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Mapping China's strategy for rare earths dominance

Craig A. Hart

The Atlantic Council **Global Energy Center** develops and promotes pragmatic and nonpartisan policy solutions designed to advance global energy security, enhance economic opportunity, and accelerate pathways to net-zero emissions.

Cover: Workers transport soil containing rare earth elements for export at a port in Lianyungang, China. REUTERS

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Executive summary

China dominates the entire value chain of rare earth elements that are foundational to the transformation of the energy future, as well as to advanced technologies including permanent magnets, electric motors, semiconductors, and electronics. These elements comprise a series of fifteen metallic elements in the lanthanum group with atomic numbers fifty-seven to seventy-one, plus two additional Group 3 elements that share similar physical and chemical properties.

China is home to one-third of rare earths reserves, more than half of mining production, 90 percent of separation and refining capacity, and an even greater percentage of magnet production, perhaps rare earths' most important application.[1] As a result, China wields unrivaled influence over the global market for rare earth elements, as well as many critical minerals that commonly accompany their production.

Given that China already holds the world's single largest reserves of rare earths by a large margin, China's aggressive expansion of mining investment in the developing world is significant and revealing of a simultaneously defensive and offensive strategy. China's investment abroad reflects its tradition of long-term, far-sighted strategic commitments to its core goal of controlling its own technology future—and likely the technology futures of its competitors and allies. Because rare earths are increasingly indispensable to advanced technology manufacturing, Beijing has prioritized expanding China's control over global supplies to ensure its dominance decades into the future.

Through its control over global rare earth supplies and its efforts to expand its influence even further, China continues to amass geopolitical and economic leverage in rare earths markets and associated clean energy technologies that are critical for all countries to achieve their decarbonization goals. This situation poses serious energy security and national security risks for the United States that necessitate an understanding of China's vast, whole-of-government approach to rare earths, and a multifaceted and equally farsighted strategy to counterbalance it.

China pursues its goals of technological independence and leadership through a combination of policies articulated in its Made in China 2025 policy and research initiatives such as the 863 Program, both of which aim to reduce China's reliance on foreign technologies by catalyzing indigenous innovations to position Chinese state-owned enterprises (SOE) to compete globally and ensure China's status as a technology superpower. China's achievement of its technology goals depends on securing abundant supplies of the rare earths and other critical minerals essential to advanced technologies. China developed its rare earths resources through decades of planning and policy support, extended its sourcing of rare earths and critical minerals, and opened markets for its finished products throughout the developed world through its Belt and Road Initiative.

China's whole-of-government strategy encompasses the Communist Party, state apparatus, military complex, industry, and research institutions, mobilizing a broad range of policies including industry policy, price controls, tax policy, environmental law, standards setting, foreign policy, defense policy, and research and development (R&D). China's goals are to ensure its own rare earths demand is satisfied now and into the future, to nurture the expansion and protect the profitability of its domestic rare earths and rare earths-dependent industries, and to provide China with enduring technological superiority across a range of advanced manufacturing technologies that ensure its economic and military competitiveness throughout this century.

The effectiveness of China's rare earths strategy is confirmed by its emergence as a recognized leader in both rare earths and the advanced technologies that depend on rare earths, as well as its growing share of global markets in these sectors. One independent study assessed that China now leads all other nations in thirty-seven of forty-four advanced technologies, almost all of which depend on rare earths.[2]

In the immediate term, China's international rare earths policies and investments aim to protect its market share and dominant position as the world's primary supplier of rare earths. China's mining investments on five continents resemble the Chinese game of Go, in which the objective is to occupy territory and surround the adversary, denying them a viable position. Facilitated by China's Belt and Road Initiative—its foreign policy and global infrastructure development strategy that aims to expand China's influence over trade, connectivity, and investment across Asia, Africa, Europe, Latin America, and beyond—China's acquisition of existing mines and development of new ones expand its influence in regional and global minerals markets, and also deepen its influence with participating Belt and Road countries, likely to the exclusion of competitors.

Over a longer horizon, in light of advanced manufacturing's increasing demand for rare earths, China's leadership is likely

1. Braeton Smith, et al., "Rare Earth Permanent Magnets: Supply Chain Deep Dive Assessment," US Department of Energy, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

2. Jamie Gaida, et al., "ASPI's Critical Technology Tracker: The Global Race for Future Power," Australian Strategic Policy Institute, 2023, https://www.aspi.org.au/report/critical-technology-tracker.

preparing for the day its growing consumption of rare earths makes it a net importer. As China's paramount leader, Deng Xiaoping, compared rare earths to oil, China is preparing itself for what many oil-producing countries experienced when their domestic consumption outpaced their own production as they developed.

Enabled by the Belt and Road Initiative, a secure and stable supply of rare earths under China's control guarantees that China's industry and its defense establishment have priority access to the limited supply of rare earths and other critical minerals. China controls supply through investment partnerships where available, and through long-term supply contracts with friendly developing countries that depend on China's support through the Belt and Road Initiative.

Ultimately, China's control over rare earths supplies and pricing enable its transition from low-value extraction and processing to high-value advanced manufacturing. China's leading firms controlling rare earths extraction and processing confer great influence over the terms of trade, enabling greater ability to influence pricing and advantaging China's domestic manufacturing industries by supplying it with rare earths at lower cost than its international competitors. China favors rare earth production and its downstream industry through a combination of export restrictions and tax policy.[3] In turn, these advantages enable China to expand its market share downstream with higher-value finished products like permanent magnets, electric vehicles, and wind turbines.

Finally, in the event of hostilities with other countries, China's investments in rare earths provide it with greater ability to wage economic warfare, damaging the economies of adversaries and, over longer time horizons, potentially disabling industries vital to national defense that rely on rare earths. China demonstrated its ability to use rare earths supply as a weapon in 2010, when it halted exports to Japan for two months following the collision of a Japanese fishing trawler with a Chinese coast guard vessel, and again in 2019 when it threatened to leverage rare earths by restricting their export in its trade dispute with the United States. China further escalated in 2023 when it imposed export bans on processing equipment and certain minerals, and again in 2024 and 2025 when it increased restrictions on the export of critical minerals vital to defense, chip manufacturing, and other industries.

"Mapping China's Strategy for Rare Earth Dominance" expands upon the research presented in the author's *Mapping China's Energy, Environmental, and Industrial Policies*, now in its fifth edition.[4]

This report is organized in five chapters. The first chapter explains rare earth elements and certain other critical elements, their characteristics, and their applications in advanced technologies. The second chapter describes China's dominance in rare earths and presents China's government and industry stakeholders, which collectively comprise China's rare earths sector. The third chapter analyzes China's rare earths objectives, policies, and investments that have made China the leading producer of rare earths and aim to ensure its continued dominance in this sector. This chapter covers China's long-term rare earth planning in detail, the provision of subsidies, industrial policy, how China plans to use internationalization of its domestic rare earths standards to advance its goals, the challenges of illegal mining, and environmental and human rights violations. The fourth chapter suggests priorities to inform a coordinated international response to China's dominance in the rare earth domain. The final chapter summarizes the main findings.

The report recommends that the United States, Europe, Japan, Australia, and others develop their own coordinated long-term strategies, learning from China's successes and outperforming China in areas such as environmental stewardship. The following priorities are proposed in response to China's domination of the rare earths field.

- Match and exceed China's investment in R&D in rare earths and substitutes.
- Invest patient capital in rare earths.
- Establish a system of rare earths reserves.
- Use government procurement to ensure domestic demand supports domestic suppliers.
- Support China in fighting illegal minerals trade if its global industry complies with law.
- Step up allied collaborative research to develop technologies across the value chain.
- Streamline approvals for appropriately sited and designed rare earth operations.
- Invest in foreign alliances to develop rare earth extraction and processing.
- Adopt international standards to protect the environment, workers, and fair competition.

3. Dudley Kingsnorth, "Meeting the Challenges of Supply this Decade," Industrial Minerals Company of Australia, March 2011, https://www.eesi.org/files/kingsnorth_031111.pdf.

4. Craig Hart, *Mapping China's Energy, Environmental and Industrial Policies*, Fifth edition, Government of the United Kingdom, February 2025.

A worker at the Jinyuan Company's smelting workshop in China's Inner Mongolia Autonomous Region stokes the pots containing the rare earth metal lanthanum. REUTERS/David Gray.

1. Rare earths and critical elements for advanced technologies

Rare earth elements are critical to the transformation of the energy future and are essential to enabling many advanced technologies due to their physical-chemical characteristics.

Rare earth elements, referring to the lanthanum group of elements, are a series of fifteen metallic elements with atomic numbers 57 to 71, located in the f-block of the periodic table. This group includes elements such as lanthanum, cerium, and neodymium, among others. These elements share a unique electronic configuration, with their 4f electron shell progressively filling as one moves across the series in the periodic table. The electrons in this 4f subshell, located deep within the atom, are shielded by the outer 5d and 6s electron shells, making them less accessible for bonding. However, the 4f electrons contribute significantly to the elements' magnetic and optical properties. When these electrons are manipulated—whether through heat, light, or electric current—the resulting changes in the elements' electronic configuration enable them to be employed in calibrating and controlling advanced technologies that depend on electronic and magnetic interactions, making them crucial for a wide range of advanced technologies.

In combination with transition metals, lanthanide elements can facilitate strong magnetic fields without the requirement of a power source, making them essential components in the development of powerful permanent magnets. These magnets are critical to various applications, including electric vehicle motors and wind turbines. Further, lanthanides' unique electronic properties are crucial in the production of phosphors, which emit light when exposed to radiation, making them indispensable in light-emitting diodes (LEDs) and other energy-efficient lighting systems. Lanthanides also play a key role as catalysts in industrial processes and are integral to control and guidance systems in aerospace and defense industries, as well as in semiconductor devices and other electronics.

Figure 1: Periodic table

Source: National Energy Technology Laboratory.

Rare earths are found in about two hundred minerals.[5] Although found widely throughout the Earth's crust, rare earth elements are referred to as "rare" because they exist in low concentrations relative to other elements, making their extraction and separation challenging and costly.

Based on their atomic numbers and corresponding characteristics, the rare earth elements can be further divided into two main groups—seven light rare earth elements and eight heavy rare earth elements. The heavy rare earth elements have higher atomic numbers spanning from gadolinium (64) to lutetium (71). While all rare earth elements are considered relatively scarce compared to more common elements, the heavy rare earth elements are found in even lower concentrations in the Earth's crust compared to their lighter counterparts, making their extraction and separation more physically and economically challenging.

The following are the rare earth elements and their representative applications.

- **Lanthanum (La)—atomic number 57**—used in nickel-metal hydride (NiMH) batteries and as a catalyst in petroleum refining.
- **Cerium (Ce)—atomic number 58**—used in catalytic converters in automotive exhaust systems and as a polishing agent for glass.
- **Praseodymium (Pr)—atomic number 59**—used in high-strength magnets for electric motors and other applications and rare earth alloys for military applications.
- **Neodymium (Nd)—atomic number 60**—used in strong permanent magnets used in wind turbines, electric vehicles, and various military technologies.
- **Promethium (Pm)—atomic number 61**—being radioactive, it has limited uses, primarily in nuclear batteries for military applications.
- **Samarium (Sm)—atomic number 62**—used in permanent magnets, control rods in nuclear reactors, and certain military applications.
- **Europium (Eu)—atomic number 63**—used in red phosphors in liquid crystal display (LCD) and light-emitting diode (LED) displays, and in certain military technologies.
- **Gadolinium (Gd)—atomic number 64**—used as a contrast agent in magnetic resonance imaging (MRI), and in some military applications.
- **Terbium (Tb)—atomic number 65**—used in green phosphors in LCD and LED displays, magnetic actuator materials, and in military technologies like night-vision devices.

