 2025-35.[40] The RIPIN encourages increased production of value-added

[32] Nickel Institute, "Nickel in Batteries," accessed September 14, 2023.
[33] U.S. Department of Energy, "Reducing Reliance on Cobalt for Lithium-Ion Batteries," accessed November 14, 2023.
[34] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, March 2022, 91.
[35] MMC Norilsk Nickel, *Nornickel 2022 Annual Report*, February 10, 2023, 31.
[36] Perry, "Nickel Metal Dissolution Remains Dominant Sulfate Production Route Outside of China," accessed September 20, 2023.
[37] The Sorowako mine in South Sulawesi Province is the largest nickel mine in Indonesia. Mining Technology, "The Five Largest Nickel Mines in Operation in Indonesia," July 21, 2023.
[38] Ministry of Energy and Mineral Resources of the Republic of Indonesia, *2022 Ministry of Energy and Mineral Resources Performance Report*, March 21, 2023, 21–23.
[39] Tribhakti Inspektama, "History of Indonesian Nickel Mining," September 26, 2021.
[40] Ministry Of Energy and Mineral Resources: Republic of Indonesia, *Grand Strategy Mineral Dan Batubara*, May 10, 2022, 45.

products that are derived from its minerals. These downstream products include copper cathodes, gold metal, silver metal, tin bullion, ferronickel, nickel pig iron and nickel matte, which make a significant contribution as export commodities. Ferronickel is the largest of these products in terms of export value, as illustrated further in this section. Indonesia also plans to boost production of nickel products used in lithium-ion batteries.[41]

Nickel Mining in Indonesia

Indonesia's nickel mining areas are spread across seven provinces, namely Maluku, North Maluku, Papua, West Papua, South Sulawesi, Central Sulawesi, and Southeast Sulawesi.[42] While nickel mining in Indonesia has increased over the past decades, this mine production can be characterized as extraction of lower-grade laterite ores that have historically been used to make ferronickel or nickel pig iron for stainless steel production.

Mining nickel laterite ore like those found in Indonesia accounts for about 60 percent of global identified resources of nickel and an increasing share of global nickel production; however, development of laterite resources poses challenges. In the past, much of the raw nickel ore extracted in Indonesia (as well other mineral ore types) was mined and exported directly to China or other destinations without any processing in Indonesia.[43] Nickel ore extraction from lateritic deposits is accomplished through strip or "opencast" mining techniques. It is an earth-moving process requiring land clearing rather than vertical digging. This facilitates the development of small but land intensive nickel mines with strip-mining operations. Relatively rudimentary techniques are employed in these operations, which have a higher impact on the environment, mainly in terms of deforestation and water pollution.[44] Some of these challenges are discussed below (see Challenges and Issues in the Nickel Sector).[45]

As mentioned earlier, laterite nickel ore comes in two forms, and until recently there was no need to use a high-pressure acid-leaching technology in part because most of the mining in Indonesia was saprolite, which can be processed using traditional pyrometallurgical smelters. But Indonesia and much of the rest of the world is thought to be depleting saprolite ore. [46] What remains is lower-grade limonite ore, which consists of less than 1.5 percent nickel, making processing by traditional means nearly impossible. Historically, most of the nickel mined in Indonesia was either exported in a raw form or processed into lower-grade ferronickel/NPI for use in stainless steel. However, batteries require a higher-grade nickel and that has led to a rise in projects that use an acid-leaching process to upgrade limonite ore into intermediate products that can ultimately be uses in lithium-ion batteries.[47]

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[41] Huang, "Turning Nickel into EV Batteries," April 14, 2022.
[42] PT Vale Indonesia Tbk, *Annual Report: 2022*, May 2023, 90.
[43] Mackay, "Nickel Pig Iron Market Contributes to Indonesian Nickel Mining Growth," accessed September 25, 2023.; McKinsey & Company, "Optimizing Processes in Southeast Asia's Mining Industry," March 1, 2023.
[44] British Geological Survey, *Nickel Profile*, September 2008, 8–9. World Trade Organization, *Indonesia: Measures Relating to Raw Materials*, November 30, 2022, 28–30.
[45] Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023.
[46] Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023.
[47] Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023.

Nickel Export Restrictions

Along with its long history of extracting mineral resources, Indonesia's mining and trade policies have evolved with the intent of protecting such resources and boosting value chains. This approach to resource management came at a time when exports of raw minerals were increasing. For example, during 2003–13, Indonesia's exports of nickel ore grew rapidly and its share of global nickel ore exports, by value, increased from 8 percent to 37 percent.[48] The Indonesian government had signaled its intent to ban exports of nickel since 2014. Most recently, in January 2020, the country banned nickel ore exports in an effort to encourage investment into its downstream manufacturing industry. Domestic processing requirements for nickel have ensured that companies can only ship refined nickel out of Indonesia–as opposed to nickel ore. While the ban has improved Indonesia's smelting capacity, it has also served to create a demand-supply imbalance, according to market sources. [49]

Historical Background of Export Restrictions

Indonesia's 2009 Mining Law requires companies to process ore locally before shipping it abroad.[50] Indonesia has implemented this law through a series of regulations that ban exports of over 200 types of mineral ore. In 2014, as part of implementation of the 2009 Mining Law, Indonesia prohibited the export of nickel ore, one of several recent measures restricting the export of key steelmaking raw materials. From 2014–2017, companies were only able to export concentrates associated with certain mineral ores (including nickel, copper, lead, and iron) if they paid an export tax and met other requirements, such as building smelters in Indonesia. Indonesia temporarily relaxed the nickel export ban in 2017, intending for the full ban to be reinstated in January 2022.[51] Indonesia established a new set of requirements for the mining industry, as specified in Government Regulation 1/2017.[52] Among other things, this regulation required companies with existing contracts of work to convert to special mining business licenses and build a domestic smelter by January 2022. These licenses allowed companies to export mineral concentrates.[53] Following an announcement in August 2019, Indonesia reinstated the full export ban as of January 1, 2020 (earlier than the January 2022 date previously announced), which essentially halted all exports of nickel ores and concentrates. [54]

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[48] S&P Global, GTAS, accessed February 14, 2024; Data are from HS subheading 2604.00.

[49] Fulton, "Resource Nationalism on the Rise in Commodity Markets, Experts Say | Metal Bulletin.Com," April 14, 2023.

[50] The legal instruments through which the policies discussed in this section were implemented include: Republic of Indonesia, *Law on Mineral and Coal Mining, Pub. L. No. 4/2009*, January 12, 2009; Republic of Indonesia, *Regulation of the Minister of Energy and Mineral Resources Number 1/2014*, January 11, 2014; Republic of Indonesia, *Regulation of the Minister of Trade Number 1/2017*, January 11, 2017; Republic of Indonesia, *Regulation of the Minister of Trade Number 96/2019*, December 2, 2020.

[51] Office of the U.S. Trade Representative (USTR), *2020 National Trade Estimate Report on Foreign Trade Barriers*, March 31, 2020.

[52] Republic of Indonesia, *Regulation of the Minister of Energy and Mineral Resources Number 1/2017*, January 11, 2017.

[53] Office of the U.S. Trade Representative (USTR), *2020 National Trade Estimate Report on Foreign Trade Barriers*, March 31, 2020.

[54] Office of the U.S. Trade Representative (USTR), *2020 National Trade Estimate Report on Foreign Trade Barriers*, March 31, 2020.

Stated Intent of Export Restrictions

Indonesia has provided three reasons that outline why the government chose to impose export restrictions on nickel ore coupled with a domestic processing requirement on nickel products. First, the overall mining sector accounts for a substantial portion (about 12 percent in 2022) of Indonesia's GDP.[55] Indonesia is a top nickel producer in the world and, therefore, nickel mining contributes significantly to government revenue and national employment. Nickel mining is of economic and strategic significance in some of the impoverished regions where it is produced, such as Sulawesi and Maluku. Second, Indonesia claims that the nickel sector, a vital input for its steel industry, which accounts for about four percent of its total industrial GDP. Indonesia notes that its domestic steel industry is not able to meet demand and that nearly half of Indonesia's steel consumption is supplied by imports. Third, Indonesia points to the implementation of a strategic plan to expand EV battery production in Indonesia, which will result in a need to secure critical inputs for this type of production, such as nickel.[56]

Many government officials in Indonesia have gone on the public record and discussed the plan for nickel and the export ban. President Joko Widodo of Indonesia has publicly stated that he intends to wean the country off exports of raw commodities by forcing producers to conduct processing and manufacturing onshore. To that end, he led the ban of nickel ore exports in 2020, limiting exports to refined products. In the two years following the ban, the value of Indonesia's nickel exports surged from $3 billion to $30 billion, and President Widodo remarked: "we want to benefit from added-value exports so that there's income for the state in the form of taxes and new job opportunities," in an August 2023 interview in Jakarta. He went on to state, "We don't just want to build batteries. This is just half of it. We want to build electric cars in Indonesia."[57] Industry observers have noted that in the production process for nickel used in batteries for EVs, the higher value-added products that deliver greater returns are further downstream in the supply chain (e.g., battery components).[58] To help achieve President Widodo's plan to focus on expanding the downstream nickel industry, the government has targeted foreign investment of $21.3 billion in mining and processing projects in Indonesia.[59]

