Research Report

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Securing South Korea's Critical Minerals Supply Chains Through Trilateral Cooperation

Analysis and Tools for Supply Chain Net Assessment, Supply Chain Cooperation, and Economic Security

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About This Report

South Korea, Japan, and the United States' trilateral partnership has expanded to include collaboration on economic security, including on critical minerals supply chains (CMSCs). This report offers analysis and ideas to strengthen CMSC trilateral collaboration. We analyze CMSC vulnerabilities and policy approaches for each country, provide case studies of potential trilateral engagement with India and Mongolia, and identify potential opportunities for and barriers to trilateral cooperation. This report should be of interest to South Korean, Japanese, and U.S. policymakers and to researchers of Indo-Pacific and East Asian security, economic security, techno-economic competition, supply chain resilience, and related policy. It should also be of interest to industry.

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Summary

This report provides the Republic of Korea with insights and options to enhance the resilience of critical minerals supply chains (CMSCs) through strategic cooperation with Japan and the United States. In 2023, the three countries agreed to inaugurate a new era of trilateral partnership and expand collaboration on economic security, including on CMSCs. We provide analysis and ideas to strengthen the scale and scope of trilateral collaboration among the three countries and with key partners.

Issue

The literature on risks posed by CMSC dependencies points to threats arising from the market power of a small number of countries with outsized market share. This market power has allowed China and other countries to restrict the export of commodities to South Korea, Japan, and the United States and affects South Korea's economic security and its defense industrial base.

Approach

We conducted a risk assessment for South Korea's critical minerals list using an adapted U.S. Geological Survey methodology. After prioritizing South Korea's list, a heuristic was used to select four minerals for case studies. We then reviewed the industrial policy of the trio to compare differing approaches to supply chain securitization. To do so, we crafted a supply chain net assessment framework informed by industry analysis and a roundtable discussion. Because not all minerals are present within the trio's territories, we conducted case studies on two countries outside the trio—India and Mongolia—that have key critical materials and whose overall policy alignment may make them well suited for cooperation. The results of the analysis are combined with data from structured interviews with South Korean, Japanese, and U.S. officials, policy experts, academics, and industry representatives to unearth potential areas for trilateral cooperation and barriers to doing so.

Key Findings

We found that the trio can learn from—and leverage—each other's differing approaches to supply chain security but will eventually need to work with partners outside the trio to enhance CMSC resilience.

Opportunities for cooperation include

- pursuing cooperation on trade and reducing barriers to the movement of skilled professionals

- reducing barriers to sharing economic security information, such as through the identification or creation of new trade codes
- improving joint crisis management systems
- pooling resources to target foreign mining, processing, refining, and infrastructure projects
- providing technical assistance and expertise on institution-building in developing nations
- increasing access to foreign markets and protecting the assets of domestic firms.

Barriers to cooperation include

- U.S. trade policy
- foreign investment reviews in the United States
- historical divides between South Korea and Japan
- competition between South Korean and Japanese firms
- private-sector aversion to investment in regions with uncertain regulatory regimes
- lack of emphasis on defense industrial base supply chain security
- uncertain commitment to trilateral cooperation, including of South Korea's new leadership.

Recommendations

Our recommendations for South Korea are as follows:

- There are numerous opportunities for cooperation on CMSCs and economic security. South Korea should designate specific government organizations to pursue these opportunities at the appropriate level with Japan and the United States—for example, pursuing cooperation on trade, especially on sectoral agreements toward a critical minerals buyer's club and reducing barriers to the movement of personnel with expertise.
- Pursuing opportunities may mitigate highlighted barriers. South Korea should prioritize the communication of low-regret, near-term opportunities with leadership in Japan and the United States. Bilateral engagement within the trio can also set the stage to bring in a third party in the future.
- As chair of the Minerals Security Partnership, South Korea should investigate alternative or expanded priorities for the partnership beyond project development and standards; trade policy is one such area.
- South Korea should expand its concept of economic security to include support for the defense industrial base.
- South Korean agencies should brief the incoming head of state on the importance of trilateral cooperation for economic security, supply chain securitization, and foreign dependencies to include critical minerals dependencies.

Together, the trilateral partnership will be important to address South Korea, Japan, and the United States' shared CMSC vulnerabilities and enhance their collective resilience to China's demonstrated willingness and capacity to weaponize those vulnerabilities to advance its geopolitical aims.

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Chapter 1

Introduction

From 2022 to 2024, South Korea passed four landmark pieces of legislation aimed at increasing supply chain resilience and addressing broader economic security threats. The root of these concerns stems from the economic statecraft of the People's Republic of China (PRC) and reverberations from broader U.S.-Sino techno-economic competition. In 2016, in response to the placement of a U.S. Terminal High Altitude Area Defense air defense system on the Korean peninsula, South Korea faced retaliation in the form of the PRC blocking tourism into South Korea by Chinese citizens. In 2021, in the aftermath of the coronavirus disease 2019 (COVID-19) pandemic, South Korea experienced supply shortages of urea, an additive to diesel fuel, causing disruptions to transportation and logistics. South Korea has also been subject to third-party export restrictions levied at the United States.

Background on Trilateral Cooperation

The U.S. alliances with the Republic of Korea (ROK) and Japan have traditionally been bilateral.[1] The ROK and Japan have held antagonism toward one another because of Japan's occupation of Korea from 1910 to 1945. But as the Chinese and North Korean threats have grown, the United States has been anxious to create a strategic trilateral relationship with the ROK and Japan to counter these threats. Over time, both the ROK and Japan have realized that they have many common interests and could profitably work together. Still, reconciliation has taken some time because some in both the ROK and Japan have held residual antagonism, and cooperation has been difficult given disputes rooted in historical legacy—including forced labor, comfort women, and historical textbooks—and contemporary issues, such as competing territorial claims with significant economic implications.[2]

The United States encouraged the ROK and Japan to share intelligence on North Korea, leading to the General Security of Military Information Agreement (GSOMIA) of 2016. As part of this agreement, some trilateral missile tracking exercises were held. But issues related to World War II reparations and trade arose between the two countries, undermining GSOMIA. The confluence of reparations for World War II comfort women and forced labor from court rulings and subsequent bilateral agreements, export restrictions on important semiconductor industrial inputs, the removal of both countries from each other's respective trade country "white lists," and filings at the World Trade Organization resulted in threats by South Korea to end cooperation on North Korean intelligence-sharing. The threat remained so, but cooperation was strained. After new rounds of North Korean

[1] Michael Auslin and Christopher J. Griffin, "Time for Trilateralism?" American Enterprise Institute, March 6, 2008. Throughout the report, we use *ROK* and *South Korea* interchangeably

[2] Olivia Tasevski, "Islands of Ire: The South Korea–Japan Dispute," *The Interpreter*, April 27, 2020.

missile tests reignited security concerns, Japan and the ROK resumed using the GSOMIA, which was upgraded in 2023 to share real-time information with and through the United States.[3]

In August 2023, President Joe Biden convened a Camp David trilateral summit with the leaders of the ROK and Japan.[4] The three countries signed a pact to sharply enhance mutual security efforts by treating a threat to any of the countries as a threat to all. In addition to a focus on North Korea, cooperation on supply chains was identified as a priority. Trilateral cooperation on supply chains could be supported by initiatives in the announcement, including annual meetings at the ministerial and senior adviser level; trilateral development finance cooperation; and deepening economic and technology cooperation through economic security dialogues, the Minerals Security Partnership (MSP), the Indo-Pacific Economic Framework for Prosperity (IPEF), and a supply chain early warning system. Other aspects of trilateral cooperation followed as well.[5]

With respect to minerals, the main avenue for cooperation has been conducted through the MSP, a diplomatic channel for 15 economies and a forum for nonmember economies. The MSP primarily helps match mining and refining projects with capital with its Minerals Investment Network for Vital Energy Security and Transition arm and advocates for high standards in mining operations.[6] The trio have also held in-depth discussions on cooperation in the critical minerals sector through the Korea-U.S.-Japan Economic Security Dialogue and the Trilateral Industry Ministers' Meeting in June 2024.[7] Although originally a U.S. initiative, the ROK took over as chair of the MSP in July 2024. The April 2025 trilateral foreign ministers' joint statement explicitly reaffirmed their commitment to strengthening cooperation on critical minerals supply chains (CMSCs) through the MSP.[8]

Critical Minerals Supply Chain Issues

The characterization of critical minerals and the designation of a mineral as *critical* varies, but in general, they are defined as a group of mineral commodities in which "there is deep uncertainty about the ability to secure access to these materials at fair market prices."[9] This uncertainty manifests both in commercial and military technology value chains. The problem of dual-use technologies is readily apparent.[10] The literature on risks posed by CMSC dependencies points to threats arising from the

[3] Colin Clark, "South Korea and Japan Resume Intel Sharing Agreement, but Not All Problems Are Solved," Breaking Defense, April 17, 2023.

[4] White House, "Fact Sheet: The Trilateral Leaders' Summit at Camp David," August 18, 2023.

[5] Toluse Olorunnipa and Ellen Nakashima, "Biden Declares 'New Era' of Partnership with South Korea and Japan," *Washington Post*, updated August 18, 2023.

[6] Samantha Carl-Yoder, Fabian Villalobos, Kenyon Weaver, and J. Rabini-Jenkins, "The Minerals Security Partnership and the Pursuit of Global Supply Chain Resilience," *Proceedings of the 70th Annual Natural Resources and Energy Law Institute (2024)*, January 2025.

[7] South Korean official, interview with the authors, April 2025.

[8] South Korean official, interview with the authors, April 2025.

[9] Fabian Villalobos, Emily Allendorf, Jo Caulkins, Sophia Charan, Elisa Yoshiara, Richard Silberglitt, and Zohan Hasan Tariq, *From Mines to Markets Critical Mineral Suppliers and Dependencies in the Middle East and Central Asia: Critical Mineral Suppliers and Dependencies in the U.S. Central Command Area of Responsibility*, RAND Corporation, RR-A2914-1, 2024, p. 1.

[10] Fabian Villalobos, "Implications of Dual-Use Technologies on Critical Minerals Policy and Strategy," Colorado School of Mines, September 21, 2023.

market power of a small number of countries with outsized market share. This includes so-called foreign entities of concern (FEOCs),[11] but it mostly refers to both state-owned and nonstate Chinese firms. This market power has allowed China and other countries to restrict the export of commodities to the United States and others while also making dependent countries vulnerable to non-malign disruption.

Because this market power stems from China's alternative economic development model and broader industrial policy,[12] that market power is not likely to recede or end in the near term. This is evident in the most recent form of the PRC's critical minerals industrial policy, the 14th Five-Year Plan for the Development of Raw Materials.[13] This outsized market power and China's leverage for geopolitical influence and coercion are the origin of concerns over economic statecraft and supply chain disruptions. These threats are further reviewed in the next section.

China's alternative economic development model poses a problem for Western firms competing in the same industries as Chinese firms. Western firms trying to operate profitably are undercut by lower prices from state-owned and nonstate Chinese competitors and have been forced out of the market in numerous cases while state-owned enterprises (SOEs) remain operational. Western countries have responded with industrial policies of their own.

Economic Statecraft and Supply Chain Disruptions Affecting the Trio

China has used different methods of economic coercion in the past,[14] but it has become more nuanced and sophisticated over time by tailoring the scale and method of implementation to the target for fear of overreacting and causing lasting diplomatic damage.[15]

The origin of modern CMSC disruption threats stems from the now-infamous 2010 Diaoyu-Senkaku Island dispute between China and Japan.[16] Even before the de facto ban on REEs, Japanese

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[11] "The term *foreign entity of concern* describes nonstate actors potentially posing economic or security threats to the United States. Terrorist groups, for example, are classified as FEOCs; so too are businesses significantly influenced by the governments of China, Russia, North Korea, or Iran (known as 'covered nations')." See Nicholas E. Buffie, *Foreign Entity of Concern Requirements in the Section 30D Clean Vehicle Credit*, Congressional Research Service, IN12322, updated September 30, 2024, p. 1. For the purposes of this study, we refer to *FEOCs* as state-owned or nonstate firms from China, Russia, Iran, and North Korea. We use the terms interchangeably.

[12] In this report, we refer to *industrial policy* as "government policies that explicitly target the transformation of the structure of economic activity in pursuit of some public goal. The goal is typically to stimulate innovation, productivity, and economic growth, but it could also be to promote climate transition, good jobs, lagging regions, exports, or import substitution." See Réka Juhász, Nathan Lane, and Dani Rodrik, "The New Economics of Industrial Policy," *Annual Review of Economics*, Vol. 16, 2024.

[13] Ministry of Industry and Information Technology of the People's Republic of China, *Notice on Issuing the 14th Five-Year Plan for the Development of Raw Materials Industry* [三部委关于印发“十四五”原材料工业发展规划的通知], MIIT Joint Regulation, No. 212, December 29, 2021.

[14] Harrell, Peter, Elizabeth Rosenberg, and Edoardo Saravalle, *China's Use of Coercive Economic Measures*, Center for a New American Security, June 11, 2018.

[15] Heo, Jai Chul, "Analysis of Chinese Response Patterns to Diplomatic Friction and Its Influencing Factors," Korea Institute for International Economic Policy, *World Economy Brief*, Vol. 22, No. 10, March 10, 2022.

[16] For the history of the threat of rare earth element (REE) restrictions and bans, see Fabian Villalobos, Jonathan L. Brosmer, Richard Silberglitt, Justin M. Lee, and Aimee E. Curtright, *Time for Resilient Critical Material Supply Chain Policies*, RAND Corporation, RR-A2102-1, 2022.

companies had concerns over access to REEs in 2007 in response to Chinese export quotas and had pursued diversification strategies. Following the de facto ban in 2010, Japan quickly passed legislation to mitigate or reduce future disruptions, including by funding a $1.25 billion package with five pillars of industry support that include developing technologies to reduce REE demand, pursuing recycling efforts, developing substitute materials, developing or acquiring equity in REE mines abroad and strengthening financial capacity to do so, and stockpiling REEs.[17] This package, and subsequent efforts, included investment in Australian companies, such as Lynas Rare Earth, and those in other countries. These efforts laid the groundwork for Japan's Economic Security Law of 2022.

In 2019, the PRC's National Development and Reform Commission suggested restrictions on REE products in response to U.S. trade policy. In addition, the PRC's Ministry of Industry and Information Technology suggested that U.S. defense contractors were potential targets for export restrictions in 2020 because of their role in supplying military technology to Taiwan.[18]

Meanwhile, in South Korea, the PRC's response to the placement of the U.S. Terminal High Altitude Area Defense air defense system in 2016 was to block its citizens from visiting South Korea for tourism and to instigate protests at Lotte storefronts, essentially chasing the company out of the country.[19] In 2021, China experienced internal urea shortages and restricted shipments to Korea.[20] This unforeseen but non-malign event slowly crept into the view of South Korean policymakers and unexpectedly lead to fuel shortages in South Korea.[21] As noted earlier, Japan placed export restrictions on important inputs for South Korea's semiconductor industry during the late 2010s as part of their trade and social disagreements.

Following the onset of U.S. export controls of semiconductor and advanced computing equipment in 2022, China increased threats of export restrictions and export bans. By this time, China's market power had grown in other mineral value chains, thus providing a wider array of options. Table 1.1 provides a review of restrictions and export bans from 2023 to April 2025.

However, China has become more sophisticated in its execution of the critical minerals economic weapon. Obtaining an export license from the PRC's Ministry of Commerce requires applicants to submit information that some companies consider sensitive—including data on importers, company internal operations, and their customers.[22] Along with their coercive effects, export restrictions and

[17] Cindy Hurst, "Japan's Approach to China's Control of Rare Earth Elements," Jamestown Foundation, *China Brief*, Vol. 11, No. 7, April 22, 2011.

[18] Sun Yu and Demetri Sevastopulo, "China Targets Rare Earth Export Curbs to Hobble US Defence Industry," *Financial Times*, February 15, 2021.

[19] U.S. official, interview with the authors, April 2025; Yi Whan-woo, "THAAD Retaliation Appears to Be Continuing," *Korea Times*, November 13, 2019.

[20] Kim Bo-eun, "Korea Urged to Diversify Material Imports," *Korea Times*, November 11, 2021; Yukyung Yeo, "Urea Crisis Sparks South Korean Supply Chain Revamp," East Asia Forum, August 23, 2024.

[21] Jahyun Koo and Daehee Jeong, *Economic Security and Strategies to Strengthen Supply Chains*, Korea Development Institute, December 30, 2023.

[22] "Japan Complains That China's Export Control Law Is Too Broad and Unclear," *WorldECR*, June 22, 2023.

licensing requirements may serve an additional purpose: to find targets for future sanctions by adding them to China's export-control list or unreliable entity list.[23]

These restrictions also affect third-party suppliers reliant on China for production inputs and who export value-added products to the United States. For example, in April 2025, the PRC's Ministry of Commerce "asked South Korean companies not to export products containing China's rare earth minerals to U.S. defense firms."[24]

Table 1.1. Timeline of Chinese Export Restrictions from August 2023 Through April 2025

Date	Action (China)	Target Country	Preceding Action(s)	Date (Preceding Action)
August 1, 2023	Export controls on gallium and germanium-related items[a]	None	• United States: Bureau of Industry and Security initial rule restricting Chinese access to semiconductors[b] • European Union: antisubsidy investigation on Chinese electric vehicles (EVs)[c]	• October 7, 2022 • September 30, 2023
October 20, 2023 (announced on this day but implemented in December 2023)	Export permits for some graphite products[d]	None	• Netherlands: new export restrictions on advanced semiconductor equipment[e] • United States: restrictions on outbound investment in the semiconductor, quantum information, and artificial intelligence (AI) sectors in foreign "countries of concern"[f] • United States: expansion of restrictions on AI chips and semiconductor manufacturing equipment; 13 Chinese firms added to the U.S. Entity List[g]	• June 30, 2023 • August 9, 2023 • October 17, 2023 (announced on this day but went into effect 30 days after)
December 21, 2023	Export ban on rare earth processing technology[h]	None	• Likely the same as listed in the above row	• N/A
August 14, 2024 (announced on this day but implemented in September 2024)	Export restrictions on six antimony-related products, including antimony ore, antimony	None	• United States: new or increased tariffs on Chinese EVs, EV batteries, battery parts, semiconductors, solar	• May 14, 2024 (day announced)

[23] The export control list prohibits the export of Chinese dual-use items to these companies, and the unreliable entity list "prohibit[s] . . . exporting or importing in China or from making new investments in the country" (Liza Lin, "China Adds 15 American Companies to Export-Control List," *Wall Street Journal*, March 4, 2025).

[24] Hyunjoo Jin, "China Asks Korea Not to Export Products Using Rare Earths to US Defense Firms—Reports," Mining.com, April 22, 2025; Ri-Ahn Kim and Dae-Hun Kim, "China Bans Export of Korean Goods Using Its Rare Earth Metals to US," *Korea Economic Daily*, April 22, 2025.

Date	Action (China)	Target Country	Preceding Action(s)	Date (Preceding Action)
	metals, antimony oxide, and gold-antimony smelting and separation technologies; export ban on gold-antimony smelting and separation technology exports[i]		cells, permanent magnets, and certain steel and aluminum products[j]	
December 3, 2024	Ban on shipments of gallium, germanium, antimony, and so-called superhard materials to the United States[k]	United States (first time restrictions specially targeted the United States)	• United States: second expansion of export restrictions on semiconductor equipment; 140 Chinese entities added to the export-control list[l]	• December 2, 2024
February 4, 2025	Export licenses required for tungsten, tellurium, bismuth, indium, and molybdenum	United States	• Likely the same as listed in the above row	• N/A
April 4, 2025	Export licenses required for samarium, gadolinium, terbium, dysprosium, lutetium, scandium, and yttrium oxides; intermediate compounds; and related products (magnets) and manufacturing technology	United States	• United States: increased and broad sweeping tariffs placed on imports from China	• April 2, 2025

NOTE: N/A = not applicable.

[a] International Energy Agency (IEA), "Announcement on the Implementation of Export Control of Items Related to Gallium and Germanium," last updated April 25, 2025c.

[b] Sujai Shivakumar, Charles Wessner, and Thomas Howell, *Balancing the Ledger: Export Controls on U.S. Chip Technology to China*, Center for Strategic and International Studies, February 2024.

[c] European Commission, "EU Imposes Duties on Unfairly Subsidised Electric Vehicles from China While Discussions on Price Undertakings Continue," press release, October 28, 2024.

[d] Siyi Liu and Dominique Patton, "China, World's Top Graphite Producer, Tightens Exports of Key Battery Material," Reuters, October 20, 2023.

[e] Arjun Kharpal, "Netherlands, Home to a Critical Chip Firm, Follows U.S. with Export Curbs on Semiconductor Tools," CNBC, June 30, 2023.

[f] Shivakumar, Wessner, and Howell, 2024.

[g] Emily Benson and Thibault Denamiel, "China's New Graphite Restrictions," Center for Strategic and International Studies, October 23, 2023.

[h] Edward White, "China Bans Export of Rare Earth Processing Technologies," *Financial Times*, December 21, 2023.

[i] Gracelin Baskaran and Meredith Schwartz, "China's Antimony Export Restrictions: The Impact on U.S. National Security," Center for Strategic and International Studies, August 20, 2024a.

[j] Brooks E. Allen, Joseph L. Barloon, Brian J. Egan, Michael E. Leiter, Christian Knipfer, and Joe Sandman, "US Announces New Tariffs on Chinese-Origin Goods, With an Exclusion Process," Skadden, May 15, 2024.

Date	Action (China)	Target Country	Preceding Action(s)	Date (Preceding Action)

[k] Gracelin Baskaran and Meredith Schwartz, "China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet Amidst Escalating U.S.-China Tech War," Center for Strategic and International Studies, December 4, 2024b.
[l] "US Unleashes Another Crackdown on China's Chip Industry," Al Jazeera, December 2, 2024.

This series of economic statecraft and supply disruptions demonstrates that China's market power in these value chains is a coercive weapon that can be implemented in different contexts and may be used in contexts not yet envisaged. Even when not intentionally malign, China's outsized role as a supplier of midstream and upstream manufacturing inputs creates risk for consumers.[25] Trilateral cooperation on CMSC issues is therefore an important arena in which to practice and implement economic security measures and to shore up existing vulnerabilities.

Scope

To assess potential for trilateral CMSC cooperation, we focus our analysis on high-risk minerals within the trio and their related industries, trilateral countries' supply chain securitization capabilities, and potential partners outside the trio in the Indo-Pacific region.

Approach and Methods

We conducted a risk assessment by adapting a supply risk assessment methodology developed by the U.S. Geological Survey (USGS). We assessed South Korea's CMSC risks via its critical minerals list using Harmonized System (HS) codes identified by the U.S. Department of Commerce. In so doing, we level set differences in risk assessment across the trio. Methods of trade analysis are reviewed in Appendix B. After prioritizing South Korea's list, we used a heuristic to select four minerals for case studies: cobalt, gallium, molybdenum, and tungsten. Case studies focused on mineral demand, trade into and between the trio, mineral sources in the trio, and geopolitical activity.

We assessed the CMSC policy activities of the trilateral countries to compare the trio's approach to supply chain securitization and to present an analysis of each countries' capabilities to achieve relevant policy objectives. A review of each country's overall minerals strategy includes reviewing governmental organizations issuing guidance and implementing policy, as well as the legal basis for doing so; creating a summary of policy tactics and tasks; and reviewing important financial mechanisms used to shape industry incentives. To support the analysis, we developed a supply chain net assessment methodology, which is presented in Appendix C. It involved the collection and categorization of the trio's CMSC policies and programs, language translation, and framework and metric development.

[25] Ryu Yeri, "China's Export Control Measures: Accurate Diagnosis and Prescription" ["중국의 수출통제조치: 정확한 진단과 처방"], CSF (China Expert Forum), February 13, 2024.

To analyze the potential for cooperation with countries outside the trio, we developed a political alignment framework. Development of the framework is reviewed in Appendix D. Two country case studies illustrate the potential for cooperation outside the trio: India and Mongolia.

The results of this analysis are combined with insights gained from structured interviews with South Korean, Japanese, and U.S. officials, policy experts, academics, and industry representatives to unearth areas for trilateral cooperation and barriers to doing so.[26] Additional details on the interviews are provided in Appendix A.

Finally, we report key findings and recommendations for South Korea and insights for Japan and the United States.

[26] Interviews were also conducted with other country officials and experts for the country case studies.

Chapter 2

Critical Minerals Supply Risk Across the Trilateral

This chapter provides an overview of CMSCs across the trilateral countries. The chapter includes a risk assessment using an adapted supply risk methodology. After prioritizing South Korea's critical minerals list, a heuristic was developed to select four minerals for deeper dive case studies on cooperation: cobalt, gallium, molybdenum, and tungsten.

Terminology

When presenting data and analysis of mineral deposits and trade, we use the terminology established by RAND researchers in a 2024 report:[a]

> Mineral production happens over several stages in the value chain. . . . *Extraction* refers to the removal of minerals from the site of a mineral deposit. Countries have *resources* of raw ore that occur as natural deposits in the earth's surface.[b] Some resources are more economical to extract than others, thus *reserves* are the total resources that have been proven to be economically feasible. However, not all reserves have extraction operations underway. When *production* is used in the context of extracted material, we refer to the quantity of raw material originating from reserves that have ongoing operations. For extracted material to be usable to industry as a material input, it must be *processed*—i.e., refined from a raw state, like ore—to a usable intermediate or final product, such as a metal ingot or specialty chemical. *Production* in this context then refers to the quantity of ingots, specialty chemicals, and related products emerging from these operations. Processing can occur off-site, and some companies extract and export ore to be processed elsewhere; however, some companies process their ore before exporting it. Because of this, production data are sometimes limited, and assumptions must be made. Where appropriate, we state our assumptions.

The tables presented in this chapter and subsequent references to them follow this nomenclature.[c]

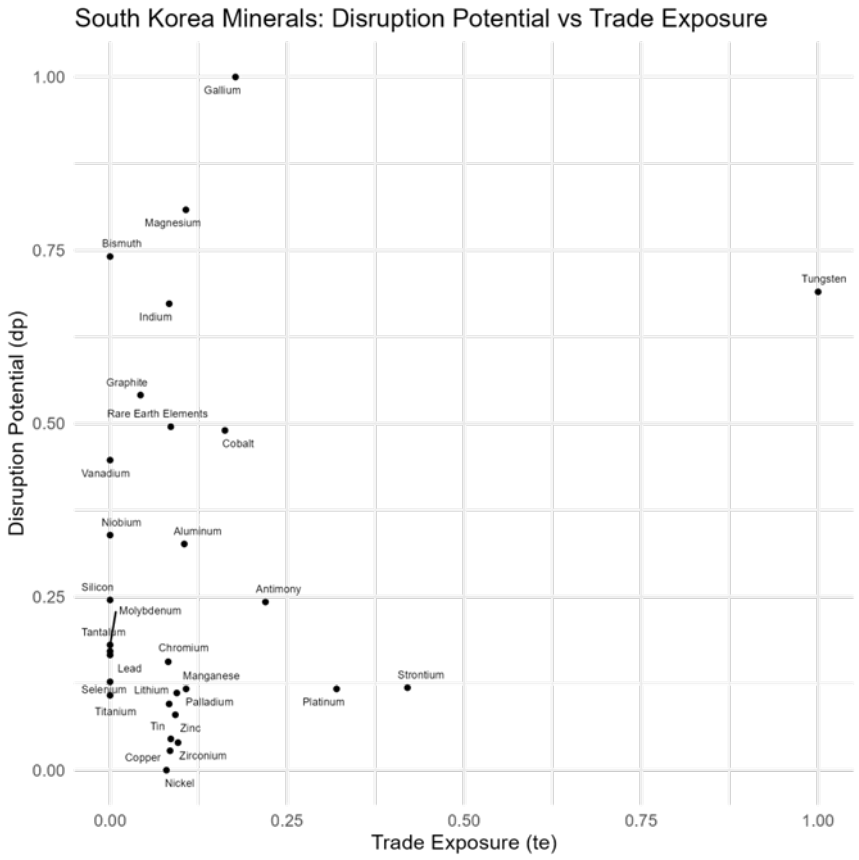
[a] Villalobos et al., 2024.
[b] British Geological Survey, "What Is the Difference Between Resources and Reserves for Aggregates?" webpage, undated.
[c] For an in-depth overview of terms, we refer the reader to the USGS mineral commodity surveys (USGS, *Mineral Commodity Summaries 2025*, version 1.2, March 2025).

Risk Assessment of South Korea's Critical Minerals List

Analyzing CMSC risk for more than one country at a time has its challenges. Not every country has the same methodology for determining risk or which minerals to include on a list.

To level set and foster a shared perception of risk across the trilateral, we used an adapted USGS method published in a 2020 journal article,[27] focusing on South Korea's list of 33 critical minerals and analyzing the critical minerals trade codes drafted by the U.S. Department of Commerce.[28] Appendix B reviews the approach. The result was a calculation of trade exposure and disruption potential for the 33 minerals on South Korea's critical minerals list as seen in Figure 2.1. Because of data limitations (further explained in Appendix B), the supply risk for REEs was assessed as a whole rather than by individual element.

Figure 2.1. Disruption Potential vs. Trade Exposure of South Korea's Critical Minerals List



SOURCE: Authors' analysis of 2022 United Nations Comtrade data (United Nations Statistic Division, UN Comtrade Database, International Merchandise Trade Statistics, undated) and other datasets as described in Appendix B.
NOTE: The results for trade exposure lack domestic stockpiling data, which may bias the results higher. For definitions of *trade exposure* and *disruption potential*, see Appendix B.

[27] Nedal T. Nassar, Jamie Brainard, Andrew Gulley, Ross Manley, Grecia Matos, Graham Lederer, Laurence R. Bird, David Pineault, Elisa Alonso, Joseph Gambogi, and Steven M. Fortier, "Evaluating the Mineral Commodity Supply Risk of the U.S. Manufacturing Sector," *Science Advances*, Vol. 6, No. 8, February 21, 2020.

[28] International Energy Agency, "Critical Mineral List in Korea," webpage, December 8, 2023a; International Trade Administration, U.S. Department of Commerce, "Draft List of Critical Supply Chains," webpage, undated.

Mineral Case Studies

We conducted case studies to investigate the potential for trilateral collaboration on high-priority CMSCs. Each case study delves into the broader commodity market, industry presence within the three countries, relevant country policies, and geopolitical activity.

Case Study Selection Criteria

The adapted supply risk calculation provides a rank ordering of critical minerals twice over. To prioritize a selection of minerals for further investigation, we repeated the adapted supply risk calculation for Japan and the United States using the same 33 minerals on South Korea's list and with the same trade codes. Differences in rank ordering for trade exposure and disruption potential means that a heuristic is needed to make the final selection.

We selected four minerals that appear in the three countries' critical minerals lists and that appear in the top five of at least a single country for trade exposure or disruption potential.[29] We prioritized South Korean risk, followed by Japanese risk, and the presence (or lack thereof) of reserves in the three countries. We selected two minerals with high demand from the civilian commercial sector (e.g., consumer electronics or EVs) and two minerals with high demand from the defense and aerospace sector. Using the heuristic, we selected four minerals for deeper dive case studies: cobalt, gallium, molybdenum, and tungsten. Table 2.1 lists the disruption potential and trade exposure rankings across the three countries for the four minerals.

Table 2.1. Rank Ordering of Minerals According to Disruption Potential and Trade Exposure

	South Korea		Japan		United States	
Mineral	**Disruption Potential**	**Trade Exposure**	**Disruption Potential**	**Trade Exposure**	**Disruption Potential**	**Trade Exposure**
Cobalt	6	6	5	3	3	3
Gallium	1	5	1	6	1	13
Molybdenum	16	N/A	17	1	14	N/A
Tungsten	4	1	4	N/A	4	N/A

SOURCE: Authors' analysis of 2022 United Nations Comtrade data (United Nations Statistic Division, undated) and related datasets described in Appendix B.
NOTE: South Korea and Japan stockpiling data were unable to be included for all minerals—the stockpiling component of the trade exposure calculation was therefore left out for all three countries. This may bias the results toward a higher trade exposure. N/A signifies that the country is a net exporter or that no import, export, or consumption data were available.

[29] Because of limitations in aggregated trade data in REEs, individual REEs that receive priority on South Korea's list (e.g., neodymium, dysprosium, terbium, cerium, and lanthanum) are ranked at 7 for disruption potential.