5. Artem Golev, et al., "Rare Earths Supply Chains: Current Status, Constraints and Opportunities," *Resources Policy* 41 (2014) 52–59, https://www.sciencedirect.com/science/article/abs/pii/S0301420714000282.

- **Dysprosium (Dy)—atomic number 66**—used in high-strength magnets and certain military technologies.
- **Holmium (Ho)—atomic number 67**—used in lasers for medical and military use, and in certain nuclear control applications.
- **Erbium (Er)—atomic number 68**—used in fiber-optic communications and in military applications involving lasers and sensors.
- **Thulium (Tm)—atomic number 69**—used in medical imaging and potentially in military technologies.
- **Ytterbium (Yb)—atomic number 70**—used in solid-state lasers and military communication devices.
- **Lutetium (Lu)—atomic number 71**—used in positron emission tomography (PET) imaging and in certain military applications.[6]

In addition to the rare earth lanthanides, certain other elements are considered critical due to their characteristics and their scarcity relative to demand. Yttrium (Y) and scandium (Sc) are transitional metals that lie just above the lanthanide series in Group 3 of the periodic table and have electron structures and chemical behaviors similar to those of lanthanides. They also typically occur together with rare earth elements in mineral deposits. Like the rare earths, yttrium and scandium are also used in various advanced technology applications due to their similar behavior in chemical reactions.

- **Scandium (Sc)—atomic number 21**—used in the manufacture of semiconductors and lasers.[7]
- **Yttrium (Y)—atomic number 39**—used as a component in the production of phosphors for LCD and LED displays and LED lights, and utilized in the manufacturing of superconductors, certain types of lasers, and other advanced technologies.[8]

This report will focus on rare earth elements and, to a lesser extent, on certain critical elements like lithium, because of their application in combination with rare earths as well as their co-production.

With the accelerating transition toward clean energy technologies, global trade in rare earths and critical minerals has continued to grow rapidly.[9] Since 2010, the average amount of minerals required per unit of new power-generation capacity has increased by 50 percent as renewables displace conventional energy.[10]

Estimates vary widely and the market is difficult to assess due to gray- and black-market trade, but—to illustrate rough magnitude—in 2023, global trade in rare earths was estimated to be worth as much as $7.5 billion, and trade in critical minerals was estimated at $378 billion.[11]

Global trade for leading industries that depend in some part on rare earth minerals—electronics, metals and minerals, transportation, petrochemicals, machinery, medical and scientific devices—exceeded $13 trillion in 2022.[12]

The value of industries dependent on rare earth and critical minerals is far greater than the value of the elements and minerals themselves. For example, global sales of electric vehicles, each of which contains, on average, a kilogram or more of rare earths, reached $425 billion in 2022.[13] Also, the market capitalization of the three dozen largest publicly traded manufacturers with revenues derived mostly from electric vehicles is roughly $750 billion, a figure that fluctuates with the market and has been far higher at times.[14]

6. Brandon Tracy, "An Overview of Rare Earth Elements and Related Issues for Congress," Congressional Research Service, November 24, 2020, https://crsreports.congress.gov/product/pdf/R/R46618.
7. Daniel Cordier, "Mineral Commodity Summaries—Scandium," US Geological Survey, 2023, https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-rare-earths.pdf.
8. Tracy, "An Overview of Rare Earth Elements and Related Issues for Congress."
9. Estimates for the value of the global rare earths and critical-minerals markets vary widely. For World Trade Organization data, see: Mona Snoussi-Mimouni and Sandra Avérous, "High Demand for Energy-Related Critical Minerals Creates Supply Chain Pressures," World Trade Organization, January 10, 2024, https://www.wto.org/english/blogs_e/data_blog_e/blog_dta_10jan24_e.htm.
10. "About WITS," World Integrated Trade Solution, last visited February 17, 2024, https://wits.worldbank.org/about_wits.html.
11. "Rare Earth Element Market: Global industry Forecast (2024–2030)," Maximize Market Research, April 2024, https://www.maximizemarketresearch.com/market-report/rare-earth-elements-market/99093/; International Trade Council, 2025.
12. "What Are the Main Traded Sectors and Who Are the Main Trade Partners of an Economy?" McKinsey Global Institute, last visited February 24, 2024, https://www.mckinsey.com/mgi/our-research/global-trade-explorer-what-are-the-main-traded-sectors-of-an-economy.
13. "Global EV Outlook 2023," International Energy Agency, April 27, 2023, https://www.iea.org/reports/global-ev-outlook-2023.
14. "Largest Electric Vehicle Companies by Market Cap," Marketcap, last visited February 17, 2024, https://companiesmarketcap.com/electric-vehicles/largest-ev-companies-by-market-cap/; Al Root, "The EV Bubble Has Popped. There's No Denying the Numbers," *Barron's*, December 7, 2023, https://www.barrons.com/articles/electric-vehicles-stock-tesla-ford-gm-rivian-bubble-73c949c6.

The total market capitalization of all industries dependent on rare earths and critical minerals is more than $82 trillion.

Technology	$34 trillion
Communications	$18.4 trillion
Materials	$11 trillion
Energy	$10.6 trillion
Machinery	$4.7 trillion
Aerospace and Defense	$2.5 trillion
Transportation	$1.2 trillion[15]

The global economy will increasingly depend on these critical minerals. The International Energy Agency (IEA) anticipates that demand for rare earth elements will grow from three to seven times by 2040 in pursuit of net-zero goals, with demand for the critical element lithium expected to grow by more than forty times, with graphite, cobalt, and nickel growing by twenty to twenty-five times.[16]

15. Bloomberg L.P., accessed March 4, 2025.

16. "The Role of Critical Minerals in Clean Energy Transitions," International Energy Agency, May 2021, https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

Miners are seen at the Bayan Obo mine containing rare earth minerals in Inner Mongolia. REUTERS.

2. China's domination of global rare earths

Rare earth elements are found on all continents and are mined in dozens of countries.[17]

China is the single largest holder of proven economic reserves, accounting for 36.7 percent of global reserves. Vietnam (18.3 percent), Brazil (17.5 percent), Russia (17.5 percent), and India (5.8 percent) also control significant reserves, together accounting for roughly 59 percent of global reserves.[18]

Together, the top five countries—China, Vietnam, Brazil, Russia, and India—control more than 88 percent of global reserves. Such concentrated control presents a chokepoint for the supply of rare earth elements that poses a threat to technology development by the United States, European Union, Japan, and all other Organisation for Economic Co-operation and Development (OECD) countries.

Beyond reserves, China holds a dominant position across the entire supply chain—mining, separation, refining, and production of finished products. At each step in the value chain, China controls an even larger portion of the global trade. For example, for NdFeB permanent magnets (composed of neodymium, iron, and boron)—which are used in motors for electric and hybrid electric vehicles, wind turbines, and a wide range of electronics applications—China is home to 58 percent of mine production, 89 percent of separation capacity, 90 percent of refining capacity, and 92 percent of magnet production.[19]

17. Zhanheng Chen, "Global Rare Earth Resources and Scenarios of Future Rare Earth Industry," *Journal of Rare Earths* 29, 1 (2011), 1–6, https://www.sciencedirect.com/science/article/abs/pii/S1002072110604012.

18. Desiree Polyak, "Mineral Commodity Summaries—Rare Earths," US Geological Survey, 2023, https://pubs.usgs.gov/periodicals/mcs2023/mcs2023_prior-to-print-revisions.pdf.

19. Smith, et al., "Rare Earth Permanent Magnets: Supply Chain Deep Dive Assessment."

Figure 2: Top countries receiving mining investments from China (by number of investments; dollar amounts are difficult to confirm)

Country	Number of investments
Russia	34
Peru	31
Indonesia	25
Kazakhstan	25
Tajikistan	22
Democratic Republic of the Congo	15
Brazil	14
Chile	10
Laos	10
South Africa	9

Source: Author's analysis based on the AidData Global Chinese Development Finance Dataset 3.0.

Critically, China has developed its own technologies for processing, measurement, and other aspects that have been supported by state investment in technology innovation, and a patent system that protects indigenous innovation.[20] Separating and refining each of the rare earth elements requires unique processes, an area in which China has the greatest experience and human capital, and has developed the leading technologies.[21] In late 2023, following the imposition of export restrictions on advanced semiconductor manufacturing technologies by the United States, Japan, and the Netherlands, China restricted the export of rare earth extraction and separation technologies, defending its dominance over rare earths production.[22] Restricting export of extraction and processing technologies over which China controls the intellectual property advantages China's own advanced technology industries as well as its national defense, which depends on them.

Beyond its own production, China is rapidly expanding its investment in rare earth mines as well as other critical mineral mines outside its own borders. Through the Belt and Road Initiative—China's foreign policy and global infrastructure development strategy that aims to expand China's influence over trade, connectivity, and investment across Asia and the rest of the developing and developed world—China has invested extensively in mining and processing facilities in Central and Southeast Asia, Africa, and Latin America. Based on official development finance data, from 2000 to 2021, China entered into 284 unique financing transactions or grants in the mining sector in 55 developing countries along the Belt and Road, valued at $90 billion in investments in mining and processing and $198 billion in total investment counting related infrastructure (in 2022 constant dollars).[23] On a regional basis, China invested in Asia most frequently with 36 percent of the financing transactions, followed by Africa (26 percent), the Americas (24 percent), Eastern Europe (13 percent), the Middle East (2 percent), and the Pacific (1 percent).[24]

These projects include geological surveys in twelve countries, mainly in Africa, twenty-seven transactions supporting processing projects, and the rest being extraction investments. While few projects disclosed their objective as rare earths specifically, the majority mine one or more of the critical elements designated by the US Geological Survey.[25] Of the mining investments that disclose their production, an even greater proportion of investments involve either rare earths, critical minerals, or metals commonly found as co-products or companions

20. Zhihui Leng, et al., "China's Rare Earth Industry Technological Innovation Structure and Driving Factors: A Social Network Analysis Based on Patents," *Resources Policy* 73, 6 (2021), https://www.sciencedirect.com/science/article/abs/pii/S0301420721002440.

21. "Can Anyone Challenge China's Near Monopoly on Metals Powering Our Tech?—Part 1/3: Power Scramble, Interview with Marina Yue Zhang," CNA Insider, YouTube video, November 3, 2023, https://www.youtube.com/watch?v=D-WLRoXJi78.

22. Edward White, "China Bans Export of Rare Earth Processing Technologies," *Financial Times*, December 21, 2023, https://www.ft.com/content/5b031db7-23dd-43d3-afe1-cef14817296f.