Another high-ranking Indonesian official involved in downstream investment, Deputy of the Strategic Downstream Field at the Investment Ministry/Investment Coordinating Board Heldy Satrya Putera, highlighted Indonesia's goal to rank among the world's top stainless steel and electric vehicle (EV) battery producing countries through downstream production of nickel products. Deputy Puteral remarked that Indonesia aims to become one of the world's top two producers of stainless steel and one of the top five producers of EV batteries." The country's stated priority is to use nickel as the raw material for the manufacture of both stainless steel and EV batteries.[60]

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[55] Statistics Indonesia, "Gross Domestic Product (GDP) Share of Indonesia in 2022, by Sector," June 12, 2023.
[56] Hertanti, "Between a Mineral and a Hard Place," July 13, 2023.
[57] Ho and Listiyorini, "Chinese Companies Are Flocking to Indonesia for Its Nickel," December 16, 2022.
[58] Ferreira and Pinto, *Overview of the Nickel Market in Latin America and the Caribbean*, April 2021, 15.
[59] Antaranews.com, "Indonesia to Commence Electric Car Production in 2023-2024," accessed August 9, 2023.
[60] Antaranews.com, "Indonesia Targets Ranking among World's Top Stainless Steel Producer," accessed August 9, 2023.

International Response to Export Restrictions

Indonesia's trade policy related to nickel has been challenged by stakeholders in the international community. The European Union (EU) took exception to Indonesia's export ban and related domestic processing requirements. According to the EU, the full ban on the exports of nickel ore that has been in place since January 2020 and the domestic processing requirements on nickel ore have obliged businesses to process or purify the raw materials in Indonesia prior to export. These measures "unduly and illegally restrict EU access to raw materials needed for stainless steel production and distort world market prices of ores." In 2019, the EU reached out to Indonesia to try to resolve the dispute before requesting consultations at the WTO in November 2019. After these efforts did not lead to a resolution, the EU requested the establishment of a panel to examine the matter as part of the WTO dispute settlement process in January 2021.[61]

The United States also expressed concerns about the impact of Indonesia's export ban on global nickel supply and prices, as well as Indonesia's increased volume of downstream stainless steel products. On December 11, 2019, the United States joined the EU-initiated consultations concerning the consistency of Indonesia's export ban with Indonesia's WTO obligations. The United States participated in the subsequent panel proceedings as a third party. In November 2022, the WTO panel issued a report outlining its findings in the case and determined that Indonesia's export ban on nickel ore was inconsistent with its WTO obligations. In a December 2022 response to this determination, Indonesia filed a notice of appeal to the appellate body, arguing certain issues of law and legal interpretations in the panel report.[62] As of February 2024, no further developments have been reported in this dispute as the parties await the formation of an appellate body at the WTO and next steps in the process.[63]

In July 2023, the EU launched a consultation on the possible use of the EU's Enforcement Regulation in its dispute settlement case on Indonesian nickel export restrictions. The EU's Enforcement Regulation enables the EU to enforce international obligations to which other WTO members have agreed. This occurs when a trade dispute is blocked (e.g., the lack of a functioning appellate body at the WTO) despite the EU's efforts to follow dispute settlement procedures. Based on the results of this consultation, the EU may propose countermeasures (including import duties or quantitative restrictions on trade) on Indonesia in the future. No further developments had been announced as of February 2024.[64]

Nickel Production and Trade

Nickel Production

As mentioned above, Indonesia's export restrictions are partially intended to boost downstream, value-added production of nickel products. In light of this goal, it is helpful to examine recent trends in

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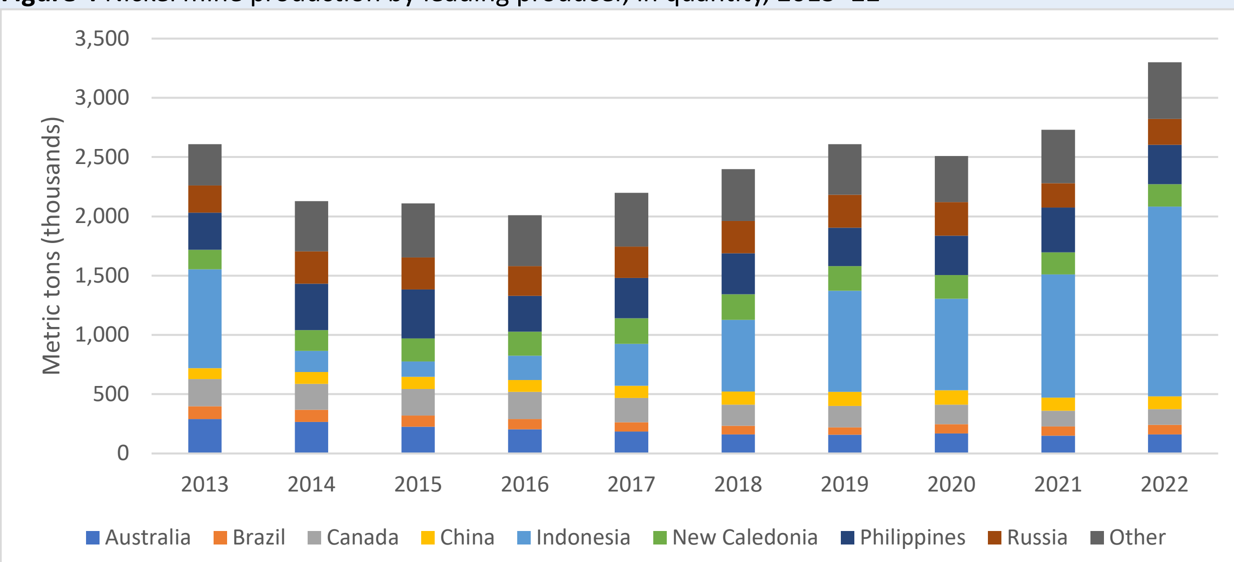
[61] European Commission, "WTO Panel Rules against Indonesia's Export Limitations," November 30, 2022.
[62] Office of the U.S. Trade Representative (USTR), *2023 National Trade Estimate Report on Foreign Trade Barriers*, March 31, 2023, 226.
[63] World Trade Organization, "WTO | Dispute Settlement - DS592," accessed November 8, 2023.
[64] European Commission: Directorate-General for Trade, "EU Launches Consultation on Use of Enforcement Regulation on Indonesian Nickel Export Restrictions," July 7, 2023.

Indonesia's nickel production and exports. These data illustrate that both nickel production and the value of nickel exports have increased consistently since 2014, when the export ban was first implemented. [65]

Indonesia's nickel mine production in 2013 was 834,200 tons making it the leading global producer. Some industry observers believe the country's production of nickel declined from 2014 to 2018 to its enforcement of an export ban on direct shipping ore, which was intended to stimulate development of domestic processing facilities. In 2018, Indonesia again became the leading global producer of mined nickel. The increased production was primarily a result of the development and commissioning of NPI smelters in the country that consumed nickel ore and the easing of export restrictions on unprocessed ore beginning in January 2017 and lasting though 2020.[66] Indonesia's nickel mine production has trended upward since 2017, driving up total global production. In 2022, estimated global nickel mine production increased by about 20 percent, with almost all the increased production attributed to Indonesia (figure 4). The increase was reportedly facilitated by the commissioning of domestic integrated NPI and stainless steel manufacturing projects that processed nickel ores. [67]

As of June 2021, the Directorate General of Mineral and Coal of Indonesia noted a total of 339 active mining permits on record in Indonesia.[68]

Figure 4 Nickel mine production by leading producer, in quantity, 2013–22



Source: "Nickel," Mineral Commodity Summaries, USGS, various years; "Nickel," Minerals Yearbook, USGS (2014-19)

Since Indonesia fully banned the export of ore in 2020, essentially all of its mine output is converted to nickel products domestically. Some of the processing capacity is to produce NPI for the stainless sector and, according to industry experts, Indonesia's growth in production will offset lower Chinese output