Cobalt

Cobalt is a silvery gray metal known for its ferromagnetism, hardness, wear resistance, low conductivity, and high melting point. Cobalt is used in lithium-ion batteries (for EVs, consumer electronics, and energy storage systems), in catalysts for refining petroleum, in REE permanent magnets[30] (for direct drive motors in vehicles and wind turbines), and for production of cemented carbides and diamond tools.[31] Military uses of cobalt include superalloys in gas turbine jet engines (combustors) and electronic components of fixed wing and rotary aircraft and the propulsion, arming, firing, and motor pump actuators of missiles.[32]

Cobalt sulfate and cobalt oxides are the key refined cobalt materials used in lithium-ion battery cathodes,[33] and metal cobalt is used in alloys.

Mineral Demand

Battery demand drives the cobalt market, which constitutes 73 percent of global demand.[34] This demand stems from EVs (45 percent), portable electronics (26 percent), and energy storage systems (2 percent). In 2023, cobalt-containing cathodes held 55-percent market share, and the balance was filled mainly by lithium-iron-phosphate cathodes. In non-battery applications, superalloys account for 9 percent of global demand primarily for aerospace applications, followed by hard metals at 4 percent, and catalysts and ceramics/colors at 3 percent each.

According to the USGS,[35] in 2024, 51 percent of cobalt consumption in the United States was used for superalloys for aircraft gas turbine engines. Chemical applications comprised 25 percent, 15 percent was from other metallic applications, and 9 percent was for cemented carbides. From 2020 to 2023, the United States imported cobalt metal, oxide, and salts primarily from Norway, Finland, Japan, and Canada.

The trade flow analysis shows trilateral countries relying heavily on cobalt imports, particularly for metals and chemical compounds. Figure 2.2 illustrates the trade flows of cobalt ores and concentrates (panel a), chemical compounds (panel b), metals (panel c), and waste and scrap (panel d) between the trilateral nations and other countries.

In 2023, South Korea imported most of its refined cobalt from the Democratic Republic of Congo (DRC) (28 percent), Japan (12 percent), and China (10 percent). South Korea imported cobalt compounds primarily from China (54 percent) and cobalt scrap mostly from Japan (97 percent).[36]

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[30] For example, in cobalt-samarium permanent magnets.

[31] Kwasi Ampofo and Marina Demidova, *Cobalt 2050: Unlocking Potential for a Net-Zero Future*, Bloomberg NEF and Cobalt Institute, October 2024.

[32] Benedetta Girardi, Irina Patrahau, Giovanni Cisco, and Michel Rademaker, *Strategic Raw Materials for Defence: Mapping European Industry Needs*, Hague Centre for Strategic Studies, January 2023.

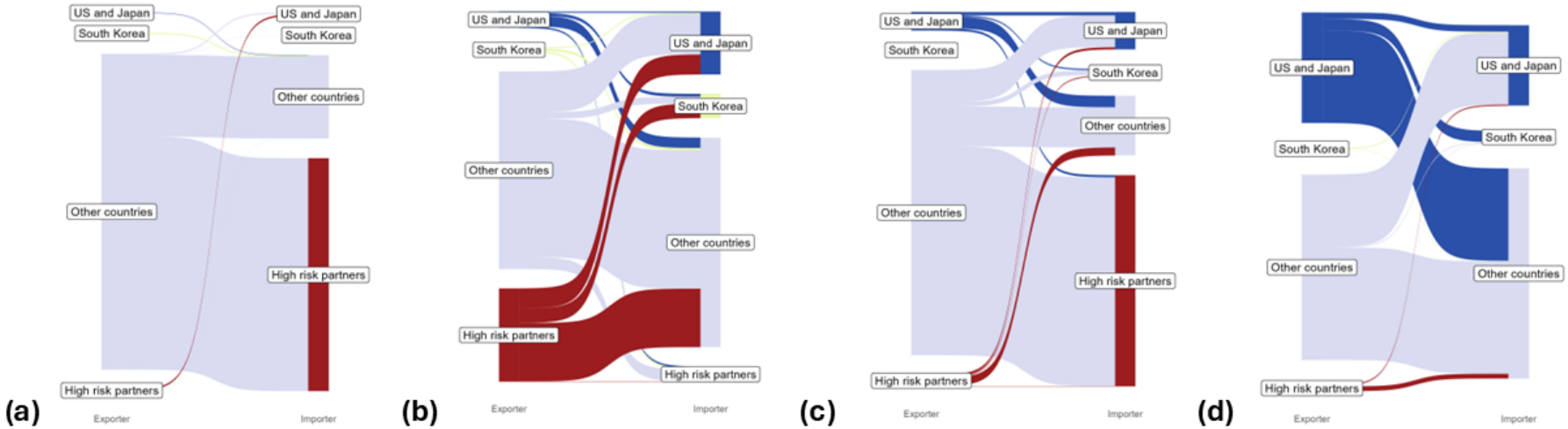
[33] Daniel Matthews, *Global Value Chains: Cobalt in Lithium-Ion Batteries for Electric Vehicles*, Office of Industries, U.S. International Trade Commission, ID-20-067, May 2020.

[34] Cobalt Institute, *Cobalt Market Report 2023*, May 2024.

[35] USGS, 2025.

[36] Korea Institute of Geoscience and Mineral Resources, *Rare Metal Raw Material Trade Analysis 2024* [희유금속 원재료 교역 분석 2024], 2024, p. 92.

Figure 2.2. Trade Flows of Cobalt in Trilateral Countries



SOURCE: Authors' analysis of 2022 United Nations Comtrade data (United Nations Statistics Division, undated).
NOTE: Panel a = cobalt ores and concentrates (HS 260500). Panel b = cobalt oxides and hydroxides, commercial cobalt oxides (HS 282200); chlorides: other than of ammonium, calcium, magnesium, aluminum, and nickel (HS 282739); acids: saturated acyclic monocarboxylic acids, acetic acid and its salts not elsewhere specified in HS 2915.2 (HS 291529); sulphates: not elsewhere specified in item no. 2833.2 (HS 283329); and carbonates, not elsewhere specified in HS 2836 and other than lithium or strontium (HS 283699). Panel c = mattes and other intermediate products of cobalt metallurgy, unwrought cobalt, powders (HS 810520); and articles not elsewhere specified in HS 810590. Panel d = cobalt waste and scrap (HS 810530).

According to the USGS *2020–2021 Minerals Yearbook*,[37] the main driver of domestic cobalt demand in Japan in 2020 was from batteries. In that year, Japan imported cobalt in the form of matte, unwrought cobalt, and cobalt powder. The top Japanese supplier was Finland (61 percent), and China supplied 3.8 percent. With no large-scale domestic production, Japan relies entirely on imports for cobalt oxide and hydroxide.

Source Countries and Industry

Cobalt is mainly extracted as a byproduct of nickel and copper mining (60 percent and 38 percent, respectively), with only 2 percent from primary cobalt mining in Morocco and Canada.[38] The DRC—otherwise known as Congo-Kinshasa—dominates global cobalt production, supplying 74 percent of mined output and holding 57 percent of reserves, primarily from copper deposits. Indonesia, driven by its growing nickel industry, has become the second-largest producer, contributing 10 percent of global supply and 5.8 percent of reserves in 2024. One of the trilateral countries—the United States—holds just 1 percent of reserves and produces negligible share.

China is the leading producer of refined cobalt, sourcing ores and concentrates primarily from the DRC and Indonesia. It is also the largest consumer of ores and concentrates mostly because of battery demand.[39] In 2023, China accounted for 78.5 percent of global-refined cobalt output, while Japan accounted for 1.9 percent.[40] Among the top ten cobalt refiners worldwide, eight were headquartered in China.

Cobalt production at the firm level is highly concentrated, and Chinese companies play a prominent role. The major cobalt producers in the trilateral countries include

- Eagle Mine: Located in Michigan, it primarily extracts nickel and copper and produces a nickel concentrate containing cobalt.[41]
- Sumitomo Metal Mining: A supplier of nickel-cobalt-aluminum cathode materials with a capacity of 60,000 tonnes,[42] it owns the Niihama and Harima plants and manufactures cobalt-samarium magnets.

Government Policy and Priorities

Cobalt is on each trilateral countries' critical minerals list and many other nations' lists, including China and the European Union countries.[43] Its inclusion on the North Atlantic Treaty Organization's (NATO's) list of defense critical raw materials underscores its vital role in defense technologies.[44] The

[37] Keita F. DeCarlo, "Japan [Advance Release]" in *2020–2021 Minerals Yearbook*, U.S. Geological Survey, December 2024.

[38] Cobalt Institute, "Cobalt Mining," webpage, undated.

[39] USGS, 2025.

[40] Cobalt Institute, 2024.

[41] USGS, 2025.

[42] Mayurakshi Ganguly, ed., "Sumitomo Expands Battery Plant Capacity with Plans to Explore USA's Electric Vehicle Market," AI Circle, November 17, 2023.

[43] Masato Nagahara, "Introduction of the Lists of Critical Minerals and Materials Around the World" ["各国および地域連合等の重要鉱物·物質リスト概論"], Japan Organization for Metals and Energy Security, January 14, 2025.

[44] NATO, "NATO Releases List of 12 Defence-Critical Raw Materials," last updated December 16, 2024.

United States, Japan, and South Korea are actively diversifying and securing their cobalt supplies through financial support, international agreements and private-sector partnerships, and stockpiling strategies.

The United States has forged agreements with cobalt nations—such as the DRC, Zambia,[45] Philippines[46], and Japan[47]—to diversify its supply sources. Additionally, through the U.S. Partnership for Global Infrastructure and Investment, the United States is backing the Lobito Trans-Africa Corridor to improve cobalt transportation and global supply chain resilience.[48] In terms of stockpiling, as of 2020, U.S. industries held 952 metric tons of cobalt, and the government stockpiled 317 metric tons of cobalt,[49] highlighting efforts to secure a stable supply amid growing demand.

Similarly, Japan secures cobalt through multiple government agreements, including those with Australia,[50] Canada,[51] the DRC, and Zambia,[52] as well as various private-sector partnerships, such as Marubeni Corporation with Eurasian Resources Group and Sumitomo Metal Mining, Mitsubishi Corporation, and Mitsui & Co. with the Ardea Kalgoorlie Nickel Project in Australia.[53] In terms of stockpiling, Japan plans to maintain 180-day inventories of critical minerals, including cobalt.[54]

South Korea is actively strengthening its cobalt supply by expanding cooperation with cobalt-rich countries, such as Australia and Canada,[55] while also securing resources through private-sector partnerships, such as LG Energy Solution with Australian Mines Ltd. and Samsung SDI with

[45] Memorandum of Understanding Among the United States of America, the Democratic Republic of the Congo, and the Republic of Zambia, Concerning Support for the Development of a Value Chain in the Electric Vehicle Battery Sector, December 13, 2022.

[46] White House, "Fact Sheet: Vice President Harris Launches New Initiatives to Strengthen U.S.-Philippines Alliance," November 20, 2022.

[47] Agreement Between the Government of the United States of America and the Government of Japan on Strengthening Critical Minerals Supply Chains, March 28, 2023.

[48] White House, "Fact Sheet: Partnership for Global Infrastructure and Investment in the Lobito Trans-Africa Corridor," December 3, 2024b.

[49] Of the 317 metric tons, there were 302 metric tons of cobalt metal, 1 metric ton of lithium-cobalt oxide, 3 metric tons of Lithium-nickel-cobalt-aluminum oxide, and 11 metric tons of cobalt alloys (Kim B. Shedd, "Cobalt [Advance Release]," in *2020 Minerals Yearbook*, U.S. Geological Survey, October 2024b).

[50] GlobalData, "Australia's Northern Territory, Japan Partner on Critical Minerals," July 22, 2024; Madeleine King and Anthony Albanese, "Australia-Japan Strengthen Critical Minerals Cooperation," press release, October 22, 2022.

[51] Memorandum of Cooperation Between the Department of Industry of Canada, the Department of Natural Resources of Canada, the Department of Foreign Affairs, Trade and Development of Canada and the Ministry of Economy, Trade and Industry of Japan, the Ministry of Foreign Affairs of Japan Concerning Battery Supply Chains, October 25, 2023.

[52] Japan Organization for Metals and Energy Security (JOGMEC), "JOGMEC Signed an Agreement with African Countries to Secure Critical Minerals—Strengthening Relationships with African Countries Through Accompanying Minister NISIMURA on a Visit to Southern African Countries," press release, August 18, 2023.

[53] Jane Bentham, "ERG Signs Cobalt Agreements in North America, Europe, and Japan," *Global Mining Review*, July 31, 2024; Ardea Resources Limited, "Ardea Kalgoorlie Nickel Project MOU with Sumitomo Metal Mining, Mitsubishi Corporation, and Mitsui & Co," press release, July 5, 2023.

[54] IEA, "International Resource Strategy—National Stockpiling System," webpage, last updated April 9, 2025.

[55] Keith Pitt, "Australia, Republic of Korea to Work Closer on Critical Minerals," press release, December 13, 2021; South Korean Ministry of Trade, Industry, and Energy, "Korea and Canada Sign Critical Minerals Supply Chain Cooperation MOUs," press release, September 26, 2022.

Alliance Nickel on the Western Australian nickel-cobalt project.[56] South Korea aims for a 180-day stockpile of cobalt but had only achieved 12.4 days' worth in 2023.[57]

Geopolitical Activity

Cobalt's market stability is closely tied to the production of copper and nickel, as it is often extracted as a byproduct from copper and nickel mines primarily owned by Chinese firms, including in the DRC. This monopolistic concentration heightens geopolitical risks atop geographic risks associated with the cobalt supply,[58] especially in light of China's restrictions on gallium, germanium, and antimony.[59] These actions highlight the sensitivity of global supply chains. Excluding China as the largest supplier of processed cobalt would result in a significant shortfall in supply compared with demand; remaining global supplies would only satisfy 25 percent of the demand by 2035, which is far from adequate to meet the projected mineral requirements.[60] To reduce reliance on DRC ore and concentrate and Chinese-processed cobalt, countries and companies are exploring alternative sources and investing in recycling technologies.[61] Efforts are also being made to develop battery technologies that require less or no cobalt.[62] In 2024, the United States increased tariffs on cobalt ores and concentrates and cobalt-containing products, such as EVs and lithium-ion batteries, imported from China,[63] which means that the United States is taking more intense actions to diversify cobalt supplies and reduce dependency on Chinese imports.

Gallium

Gallium is a silvery-white metal sourced primarily as a coproduct of refining bauxite ore into alumina and in the coproduction of zinc. Initially used for high-temperature thermometers and metal alloys, gallium has found demand from semiconductors that outperform conventional silicon chips by handling higher temperatures, voltages, and frequencies, thereby enabling the development of smaller, faster, and more-efficient electronic devices.[64] There is now demand for gallium-based power conversion devices (e.g., charging equipment in electronic devices), telecommunications devices (e.g., for 5G or 6G), and optoelectronic devices (e.g., light-emitting diodes screens, photodetectors, and

[56] LG Energy Solution, "LG Energy Solution to Have 6-Year Access to Nickel, Cobalt from Australian Mines Amid Heated Competition over Raw Materials," press release, August 16, 2021; Sarah MacNamara, "Alliance Nickel, Samsung SDI Sign Non-Binding Term Sheet," *Mining*, February 12, 2024.

[57] "S. Korea Targets Stockpiling 100 Days' Worth of Rare Metals," *Dong-A Ilbo*, July 25, 2023.

[58] Gavin D. J. Harper, "The Geopolitics of Cobalt," *American Affairs*, Vol. 5, No. 4, Winter 2021.

[59] "China Bans Export of Gallium, Germanium and Antimony to the US," Mining.com, December 3, 2024.

[60] Shobhan Dhir, Eric Buisson, and Tae-Yoon Kim, "Growing Geopolitical Tensions Underscore the Need for Stronger Action on Critical Minerals Security," International Energy Agency, February 9, 2025.

[61] Heffernan, Marissa, "Samsung Starts Battery-to-Battery Cobalt Recycling," Resource Recycling, January 30, 2025.

[62] Anne Trafton, "Cobalt-Free Batteries Could Power Cars of the Future," MIT News, January 18, 2024.

[63] USGS, 2025.

[64] U.S. Department of Energy (DOE), "Wide Bandgap Semiconductors: *Pursuing the Promise*," April 2013.

photovoltaic solar cells).[65] These components and subsystems are found in vehicles, consumer electronics, and data-centric networks.

Gallium enhances devices and electronic systems with military utility. Such devices as sensors, avionics, communication equipment, and identification systems are used in the air and land domain.[66] Gallium arsenide supports advancements in the Global Positioning System (GPS), precision-guided weapons, and radar systems, and gallium nitride benefits radar technology by tracking smaller, faster threats from greater distances, such as hypersonic missiles and stealth aircraft. Gallium nitride devices are used in such platforms as the U.S. Army's Lower Tier Air and Missile Defense Sensor, the F-35 Lightning II, and naval radar systems.[67]

Mineral Demand

The global demand for gallium is driven by the electronics sector, particularly for semiconductors and LEDs.[68] The increasing adoption of 5G technology, devices with high radio frequency content, and renewable energy is expected to boost demand further.[69]

As seen in Figure 2.3, trilateral countries are significant consumers of gallium because of their advanced electronics and defense industries. According to the USGS, in 2024, the United States had a 100-percent net import reliance on gallium metal; primary import sources were Japan (24 percent), China (19 percent), Germany (19 percent), and Canada (17 percent).[70] Integrated circuits made up 79 percent of U.S. gallium usage, while 20 percent was used for optoelectronic devices and 1 percent for research and development (R&D). Approximately 83 percent of the gallium consumed in the United States was used in the form of gallium arsenide, gallium nitride, and gallium phosphide wafers; gallium metal, triethyl gallium, and trimethyl gallium comprised the remaining consumption.

In 2023, South Korea imported gallium metal mainly from China (43 percent) and the United States (42 percent).[71] In 2022, Japan imported 57 percent of its gallium metal from China. In 2021, Japan accounted for 34 percent of the global demand for gallium.[72]

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[65] Specifically, such gallium compounds as gallium arsenide, gallium nitride, and gallium phosphides are pivotal in optoelectronics. See USGS, 2025; and Nora Foley and Brian Jaskula, "Gallium—A Smart Metal," U.S. Geological Survey Fact Sheet 2013–3006, 2013.

[66] Girardi et al., 2023.

[67] Matthew P. Funaiole, Brian Hart, and Aidan Powers-Riggs, *De-Risking Gallium Supply Chains: The National Security Case for Eroding China's Critical Mineral Dominance*, Center for Strategic and International Studies, August 2023; Defense Advanced Research Projects Agency, "Gallium Arsenide," webpage, undated.

[68] Asaesja Young, "Critical Minerals: The Quiet Achievers Gallium and Germanium," Commonwealth Scientific and Industrial Research Organisation, June 20, 2024.

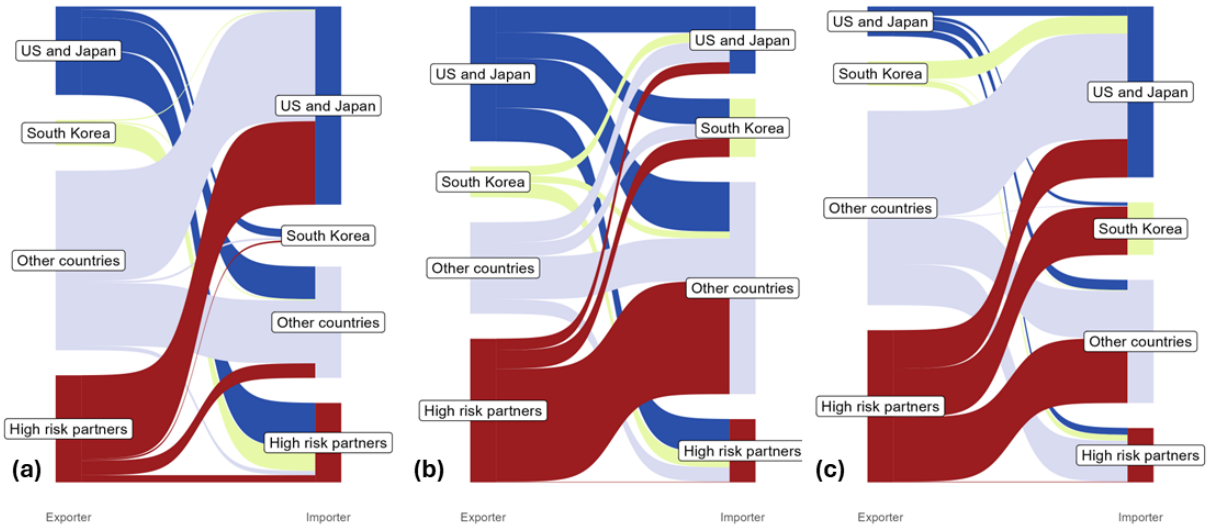
[69] Brian W. Jaskula, "Gallium [Advance Release]," in *2020 Minerals Yearbook*, U.S. Geological Survey, December 2024b.

[70] USGS, 2025.

[71] Korea Institute of Geoscience and Mineral Resources, 2024, p. 92.

[72] Japan Oil, Gas and Metals National Corporation, *Mineral Resources Material Flow 2022* [鉱物資源マテリアルフロー 2022. 16. ガリウム (Ga)], 2022.

Figure 2.3. Trade Flows of Gallium on Trilateral Countries



SOURCE: Authors' analysis of United Nations Comtrade data (United Nations Statistics Division, undated).
NOTE: Panel a = phosphides, chemically defined or not, not ferrophosphorus; other inorganic compounds not elsewhere classified (including distilled, conductivity water and water of like purity); liquid air, rare gases removed or not; compressed air; amalgams, not precious metal amalgams (HS 285390). Panel b = chemical elements; doped for use in electronics, in the form of discs, wafers or similar forms; chemical compounds doped for use in electronics (HS 381800). Panel c = waste and scrap of gallium (HS 811292).

Source Countries and Industry

Gallium is primarily extracted as a byproduct during the processing of bauxite ore for aluminum and, to a lesser extent, from sphalerite ore during zinc extraction. The USGS reports global bauxite reserves of 29 billion metric tons and zinc reserves of about 230 million tons.[73] Despite this abundance of bauxite and zinc, separating gallium is costly, is largely seen as unprofitable, and therefore sees less investment from Western firms.

China is the leading producer of primary low-purity gallium, with 98 percent of production in 2023; Russia contributed 1 percent, and Japan and South Korea each had a negligible share. China overwhelmingly dominates the global gallium separation capacity, holding 89 percent of the total capacity in 2023, whereas South Korea, Russia, and Japan each hold just 1 percent.[74]

China and Japan are the major producers of primary refined high-purity gallium, contributing 61 percent and 31 percent, respectively. Japan leads secondary refined gallium production, with 43 percent, followed by China and Canada at 32 percent and 16 percent, respectively.[75]

[73] USGS, 2025.

[74] Brian W. Jaskula, "Gallium" in *Mineral Commodity Summaries 2024*, U.S. Geological Survey, January 2024a.

[75] Nedal T. Nassar, Ensieh Shojaeddini, Elisa Alonso, Brian Jaskula, and Amy Tolcin, *Quantifying Potential Effects of China's Gallium and Germanium Export Restrictions on the U.S. Economy*, U.S. Geological Survey, Open-File Report 2024–1057, 2024, p. 66.

The major gallium producers in the trilateral countries include

- Korea Zinc Co. Ltd.: produces primary gallium as a by-product of its zinc smelting operation at Onsan, Korea[76]
- Akita Zinc Co. Ltd.: a high-purity gallium producer, from the by-products of the zinc smelting process in Japan (Dowa Metals & Mining Co. has 85 percent and Sumitomo Metal Mining Co. Ltd has 14.5 percent of ownership)[77]
- Dowa Electronic Materials Co., Ltd.: a Japanese company that claims to hold the leading position globally in the sales of high-purity gallium[78]
- Mitsubishi Chemical Corp., Sciocs Co. Ltd., and Sumitomo Electric Industries, Ltd.: three Japanese companies that held 85 percent of gallium nitride wafer sales.[79]
- Indium Corporation: operates facilities in Rome and Utica, New York, where it refines high-grade gallium from low-grade primary sources and recycled gallium obtained from new scrap.[80]

Government Policy and Priorities

Gallium appears on the trio's critical minerals lists and on other nations'.[81] Its inclusion on NATO's list of defense critical raw materials underscores its role in defense technologies.[82] The United States has one gallium-specific initiative in the U.S.-India Critical and Emerging Technology partnership's aim to enhance cooperation on gallium technologies.[83] South Korea aims for a 100-day supply stockpile but has only achieved 40 days' worth in 2023,[84] and Japan plans to maintain 180-day inventories of critical minerals.[85] In contrast, the United States does not currently maintain a strategic stockpile of gallium.[86]

Geopolitical Activity

In December 2024, China imposed export restrictions on gallium, germanium, and antimony to the United States.[87] USGS estimates that U.S. gross domestic product could decrease by $3.1 billion

[76] Jaewon Chung, "Republic of Korea [Advance Release]," in *2020–2021 Minerals Yearbook*, U.S. Geological Survey, May 2024.

[77] DeCarlo, 2024.

[78] Dowa Electronics Materials Co., "High-Purity Metals," webpage, undated.

[79] Jaskula, 2024b.

[80] Brian W. Jaskula, "Gallium [Advance Release]," in *2021 Minerals Yearbook*, U.S. Geological Survey, January 2025.

[81] Nagahara, 2025.

[82] NATO, 2024.

[83] White House, "Fact Sheet: The United States and India Committed to Strengthening Strategic Technology Partnership," January 6, 2025a.

[84] Oh Seok-min, "S. Korea to Enhance Monitoring of Metal Supply Chains over China's Export Curbs," Yonhap News Agency, July 4, 2023.

[85] IEA, 2025.

[86] Matthew Blackwood and Catherine DeFilippo, *Germanium and Gallium: U.S. Trade and Chinese Export Controls*, U.S. International Trade Commission, March 2024.

[87] "China Bans Export of Gallium, Germanium and Antimony to the US," 2024.

if all of China's net gallium exports were restricted for a full year.[88] The trilateral countries have similarly faced export restrictions since 2023, limiting their ability to import gallium-related products from China without first acquiring export licenses from the PRC's Ministry of Commerce. As noted earlier, these data-gathering exercises may introduce the risk of supplying intelligence to the Ministry of Commerce for use in further economic statecraft. These restrictions reflect a broader pattern of geopolitical tension around access to critical minerals.

Molybdenum

Molybdenum is a silvery-gray transition metal with one of the highest melting points among metals and is known for its high strength, excellent thermal and electrical conductivity, and resistance to thermal expansion.[89] Thus, molybdenum is frequently employed in applications requiring strength and resistance to degradation at high temperatures.

In industrial applications, molybdenum is used as an alloying agent for cast iron, steels, and other alloys.[90] In 2023, more than 70 percent of molybdenum by first use was used as an input for steelmaking.[91] Molybdenum is also used in certain nickel-based alloys and specialized alloys, such as molybdenum-rhenium alloys used in rocket engines.[92] Around 8 percent of molybdenum consumption in 2023 was used for these purposes.[93] Molybdenum chemical compounds accounted for 13 percent of consumption in 2023.[94] Such compounds as molybdenum disulfide and sodium molybdate are used as catalysts, pigments, corrosion inhibitors, and lubricants.[95]

Steels and specialty alloys using molybdenum are used in a variety of defense products spanning the air, naval, and land domains. Molybdenum is extensively used in aerospace alloys; MLX19 steel is used to make aircraft landing gears, and molybdenum-containing nickel alloys, such as N-18 and AM-1, are used in gas turbine fans, compressors, and other engine components. Meanwhile, the alloy HY-80 is used to construct submarine hulls, and a variety of other steels are used to manufacture gun barrels for land artillery. Molybdenum is also extensively used in the manufacturing of missile components, such as warheads, booster motors, and the missile frame, often in the form of copper-tantalum-molybdenum alloys.[96]

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[88] This estimate was reduced from an earlier estimate of $602 billion. See Nassar et al., 2024.

[89] International Molybdenum Association, "Role of Molybdenum," webpage, undated.

[90] Désirée E. Polyak, "Molybdenum [Advance Release]," in *2019 Minerals Yearbook*, U.S. Geological Survey, March 2024b.

[91] International Molybdenum Association, "Molybdenum Market Information," webpage, undated-b.

[92] International Molybdenum Association, "Nickel-Based Superalloys," webpage, undated-d; International Molybdenum Association, "Molybdenum Metal & Alloys," webpage, undated-c.

[93] International Molybdenum Association, undated-b.

[94] International Molybdenum Association, undated-b.

[95] International Molybdenum Association, "Molybdenum Compounds & Their Chemistry," webpage, undated-a.

[96] Claudiu C. Pavel and Evangelos Tzimas, *Raw Materials in the European Defence Industry*, European Commission, EUR 27542, 2016.

Mineral Demand

China leads the world in molybdenum consumption; in 2023, it consumed 278.5 million pounds of the metal, or about 44 percent of global consumption. The United States and Japan consumed about 10 percent and 7.5 percent, respectively.[97]

Molybdenum demand is forecast to grow over the following years, propelled by the steel, renewables, and aerospace sectors. Growth in global defense spending and civil aviation are expected to also boost demand for molybdenum.[98] Molybdenum is also used in conventional and renewable energy applications, from oil pipelines to windmills and solar cells; consequently, growing global demand for traditional and renewable energy may also increase demand.[99]

Trilateral countries are import-reliant for their molybdenum needs, but dependence and the role played by China and other high-risk partners vary. Figure 2.4 illustrates the trade flows of molybdenum ores and concentrates (panel a), molybdenum chemicals (panel b), molybdenum metal products (panel c), and molybdenum ferroalloys (panel d) between trilateral countries and other trade partners.

The United States is the least dependent of the three countries. It boasts the second-largest molybdenum reserves in the world and is the fourth-largest global producer of molybdenum concentrate. There are eight molybdenum-producing mines in the United States, two of which produce primarily molybdenum, and three processing facilities that can convert concentrate to value-added products, such as ferromolybdenum and chemicals.[100] Although the United States imports significant quantities of both molybdenum concentrates and higher-value products, the bulk of imports are sourced from Latin American nations, such as Peru, Chile, and Mexico.[101]

South Korea and Japan account for minimal molybdenum production—though both countries produce some quantities of higher-value goods—and China accounts for a higher share of their imports than for the United States. Japan is heavily reliant on imports of both concentrates and processed molybdenum goods; China is the leading exporter of processed molybdenum materials to Japan, accounting for around 70 percent of the value of imported processed molybdenum goods.[102] Similarly, South Korea depends on China for around 20 percent of its concentrate imports and 25 percent of its processed good imports by value, although it is also a major exporter of both to the United States and Japan.[103]

[97] Mining See, "Global Molybdenum Production and Usage Trends in 2023," April 4, 2024.

[98] Grand View Research, "Molybdenum Market Size and Share Analysis Report, 2030," webpage, undated.

[99] Straits Research, "Molybdenum Market Size, Trends and Growth Forecast by 2033," webpage, undated.

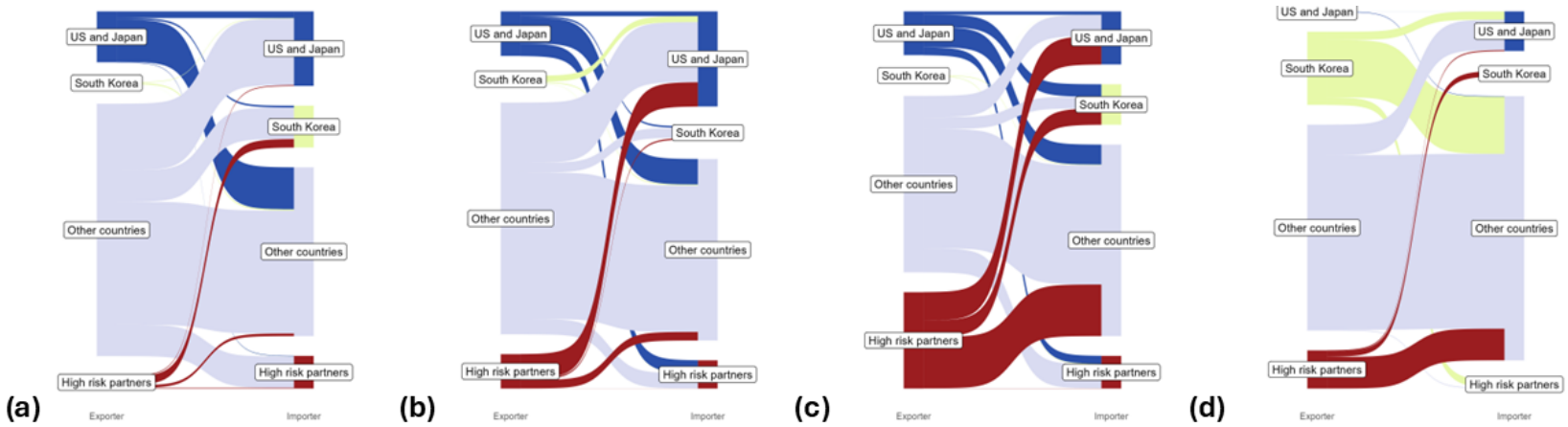
[100] Désirée E. Polyak, "Molybdenum," in *Mineral Commodity Summaries*, U.S. Geological Survey, January 2024a.