23. Author's analysis based on the AidData Global Chinese Development Finance Dataset 3.0.

24. Ibid.

25. Ibid; see also: "2022 Final List of Critical Minerals," *Federal Register* 87, 37 (February 2022), https://www.federalregister.gov/documents/2022/02/24/2022-04027/2022-final-list-of-critical-minerals.

to rare earth minerals. It is therefore possible that these Belt and Road and other foreign-assistance investments in the mining sector have the potential to produce rare earth elements or critical minerals, now or in the future.[26]

Importantly, available data only capture loans and grants from China's state-controlled institutions to developing countries, even though China is believed to be making substantial foreign investments through state-owned enterprises and proxy companies that are not captured in official datasets. As a result, China's actual level of investment in the global mining sector might be significantly greater than officially reported.

In addition to these projects, China is also investing heavily in other infrastructure sectors of Belt and Road partner countries, including power generation and grid expansion, oil and gas, telecommunications, transportation, construction, manufacturing, and agriculture. These investments strengthen China's influence across all aspects of Belt and Road countries' development. Investments in road, rail, shipping, and ports also strengthen China's reach for global rare earths, as Belt and Road investments in transportation that connect otherwise isolated mines to China's processing plants make these projects operationally and economically feasible.

2.1. Key stakeholders in China's rare earths sector

China's domination of the global rare earth sector is the result of decades of coordinated planning, investment, and policy by the Chinese Community Party, the national government, the People's Liberation Army, and state-owned enterprises at the national and provincial levels.

Rare earth mineral production has enjoyed the support of China's party-state since at least the 1990s. In 1992, China's leader Deng Xiaoping compared China's rare earth resources to the Middle East's oil in terms of importance. In 1999, Deng's successor, Jiang Zemin, reportedly directed the state to "improve the development and applications of rare earths, and change the resource advantage into economic superiority."[27]

During the 1990s, China surpassed the United States as the world's largest producer of rare earths, driven by subsidies to state-controlled industry, low labor costs, and weak and unenforced environmental laws.[28]

To understand China's coordinated approach to advancing its rare earths and critical minerals industry, this chapter presents the various stakeholders that have mobilized to support the development and growth of the rare earths sector, through various tools of China's industrial policy framework, pricing policy and market structure, and research and development.

These tools encompass

- industry structure;
- production targets;
- pricing policy;
- tax policy;
- subsidies;
- trade policy;
- foreign policy and investment, such as through the Belt and Road Initiative;
- environmental law and policy;
- standards development;
- national defense and security policy;
- R&D investment; and
- intellectual-property protection.

These mechanisms are implemented by China's party-state, encompassing the political, administrative, military, industrial, and academic realms. The figure below presents the institutions primarily responsible for advancing China's rare earths policies.

2.1.1. Policy framework

China's policies coordinate rare earth exploration, production, infrastructure development, trade, and environmental standards. The state's policy goals aim to develop new resources, avoid over-exploitation, accelerate innovation, and develop indigenous technologies. China mobilizes its party-state to support its dominance in rare earths by mobilizing government ministries, state-owned industry, its party-military complex, academic and state research institutions, and combinations of these agents acting through industry associations to develop and implement policies.

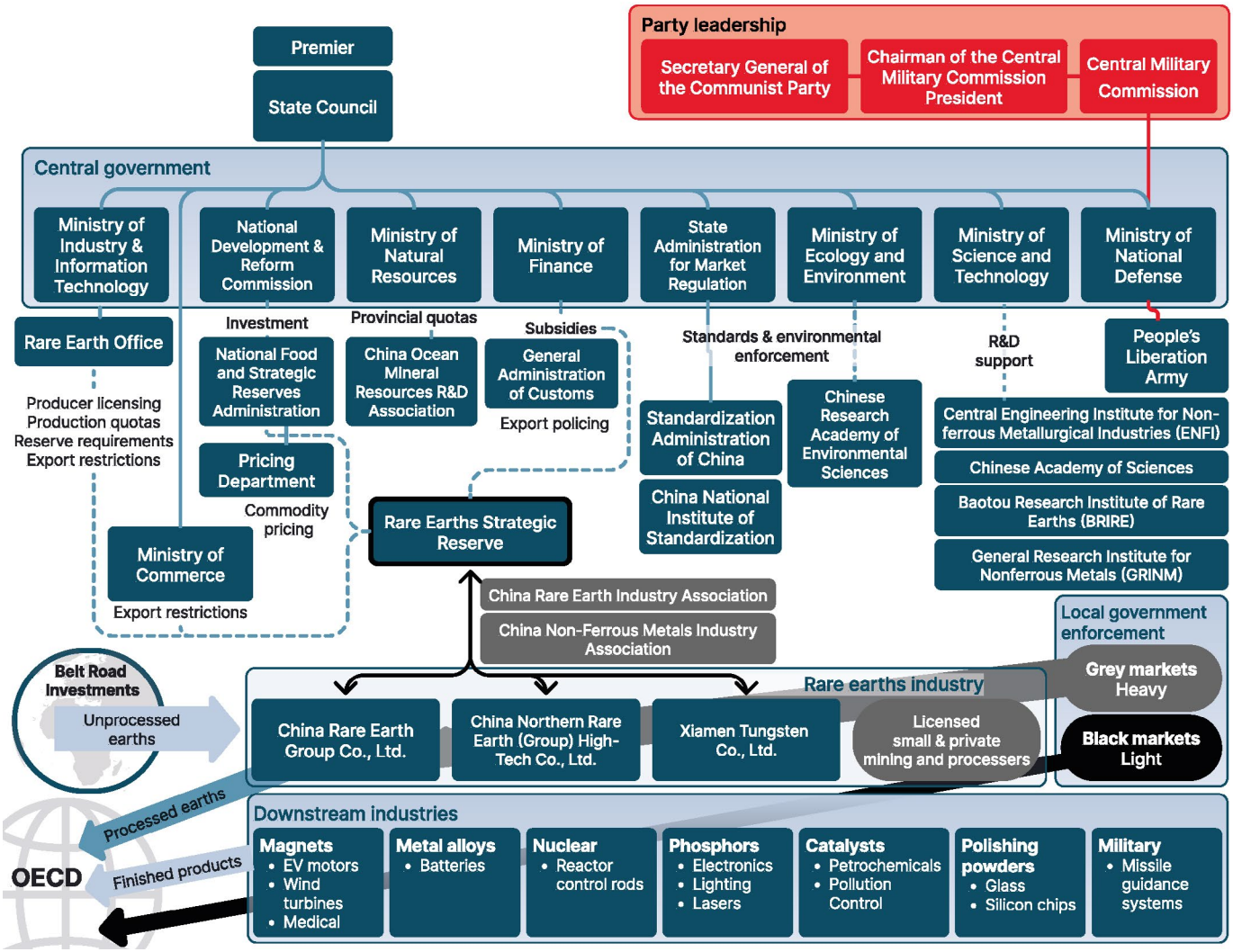
The following stakeholders are involved in setting China's course for rare earth production goals along with the infrastructure investment, fiscal and taxation policies, regulations, and standards to achieve these goals.

26. Author's analysis based on Nedal T. Nassar, Thomas E. Graedel, and Elizabeth M. Harper, "By-product Metals Are Technologically Essential but Have Problematic Supply," *Science Advances* 1, 3 (2015), https://www.science.org/doi/10.1126/sciadv.1400180; "AidData's Geospatial Global Chinese Development Finance Dataset 3.0," AidData, June 11, 2024, https://www.aiddata.org/publications/aiddatas-geospatial-global-chinese-development-finance-dataset#:~:text=AidData's%20Global%20Chinese%20Development%20Finance,lenders%20from%202000%20to%202021.

27. Cindy Hurst, "China Rare Earth Elements Industry: What Can the West Learn?" Institute for the Analysis of Global Security, 2010, http://www.iags.org/rareearth0310hurst.pdf.

28. Ibid.; Tracy, "An Overview of Rare Earth Elements and Related Issues for Congress."

Figure 3: China's rare earths stakeholders



Source: Hart, *Mapping China's Energy, Environmental and Industrial Policies.*

- The **National Development and Reform Commission** (NDRC) (国家发展和改革委员会), a super ministry positioned a half rank above all other ministries, was established to study and formulate China's economic and social development, directly advise the State Council, manage the five-year planning process, and plan and implement China's continuing reform and opening policies.

  The NDRC plans rare earth investment to ensure supply and sets total export volume. The NDRC and its local Development Reform Commissions plan and approve all of China's energy and industrial infrastructure investment projects, including mining infrastructure.

- Under the **Ministry of Industry and Information Technology** (MIIT) (工业和信息化部), the **Raw Material Industry Division** oversees the **Rare Earth Office**, which formulates rare earths' industry planning, policy support, and standards.
- The **Ministry of Natural Resources** (自然资源部), with other ministries, sets rare earth policy, including devolving annual production limits (quotas) for rare earth elements to control output and prevent over-exploitation at the provincial level, participating in development of environmental regulations, and administering export quotas for rare earth elements.[29] The Ministry of Finance (财政部) leads the formulation and implementation of fiscal and taxation policies, inclu-

29. "Several Opinions of the State Council on Promoting the Sustained and Healthy Development of the Rare Earth Industry," China IP News, July 17, 2017, https://english.cnipa.gov.cn/transfer/specialtopic/chinapmanual/917531.htm.

ding value-added tax policy favoring domestic industry in the rare earths sector.

- The **Ministry of Ecology and Environment** (生态环境部), through its role-setting and enforcing environmental regulations, plays an important role in supporting national government efforts to identify and prosecute illegal rare earth mining.

Two administrative offices oversee activities to combat smuggling, regulate markets, and enforce quality control regulations, including for rare earth exports.

- The **General Administration of Customs** (海关总署) is responsible for collection of value-added tax, excise taxes, and customs duties, and for countering smuggling. It works with the **General Administration of Quality Supervision, Inspection, and Quarantine** to enforce export restrictions and combat evasion in the rare earths sector.
- The **State Administration for Market Regulation** (SAMR) (国家市场监督管理总局) monitors and regulates China's markets to promote fair competition; the Standardization Administration of China (SAC) formulates national standards and promotes their implementation, including for rare earths.

These bodies support the exploration and expansion of rare earth production beyond China's national jurisdiction and in international waters.

- The **China International Development Cooperation Agency** (国家国际发展合作署) facilitates relationships and financing for foreign aid efforts, including global mineral extraction and processing projects via the Belt and Road Initiative.
- The **China Ocean Mineral Resources Research and Development Association** (COMRA) (中国大洋协会), under the Ministry of Natural Resources, manages the exploration of the seabed, ocean floor, and subsoil beyond the limits of China's national jurisdiction. COMRA is promoting a deep-seabed rare earths mining project in the Pacific Ocean.[30]

China's military has no publicly acknowledged role in rare earths policymaking, but its responsibility for national security provides it an influential role in ensuring priority over a reliable supply of high-quality rare earths.