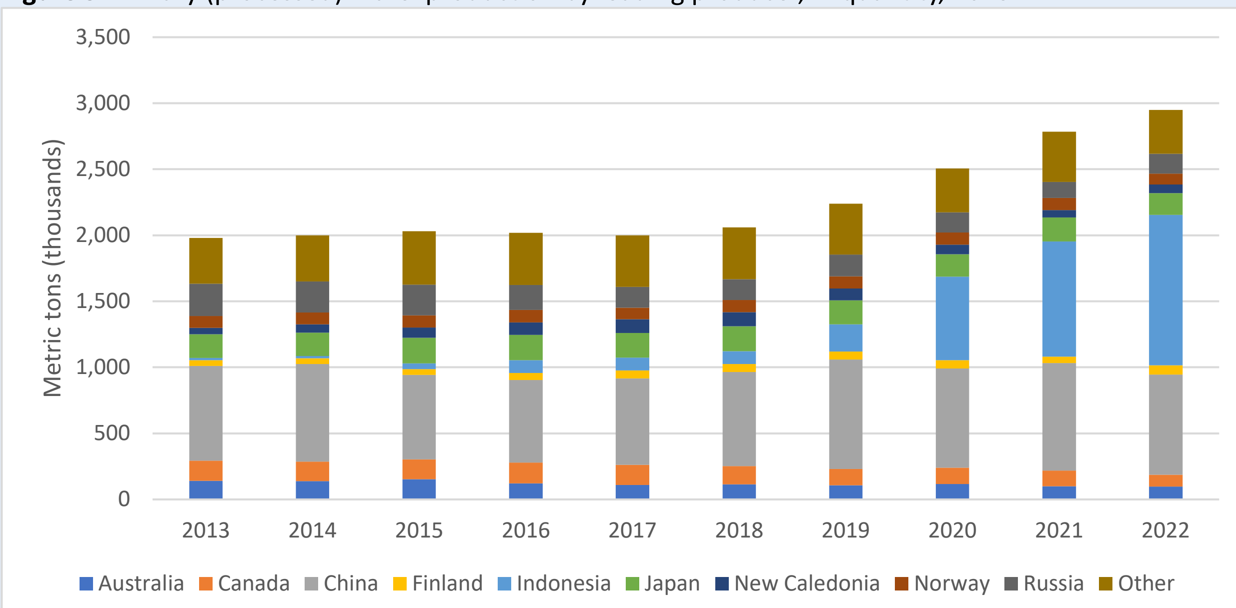
[65] Another technique that can be used by researchers to study the economic effects of the Indonesia nickel ore export ban is partial equilibrium modeling. An approach to modeling this export ban is provided in the appendix.
[66] McRae, *2018 Minerals Yearbook: Nickel*, August 2023, 51.4-51.5.
[67] U.S. Geological Survey, *Mineral Commodity Summaries 2023: Nickel*, January 2023.
[68] Ministry Of Energy and Mineral Resources: Republic of Indonesia, *Grand Strategy Mineral Dan Batubara*, May 10, 2022, 42.

(due to the lack of upstream nickel ore from Indonesia) as the offshoring trend continues.[69] Much of the new production is also targeted at the fast-growing battery sector, as producers experiment with new technology to cross the processing hurdle of converting Indonesia's relatively low-grade laterite resources into a form that can be used in lithium-ion batteries.[70] Several companies are developing projects to produce intermediate products that could be used as feedstock to produce battery-grade nickel sulfate.[71]

Industries producing NPI, ferronickel, and matte nickel have developed and grown in Indonesia. Before 2014 (and the export ban), only two nickel smelters operated in Indonesia.[72] At least 29 nickel refineries were operating in 2021, based on data compiled by the Ministry of Industry of the Republic of Indonesia.[73]

Indonesia's production of primary nickel products (including NPI, ferronickel, and matte) has increased dramatically since 2013 when Indonesia produced essentially no processed nickel. In less than a decade, Indonesia accounted for about 40 percent of global primary nickel production (figure 5).

Figure 5 Primary (processed) nickel production by leading producer, in quantity, 2013–22



Source: "Nickel," Minerals Yearbook, USGS (2014-19) and World Metal Statistics Yearbook 2022, World Bureau of Metal Statistics.
Note: Primary nickel production refers to a nickel product ready for use by downstream consuming industries such as nickel chemicals and salts, ferronickel, nickel metal in various forms, nickel oxide sinter, and nickel pig iron.

[69] Home, "Nickel Faces Huge Supply Glut as Indonesian Output Booms," April 28, 2023.
[70] Home, "Nickel Faces Huge Supply Glut as Indonesian Output Booms," April 28, 2023.
[71] U.S. Geological Survey, *Mineral Commodity Summaries 2023: Nickel*, January 2023.
[72] McKinsey & Company, "Optimizing Processes in Southeast Asia's Mining Industry," March 1, 2023.
[73] *Grand Strategy Mineral Dan Batubara*, May 10, 2022, 51.

Nickel production in Indonesia hit a record high in 2022 and continued growth is projected. By 2028, according to a Macquarie forecast, the country will produce at least 2.5 million metric tons of nickel annually, relative to 1.1 million metric tons in 2022.[74]

Nickel Exports

This section provides relevant trade statistics that illustrate observed trends since the nickel ore export ban was implemented.

While Indonesia's nickel production is historically export-oriented, the country did not export nickel ores and concentrates during the 2015-2016 period following the initial implementation of the export ban in 2014. Exports resumed in 2017 with the relaxation of enforcement of the ban. This was short-lived, however, as exports of ores and concentrates ceased again in 2020 when the ban was reinstituted (figures 6a and 6b). Since Indonesia banned nickel ore exports, the value of its nickel product exports rose to nearly $20 billion in 2022 from less than $1 billion in 2015. The primary nickel exports are ferronickel, NPI, nickel ore, and nickel matte. As illustrated in table 3, the value of nickel products increases depending on the amount of processing involved in production and nickel contained in the product. At the lowest end of the spectrum, raw, unprocessed nickel ores and concentrates were exported from Indonesia at an average of 60 dollars per ton in 2022. However, moving further down the value chain to processed ferronickel and different intermediate nickel products boosts the unit values of the products that are exported.

Indonesia produces and exports all of the products shown in table 3 below with the exception of unwrought nickel. These large differences in unit values of nickel products are important to keep in mind when examining the trends in nickel exports from Indonesia, as the product mix has changed since the export ban.

Table 3. Primary nickel products and average unit values of exports from Indonesia in 2022

HS Subheading	Title	Category	Average unit value of exports ($/metric ton)
2604.00	Nickel ores and concentrates	Raw material	60
7202.60	Ferronickel (includes nickel pig iron)	Processed (Class 2)	2,357
7501.20	Nickel oxide sinter and other intermediate products	Intermediate	3,784
7501.10	Nickel matte	Intermediate	14,834
7502.10	Unwrought nickel, not alloyed	Processed (Class 1)	25,053

Source: S&P Global, GTAS, accessed October 10, 2023; Data are from HS subheadings 2604.00, 7202.60, 7501.10, 7501.20, and 7502.10.

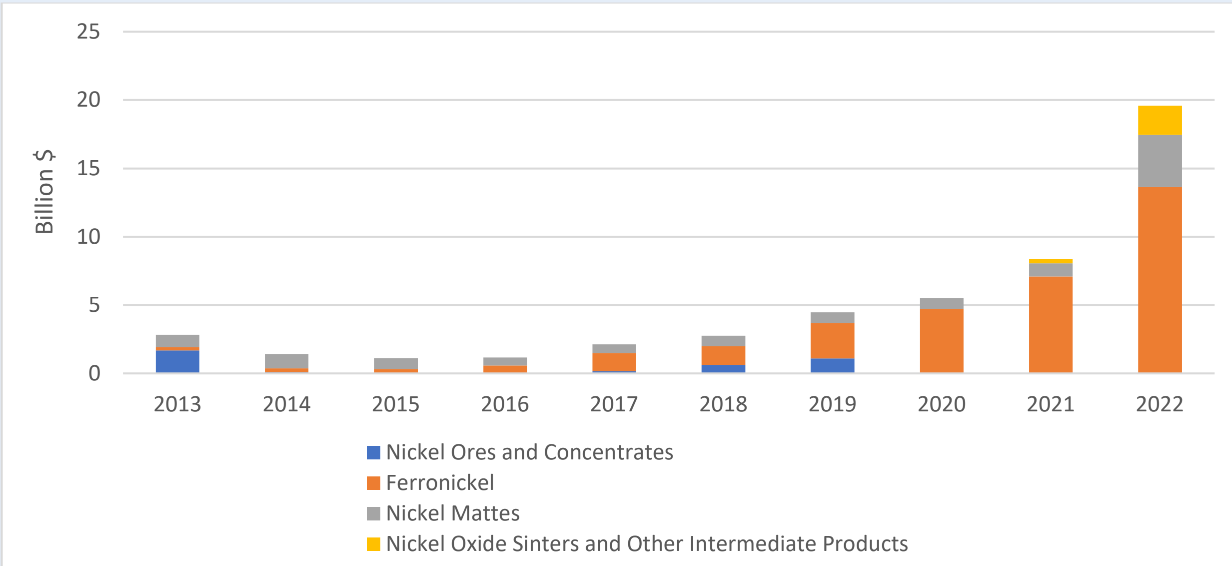
Note: Although Indonesia does not produce unwrought nickel, not alloyed (refined nickel metal), the average unit value of global exports in 2022 was provided for reference.

A comparison of figures 6a and 6b reveals that while the quantity of nickel products exported from Indonesia has decreased since 2019, the value of exports increased significantly. This was reflective of Indonesia’s transition away from exporting raw nickel ores and concentrates to exporting more

[74] Tan, Sijabat, Irwandi, “To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous,” accessed September 25, 2023.