[101] Center on Global Energy Policy, Columbia University, "USA," webpage, *Critical Materials Monitor*, undated-c.

[102] Center on Global Energy Policy, Columbia University, "Japan," webpage, *Critical Materials Monitor*, undated-a.

[103] Center on Global Energy Policy, Columbia University, "Rep. of Korea," webpage, *Critical Materials Monitor*, undated-b.

Figure 2.4. Trade Flows of Molybdenum in Trilateral Countries



SOURCE: Authors' analysis of United Nations Comtrade data (United Nations Statistics Division, undated).
NOTE: Panel a = molybdenum ores and concentrates: roasted (HS 261310); and molybdenum ores and concentrates: other than roasted (HS 261390). Panel b = molybdenum oxides and hydroxides (HS 282570); and salts: molybdates (HS 284170). Panel c = molybdenum: unwrought, including bars and rods obtained simply by sintering (HS 810294); molybdenum: bars and rods, other than those obtained simply by sintering, profiles, plates, sheets, strip and foil (HS 810295); molybdenum: wire (HS 810296); and molybdenum: articles not elsewhere classified in heading no. 8102 (HS 810299). Panel d = ferro-alloys, ferro-molybdenum (HS 720270).

Source Countries and Industry

The global supply of molybdenum exhibits more diversification than the other case study minerals, although China still plays a leading role. The USGS estimates that China has the world's largest share of reserves (40 percent), the United States has 24 percent, and Russia has 8 percent. China leads in global molybdenum production, at 42 percent in 2023. Although Chile and Peru have smaller reserves than the United States, they account for a greater share of mine production. The United States accounts for only 13 percent of global mine production.[104]

At the firm level, molybdenum production is diversified, and exhibits overlap with copper production.[105] The major molybdenum mining company in the trilateral countries is Freeport-McMoRan, which operates several copper-molybdenum operations across North and South America, notably in Arizona, New Mexico, and Colorado. Molybdenum refining occurs in Colorado and Iowa. In 2023, Freeport-McMoRan produced 82 million pounds of molybdenum,[106] accounting for about 14 percent of global production that year. Centerra Gold also produces molybdenum metallurgical products in Pennsylvania using concentration from third parties and plans to use raw materials from its mine in Idaho when it opens in 2028.[107]

Government Policy and Priorities

Trilateral countries have accorded varying levels of significance to molybdenum. Japan's steel industry is reliant on molybdenum, and the metal tops Japan's trade exposure ranking. South Korea included molybdenum on its critical minerals list but not as a strategic critical mineral.[108] Molybdenum is not included in the 2022 U.S. critical minerals list.[109] At the bilateral and multilateral level, we did not identify any instruments or agreements between the trilateral countries and other countries that specifically address molybdenum.

Geopolitical Activity

China imposed export restrictions on certain molybdenum compounds in February 2025, just after the new U.S. administration took office.[110] Japan stands out for its dependence on China for 70 percent (by value) of its imported processed molybdenum goods. Japanese firms will need to apply for export licenses from the PRC's Ministry of Commerce in exchange for data.

[104] Polyak, 2024a.

[105] Polyak, 2024b.

[106] Freeport-McMoRan Inc., *The Value of Copper: 2023 Annual Report*, 2024.

[107] Centerra Gold, "Molybdenum Business Unit," webpage, undated.

[108] IEA, 2023a.

[109] IEA, 2025b.

[110] Cecilia Jamasmie, "China Hits Back at US Tariffs with Mineral Export Curbs," Mining.com, February 4, 2025.

Tungsten

Tungsten is a metal notable for having the highest melting point, high thermal and chemical stability, and hardness that rivals that of diamonds.[111] These properties make it desirable where strength and thermal stability are required. Approximately two-thirds of global demand comes from tungsten carbide products, which are high wear-resistant materials used in abrasive applications, such as drill bits, metal machining, construction, and other industries.

Tungsten metal powder is a key input for the manufacture of electrical, electronic, lighting, and heating components in the form of filaments, welding electrodes, and sheets. Tungsten can be alloyed with iron to produce ferrotungsten or with nickel and chromium to produce high-strength steels for high-temperature applications.[112] Tungsten chemicals, such as ammonium paratungstate and ammonium metatungstate, tungstic acid, and tungsten oxide, find use in catalysts, lubricants, semiconductor sputtering targets, and more.[113]

In the defense industry, tungsten applications range from armaments and ammunition to hulls. These include armor-piercing tank ammunition and missile components.[114] Tungsten alloys, such as the cobalt-based HS-25 and HS-31, and tungsten steels form an essential part of tank armor, naval hulls and propulsion systems,[115] jet engines, and airframes.[116] Tungsten-containing superalloys are also used in radiation shielding and kinetic energy penetrators.

Mineral Demand

Tungsten demand is more diverse than supply. China accounts for the greatest share (36 percent), followed by Europe (20 percent) and North America (17 percent). Japan is also a significant consumer, accounting for 8 percent of global tungsten consumption.[117]

Demand for tungsten is projected to grow rapidly because of defense, robotics and semi-conductors, and the global energy transition, which collectively account for about 50 percent of future global estimated consumption.[118] The defense sector currently accounts for around 8 percent of global tungsten demand. Rising global tensions, coupled with increased investments in nations' defense industrial bases since the Russian invasion of Ukraine, are expected to contribute to increased demand. Tungsten is also a key component in the production of manufacturing robots and semiconductor chips; the growth of automated manufacturing and integration of information technology in industrial equipment are likely to contribute to demand. Growing demand for EVs is also expected to contribute to growth in tungsten consumption.[119]

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[111] International Tungsten Industry Association, "Properties and Intermediates," webpage, undated-b.

[112] International Tungsten Industry Association, "Applications and Markets," webpage, undated-a.

[113] Kim B. Shedd, "Tungsten [Advance Release]," in *2020 Minerals Yearbook*, U.S. Geological Survey, December 2024c.

[114] Pavel and Tzimas, 2016.

[115] Girardi et al., 2023.

[116] Pavel and Tzimas, 2016.

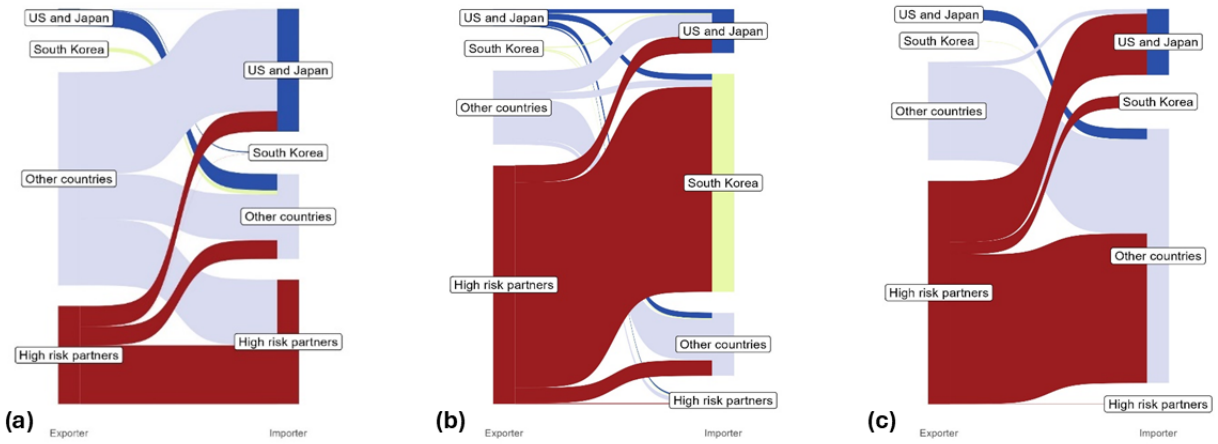
[117] International Tungsten Industry Association, undated-a.

[118] Brandon Beylo, "An Industry Primer on Tungsten," Macro Ops, January 4, 2024.

[119] "Global Tungsten Industry Report 2024–2030: Why New Tungsten Production Sources Are Critical to Meet Surging EV Demand," Yahoo Finance, June 11, 2024.

The trilateral countries are heavily dependent on imports of tungsten, particularly for processed tungsten materials. Figure 2.5 illustrates the trade flows of tungsten ores and concentrates (panel a), tungsten chemicals (panel b), and tungsten ferroalloys (panel c).

Figure 2.5. Trade Flows of Tungsten in Trilateral Countries



SOURCE: Authors' analysis using United Nations Comtrade data (United Nations Statistics Division, undated).
NOTE: Panel a = tungsten ores and concentrates (HS 261100). Panel b = inorganic bases, metal oxides, hydroxides and peroxides: not elsewhere classified in heading no. 2825 (HS 282590); salts: tungstates (wolframates) (HS 284180); and carbides: whether or not chemically defined, other than of calcium or silicon (HS 284990). Panel c = ferro-alloys: ferro-tungsten and ferro-silico-tungsten (HS 720280).

Both the United States and South Korea source the majority of their ore and concentrate imports from within the trilateral or from non–high-risk partner nations. Japan relies on Russia for most of its imports of these goods, but the dependence is minimal in terms of value.[120]

Imports of processed tungsten materials represent a much more vulnerable situation for the trilateral. As seen in Figure 2.5, panel b, South Korea is almost entirely dependent on high-risk nations for its imports of tungsten chemicals, and the United States and Japan also source a significant share. These chemicals play an important role for their use as catalysts and lubricants. Furthermore, high-risk nations produce the bulk of global tungsten ferroalloys. As a result, all three countries source almost exclusively from high-risk nations. This dependence stems from the minimal presence of tungsten mining and processing infrastructure within the trilateral countries.

Source Countries and Industry

The USGS estimates that China holds more than half (52 percent) of the world's identified tungsten reserves. Other significant reserve-holders include Australia (13 percent) and Russia (9 percent). Vietnam, Spain, and North Korea also possess appreciable amounts of tungsten resources. There is greater concentration of tungsten producers; of an estimated 78,000 tons of tungsten

[120] Center on Global Energy Policy, Columbia University, undated-a.

produced globally in 2023, China accounts for 81 percent. Vietnam is a distant second, with 4 percent, followed by Russia at 2.5 percent.[121]

At the firm level, tungsten production is dominated by a few major players. In the United States, there are no active tungsten mines. There are six companies that have the capability to process tungsten concentrates and produce a variety of intermediate products, such as ammonium paratungstate and ammonium metatungstate, tungsten metal powders, and tungsten carbide powders. Tungsten metal and tungsten carbide powders are each produced by four firms, and two firms—Buffalo Tungsten Inc. and Global Tungsten and Powders—can produce both. The latter can also produce APT, AMT, and tungsten oxides, and another firm, Niagara Refining LLC, produces APT and tungsten oxides.[122] The United States exports some tungsten goods but is a net importer, with net import reliance over 50 percent.[123]

In South Korea, the hub of tungsten activity is the Sangdong mine. Originally commissioned in the 1950s, the mine closed in 1994 amid an inability to compete with cheaper Chinese tungsten. In 2015, the mine was acquired by Almonty Industries. The firm expects to resume operations in 2025 with a projected annual output of 4,000 metric tons. The first 45 percent of output is destined for the U.S. market, and the firm has secured offtake agreements with Global Tungsten and Powders.[124] The remaining 55 percent is destined to feed local demand in South Korea. Almonty estimates that, at full-scale production, it will account for about 50 percent of non-Chinese tungsten production.[125]

A list of non-Chinese tungsten producers and their areas of operation is as follows:

1. **Almonty Industries:** Almonty Industries is the only non-Chinese mining company with a significant global presence. Registered in Canada, it owns mines in Spain and Portugal. In 2015, the firm acquired the Sangdong mine in South Korea and expects to account for around half of non-Chinese tungsten output when Sangdong resumes operation.[126]
2. **Masan High-Tech Materials:** Masan is a major global producer of tungsten products. Through its subsidiary, Nui Phao Mining Ltd., it operates the largest tungsten mine outside China,[127] and, according to some sources, it controls as much as 90 percent of tungsten output in Vietnam, the second-largest global producer.[128]
3. **EQ Resources:** EQ Resources owns the only operating tungsten mine in Australia, at Mount Carbine, and also acquired a tungsten mine in Spain.[129]

[121] Kim B. Shedd, "Tungsten," in *Mineral Commodity Summaries*, U.S. Geological Survey, January 2024a.

[122] Kim B. Shedd, "Tungsten [Advance Release]," in *2021 Minerals Yearbook*, U.S. Geological Survey, June 2025.

[123] Shedd, 2024a.

[124] Wendy Teo, "The Revival of Tungsten Mining in a South Korean Town May Be a Game Changer," *Straits Times*, October 19, 2024.

[125] Almonty Industries, "Almonty Korea Tungsten Project," webpage, undated-a.

[126] Almonty Industries, homepage, undated-b.

[127] Masan High-Tech Materials, "Tungsten Raw Materials Procurement," webpage, undated.

[128] Beylo, 2024.

[129] EQ Resources, "EQR Project Portfolio," webpage, undated.

Government Policy and Priorities

All three countries have designated tungsten as a critical mineral. However, most of these activities have been pursued individually, with minimal cooperation among the trio. As part of a larger effort to expand support for domestic production of critical minerals, tungsten projects have been supported through Defense Production Act Title III funding from the Additional Ukraine Supplemental Appropriations Act of 2022.[130] DoD is also funding the development of the Mactung tungsten mine in Canada.[131] South Korea reportedly maintains a six-month stockpile of the metal.[132]

Geopolitical Activity

In December 2024, the United States imposed increased tariffs on imports of certain tungsten products from China.[133] China leveraged its position as the leading tungsten producer by imposing new restrictions on the export of tungsten products, among other commodities.[134]

Takeaways from Mineral Case Studies

The trilateral countries have the potential to collaborate on the value chains of case study minerals. On cobalt, the United States has a mine, the Jervois Idaho cobalt processing facility, which has paused its operations in the face of cobalt price volatility,[135] and Japan has a cobalt battery cathode manufacturer and magnet producer. Gallium can be sourced from deposits in all three countries, and Japan has advanced manufacturing of gallium semiconductor wafers. Molybdenum is produced in the United States as a coproduct of copper, and the United States has some processing capacity. U.S. molybdenum might be outsourced to Japan to supply the steel industry. Tungsten is the most difficult mineral for cooperation among the trio. A tungsten mine is scheduled to open in South Korea that may support demand from the United States and Japan. Otherwise, another partner country, such as Vietnam, Australia, or Mongolia, could potentially help fill the demand.

[130] U.S. Department of Defense (DoD), "Department of Defense Makes Investment to Strengthen the Tungsten Supply Chain," press release, December 13, 2024.

[131] DoD, 2024.

[132] Kim Na-Young, "Gov't to Respond to Possible Impact of China's Export Curb on Strategic Minerals," Yonhap News Agency, February 5, 2025.

[133] Office of the United States Trade Representative, "USTR Increases Tariffs Under Section 301 on Tungsten Products, Wafers, and Polysilicon, Concluding the Statutory Four-Year Review," December 11, 2024.

[134] Amy Lv, Lewis Jackson, and Ashitha Shivaprasad, "China Expands Key Mineral Export Controls After US Imposes Tariffs," Reuters, February 4, 2025.

[135] Ernest Scheyder and Eric Onstad, "Cobalt Miner Jervois in Rescue Deal to Better Compete with China," Reuters, January 2, 2025.

Chapter 3

Industrial Policies and Supply Chain Securitization Capabilities of Trilateral Countries

This chapter presents an overview of the CMSC policy activities and analysis of supply chain securitization capabilities of trilateral countries. We review the current suite of CMSC policy activities and overall strategy of each country. To support an analysis of each countries' supply chain security capabilities, a supply chain net assessment methodology was developed. The approach to develop this methodology—which involved the collection and categorization of CMSC policies and programs in the trilateral countries,[136] language translation, and framework and metric development—is presented in Appendix C. The results of the net assessment are presented as a qualitative supply chain securitization capability score after a review of policy objectives and policy instruments.

South Korea

Key Organizations and Governance

South Korea's policy framework for securing its CMSCs is a whole-of-government effort supported by innovative legislation, resourcing, and clearly delineated responsibilities. The Ministry of Economy and Finance (MOEF) serves as the central coordinating body, overseeing the Comprehensive Supply Chain Stabilization Plan; leads macro-level strategies; and is responsible for budget allocation and tax policy formulation.[137] The Ministry of Trade, Industry, and Energy (MOTIE) implements key strategies for securing critical minerals, overseeing resource exploration, procurement, and the diversification of import sources. The Ministry of Science and ICT protects industrial technologies and fosters innovation, and the Ministry of Foreign Affairs (MOFA) drives international cooperation and engagement with resource-rich countries through bilateral diplomacy and multilateral initiatives, such as the MSP.

Financial institutions, such as the Export-Import Bank of Korea (KEXIM), provide support for overseas resource development projects by offering loans, long-term investments, and export credit

[136] Quantification of policy instruments and objectives has limitations in that it cannot speak to the magnitude of impact from an instrument or the pursuit of an objective (e.g., the amount of foreign direct investment that was incentivized from the use of a financing instrument), and quantification can also not speak to the flexibility with which instruments can be leveraged. But it does give the analyst a sense of tools in the toolbelt that can be applied toward supply chain security objectives, which in and of itself is often a large barrier to addressing policy issues.

[137] MOEF, "The Enactment of Framework Act on Supply Chain," press release, December 27, 2023.

guarantees to support Korean industry. KEXIM also manages the newly established Supply Chain Stabilization Fund. The Korea Trade Insurance Corporation mitigates risks for South Korean companies operating in high-risk regions, providing insurance products to support supply chain diversification.

Other institutions, such as the Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR), are dedicated to resource development and securing stable mineral supplies. Existing agencies with a history dating back to the 1960s were merged to establish KOMIR in 2021 to support domestic mining regions and facilitate comprehensive resource management. The Korea Institute of Geoscience and Mineral Resources conducts geological surveys and R&D on critical minerals, providing scientific backing for national resource acquisition strategies.

The governance structure is anchored by the Supply Chain Stabilization Committee. This committee serves as a cross-government control tower for supply chain management, with functions that include policy formulation, crisis response, and the operation of an early warning system. Comprising 25 members, including the deputy prime minister as chairperson, the committee is supported by specialized subcommittees.[138]

National Legislation

Between 2022 and 2024, the ROK enacted several key pieces of legislation to resource and authorize an economic security framework that has created nearly comprehensive supply chain securitization capability.[139] They are as follows:

- Act on Special Measures for Strengthening the Competitiveness of, and Protecting National High-Tech Strategic Industries (February 3, 2022)
- Act on Special Measures to Strengthen Competitiveness and Stabilize Supply Chain of Materials, Components, and Equipment Industry (May 25, 2023)
- Framework Act on Supply Chain Stabilization Support for Economic Security (December 8, 2023)
- Special Act on National Resource Security (January 9, 2024).

These four laws aim to provide a legal foundation for policy tools that (1) minimize the risk of supply chain disruptions in advance and (2) enable fast recovery when disruptions occur. The Act on Special Measures for Strengthening the Competitiveness of, and Protecting National High-Tech Strategic Industries, passed in February 2022, regulates the export of certain "national high-tech strategic technologies" deemed important to national and economic security. The Framework Act on Supply Chain Stabilization Support for Economic Security, passed in December 2023, aims to prevent supply chain disruptions and activate cross-governmental response systems during emergencies. Most of the ROK's policy measures related to CMSCs are outlined in the 1st Basic Plan

[138] MOEF, 2023.

[139] Jeon Hyun-hee and Lee Jun [전현희, 이 준], "The Three Supply Chain Laws and Korean-Style Economic Security: Challenges and Issues?" ["공급망 3법과 한국형 경제안보, 도전과 과제는?"], Korea Institute for Industria Economics and Trade, February 2024; Yukyung Yeo, "Urea Crisis Sparks South Korean Supply Chain Revamp," East Asia Forum, August 23, 2024.

for Supply Chain Stabilization.[140] The Special Act on National Resource Security, passed in January 2024, and the Act on Special Measures to Strengthen Competitiveness and Stabilize Supply Chain of Materials, Components, and Equipment Industry, passed in May 2023, further delineate the classification of critical items into economic security items, supply chain stabilization items, and critical resources, establishing a structured approach to policy oversight and management.

Policy Tactics and Tasks

South Korea's CMSC strategy encompasses a comprehensive set of policy tactics and tasks aimed at enhancing resilience and stability. Its vision is to "[s]trengthen economic security through supply chain stabilization," and the goals are to "[a]chieve dependency on specific countries for economic security items to below 50 percent by 2030."[141] To achieve these ends, the ROK will pursue four policy directions and ten policy tasks, as depicted in Table 3.1.

Table 3.1. South Korea's Four Policy Directions and Ten Policy Tasks

Policy Direction	Policy Task
1. Stabilizing the supply of economic security items	• **Designation and monitoring:** The government will designate economic security items and conduct regular vulnerability assessments. • **Early warning system:** An integrated early warning system will be developed to monitor domestic and international supply chain dynamics. • **Crisis response system:** A robust crisis response framework will be established to facilitate rapid interventions during emergencies.
2. Enhancing supply chain resilience	• **Stockpiling:** The government aims to expand public stockpiles of critical resources, including rare metals, to ensure immediate availability during crises. • **Domestic production:** Efforts will be made to strengthen domestic production capabilities in key sectors, reducing reliance on imports. • **Diversification of import sources:** The strategy includes promoting import diversification to mitigate risks associated with overdependence on specific countries.
3. Strengthening the economic security foundation	• **Logistics and cybersecurity:** Enhancements in logistics infrastructure and cybersecurity measures will be prioritized to protect supply chains from disruptions. • **Core technology competitiveness:** The government will invest in R&D to safeguard and enhance competitiveness in core technologies critical to economic security.
4. Strengthening global supply chain cooperation	• **Foreign policies:** Proactive foreign policies will be developed to stabilize supply chains, aligning trade and official development assistance strategies with supply chain objectives. • **Bilateral and multilateral cooperation:** The government aims to enhance cooperation networks with resource-rich countries, fostering partnerships that support supply chain stability.

SOURCES: Features information from MOEF, 2024; and MOEF, 2023.
NOTE: Each policy task includes an action plan and subtasks and designates a responsible government entity.

[140] MOEF, "1st Basic Plan for Supply Chain Stabilization," December 19, 2024.

[141] MOEF, 2024 (as translated by the authors).

Financial Mechanisms

The Supply Chain Stabilization Fund, established within KEXIM, is a financial instrument designed to support projects aimed at securing critical minerals and stabilizing supply chains. The fund is projected to mobilize KRW 55 trillion by 2027,[142] with a focus on advanced strategic industries, resource security, essential economic materials, and logistics infrastructure. Projects eligible for funding must align with the objectives set forth in the Framework Act on Supply Chain and include those recognized by relevant administrative institutions and the Supply Chain Committee. The fund aims to foster public-private partnerships and facilitate investments in mineral resources.

Japan

Key Organizations and Governance

Japan has a smaller group of ministries and public-sector organizations targeting CMSCs compared with South Korea or the United States. However, the cabinet office is pivotal in shaping and executing the prime minister's policy initiatives related to economic security and critical minerals. It plays a coordinating role among the various ministries to ensure alignment with national interests and priorities.

Japan's Ministry of Foreign Affairs (MOFA) manages diplomacy and international engagement. Within MOFA, the Resource Security Division of the Economic Affairs Bureau (commonly referred to as *Keishian*) is responsible for diplomacy concerning energy, mineral resources, and food supplies. This division conducts international negotiations and engages with diplomatic missions, many of which have attachés specializing in energy and minerals. The division oversees the MSP, the Extractive Industries Transparency Initiative, and the Group of Seven (G7) CONNEX Initiative, which focus on enhancing global cooperation, transparency, and the sustainability of mineral resource management. The Japanese MOFA was instrumental in negotiating the Agreement Between the Government of Japan and the Government of the United States of America on Strengthening Critical Minerals Supply Chains.[143]

The Ministry of Economy, Trade, and Industry (METI) oversees and coordinates industrial policy for the private sector. In July 2024, METI underwent a reorganization and established the Trade and Economic Security Bureau to focus on related policy issues.[144] METI's Agency for Natural Resources and Energy (commonly referred to as *Enecho*) also has remit over the development and management of Japan's mineral resources. METI shapes and outlines critical minerals policy that is then executed by the Japan Organization for Metals and Energy Security (JOGMEC), which specializes in mineral resource "financing, investment and loan guarantees, technology development and technical support, information collection and provision, and geological surveys."[145] JOGMEC is an

[142] MOEF, 2024.

[143] Ministry of Foreign Affairs of Japan, "Signing of the Japan-U.S. Critical Minerals Agreement (CMA)," press release, March 28, 2023.

[144] Japanese Ministry of Economy, Trade, and Industry, "METI Reorganization," briefing slides, undated-b.

[145] Japan Organization for Metals and Energy Security, "Metal Resource Development" ["金属資源開発"], webpage, undated-b.

independent administrative agency affiliated with METI that specializes in managing Japan's mineral resources. It provides expertise in mineral exploration, development, and financing, playing a crucial role in developing overseas mineral projects essential for Japan's economy. JOGMEC's financial instruments include subsidies, loans, and loan guarantees for mining projects that have investment by a Japanese business or a foreign business with some Japanese ownership.

The Japan Bank for International Cooperation (JBIC) is Japan's export credit agency—the equivalent of an export-import bank. JBIC is instrumental in funding international projects to the benefit Japan's private sector.[146] It offers financial support for overseas investments and collaborates with JOGMEC to enhance supply chain resilience.

National Legislation

Japan's legislative framework for critical minerals is anchored by the 2022 Economic Security Law, which outlines five specific objectives, including the stabilization of the supply of important materials.[147] This law empowers relevant ministers to approve plans from the private sector for securing critical minerals and provides government support where private initiatives fall short. The government also aims to establish a market for critical minerals by adjusting trade regulations and tariffs.

Special provisions that benefit qualifying companies diversifying CMSCs are present under the Japan Finance Corporation Act, the Small and Medium Enterprise Investment and Development Corporation Act, and the Small and Medium Enterprise Credit Insurance Act.

Policy Tactics and Tasks

Japan's strategy encompasses several policies aimed at enhancing the resilience and stability of its CMSC rooted in a broader economic security framework.[148] The Strategic Policy for Economic Security sits atop the Basic Policy for Economic Strength and Stability. The basic goals of the policies are to (1) restore autonomy and ensure Japan's technological advantage and (2) prevent overdependence on foreign entities and enhance domestic capabilities. The policies do this through implementation and review of the Economic Security Promotion Act. There are four important pillars of Japan's economic security apparatus, as illustrated in Table 3.2.

[146] Japan Bank for International Cooperation, "Resources Sector" ["資源分野"], webpage, undated.

[147] *Important materials* is a broad term, covering 12 different types of materials, including fertilizers, aircraft parts, semiconductors, storage batteries, and critical minerals. What constitutes *important materials* is determined by the government, based on the risk that external actions could restrict the supply of the material in ways that threaten the security of Japan and Japanese citizens.

[148] Japanese Ministry of Economy, Trade, and Industry, "Economic Security Policy" ["経済安全保障政策"], webpage, undated-a.

Table 3.2. Japan's Four Pillars of Economic Security Policy

Pillar	Description
1. Supply chain resilience	• Designation of 12 specified critical materials[a] • Approximately 910 billion yen in the FY 2023 supplementary budget and 230 billion yen in the FY 2024 main budget (METI portion)
2. Economic security critical technology development program	• A total of 19 projects related to METI are identified for R&D in space, aviation, ocean, cyber, etc. • A total of 250 billion yen (METI portion) was allocated in the FYs 2021 and 2022 supplementary budgets
3. Advanced notification system for core infrastructure	• Prior review of critical facilities for 14 eligible projects (of which four are related to METI)
4. Nondisclosure of patent applications	• If the description of a patent application includes an invention that, if made known to the public, would create a situation to undermine security, the patent procedures will be suspended through a "security designation"

SOURCE: Features information from Japanese Ministry of Economy, Trade, and Industry, undated-b.
NOTE: FY = fiscal year.
[a] The nine METI-related materials (as of April 2024) are semiconductors, storage batteries, cloud computing, permanent magnets, machine tools and industrial robots, aircraft parts, important minerals, natural gas, and advanced electronic components.

The three policy actions derived from this framework are as follows:[149]

1. **Industry promotion measures (promotion):** This focuses on ensuring technological superiority in specific areas and crosscutting measures to support industrial and technological bases.
2. **Industry protection measures (protection):** This includes implementing new trade controls, corresponding through public-private partnerships (e.g., chokepoint technology policy), and strengthening cyber security measures and data policy.
3. **Establishment of international framework and industrial dialogue (partnership):** This includes organizing and developing an economic security agenda within foreign policy to account for economic coercion; conducting industrial dialogues based on the economic security action plan to materialize and elaborate threat analysis and countermeasures; and continuously reviewing the action plan based on the suggestions from the industrial dialogue.

The action plan is supported by such activities as certification of private-sector actors to receive government support for activities related to securing critical minerals; updating the stockpiling system to ensure swift release and increased stockpiles for minerals with high supply disruption risks; encouraging private actors to diversify supply sources and establish production bases through financial support and subsidies; strengthening international partnerships to secure critical minerals, especially through initiatives led by JOGMEC and MOFA; promoting the development of technologies for

[149] Japanese Ministry of Economy, Trade, and Industry, undated-b.

mineral exploration, processing, and recycling to reduce dependence on imports and enhance domestic capabilities; and promoting sustainable practices.

Financial Mechanisms

Japan's financial support for critical minerals involves a variety of mechanisms aimed at facilitating investment and development.

JOGMEC is a key organization providing subsidies, loans, guarantees, and investment for exploration, mine development, and refining projects. Loan ratios are based on the type of mineral.[150] JOGMEC facilitates overseas exploration through joint research agreements with Japanese corporations, providing financial support for geological surveys and exploration activities. This unique set of authorities makes JOGMEC a strong policy instrument for diversifying Japan's supply chains.

The Japan Finance Corporation and Development Bank of Japan provides support to industry via financial lending to certified businesses. These are based on special provisions in the Japan Finance Corporation Act, the Small and Medium Enterprise Investment and Development Corporation Act, and the Small and Medium Enterprise Credit Insurance Act.

As an export credit agency, JBIC oversees financial assistance. This includes loans to overseas and domestic activities. The Nippon Export and Investment Insurance offers insurance for loans related to overseas activities aimed at strengthening supply chains. This includes coverage for loans needed for Japanese businesses' overseas operations.

Finally, foreign firms can benefit from many of these programs if they are conducting exploration for metallic minerals in which a Japanese person or Japanese corporation has invested, directly or indirectly, and in which the management is substantially controlled thereby. This means that there may be potential for South Korea and the United States to leverage Japanese financing for win-win project development and securitization efforts.

United States

Key Organizations and Governance

Through the current and past administrations, the U.S. CMSC strategy has been coordinated by the Executive Office of the President. This may be a natural outcome because some of the most used policy instruments are rooted in the authority of the President or through executive office arms—for example, the Defense Production Act Title III program or the Office of the U.S. Trade Representative. Interagency councils, such as the White House Council on Supply Chain Resilience or the National Energy Dominance Council, have played a coordinating role in the cabinet and their respective departments. Additional executive groups that regularly engage on CMSC and economic

[150] For instance, loans and guarantees for base metals are up to 70 percent of exploration costs and are up to 80 percent of exploration costs for rare metals and uranium. Subsidies are up to 50 percent of costs for projects that contribute to diversifying Japan's supply chain, including exploration, mine development, and smelting projects. For more, see JOGMEC, homepage, undated-a.

security issues include the National Security Council, National Economic Council, and National Science and Technology Council. The National Intelligence Council also covers the topic.