- **China's Central Military Commission** (中国共产党中央军事委员会), the party organ at the apex of China's national defense establishment, is chaired by China's president, who also serves as general secretary of the Chinese Communist Party (CCP), combining the roles of party, state, and military in one paramount leader.
- The **Ministry of National Defense** (国防部) is a civilian-run body primarily responsible for defense policy communication and military diplomacy, rather than direct oversight of military logistics or supply chains.
- The **People's Liberation Army** (PLA), under the direction of the Central Military Commission (中央军事委员会), manages military logistics and procurement, including securing rare earths and other critical minerals for defense and aerospace applications.
- Formally, the relationship between the Ministry of National Defense and the PLA is one of civilian control over the military. However, the supremacy of the party's Central Military Commission in directing the PLA requires that the Ministry of National Defense provides the PLA with administrative and logistical support, which extends to security of the supply of rare earths and other critical minerals for military and aerospace applications, dictating that the military be an important stakeholder in rare earths policy decisions.

Party-affiliated trade associations support the central government in coordinating industry, research, and other stakeholders in policy formation and standard setting.

- The **China Non-Ferrous Metals Industry Association** (中国有色金属工业协会) facilitates cooperation within China's rare earths industry under party supervision. The association provides industry market analysis and advocates for industry on policies, such as environmental regulations and resource-management strategies.
- The **China Rare Earth Industry Association** (中国稀土行业协会), established in 2012, is a national organization with members from rare earth mining, separation, and application companies and public institutions. The association assists government in formulating policies, development plans, and national and industry standards for the rare earth industry, as well as in conducting evaluations of enterprises, product quality, and environment and safety compliance in the review of business licenses.

2.1.2. Pricing policy and market structure

A combination of various levers can influence the pricing of rare earth minerals mined in China for both domestic and export markets. These include industry structure (discussed further in Section 2.2), production and export quotas, the management of strategic reserves, and direct price setting. Multiple stakeholders are involved in managing these levers to meet policy objectives.

30. Marc Schmid, "Mitigating Supply Risks through Involvement in Rare Earth Projects: Japan's Strategies and What the US Can Learn," *Resources Policy* 63 (2019), https://www.sciencedirect.com/science/article/abs/pii/S0301420719301667.

- The **NDRC's Pricing Department** sets prices for commodities and other economically important inputs, such as coal, oil, and steel, as well as rare earth elements produced by state-owned enterprises, prices for items purchased by the government including the military, and prices and subsidies for commodities controlled for price-stabilization purposes. The regulations governing pricing decisions are not published.
- The **MIIT's Rare Earth Office** coordinates policy with other ministries and issues regulations and policies for the rare earth industry, including producer licensing, production quotas, export restrictions, and reserve requirements.[31]
- The **Ministry of Commerce** (商务部) plays a leading role in establishing and implementing China's rare earths export quotas and restrictions, as well as export prohibitions on rare earth processing equipment.[32]
- The **NDRC's National Food and Strategic Reserves Administration** manages the strategic reserve of rare earths, with support from the **Ministry of Industry and Information Technologies**, the **Ministry of Finance**, and the **Ministry of Natural Resources**.[33]
- Importantly, the **NDRC**, **MIIT**, and **Ministry of Commerce** coordinate China's general competition and antitrust policies, determining industry structure as part of these duties. As described further in Section 2.2, these ministries maintain an oligopolistic industry structure within the rare earths sector, aimed at ensuring favorable pricing for the large state enterprise rare earth conglomerates.

2.1.3. Research and development

Research on rare earth minerals is a critical component in maximizing their utility in clean energy innovation and the economic competitiveness of applied technologies. Researchers in China are global leaders on this front. According to the Chinese Academy of Sciences, Chinese State Key Laboratories and university academics produced the greatest volume of Science Citation Index (SCI) scientific research papers on rare earth materials worldwide from 2000 to 2016, with the Chinese Academy of Sciences producing the greatest number at 2,018 publications during that period.[34] The central government, together with academic and industry research institutions, leads China's rare earths R&D efforts.

- The **Ministry of Science and Technology** (中国科学技术部) supported rare earth research through the High Technology Research and Development Program (863 Program) and the National Basic Research Program of China (973 Program), both of which have been merged into the National Key R&D Program.
- The **National Natural Science Foundation of China** (国家自然科学基金委), a government-funded organization under China's State Council, supports basic research across scientific disciplines and funded the greatest number of published research articles on rare earths during the period from 2000 to 2016.[35]
- The **Chinese Academy of Sciences** (CAS) (中国科学院), China's foremost scientific research institution, houses the **Institute of Rare Earths**, which studies rare earth materials, extraction processes, and their applications in various industries, including electronics, renewable energy, and environmental protection.
- Several other research institutions associated with government, academia, and industry focus on rare earths research and advise policymakers. These include: the **Chinese Research Academy of Environmental Sciences** (中国环境科学研究院), affiliated with the Ministry of Ecology and Environment; the **Central Engineering Institute for Non-ferrous Metallurgical Industries** (ENFI) (中国有色工程设计研究总院), a subsidiary of the Metallurgical Corporation of China (中国冶金科工股份有限公司), one of China's largest publicly traded global engineering companies; the **General Research Institute for Nonferrous Metals** (GRINM) (有研科技集团有限公司); and the **Baotou Research Institute of Rare Earths** (BRIRE) (包头稀土研究院), a subsidiary of the state-owned Baogang Group, China's second-largest steel company and the largest in Inner Mongolia.

31. "Several Opinions of the State Council on Promoting the Sustained and Healthy Development of the Rare Earth Industry."
32. Ibid.
33. Ibid.
34. Ying Lu, et al., "Study on Development Situation of Rare Earth Materials Research and Suggestions in China," *World Sci-Tech R&D* 41, 1 (2019) 63–76.
35. Ibid.

2.2. Rare earths industry

China's rare earth industry's legal production accounted for approximately 70 percent of global supply in 2023, the majority of which was produced by China's large state-owned enterprises (SOEs).[36]

China's rare earth resources are concentrated in Inner Mongolia (Baotou), accounting for 58 percent of national production, followed by Sichuan (Liangshan) producing 23 percent of China's output, and Jiangxi (Ganzhou) producing 7 percent of China's rare earths, with Fujian and Shandong each accounting for 3 percent of national production. Light rare earths are primarily found in northern China, and medium and heavy rare earths in China's southern provinces.[37] Each region is dominated by a different group, essentially organized as regional oligopolies.[38]

2.2.1. Big three conglomerates and supporting enterprises

China's rare earth industry is dominated by large, central SOEs, local SOEs, and private enterprises.

The most important producers are China's central rare earth industry SOEs. China's central government has shaped the industry in two waves of consolidation. The first wave completed during the 2010s resulted in six large centrally owned and provincially owned state enterprises. In late 2021, China further consolidated the industry by combining China Minmetals Rare Earth Co., Ltd., Chinalco Rare Earth and Metals Co., Ltd., and China Southern Rare Earth Group Co. Ltd., together with two smaller companies—Ganzhou Zhonglan Rare Earth New Material Technology and Jiangxi Ganzhou Rare Metal Exchange—creating the China Rare Earth Group.[39]

Following consolidation, these are China's largest rare earth conglomerates.

China Northern Rare Earth (Group) High-tech Co., Ltd. [中国北方稀土(集团)高科技股份有限公司]

Founded in 1961 and consolidated in 2015 as a centrally owned enterprise, China Northern Rare Earth today has nearly fifty branch companies and more than nine thousand employees. Headquartered in Baotou, Inner Mongolia, it is the world's largest and highest-value enterprise in the rare earth industry that integrates extraction, separation, refining, production of intermediate products including rare earth salts, oxides, and metals, and produces permanent magnets, permanent magnet motors, and nickel-hydride batteries. It is listed on the Shanghai Stock Exchange and accounts for approximately 70 percent of China's mining and extraction quota.[40]

China Rare Earth Group Co., Ltd. (中国稀土集团有限公司)

Established in late 2021 as a centrally owned enterprise by combining China Aluminum Corporation, China Minmetals Corporation, Ganzhou Rare Earth Group Co., Ltd., and two other rare earth technology R&D enterprises with the stated intention of creating a heavy rare earths super company with enhanced pricing power.[41] China Rare Earth Group is the second-largest rare earths producer globally, controlling an estimated 28 percent of China's mining and extraction quota, and 60 to 70 percent of its high-value heavy rare earth production.[42] Its operations are located in southern China, including the provinces of Jiangxi, Guangxi, and Anhui. In 2024, Guangdong Rare Earths Industry Group Co., Ltd. (广东省稀土产业集团有限公), a Guangdong province-owned enterprise and one of the original six rare earth companies consolidated in 2015, was transferred to China Rare Earth Group for no consideration, further strengthening the parent.[43] It holds 1 percent of China's mining and extraction quota.[44]

36. "China's Share of Rare Earths Production Worldwide from 2016 to 2023," Statista, last visited May 11, 2024, https://www.statista.com/statistics/1294393/share-of-global-rare-earths-production-in-china/.
37. Hongqiao Liu, "Rare Earths: Shades of Grey—Can China Continue to Fuel Our Global Clean & Smart Future?" China Water Risk, 2016, https://www.chinawaterrisk.org/wp-content/uploads/2016/07/CWR-Rare-Earths-Shades-Of-Grey-2016-ENG.pdf.
38. "Forward Looking Industries Research Institute, Current Status and Future Development Trends of China's Rare Earth Industry 2021," last visited February 14, 2024, https://xueqiu.com/5984233728/201846909.
39. Keith Zhai, "China Set to Create New State-Owned Rare-Earths Giant," *Wall Street Journal*, December 3, 2021, https://www.wsj.com/articles/china-set-to-create-new-state-owned-rare-earths-giant-11638545586.
40. Shunsuke Tabeta, "China Ramps Up Rare-Earth Production to Meet EV, Wind Power Demand," Nikkei Asia, April 26, 2023, https://asia.nikkei.com/Business/Materials/China-ramps-up-rare-earth-production-to-meet-EV-wind-power-demand.
41. "China Creates New State-Owned Rare Earths Giant," S&P Global Market Intelligence, December 23, 2021, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/china-creates-new-state-owned-rare-earths-giant-68185761.
42. Felix K. Chang, "China's Rare Earth Metals Consolidation and Market Power," Foreign Policy Research Institute, March 2, 2022, https://www.fpri.org/article/2022/03/chinas-rare-earth-metals-consolidation-and-market-power.
43. "Announcement Regarding Disclosure of Acquisition Report," Board of Directors of Guangsheng Nonferrous Metals Co., Ltd., January 6, 2024.
44. "The Top Companies Behind the Rare Earth Industry," WireScreen, August 12, 2024, https://wirescreen.ai/blog/rare-earth.