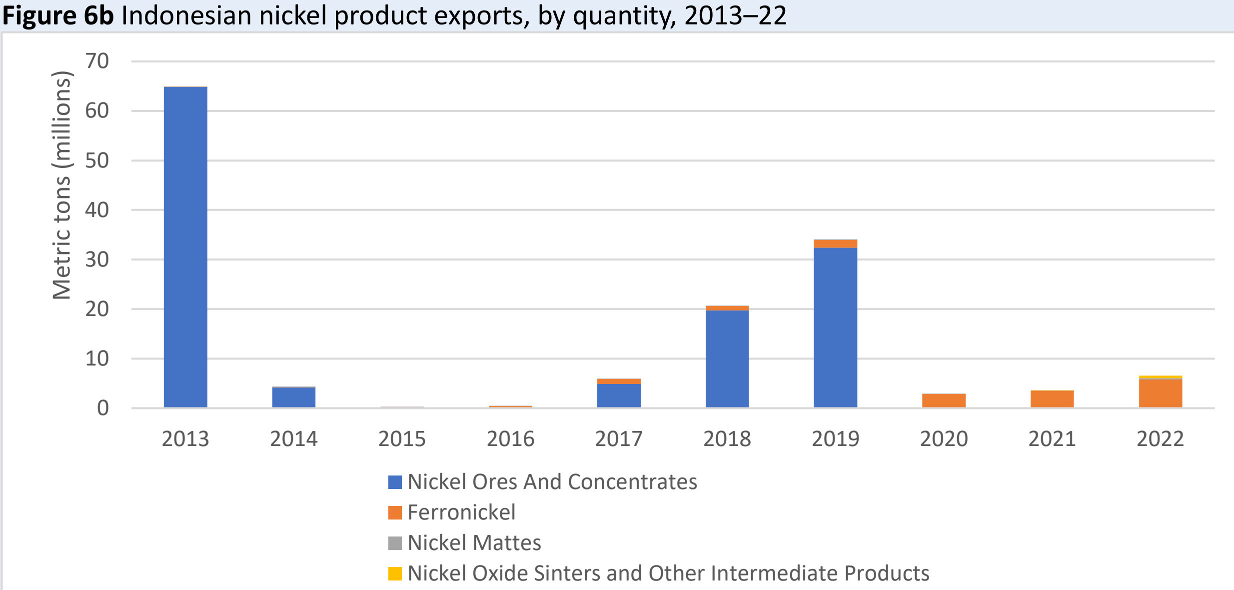
processed nickel, higher-value, nickel products. This transition coincides with the most recent imposition of the export ban in 2020. The trade data shows that exports of higher-value nickel products account for a much greater share of total nickel exports from Indonesia since the 2014 ban, while exports were almost entirely comprised of lower value ores and concentrates in 2013.

Figure 6a Indonesian nickel product exports, by value, 2013–22



Source: S&P Global, GTAS, accessed October 10, 2023; Data are from HS subheadings 2604.00, 7202.60, 7501.10, 7501.20, and 7502.10.

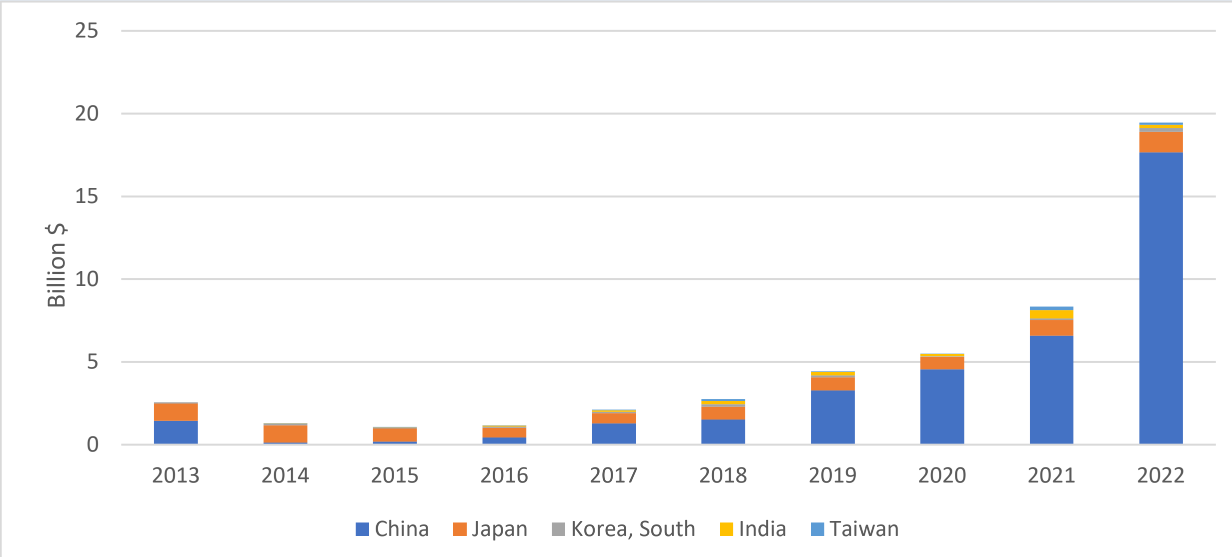
Figure 6b Indonesian nickel product exports, by quantity, 2013–22



Source: S&P Global, GTAS, accessed October 10, 2023; Data are from HS subheadings 2604.00, 7202.60, 7501.10, 7501.20, and 7502.10.

Indonesia's major export destinations are China, Japan, India, South Korea, and Taiwan. While the value of Indonesia’s exports has increased during the past several years, such exports have become highly concentrated to China. In 2022, about 90 percent of nickel exports went to China, with Japan receiving about 6 percent (figure 7). This is reflective of China's position as the largest nickel consumer in the world (table 2). In terms of the leading destinations for nickel product exports in 2022, about 97 percent of ferronickel went to China (for stainless steel), and all nickel matte produced in Indonesia was exported to China and Japan.[75]

Figure 7 Indonesian nickel exports, leading destinations, by value, 2013–22



Source: S&P Global, GTAS, accessed October 10, 2023; Data are from HS subheadings 2604.00, 7202.60, 7501.10, 7501.20, and 7502.10.

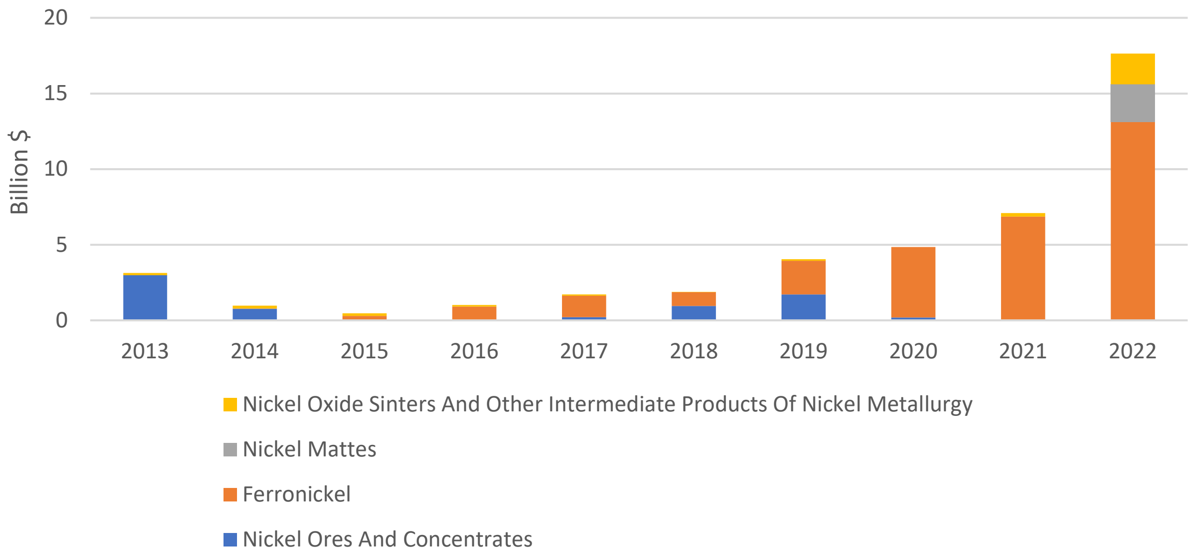
Chinese Nickel Imports from Indonesia

China has a longstanding trading relationship with Indonesia that has evolved since Indonesia implemented its 2014 export ban on nickel ores and concentrates. Before 2014, China primarily imported unprocessed nickel ore for use in production of NPI and ferronickel for its large stainless steel industry.