The U.S. Department of State plays a major role in conducting diplomacy and engaging partners and allies on CMSC issues. The Bureau of Energy Resources (ENR) leads "efforts to develop and carry out international energy policy" by "developing and deploying innovative energy technologies; and is at the forefront of global efforts to secure and diversify critical mineral supply chains."[151] The ENR led the effort to establish the MSP and coordinates with other offices for technical assistance to other countries, such as the Energy Resource Governance Initiative. Meanwhile, the Bureau of Oceans and International Environmental and Scientific Affairs engages with the United Nations International Seabed Authority as an observer on deep sea mining.[152] Regional bureaus also play a major role, for example, in the Arctic.[153]

DoD plays a role as financier and strategic planner of minerals policy for the defense industrial base. Major funding mechanisms fall under the auspices of the Office of the Assistant Secretary for Defense Industrial Base Policy (OASD[IBP]) through its Manufacturing Capability Expansion and Investment Prioritization (MCEIP). Such efforts as the National Defense Industrial Strategy highlight the role of OASD(IBP) in shaping CMSC policy for the defense industrial base.[154]

The U.S. Department of Energy (DOE) has played a large role as a financier and planner for economic security and maintaining energy technology and innovation supremacy. The DOE's Loan Program Office was funded by the Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act (otherwise known as the Bipartisan Infrastructure Law [BIL]).[155] Together, these statutes have played a large role in incentivizing foreign production to relocate domestically while also stimulating demand for minerals from non-FEOCs. The DOE also oversees a national laboratory network conducting research on energy technologies, on the recovery and extraction of critical minerals from coal and other sources, and on maintaining technological supremacy.

The U.S. Department of Commerce plays a role in conducting supply chain risk analysis through the International Trade Administration's Office of Critical Minerals and Metals and Supply Chain Center. The Bureau of Industry and Security coordinates on related export controls from China and on U.S. controls on semiconductor and microchip technology. The Commercial Law Development Program provides technical assistance to mineral-rich developing countries. The National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology also support CMSC policy.

The U.S. Department of the Interior oversees several resource extraction agencies critical in conducting risk assessments, managing the nation's mineral resources, overseeing land and ocean use

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[151] Bureau of Energy Resources, homepage, undated.

[152] Tom LaTourrette, Fabian Villalobos, Elisa Yoshiara, and Zohan Hasan Tariq, *The Potential Impact of Seabed Mining on Critical Mineral Supply Chains and Global Geopolitics*, RAND Corporation, RR-A3560-1, 2025.

[153] Abbie Tingstad, Fabian Villalobos, Rebecca Tisherman, and Michelle D. Ziegler, *Unlocking Alaska's Critical Minerals Development Potential: Evaluating Opportunities and Barriers—Findings from a Tabletop Exercise*, RAND Corporation, PE-A2970-1, June 2024.

[154] DoD, *National Defense Industrial Strategy*, 2023.

[155] Public Law 117-169, Inflation Reduction Act of 2022, August 16, 2022; Public Law 117-58, Infrastructure Investment and Jobs Act, November 15, 2021.

for mining, conducting assessments to identify domestic mineral reserves, and providing technical assistance abroad. The agencies include the USGS, Bureau of Land Management, U.S. Forest Service, and Bureau of Ocean Energy Management.

Financial institutions, such as the Export-Import Bank of the United States (EXIM) and the International Development Finance Corporation (DFC), have played roles in developing policy and projects. EXIM's China and Transformational Exports Program focuses on countering China's overseas capital, and DFC helped finance the Lobito Atlantic Railway infrastructure program.[156]

Overall, we found almost 100 U.S. government offices and programs that are currently engaged in CMSC activities.

National Legislation

As stated in a 2025 Congressional Research Service report, "Section 7002 of the Energy Act of 2020 (Division Z of P.L. 116-260) directed the Secretary of the Interior, acting through the Director of the U.S. Geological Survey (USGS), to identify critical minerals and develop a [critical minerals list]."[157] However, several lists across the U.S. government undermine the quantitative definition developed by USGS.

The main legislation advancing CMSC policy in the United States lies in the IRA, the BIL, and the annual National Defense Authorization Act (NDAA).

Combined, the IRA and BIL allocate funding for the development of infrastructure and manufacturing of consumer products with a high demand for critical minerals. In 2022, the IRA was passed to boost clean energy technology manufacturing and incentivize the consumption of products that heavily rely on critical minerals through the adoption and production of EVs, solar panels, and wind turbines. The incentives include tax credits: up to $7,500 in tax credits for qualifying EV purchases split into domestic battery manufacturing and sourcing of critical minerals from non-FEOC countries.[158] The IRA also provides billions in funding for investment in domestic clean energy manufacturing projects. The BIL complements the IRA by dedicating funding for infrastructure, such as EV supply equipment. It provides loans and guarantees for upgrading and constructing the infrastructure necessary for the adoption of energy technologies.

The NDAA has much influence on U.S. decisionmaking on critical minerals policies. The NDAA authorizes funds for finance mechanisms in OASD(IBP), the Defense Logistics Agency's Strategic Materials Stockpile, collaboration with the defense industrial base, and R&D. The ability to leverage defense assets to assess supply chain risk is also essential to informing economic security.

[156] U.S. Department of State, "Signing of the Memorandum of Understanding on the Development of the Lobito Corridor and the Zambia-Lobito Rail Line," press release, October 26, 2023b.

[157] Rowan, Linda R., *Critical Mineral Resources: National Policy and Critical Minerals List*, Congressional Research Service, R47982, updated February 21, 2025.

[158] Internal Revenue Service, "Advanced Manufacturing Production Credit," *Federal Register*, Vol. 89, No. 208, October 28, 2024.

Policy Tactics and Tasks

Because there is a lack of legislation codifying department and agency remits and resources to address CMSC issues, much of the direction on critical minerals policy has been via executive orders. These orders have minor conflicting priorities from one administration to the next but have largely built on one another since 2017's "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals."[159]

U.S. critical minerals policy is heavily focused on providing incentives to building domestic mining and manufacturing capability and capacity. The use of loans and loan guarantees helps build domestic supply, and tax credits help create domestic demand. These financing mechanisms have origins in DoD and the DOE. The use of Defense Production Act Title III funding, the Industry Base Analysis and Sustainment fund, and DOE Loan Program Office funds have all played a role in domestic finance. Abroad, the DFC has been instrumental in financing the infrastructure to support the transportation of mineral ore and concentrate out of the DRC and Zambia to increase access to Western markets.

Ongoing U.S.-Sino techno-economic competition has been a key influence on U.S. CMSC policy.[160] In concert with domestic incentives has been the increasing use of trade policy to protect domestic suppliers. Tariffs on EVs, batteries, and critical minerals from China have been implemented from 2023 to the 2025, as shown in Table 1.1. In April 2025, another round of Section 232 tariff reviews was announced, signaling the potential for more in the future.[161] The use of trade policy was characterized by a former U.S. trade official as part of a broader motivation to create "deliberate uncertainty" for the purpose of making it difficult to supply the United States from a foreign position and more likely to reshore manufacturing inside the United States.[162] Alongside those tariffs have been U.S. export controls on semiconductor and advanced chip technologies in an effort to reduce the People's Liberation Army's access to advanced technology.

The use of multilateral partnerships, such as the MSP and MSP Forum, has led to meaningful engagement and alignment on CMSC issues with other countries. However, there is a lack of project development stemming from these engagements. Those that have been successful have been met with unforeseen disruptions.[163] Bilateral engagement has been frequent; the United States has pursued and signed memorandums of understanding (MOUs) and soft agreements to collaborate on CMSCs with countries all over the globe.

The United States has also leveraged its R&D ecosystem to pursue innovation in the way of making more-efficient mining and manufacturing technologies, sourcing critical minerals from

[159] Executive Order 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," Executive Office of the President, December 20, 2017.

[160] Fabian E. Villalobos and Morgan Bazilian, "Understanding America's Technological Tit-for-Tat with China," *The Hill*, June 25, 2023.

[161] White House, "Fact Sheet: President Donald J. Trump Ensures National Security and Economic Resilience Through Section 232 Actions on Processed Critical Minerals and Derivative Products," April 15, 2025c.

[162] U.S. academic or think tank representative, interview with the authors, March 2025.

[163] Cullen S. Hendrix, "New-Risking Rather Than De-Risking: The Challenges in US Efforts to Reduce Dependence on Chinese Critical Minerals," Peterson Institute for International Economics, December 13, 2024.

unconventional sources, or pursuing substitute components and systems with less reliance on critical minerals. This is done through the U.S. national laboratory network and university systems.[164]

Financial Mechanisms

Within DoD, OASD(IBP)'s MCEIP administers the Defense Production Act Investments Office and the Innovation Capability and Modernization Office. These two offices administer the Defense Production Act Title III program and Industrial Base Analysis and Sustainment program financial mechanisms, respectively. The Office of Strategic Capital aims to "build an enduring technological advantage by partnering with private capital providers to accelerate and scale investment in companies developing technologies critical to national security."[165] It does so by offering debt financing and investment fund financing to companies focused on critical technology areas.[166]

In the DOE, the Loan Program Office supports such offices as the Advanced Technology Vehicles Manufacturing Program, the Title 17 Clean Energy Financing Program—Innovative Energy and Innovative Supply Chain, the Title 17 Clean Energy Financing Program—Energy Infrastructure Reinvestment Program, and the Tribal Energy Finance Program.

The DFC provides financing for infrastructure and other development projects in developing countries. EXIM provides loans and loan guarantees to companies wishing to partner with U.S. firms on economic development projects. It also works with ally and partner countries' export credit agencies on these issues. On February 25, 2025, an executive order charged the DFC, DoD (through the Defense Production Act Title III program and the Office of Strategic Capital), and EXIM to collaborate and coordinate on financing tools for CMSC securitization similar to the supply chain coordination activity during the COVID-19 crisis.[167]

Comparison of Trilateral Supply Chain Securitization Capabilities

Using Korean- and Japanese-language researchers, a search of ROK, Japanese, and U.S. government websites and documents was conducted to quantify the number of offices, strategy documents, and related programs associated with CMSCs that we collectively term *policy instruments*. We also categorized the policy objectives of the policy instruments collected. The categories of policy objectives were based on industry analysis and work conducted by RAND researchers that was published in 2025.[168] There are limitations to analyzing the quantity of policy instruments as a proxy for capability. For example, the quantification of policy instruments may yield a repository of instrument that are available to the country; however, these instruments might be latent. The quantification of policy instruments also does not measure the depth of implementation (e.g., how

[164] Villalobos et al., 2022.

[165] Office of Strategic Capital, U.S. Department of Defense, homepage, undated.

[166] Office of Strategic Capital, U.S. Department of Defense, homepage, undated.

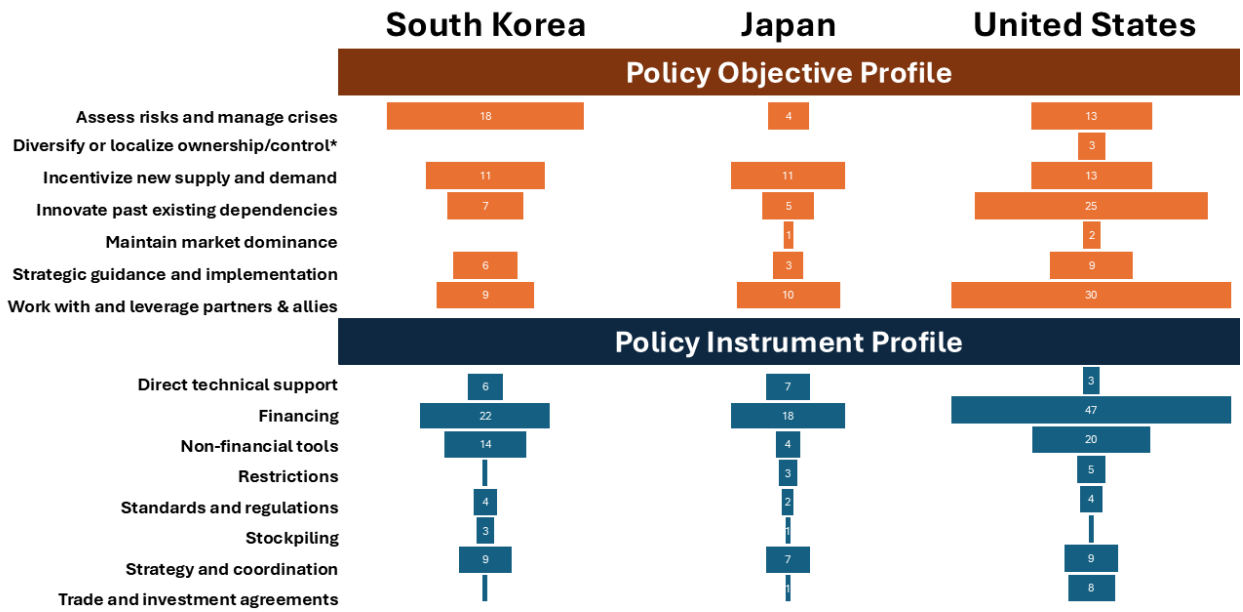
[167] Executive Order 14241, "Immediate Measures to Increase American Mineral Production," Executive Office of the President, March 20, 2025.

[168] LaTourrette et al., 2025.

many financial resources might be leveraged toward a specific policy objective). Yet building the repository of policy instruments and their alignment with policy objectives is necessary for interagency coordination and to develop a comprehensive approach to strategy development and implementation. See Appendix C for more details on methodology and policy objective category definitions.

Figure 3.1 tabulates the total policy instruments and objectives reviewed for the trilateral countries for comparison and presents the data as policy profiles. The ROK, Japan, and the United States had 60, 43, and 97 policy instruments, respectively.

Figure 3.1. Trilateral Supply Chain Policy Profiles



NOTE: An asterisk (*) indicates referring to ownership of or control over existing supply. Quantities depicted are count of CMSC policy offices, programs, or initiatives. Width is normalized to the United States.

South Korean Supply Chain Securitization Capability

The ROK's top four categories were financing, nonfinancial tools, strategy and coordination, and direct technical assistance. The top three objectives of ROK policy instruments focus on assessing risk and managing crisis, incentivizing new supply and demand, and working with partners and allies. The ROK's policy objectives lack focus on diversifying the ownership or control over existing firms and maintaining market dominance. This may be due to a lack of strong position in the extraction, processing, and refining nodes of the value chain.

ROK CMSC policies are rooted in a nearly comprehensive legislation that lays the legal precedent to monitor and track risk, use the MOEF to fund policy instruments and strengthen supply chain securitization capabilities, and leverage the MOTIE and the MOFA for diplomatic engagement through IPEF and the MSP, respectively. One of the top nonfinancial tools was industry/market analysis, which aligns with risk assessment and crisis management objectives.

Japanese Supply Chain Securitization Capability

Using a Japanese-language researcher, a search of Japanese government websites and documents was conducted to quantify the number of offices, policies, and programs associated with CMSCs. There were 43 in total across the eight categories of policy instruments. Japan's policy instrument profile is depicted in Figure 3.1. The top four categories of policy instruments were financing, strategy and coordination, direct technical assistance, and nonfinancial tools.

As depicted in Figure 3.1, Japan's top three objectives focus on incentivizing new supply and demand, working with partners and allies, and innovating past existing dependencies. Japan's ability to produce important industrial chemicals may reflect the emphasis on maintaining market dominance. One Japanese official noted that Japan has the ability to produce several valuable chemical precursor materials across many industries, including semiconductors, on which China, South Korea, and other countries rely.[169] Japan's policy objectives lack focus on diversifying ownership or control over existing firms. This may be due to a lack of strong position in the extraction, processing, and refining nodes of the mining value chain.

As reviewed above, Japanese CMSC policies are rooted in a broader economic security legislation that focuses on the promotion and protection of key technologies and leveraging the MOFA for diplomatic engagement. Japan had more intergovernmental coordination instruments and direct grants and subsidies recorded than the United States or South Korea.

U.S. Supply Chain Securitization Capability

The United States' policy profile may reflect its broader participation in the extraction, processing, and refining nodes of the mining value chain and larger pool of resources from which to draw on. The top three objectives of U.S. policy instruments focus on working with partners and allies, innovating past existing dependencies, and incentivizing new supply and demand. The United States' broad and deep diplomatic apparatus is surpassed only by China in terms of the number of bilateral posts and permanent missions.[170] The top four categories of policy instruments were financing, nonfinancial tools, strategy and coordination, and trade and investment agreements.

Supply Chain Net Assessment

To better assess a nation's capability to achieve CMSC policy objectives and compare its capability with other countries, we developed a qualitative supply chain security net assessment tool. Though qualitative in nature, data on strategy documents, legislation, policy instruments and policy objectives can inform the scoring. We scored the trio's capability using the criteria described in Appendix C. These criteria generally prefer, in ascending order, identifying requirements to achieve policy objectives, studying available policy instruments, establishing authorities and resourcing, and

[169] Japanese official, interview with the authors, February 2025.

[170] Visual Capitalist, "China Has More Embassies Than Any Other Country," webpage, June 9, 2024.

implementing or demonstrating the capability. The capability scores for the trio are depicted in Table 3.3.

Table 3.3. Trilateral Supply Chain Securitization Capability Scores

Supply Chain Policy Objectives	South Korea	Japan	United States
Incentivize new supply and demand	3	3	3
Diversify or localize ownership or control over existing sources	1	1	4
Innovate past existing dependencies	2	2	2
Work with and leverage partners and allies	4	4	4
Assess risk and manage crisis	3	2	1
Maintain market dominance	1	2	2
Strategic guidance and implementation	3	3	2

NOTE: Scores are on a scale of 1 to 4, with 1 the lowest ability to meet policy objectives (no shading) and 4 the highest (darkest shading).

South Korea's scores reflect a nearly comprehensive legislation to secure supply chains and focus on building risk assessment and crisis management mechanisms. South Korea's position as chair of the MSP and its capacity to leverage allies and partners and pursue overseas opportunities with its policy instruments are also reflected. Despite the existence of several industry level critical minerals initiatives, South Korea is penalized for a lack of focus on fulfilling supply chain requirements for its defense industry.

Japan's scores reflect its focus on diplomatic engagement and overseas financing, especially through JOGMEC. Japan's focus on broader economic security issues is reflected in the strategic guidance and implementation score, along with its emphasis on protecting perceived technological advantages. However, Japan is penalized for a lack of focus on fulfilling supply chain requirements for its defense industry.

U.S. scores reflect the use of policy instruments and pursuit of objectives to date. These may change as the United States shifts its use of instruments to focus on trade policy and less so on diplomatic efforts, incentivizing even new supply, and limiting China's presence in overseas sources. The United States has an outsized latent capacity to address supply chain security issues. However, its lack of codifying legislation stands out from the South Korean and Japanese approaches. The United States' focus on competition with China is also reflected in its emphasis on diversifying ownership and control over existing sources, whereas South Korea and Japan focus more on risk assessment and crisis response. The scores also reflect the United States' lack of codifying legislation to grant authorities and clearly define remits because of its reliance on executive orders. Lack of codifying legislation, and the accompanying authorities and resources, also affects the United States' ability to build capacity across other policy objectives, such as risk assessment and crisis management.

Takeaways from Industrial Policy and Capability Assessment

South Korea's CMSC strategy represents a nearly comprehensive and whole-of-government approach to addressing the supply chain challenges posed by mercantilist policy, economic coercion, or natural disruptions. The 2023 Act on Special Measures to Strengthen Competitiveness and Stabilize Supply Chain of Materials, Components, and Equipment Industry; the 2023 Framework Act on Supply Chain Stabilization Support for Economic Security; and the 2024 Special Act on National Resource Security provide a foundation for clear delineation of authorities, resourcing, policy direction, and objectives. South Korea's strategy focuses on economic security and staying competitive in an environment of greater U.S.-Sino competition, building domestic capabilities to monitor and respond to risk, and leveraging international relationships to fill domestic gaps (which aligns well with its position as the chair of the MSP).

Japan's CMSC strategy is aimed at ensuring the stable supply of essential raw materials needed for the nation's economic and technological advancement. Like South Korea, Japan's approach focuses on economic security and being resilient to mercantilist policy and economic coercion. However, Japan's economic security framework incorporates a broader remit that includes technology protection. Japan's early exposure to de facto export bans has led to the creation of a unique policy execution agency with flexibility and expertise: JOGMEC. Japan's approach also coordinates between key government organizations, the private sector, and international partners.

The United States' CMSC strategy is characterized by financial incentives and trade barriers in response to ongoing U.S.-Sino techno-economic competition. Other than financial support to increase demand for domestic and non-Chinese supply of minerals, there is a lack of legislation codifying the roles and authorities of numerous U.S. governmental organizations. Instead, U.S. CMSC policy had been driven by executive order and centrally coordinated by the White House. However, the financial incentives in place have had an enormous impact on the rerouting of supply chains, more so than other countries' efforts.[171] U.S. CMSC strategy also places much more emphasis on defense and military security in terms of securing material inputs for the U.S. defense industrial base.

The trilateral countries' different approaches present opportunities to learn from one another and leverage existing capabilities. These opportunities are discussed in Chapter 5.

[171] William Tobin, "The IRA Two Years On: A Signpost of the New Economic Policy Consensus," Atlantic Council, August 15, 2024.

Chapter 4

Partnering Outside the Trilateral

In this chapter, we review the potential for cooperation with countries outside the trilateral. A partner alignment framework is introduced before delving into two country case studies that illustrate how the trilateral relationship could be leveraged to work with those who may have access to mineral resources, reserves, processing, refining, or other ancillary capabilities in the mining and intermediate chemical value chains—in this case, India and Mongolia.

Partner Alignment Framework

Trilateral countries will need to partner with other nations to secure access to certain minerals. Any one nation might be a willing partner simply because of access to mineral deposits and a desire for economic development.[172] But it does not follow that any nation with minerals aligns with the trio's goals. Multi-aligned nations or economies require more nuance as to their potential alignment with the trio on strategic considerations. Countries with access to minerals will have varying degrees of military, diplomatic, and economic engagement with the trio. Such metrics as the supply risk take account of disruption potential but say little about the potential willingness to cooperate on trade issues or aligning internal institutions and governance to foster better investment environments—both of which are important factors in working with the trio to develop mining projects outside their territories. We developed a framework to assess candidate partners beyond disruption potential parameters or simple presence of minerals. The framework consists of two elements: political alignment and country characteristics.

Political alignment reflects the candidate's shared political values and stances using two indicators: (1) the difference between the two countries' Global Democracy Index scores from *The Economist* and (2) their voting consistency at the United Nations General Assembly.[173]

Country characteristics measure the candidate's political stability and the effectiveness of its government and institutions as characterized by four indicators: (1) the country's national power, as measured by the Lowy Institute's Asia Power Index;[174] (2) its stability in terms of the likelihood of violent internal conflict; (3) the effectiveness of its governance institutions; and (4) its economic

[172] Fabian Villalobos, Elisa Yoshiara, Aimee E. Curtright, Harry Broadman, Tom LaTourrette, and Richard Silberglitt, *Technology-Driven Opportunities and Risks to Sustainable Development of Critical Minerals in Developing Countries: Consolidated Remarks Delivered to a United Nations Expert Group Meeting*, RAND Corporation, PE-A4008-1, May 2025.

[173] "The Global Democracy Index: How Did Countries Perform in 2024?" *The Economist*, February 27, 2025; United Nations Digital Library, "United Nations General Assembly Voting Data: Resolutions 1 (11 December 1946) to 79/278 (25 March 2025) / United Nations Dag Hammarskjöld Library," dataset, March 2025.

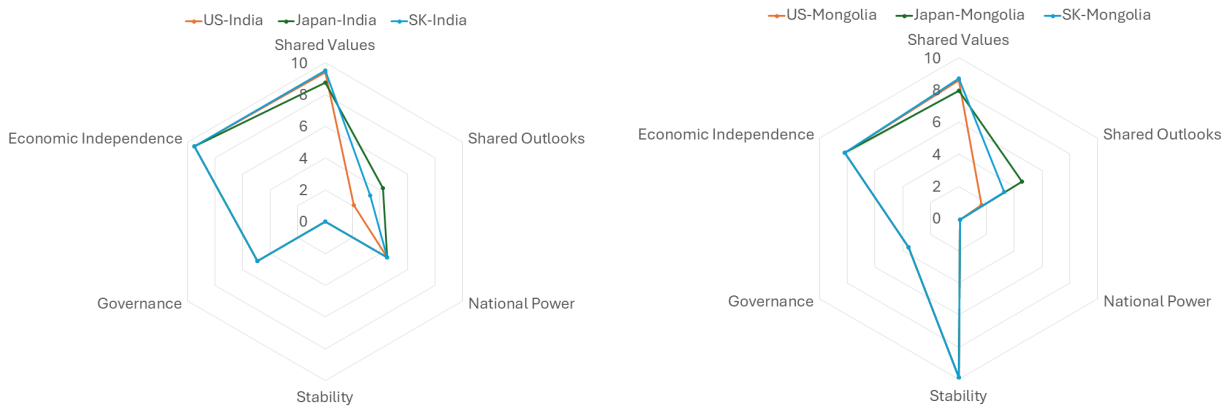
[174] Lowy Institute, "Asia Power Index, 2024 Edition," webpage, undated.

independence from foreign aid and remittances. The latter three indicators are sourced from the INFORM Risk index published by the European Commission.[175]

Each indicator is normalized on a scale of 0–10 based on inputs from relevant variables and reported using radar plots. Further details on indicators and metric scoring are provided in Appendix D. To illustrate the utility of the framework, we assess India and Mongolia's potential for partnership and cooperation.

Figure 4.1 characterizes India's relationships with trilateral countries. India rates highly on shared values but not on shared outlooks. The outlooks metric indicates that India is slightly more aligned with South Korea and Japan than the United States. Of the four country characteristics, India scores highly on economic independence but is considered highly unstable, reflecting a relatively high likelihood of violent internal conflict. On the other hand, India performs relatively well on national power, in line with South Korea and Japan. India presents as a viable partner from a political lens. India appears to be committed to democratic ideals and is independent of foreign inflows, making it less vulnerable to economic reliance on high-risk countries, such as China. India could be a better partner if it improved its governance capacity and reduced its potential for internal social unrest or conflict, which also disincentivizes investment.

Figure 4.1. Trilateral Political Alignment with India and Mongolia



SOURCE: Authors' analysis using the data sources identified in Appendix D.
NOTE: Left panel = India. Right panel = Mongolia. Overlapping lines indicate identical scores across bilateral relationships. The economic independence, governance, stability, and national power metrics provide information solely about a potential partner. The shared values and shared outlooks metrics consider alignment between a potential partner and a member of the trilateral. SK = South Korea.

Mongolia's political alignment with the trio shares similarities to India but differs in important ways. Mongolia is rated highly on shared values with trilateral countries and scores higher on shared outlooks. Like India, Mongolia is more geopolitically aligned with South Korea and Japan than the United States. In country characteristic metrics, Mongolia scores highly on economic independence and rates very highly on stability, which India does not. On the other hand, Mongolia's national power score is much lower. Both nations also appear to have an average performance in terms of the

[175] European Commission, "DRMKC – INFORM," webpage, undated.

effectiveness of governance. Overall, Mongolia appears to be an excellent political partner, especially for Japan.

Country Case Studies

We chose India and Mongolia for case studies based on their access to minerals, political alignment metrics, existing relationships with the trio, recent priorities, and the literature on potential for CMSC cooperation. Other countries in the Indo-Pacific region could have been chosen for case studies but were disregarded. Australia has already been the focus of much cooperation with the trio, including in investment and project development. Indonesia's reliance on Chinese investment limits its ability to avoid FEOC concerns. Singapore has no minerals but may have utility as a financial partner. Still others, such as Philippines or Vietnam, are good choices and deserve further investigation. Other Southeast Asian nations, such as Thailand, Cambodia, Laos, Malaysia, and Myanmar, have internal stability issues, large populations of Chinese diaspora, and other concerns. In the end, India and Mongolia were selected because of their engagement with trilateral countries on regional security issues, economic development, military diplomacy, and geological deposits (due, in part, to their geographic size).

The firms reviewed in the case studies are not exhaustive of global industry. We collated as inclusive a set as possible by sifting through material from industry associations, mineral and country reports, and other literature. We then filtered for those based in trilateral countries for brevity and to better point toward specific non-FEOC entities in the value chain within the trilateral countries of potential interest.

Case Study: India

India has a history of collaboration with the trilateral countries on issues of trade and investment, security, energy, and more, reflecting its strategic interests of enhancing relations in the Indo-Pacific region. The four countries participate in various multilateral and minilateral groups. In February 2025, the United States and India launched the U.S.-India COMPACT (Catalyzing Opportunities for Military Partnership, Accelerated Commerce & Technology) for the 21st Century to enhance cooperation in areas including defense, trade, and supply chains.[176] India signed several key defense trade agreements with the United States and on foreign military sales. The two countries collaborate on counterterrorism and counternarcotics and have conducted joint military exercises with Japan.[177] India has similarly strong security and economic ties with Japan and South Korea. With Japan, India has engaged in maritime security cooperation and joint naval exercises. India signed Comprehensive Economic Partnership Agreements to enhance trade with Japan and South Korea. South Korea and India's relationship stems from India's involvement in resolving Korean War issues. South Korea has

[176] White House, "United States–India Joint Leaders' Statement," February 13, 2025b.

[177] U.S. Department of State, "U.S. Security Cooperation with India," fact sheet, January 20, 2025.

invested heavily in India's manufacturing and technology sectors. Finally, the India-ROK-US Trilateral Dialogue on Critical & Emerging Technologies started in 2024.[178]

Resources, Reserves, and Production

India is endowed with a variety of mineral resources.[179] However, its deposits require investment to map reserves and develop production capacity. India's reserves include bauxite, barite, chromium, graphite, magnesium, manganese, REEs, selenium, silicon, titanium, and zinc.[180] Despite this, the country's production levels fall short of their potential, highlighting the necessity to enhance India's exploration and production capacity.

India also produces tin ore (coltan) and metal, fluorite/fluorspar,[181] vanadium, and zirconium.[182] In 2023, the Geological Survey of India announced the discovery of 5.9 million tons of lithium resources, the seventh-largest deposit globally.[183] India's mineral processing landscape is heavily reliant on imports to meet domestic demands, despite some advancements in specific sectors.[184]

Although such companies as Adani and Hindalco are globally competitive in copper smelting and refining,[185] India's global contribution is just 3 percent. Government restrictions limit private-sector involvement.[186] India's aluminum smelting industry is dominated by three private companies and one public-sector entity. Most smelters are located near alumina refineries, with the National Aluminium Company operating one of the largest integrated bauxite-alumina-aluminum-power complexes. India also has cobalt refining and zinc smelting capability.[187]

Critical Minerals Policies

India's government has enacted several policies and initiatives to develop the critical minerals sector in support of strategic goals. The National Critical Minerals Mission launched in January 2025 and aims to strengthen India's critical minerals value chains and achieve self-sufficiency by enhancing

[178] Indian Ministry of External Affairs, "India – Republic of Korea Bilateral Relations," July 12, 2024.

[179] This section includes minerals listed on the critical minerals list of any of the trilateral countries according to the International Institute for Sustainable Development (Isabelle Ramdoo, Grégoire Bellois, and Murtiani Hendriwardani, "Appendix A. List of Critical Minerals in Selected Countries," in *What Makes Minerals and Metals "Critical"? A Practical Guide for Governments on Building Resilient Supply Chains*, International Institute for Sustainable Development, 2024).

[180] Keita F. DeCarlo, "India [Advance Release]," in *2022 Minerals Yearbook*, U.S. Geological Survey, March 2025.

[181] Fluorite (also known as fluorspar) is needed for the production of lithium-ion battery electrolyte solution.

[182] Ministry of Mines, Government of India, *Indian Minerals Yearbook 2022*: Vol. II, *Metals and Alloys*, December 2024b; Ministry of Mines, Government of India, *Indian Minerals Yearbook 2022*: Vol. III, *Minerals Reviews*, December 2024c.