Xiamen Tungsten Co., Ltd. (厦门钨业股份有限公司)

Founded in 1997, Xiamen Tungsten is a Fujian provincially owned enterprise traded on the Shanghai Stock Exchange. It produces tungsten, molybdenum, rare earths, magnetic, luminescent, and lithium-ion battery cathode materials. The company is vertically integrated, including mining, smelting and separating, and materials production. It accounts for 1 percent of China's mining and extraction quota.[45]

In addition to China's big three rare earths groups, hundreds of medium and smaller enterprises are licensed to own and operate rare earth mines, processing plants, and manufacturing facilities for intermediatory products such as permanent magnets, as well as providing scientific measurement, certification services, and trading.[46]

Several of these small and medium-size enterprises—like Zijin Mining, CMOC (previously known as China Molybdenum Company Limited), and China Nonferrous Metal Mining (Group) Company—are publicly traded, multi-billion-dollar companies doing business globally. These companies often partner with international majors and sometimes are among the largest global producers in a dedicated metals category. Furthermore, many of China's overseas mining companies establish special-purpose companies dedicated to specific projects or periodically change their name or ownership, making efforts to trace accountability difficult. For example, in the case of the February 2025 tailings dam breach that polluted Zambia's Kafue River, Chinese company Sino Metals Leach Zambia Limited—a special-purpose project company within the China Nonferrous Metal Mining (Group) Company family—illustrates how such practices can obscure or further attenuate the accountability of China's mining industry, both at home and abroad.[47]

2.2.2. Black- and gray-market operations

Beyond licensed operations, an unknown number of unlicensed operations illegally mine and smuggle a significant volume of rare earth elements. Significantly, not only do China's illegal rare earth mining operations undermine Chinese policies aimed at limiting production to maintain environmental standards and the profits of licensed mine operators, but illegal mining also undercuts the prices required by US, Australian, and European producers to sustain operations that are critical to a Western response breaking China's near monopoly over rare earths production.[48]

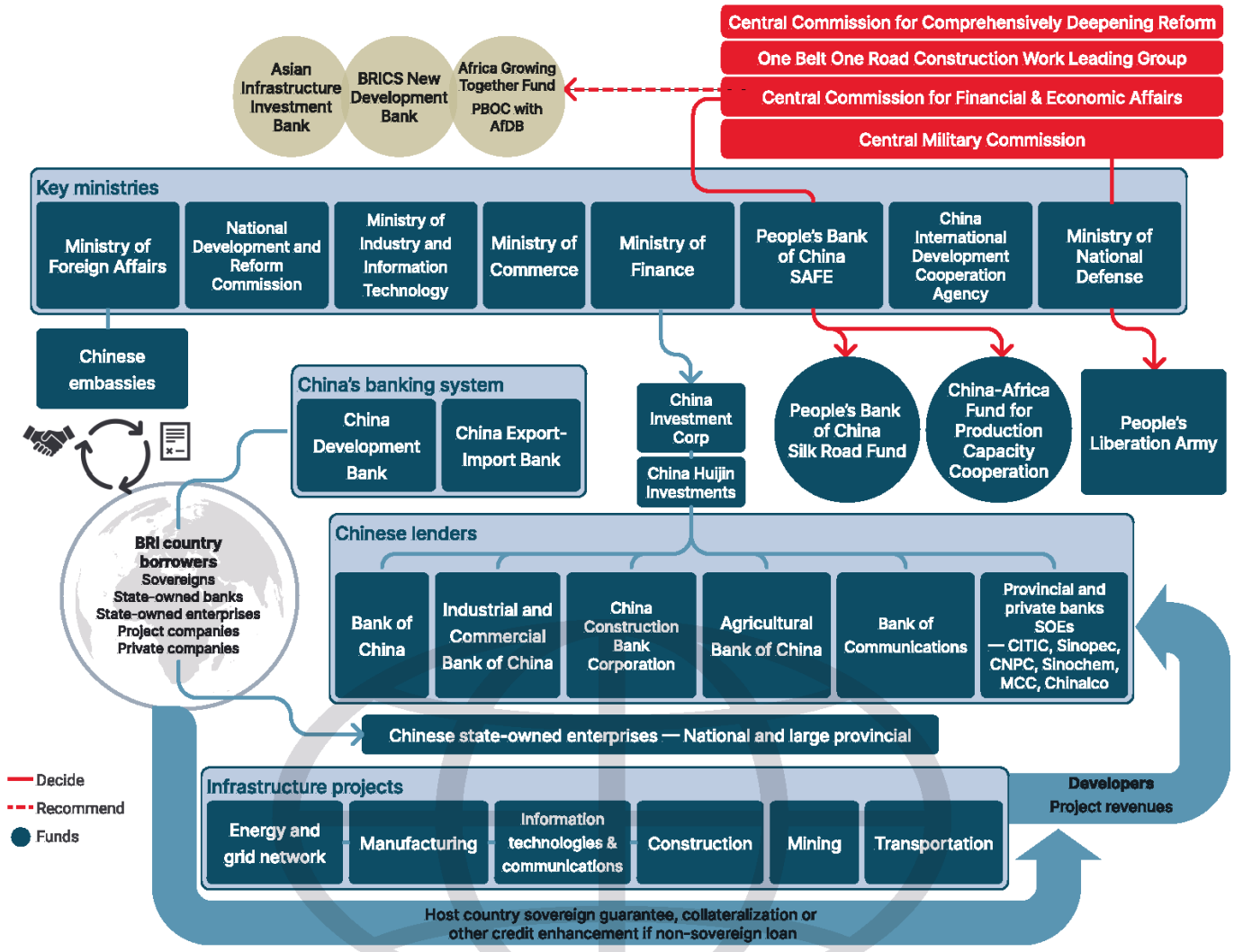
China's illegal mining operations can be categorized as gray- and black-market producers. Although illegal, gray-market operations support China in meeting demand for those rare earths that China's licensed companies are unable to meet, typically the magnetic rare earths (neodymium, praseodymium, and dysprosium) and high-value heavy rare earths.

Illegal rare earth mining product enters the regulated market through sales to licensed companies, typically without formal receipts or documentation. Because China's rare earth quotas are set below the levels required by Chinese permanent magnet producers and other domestic users, the government tolerates a degree of unlicensed, albeit illegal, mining. These companies, as well as other illegal producers, also supply rare earths that exceed domestic demand, typically light rare earths, selling low-grade product through domestic black-market transactions and illegal exports.[49] Both gray- and black-market operations violate labor and environmental laws, and, when dealing in products that exceed quotas, drive down the price of rare earths, thereby undermining state policies to maintain rare earth prices at levels profitable for the large centrally owned enterprises. According to China's Rare Earth Industry Association, illegally mined ores are generally around 60–70 percent less expensive than legal ores.[50]

Although China shut down hundreds of illegal rare earth mines through the mid-2010s, illegal mining has remained incentivized through China's policies of consolidating industry, limiting production through low quotas that do not meet demand, and restricting exports.[51] An unknown but large volume of illegal rare earths continue to enter China's domestic market, accounting for an estimated two to three times the amount of China's production quotas in some years, according to the China Rare Earth Industry Association. Discrepancies in export-import data between China and trade partners also confirm that large volumes are illegally exported, with trading partners reporting between 35 and 120 percent greater volumes than Chinese official exports.[52]

45. Ibid.
46. "Minerals Yearbook," US Geological Survey, 2019, https://www.usgs.gov/centers/national-minerals-information-center/minerals-yearbook-metals-and-minerals.
47. Richard Kille and Jacob Zimba, "A River 'Died' Overnight in Zambia After an Acidic Waste Spill at a Chinese-Owned Mine," Associated Press, March 14, 2025, https://apnews.com/article/mining-pollution-china-zambia-environment-93ee91d1156471aaf9a7ebd6f51333c1.
48. Daniel J. Packey and Dudley Kingsnorth, "The Impact of Unregulated Ionic Clay Rare Earth Mining in China," *Resources Policy* 48 (2016), 112–116, https://www.sciencedirect.com/science/article/abs/pii/S0301420716300289.
49. Ibid.
50. Liu, "Rare Earths: Shades of Grey."
51. Packey and Kingsnorth, "The Impact of Unregulated Ionic Clay Rare Earth Mining in China."
52. Ibid.; Liu, "Rare Earths: Shades of Grey."

Figure 4: Belt and Road Initiative



Source: Hart, *Mapping China's Energy, Environmental and Industrial Policies.*

2.3. China rare earths international investment

The major state-owned enterprises that dominate China's rare earth sector all operate globally, and all are supported by China's state policies promoting global expansion to capture market share and secure raw materials, with high-value industries manufacturing technologically advanced components and processes within China.

China's Going Out policy, announced in 2000, was the first of three policies explicitly encouraging Chinese SOEs to invest abroad. The initiative aims to secure resources, access new markets, and foster economic growth globally. China's government supports overseas expansion through facilitating relationships through the Ministry of Foreign Affairs and its networks of embassies, and financial backing through direct state subsidies, as well as through state policy banks, state-owned commercial banks, and Chinese commercial banks that are directed to support government policies.

State support for the Going Out policy was expanded and formalized in 2013 in what is now the Belt and Road Initiative. The initiative adopts a whole-of-government approach to support Chinese enterprises, with a focus on the large centrally owned state enterprises in the power, oil and gas, renewable energy, mining, construction, transportation, and telecommunications infrastructure sectors.

The approximately 160 Belt and Road countries are located on the six populated continents, with most concentrated in Asia, Africa, and the Americas. The Belt and Road Initiative is simultaneously a foreign policy and global infrastructure development strategy to expand China's position in global trade and to solidify alliances among the developing world for China—bilaterally and in international organizations such as the United Nations—and is also a means of expanding markets for China's state enterprises. Through the Belt and Road, its state enterprises expand China's access to raw materials, secure infrastructure projects to maintain their operations at full

employment, and capture global market share to ensure the growth and standing of China's domestic economy.

Going Out and the Belt and Road Initiative work together with the Made in China 2025 policy, also formally adopted in 2013, which emphasizes domestic production and innovation to bolster China's manufacturing prowess. Through Made in China, the government aims to ensure China leads the world in advanced technology industries, and reduces its own dependence on foreign technology. The Made in China policy supports international expansion of China's state enterprise to secure its future demand for rare earth elements and other critical minerals, energy, and other raw resources that are exported to China for processing and manufacturing of higher-value products, as well as to capture market share for its advanced manufacturing industries, such as power and information technologies that depend on rare earths and other critical minerals. Significantly, China's traditional trade finance programs and Belt and Road Initiative investments in mining and other extractive industries like oil and gas are often equity stakes or loans collateralized or repaid in raw materials and commodities, thereby helping China de-risk its portfolio of overseas investments.[53]

The success of China's rare earths strategy is confirmed by China's emergence as a recognized leader in both rare earths and the advanced technologies that depend on them, and its growing share of global markets across advanced technology sectors. One independent study assessed that China now leads all other nations in thirty-seven of forty-four advanced technologies, almost all of which depend on rare earths.[54]

Figure 4 illustrates how China adopts a whole-of-government approach to supporting its state-owned enterprises in overseas expansion through the Belt and Road Initiative. For mineral extraction and processing projects, as well as other Belt and Road infrastructure projects, the Ministry of Foreign Affairs coordinates government-to-government relationship building; the NDRC, MIIT, and Ministry of Commerce facilitate investment by China's state enterprises and financing through the state banking system at the direction of the Ministry of Finance, the People's Bank of China, and the China International Development Cooperation Agency. These ministries even directly invest in Belt and Road projects, through loans and equity, supplementing funds provided by China's state enterprises and banks.[55] China's government further views international organizations in which China has a leading role—the Asia Infrastructure Investment Bank (AIIB) and the New Development Bank (formerly the BRICS Development Bank)—as direct support for its Belt and Road Initiative and broader foreign policy objectives.[56]

Belt and Road Initiative lending and grants exceeded $1.3 trillion from 2000 to 2021. During this period, China-financed infrastructure projects required only 2.7 years to issue loans, in contrast to World Bank and regional multilateral development bank lending requiring five to ten years to financial close. The initiative's vast scale, speed in lending, and rapid impact have made China the world's largest official creditor to the developed world, conferring tremendous influence with the Global South.[57]

53. Ammar Malik, et al., "Banking on the Belt and Road: Insights from a New Global Dataset of 13,427 Chinese Development Projects," AidData, September 2021, https://www.aiddata.org/publications/banking-on-the-belt-and-road.