Since the first nickel ore export ban was instituted in 2014, China, the world's largest market and producer of electric vehicles, has begun importing more intermediate nickel products, such as nickel matte and other products, from Indonesia (figure 8). Such intermediates are used to produce nickel sulfate in China, the key component to produce nickel rich batteries.[76] According to industry observers, the trading relationship between Indonesia and China has evolved to be mutually beneficial; China gets access to a steady stream of intermediates while Indonesia has the opportunity to diversify its mining-based economy and export more downstream products. [77] Chinese companies with ore extraction and mineral processing operations in Indonesia and nickel chemical processing operations in China are building Indonesia's midstream battery supply chain.[78]

[75] S&P Global, GTAS, accessed November 16, 2023; Export data are from HS subheading 7501.10.
[76] Mandavia, "Indonesia's Battery Success Runs on China and Coal," October 20, 2022.
[77] Mandavia, "Indonesia's Battery Success Runs on China and Coal," October 20, 2022.
[78] Mandavia, "Indonesia's Battery Success Runs on China and Coal," October 20, 2022.

Figure 8 Chinese imports of nickel products from Indonesia, by value, 2013–22



Source: S&P Global, GTAS, accessed October 10, 2023; Data are from HS subheadings 2064.00, 7202.60, 7501.10, 7501.20, and 7502.10.

Converting Nickel Pig Iron into Matte

The majority of nickel ore in Indonesia is processed via pyrometallurgical methods to produce NPI, much of which is in turn used to produce stainless steel. However, in 2021 Chinese nickel producer, Tsingshan Holding Group Co. Ltd., revealed plans to process NPI into high-grade nickel matte that can be converted into nickel sulfate for use in the EV battery sector.[79] Tsingshan stated that it plans to produce both the nickel matte and NPI in Indonesia, with volumes dependent on market demand and prices. This development was viewed by many industry observers as one that has the potential to affect the global nickel market by making a significant amount of lower-grade nickel available for use in lithium-ion batteries.[80] However, this process has drawbacks and risks.

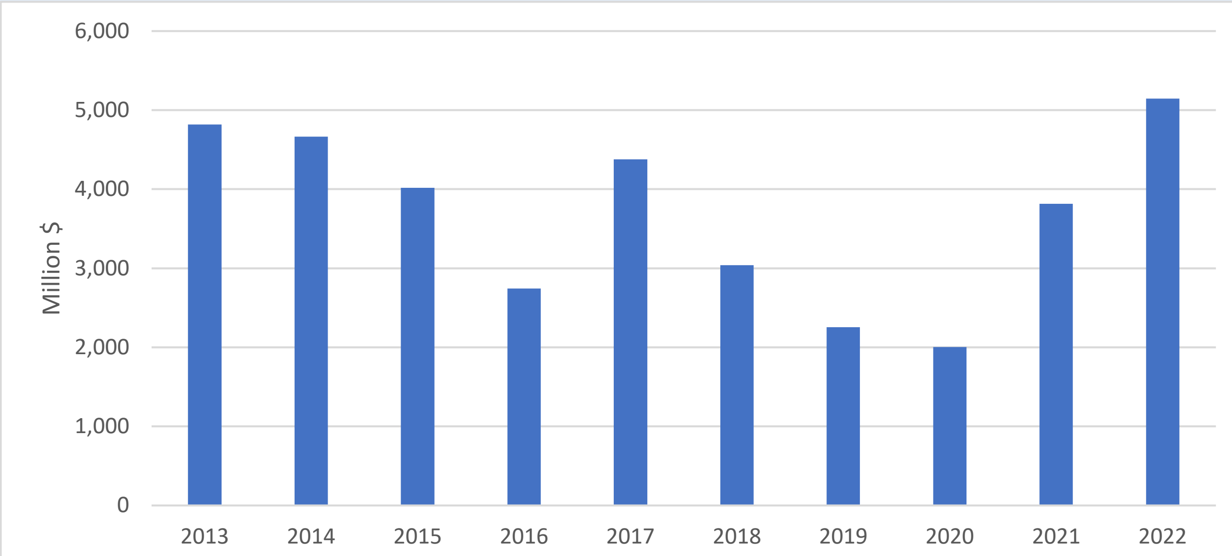
The first drawback is its energy intensity. In Indonesia, energy usually comes from coal-fired power stations built near the mines. While coal is cheap and reliable, it produces significant quantities of greenhouse gases, and many EV producers are likely to be concerned with the environmental aspects of production.[81] Additionally, much of Indonesia's saprolite ore is reported to have been extracted and exported (mostly to China). It is believed that most of the country's remaining nickel is contained in deposits of the limonite type, which are not suitable for the pyrometallurgical process used to make NPI.[82]

[79] Sappor, "Profit Margins Key to Tsingshan's Battery Nickel Supply Plans," July 27, 2021.
[80] Sappor, "Profit Margins Key to Tsingshan's Battery Nickel Supply Plans," July 27, 2021.
[81] Emont, "EV Makers Confront the 'Nickel Pickle,'" June 4, 2023.
[82] The Economist, "New Technology Could Cement Indonesia's Dominance of Vital Nickel," July 5, 2023.

Foreign Direct Investment and New Development in Indonesia

In 2022, the foreign direct investment (FDI) in mining and quarrying in Indonesia amounted to approximately 5.2 billion U.S. dollars (figure 9). Indonesia is one of the world's largest producers of mineral products. The mining industry in Indonesia is expected to keep growing in coming years.[83]

Figure 9 Foreign direct investment (FDI) in mining and quarrying in Indonesia 2013–22



Source: Statista, "Indonesia," February 2023.

The country has attracted investments to develop downstream processing capabilities for NPI, nickel matte, and mixed hydroxide precipitate (MHP), with the latter two expected to become mainstream raw materials for battery-grade nickel sulfate production. Indonesia is expected to make up nearly half of global primary nickel output in the coming years, and progress on Indonesian projects is focused on the battery markets amid growing scrutiny on environmental, social and governance (ESG) issues related to nickel extraction and production (discussed later). Despite the ESG concerns, investments from midstream and downstream firms in new capacity building Indonesian projects continued to flow in since 2020 – including announcements by lithium-ion battery producers and automakers. Chinese FDI in both extraction and processing of Indonesian nickel has grown and industry observers note that after 2013, Chinese firms became the most prominent source of FDI in this sector.[84] The growth in Chinese FDI in the Indonesia nickel industry was directly attributed to the implementation of Indonesia's export ban on unprocessed nickel in 2014.[85]

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[83] Statista, "Indonesia," February 2023.
[84] Tritto, "How Indonesia Used Chinese Industrial Investments to Turn Nickel into the New Gold," accessed August 4, 2023.
[85] Tritto, "How Indonesia Used Chinese Industrial Investments to Turn Nickel into the New Gold," accessed August 4, 2023.

Industry observers have speculated that the limited growth in development of new global nickel resources outside of Indonesia and cheaper prices for nickel produced in Indonesia could make securing affordable nickel supply a greater priority for most consumers in the coming years, leading to continued investment in Indonesian projects.[86]

A review of nickel producers in Indonesia indicated that 29 nickel processing and refining companies with pyrometallurgical and hydrometallurgical capacity were operating in 2021.[87] These plants produced NPI, ferronickel, intermediate nickel products, and matte. Looking forward, 33 new pyrometallurgical plants were under construction or had plans for constructions in 2021. These plants were focused on producing NPI and ferronickel. Additionally, nine hydrometallurgical plants were under construction or in development in 2021. These plants will produce intermediate nickel products as well as nickel sulfate for lithium-ion batteries.[88]

New Nickel and Downstream Projects

Indonesia's plan is to develop downstream nickel production, become the world's largest battery producer, and to eventually develop EV manufacturing infrastructure in the country, according to government officials.[89] Examples of FDI include China's CATL and South Korea's LG, the world's largest EV battery manufacturers, which recently announced they would open HPAL plants in Indonesia. Ford Motor Co. said it would join an HPAL project being developed by Vale and Chinese mining company Huayou on Sulawesi island in eastern Indonesia. In 2022, Tesla signed a $5 billion deal to buy nickel from Indonesia.[90] Table 4 illustrates the magnitude and variety of nickel-related projects that are in development in Indonesia since enforcement of the export ban was re-implemented in 2020.

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[86] S&P Global, "Indonesian Projects to Boost Nickel Supply," April 25, 2023.
[87] This figure is based on official Ministry of Energy and Mineral Resources of the Republic of Indonesia (EDSM) publications.
[88] Republic of Indonesia: Ministry of Energy and Mineral Resources, *Buku Grand Strategy Komoditas Minerba [Minerba Commodity Grand Strategy Book]*, July 2021, 52–54.
[89] Antaranews.com, "Indonesia to Become World's Leading Battery Producer," accessed August 9, 2023.
[90] Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023.