[183] Vishwa Mohan, "GSI Discovery Makes India 7th Largest Lithium Resource-Rich Country," *Times of India*, February 10, 2023.

[184] Karthik Bansal and Rajesh Chadha, *Critical Mineral Supply Chains: Challenges for India*, Centre for Social and Economic Progress, CSEP Working Paper 88, February 2025.

[185] International Copper Study Group, *The World Copper Factbook 2024*, 2024.

[186] Bansal and Chadha, 2025.

[187] Ministry of Mines, Government of India, 2024a.

exploration and encouraging private-sector involvement.[188] This is resourced by an investment of approximately $1.9 billion over the next seven years. Objectives of the mission include expediting regulatory approvals for mining projects, offering financial incentives for exploration, and promoting mineral recovery from overburden and tailings. It also encourages Indian public-sector undertakings and private companies to acquire mineral assets overseas and increase trade with resource-rich countries. The mission includes plans to establish domestic processing facilities and promote the recycling of critical minerals.[189] Also included are initiatives to build a domestic stockpile, establish mineral processing parks, support recycling, and conduct research. The Ministry of Mines administers the National Mineral Exploration Trust, which provides financial and technical support for exploration.

Some of India's previous policies had deterred investment in the past. Mineral concessions are issued via composite licenses through an auction system that favored public-sector undertakings.[190] Moreover, the policy under the Mines and Minerals (Development and Regulation) Act, 1957, reserves development of minerals on India's list of atomic minerals exclusively for public-sector undertakings.[191]

Recent efforts have been addressing these previous limitations. In 2023, recognizing the need for private-sector investment in exploration, India introduced the Exploration Licenses system through the Mines and Minerals (Development and Regulation) Amendment Bill.[192] This allows reconnaissance operations via a reverse auction process and removed six minerals from the atomic minerals list and opened the sector to private and foreign participation.[193] This bill also empowered the central government[194] to expedite auctions for certain critical minerals concessions.[195] Customs duties were eliminated on 25 critical minerals and blister copper, and the basic customs duty was

[188] Ministry of Mines, Government of India, "Cabinet Approves 'National Critical Mineral Mission' to Build a Resilient Value Chain for Critical Mineral Resources Vital to Green Technologies, with an Outlay of Rs.34,300 Crore over Seven Years," press release, January 29, 2025.

[189] Ministry of Mines, Government of India, 2025.

[190] For example, private projects have received less than 4 percent of total funding (see Bansal and Chadha, 2025).

[191] These minerals are beryllium, lithium, REEs, niobium, titanium, tantalum, zirconium, and beach sand minerals.

[192] The minerals governed by the licenses system are "copper, gold, silver, diamond, lithium, cobalt, molybdenum, lead, zinc, cadmium, elements of the rare earth group, graphite, vanadium, nickel, tin, tellurium, selenium, indium, rock phosphate, apatite, potash, rhenium, tungsten, platinum group of elements and other minerals proposed to be removed from the list of atomic minerals." See Ministry of Mines, Government of India, "Parliament Passes Mines and Minerals (Development & Regulation) Amendment Bill, 2023," press release, August 2, 2023b.

[193] The mining and exploration of atomic minerals is only being done through public-sector undertakings. The six minerals removed from atomic minerals are lithium, beryllium, titanium, niobium, tantalum, and zirconium.

[194] Even though the central government arranges the auction, the state government grants the successful bidders the rights, and the auction premium along with other payments are made to state government.

[195] The critical minerals are "molybdenum, rhenium, tungsten, cadmium, indium, gallium, graphite, vanadium, tellurium, selenium, nickel, cobalt, tin, platinum group of elements, minerals of 'rare earth' group (not containing Uranium and Thorium); fertilizer minerals such as potash, glauconite and phosphate (without uranium) and minerals being removed from the list of atomic minerals" (Ministry of Mines, Government of India, 2023b).

reduced on two others.[196] The Geological Survey of India established the National Geoscience Data Repository to integrate data into a centralized and accessible resource.[197]

In 2023, the Ministry of Mines expanded its Science and Technology program to fund start-ups and micro, small, and medium enterprises engaged in mining projects.[198] This program leverages India's strong academic engineering institutions and history of metallurgical expertise. The program's companies and universities may make for good R&D partners, targets for technology transfer, or knowledge-sharing with trilateral countries.

Khanij Bidesh India Limited (KABIL), a joint venture launched in 2019 under the Ministry of Mines,[199] plays a pivotal role in identifying and acquiring critical mineral assets abroad.

Together, these measures aim to enhance the availability of critical minerals in India and establish processing and refining facilities. The data repository is significant in enhancing mineral exploration and exploitation efforts. The KABIL organization may be a partner for overseas organizations, such as Japan's JOGMEC or the U.S. DFC. Overall, these initiatives mark steps toward greater market accessibility and avenues for investment from trilateral countries.

Cooperation with Trilateral Countries

India is proactively forging strategic agreements and partnerships with both resource-rich and developed countries to secure critical minerals and enhance self-reliance, as demonstrated by its involvement in various bilateral and multilateral initiatives. Agreements involving trilateral countries are listed in Table 4.1.

India has other mineral agreements with Indo-Pacific partners, such as Australia, Chile, and Argentina. Through international engagements, India has built strong ties to trilateral countries, especially the United States, and is working to secure resilient CMSCs, positioning itself to meet both national needs and global demand.

[196] Ministry of Mines, Government of India, 2023b.

[197] Ministry of Mines, Government of India, "Mines Ministry to Launch National Geoscience Data Repository Portal to Foster Innovation in Exploration," press release, December 18, 2023e.

[198] Ministry of Mines, Government of India, "Mines Ministry to Invite Proposals from Start-ups, MSMEs & Individual Innovators to Promote Research and Innovation in Mining and Mineral Processing," press release, November 15, 2023d; Ministry of Mines, Government of India, "Mines Minister Shri Pralhad Joshi Hands over Letters of Financial Grants to Five Start-Ups for Funding Innovations in Mining and Mineral sector," press release, March 1, 2024a.

[199] Ministry of Mines, Government of India, "KABIL Set Up to Ensure Supply of Critical Minerals," press release, August 1, 2019.

Table 4.1. Select Indian Agreements with Trilateral Countries

Agreement	Year	Short Description
U.S.-India TRUST (Transforming the Relationship Utilizing Strategic Technology) Initiative[a]	2025	One of the aims is to develop trusted and resilient supply chains, focusing on semiconductors, critical minerals, advanced materials, and pharmaceuticals.
Strategic Mineral Recovery Initiative[a]	2025	This U.S.-India program is aimed at recovering and processing critical minerals, such as lithium, cobalt, and REEs, from heavy industries, such as aluminum, coal mining, and oil and gas.
U.S.-India Critical and Emerging Technology Expansion[b]	2024	The bilateral partnership was expanded to include cooperation on critical minerals.
MOU with the United States[c]	2024	The MOU was signed to develop critical minerals exploration, extraction, processing, recycling, and related activities in both India and the United States.
Mineral Security Partnership (MSP)[d]	2023	India became a member to enhance collaboration on mineral security.
Quadrilateral Security Dialogue (QUAD)[e]	2023	The QUAD is a partnership among Australia, India, Japan, and United States to address urgent regional issues.
Indo-Pacific Economic Framework for Prosperity (IPEF)[f]	2023	India participates in the Critical Minerals Dialogue to enhance cooperation in CMSCs.
Supply Chain Resilience Initiative[g]	2021	This initiative was launched during the Trilateral Trade Ministerial between India, Australia, and Japan to strengthen supply chain resilience.

[a] White House, 2025b.

[b] White House, "Joint Fact Sheet: The United States and India Continue to Chart an Ambitious Course for the Initiative on Critical and Emerging Technology," June 17, 2024a.

[c] Ministry of Commerce and Industry, Government of India, "Commerce and Industry Minister Shri Piyush Goyal Co-Chairs 6th India-US Commercial Dialogue in Washington D.C.," October 4, 2024.

[d] Ministry of Mines, Government of India, "Strengthening of Mineral Supply Chains," press release, August 7, 2023c.

[e] International Energy Agency, "Quad Statement of Principles on Clean Energy Supply Chains in the Indo-Pacific," December 11, 2023b.

[f] Prime Minister of Australia, "Landmark Indo-Pacific Framework Agreements," press release, November 17, 2023.

[g] Ministry of Commerce and Industry, Government of India, "Australia-India-Japan Trade Ministers' Joint Statement on Launch of Supply Chain Resilience initiative," press release, April 27, 2021.

Potential Barriers to Cooperation

Although India has reserves of key minerals with potential for trilateral collaboration, barriers remain, including uncertainty about regulatory hurdles and ongoing conflict with neighbors in regions with mineral wealth.[200]

[200] The barriers to cooperation reported for this case study country are not exhaustive but should represent a meaningful array of areas to address.

The current exploration license system lacks mineral concession rights and requires companies to return explored areas to the government.[201] Uncertainty over feasible reserves, high exploration costs,[202] and, ultimately, uncertainty over profitability deter private investment. Obtaining clearances for greenfield projects can take up to six years because of the existing regulatory framework.[203]

Finally, India has a history of internal strife and tension with Pakistan, which may be exacerbated by the development of mineral deposits. In addition, RAND Europe's list of conflict affected and high-risk areas compiled locations in which mineral conflict has been recorded around gold, tin, tantalum, and niobium deposits.[204] Indian territories on the list include Chhattisgarh, Jammu and Kashmir, and Manipur. Similarly, in February 2023, the Geological Survey of India announced the discovery of 5.9 million tons of lithium reserves in Jammu and Kashmir, a militarized territory disputed by Pakistan.[205] After the announcement, a Kashmir-based militant group threatened to attack Indian companies that might develop mines and extract lithium. These issues hinder India's ability to attract investors, challenging effective trilateral cooperation.

Case Study: Mongolia

Mongolia's engagement with trilateral countries to enhance its security and trade relations sets a precedence for cooperations on CMSCs. Mongolia has developed a Strategic Third Neighbor Partnership with the trio to balance its strategic position between Russia and China. South Korea and Mongolia have cooperated on security and trade. The two have worked on North Korean security issues through the Ulaanbaatar Dialogue on Northeast Asian Security,[206] and they have engaged in talks for an Economic Partnership Agreement that would involve joint projects on energy, mining, supply chains, logistics, infrastructure, and digital sectors.[207] Mongolia collaborates with Japan on defense and peacekeeping initiatives, having upgraded its bilateral relationship to "Special Strategic Partnership for Peace and Prosperity" to strengthen cooperation and collaboration in solving global challenges under the vision of a "Free and Open Indo-Pacific."[208] "In August 2024, the two countries started coordinating on a Defense Equipment and Technology Transfer Agreement" to lessen Mongolia's dependence on China and Russia.[209] Mongolia is also a NATO partner nation, having

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[201] Bansal and Chadha, 2025.

[202] Siddharth Aryan, Joshua Huminski, Mahnaz Khan, Nolty Theriot, Kristi Rogers, and Sarah Stewart, *Policy Recommendations on Enhancing U.S.-India Critical Minerals Collaboration*, U.S.-India Strategic Partnership Forum, Silverado Policy Accelerator, and P2P Strategies, July 2024.

[203] Karthik Bansal and Ishita Kapoor, *Post-Lease Clearances: Streamlining the Time-Cost*, Centre for Social and Economic Progress, CSEP Working Paper 47, December 2022.

[204] Jacopo Bellasio, Victoria Jordan, Pauline Paillé, Anna Knack, and Ruth Harris, *Provision of an Indicative, Non-Exhaustive List of Conflict-Affected and High-Risk Areas (CAHRAs) Under Regulation 2017/821: Updated Methodology*, RAND Corporation, RR-A158-1-v2, 2023.

[205] Mohan, 2023.

[206] Shinae Hong, "Mongolia and the Korea Conflict," *The Diplomat*, July 15, 2021.

[207] Bolor Lkhaajav, "Expanding Mongolia's Partnership with Japan and South Korea," *The Diplomat*, February 27, 2025.

[208] Ministry of Foreign Affairs of Japan, "Japan-Mongolia Relations (Basic Data)," webpage, September 9, 2024.

[209] Sumiya Chuluunbaatar, "Why Did Mongolia's Foreign Minister Visit Japan?" *The Diplomat*, March 7, 2025.

deployed troops to Kosovo, Afghanistan, and Iraq, and continues to contribute to peacekeeping and humanitarian missions.[210]

Resources, Reserves, and Production

Mongolia's position in the mineral market is characterized by significant resources, reserves, and production capability. Mongolia's mineral wealth is further illustrated by its diverse array of mineral reserves, including arsenic, manganese, uranium, and zinc.[211] Of interest are several minerals included on China's export bans (e.g., antimony, tungsten, bismuth, and molybdenum). According to the USGS, Mongolia ranks fourth worldwide in fluorspar reserves,[212] with 34 million tons, and the second-leading producer, with an output of 1.2 million tons. In molybdenum, Mongolia is 13th in global reserves, possessing 10,000 tons, eighth in production, and outputs 3,100 tons annually. The National Geologic Agency reported in 2023 that Mongolia has substantial reserves of REEs, estimated at approximately 3 million tons, and confirmed lithium reserves of about 1.2 million tons.[213]

Despite these abundant resources, Mongolia's processing infrastructure remains relatively underdeveloped, with approximately 88 percent of minerals exported without processing.[214] The majority are exported to China, where they are processed and used by Chinese manufacturers.

Mongolia's processing efforts are focused on copper concentration and smelting. Key facilities include the Erdenet Mining Corporation's Erdenetiin-Ovoo Mine and processing plant, which boasts an annual processing capacity of 150,000 tons of copper and 3,000 tons of molybdenum.[215] Additionally, Mongolrostsvetmet LLC's processing plant at the Bor-Undur Mine produces fluorspar acid concentrate, with an annual capacity of 120,000 tons.[216] Both are SOEs, reflecting the role of the Mongolian government in the mining sector.

Critical Minerals Policies

A 2024 United Nations report identifies several legislative measures as key components for developing critical minerals in Mongolia,[217] including the Long-Term Development Policy (Vision 2050),[218] which outlines development goals that include enhancing geological surveys, increasing mineral reserves, and constructing railway infrastructure to facilitate export and trade. The report

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[210] Bolor Lkhaajav, "The Mongolia-NATO Partnership," *The Diplomat*, July 24, 2024c.

[211] Jaewon Chung, "Mongolia [Advance Release]," in *2022 Minerals Yearbook*, U.S. Geological Survey, March 2025.

[212] Fluorspar is on the DOE's critical materials for energy list (DOE, "What Are Critical Materials and Critical Minerals?" webpage, undated).

[213] Shurka, Baigalmaa, Tuya Oktyabri, and Amartuul Nyamsuren, *Overview of the Critical Minerals Policy Framework and Governance in Mongolia*, United Nations Development Programme, December 27, 2024, p. 6.

[214] Charles Krusekopf, "Mongolia's Development of Critical Minerals Opportunities and Challenges," National Bureau of Asian Research, August 16, 2023.

[215] Jaewon Chung, "Mongolia [Advance Release]," in *2020–2021 Minerals Yearbook*, U.S. Geological Survey, December 2024b. However, according to the Erdenet Mining Corporation's website, it has 19.8 million tons of ore processing capacity in a year (Erdenet, "Enrichment" ["БАЯЖУУЛАЛТ"], webpage, undated).

[216] Chung, 2024b.

[217] Shurka, Oktyabri, and Nyamsuren, 2024.

[218] Government of Mongolia, *Vision-2050 Introduction to Mongolia's Long-Term Development Policy Document*, 2020.

highlights the 2006 Law on Minerals, the primary legislation governing Mongolia's mineral sector and that outlines procedures for the exploration, licensing, and extraction of minerals.[219]

As of this writing, Mongolia does not have a mineral strategy or critical minerals list but plans to announce a new critical minerals policy and strategy in 2025.[220] Mongolia does specify strategic mineral deposits. According to the Law of Mongolia on Minerals,[221] "mineral deposits of strategic importance" are those relating to national security, the economy, or social development or that contribute more than five percent to gross domestic product. The law allows state ownership of strategic deposits,[222] with recent changes extending ownership to derivative deposits.[223]

In April 2024, Mongolia's parliament passed the Law on the Sovereign Wealth Fund to manage and distribute subsoil resource benefits equitably among citizens, funded primarily by mineral resource royalties.[224] The fund could help resource infrastructure projects and further increase the attractiveness of its mining industry by lowering the cost of project development.[225]

Mongolia's mining sector saw increased foreign investment after the Oyu Tolgoi discovery in 2001, but concerns over foreign influence led to restrictive policies and greater state control.[226] To restore investor confidence, the government amended the Foreign Investment Law in 2013,[227] offering equal opportunities and protections for foreign and domestic investors. Reforms, such as tax stabilization certificates, simplified business registration, and the establishment of the Investor Protection Council in 2016,[228] improve the investment climate.

Mongolia issues exploration and mining licenses through a competitive selection process. To enhance transparency and efficiency, Mongolia has digitalized its license tendering process as part of the Digital Nation initiative.[229] Following the Ministry of Mining and Heavy Industry's updated regulations in April 2022,[230] the government aims to increase exploration licenses to support geological surveys and expand proven mineral reserves.[231]

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[219] Other relevant legislation includes the 2007 Law on Renewable Energy, the 2012 Law on Environmental Impact Assessments, the 2013 Law on Investment and Law on Land, and the 2022 Law on Legal Status of Industrial and Technological Parks (Shurka, Oktyabri, and Nyamsuren, 2024).

[220] Mongolian official, interview with the authors, March 2025.

[221] Government of Mongolia, Minerals Law of Mongolia, July 8, 2006.

[222] State ownership can be up to 50 percent of a mineral deposit if state-funded exploration determined its reserves or up to 34 percent if exploration was funded privately.

[223] Government of Mongolia, Minerals Law Amendment [Ашигт Малтмалын Тухай Хуульд Нэмэлт, Өөрчлөлт Оруулах Тухай], April 19, 2024.

[224] Bolor Lkhaajav, "Mongolian Parliament Passes Legislation to Establish Sovereign Wealth Fund," *The Diplomat*, April 26, 2024a.

[225] Mongolian official, interview with the authors, March 2025.

[226] Krusekopf, 2023.

[227] Government of Mongolia, "On Investment," draft revision, April 14, 2023.

[228] Enkhbold Vorshilov, "Mongolia's Foreign Investment Policies and Perspectives," Ministry of Foreign Affairs, Mongolia, briefing slides, undated.

[229] Dashnyam Partners LLC, "Mongolia Digitalized the Minerals License Tendering and Issuance Process," September 1, 2022.

[230] As of this writing, this update is not valid, and the ministry is in process of updating the Regulation on Minerals License Tendering Procedure (Government of Mongolia, "On Voting for the Selection Procedure for Granting Special Permits for Profitable Minerals," November 21, 2024).

[231] Dashnyam Partners LLC, 2022.

Mongolia's geological information presents near-term barriers to development but opportunities for collaboration. Previously, Mongolia's geological information was scattered across paper records and isolated digital formats, making it difficult for investors and geoscientists to access and use. Mapping data cover only 40 percent of the county's territory.[232] To address the issue, Mongolia, Australia, and the European Bank for Reconstruction and Development have funded an initiative to develop a national geoscience database managed by the National Geological Survey.[233] Launched in 2019 and completed in 2021, the database consolidates and digitizes critical geological information, enhancing transparency and supporting the mining development. But more assistance is needed to update and translate data, map additional resources, and ultimately prove reserves.[234] The use of artificial intelligence tools by trilateral countries may help address these data issues for low cost.

Recent efforts to enhance geological mapping and surveys include establishing a Mongolia-Korea Rare Earth Elements Research Center, with support from the South Korean government,[235] alongside Mongolia's planned collaboration with the British Geological Survey to conduct mapping and surveys.[236]

Mongolia's mineral policy is a mix of a state-centric approach and expanding efforts to attract foreign investment and improve its geological database. This reflects the country's attempts to balance its ambition to harness resource wealth with long-term economic stability.

Cooperation with Trilateral Countries

Mongolia is proactively advancing its mining sector trough international collaboration through public and private-sector agreements and dialogues. Table 4.2 lists selected agreements.

Besides mineral agreements, Mongolia has a strong tradition of working with South Korea on North Korean security issues. Extending this cooperation to economic security by bringing Mongolia into the MSP Forum could strengthen the relationship.

[232] Investment and Trade Agency of Mongolia, "Metals and Mining: Abundant Natural Resources and Minerals," webpage, undated.

[233] National Geological Survey, Government of Mongolia, homepage, undated; Mongolia Geonetwork, "Search" ["Хайлт"], webpage, undated.

[234] Industry representative, interview with the authors, March 2025.

[235] Ministry of Mining and Heavy Industry, Government of Mongolia, "A Joint Mongolia-Korea Rare Metals Research Center Will Be Established with Grant Assistance from the Government of the Republic of Korea" ["Бнсу-Ын Засгийн Газрын Буцалтгүй Тусламжаар Монгол-Солонгосын Хамтарсан Ховор Металлын Судалгааны Төвийг Байгуулна"], November 20, 2023.

[236] B. Ooluun, "Mongolia to Conduct Geological Mapping and Surveys of Critical Minerals in Cooperation with the British Geological Survey," Mongolian National News Agency, February 17, 2025.

Table 4.2. Select Mongolian Agreements with Trilateral Countries

Agreement	Year	Short Description
Ulaanbaatar Dialogue on Regional Cooperation in Energy Transition and Critical Minerals[a]	2024	Mongolia hosted the Ninth Ulaanbaatar Dialogue on Northeast Asian Security, focusing on regional cooperation amid geopolitical and environmental challenges. One of the themes was developing sustainable and resilient value chains for critical energy transition minerals. The conference attracted participants from Russia, China, South Korea, Japan, Kazakhstan, and other nations.
Mongolian National Rare Earth Corporation (MNREC) and JOGMEC nonbinding MOU on Khalzan Buregtei (KB) rare earth project[b]	2024	The partnership between MNREC and JOGMEC focuses on combining expertise to improve mining strategies and project management for the KB rare earth deposit while also attracting Japanese investors to enhance the project's viability and development.
Inaugural U.S.-Mongolia-ROK Critical Minerals Dialogue[c]	2023	The dialogue facilitated information exchange and collaboration among the three governments, which agreed to share expertise and establish U.S. technical and regulatory support for Mongolia.
U.S.-Mongolia MOU on critical minerals[d]	2023	The MOU aims to collaborate on strengthening CMSCs in the Indo-Pacific, promoting investment in Mongolia's mineral sector, and advancing high environmental, social, and governance standards in global mining.
South Korea–Mongolia MOU[e]	2023	The MOU focuses on enhancing cooperation in the supply chains of tin, nickel and other rare metals by establishing a bilateral committee to facilitate joint exploration projects, technology collaboration, and exchange of personnel and information.
Mongolia and South Korea Cooperation on REE[f]	2022	The two sides agreed to establish a joint center on rare earth metals between Mongolia and South Korea focusing on strengthening economic security cooperation and promoting shared values, such as democracy and human rights. This initiative could address the challenges in commercializing the REE deposits.

NOTE: Mongolia has other mineral agreements with France, Germany, and the United Kingdom (UK).

[a] Bolor Lkhaajav, "Mongolia's Ulaanbaatar Dialogue Focuses on Regional Cooperation in Energy Transition and Critical Minerals," *The Diplomat*, June 12, 2024b.

[b] Mongolian National Rare Earth Corp LLC, "Mongolia and Japan Forge Rare Earth Partnership," September 12, 2024.

[c] E. Misheel, "Mongolia to Join International Critical Minerals Network," *Mining Insight Magazine*, September 8, 2023.

[d] U.S. Department of State, "The United States and Mongolia Sign MOU to Collaborate on Critical Minerals," June 26, 2023a.

[e] "Korea, Mongolia Sign MOU on Rare Metals Supply," *Korea Times*, February 15, 2023.

[f] Kim Eun-jung, "S. Korea, Mongolia Agree to Seek Closer Ties on Rare Earth Supply," Yonhap News Agency, August 29, 2022.

Potential Barriers to Cooperation

Challenges exist to working with Mongolia on CMSC issues, including a lack of recent geological survey data and feasibility studies, high exploration and infrastructure costs, inconsistency of government policies, and potential Chinese and Russia export blockades.[237]

As noted by a Mongolian mining expert,[238] past geological data, largely funded by the Soviet Union before 1990, are not digitally archived or accessible to potential investors. This absence of detailed information makes it difficult to assess the feasibility of large-scale mining.

Mongolia's infrastructure requires investment. For example, despite global interest in Mongolia's REEs, mine development has stalled because of high costs and limited returns.[239] The development of transportation, energy, and communication systems is crucial. However, the interviewee noted that over the past two decades, the southern part of the country is developing faster than other regions, driven by major mining projects, such as Oyu Tolgoi, one of the largest known copper and gold deposits in the world.[240]

The internal policy instability can create an unpredictable environment for mining operations. State ownership of natural resources has led to political interference in mining projects, causing delays and creating risks for investors, as seen in the disputes between the government and Rio Tinto over the Oyu Tolgoi copper mine.[241] Strong domestic opposition to mining is a political challenge as well because of environmental costs.[242]

Finally, Mongolia's geographic position between China and Russia potentially puts export routes and trade at risk. The potential for these two countries to impose export blockades on critical minerals adds a layer of strategic risk that must be carefully managed.

Takeaways from Country Case Studies

India and Mongolia have strong histories of cooperation with trilateral countries on trade, investment, and security. This reflects strategic alignment and is borne out in some of the political alignment metrics.

India has a focus on security cooperation and enhancing its defense industry. As a member of IPEF, the QUAD, and other frameworks, India is aligned with trilateral countries on broader security issues in the Indo-Pacific region. The defense and aerospace industries in all four countries likely all rely on critical minerals sourced from China. In this way, the U.S.-India COMPACT initiative aligns with India's defense and trade interests.

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[237] The barriers to cooperation reported for this case study country are not exhaustive but should represent a meaningful array of areas to address.

[238] Industry representative, interview with the authors, March 2025.

[239] Martin Erdmann and Tamiraa Altangerel, *Rare Earths of Mongolia: Evaluation of Market Opportunities for the Principal Deposits of Mongolia*, 2nd ed., Bundesanstalt für Geowissenschaften und Rohstoffe, June 2023.

[240] Industry representative, interview with the authors, March 2025.

[241] Krusekopf, 2023; Simon Lewis and David Brunnstrom, "Exclusive-Mongolia, Rio Tinto Have Resolved Nearly All Copper Mine Tax Issues-PM," Reuters, August 3, 2023.

[242] R. Muff and A. Tamiraa, *Rare Earths of Mongolia: Evaluation of Market Opportunities for the Principal Deposits of Mongolia*, Bundesanstalt für Geowissenschaften und Rohstoffe and Mineral Resources Authority of Mongolia, 2013.

India's National Critical Minerals Mission, significant investments for promoting exploration, and increasing private-sector involvement demonstrates India's commitment to enhancing its position in CMSCs. India possesses substantial reserves of critical minerals, such as REEs and graphite, and existing production capacity for aluminum and zinc could have the potential for sourcing gallium or germanium. However, the country requires investment in exploration and production to meet its true potential. The exploration policies of India likely need more reform to remove restrictions on private-sector investments and simplify the mineral concession process to attract both domestic and foreign investments. India's rich history of expertise in metallurgy and engineering could be leveraged for building out refining capacity. However, India's history of instability and internal conflict create uncertainty and poses barriers to investment in long-term assets, such as mines and related infrastructure.

Mongolia also has a strong history of cooperation with trilateral countries on security issues in East Asia and is looking to increase defense trade with trilateral countries. Mongolia's Strategic Third Neighbor Partnership with trilateral countries aims to balance its relations between China and Russia, and Mongolia's cooperation with trilateral countries through the Ulaanbaatar Dialogue on Northeast Asian Security continues to keep communications channels open with North Korea. However, its geographic location creates uncertainty as to the availability of supply under disruptive conditions, such as conflict. Mongolia is aiming to leverage its mineral wealth to enhance diplomacy and security cooperation.

Mongolia is a large nation with mineral wealth with a long-term development policy that focuses on leveraging its natural resources. Recent legislation creates a framework for the development of its mineral sector while promoting foreign investment and transparency. Mongolia is endowed with several critical minerals that were recently the target of export bans by China: REEs, antimony, tungsten, bismuth, molybdenum, and zinc (which may produce gallium and germanium as coproducts). Mongolia's ore is primarily exported without processing, emphasizing the need for greater capacity in domestic processing and refining facilities, which require investment in infrastructure.

Chapter 5

Opportunities and Barriers to Trilateral Cooperation

In this chapter, we leverage the previous work and combine it with interviews from subject-matter experts from different backgrounds, countries, and equities. A list of organizations interviewed for the study is available in Appendix A. This chapter is divided into two sections: opportunities and barriers.

Trilateral Cooperation Opportunities

We categorize the opportunities for cooperation based on the supply chain capability subcomponent for working with partners and allies. The policy objective subcategories are organized below.

Reduce Barriers to Desirable Foreign Investment, Trade, Specialized Labor, and Knowledge and Skills Transfer

Although recent U.S. trade policy remains unpredictable, there were some interviewees who saw the potential for collaboration on trade in the form of sectoral trade agreements, buyer's clubs, or buyer's cartels. The initial exclusion of critical minerals from tariffs demonstrates that the U.S. administration is sensitive to their importance and U.S. vulnerability to supply chain disruptions. With the announcement of the Section 232 tariff investigation in April 2025, there may be opportunity for protective sectoral trade agreement talks. The concept is not without precedent—the World Trade Organization Information Technology Agreement is an example.[243] The Office of the U.S. Trade Representative released a report in early 2025 on using trade policy for building supply chain resilience.[244] Sectoral trade agreements and buyer's clubs have also been proposed by think thanks, such as the Nakasone Peace Institute, Konrad Adenauer Stiftung,[245] and Silverado Policy Accelerator. A former Korean trade official noted that the persistence of Chinese industrial policy presented long-term challenges to South Korea and that guardrails could be put in place to help

[243] U.S. academic or think tank representative, interview with the authors, March 2025.

[244] Office of the United States Trade Representative, *Adapting Trade Policy for Supply Chain Resilience: Responding to Today's Global Economic Challenges*, January 2025.

[245] Jan Cernicky, Tim Peter, Gunter Rieck Moncayo, Yosuke Ishigami, and Hiroyasu Hosoi, *EU-Japan Critical Raw Materials Alliance*, Konrad-Adenauer-Stiftung and Nakasone Peace Institute, 2024.

stabilize the situation.[246] The fact that South Korea imposed antidumping duties on Chinese steel demonstrates Korean openness to the concept.[247]

South Korea could begin talks with Japan and the United States on how to address China's ongoing exports of underpriced commodities through tariffs, investment rules, and other incentives. The phasing in of tariffs and being nuanced on rules of origin and value-added definitions will be crucial. A gradual increase of tariffs is needed to provide Korean, Japanese, and U.S. firms enough time to adjust the supply chains by finding new suppliers. This could also be done initially on a bilateral basis. Should trilateral guardrails be put in place, they could be expanded to like-minded countries. Because Korea is the current chair, trade discussions can also be conducted within the MSP framework. Other interviewees suggested that alternative venues for trade discussions could include IPEF, the Chip 4 Alliance,[248] the G7, or the Multi-Party Interim Appeal Arbitration Arrangement.

This stick approach could be complemented with a carrot in the form of tax incentives for companies with traceability certifications to set apart high-quality minerals and metals that avoid Chinese practices that violate environmental, labor, and human rights concerns. As an additional incentive to increase demand, the trio could leverage import quotas for certification compliant material that gradually increase and stimulate demand for non-Chinese supply.

Finally, to fully expand domestic capabilities, the trilateral would need to reduce barriers to allow skilled professionals into each other's jurisdictions to allow for specialized knowledge and skills transfer. A similar concept was discussed in a workshop for CMSC cooperation in the Arctic.[249] With expertise in short supply, allowing for easier travel would allow for faster sharing of knowledge and skills.

Reduce Barriers to Sharing Data and Intelligence

Advancing knowledge of disruption, vulnerabilities, and concepts of risk is important for crisis management and risk mitigation. The early warning system established by South Korea and the United States now includes knowledge-sharing with Japan.[250] One interviewee noted that IPEF also has a crisis response network that is underutilized and could be expanded to the member countries.[251]

One U.S. official noted that cooperating on potential new trade codes represented a high payoff opportunity—but one which would take time to review and implement.[252] Working together could speed up those efforts. Existing trilateral information-sharing agreements on North Korean issues

[246] U.S. academic or think tank representative, interview with the authors, March 2025.