54. Gaida, et al., "ASPI's Critical Technology Tracker."

55. Malik, et al., "Banking on the Belt and Road," appendix.

56. Craig Hart, *Mapping China's Energy, Environmental and Industrial Policies*, Government of the United Kingdom, January 2025.

57. Bradley C. Parks, et al., "Belt and Road Reboot: Beijing's Bid to De-Risk Its Global Infrastructure Initiative," AidData, 2023, https://docs.aiddata.org/reports/belt-and-road-reboot/Belt_and_Road_Reboot_Full_Report.pdf.

Pipes coming from a rare earth smelting plant spew polluted water into a vast tailings dam near Xinguang village. REUTERS.

3. China's rare earths policies

China's dominance in rare earth production and processing is the result of long-term vision and decades of focused government financial and policy support. This chapter summarizes China's current policies supporting rare earths, reflected in its five-year plans, subsidies to industry, pricing and competition, trade and investment practices, environmental sustainability regulations, standards development, and research priorities. China's policies aim to further expand China's already commanding share of global supply and production, as well as to prevent competitors from entering the market or maintaining a profitable competing operation.

3.1. Central government strategic plan for the rare earths sector

China's strategic plan for the rare earths sector is most recently defined by the Ministry of Industry and Information Technology in its Rare Earth Industry Development Plan (2016–2020) as part of China's thirteenth five-year planning cycle, which today remains China's current articulation of national priorities for the rare earths sector.[58]

The plan recognizes progress restructuring the sector to consolidate market share in several large national state-owned enterprises that vertically integrate extraction, separation, and processing operations. As described in greater detail in Sections 2.2 and 3.2.1 of this report, China's efforts to rationalize the industry structure are accomplished by consolidating firms in order to eliminate excess capacity through the merger of smaller firms into larger national conglomerates. Through this process, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and the Ministry of Commerce created six large national SOEs, and subsequently merged three of those firms, further consolidating the industry in four major firms presented in Section 2.2 of this report.

58. "Rare Earth Industry Development Plan (2016–2020)," Ministry of Industry and Information Technology, last visited February 11, 2024, http://www.gov.cn/xinwen/2016-10/18/content_5120998.htm.

Supporting the major centrally owned state enterprises are a limited number of medium-sized enterprises that provide additional mining capacity and smelting, processing, and trading services. The central government tightly controls the number of these smaller companies through a market-access licensing regime and a system of production quotas in order to maintain prices of rare earth elements at levels that are profitable for the centrally owned enterprises. The government might withdraw licenses or market access for failure to comply with commercial or environmental laws, or for purposes of eliminating overcapacity, typically eliminating firms with inefficient and outdated equipment. For example, during the industry consolidation of the mid-2010s, MIIT reported that China reduced the number of rare earths smelting and processing companies from ninety-nine to fifty-nine firms.[59] The government actively prosecutes and closes illegal mining operations, closing a reported six hundred illegal mines by the mid-2010s.[60]

In addition to the consolidation of the industry, the plan also directs the geographic concentration of the rare earth industry, establishing mining and smelting centers in Baotou (Inner Mongolia province), Ganzhou (Jiangxi), Liangshan (Sichuan), and Longyan (Fujian), and industrial processing bases in Ningbo (Zhejiang), Xiamen (Fujian), Chengdu (Sichuan), and Baotou.[61]

China's government adopts a more expansive view of competition in R&D enterprises dedicating to innovating equipment, processes, and products in the rare earths sector. In these areas, the government also supports innovation hubs, specifically through collaboration among government, industry, and academic institutions. Linked to the geographic hubs described above, the plan calls for the development of seven rare earth public technical service platforms, integrating technology research and development, industrial transformation, and analysis and testing.[62]

The Made in China 2025 policy is pivotal in driving advances in, and support for, the rare earths sector. The Made in China 2025 policy is a ten-year government initiative aimed at fostering innovation in pillar industries. This strategy seeks to reduce China's reliance on foreign technology by 2025 and to establish China as a leading manufacturing power by 2049, coinciding with the one hundredth anniversary of modern China's founding. This policy builds on earlier initiatives, such as the Medium- and Long-Term Plan for the Development of Science and Technology issued in 2006, which emphasized "indigenous innovation" (自主创新), and the 2010 identification of seven "strategic emerging industries" (略性新兴产业) critical for China's advancement into a developed economy. The Made in China program focuses on expanding China's manufacturing capabilities through innovation, targeting ten core industries, including

- information technology;
- numerical control tools and robotics;
- aerospace equipment;
- ocean engineering equipment and high-tech ships;
- railway equipment;
- energy-saving and new energy vehicles;
- power equipment;
- new materials;
- medicine and medical devices; and
- agricultural machinery.[63]

The central government manages the rare earths sector by setting targets and metrics for industry to achieve, which include targets relating to

- profitability;
- R&D investment;
- production output;
- environmental performance;
- market share; and
- exports volume.

Government priorities for the future development of the rare earths industry include the following.

3.1.1. Industry structure and regulation

- Combat global overcapacity that drives down prices and makes environmentally sustainable production of rare earths arduous. This can be done through further rationalization of the industry to maintain pricing at profitable levels and drive growth and innovation.
- Coordinate upstream and downstream industry, with expansion of upstream industry to downstream applications, potentially creating further industry concentration and verticalization.
- Combat illegal mining and smuggling operations to strengthen strict government control over market access through licensing.
- Establish a rare earth product tracing system to enable identification of product from mine through processing

59. Ibid.
60. Packey and Kingsnorth, "The Impact of Unregulated Ionic Clay Rare Earth Mining in China."
61. "Rare Earth Industry Development Plan (2016–2020)."
62. Ibid.
63. Hart, *Mapping China's Energy, Environmental and Industrial Policies.*

stages to support export-control and market-supervision efforts.

- Use social credit, whitelists and blacklists, and enforcement of environmental and compliance requirements to regulate industry.
- Collaborate internationally to achieve China's rare earth objectives, including through international acquisitions.

3.1.2. R&D and product innovation

- Focus on the higher-value medium and heavy rare earth elements.
- Increase rare earth enterprise R&D investments to at least 5 percent of operating income.
- Expand high-value applications of rare earths to improve the quality and efficiency of industry, such as high-purity rare earth materials and high-strength magnets for electronics, aerospace, rail, marine, and other advanced applications.
- Promote collaboration by government, industry, and academia for research and application, integrated with key national laboratories and supported with intellectual property protection for indigenous innovation in rare earths, in such areas as fundamental elemental research, rare earth magnetism, catalysis, and optical functions based on "material genetic engineering" (材料基因工程), an artificial intelligence (AI)-based computational approach drawing on biological genetic engineering, with focus applications that include batteries, hydrogen storage, luminescence, and frequency-articulated materials.
- Develop technologies to reduce consumption of elements that are less abundant than other rare earths, including terbium and dysprosium, and replace praseodymium and neodymium with more abundant lanthanum, cerium, and yttrium.

3.1.3. Standardization and environmental performance

- Develop comprehensive standards covering the entire rare earths value chain, from extraction to smelting and separation to processing, and the internationalization of Chinese standards.
- Enhance environmental protection through law and standards, including development of technologies for recycling and low-cost green production, including a focus on water pollution, soil pollution, and low-carbon emissions.

3.2. Subsidies

Government subsidies to SOEs are fundamental to China's system of government and industry, and they are generous. Among other functions, they strengthen China's large national SOEs into "national champions" that capture dominant global market share and ensure that they maintain stable employment for urban party elites who dominate their ranks—a critically important constituency to maintain party and domestic cohesion.

Although China's government does not publish comprehensive statistics of its subsidies to SOEs, and data for subsidies to rare earth companies are not published, the magnitude of China's subsidies to state industry is significant. As described further below, the 2013 study of more than one hundred national-level SOEs, which remains the most comprehensive study available, estimated that all of their profits were attributable to subsidies from 2001 to 2009.[64]

MIIT has identified numerous distinct types of subsidies provided to the rare earths industry in order to support the industry development plan. These subsidies span science and technology, finance and taxation, land resources, finance, and other policies.

- Increase fiscal and taxation support, including the pretax super deduction for rare earths corporate research and development expenses.
- Provision of land resources.
- Central fiscal science and technology planning and funding for special projects.
- Central government pilot projects for the transformation and modernization of the rare earth industry in key resource areas, build industrial bases, support advanced manufacturing applications, and cultivate regional industries.
- Provincial government subsidies and expanded access for minerals exploration and development.[65]
- Investment and financing guarantee mechanisms, including insurance compensation mechanisms for the development of new materials and applications.
- Innovative credit products and services to support rare earths industry development.
- Guide private capital and "social resources" to invest in new rare earth material application fields, and support innovative and growing rare earth enterprise.

64. Hong Sheng and Nong Zhao, *China's State-Owned Enterprises: Nature, Performance and Reform* (Singapore: World Scientific Publishing, 2012).

65. Edward White, "China Raises State Funding for Strategic Minerals Amid US Trade War," *Financial Times*, March 19, 2025, https://www.ft.com/content/cace5b0f-e08c-4cb9-aac5-c3117d5a93bc.

- Financial support for international cooperation among rare earth enterprises.
- Support qualified rare earth companies to raise capital through public offerings of equity and debt on capital markets.[66]

To fully appreciate the potential extent to which China's rare earths industry is subsidized in the absence of published data requires an understanding of China's system of subsidies and political economy.

SOEs receive protection from competition by government rules limiting market entry and through other preferential policies. Most notably, state protection relieves SOEs from hard budget constraints or the possibility of bankruptcy. The government also provides significant subsidies, many in the form of reduced costs. Although China has ostensibly embarked on reforms aimed at strengthening markets, China's National Development and Reform Commission still maintains a powerful central-planning apparatus that controls the costs of many of the most important basic inputs at artificially low prices that favor SOEs. These inputs include capital (interest rates on savings and lending), energy (fuels and electricity), water, and land, all of which affect the entire economy and the incentives for Chinese state enterprise.

The National Development and Reform Commission's Pricing Department and the Ministry of Industry and Information Technology's Rare Earths Office likely consult the four large centrally owned rare earth industry companies in establishing policies that affect rare earth prices, and may even attempt to set prices, notwithstanding the operations of markets. Market observers have described the pricing of rare earths as highly obscure but clearly affected by Chinese domestic policies, as the country controls more than 90 percent of global supply.[67]

Hong Sheng and Nong Zhao document that China's centrally owned SOEs received subsidies amounting to well above 100 percent of their reported profits during the 2001–2009 period.[68] The sources of these subsidies are varied, including reduced costs for land and fuel, tax breaks, and monopoly pricing. Other subsidies, such as systemic failure to enforce environmental laws and regulations against China's SOEs, are difficult to quantify. Below, we review the most important subsidies commonly available to China's SOEs, each of which was specifically identified by the MIIT to be provided to the rare earths industry in its Rare Earth Industry Development Plan (2016–2020).