Table 4 Notable nickel projects in development in Indonesia since the 2020 export ban

Firm	Type of project	Date announced	Description
LG Energy Solution and Hyundai Motor Group	EV battery facility	September 2021	LG and Hyundai started construction on a $1.1 billion plant to make batteries for electric vehicles (EVs) in Indonesia. Production to begin in 2024.
LG Energy Solution	Nickel chemicals for batteries	June 2022	LG broke ground on $3.5 billion nickel processing plant to produce 150,000 ton per year of nickel sulfate for lithium-ion batteries.
CNGR Advanced Material Co Ltd	Intermediate nickel products	May 2022	China's CNGR will invest in three new projects in Indonesia to produce 120,000 tons per year of nickel matte for use in lithium-ion batteries.
PT Vale Indonesia	Ferronickel and intermediate nickel products	September 2022	PT Vale Indonesia plans to build a $2 billion ferronickel smelter in Southeast Sulawesi and two HPAL plants that will produce intermediate nickel products (MHP) for lithium-ion batteries. Construction of the ferronickel plant is expected to be completed in 2025.
BASF and Eramet	Intermediate nickel products	January 2023	BASF and Eramet plan to build a $2.6 billion nickel/cobalt refinery in Indonesia. The project will produce about 67,000 tons of nickel and 7,500 tons of cobalt intermediate products per year for use in lithium-ion batteries.
Ford, Vale Indonesia, and Zhejiang Huayou Cobalt	Intermediate nickel products	March 2023	Ford joined PT Vale Indonesia and China's Zhejiang Huayou Cobalt's to build a $4.5 billion HPAL nickel processing plant in Indonesia. Operations are expected to start in 2026. Ford representatives commented that "This framework gives Ford direct control to source the nickel we need — in one of the industry's lowest-cost ways".
POSCO Holdings	Intermediate nickel products	May 2023	South Korean steelmaker POSCO announced that it will build a $441 million refinery to produce nickel intermediates for use in lithium-ion batteries that could power the equivalent of one million EVs. The goal is to start operations in 2025.
GEM	Intermediate nickel products	May 2023	GEM, a Chinese battery and material recycler, has proposed to build a $500 million nickel smelter to produce intermediate products for batteries.
Zhejiang Huayou Cobalt	Nickel chemicals	July 2023	Zhejiang Huayou Cobalt (China) plans to build a $200 million plant that will produce 50,000 tons per year of nickel sulfate for batteries.
Mitra Murni Perkasa	Intermediate nickel products	July 2023	Mitra Murni Perkasa is building a nickel matte smelter with production capacity of 27,000 tons per year. The plant is expected to open in 2025.
Aneka Tambang and LG Energy Solution Ltd.	Intermediate nickel products and battery components	August 2023	Indonesian state miner Aneka Tambang, Indonesia Battery Corporation and a consortium led by LG are building a $9.8 billion "grand package" for battery production. This project includes a battery cathode plant, a nickel smelter, precursor factory, and a battery cell factory.
Huayou Cobalt and Vale Indonesia	Intermediate nickel products	August 2023	Chinese battery producer Huayou Cobalt signed a definitive agreement with Vale Indonesia (PTVI) to build a HPAL plant to produce mixed hydroxide precipitate (MHP) for batteries, and open in early 2027.

Sources: "South Korea's LGES, Hyundai Motor Start Work on Indonesian EV Battery Plant | Reuters," accessed November 22, 2023; Reuters, "S.Korea's LG Energy Solution Launches Nickel Processing Plants in Indonesia," accessed November 22, 2023; Reuters, "China CNGR Expands Nickel Investments in Indonesia to Meet EV Demand," accessed November 22, 2023; Indonesia Miner, "Vale Indonesia Inks $2.1b Ferronickel

Project Deal with China's Baowu Steel," September 6, 2022.; PT Vale Indonesia Tbk, *Annual Report: 2022*, May 2023, 91; Bloomberg, "BASF, Eramet Plan $2.6bn Nickel Smelter in Indonesia," accessed November 22, 2023; Bushey, Dempsey, and Ruehl, "Ford Gambles on $4.5bn Indonesia Nickel Plant with Chinese Partner," March 30, 2023; Reuters, "Ford in $4.5 Bln Deal for EV Battery Materials Plant," accessed October 12, 2023; Jibiki, "Indonesia's Nickel Export Ban Spurs Rush into Vital EV Metal Supplier," May 20, 2023; Liu and Patton, "China's GEM to Build a $500 Mln Joint Nickel Project in Indonesia," May 11, 2023; Reuters, "Huayou Cobalt Boosts Nickel Capacity in Indonesia," accessed November 22, 2023; Indonesia Miner, "Indonesia-China Companies Collaborate on Nickel Smelter Project in East Kalimantan," July 31, 2023; Bloomberg, "Jokowi's EV Ambition Takes a Step Forward with Cathode Factory," August 3, 2023; Argus Media, "Huayou, Vale Commit to Indonesian Huali MHP Project," August 28, 2023.

Challenges and Issues in the Nickel Sector

While the nickel sector in Indonesia has been expanding, industry observers have expressed concerns related to ESG practices of some Indonesian nickel operations. Due to Indonesia's reliance on coal-generated power, nickel produced within the country typically has a higher carbon intensity than other producer countries. Significant concerns also surround the handling of tailings within the country, due to the seasonal heavy rains which make many conventional methods of mine waste storage unsuitable.[91] Reportedly, "[t]here are some who will be able to take Indonesian-produced nickel and use it in batteries, however, there will be others who will be unable to accept such material due to the ESG challenges it raises." [92]

Environmental Issues

The nature of both the mining and processing of nickel in Indonesia poses environmental challenges, especially given Indonesia's tropical ecosystem. Its nickel processing industry is especially carbon-intensive due to its reliance on coal. Civil society groups have also voiced concerns about the environmental risks of nickel mining and processing. Most recently, environmental groups urged Tesla to terminate its investment plans in the country's nickel industry, citing concerns over deforestation, pollution of water bodies, and disruption to the livelihoods of indigenous people as a result of nickel mining.[93] These issues include deforestation from strip mining and environmental hazards from managing waste produced from mining and processing operations.

Carbon Intensity

Nickel processing, and particularly the methods used to transform Indonesian nickel resources into material suited for EV batteries, is energy-intensive and potentially environmentally damaging. On average, producing Class 1 nickel from Indonesia's laterite ore resources releases two to six times more carbon dioxide emissions than producing Class 1 nickel from sulfide deposits. According to data from the International Energy Agency, processing sulfide resources produces approximately 10 metric tons of carbon dioxide equivalent emissions per metric ton of nickel produced compared to emissions that are nearly twice that amount in laterite processing using HPAL technology, and roughly six times when

[91] Tailings are a by-product of mining. After ore containing an economically recoverable commodity is mined from the earth, that commodity is extracted in a processing plant or mill. After the commodity of value is extracted from the ore material, the resultant waste stream is termed "tailings." Society for Mining, Metallurgy and Exploration, "What Are Tailings - Society for Mining, Metallurgy & Exploration," accessed February 13, 2024.
[92] Yang and Perry, "Nickel, Cobalt-Rich Indonesia Set to Propose FTA with United States," April 12, 2023.
[93] Castillo, Blumenthal, and Purdy, "Indonesia's Electric Vehicle Batteries Dream Has a Dirty Nickel Problem," September 21, 2022.

converting NPI into nickel matte. [94] Sulfide deposits tend to be higher grade than laterites and easier to process, but more laterite projects are being developed in Indonesia (and elsewhere) to meet rising demand for nickel. Indonesia's energy grid relies heavily on coal, which accounts for about 60 percent of its total electricity capacity.[95] Its burgeoning industrial parks, which have become major hubs for nickel and aluminum processing, account for 15 percent of the country's coal power output.[96] For example, one of the large nickel-producing industrial parks under development in Indonesia will ultimately be powered by 12 coal-fired plants and will use more coal than Spain or Brazil in a single year.[97]

The significant carbon footprint of Indonesia's growing nickel processing industry has come under some scrutiny as the country plans to produce more nickel products for EV batteries. "In Indonesia . . . the carbon per kilowatt-hour of power generation is much higher than most of the rest of the world," according to a market observer. "If we compare to Canada . . . Indonesia will, by 2030, produce about eight or nine times as much carbon per kilowatt-hour of electricity as Canada will."[98] Canada's nickel reserves are in the form of sulfide ore, which requires less processing to become battery-grade nickel than the laterite ore found in Indonesia. [99]

Deforestation

Indonesia is the most heavily forested region on earth after the Amazon.[100] Unlike many minerals that can be extracted in deep underground mines, the laterite nickel deposits found in Indonesia are both widespread and relatively close to the earth's surface. [101] Such deposits only form in tropical settings with high seasonal rainfall with a particular geologic setting. [102] The process used to extract the nickel removes everything on the surface, which often means destroying the rainforest. Globally, islands are often biodiversity hotspots and Indonesia is no exception. The rainforests of Indonesia are diverse and contain a multitude of unique species that are vulnerable to disruptions from mining.[103]

Mining operations are known to release toxins into waterways. Once the trees and topsoil have been removed to extract the minerals underneath, rains wash off a lot of sediment from the mining operations, which are carried into adjacent coral reefs.[104] Exposed soil from mines seep into waterways, displacing water and making flooding more frequent. Fishermen in Indonesia's Obi Islands blame the nickel mining and smelting industries for the depletion of fish in their traditional fishing grounds.