[247] In-Soo Nam, "South Korea to Levy 38% Anti-Dumping Duties on Chinese Steel Products," *Korea Economic Daily*, February 20, 2025.

[248] The Chip 4 Alliance—or the Fab 4—is a cooperation framework among the ROK, the United States, Japan, and Taiwan to promote supply chain security within the semiconductor and advanced microchip industries. It includes alignment on technology export controls, supply chain friendshoring, and implementation of the U.S. CHIPS and Science Act of 2022 (Eric Jung, "The 'Chip 4 Alliance' and Taiwan–South Korea Relations," Global Taiwan Institute, September 20, 2023).

[249] Tingstad et al., 2024.

[250] South Korean official, interview with the authors, April 2025.

[251] U.S. official, interview with the authors, April 2025.

[252] U.S. official, interview with the authors, April 2025.

already exist and could be expanded on to incorporate economic security and supply chain risk into the framework, along with intelligence-sharing. Information-sharing could also include the tracing of North Korean mineral exports to China that may enter foreign markets.

Create Shared Crisis Management Mechanisms and Processes

Both South Korea and Japan have created national stockpiles. So too has the United States with the Defense Logistics Agency's Stockpile of Strategic Materials. However, the concept of joint stockpiling between countries has not been explored in depth, but it may present unique opportunities. To be effective, many questions would need to be resolved—for example: Who contributes to the stockpile? How would it be funded? How would the stock be prioritized and released? A former South Korean trade official noted that a joint stockpiling mechanism might resemble a currency swap agreement.[253] In fact, South Korea and Japan renewed such an agreement in 2023.[254] Developing mechanisms, processes, and procedures to create a joint stockpiling mechanism would take time and should be pursued early.

Crisis management mechanisms might also include support packages for firms targeted for coercion by the PRC. When Lithuania was subjected to Chinese sanctions, Western firms put together an investment package to comes to its aid.[255] Likewise, when Micron was investigated, G7 countries created investment opportunities inside Japan.[256] These can serve as examples for processes and procedures to be institutionalized.

Pool and Target Resources in Foreign Production or Infrastructure Projects

The Lobito Atlantic Railway project is an excellent example of how foreign development projects can counter the foreign direct investment by China through the Belt and Road Initiative while also contributing to the securitization of supply chains. However, infrastructure projects in the Indo-Pacific region or even within trilateral countries could help benefit their respective mining industries and better integrate stakeholder equities. Countries with mineral resources and underdeveloped infrastructure could be targeted to increase cooperation on economic security and foster non-FEOC controlled mining assets. India and Mongolia represent such opportunities. Other countries could include Vietnam, Philippines, Tanzania, DRC, and Malaysia. The U.S. DFC, EXIM, KEXIM, and JBIC could partner on specific projects.

For specific mining projects, the MSP already covers much of the scope.[257] With South Korea as the chair, efforts within MSP could be better focused on better collaboration on financing models. One U.S. official declared that a dream scenario would have JOGMEC, KOMIR, and the Office of

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[253] U.S. academic or think tank representative, interview with the authors, March 2025.

[254] Jung-hwan Hwang, "S.Korea, Japan Seal 3-Year $10 Bn Currency Swap Deal," *Korea Economic Daily*, December 1, 2023.

[255] Bryan Frederick and Howard J. Shatz, *Countering Chinese Coercion Multilateral Responses to PRC Economic Pressure Campaigns*, RAND Corporation, PE-A796-1, December 2022.

[256] Annamarie Hordern, "Micron-Japan Deal Counters China 'Coercion,' Rahm Emanuel Says," Bloomberg, May 18, 2023.

[257] Daeyoung Kim, "U.S.-ROK Cooperation in Critical Mineral Chains," Center for Strategic and International Studies, briefing, September 11, 2024.

Strategic Capital cooperate on project development.[258] One interviewee noted that developing countries do not have as much aversion to working with South Korea or Japan as they do with the United States and that the United States could benefit from having East Asian partners facilitate the discussion through the MSP or on a bilateral basis.[259]

Finally, foreign military sales present an opportunity to tie defense cooperation and investment in CMSCs. When foreign military sales come at the expense of a buyer countries' domestic industry, an offset investment can be targeted at a local mine and may include preferential offtake agreements. South Korean and U.S. defense sectors keen on securing supply could lead these efforts.

Provide Expertise to Improve Mineral Resource Exploration, Management, and Development in Resource-Rich Countries

Developed economies hold tremendous technical expertise with respect to governance, technology, mineral exploration, and more. Developing countries with access to minerals need better institutions to govern and regulate their mining industries. Helping developing countries develop institutions can also create more clear and more certain business environments that would benefit multinational mining corporations originating in developed countries. It also would serve to counter China's efforts to exploit grey areas of governance in foreign markets.

One area of note is the development of unconventional sources of minerals—from recycling and deep sea mining for example. In April 2025, the Trump administration issued an executive order to help the seabed mining industry transition into operation.[260] Both Japan and South Korea have ongoing research into deep sea mining. Collaboration on setting industry regulations and standards may help foster new avenues of supply outside Chinese influence.[261]

Increase Access to Foreign Markets for Domestic Industry and Protect Domestic Investments in Foreign Countries

Finally, working together to open new markets for foreign direct investment or protecting existing investments can help reduce risks in existing and future supply chains. This could include diplomatic engagement through the MSP Forum or through alternative financing mechanisms and trade policy.

Trilateral Cooperation Barriers

Although the trilateral relationship has many opportunities for cooperation, barriers also exist.[262] The main barrier noted by multiple interviewees was current U.S. trade policy. The use of blanket

[258] U.S. official, interview with the authors, April 2025.

[259] U.S. academic or think tank representative, interview with the authors, March 2025.

[260] Executive Order 14285, "Unleashing America's Offshore Critical Minerals and Resources," Executive Office of the President, April 24, 2025.

[261] LaTourrette et al., 2025.

[262] The barriers to cooperation reported is not exhaustive but should represent an array of areas to address.

tariffs makes it difficult for multinational corporations big and small to make investment decisions that may take years until profits are realized.[263] Even if strategic uncertainty is the goal of recent trade policy, as suggested by one former U.S. official, then businesses will still need time to adapt. A Japanese official noted that there were Japanese companies currently operating in the United States to develop U.S. mining projects that need to import equipment from abroad. Increasing costs limit the companies' ability to develop a mine and consequently make it harder to accomplish U.S. objectives.[264]

Another barrier was the denial of the acquisition of U.S. Steel by Nippon Steel. The block of the acquisition was noted as having dissuaded Japanese companies from investment in the United States for fear of future CFIUS reviews.[265] Even with an eventual decision to greenlight the deal, uncertainty regarding the political considerations of CFIUS acts as a disincentive for investment.

One interviewee noted that the historical division between South Korea and Japan based on Japan's occupation of Korea in World War II is another barrier.[266] While trilateral governments may want to cooperate more and in greater capacity, the populace may not share the same sentiments. However, a different interviewee noted that younger citizens enjoyed each countries' cultures more than older generations.[267]

More than one interviewee noted that competition between South Korean and Japanese firms, especially in same industry, could be a barrier. When it came to joint investments in upstream projects, battery or intermediate chemical producers might be unwilling or untrusting of rival companies investing in the same supplier. In this case, policy sticks, such as loss of subsidies, would need to be implemented to help stimulate desired outcomes.[268] One South Korean official commented that this is why the United States is needed to lead engagement on cooperation—to break through historical barriers and highlight areas of shared priority and opportunity.[269]

Operating in developing countries presents its own challenges. A representative from one organization we interviewed noted that "[c]ompanies participating in MSP projects are facing significant risks, such as domestic political instability, lack of infrastructure, and difficulty in raising large-scale funding at early project stages."[270] Japanese firms were noted as being averse to working in developing countries, where there is potential for corruption.[271] The U.S. Commercial Law Development Program may be able to help address these challenges.

An important barrier—or rather limitation—to cooperation was the respective defense industries of all three countries. For one, both South Korean and Japanese policy do not share the same emphasis on securing defense industrial base supply chains as compared with the United States. This limits the number of tools available for securitization. Many interviewees noted that Korea and Japan

[263] U.S. academic or think tank representative, interview with the authors, March 2025.

[264] Japanese official, interview with the authors, April 2025.

[265] Japanese academic or think tank representative, interview with the authors, March 2025.

[266] South Korean official, interview with the authors, April 2025.

[267] Japanese official, interview with the authors, April 2025.

[268] Japanese official, interview with the authors, March 2025.

[269] South Korean official, interview with the authors, April 2025.

[270] South Korean official, interview with the authors, April 2025.

[271] Japanese official, interview with the authors, March 2025.

needed to widen their aperture to take into account their defense sectors' need for raw material inputs.[272] The ongoing Russian war of aggression in Ukraine demonstrates that protracted warfare between great powers is still possible in the 21st century. The need to establish a defense industrial base that is responsive to changes in demand is part of integrated deterrence.[273] Several U.S. DoD efforts to establish military cooperation on the defense industrial base underscore this priority. They include the U.S. and ROK Security of Supply Arrangement, Pillar II of the Australia-UK-U.S. (AUKUS) Trilateral Security Partnership, the Partnership for Indo-Pacific Industrial Resilience, and efforts to expand shipbuilding and submarine maintenance, repairs, and operations. Pursuing further defense industrial cooperation is suggested by researchers at the Korean Institute for Defense Analysis.[274] Japan and the United States have agreed to coproduce air-to-air missiles.[275] These multilateral partnerships could include CMSC cooperation. Defense policy instruments can also be incorporated into CMSC cooperation. For example, through offset agreements in foreign military sales, the purchasing country can ask for investment in a domestic mining project.

Finally, there is deep uncertainty as to the future of South Korea's leadership.[276] With the impeachment of President Yoon Suk Yeol, a leading voice in trilateral cooperation is leaving the international scene.[277] Japan and the United States must wait for further engagement with the South Korean President Lee Jae Myung. In a call with Japanese Prime Minister Shigeru Ishiba, Lee and Ishiba "emphasized the importance of trilateral cooperation with the United States, the Japanese government said, amid growing security threats from North Korea."[278]

[272] South Korean academic or think tank representative, interview with the authors, March 2025.

[273] DoD, *National Defense Industrial Strategy Implementation Plan for FY2025*, 2024.

[274] Bo Ram Kwon, "US-South Korea Defense Industrial Cooperation: Drivers, Developments, and Tasks Ahead," Korea Economic Institute of America, policy brief, December 17, 2024.

[275] "Japan, U.S. Agree to Urgently Boost Deterrence amid Assertive China," Kyodo News, March 30, 2025.

[276] U.S. academic or think tank representative, interview with the authors, March 2025.

[277] Jinwan Park, "South Korea's Politics After Impeachment," Council of Foreign Relations, April 15, 2025.

[278] "Japan, South Korea Leaders Agree to Build Stable Ties in 1st Phone Talks," Kyodo News, June 9, 2025.

Chapter 6

Findings and Recommendations

In this chapter, we report key findings and recommendations for South Korea and insights for Japan and the United States.

Key Findings

South Korea has large import dependencies on China and other countries, which are also reflected in Japanese and U.S. trade flows. Minerals that could be prioritized for trilateral cooperation include cobalt, gallium, molybdenum, and tungsten. Of these, tungsten proves to be the most problematic. For other minerals, sources within each country could be stitched together to connect suppliers and off-takers. However, not every node in these value chains has been secured. The trio will need to engage with outside partners to better mitigate risk.

The strategies, policy objectives, and policy instruments of trilateral countries differ in their approach but offer valuable insights into building supply chain capability and economic security more broadly. South Korea has built a legal framework that supports the resourcing of a strategy developed by a coordinating body. The legislation clearly delineates responsibilities to Korean government organizations and allows for a whole-of-government approach. Korea's overall strategy focuses more on risk assessment and crisis management, along with leveraging partners and allies. Together, these policies offer a model for further investigation and potential emulation by other countries seeking to establish a comprehensive economic security apparatus. However, the lack of attention to defense supply chains leaves room for improvement in a vital area during a time of increasing global conflict.

Japan's approach to CMSC securitization is embedded within a broader economic security framework and includes a plan to promote, protect, and stay technologically competitive in the face of techno-economic competition and coercion from China. Japan's early exposure to CMSC disruptions gave it a head start in designing policy instruments and agencies with the authority to execute CMSC policy in a comprehensive way. In this context, JOGMEC presents an interesting model for further investigation and potential emulation. As with Korea, Japan lacks a focus on securing supply chains for its defense and aerospace sector.

The U.S. approach to CMSC strategy has been centered on top-down direction with diffuse implementation and coordination across multiple agencies. The massive amount of financing available through such landmark legislation as the IRA or BIL provide strong incentives to invest in the United States. Alongside these pieces of legislation, the NDAA and DoD pay an outsized role in onshoring and near-shoring domestic mining and processing capacity.

Partnering with countries outside the trio will be essential to securing CMSCs without outsized Chinese ownership or market influence because not every mineral will be available within their territories—the rocks are where the rocks are. Two countries of interest are India and Mongolia for

their current engagement on security issues, trade, and development. Trilateral collaboration on geological mapping and resource assessments will enable the identification and exploitation of untapped mineral reserves. Providing technical and financial assistance for developing infrastructure, such as rail, ports, and processing facilities, will facilitate the export and domestic use of critical minerals, subsequently enhancing trade and supply chain resilience. Additionally, addressing regulatory challenges in India and Mongolia could support smoother investment processes, and developing contingency plans might bolster resilience against geopolitical risks. Reviewing the political alignment metrics could help in the selection of other partners in economic security, supply chain securitization, and development. Other countries of interest in the Indo-Pacific region may include Vietnam, Philippines, and Singapore.

Opportunities to foster trilateral cooperation on CMSC include

- pursuing cooperation on trade, especially on sectoral agreements toward a critical minerals buyer's club and reducing barriers to movement of personnel with expertise
- reducing barriers to sharing intelligence, which could improve the early warning system, and cooperation on identifying or creating new trade codes can help with tracking trade of minerals and the associated risk.
- improving joint crisis management systems, which could provide alternative ways to enduring disruption—potential mechanisms include joint stockpiling, mineral security swap agreements, and economic support packages for firms targeted for coercion
- pooling resources and agency support to target foreign mining projects and infrastructure projects to increase mining assets outside the control of FEOCs
- providing technical assistance and expertise on institution-building to foster a business environment that incentivizes foreign investment outside China, thereby reducing China's market power
- increasing access to foreign markets and protecting the assets of domestic firms to incentivize development in regions with untapped potential or less regulatory certainty.

Barriers to cooperation include

- U.S. trade policy
- foreign investment reviews in the United States
- historical division between South Korea and Japan
- competition between South Korean and Japanese firms in the same industry
- private-sector aversion to investment in regions with uncertain regulatory regimes
- lack of emphasis on defense industrial base supply chain security
- uncertainty of the new South Korean administration's commitment to trilateral cooperation.

Recommendations for South Korea

There are numerous opportunities for CMSC cooperation or broader cooperation on economic security. Identifying resources and authorities to pursue these opportunities will be needed. South

Korea should designate specific government organizations to pursue these opportunities at the appropriate level and diplomatic channels with Japan and the United States.

Pursuing opportunities may mitigate potential barriers. For example, the pursuit of sectoral trade agreements may align with U.S. trade policy to respond to Chinese industrial policy and help the United States meet is policy objectives. South Korea should investigate win-win pathways and prioritize communication of these pathways with leadership in Japan and the United States. Should the political environment not be suitable in the near term, bilateral engagement can set the stage to bring in a third party in the future. Working with the trio on the trade codes needed to increase transparency and information on supply risk would facilitate better tracking of critical mineral imports and exports and is recommended as a high-impact, low-barrier, low-regret option.

Traditionally, the MSP has focused on project development; however, this pursuit has limited effectivity in the face of Chinese industrial policy that is not likely to decrease in the near term and thereby places any projects developed by the MSP in danger of price volatility and uncertain profitability. Given the ROK's position as chair, the ROK has a chance to shift emphasis. Instead of attempting to match investors and projects, South Korea could emphasize the need for a long-term, sustainable solution to China's industrial policy and its deleterious effects on the MSP countries' competitiveness in commercial and defense industries. These could include similar opportunities as described for the trilateral (including trade policy, knowledge-sharing, joint R&D, and joint crisis management mechanisms). South Korea should investigate the possibility of pushing the MSP toward a buyer's cartel with guard rails to address China's industrial policy.

South Korea's policy framework is thoughtfully crafted but lacks focus on securing supply chains for Korea's defense industrial base. The South Korean defense sector may be smaller than other sectors of South Korea's economy, such as consumer electronics or automotives, but is nonetheless critical to sustain a deterrent against aggression on and off the peninsula. South Korea should include defense in its economic security and international efforts. Foreign military sales can be leveraged in support of economic security objectives and military diplomacy through mineral offset agreements.[279]

Once a new leader is elected, South Korean agencies should brief the incoming head of state on the importance of trilateral cooperation on economic security, supply chain securitization, defense sector supply needs, and foreign dependencies to include critical minerals dependencies.

Insights for Japan

Leveraging its experience with Chinese economic statecraft, Japan crafted its own method of addressing China's market power, oversupply, and dumping practices. However, it lacks focus on securing supply chains for its defense and aerospace sector. Like South Korea, Japan needs to expand its conception of economic security to include the defense industrial base. Economic security is not a category separating commercial demand from defense demand—rather, it is a spectrum. The demand for dual-use technologies in energy and the advanced computing used in security and military weapons systems and equipment mean that supply chain disruptions and issues do not relegate themselves

[279] When selling military products abroad, investments to offset losses to local industry stakeholders can be aimed at mineral deposits if the commercial capability and capacity for the desired minerals are present.

neatly into one sector. Risks are diffuse. Conceptualizing how to address broader industrial base challenges in commercial and security sectors while maintaining sensitivity to Japan's history of pacifism will be a challenge but a necessary one. In supporting trilateral cooperation, Japan's JOGMEC could be leveraged to support investment by the United States and South Korea so long as Japanese firms or individuals are involved. Japan could leverage its advancements in seabed minerals processing to spur demand for new mineral resources. Japan could also leverage its place in the QUAD or trilateral cooperation with the United States and Philippines to bring in South Korea as a partner.

Insights for the United States

The United States can learn from the policy instruments, agencies, and legislation of South Korea and Japan to better address not only CMSCs but broader economic security objectives. The ongoing U.S.-Sino competition is not likely to slow, and China's industrial policy is not likely to stop, even in the face of increasing trade barriers. China's economic development model is just different. Long-term sustainable solutions, such as a buyer's club, are needed to handle the development goals of a semi-market economy. Learning from those who have endured supply disruptions can help inform what new policy instruments, authorities, and resources may be needed. Developing an understanding of other countries' mineral needs can help align alternative suppliers and buyers, for example on tungsten, in the face of China's increasing export restrictions and bans. Aligning trade policy with the shared objectives of partners and allies can also help mitigate the long-term challenges from China's industrial policy faced by U.S. firms in the form of guardrails and joint crisis management systems. South Korea and Japan look to the United States for leadership, and maintaining that role as a leading partner is in its interest.

Conclusion

South Korea, Japan, and the United States can leverage trilateral cooperation to strengthen the resilience of their CMSCs. This will remain a crucially important and shared policy objective given the enduring challenges stemming from China's alternative economic development model and its demonstrated capacity and willingness to weaponize supply chain vulnerabilities to advance its geopolitical goals. The challenges are pervasive across the commercial and defense sectors. Although there are formidable diplomatic, policy, and technical barriers to enhanced trilateral cooperation, the trilateral relationship presents unique opportunities not available in other multilateral forums, and the opportunities are too great to ignore.

Appendix A

Organizations Interviewed

We developed an interview protocol and reached out to relevant organizations that provided valuable input not always available from data. The interview protocol questions were as follows:

1. What country-level CMSC risks are present in South Korea/Japan/United States and which sectors or industries are affected by these risks?
   - What is the nature of those risks (e.g., political, economic, geographic)?
2. What mineral resources or processing/refining capacities are currently underutilized in South Korea/Japan/United States and for what reason?
3. What South Korean/Japanese/United States governmental offices, programs, and public private partnerships are currently addressing CMSC issues?
4. How (in your experience) have supply chain disruptions affected the country in the past (for example, during the COVID-19 Pandemic)?
5. How are South Korea, Japan, and the USA currently cooperating on CMSCs? E.g.:
   - Bilateral or multilateral diplomatic or trade agreements/reducing barriers to trade in the near term (1–3yrs)
   - Military and defense industrial base
   - Investment or other resources help develop mineral deposits in the near term (1–3yrs)
6. How could South Korea, Japan, and the USA better cooperate on CMSCs? E.g.:
   - Bilateral or multilateral diplomatic or trade agreements/reducing barriers to trade in the near term (1–3yrs)
   - Military and defense industrial base
   - Investment or other resources help develop mineral deposits in the near term (1–3yrs)
7. What other countries could the three work with on critical mineral supply chains?
   - Of specific interest are Mongolia and India
8. Is there anything else we should have asked you but did not, or anything else you would like to share with us to inform our study?
9. Who would you recommend we speak with for additional interviews or information?

For our interview outreach, we selected researchers and policymakers in the three countries working on topics related to the following: critical minerals, supply chain resilience, economic security, Indo-Pacific security, and East Asian security. We used a snowball methodology, asking interviewees for relevant researchers or policymakers they recommended we contact, as shown in the interview

protocol. We conducted a total of 28 interviews between September 2024 and April 2025, sometimes with two or more interviewees at the same time. We conducted one interview for the Mongolia case study and two interviews for the India case study. All interviews were conducted in English. Two sets of interviewees submitted written responses to our request. The organizations of the interviewees are listed in the box.

Organizations Interviewed for This Study

Atlantic Council
Center for Strategic and International Studies (CSIS)
Consulate of Japan—Los Angeles
Consulate of the Republic of Korea—Los Angeles
Hanyang University Seoul
Japan Bank for International Cooperation
Japan Ministry of Economy, Trade, and Industry (METI)
Japan Organization for Metals and Energy Security (JOGMEC)
Korea Development Institute (KDI)
Korea Institute for Economics and Trade (KIET)
Korea Institute for International Economic Policy (KIEP)
Korea Institute for Defense Analysis (KIDA)
Mongolian Embassy—Washington, D.C.
Observer Research Foundation America (ORF America)
Peterson Institute for International Economics (PIIE)
Republic of Korea Ministry of Foreign Affairs (MOFA)
Silverado Policy Accelerator
U.S. Department of State—Bureau of East Asian and Pacific Affairs
U.S. Embassy—Seoul
U.S. Embassy—Tokyo
University of California San Diego
University of Tokyo
Wilson Center

Appendix B

Methodology for Adapted Supply Risk Measure

We used an adapted version of the USGS methodology published in a 2020 journal article and further detailed in a 2021 USGS report.[280] In this appendix, we briefly review the adapted methodology and refer readers to the two studies for further details.

The USGS supply risk metric for a particular mineral measures the likelihood that a country's foreign supplies of that mineral will be disrupted and the degree to which it depends on that supply. We extract from the supply risk metric two primary components for an assessment of disruption and import risk to the trilateral countries: disruption potential and trade exposure as defined by Nassar and colleagues.

Disruption Potential

Disruption potential measures the risk of a foreign supply disruption in terms of the producing countries' market dominance and their ability and willingness to supply a mineral to the focus country. Disruption potential consists of three subcomponents:

1. **Production share:** This represents a producing country's share of the global production of a particular mineral commodity, excluding the focus country's contribution to global production sourced from the USGS mineral commodity summaries.
2. **Ability to supply index (ASI):** ASI is a measure of a producing country's ability to supply minerals to the focus country. It is calculated as the inverse of the Fraser Institute's policy perception index.[281]
3. **Willingness to supply index (WSI):** WSI assesses the potential for a producing country to deliberately disrupt mineral supplies to the focus country. It is calculated as a function of three indicators: trade ties between the producer and focus countries, shared political values between the two countries, and military cooperation between the two nations.[282]

[280] Nassar et al., 2020; Nedal T. Nassar and Steven M. Fortier, *Methodology and Technical Input for the 2021 Review and Revision of the U.S. Critical Minerals List*, U.S. Geological Survey, Open-File Report 2021–1045, 2021.

[281] The Fraser Institute's policy perception index is "[p]art of an annual survey of mining and exploration executives that rates jurisdictions on 15 different policy factors including availability of skilled labor, access to infrastructure and power, level of security and political stability, taxation regime, and uncertainties regarding laws and regulations" (Nassar et al., 2020).

[282] More information on the WSI can be found in Nassar and Fortier (2021).

Disruption potential is calculated using the following formula:

$$DP_{f,i}^{raw} = \sum_{c} \left(PS_{f,i,c}^{2} \cdot \max\left(ASI_{f,c}, WSI_{f,c}\right) \right),$$

where *f* is the focus country, *i* is the mineral commodity, and *c* is the producing country. $PS_{f,i,c}$ is thus the share of global production of mineral *i* in country *c* when excluding country *f* from the calculation; $ASI_{f,c}$ is the ASI for country *c* supplying to country *f*; and $WSI_{f,c}$ is the WSI for country *c* supplying to country *f*.

The raw disruption potential values of each mineral for a focus country are then normalized to a scale of 0–1 using the maximum and minimum raw disruption potential values across all minerals for that focus country.[283] Under this approach, the mineral with the highest raw disruption potential (gallium in the case of South Korea) will receive a normalized score of 1 without regard to the actual raw score.

Trade Exposure

The trade exposure metric for a particular mineral captures the focus country's exposure to foreign supply risks of that mineral, no matter their source, in terms of import reliance. It consists of four subcomponents:

1. **imports:** the quantity of that mineral that is imported by the focus country in a year
2. **exports:** the quantity of that mineral that is exported by the focus country in a year
3. **changes to domestic stockpiles:** the net change in the focus country's stockpiles of the mineral in a year
4. **apparent consumption:** the focus country's domestic consumption of that mineral in a year—calculated as the sum of primary production, secondary (scrap) production, imports, and net changes to domestic stockpiles, less exports.

Because this analysis involves three focus countries and includes cross-country comparisons, two data limitations arose that required adjustments to the USGS approach. The first limitation was the unavailability of complete mineral stockpile data for Japan and South Korea. To harmonize the methodology for all three countries, the calculations for trade exposure of a particular mineral assume no net changes in domestic stockpiles (i.e. the changes to the domestic stockpile subcomponent was assumed to be zero for all cases).

The second limitation relates to the trade data used to calculate imports and exports. In trade datasets, different types of minerals and their derivative commodities (ores and concentrates, metals, scrap, etc.) are assigned commodity codes for identification. Nassar et. al obtained import and export quantities for different mineral commodities from the U.S. Census Bureau using ten-digit commodity codes provided by the U.S. Harmonized Tariff Schedule (HTS), which are specific to U.S. imports

[283] Details for the normalization procedure can be found in Nassar and Fortier (2021).

and exports.[284] Because this analysis required trade data for three countries, we sourced the imports and exports from the United Nations Comtrade database, which uses six-digit commodity codes.[285] The lower resolution of this dataset created a hurdle in disaggregating mineral commodities, and, in some cases, the same code describes commodities belonging to two or more distinct minerals. Calculating net imports and apparent consumption proved to be challenging using this dataset; there were cases in which the reported exports of a mineral exceeded the sum of the reported imports and domestic production. Therefore, for this analysis, we chose to represent trade exposure in terms of import reliance rather than net import reliance (i.e., exports are omitted from the numerator in the trade exposure formula).

This limitation also required another divergence from the USGS approach. The quantity of a mineral contained in different commodities can vary; for instance, molybdenum concentrates may contain a higher proportion of molybdenum by mass than certain alloys. Because trade data typically report the total mass of a particular good or commodity, Nassar and colleagues applied conversion factors to each ten-digit HTS commodity code to obtain the actual mass of the mineral contained within the item rather than the total mass of the item.[286] In this case, however, because of the data limitations described above with several different minerals and their derivative commodities often described under the same six-digit code, conversion factors could not be applied uniformly for each commodity. The analysis thus assumes that the reported import and export quantities for each mineral are 100 percent composed of the mineral.

In light of these limitations, the revised formulas for apparent consumption and trade exposure are as follows:

$$AC_{f,i} = PP_{f,i} + SP_{f,i} + I_{f,i} - E_{f,i},$$

where i is the mineral in question, f is the focus country, AC is apparent consumption, PP is the quantity of primary production, SP is the quantity of secondary (scrap) production, I is the quantity of imports, and E is the quantity of exports, and

$$TE_{f,i}^{raw} = \frac{I_{f,i}}{AC_{i,t}},$$

where $TE_{f,i}^{raw}$ is country f's raw trade exposure for imports of commodity i.

The raw trade exposure values of each mineral for a focus country are normalized on a scale of 0–1 using an approach similar to that used for disruption potential as described above.

[284] Nassar et al., 2020, supplementary materials.

[285] United Nations Statistics Division, undated.

[286] Nassar et al., 2020, supplementary materials.

Appendix C

Methodology for Supply Chain Net Assessment

In this appendix, we review the approach to the construction of a supply chain net assessment framework and implementation. The objective in crafting a supply chain net assessment scoring methodology was to develop a country-agnostic approach to compare the industrial policy of the trilateral countries (or any other country) to assess overlapping efforts and gaps in effort and to identify how countries may learn from differing approaches to securing CMSCs. We review the data collection on policies and programing in trilateral countries, the creation of a supply chain net assessment framework to compare industrial policy across nations, and qualitative metrics to assess the extent of the implementation of such policies.

Policy and Program Data Collection

To characterize the policies and programing of the trilateral countries, we reviewed the IEA Critical Minerals Policy Tracker,[287] government websites, and reports and consulted with RAND subject-matter experts to develop country-level repositories of programs, policies, and offices addressing CMSCs for each of the trilateral partners. English-, Japanese-, and Korean-language researchers compiled data for their respective countries. The final dataset included 97 U.S., 43 Japanese, and 60 South Korean entries. Because of the authors' familiarity and prior investigations into U.S. policy, we believe the U.S. dataset is the closest to comprehensive. South Korean and Japanese data are likely missing some policy instruments, but the data collected cover most categories, as demonstrated in Chapter 3. That said, the size of the U.S. dataset may simply reflect the larger government apparatus and resources available to the United States compared with South Korea and Japan.

The dataset was coded across two dimensions: the objectives of the policy or program—as detailed below—and the type of implementation tools used to achieve a given goal, which we term a *policy instrument*. Some policies and programs involved more than one objective or instrument, so the counts in Figure 3.1 might not align with the total count of policies and programs per country. Table C.1 and Table C.2 categorize the policy objectives and policy instruments of the supply chain net assessment, respectively.

[287] International Energy Agency, "Critical Minerals Policy Tracker," webpage, last updated May 21, 2025d.

Table C.1. Supply Chain Securitization Objectives and Lines of Effort

Objective	Lines of Effort
Incentivize new supply and demand	• Support exploration and validation of new resources and reserves. • Provide regulatory support and coordination (e.g., permitting, feasibility studies, environmental impact studies). • Provide financial support for new extraction, processing, refining, and export firms, including from unconventional sources (e.g., waste, recycling, deep sea mining). • Provide financial support for related infrastructure projects (e.g., power, water, transportation). • Provide workforce development support for industry.
Diversify or localize ownership/control over existing sources	• Incentivize consumption and adoption of domestically produced products and services (e.g., "buy domestic" tax incentives). • Restrict competitors' access to domestic market or financial incentives (e.g., tariffs, FEOC regulations). • Incentivize divestment by risky firms.
Innovate past existing dependencies	• Localize knowledge and workforce (e.g., create innovation hubs or industrial parks). • Provide financial support to national labs, universities, and the private sector for advances in existing value chain (e.g., substitute manufacturing technologies for increases in efficiency or performance, waste disposal methods). • Provide financial support to national labs, universities, and private sector for development of substitute end products and industrial technologies with less or no foreign reliance. • Protect domestic technology and intellectual property (e.g., export controls, oversight of incoming and outgoing investment). • Provide support for test and evaluation infrastructure and development of common industry standards.
Work with and leverage partners and allies	• Reduce barriers to desirable foreign investment, trade, specialized labor, and knowledge and skills transfer. • Reduce barriers to sharing data and intelligence. • Pool and target resources in foreign production or infrastructure projects. • Provide expertise to improve mineral resource exploration, management, and development in resource-rich countries. • Increase access to foreign markets for domestic industry and protect domestic investments in foreign countries.
Assess risks and manage crises	• Build risk assessment and risk monitoring capabilities. • Develop mechanisms to weather disruptions (e.g., stockpiles, price support mechanisms). • Develop and practice crisis response processes. • Increase transparency of industry and trade (e.g., commodity prices, cost structure, product codes, and firm ownership).
Stabilize maintain market dominance	• Restrict competitor firms' access to products or equipment (e.g., export bans or restrictions). • Create uncertainty in markets (e.g., price dumping). • Capture foreign knowledge and technology (e.g., mandatory technology transfer, intellectual property theft) • Coerce firms or individuals (e.g., regulatory overreach, sanctions). • Pushing prices toward preferred levels (e.g., export quotas, establish a commodity cartel).