One of the most significant subsidies involves land. SOEs do not pay the full market rental value for land. Sheng and Zhao estimated that, based on average national prices for industrial land, SOEs' underpayment for land accounted for 67.2 percent of their nominal profits from 2001 to 2009.[69]

SOEs benefit from lower borrowing rates at state-controlled banks. In comparison, large and medium-sized private enterprises face interest rates that are 6 percent higher than those for similarly sized SOEs, while small private enterprises encounter a 9-percent premium over their SOE counterparts.[70]

Government regulation enables low interest rates for state industries by setting deposit interest rates below the market level.[71] Sheng and Zhao estimate that 47 percent of SOEs' profits during the 2000s were due to below-market interest payments.[72] The state uses the banking system to subsidize state-owned enterprises, shifting the cost to Chinese households through artificially low interest on their deposits, and to private borrowers who pay higher rates to compensate state banks when SOEs default on their loans.

SOEs also pay lower taxes. From 2007 to 2008, the tax burden of SOEs surveyed averaged 10 percent, as opposed to 24 percent paid by private enterprises.[73] SOEs also pay less in resource taxes on petroleum, natural gas, and coal. For example, state enterprises paid less than a 2-percent charge on oil, compared to the 12.5 percent paid by joint ventures.[74]

66. "Rare Earth Industry Development Plan (2016–2020)."

67. Nabeel Mancheri, et al., "Effect of Chinese Policies on Rare Earth Supply Chain Resilience," *Resources, Conservation and Recycling* 142 (2019) 101–112, https://www.researchgate.net/publication/329246545_Effect_of_Chinese_policies_on_rare_earth_supply_chain_resilience.

68. Sheng and Zhao, *China's State-Owned Enterprises: Nature, Performance and Reform*.

69. Ibid.

70. Ibid. 66–67, citing Xiaoxuan Liu and Xiaoyan Zhou, "Test of Allocation Relations between Financial Resources and Real Economy: Reasons for Imbalance of Economic Structure," *Journal of Financial Research* (2011), 2.

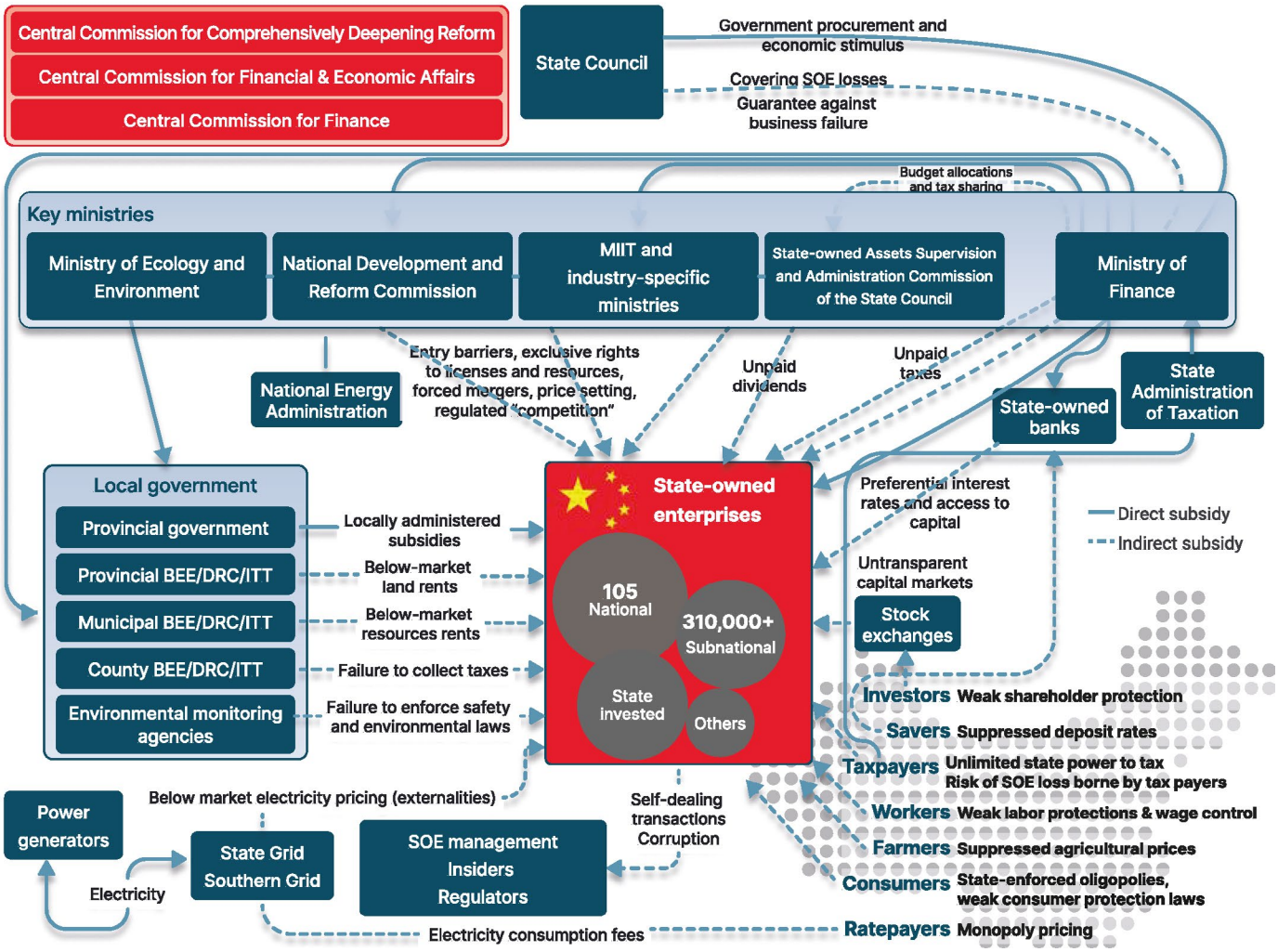
71. Nicholas Lardy, *Sustaining China's Economic Growth: After the Global Financial Crisis* (Washington, DC: Peterson Institute for International Economics, 2012), 83, 98–100; Carl Walter and Fraser Howie, *Red Capitalism: The Fragile Financial Foundation of China's Extraordinary Rise, Revised and Updated* (Singapore: John Wiley & Sons (Asia), 2012), 116–119.

72. Lardy challenges the interest rate data and methodology used by Sheng and Zhao and cites other Chinese government data suggesting that while SOEs may be charged less than private borrowers, the difference is likely less than commonly argued. Lardy, *Sustaining China's Economic Growth*, 108 and Appendix B; Sheng and Zhao, *China's State-Owned Enterprises: Nature, Performance and Reform.*

73. Sheng and Zhao, *China's State-Owned Enterprises: Nature, Performance and Reform*.

74. Ibid.

Figure 5: Direct and indirect subsidies to state industry



Source: Hart, *Mapping China's Energy, Environment and Industrial Policies.*

SOEs also benefit from both direct cash subsidies, such as payments to oil producers to ensure the supply of crude oil and petroleum products, and in-kind subsidies such as free licenses or other privileges. For instance, state-owned telecommunications firms receive valuable radio-frequency licenses at no charge. Additionally, certain subsidies are challenging to quantify yet significant, such as SOEs using political influence to evade environmental regulations, thereby imposing external costs on the public.

Finally, SOEs enjoy monopoly or oligopoly pricing for various goods and services. As described in this paper, China consolidated the rare earth industry, forming three dominant oligopolist firms, following the same strategy of creating oligopolies in tobacco, salt, civil aviation, petroleum and petrochemicals, power generation and transmission, coal, and telecommunications.

China's overall system of subsidies undermines the transparency of China's own market dynamics, which, due to China's dominant position supplying rare earths, affects the pricing of global markets. The diagram below illustrates the various types of subsidies, and the resulting transfer of wealth from Chinese citizens to industry. However, in the case of rare earths, the effects of price manipulation are born not only by Chinese citizens, but also by global consumers. The sections that follow discuss two of the principal methods that China uses to subsidize its centrally owned state enterprises by setting prices—in the long term through market structure and, in the shorter term, by restricting supply.

3.2.1. Oligopoly pricing through market structure—capacity rationalization

China's long-term approach to building and maintaining national champion SOEs is to limit the number of competitors by limiting market access and merging smaller firms into larger conglomerates. In the rare earths sector, MIIT's Rare Earth Industry Development Plan (2016–2020) specifically cites China's policy of merging smaller competitors into large state oligopolies—"reverse the many, small and scattered" (扭转了"多、小、散")—in the creation of the large national rare earth conglomerates.[75] Designed to shift production to higher-value products and secure control of global market share for China, each of these enterprises operates within China as a regional oligopolist, which incentivizes provincial and local governments to provide additional subsidies, supplementing national subsidies.

Notwithstanding the array of policy options available to the central government, policy mandates that intervene in markets often face resistance in China. The interests of the central government and its national state-owned industry often conflict with the interests of local governments, which are aligned with local mining operations. Beyond tax and employment considerations, many provincial and local governments, or even local officials, own and operate small-scale mining enterprises targeted by the central government's capacity-rationalization policy. Worse, local officials have leased land to, or accepted bribes from, illegal rare earth mining operations, offering them protection from enforcement in the process.[76]

To place China's rare earths industry consolidation in perspective, the Herfindahl–Hirschman Index (HHI) illustrates how market concentration translates into pricing power. Within the index's range from 0 to 10,000, an HHI score below 1,500 is considered a competitive marketplace, a score greater than 2,500 is deemed a highly concentrated marketplace, and a score of 10,000 represents a monopoly.[77] Following the consolidation of China's big national rare earth companies, the rare earth industry scores an HHI of 7,219, representing a highly concentrated oligopolistic marketplace approaching a monopoly, which China has further consolidated into three rare earth conglomerates.[78]

During the same period that China consolidated its rare earths industry, it simultaneously consolidated the broader mining and metals sector, including coal, steel, and iron production. To limit excess industrial capacity and increase profits, China sought to reduce the overall productive capacity of the coal, iron, and steel sectors.[79]

As a mining industry, China's approach to coal illustrates how Chinese capacity rationalization is implemented, using a standard policy prescription that was also employed in iron and steel, and is identical to the restructuring outlined in the MIIT's Rare Earth Industry Development Plan (2016–2020). In 2015, China moved to improve standards for its coal-production enterprises, closing smaller coal mines with production capacity below 90,000 tons per year and expediting the closure of coal mines posing serious safety hazards, resulting in the closure of more than 1,200 mines and elimination of almost 80 million tons of "backward," or uncompetitive, production capacity. The twelfth five-year plan consolidated the industry into ten large coal enterprises and ten smaller coal enterprises, which together would account for more than 60 percent of China's coal production. Thus, as in the case of the rare earths sector, China's coal production would come from large mines, the number of which will be reduced through state intervention. China's 13th Five-Year Coal Industry Development Plan and a series of policy actions followed by imposing annual coal consumption and production limits, closing additional small and unsafe mines, and prosecuting mines that violated environmental laws, all with the aim of eliminating excess coal production to maintain industry profitability. As the central government stepped up enforcement to reduce its excess coal-production capacity, local governments were asked to commit to production capacity targets, devolving responsibility to local government and enterprises to achieve these goals within specified time frames.[80] The combination of complementary policies at multiple levels of government is the same template described in the Rare Earth Industry Development Plan (2016–2020).