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[94] Maulia, "Indonesia's High-Carbon Nickel Key Challenge in Global EV Uptake," August 31, 2022.
[95] Yi, "Analysis: As G20 Chair, Coal-Heavy Indonesia Sends Mixed Signals on Green Transition," April 8, 2022.
[96] Castillo, Blumenthal, and Purdy, "Indonesia's Electric Vehicle Batteries Dream Has a Dirty Nickel Problem," September 21, 2022.
[97] Climate Rights International, *Nickel Unearthed*, January 2024, 4–5.
[98] Maulia, "Indonesia's High-Carbon Nickel Key Challenge in Global EV Uptake," August 31, 2022.
[99] Maulia, "Indonesia's High-Carbon Nickel Key Challenge in Global EV Uptake," August 31, 2022.
[100] Central Intelligence Agency, "Indonesia," October 16, 2023.
[101] Rice, "Electric Vehicles Are Great, but the Environmental Cost of Nickel Batteries Is Too High," April 8, 2022.
[102] Rice, "Electric Vehicles Are Great, but the Environmental Cost of Nickel Batteries Is Too High," April 8, 2022.
[103] Climate Rights International, *Nickel Unearthed*, January 2024, 67–68, 80.
[104] Rice, "Electric Vehicles Are Great, but the Environmental Cost of Nickel Batteries Is Too High," April 8, 2022.

Researchers say the pollution has turned the coastal waters into a "mud puddle" because of the high levels of heavy metal contamination that has flowed in from mines.[105]

Deforestation data showed that at least 76,301 hectares—an area the size of New York City—of tropical forests have been cleared within 329 nickel concessions in Indonesia.[106] Roughly 30 percent of this area has been cut down since 2019, overlapping with the imposition of the nickel ore export restrictions and the rise in global demand for nickel used in lithium-ion batteries for EVs.[107]

Some conservationists warn that mining could have a devastating effect on the environment, owing to the large areas of trees cut down as the land is excavated to create open pits. [108] With the roots of the trees no longer present to stabilize the ground and prevent erosion, earth is more easily swept away when it rains. According to Indonesian government data, there were at least 21 floods and mudslides in the Southeast Sulawesi area in 2022. Between 2005 and 2008, before the proliferation of mines, there were two to three per year. According to local conservationist Habib Nadjar Buduha, when waste material and water are not properly managed, sediment from nickel mines ends up in the sea, damaging the island and the surrounding marine life.[109]

Reforestation and rehabilitation efforts have taken place to offset some of the deforestation caused by nickel mining. One foreign-owned firm that operates nickel mines in Indonesia claimed that it has rehabilitated 13,527 hectares of forest as of early 2023. [110]

Waste Management

The HPAL method deployed in processing low-grade nickel ore by combining it with sulfuric acid under high pressure and heat, produces a slurry that allows for the extraction of nickel from low-grade laterite deposits. The technique was pioneered in the 1960s in Cuba but has rarely been used elsewhere—until recently in Indonesia—due to the costs and technical challenges involved in deploying this technology.

HPAL produces an enormous amount of corrosive chemical tailings—often in the millions of tons for each mine per year—that are challenging to neutralize, store, and contain. Studies show that even after the slurry is treated, this waste can contain harmful heavy metals, such as certain types of chromium, which has been linked to respiratory illnesses and increased cancer risks to exposed populations.[111]

Engineers have suggested three disposal options for mine waste: putting the waste into a ditch behind a dam; drying out the waste and stacking it on vacant lots; or pumping it into the ocean.[112] In 2021,

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[105] Sawal, "Red Seas and No Fish," February 16, 2022.
[106] Some independent experts noted that the nickel concession data does not credit rehabilitation efforts and some clearance could be linked to agriculture projects rather than nickel mining. Dempsey and Ruehl, "Nickel Miners Linked to Devastation of Indonesian Forests," October 8, 2023.
[107] Dempsey and Ruehl, "Nickel Miners Linked to Devastation of Indonesian Forests," October 8, 2023.
[108] Baraputri, "The Rush for Nickel," July 10, 2023.
[109] Baraputri, "The Rush for Nickel," July 10, 2023.
[110] Dempsey and Ruehl, "Nickel Miners Linked to Devastation of Indonesian Forests," October 8, 2023.
[111] Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023.
[112] Tan, Sijabat, Irwandi, "To Meet EV Demand, Industry Turns to Technology Long Deemed Hazardous," accessed September 25, 2023.

Indonesia banned the use of deep-sea waste disposal due to its potential for environmental damage, so that option is no longer available.[113] According to some sources, the volume of nickel production expected in Indonesia by 2027 will generate around 180 million metric tons of waste annually. Dry stacking[114] is considered to be the best option for Indonesia to deal with mine waste. However, the stability of the stacks and erosion issues are yet to be examined for the particular geography of the country, which could face the possible adverse impact of heavy rains and earthquakes.[115]

Geopolitical Issues

At present, Indonesia does not have a free trade agreement in place with the United States, meaning that nickel products processed in the country would not qualify for benefits from the Inflation Reduction Act (IRA). The Inflation Reduction Act, signed into law in August 2022 by President Joseph R. Biden, Jr., offers tax credits for EV purchases where at least 80 percent (by 2027) of the lithium, cobalt, nickel, and manganese used in their batteries has been extracted or processed in the United States or in a country with which it has a free trade agreement.[116] These criteria must be met for the vehicle to qualify for specific EV credits, with EV automakers such as Tesla already outlining the financial benefits of these incentives to their company. As a result of this legislation, several automotive companies have scrambled to secure investments and purchase agreements with mining companies which qualify under the IRA's criteria. Indonesia's lack of an FTA with the United States has caused some concern among downstream participants in the EV battery supply chain due to its significant role in global supply of nickel.[117]

In a September 2023 meeting with Vice President Kamala D. Harris, Indonesia's president Widodo requested for the United States to begin talks on a trade deal for critical minerals so that exports of minerals from Indonesia would be covered under IRA benefits, specifically mentioning Indonesia's vast nickel reserves.[118] This was followed by a November 2023 meeting between Presidents Biden and Widodo at the White House, where they announced plans to "commit to develop a critical minerals action plan that encompasses all of these lines of effort and seeks to increase high standard investment in the critical minerals sectors in both countries. They commit to pursue these efforts with a view toward establishing the foundation to launch future negotiations on a critical minerals agreement."[119] In response to the ongoing negotiations, a bi-partisan group of U.S. senators sent a letter to several high-ranking officials in the Biden administration outlining concerns about a potential critical minerals

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113 Silva, "Indonesia's Nickel Processing Boom Raises Questions over Tailings Disposal," April 17, 2023.
114 Dry stacking is a method used to store mine waste in the form of filtered tailings — the silty, sandy material that's left over once the metals such as nickel are extracted. In the dry stack method, tailings are placed and compacted in a mound that is concurrently reclaimed with native soil and vegetation. Hattori, "Dry Stack Tailings Storage," accessed October 12, 2023.
115 Berlin et al., "Quintessentially Nickel," no date, 17.
116 U.S. Department of the Treasury, "Treasury Releases Proposed Guidance on New Clean Vehicle Credit," May 18, 2023.
117 Yang and Perry, "Nickel, Cobalt-Rich Indonesia Set to Propose FTA with United States," April 12, 2023.
118 Reuters, "Indonesia Proposes Critical Minerals Trade Deal with US," September 7, 2023.
119 White House, "Joint Statement from the Leaders of the United States and the Republic of Indonesia," November 14, 2023.

agreement with Indonesia. Their concerns included labor and environmental issues related to nickel production in Indonesia as well as the high levels of Chinese investment in the industry.[120]

Labor Issues

When Indonesia banned exports of raw nickel ore to attract investment into downstream processing plants, Chinese companies arrived in large numbers, building multiple new smelters. They were eager to secure nickel for factories in China that needed the mineral to make batteries for electric vehicles. Friction between workers from China brought in by their parent companies and the local workers has increased with the influx of Chinese investment.