Objective	Lines of Effort
Strategic guidance and implementation	• Coordinate actions across government entities (e.g., sign executive orders, create councils or working groups, designate leading authority). • Establish national objectives and set priorities (e.g., development of a critical minerals strategy, creation of critical minerals list, five-year plans) • Pass supporting legislation (e.g., to increase authority and resources, create new government agencies or entities)

Table C.2. Supply Chain Securitization Policy Instrument

Category	Policy Instrument
Direct technical support	• Technology transfer • Testing and validation • Mapping resources • Direct government R&D • Operation of scientific user facilities
Financing	• Competition or hackathon • Contracting • Cost-sharing • Equity investments • Grants • Insurance • Letter interest or preliminary commitment • Loan guarantees • Loans • Other financial support • Structured finance • Tax credits and deductions
Nonfinancial tools	• Capacity-building • Consumption quotas • Industry/market analysis • Nonfinancial assistance to industry • Prioritization of government contracts and orders • Production quotas • Workforce development
Restrictions	• Eligibility criteria for incentives • Export ban and quotas • Tariff • Foreign investment reviews
Standards and regulations	• Assessing mining impacts • Permitting and regulatory oversight of projects • Standards development and dissemination
Stockpiling	• Stockpiling

Category	Policy Instrument
Strategy and coordination	• Intergovernmental coordination • Intragovernmental coordination • Strategy development
Trade and investment agreements	• Trade and investment agreements

Data

We reviewed and scored the policies, programs, and offices of the three countries accordingly to produce country policy instrument profiles to better assist in scoring the net assessment. These are depicted in Chapter 3 in the respective country sections.

For brevity, a full list of the offices, policies, and programs recorded for this study are omitted but are available on request from the authors.

Supply Chain Net Assessment Framework Development

To derive industrial policy objectives that would address the challenges of critical mineral industries, we used the results of a 2025 industry analysis conducted by RAND researchers.[288] The Five Forces industry analysis[289] (existing competitors, threat of new entrants, threat of substitutes, bargaining power of suppliers, and bargaining power of buyers) was used to assess the challenges and limitations of the mining industry in the 2025 RAND report.[290] The challenges in turn were used to abstract general market characteristics. Potential supply chain industrial policy objectives were proposed to address those characteristics based on existing country strategy documents available in the IEA Critical Minerals Policy Tracker (critical minerals strategy documents in trilateral countries, the PRC's 14th Five-Year Plan, etc.). Figure C.1 depicts this process.

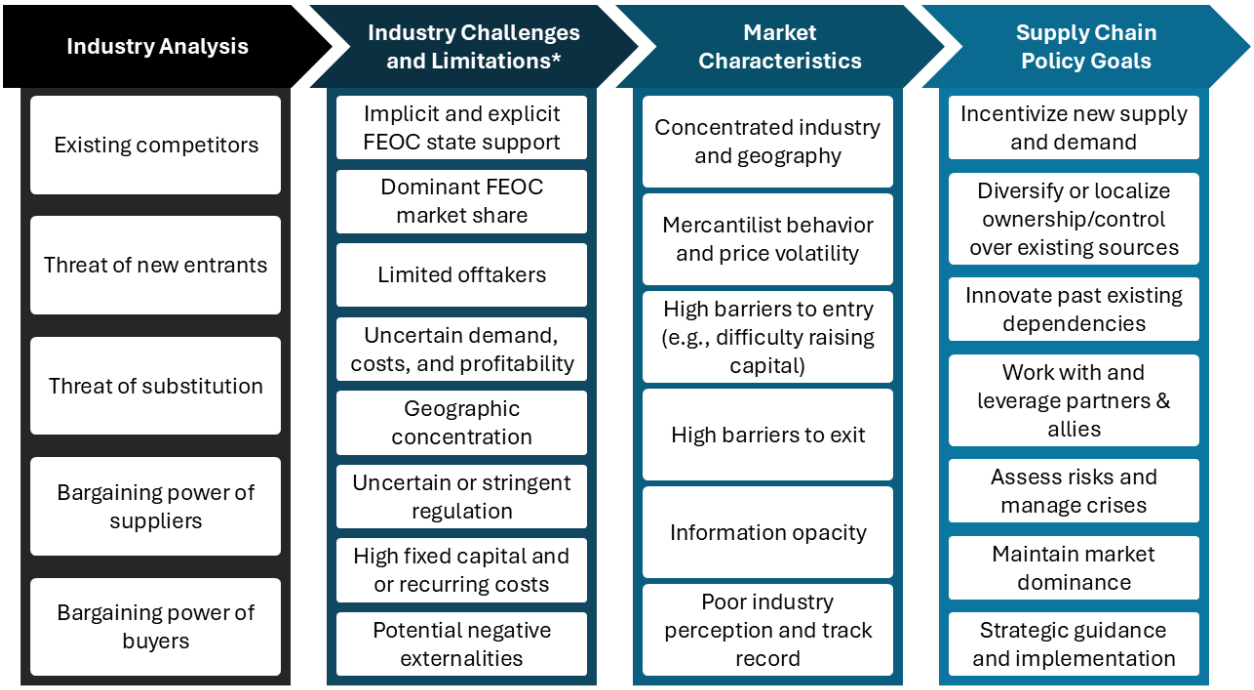
An initial industrial policy objective framework was drafted from the proposed industrial policy objectives. We held a roundtable discussion with RAND CMSC and policy subject-matter experts who reviewed the framework and offered feedback on ways to expand and adjust it to better capture the objectives of government offices, programs, and policies within the plethora of critical minerals activity across nations. This was an iterative process that involved adjusting and modifying the categories and intermittent review of changes.

[288] LaTourrette et al., 2025.

[289] See Michael E. Porter, "How Competitive Forces Shape Strategy," *Harvard Business Review*, March–April 1979; and Michael E. Porter, "The Five Competitive Forces That Shape Strategy," *Harvard Business Review*, January 2008.

[290] Porter uses these components of the Five Forces analysis because of their ability to connect industry behavior to impacts on supply, demand, or price of the product or service offered and better elucidate market effects. The RAND analysis includes relevant observations in CMSCs, such as goals other than profitability, high barriers to entry and exit, information opacity, and concentrated industry and geography.

Figure C.1. Deriving Policy Goals from Industry Analysis



SOURCE: Authors' analysis based of the industry analysis conducted by LaTourrette et al., 2025.
NOTE: Asterisk indicates not meant to be an exhaustive list.

We reviewed and scored the policies, programs, and offices of the three countries accordingly to produce country policy objective profiles to better assist in scoring the net assessment. These are depicted in Figure 3.1 in Chapter 3.

Supply Chain Net Assessment Guidance

The supply chain securitization capability score is determined by a qualitative assessment of the extent of the implementation of policy instruments to achieve the seven supply chain industrial policy objectives detailed in Table C.1. To assist with the assessment, a set of qualitative metrics was created. The metrics work on a four-point scale, describing detectable activity that would indicate progress toward the seven objectives. These metrics are shown in Table C.3, along with suggested criteria for scoring the metrics. We used these criteria to report the country scores in Chapter 3.

Table C.3. Supply Chain Net Assessment Guidance

Objective	Scale	Score Assessment Criteria
Incentivize new supply and demand	1	Domestic and foreign sources of new supply, potential markets with demand, and relevant national capabilities identified
	2	Required policy instruments to support industry and lower barriers to entry studied
	3	National capabilities to provide support and lower barriers to entry granted authority and resourced
	4	New entrants producing sustainably; new entrant activity monitored; support adjusted as needed
Diversify or localize ownership/control over existing sources	1	Domestic and foreign sources of existing supply, level of FEOC control, and relevant national capabilities identified
	2	Required policy instruments to establish acceptable or preferred level of FEOC control studied
	3	National capabilities to establish acceptable or preferred FEOC control granted authority, resourced, and enacted
	4	Sustained reshoring or friendshoring selectively detected; existing industry exhibits reduced FEOC control
Innovate past existing dependencies	1	Products with foreign dependencies or areas to advance industrial technology identified by R&D ecosystem
	2	Required policy instruments and priorities to support innovation studied
	3	Grants, facilities and industrial parks, and initiatives resourced; commercialization pathways identified
	4	Products or equipment with less foreign dependencies or which enable advances in existing value chain are commercialized
Work with and leverage partners and allies	1	Bilateral or multilateral nonpublic engagement on shared understanding of supply chain risks or concerns
	2	Bilateral or multilateral joint statements issued on shared supply chain interests or concerns
	3	Bilateral or multilateral supply chain cooperation initiatives announced and resourced
	4	Bilateral or multilateral agreements signed on trade, joint investments, standards, etc.; increased international cooperation detected (e.g., trade, projects developed)
Assess risk and manage crisis	1	Required risk assessment and crisis management capabilities and processes studied
	2	Required capabilities and processes granted authority and resourced
	3	Required capabilities and processes implemented and practiced

Objective	Scale	Score Assessment Criteria
	4	Required capabilities and processes providing ongoing monitoring and lessons learned
Maintain market dominance	1	Market or industry strength and point of leverage identified
	2	Market or industry strength and point of leverage aligned with strategic interests and national capabilities
	3	Policy guidance issued to coordinate national capabilities
	4	Government and industry actions actively support national strategic interests and/or market dominance
Strategic guidance and Implementation	1	National defense and commercial industrial requirements, priorities, and relevant national capabilities identified
	2	National strategy and key performance metrics developed
	3	National capabilities granted authority and resources; strategy implemented
	4	National defense and commercial industrial requirements being met; analysis and monitoring of strategy key performance metrics underway

These metrics prioritize the ability to achieve the policy objectives as developed by this study's framework. These objectives are largely based on countries who want to pursue diversification, onshoring, friendshoring, and other forms of de-risking. However, the scoring guidance prioritizes creating a capability and capacity to sustainably approach these goals with the identified policy instruments. Some instruments do not fit neatly into a single objective. It is entirely possible that multiple objectives are addressed by one policy instrument, or that one instrument's application benefits one objective but detracts from another. Overall, the alignment of policy instruments with objectives is a balance that each country must take seriously. The framework also leans onto dual-use technologies and their implications for defense industrial base security—which may not be applicable to some countries that do not produce their own war materiel. That said, the goal in creating this framework was also to facilitate its use in other technology or product supply chains with security concerns. We strove to create a framework that could describe the desirable objectives of any country seeking to secure supply chains in search of broader economic security, even China.

Appendix D

Methodology for Partner Alignment Metrics

This appendix provides details about the methodology and sources—including any data transformations and normalizations—that underpin the potential metrics that trilateral countries could use to evaluate candidate partners for cooperation on critical minerals and related issues.

These metrics were selected because of their focus on parameterizing relational alignment, the availability of quantifiable data, and their ability to be normalized and presented alongside other measures.

Partner Alignment Metrics

Table D.1 provides a summary of the indicators used to calculate these metrics.

Table D.1. Details of Indicators Used to Calculate Metrics

Component	Indicator	Measurement	Year of Data	Source
Political alignment	Shared values	Civil liberties, political culture, political participation, government functioning, electoral process	2024	*The Economist* Democracy Index[a]
	Shared outlooks	Voting consistency in the United Nations General Assembly	2019–2024	United Nations Digital Library[b]
Country characteristics	National power	Weighted average score across eight measures of power	2024	Lowy Institute Asia Power Index[c]
	Stability	Estimated risk of internal conflict within the next four years	2025	INFORM Risk Index[d]
	Governance	Government effectiveness and perception of corruption	2025	INFORM Risk Index
	Economic independence	Dependence on public and foreign aid and remittances	2025	INFORM Risk Index

[a] "The Global Democracy Index: How Did Countries Perform in 2024?" 2025.
[b] United Nations Digital Library, 2025.
[c] Lowy Institute, undated.
[d] European Commission, undated.

Shared Values

This indicator assesses the degree to which the candidate country and the trilateral country are similar in their democratic and pluralistic practices. The raw value for the candidate and trilateral country were sourced from the country scores provided by the 2024 version of *The Economist* Democracy Index, which assigns scores on a scale of 0–10 based on five metrics: civil liberties, political culture, political participation, government functioning, and electoral process.

The similarity between the two countries in the pairing was calculated by taking the absolute value of the difference in scores for the two nations. This difference was then normalized to a scale of 0–1 using the following formula:

$$Shared\ Values_{norm} = \frac{Distance_i - Distance_{min}}{Distance_{max} - Distance_{min}},$$

where $Distance_i$ is the calculated difference between the two countries, $Distance_{max}$ is the maximum absolute difference between any two countries in the Democracy Index, and $Distance_{min}$ is the minimum absolute difference in the dataset. The maximum and minimum absolute differences were found to be 9.56 and 0, respectively.

The normalized value for shared values was multiplied by 10 to produce a scale of 0–10. This value was then subtracted from 10 for the radar plot so that higher values represent less distance and thus a better outcome, while lower values represent greater distance between countries.

Shared Outlooks

This indicator assesses the degree to which the candidate country and the trilateral member have similar stances on global issues. We measured this through the voting consistency between the two countries in the United Nations General Assembly between 2019 and 2024. The 2019 cutoff was implemented to capture geopolitical alignment in recent times and to avoid voting records from earlier decades distorting the analysis. The raw value for voting consistency was calculated using the U.S. Department of State methodology, as follows:

1. Where two countries voted the same (both *yes*, both *no*, or both abstentions) = 1 point.
2. Where countries voted opposite of one another (one voted *yes*, other voted *no*) = 0 points.
3. Where countries partially align (one voted *yes* or *no*, other abstained) = 0.5 points.
4. Sum the total points.
5. Calculate the total number of resolutions that both countries recorded a vote on, discarding anywhere that either or both did not vote. Record this value as total votes.
6. Voting consistency is calculated as: $Voting\ consistency\ (\%) = 100 * \frac{Total\ Points}{Total\ Votes}$

The voting consistency was then normalized to a scale of 0–1 using the following formula:

$$Voting\ Consistency_{norm} = \frac{Voting\ Consistency_i - Voting\ Consistency_{min}}{Voting\ Consistency_{max} - Voting\ Consistency_{min}},$$

where *Voting Consistency*$_i$ is the voting consistency between the two countries, *Voting Consistency*$_{max}$ is the maximum voting consistency between the trilateral country and any other country, and *Voting Consistency*$_{min}$ is the minimum voting consistency that the trilateral member has with any country. In the cases of the South Korea-U.S. and Japan-U.S. relationships, the maximum and minimum voting consistency values for the United States were used.

Finally, the normalized value for shared values was multiplied by 10 to convert it to a scale of 0–10 for the radar plot.

National Power

This indicator assesses the national power of the partner as measured by the Lowy Institute Asia Power Index. Raw values were sourced from the 2024 version of the index, which assigns scores on a scale of 0–100 that are weighted averages of country capabilities across eight measures: economic capability, military capability, resilience, future resources, economic relationships, defense networks, diplomatic influence, and cultural influence.

The country scores were then normalized to a scale of 0–1 using the following formula:

$$National\ Power_{norm} = \frac{National\ Power_i - National\ Power_{min}}{National\ Power_{max} - National\ Power_{min}},$$

where *National Power*$_i$ is the national power of the candidate country, *National Power*$_{max}$ is the highest national power recorded in the dataset, and *National Power*$_{min}$ is the minimum recorded national power in the dataset. The maximum and minimum values were found to be 81.7 (United States) and 4.2 (Papua New Guinea), respectively.

Finally, the normalized value for shared values was multiplied by 10 to convert it to a scale of 0–10 for the radar plot.

Stability

This indicator assesses the political stability of the candidate country. To measure this, we used the projected conflict probability measurement in the INFORM Risk Index. This measure reflects the probability of violent internal conflict erupting within the candidate country in the next four years on a scale of 0–10.

The country scores were then normalized to a scale of 0–1 using the following formula:

$$Conflict\ Probability_{norm} = \frac{Conflict\ Probability_i - Conflict\ Probability_{min}}{Conflict\ Probability_{max} - Conflict\ Probability_{min}},$$

where *Conflict Probability*$_i$ is the conflict probability of the candidate country, *Conflict Probability*$_{max}$ is the highest conflict probability recorded in the dataset, and *Conflict Probability*$_{min}$ is the minimum recorded conflict probability in the dataset. The maximum and minimum values were found to be 10 and 0, respectively.

The normalized value for shared values was multiplied by 10 to convert it to a scale of 0–10. This value was then subtracted from 10 for the radar plot so that higher values represent less likelihood of conflict (and greater stability) and thus a better outcome, while lower values represent greater likelihood of conflict.

Governance

This indicator assesses the governance effectiveness of the candidate country. The measure uses the governance index from the INFORM Risk Index. It reflects the ineffectiveness and perception of government corruption for the selected country on a scale of 0–10.

The country scores were then normalized to a scale of 0–1 using the following formula:

$$Governance_{norm} = \frac{Governance_i - Governance_{min}}{Governance_{max} - Governance_{min}},$$

where $Governance_i$ is the government ineffectiveness of the candidate country, $Governance_{max}$ is the highest government ineffectiveness recorded in the dataset, and $Governance_{min}$ is the minimum recorded government ineffectiveness in the dataset. The maximum and minimum values were found to be 9.3 and 1, respectively.

The normalized value for shared values was multiplied by 10 to convert it to a scale of 0–10. This value was then subtracted from 10 for the radar plot so that higher values represent less government ineffectiveness (and greater effectiveness) and thus a better outcome, while lower values represent less effectiveness.

Economic Independence

This indicator assesses the economic independence of the candidate country in relation to inflows from foreign sources. To measure this, we used the economic dependency index from the INFORM Risk Index. This measure reflects the dependence on public aid, foreign aid, and foreign remittances for the selected country on a scale of 0–10.

The country scores were then normalized to a scale of 0–1 using the following formula:

$$Dependency_{norm} = \frac{Dependency_i - Dependency_{min}}{Dependency_{max} - Dependency_{min}},$$

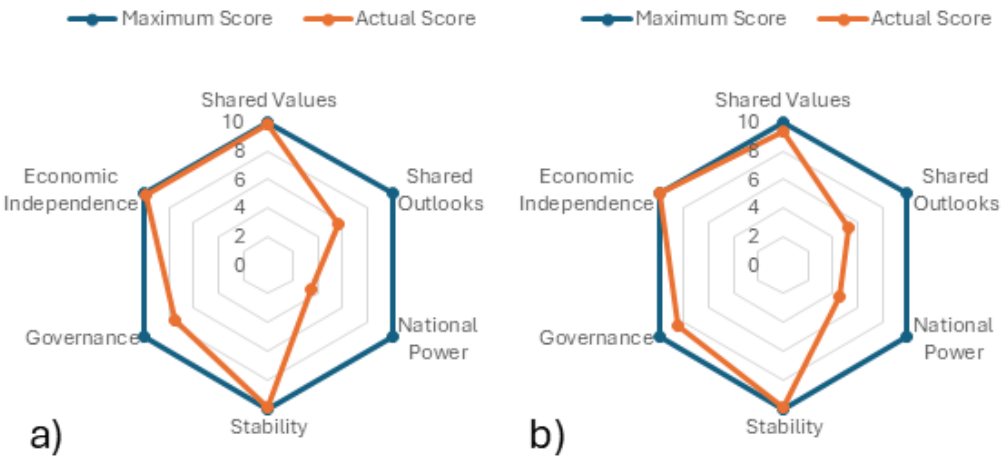
where $Dependency_i$ is the economic dependence of the candidate country, $Dependency_{max}$ is the highest economic dependence recorded in the dataset, and $Dependency_{min}$ is the minimum recorded economic dependence in the dataset. The maximum and minimum values were found to be 10 and 0, respectively.

The normalized value for shared values was multiplied by 10 to convert it to a scale of 0–10. This value was then subtracted from 10 for the radar plot so that higher values represent less economic dependence (and greater independence) and thus a better outcome, while lower values represent less independence.

Metric Calibration

The metrics were applied to the South Korea-U.S. and Japan-U.S. relationships to illustrate the metrics. Figure D.1 visualizes the results for the South Korea-U.S. (panel a) and Japan-U.S. (panel b) relationship in the form of a radar plot. Both Japan and South Korea are highly stable, well-governed, and economically independent of aid and remittance inflows. They also exhibit a high degree of shared values with the United States, implying a high commitment to democratic ideas and pluralistic practices. However, both countries rank relatively low on national power and appear to have a middling record in how similarly they view global issues to the United States.

Figure D.1. Radar Plots Illustrating U.S.-South Korea and U.S.-Japan Relationships



NOTE: Panel a = U.S.-South Korea alignment. Panel b = U.S.-Japan alignment.

Abbreviations

BIL	Bipartisan Infrastructure Law
CMSC	critical minerals supply chain
COMPACT	Catalyzing Opportunities for Military Partnership, Accelerated Commerce & Technology
COVID-19	coronavirus disease 2019
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DRC	Democratic Republic of the Congo
DFC	International Development Finance Corporation
EV	electric vehicle
EXIM	Export-Import Bank of the United States
FEOC	foreign entity of concern
G7	Group of Seven
GSOMIA	General Security of Military Information Agreement
HS	Harmonized System
HTS	Harmonized Tariff Schedule
IEA	International Energy Agency
IPEF	Indo-Pacific Economic Framework for Prosperity
IRA	Inflation Reduction Act
JBIC	Japan Bank for International Cooperation
JOGMEC	Japan Organization for Metals and Energy Security
KEXIM	Export-Import Bank of Korea
KOMIR	Korea Mine Rehabilitation and Mineral Resources Corporation
MOU	memorandum of understanding
MCEIP	Manufacturing Capability Expansion and Investment Prioritization
METI	Ministry of Economy, Trade, and Industry
MOEF	Ministry of Economy and Finance
MOFA	Ministry of Foreign Affairs
MOTIE	Ministry of Trade, Industry, and Energy
MSP	Minerals Security Partnership
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
PRC	People's Republic of China
QUAD	Quadrilateral Security Dialogue

R&D	research and development
REE	rare earth element
ROK	Republic of Korea
SOE	state-owned enterprise
UK	United Kingdom
USGS	U.S. Geological Survey

Bibliography

Unless otherwise indicated, the authors of this report provided the translations of bibliographic details for the non-English sources included in this report. To support conventions for alphabetizing, sources in Japanese, Korean, and Mongolian are introduced with and organized according to their English translations. The original rendering appears in brackets after the English translation.

Agreement Between the Government of the United States of America and the Government of Japan on Strengthening Critical Minerals Supply Chains, March 28, 2023.

Allen, Brooks E., Joseph L. Barloon, Brian J. Egan, Michael E. Leiter, Christian Knipfer, and Joe Sandman, "US Announces New Tariffs on Chinese-Origin Goods, With an Exclusion Process," Skadden, May 15, 2024.

Almonty Industries, "Almonty Korea Tungsten Project," webpage, undated-a. As of February 05, 2025: https://almonty.com/project/almonty-korea-tungsten/

Almonty Industries, homepage, undated-b. As of June 12, 2025: https://almonty.com/project

Ampofo, Kwasi, and Marina Demidova, *Cobalt 2050: Unlocking Potential for a Net-Zero Future*, BloombergNEF and Cobalt Institute, October 2024.

Aryan, Siddharth, Joshua Huminski, Mahnaz Khan, Nolty Theriot, Kristi Rogers, and Sarah Stewart, *Policy Recommendations on Enhancing U.S.-India Critical Minerals Collaboration*, U.S.-India Strategic Partnership Forum, Silverado Policy Accelerator, and P2P Strategies, July 2024.

Auslin, Michael, and Christopher J. Griffin, "Time for Trilateralism?" American Enterprise Institute, March 6, 2008.

Bansal, Karthik, and Rajesh Chadha, *Critical Mineral Supply Chains: Challenges for India*, Centre for Social and Economic Progress, CSEP Working Paper 88, February 2025.

Bansal, Karthik, and Ishita Kapoor, *Post-Lease Clearances: Streamlining the Time-Cost*, Centre for Social and Economic Progress, CSEP Working Paper 47, December 2022.

Baskaran, Gracelin, and Meredith Schwartz, "China's Antimony Export Restrictions: The Impact on U.S. National Security," Center for Strategic and International Studies, August 20, 2024a.

Baskaran, Gracelin, and Meredith Schwartz, "China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet Amidst Escalating U.S.-China Tech War," Center for Strategic and International Studies, December 4, 2024b.

Bellasio, Jacopo, Victoria Jordan, Pauline Paillé, Anna Knack, and Ruth Harris, *Provision of an Indicative, Non-Exhaustive List of Conflict-Affected and High-Risk Areas (CAHRAs) Under Regulation 2017/821: Updated Methodology*, RAND Corporation, RR-A158-1-v2, 2023. As of June 18, 2025: https://www.rand.org/pubs/research_reports/RRA158-1-v2.html

Benson, Emily, and Thibault Denamiel, "China's New Graphite Restrictions," Center for Strategic and International Studies, October 23, 2023.

Bentham, Jane, "ERG Signs Cobalt Agreements in North America, Europe, and Japan," *Global Mining Review*, July 31, 2024.

Beylo, Brandon, "An Industry Primer on Tungsten," Macro Ops, January 4, 2024.

Blackwood, Matthew, and Catherine DeFilippo, *Germanium and Gallium: U.S. Trade and Chinese Export Controls*, U.S. International Trade Commission, March 2024.

British Geological Survey, "What Is the Difference Between Resources and Reserves for Aggregates?" webpage, undated. As of May 29, 2024:
https://www2.bgs.ac.uk/mineralsuk/mineralsYou/resourcesReserves.html

Buffie, Nicholas E., *Foreign Entity of Concern Requirements in the Section 30D Clean Vehicle Credit*, Congressional Research Service, IN12322, updated September 30, 2024.

Bureau of Energy Resources, homepage, undated. As of April 28, 2025:
https://www.state.gov/bureaus-offices/under-secretary-for-economic-growth-energy-and-the-environment/bureau-of-energy-resources/

Carl-Yoder, Samantha, Fabian Villalobos, Kenyon Weaver, and J. Rabini-Jenkins, "The Minerals Security Partnership and the Pursuit of Global Supply Chain Resilience," *Proceedings of the 70th Annual Natural Resources and Energy Law Institute (2024)*, January 2025.

Centerra Gold, "Molybdenum Business Unit," webpage, undated. As of April 24, 2025:
https://www.centerragold.com/operations/molybdenum-business-unit/

Cernicky, Jan, Tim Peter, Gunter Rieck Moncayo, Yosuke Ishigami, and Hiroyasu Hosoi, *EU-Japan Critical Raw Materials Alliance*, Konrad-Adenauer-Stiftung and Nakasone Peace Institute, 2024.

"China Bans Export of Gallium, Germanium and Antimony to the US," Mining.com, December 3, 2024.

Chuluunbaatar, Sumiya, "Why Did Mongolia's Foreign Minister Visit Japan?" *The Diplomat*, March 7, 2025.

Chung, Jaewon, "South Korea [Advance Release]," in *2020–2021 Minerals Yearbook*, U.S. Geological Survey, May 2024a.

Chung, Jaewon, "Mongolia [Advance Release]," in *2020–2021 Minerals Yearbook*, U.S. Geological Survey, December 2024b.

Chung, Jaewon, "Mongolia [Advance Release]," in *2022 Minerals Yearbook*, U.S. Geological Survey, March 2025.

Cobalt Institute, "Cobalt Mining," webpage, undated. As of February 6, 2025:
https://www.cobaltinstitute.org/about-cobalt/cobalt-life-cycle/cobalt-mining/

Cobalt Institute, *Cobalt Market Report 2023*, May 2024.

Clark, Colin, "South Korea and Japan Resume Intel Sharing Agreement, but Not All Problems Are Solved," Breaking Defense, April 17, 2023.

Center on Global Energy Policy, Columbia University, "Japan," webpage, *Critical Materials Monitor*, undated-a. As of February 04, 2025:
https://criticalmaterials.energypolicy.columbia.edu/countries/392/

Center on Global Energy Policy, Columbia University, "Rep. of Korea," webpage-b, *Critical Materials Monitor*, undated. As of February 04, 2025: https://criticalmaterials.energypolicy.columbia.edu/countries/410/

Center on Global Energy Policy, Columbia University, "USA," webpage, *Critical Materials Monitor*, undated-c. As of February 04, 2025: https://criticalmaterials.energypolicy.columbia.edu/countries/842/

Dashnyam Partners LLC, "Mongolia Digitalized the Minerals License Tendering and Issuance Process," September 1, 2022.

DeCarlo, Keita F., "Japan [Advance Release]" in *2020–2021 Minerals Yearbook*, U.S. Geological Survey, December 2024.

DeCarlo, Keita F., "India [Advance Release]" in *2022 Minerals Yearbook*, U.S. Geological Survey, March 2025.

Defense Advanced Research Projects Agency, "Gallium Arsenide," webpage, undated. As of April 25, 2025: https://www.darpa.mil/about-us/timeline/gallium-arsenide-research

Dhir, Shobhan, Eric Buisson, and Tae-Yoon Kim, "Growing Geopolitical Tensions Underscore the Need for Stronger Action on Critical Minerals Security," International Energy Agency, February 9, 2025.

DoD—*See* U.S. Department of Defense.

DoE—*See* U.S. Department of Energy.

Dowa Electronics Materials Co., "High-Purity Metals," webpage, undated. As of April 25, 2025: https://www.dowa-electronics.co.jp/en/semiconductor/high-purity-metal.html

Ellison, Tom, *India's Lithium Resources in Kashmir Highlight Conflict Risks Around Critical Minerals*, Council on Strategic Risks, Briefer No. 48, March 30, 2023.

EQ Resources, "EQR Project Portfolio," webpage, undated. As of February 5, 2025: https://www.eqresources.com.au/site/what-we-do/eqr-project-portfolio

Erdenet, "Enrichment" ["Баяжуулалт"], webpage, undated. As of April 30, 2025: https://www.erdenetmc.mn/operations/processing

Erdmann, Martin, and Tamiraa Altangerel, *Rare Earths of Mongolia: Evaluation of Market Opportunities for the Principal Deposits of Mongolia*, 2nd ed., Bundesanstalt für Geowissenschaften und Rohstoffe, June 2023.

European Commission, "DRMKC – INFORM," webpage, undated. As of April 7, 2025: https://drmkc.jrc.ec.europa.eu/inform-index

European Commission, "EU Imposes Duties on Unfairly Subsidised Electric Vehicles from China While Discussions on Price Undertakings Continue," press release, October 28, 2024.

Executive Order 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," Executive Office of the President, December 20, 2017.

Executive Order 14241, "Immediate Measures to Increase American Mineral Production," Executive Office of the President, March 20, 2025.

Executive Order 14285, "Unleashing America's Offshore Critical Minerals and Resources," Executive Office of the President, April 24, 2025.

Foley, Nora, and Brian Jaskula, "Gallium—A Smart Metal," U.S. Geological Survey Fact Sheet 2013–3006, March 2013.

Foley, Nora K., Brian W. Jaskula, Bryn E. Kimball, and Ruth F. Schulte, "Gallium," in Klaus J. Schulz, John H. DeYoung, Jr., Robert R. Seal II, and Dwight C. Bradley, eds., *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply*, U.S. Geological Survey Professional Paper 1802, December 2017.

Frederick, Bryan, and Howard J. Shatz, *Countering Chinese Coercion: Multilateral Responses to PRC Economic Pressure Campaigns*, RAND Corporation, PE-A796-1, December 2022. As of June 17, 2025: https://www.rand.org/pubs/perspectives/PEA796-1.html

Freeport-McMoRan Inc., *The Value of Copper: 2023 Annual Report*, 2024.