Early in 2023, roughly 3,000 workers staged a protest at a smelter in Central Sulawesi that is owned by PT Gunbuster Nickel Industry, a subsidiary of a Chinese company. The workers were enraged by a series of fatal accidents and what they described as a lack of protective gear and disparities in pay. The workers set fire to vehicles and destroyed property before Indonesia's military was dispatched to disperse the crowd.[121] According to reports, the influx of Chinese workers brought in by Chinese firms to work at nickel smelters in Indonesia has created friction with domestic employees. Throughout the "nickel belt of Sulawesi", there are reports that local employees earn less than their Chinese counterparts, many of them supervisors. [122] The situation has created friction between the local and foreign workers, and violent protests mounted by local workers prompted crackdowns by the police and the Indonesian military.[123]

Illegal Exports after The Ban

As of July 2023, more than three years after the latest ban, Indonesian officials began investigating potential illegal nickel ore shipments to China. While official exports ceased in the beginning of 2020, data from China's customs office showed the country still imported nickel ore from Indonesia after the ban–5.56 million metric tons between 2020 and May 2023. These nickel ore imports into China are much higher than the corresponding nickel ore exports reported by Indonesia's statistics bureau during that time period. Some analysts and traders speculated that the material was classified as iron ore rather than nickel ore (which typically has some iron content) when it was exported from Indonesia in an attempt at circumvention, but it was identified as nickel ore when it was imported into China.[124]

Summary and Outlook

Nickel production, particularly that of ferronickel, NPI, and nickel intermediate products used in lithium-ion batteries, is expected to continue to increase in Indonesia. According to information released in

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[120] Office of U.S. Senator Kevin Cramer, "Senators Express Concerns Regarding Critical Minerals Trade Agreement with Indonesia," October 25, 2023.
[121] Goodman and Ifansasti, "How Geopolitics Is Complicating the Move to Clean Energy," August 18, 2023.
[122] Goodman and Ifansasti, "China's Nickel Plants in Indonesia Created Needed Jobs, and Pollution," August 18, 2023.
[123] Goodman and Ifansasti, "China's Nickel Plants in Indonesia Created Needed Jobs, and Pollution," August 18, 2023.
[124] Reuters, "Indonesia Probes Possible Illegal Nickel Ore Exports to China," July 7, 2023.

October 2023 following the semi-annual meeting of the International Nickel Study Group, NPI production in Indonesia is expected to continue to rise, along with the number of HPAL plants that produce MHP and nickel sulfate projects.[125] The growth in downstream nickel production and exports from Indonesia have coincided with the imposition of the 2020 export ban on nickel ores and concentrates. Factors such as the widespread growth in demand for nickel used in lithium-ion batteries have also contributed to the expansion and extension of Indonesia's nickel sector. Some market analysts have forecasted that Indonesia could constitute as much as 70 percent of global nickel supply by the end of 2028.[126] Repercussions from the impact of Indonesia's trade policy and ensuing capacity expansion are likely to continue to affect the global nickel market. The rapid rise in Indonesian nickel production, including lower-cost intermediate products, was reportedly one of the factors that led to significant price declines for nickel in 2023. [127] Industry stakeholders speculate that Indonesia's share of global nickel supply could increase if nickel prices drop to levels that jeopardize the economic viability of nickel projects in other parts of the world.[128]

Indonesia's export restrictions were not implemented in a vacuum and support a broader global trend. According to the OECD, while countries like Indonesia, Namibia and Zimbabwe have imposed bans on exports of certain unprocessed mineral ore to encourage higher value-added domestic processing, the effectiveness of these export restrictions hinges on a country's leverage in global markets. The report specifically cited that in the case of Indonesia, with its significant nickel reserves and supply base, there was more than a fourfold surge in nickel export value from 2019 to 2022, coinciding with the ban.[129]

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[125] International Nickel Study Group, "Press Release: INSG April 2023 Meetings," April 26, 2023.
[126] Roberts, "Indonesia to Account for More than 70% of Global Nickel Supply in next Five Years: LME Week," October 17, 2024.
[127] London Metal Exchange nickel prices declined by 41.6 percent from $28,195 per metric ton in January 2023 to 16,461 per metric ton in December 2023. "Commodities Price Data (The Pink Sheet)," World Bank, February 2, 2024; Dempsey, Lakshmi, and Ruehl, "Indonesia's Flood of Nickel Sparks 'Darwinian' Battle for Survival among Miners," January 30, 2024.
[128] Dempsey, Lakshmi, and Ruehl, "Indonesia's Flood of Nickel Sparks 'Darwinian' Battle for Survival among Miners," January 30, 2024.
[129] Economist Intelligence Unit (EIU), "Is Critical Mineral Diversification Possible?," August 3, 2023.

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Appendix

Application: Potential Modeling Approach to Estimate the Economic Effects of the Indonesia Nickel Ore Export Ban

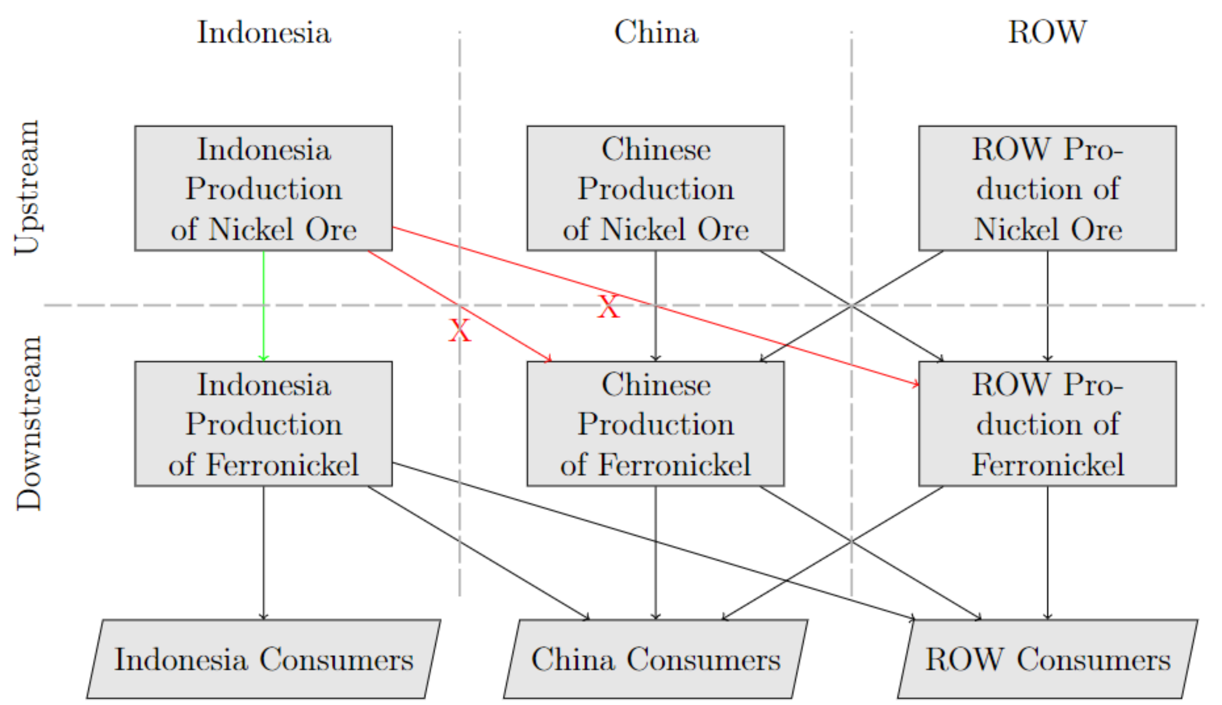
The Indonesian nickel export ban is not modeled in this paper. However, a researcher could use the model methodology described in the first export restrictions working paper of this multi-part series to estimate the economic impact of the current Indonesian nickel export ban on a particular downstream industry.[130] The modeling approach described in the first paper is a partial equilibrium framework that links the upstream mineral subject to the export restriction with a downstream industry that consumes the mineral as a production input. In the model, there are multiple country markets for both the upstream and downstream industries, including a rest of world category, so an export restriction in country A will cause changing trade patterns for countries B and C. For example, an export ban by country A of the upstream product may increase supply available to country A downstream producers, and downstream producers in countries B and C may buy more of the upstream product from their own producers as well as from the other country markets. Restricted supply and higher input costs may lead to higher prices in the downstream industries modeled. This modeling approach can capture the ripple effects of the upstream restriction on downstream prices, as well as the tapering of effects as the degree of separation from the restriction increases.[131]

The model can be calibrated with trade and production data from the year before the export restriction is implemented. Then, the model imposes the export restriction and simulates a new market equilibrium with the export restriction in place. The impact of the policy is measured as the difference between actual market outcomes in the year before the ban and the counterfactual scenario where the ban is applied.

If applying this methodology, one could label the upstream industry as nickel production (HS 2604.00) and the downstream industry as ferronickel production (HS 7202.60), with downstream consumers, or users, of ferronickel labeled as stainless steel producers. In the model, with the export ban in place, the nickel ore is processed entirely into ferronickel by Indonesia and then exported. The model could be calibrated with data from the year before the export ban was implemented, or 2019. Figure A1 illustrates a potential model structure based on UN Comtrade data and world production statistics.

[130] For example, a researcher could use this approach to estimate the impacts of the Indonesian nickel export restriction on either the stainless steel or EV battery supply chains.
[131] For a detailed description of the economic effects of the Zimbabwe export ban on chromium ore, see the USITC working paper titled, "*Estimation and Analysis of Supply Chain Effects from Zimbabwe's Chromium Ore Export Ban".*

Figure A1 Model structure as applied to the Indonesia nickel ore export ban analysis.



Source: authors own drawing based on UN Comtrade data.
Note: This figure shows how the partial equilibrium modeling approach described in the first paper of this multi-part series could be applied to the Indonesian nickel export ban analysis. ROW = rest of world.