Funaiole, Matthew P., Brian Hart, and Aidan Powers-Riggs, *De-Risking Gallium Supply Chains: The National Security Case for Eroding China's Critical Mineral Dominance*, Center for Strategic and International Studies, August 2023.

Ganguly, Mayurakshi, ed., "Sumitomo Expands Battery Plant Capacity with Plans to Explore USA's Electric Vehicle Market," AI Circle, November 17, 2023.

Girardi, Benedetta, Irina Patrahau, Giovanni Cisco, and Michel Rademaker, *Strategic Raw Materials for Defence: Mapping European Industry Needs*, Hague Centre for Strategic Studies, January 2023.

GlobalData, "Australia's Northern Territory, Japan Partner on Critical Minerals," July 22, 2024.

"The Global Democracy Index: How Did Countries Perform in 2024?" *The Economist*, February 27, 2025.

"Global Tungsten Industry Report 2024–2030: Why New Tungsten Production Sources Are Critical to Meet Surging EV Demand," Yahoo Finance, June 11, 2024.

Government of Mongolia, Minerals Law Amendment [Ашигт Малтмалын Тухай Хуульд Нэмэлт, Өөрчлөлт Оруулах Тухай], April 19, 2024. As of April 30, 2025: https://legalinfo.mn/mn/detail?lawId=17140237039871&showType=1

Government of Mongolia, Minerals Law of Mongolia, July 8, 2006. As of April 30, 2025: https://www.legalinfo.mn/en/edtl/16389997472991

Government of Mongolia, *Vision-2050: Introduction to Mongolia's Long-Term Development Policy Document*, 2020. As of April 30, 2025: https://cabinet.gov.mn/en/wp-content/uploads/Алсын-хараа-English-1.pdf

Government of Mongolia, "On Investment," draft revision, April 14, 2023. As of April 30, 2025: https://investmongolia.gov.mn/law/download/compressed/investment_law_draft_en.pdf

Government of Mongolia, "On Voting for the Selection Procedure for Granting Special Permits for Profitable Minerals" ["Ашигт Малтмалын Тусгай Зөвшөөрөл Олгох Сонгон Шалгаруулалтын Журамд Санал Авах Тухай"], November 21, 2024. As of April 30, 2025: https://mmhi.gov.mn/2024/11/21/ашигт-малтмалын-тусгай-зөвшөөрөл-олг-4/

Grand View Research, "Molybdenum Market Size and Share Analysis Report, 2030," webpage, undated. As of February 04, 2025: https://www.grandviewresearch.com/industry-analysis/molybdenum-market-report

Harper, Gavin D. J., "The Geopolitics of Cobalt," *American Affairs*, Vol. 5, No. 4, Winter 2021.

Harrell, Peter, Elizabeth Rosenberg, and Edoardo Saravalle, *China's Use of Coercive Economic Measures*, Center for a New American Security, June 11, 2018.

Heffernan, Marissa, "Samsung Starts Battery-to-Battery Cobalt Recycling," Resource Recycling, January 30, 2025.

Hendrix, Cullen S., "New-Risking Rather Than De-Risking: The Challenges in US Efforts to Reduce Dependence on Chinese Critical Minerals," Peterson Institute for International Economics, December 13, 2024.

Heo, Jaichul, "Analysis of Chinese Response Patterns to Diplomatic Friction and Its Influencing Factors," Korea Institute for International Economic Policy, *World Economy Brief*, Vol. 22, No. 10, March 10, 2022.

Hong, Shinae, "Mongolia and the Korea Conflict," *The Diplomat*, July 15, 2021.

Hordern, Annamarie, "Micron-Japan Deal Counters China 'Coercion,' Rahm Emanuel Says," Bloomberg, May 18, 2023.

Hurst, Cindy, "Japan's Approach to China's Control of Rare Earth Elements," Jamestown Foundation, *China Brief*, Vol. 11, No. 7, April 22, 2011.

Hwang, Jung-hwan, "S.Korea, Japan Seal 3-Year $10 bn Currency Swap Deal," *Korea Economic Daily*, December 1, 2023.

IEA—*See* International Energy Agency.

Indian Ministry of External Affairs, "India–Republic of Korea Bilateral Relations," July 12, 2024.

Internal Revenue Service, "Advanced Manufacturing Production Credit," *Federal Register*, Vol. 89, No. 208, October 28, 2024.

International Copper Study Group, *The World Copper Factbook 2024*, 2024.

International Energy Agency, "Critical Mineral List in Korea," webpage, December 8, 2023a. As of April 22, 2025:
https://www.iea.org/policies/17943-critical-mineral-list-in-korea

International Energy Agency, "Quad Statement of Principles on Clean Energy Supply Chains in the Indo-Pacific," December 11, 2023b.

International Energy Agency, "International Resource Strategy—National Stockpiling System," webpage, last updated April 9, 2025a. As of April 25, 2025:
https://www.iea.org/policies/16639-international-resource-strategy-national-stockpiling-system

International Energy Agency, "Final List of Critical Minerals 2022," webpage, April 24, 2025b. As of February 4, 2025:
https://www.iea.org/policies/15271-final-list-of-critical-minerals-2022

International Energy Agency, "Announcement on the Implementation of Export Control of Items Related to Gallium and Germanium," last updated April 25, 2025c.

International Energy Agency, "Critical Minerals Policy Tracker," webpage, last updated May 21, 2025d. As of June 27, 2025:
https://www.iea.org/data-and-statistics/data-tools/critical-minerals-policy-tracker

International Molybdenum Association, "Molybdenum Compounds & Their Chemistry," webpage, undated-a. As of February 4, 2025:
https://www.imoa.info/molybdenum-uses/molybdenum-chemistry-uses/molybdenum-chemistry-uses.php

International Molybdenum Association, "Molybdenum Market Information," webpage, undated-b. As of February 4, 2025:
https://www.imoa.info/molybdenum/molybdenum-market-information.php

International Molybdenum Association, "Molybdenum Metal & Alloys," webpage, undated-c. As of February 4, 2025:
https://www.imoa.info/molybdenum-uses/molybdenum-metal-alloys.php

International Molybdenum Association, "Nickel-Based Superalloys," webpage, undated-d. As of February 4, 2025:
https://www.imoa.info/molybdenum-uses/molybdenum-grade-superalloys.php

International Molybdenum Association, "Role of Molybdenum," webpage, undated-e. As of February 4, 2025:
https://www.imoa.info/molybdenum/molybdenum-properties.php

International Trade Administration, U.S. Department of Commerce, "Draft List of Critical Supply Chains," webpage, undated. As of April 22, 2025:
https://www.trade.gov/data-visualization/draft-list-critical-supply-chains

International Tungsten Industry Association, "Applications and Markets," webpage, undated-a. As of February 5, 2025:
https://www.itia.info/applications-markets/

International Tungsten Industry Association, "Properties and Intermediates," webpage, undated-b. As of February 05, 2025:
https://www.itia.info/properties-intermediates/

Investment and Trade Agency of Mongolia, "Metals and Mining: Abundant Natural Resources and Minerals," webpage, undated. As of April 30, 2025:
https://investmongolia.gov.mn/metals-and-mining/

Jamasmie, Cecilia, "China Hits Back at US Tariffs with Mineral Export Curbs," Mining.com, February 4, 2025.

Japan Bank for International Cooperation, "Resources Sector," webpage, undated. As of April 28, 2025:
https://www.jbic.go.jp/ja/business-areas/sectors/resources.html

"Japan Complains That China's Export Control Law Is Too Broad and Unclear," *WorldECR*, June 22, 2023.

Japan Oil, Gas and Metals National Corporation, *Mineral Resources Material Flow 2022: 16. Gallium (Ga)* [鉱物資源マテリアルフロー 2022. 16. ガリウム (Ga)], 2022. As of June 23, 2025:
https://mric.jogmec.go.jp/wp-content/uploads/2024/01/material_flow2022_Ga.pdf

Japan Oil, Gas and Metals National Corporation, "Overview of Metal Resources," webpage, undated. As of February 05, 2025:
https://www.jogmec.go.jp/metal/metal_10_00001.html

Japan Organization for Metals and Energy Security, homepage, undated-a. As of June 14, 2025:
https://www.jogmec.go.jp/english/carbonneutral/carbonneutral_15_00007.html

Japan Organization for Metals and Energy Security, "Metal Resource Development" ["金属資源開発"], webpage, undated-b. As of April 28, 2025: https://www.jogmec.go.jp/metal/index.html

Japan Organization for Metals and Energy Security, "JOGMEC Signed an Agreement with African Countries to Secure Critical Minerals—Strengthening Relationships with African Countries Through Accompanying Minister NISIMURA on a Visit to Southern African Countries," press release, August 18, 2023. As of June 23, 2025: https://www.jogmec.go.jp/news/release/news_10_00131.html

"Japan, South Korea Leaders Agree to Build Stable Ties in 1st Phone Talks," Kyodo News, June 9, 2025.

"Japan, U.S. Agree to Urgently Boost Deterrence Amid Assertive China," Kyodo News, March 30, 2025.

Japanese Ministry of Economy, Trade, and Industry, "Economic Security Policy" ["経済安全保障政策"] webpage, undated-a. As of April 28, 2025: https://www.meti.go.jp/policy/economy/economic_security/index.html

Japanese Ministry of Economy, Trade, and Industry, "METI Reorganization," briefing slides, provided to the authors, undated-b.

Jaskula, Brian W., "Gallium" in *Mineral Commodity Summaries 2024*, U.S. Geological Survey, January 2024a.

Jaskula, Brian W., "Gallium [Advance Release]," in *2020 Minerals Yearbook*, U.S. Geological Survey, December 2024b.

Jaskula, Brian W., "Gallium [Advance Release]," in *2021 Minerals Yearbook*, U.S. Geological Survey, January 2025.

Jeon Hyun-hee [전현희], and Lee Jun [이 준], "The Three Supply Chain Laws and Korean-Style Economic Security: Challenges and Issues?" ["공급망 3법과 한국형 경제안보, 도전과 과제는?"], Korea Institute for Industria Economics and Trade, February 2024.

Jin, Hyunjoo, "China Asks Korea Not to Export Products Using Rare Earths to US Defense Firms—Reports," Mining.com, April 22, 2025.

JOGMEC—*See* Japan Organization for Metals and Energy Security.

Juhász, Réka, Nathan Lane, and Dani Rodrik, "The New Economics of Industrial Policy," *Annual Review of Economics*, Vol. 16, 2024.

Jung, Eric, "The 'Chip 4 Alliance' and Taiwan–South Korea Relations," Global Taiwan Institute, September 20, 2023.

Kharpal, Arjun, "Netherlands, Home to a Critical Chip Firm, Follows U.S. with Export Curbs on Semiconductor Tools," CNBC, June 30, 2023.

Kim Bo-eun, "Korea Urged to Diversify Material Imports," *Korea Times*, November 11, 2021.

Kim, Ri-Ahn, and Dae-Hun Kim, "China Bans Export of Korean Goods Using Its Rare Earth Metals to US," *Korea Economic Daily*, April 22, 2025.

King, Madeleine, and Anthony Albanese, "Australia-Japan Strengthen Critical Minerals Cooperation," press release, October 22, 2022.

Korea Institute of Geoscience and Mineral Resources, *Rare Metal Raw Material Trade Analysis 2024* [희유금속 원재료 교역 분석 2024], 2024.

"Korea, Mongolia Sign MOU on Rare Metals Supply," *Korea Times*, February 15, 2023.

Krusekopf, Charles, "Mongolia's Development of Critical Minerals: Opportunities and Challenges," National Bureau of Asian Research, August 16, 2023.

Kim, Daeyoung, "U.S.-ROK Cooperation in Critical Mineral Chains," Center for Strategic and International Studies, briefing, September 11, 2024.

Kim Eun-jung, "S. Korea, Mongolia Agree to Seek Closer Ties on Rare Earth Supply," Yonhap News Agency, August 29, 2022.

Kim Na-Young, "Gov't to Respond to Possible Impact of China's Export Curb on Strategic Minerals," Yonhap News Agency, February 5, 2025.

Koo, Jahyun, and Daehee Jeong, *Economic Security and Strategies to Strengthen Supply Chains*, Korea Development Institute, December 30, 2023.

Kwon, Bo Ram, "US-South Korea Defense Industrial Cooperation: Drivers, Developments, and Tasks Ahead," Korea Economic Institute of America, policy brief, December 17, 2024.

LaTourrette, Tom, Fabian Villalobos, Elisa Yoshiara, and Zohan Hasan Tariq, *The Potential Impact of Seabed Mining on Critical Mineral Supply Chains and Global Geopolitics*, RAND Corporation, RR-A3560-1, 2025. As of June 23, 2025: https://www.rand.org/pubs/research_reports/RRA3560-1.html

Lewis, Simon, and David Brunnstrom, "Exclusive-Mongolia, Rio Tinto Have Resolved Nearly All Copper Mine Tax Issues-PM," Reuters, August 3, 2023.

LG Energy Solution, "LG Energy Solution to Have 6-Year Access to Nickel, Cobalt from Australian Mines Amid Heated Competition over Raw Materials," press release, August 16, 2021.

Lin, Liza, "China Adds 15 American Companies to Export-Control List," *Wall Street Journal*, March 4, 2025.

Liu, Siyi, and Dominique Patton, "China, World's Top Graphite Producer, Tightens Exports of Key Battery Material," Reuters, October 20, 2023.

Lkhaajav, Bolor, "Mongolian Parliament Passes Legislation to Establish Sovereign Wealth Fund," *The Diplomat*, April 26, 2024a.

Lkhaajav, Bolor, "Mongolia's Ulaanbaatar Dialogue Focuses on Regional Cooperation in Energy Transition and Critical Minerals," *The Diplomat*, June 12, 2024b.

Lkhaajav, Bolor, "The Mongolia-NATO Partnership," *The Diplomat*, July 24, 2024c.

Lkhaajav, Bolor, "Expanding Mongolia's Partnership with Japan and South Korea," *The Diplomat*, February 27, 2025.

Lowy Institute, "Asia Power Index, 2024 Edition," webpage, undated. As of April 7, 2025: https://power.lowyinstitute.org/

Lv, Amy, Lewis Jackson, and Ashitha Shivaprasad, "China Expands Key Mineral Export Controls After US Imposes Tariffs," Reuters, February 4, 2025.

Masan High-Tech Materials, "Tungsten Raw Materials Procurement," webpage, undated. As of February 5, 2025:
https://masanhightechmaterials.com/our-products/tungsten-raw-materials-procurement/

Matthews, Daniel, *Global Value Chains: Cobalt in Lithium-Ion Batteries for Electric Vehicles*, Office of Industries, U.S. International Trade Commission, ID-20-067, May 2020.

Memorandum of Understanding Among the United States of America, the Democratic Republic of the Congo, and the Republic of Zambia, Concerning Support for the Development of a Value Chain in the Electric Vehicle Battery Sector, December 13, 2022.

Mining See, "Global Molybdenum Production and Usage Trends in 2023," April 4, 2024.

Ministry of Commerce and Industry, Government of India, "Australia-India-Japan Trade Ministers' Joint Statement on Launch of Supply Chain Resilience initiative," press release, April 27, 2021.

Ministry of Commerce and Industry, Government of India, "Commerce and Industry Minister Shri Piyush Goyal Co-Chairs 6th India-US Commercial Dialogue in Washington D.C.," October 4, 2024.

Ministry of Economy and Finance, "The Enactment of Framework Act on Supply Chain," press release, December 27, 2023. As of April 27, 2025:
https://english.moef.go.kr/pc/selectTbPressCenterDtl.do?boardCd=N0001&seq=5741

Ministry of Economy and Finance, "1st Basic Plan for Supply Chain Stabilization," December 19, 2024.

Ministry of Foreign Affairs of Japan, "Japan-Mongolia Relations (Basic Data)," webpage, September 9, 2024. As of April 27, 2025:
https://www.mofa.go.jp/region/asia-paci/mongolia/data.html

Ministry of Foreign Affairs of Japan, "Signing of the Japan-U.S. Critical Minerals Agreement (CMA)," press release, March 28, 2023. As of April 29, 2025:
https://www.mofa.go.jp/press/release/press1e_000400.html

Ministry of Industry and Information Technology of the People's Republic of China, *Notice on Issuing the 14th Five-Year Plan for the Development of Raw Materials Industry* [三部委关于印发"十四五"原材料工业发展规划的通知], MIIT Joint Regulation No. 212, December 29, 2021. As of April 16, 2025:
https://wap.miit.gov.cn/zwgk/zcwj/wjfb/tz/art/2021/art_2960538d19e34c66a5eb8d01b74cbb20.html

Ministry of Mines, Government of India, "KABIL Set Up to Ensure Supply of Critical Minerals," press release, August 1, 2019.

Ministry of Mines, Government of India, "Geological Survey of India Finds Lithium and Gold Deposits," press release, February 9, 2023a.

Ministry of Mines, Government of India, "Parliament Passes Mines and Minerals (Development & Regulation) Amendment Bill, 2023," press release, August 2, 2023b.

Ministry of Mines, Government of India, "Strengthening of Mineral Supply Chains," press release, August 7, 2023c.

Ministry of Mines, Government of India, "Mines Ministry to Invite Proposals from Start-Ups, MSMEs & Individual Innovators to Promote Research and Innovation in Mining and Mineral Processing," press release, November 15, 2023d.

Ministry of Mines, Government of India, "Mines Ministry to Launch National Geoscience Data Repository Portal to Foster Innovation in Exploration," press release, December 18, 2023e.

Ministry of Mines, Government of India, "Mines Minister Shri Pralhad Joshi Hands Over Letters of Financial Grants to Five Start-Ups for Funding Innovations in Mining and Mineral Sector," press release, March 1, 2024a.

Ministry of Mines, Government of India, *Indian Minerals Yearbook 2022*: Vol. II, *Metals and Alloys*, December 2024b.

Ministry of Mines, Government of India, *Indian Minerals Yearbook 2022*: Vol. III, *Minerals Reviews*, December 2024c.

Ministry of Mines, Government of India, "Cabinet Approves 'National Critical Mineral Mission' to Build a Resilient Value Chain for Critical Mineral Resources Vital to Green Technologies, with an Outlay of Rs.34,300 Crore over Seven Years," press release, January 29, 2025.

Ministry of Mining and Heavy Industry, Government of Mongolia, "A Joint Mongolia-Korea Rare Metals Research Center Will Be Established with Grant Assistance from the Government of the Republic of Korea" ["Бнсу-Ын Засгийн Газрын Буцалтгүй Тусламжаар Монгол-Солонгосын Хамтарсан Ховор Металлын Судалгааны Төвийг Байгуулна"], November 20, 2023. As of April 30, 2025: https://mmhi.gov.mn/2023/11/20/бнсу-ын-засгийн-газрын-буцалтгүй-тусл/

Ministry of Mining and Heavy Industry, Government of Mongolia, *Mineral Sector Statistics 2023* [*Эрдэс Баялгийн Салбарын Статистик Мэдээлэл 2023*], January 22, 2024. As of March 5, 2025: https://mmhi.gov.mn/2024/01/22/эрдэс-баялгийн-салбарын-статистик-мэ-21/

Ministry of Mining and Heavy Industry, Government of Mongolia, *Minerals and Mining Investment Guide 2023–2024*, 2024.

Mineral Resources and Petroleum Authority of Mongolia, *Mineral Resources and Petroleum Statistics*, January 2025.

Misheel, E., "Mongolia to Join International Critical Minerals Network," *Mining Insight Magazine*, September 8, 2023.

MOEF—*See* Ministry of Economy and Finance.

Mohan, Vishwa, "GSI Discovery Makes India 7th Largest Lithium Resource-Rich Country," *Times of India*, February 10, 2023.

Mongolia Geonetwork, "Search" ["Хайлт"], webpage, undated. As of April 30, 2025: https://geonet.mris.mn/geonetwork/srv/mon/catalog.search#/search

Mongolian National Rare Earth Corp LLC, "Mongolia and Japan Forge Rare Earth Partnership," September 12, 2024.

Muff, R., and A. Tamiraa, *Rare Earths of Mongolia: Evaluation of Market Opportunities for the Principal Deposits of Mongolia*, Bundesanstalt für Geowissenschaften und Rohstoffe and Mineral Resources Authority of Mongolia, 2013.

Nagahara, Masato, "Introduction of the Lists of Critical Minerals and Materials Around the World" ["各国および地域連合等の重要鉱物·物質リスト概論"], Japan Organization for Metals and Energy Security, January 14, 2025.

Nam, In-Soo, "South Korea to Levy 38% Anti-Dumping Duties on Chinese Steel Products," *Korea Economic Daily*, February 20, 2025.

Nassar, Nedal T., Jamie Brainard, Andrew Gulley, Ross Manley, Grecia Matos, Graham Lederer, Laurence R. Bird, David Pineault, Elisa Alonso, Joseph Gambogi, and Steven M. Fortier, "Evaluating the Mineral Commodity Supply Risk of the U.S. Manufacturing Sector," *Science Advances*, Vol. 6, No. 8, February 21, 2020.

Nassar, Nedal T., and Steven M. Fortier, *Methodology and Technical Input for the 2021 Review and Revision of the U.S. Critical Minerals List*, U.S. Geological Survey, Open-File Report 2021–1045, 2021.

Nassar, Nedal T., Ensieh Shojaeddini, Elisa Alonso, Brian Jaskula, and Amy Tolcin, *Quantifying Potential Effects of China's Gallium and Germanium Export Restrictions on the U.S. Economy*, U.S. Geological Survey, Open-File Report 2024–1057, 2024.

National Geological Survey, Government of Mongolia, homepage, undated. As of April 30, 2025: https://mris.mn/

NATO—*See* North Atlantic Treaty Organization.

North Atlantic Treaty Organization, "NATO Releases List of 12 Defence-Critical Raw Materials," last updated December 16, 2024.

Office of Strategic Capital, U.S. Department of Defense, homepage, undated. As of April 28, 2025: https://www.cto.mil/osc/

Office of the United States Trade Representative, "USTR Increases Tariffs Under Section 301 on Tungsten Products, Wafers, and Polysilicon, Concluding the Statutory Four-Year Review," December 11, 2024.

Office of the United States Trade Representative, *Adapting Trade Policy for Supply Chain Resilience: Responding to Today's Global Economic Challenges*, January 2025.

Oh Seok-min, "S. Korea Launches 'Early Warning System' on Supply Chains of 4,000 Key Industry Items," Yonhap News Agency, November 26, 2021.

Oh Seok-min, "S. Korea to Enhance Monitoring of Metal Supply Chains over China's Export Curbs," Yonhap News Agency, July 4, 2023.

Olorunnipa, Toluse, and Ellen Nakashima, "Biden Declares 'New Era' of Partnership with South Korea and Japan," *Washington Post*, updated August 18, 2023.

Ooluun, B., "Mongolia to Conduct Geological Mapping and Surveys of Critical Minerals in Cooperation with the British Geological Survey," Mongolian National News Agency, February 17, 2025.

Park, Jinwan, "South Korea's Politics After Impeachment," Council on Foreign Relations, April 15, 2025. As of April 29, 2025: https://www.cfr.org/blog/south-koreas-politics-after-impeachment

Pavel, Claudiu C., and Evangelos Tzimas, *Raw Materials in the European Defence Industry*, European Commission, EUR 27542, 2016.

Pitt, Keith, "Australia, Republic of Korea to Work Closer on Critical Minerals," press release, December 13, 2021.

Polyak, Désirée E., "Molybdenum," in *Mineral Commodity Summaries 2024*, U.S. Geological Survey, January 2024a.

Polyak, Désirée E., "Molybdenum [Advance Release]," in *2019 Minerals Yearbook*, U.S. Geological Survey, March 2024b.

Porter, Michael E., "How Competitive Forces Shape Strategy," *Harvard Business Review*, March–April 1979.

Porter, Michael E. "The Five Competitive Forces That Shape Strategy," *Harvard Business Review*, January 2008.

Public Law 117-58, Infrastructure Investment and Jobs Act, November 15, 2021.

Public Law 117-169, Inflation Reduction Act of 2022, August 16, 2022.

Prime Minister of Australia, "Landmark Indo-Pacific Framework Agreements," press release, November 17, 2023.

Ramdoo, Isabelle, Grégoire Bellois, and Murtiani Hendriwardani, "Appendix A. List of Critical Minerals in Selected Countries," in *What Makes Minerals and Metals "Critical"? A Practical Guide for Governments on Building Resilient Supply Chains*, International Institute for Sustainable Development, 2024.

Rowan, Linda R., *Critical Mineral Resources: National Policy and Critical Minerals List*, Congressional Research Service, R47982, updated February 21, 2025.

Ryu Yeri, "China's Export Control Measures: Accurate Diagnosis and Prescription" ["중국의 수출통제조치: 정확한 진단과 처방"], CSF (China Expert Forum), February 13, 2024. As of May 20, 2025:
https://csf.kiep.go.kr/issueInfoView.es?article_id=53261&mid=a20200000000&board_id=4

Scheyder, Ernest, and Eric Onstad, "Cobalt Miner Jervois in Rescue Deal to Better Compete with China," Reuters, January 2, 2025.

Shedd, Kim B., "Tungsten," in *Mineral Commodity Summaries 2024*, U.S. Geological Survey, January 2024a.

Shedd, Kim B., "Cobalt [Advance Release]," in *2020 Minerals Yearbook*, U.S. Geological Survey, October 2024b.

Shedd, Kim B., "Tungsten [Advance Release]," in *2020 Minerals Yearbook*, U.S. Geological Survey, December 2024c.

Shedd, Kim B., "Tungsten [Advance Release]," in *2021 Minerals Yearbook*, U.S. Geological Survey, June 2025.

Shivakumar, Sujai, Charles Wessner, and Thomas Howell, *Balancing the Ledger: Export Controls on U.S. Chip Technology to China*, Center for Strategic and International Studies, February 2024.

Shurka, Baigalmaa, Tuya Oktyabri, and Amartuul Nyamsuren, *Overview of the Critical Minerals Policy Framework and Governance in Mongolia*, United Nations Development Programme December 27, 2024.

South Korean Ministry of Trade, Industry, and Energy, "Korea and Canada Sign Critical Minerals Supply Chain Cooperation MOUs," press release, September 26, 2022.

Straits Research, "Molybdenum Market Size, Trends and Growth Forecast by 2033," webpage, undated. As of February 4, 2025:
https://straitsresearch.com/report/molybdenum-market

Tasevski, Olivia, "Islands of Ire: The South Korea–Japan Dispute," *The Interpreter*, April 27, 2020.

Teo, Wendy, "The Revival of Tungsten Mining in a South Korean Town May Be a Game Changer," *Straits Times*, October 19, 2024.

Tingstad, Abbie, Fabian Villalobos, Rebecca Tisherman, and Michelle D. Ziegler, *Unlocking Alaska's Critical Minerals Development Potential: Evaluating Opportunities and Barriers—Findings from a Tabletop Exercise*, RAND Corporation, PE-A2970-1, June 2024. As of March 7, 2025: https://www.rand.org/pubs/perspectives/PEA2970-1.html

Tobin, William, "The IRA Two Years On: A Signpost of the New Economic Policy Consensus," Atlantic Council, August 15, 2024.

Trafton, Anne, "Cobalt-Free Batteries Could Power Cars of the Future," MIT News, January 18, 2024.

United Nations Digital Library, "United Nations General Assembly Voting Data: Resolutions 1 (11 December 1946) to 79/278 (25 March 2025) / United Nations Dag Hammarskjöld Library," dataset, March 2025. As of April 7, 2025: https://digitallibrary.un.org/record/4060887

United Nations Statistics Division, UN Comtrade Database, International Merchandise Trade Statistics, undated. As of June 23, 2025: http://comtrade.un.org/

U.S. Department of Defense, "Department of Defense Makes Investment to Strengthen the Tungsten Supply Chain," press release, December 13, 2024.

U.S. Department of Defense, *National Defense Industrial Strategy*, 2023.

U.S. Department of Defense, *National Defense Industrial Strategy Implementation Plan for FY2025*, 2024.

U.S. Department of Energy, "What Are Critical Materials and Critical Minerals?" webpage, undated. As of April 26, 2025: https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals

U.S. Department of Energy, "Wide Bandgap Semiconductors: *Pursuing the Promise*," April 2013.

U.S. Department of State, "The United States and Mongolia Sign MOU to Collaborate on Critical Minerals," June 26, 2023a.

U.S. Department of State, "Signing of the Memorandum of Understanding on the Development of the Lobito Corridor and the Zambia-Lobito Rail Line," press release, October 26, 2023b.

U.S. Department of State, "U.S. Security Cooperation with India," fact sheet, January 20, 2025.

U.S. Geological Survey, *Mineral Commodity Summaries 2025*, version 1.2, March 2025.

"US Unleashes Another Crackdown on China's Chip Industry," Al Jazeera, December 2, 2024.

USGS—*See* U.S. Geological Survey.

Villalobos, Fabian, "Implications of Dual-Use Technologies on Critical Minerals Policy and Strategy," Colorado School of Mines, September 21, 2023.

Villalobos, Fabian, Emily Allendorf, Jo Caulkins, Sophia Charan, Elisa Yoshiara, Richard Silberglitt, and Zohan Hasan Tariq, *From Mines to Markets Critical Mineral Suppliers and Dependencies in the Middle East and Central Asia: Critical Mineral Suppliers and Dependencies in the U.S. Central Command Area of Responsibility*, RAND Corporation, RR-A2914-1, 2024. As of June 17, 2025: https://www.rand.org/pubs/research_reports/RRA2914-1.html

Villalobos, Fabian E., and Morgan Bazilian, "Understanding America's Technological Tit-for-Tat with China," *The Hill*, June 25, 2023.

Villalobos, Fabian, Jonathan L. Brosmer, Richard Silberglitt, Justin M. Lee, and Aimee E. Curtright, *Time for Resilient Critical Material Supply Chain Policies*, RAND Corporation, RR-A2102-1, 2022. As of March 7, 2025:
https://www.rand.org/pubs/research_reports/RRA2102-1.html

Villalobos, Fabian, Elisa Yoshiara, Aimee E. Curtright, Harry Broadman, Tom LaTourrette, and Richard Silberglitt, *Technology-Driven Opportunities and Risks to Sustainable Development of Critical Minerals in Developing Countries: Consolidated Remarks Delivered to a United Nations Expert Group Meeting*, RAND Corporation, PE-A4008-1, May 2025. As of June 17, 2025:
https://www.rand.org/pubs/perspectives/PEA4008-1.html

Visual Capitalist, "China Has More Embassies Than Any Other Country," webpage, June 9, 2024. As of April 29, 2025:
https://www.voronoiapp.com/geopolitics/China-Has-More-Embassies-Than-Any-Other-Country-1492

Vorshilov, Enkhbold, "Mongolia's Foreign Investment Policies and Perspectives," Ministry of Foreign Affairs, Mongolia, briefing slides, undated.

White, Edward, "China Bans Export of Rare Earth Processing Technologies," *Financial Times*, December 21, 2023.

White House, "Fact Sheet: Vice President Harris Launches New Initiatives to Strengthen U.S.-Philippines Alliance," November 20, 2022.

White House, "Fact Sheet: The Trilateral Leaders' Summit at Camp David," August 18, 2023.

White House, "Joint Fact Sheet: The United States and India Continue to Chart an Ambitious Course for the Initiative on Critical and Emerging Technology," June 17, 2024a.

White House, "Fact Sheet: Partnership for Global Infrastructure and Investment in the Lobito Trans-Africa Corridor," December 3, 2024b.

White House, "Fact Sheet: The United States and India Committed to Strengthening Strategic Technology Partnership," January 6, 2025a.

White House, "United States–India Joint Leaders' Statement," February 13, 2025b.

White House, "Fact Sheet: President Donald J. Trump Ensures National Security and Economic Resilience Through Section 232 Actions on Processed Critical Minerals and Derivative Products," April 15, 2025c.

Yeo, Yukyung, "Urea Crisis Sparks South Korean Supply Chain Revamp," East Asia Forum, August 23, 2024.

Yi Whan-woo, "THAAD Retaliation Appears to Be Continuing," *Korea Times*, November 13, 2019.

Young, Asaesja, "Critical Minerals: The Quiet Achievers Gallium and Germanium," Commonwealth Scientific and Industrial Research Organisation, June 20, 2024.

Yu, Sun, and Demetri Sevastopulo, "China Targets Rare Earth Export Curbs to Hobble US Defence Industry," *Financial Times*, February 15, 2021.

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