75. "Rare Earth Industry Development Plan (2016–2020)."

76. Yuzhou Shen, Ruthann Moomy, and Roderick Eggert, "China's Public Policies Toward Rare Earths, 1975–2018," *Mineral Economics* 33 (2020), 127–151, https://link.springer.com/article/10.1007/s13563-019-00214-2.

77. Michael Bromberg, "Herfindahl-Hirschman Index (HHI) Definition, Formula, and Example," Investopedia, last updated June 12, 2024, https://www.investopedia.com/terms/h/hhi.asp.

78. "Chinese Rare Earth Elements (REE) & Metals Dominance Analysis," Interos, 2022, https://www.interos.ai/wp-content/uploads/2022/04/Interos-Report-Explores-Concentration-Risk-of-Rare-Earth-Minerals-and-China.pdf.

79. "Opinions of the State Council on Resolving the Excessive Production Capacity of the Iron and Steel Industry to Realize the Development of the Depletion, Guo Fa [2016] No. 6.

80. Hart, M*apping China's Energy, Environmental and Industrial Policies.*

3.2.2. Setting pricing through short-term supply controls—rare earths strategic reserve

Beyond industry structure, China possesses several policy tools to influence market prices in the short run.

Leveraging its position as the dominant supplier globally, China attempts to regulate the production, export, and pricing of rare earths through the combination of production quotas and export quotas, coupled with purchases or sales by the strategic reserve to influence both domestic and global prices. One of these methods is constraining the production or supply of the commodity domestically and in global markets.

Yet, efforts to limit supply, limit exports, or simply set prices by fiat incentivize illegal mining and increased production by licensed producers beyond their legal quotas. In the mining sector generally, and the rare earths sector specifically, Chinese government intervention restricting supply through production quotas, export restrictions, and taxes only limits legal mines. These restrictions result in higher market prices, making illegal mining even more profitable. Illegal operations do not comply with environmental, labor, and other laws, and do not pay taxes. By some estimates, skirting these laws reduces the costs of unlicensed operations, so that their costs are around 60 to 70 percent lower than those of legal mines.[81] Higher profit margins incentivize illegal mines to increase production, which increases illicit trading and export.[82]

Another method China uses to influence market prices is to buy and sell rare earths in bulk transactions by its strategic rare earth reserves. Established in 2012, China's strategic reserve serves the dual purposes of mitigating the risks of domestic shortage and strengthening its control over global supplies and prices by removing or adding rare earths to supplies available in the market.[83] These reserves are managed by the NDRC's National Food and Strategic Reserves Administration, through government and state enterprise warehouses.[84] Under the system, China's rare earth conglomerates are required to turn a portion of production over to government control each year, or set aside a portion in their own warehouses, the cost of which is funded by the companies, as well as by government and nongovernment sources of capital.[85] To put the extent of reserves into perspective, in 2014, a combined total of 12.5 percent of production quotas were purchased by the government strategic reserve and reserved by the companies at government direction.[86] For the scarce heavy rare earths, accumulated stockpiled reserves are generally a high proportion of annual production—for example, during the mid-2010s, reserves as a proportion of production ranged from 40 percent for terbium (atomic number 65) to 500 percent for lutetium (atomic number 71).[87] Stockpiling and releasing reserves have corresponding impacts on rising and declining rare earth prices, and the high proportion of China's reserves to annual global production provide it with a powerful tool to control global prices.[88]

China's rare earth strategic reserve serves several objectives, including

- maintaining control over the global rare earths market to leverage geopolitical influence;
- ensuring domestic downstream industries are provisioned with stable and affordable supplies of rare earths, both nationally and regionally;
- protecting China's rare earth resources from overexploitation and depletion; and
- providing an investment vehicle for government and nongovernment investors.

China has used the strategic reserve to stabilize its own rare earth sector and downstream industries that depend on rare earths using a form of market-mechanism price control, as opposed to traditional price controls. By purchasing rare earths when prices are low, the strategic reserve effectively sets a price floor, maintaining prices levels at or above upstream producer break-even levels, but not too high to induce new entrants into the mining sector.[89] During price spikes, the reserve sells supply to ensure China's downstream manufacturers have adequate supply at commercially acceptable cost, in order to maintain advanced manufacturing sector margins,

81. Liu, "Rare Earths: Shades of Grey."
82. Shen, et al., "China's Public Policies Toward Rare Earths, 1975–2018," note 9.
83. James T. Areddy, "China Moves to Strengthen Grip Over Supply of Rare-Earth Metals," *Wall Street Journal*, February 7, 2011, https://www.wsj.com/articles/SB10001424052748704124504576117511251161274.
84. Mancheri, et al., "Effect of Chinese Policies on Rare Earth Supply Chain Resilience."
85. Dafang Shi and Shouting Zhang, "Analysis of the Rare Earth Mineral Resources Reserve System and Model Construction Based on Regional Development," *Computational Intelligence and Neuroscience* (2022), https://pubmed.ncbi.nlm.nih.gov/35832250.
86. Shen, et al., "China's Public Policies Toward Rare Earths, 1975–2018."
87. Mancheri, et al., "Effect of Chinese Policies on Rare Earth Supply Chain Resilience."
88. Ibid.
89. Constantine Karayannopoulos and Vasileios Tsianos, "Lessons from Three Decades in the Rare Earth Trenches," in Sophia Kalantzakos, ed., *Critical Minerals, the Climate Crisis and the Tech Imperium* (New York: Springer, 2023), https://www.researchgate.net/publication/368969550_Lessons_from_Three_Decades_in_the_Rare_Earth_Trenches.

as these industries may not be able to pass on materials cost increases to their own customers. The reserve finances its operations by profiting on the difference.

China's rare earth strategic reserve has worked as follows, in combination with its other policies.

- **Production quotas:** Production quotas set by the Ministry of Industry and Information Technology on rare earth mining companies, and production quotas set by the Ministry of Natural Resources on provinces, limit the amount of rare earths that can be extracted each year, helping to prevent overexploitation of resources and maintain control over supply.
- **Export quotas:** Until the World Trade Organization (WTO) ruled in 2014 that China's imposition of export quotas on rare earths and critical minerals violated the terms of its accession, China imposed export quotas to limit the amount of rare earths that could be sold to foreign countries. This allowed China to regulate the amount of rare earths available on the global market, influencing prices and maintaining its dominant position.
- **Export restrictions on technology:** China has imposed export restrictions on resource-constrained rare earths, as well as on processing and manufacturing technologies. In 2023, China imposed restrictions on export of the critical minerals gallium, germanium, and graphite, followed by a complete ban on all exports of rare earth extraction and separation technologies, and later restrictions on manufacturing equipment for permanent magnets. Amid growing trade tensions in 2024, China outright banned all exports of gallium, germanium, and antimony to the United States, and in 2025, further tightened export controls over critical minerals vital for defense, electronics and energy applications.[90]
- **Strategic reserves:** China maintains strategic reserves of rare earths, which are stockpiled in designated storage facilities. These reserves serve as a buffer against supply disruptions and are used to stabilize prices in times of high demand or geopolitical tensions.
- **Tax incentives:** China has employed export taxes, resource taxes, and rebates for domestic consumption to stimulate upstream and downstream production, depending on the government's priorities for the sector's development at different times. To promote domestic production of higher value-added finished products, China currently imposes a refundable value-added tax (VAT) of 13 percent for rare earth products, including oxides, metals, and magnets, which is not refunded for exports of raw rare earth materials. This tax regime advantages China's rare earth magnet producers and other finished-product manufacturers, with 13-percent lower raw materials costs relative to foreign competitors. For imports, China waives its import duties and VAT on foreign firms selling rare earth concentrates into China, but applies both a 5-percent import duty and the 13-percent VAT on imports of rare earth materials that have been further processed, thereby further advantaging Chinese domestic processers and manufacturers.[91]
- **Exchange controls:** Other approaches, such as exchange-rate controls, may also be applied. However, these would potentially affect other product categories, and therefore likely could only be used effectively economy-wide, if appropriate.

China's strategic reserve could enhance China's ability to use the supply of rare earths as leverage in international trade disputes until other countries are able to stand up independent supply chains. China has already used this leverage with countries like Japan and the United States, while maintaining a stable price domestically, and cushioning the impact of cessation in global trade on its domestic producers.

3.3. China's trade and investment policies

China's limits on production and exports of rare earths and the technologies to extract and separate them, and the ban on export of manufacturing equipment to produce permanent magnets, represent a deliberate effort to prevent other countries from developing their own rare earths industries using Chinese technologies. By extension, they are an effort to influence the terms of global trade, driving up international prices to generate higher revenues earned by Chinese state enterprise, while conferring a competitive advantage on Chinese downstream industries that enjoy priority of supply and lower input costs through China's tax regime.

China's policies of restricting rare earth exports and promoting a two-tiered pricing system that ensures a lower cost of supply for its domestic industry incentivize foreign upstream advanced-manufacturing companies dependent on rare earth elements to locate their production in China.[92]

90. Jing Zhang, et al., "Key Changes and Updates to Chinese Export Controls in 2023," Mayer Brown, February 1, 2024, https://www.mayerbrown.com/en/insights/publications/2024/02/key-changes-and-updates-to-chinese-export-controls-in-2023; Gracelin Baskaran, "What China's Ban on Rare Earths Processing Technology Exports Means," Center for Strategic and International Studies, January 8, 2024, https://www.csis.org/analysis/what-chinas-ban-rare-earths-processing-technology-exports-means.

91. Mary Hui, "How China Uses Tax Policies to Defend Its Rare Earths Monopoly," *Quartz*, February 22, 2022, https://qz.com/2129104/how-china-uses-tax-policies-to-defend-its-rare-earths-monopoly.

92. Leslie Hayes-Labruto, et al., "Contrasting Perspectives on China's Rare Earths Policies: Reframing the Debate Through a Stakeholder Lens," *Energy Policy* 63 (2013) 55–68, https://www.sciencedirect.com/science/article/abs/pii/S0301421513007805.

China has been accused of manipulating rare earths prices to force foreign competitors to exit the market—at times pricing rare earths high to earn economic rents and disadvantage downstream competitors, and at other times flooding the market with low-priced supply, a practice known as limit pricing—forcing upstream competitors to abandon plans to expand capacity or to shutter existing mines.[93]

During the 2009–2011 period, China constrained supplies of heavier rare earths (e.g., dysprosium, terbium, and europium), causing prices to spike, which, in turn, triggered the market to diversify production and foreign governments to seek redress through trade channels.

Volatility of these pricing extremes has itself proven effective at forcing competitors out of the rare earths market.[94] During the 2012–2019 period, of four hundred publicly listed rare earth start-ups globally, fewer than five reached production stage—and, of these, only two achieved significant production volumes. The two firms both experienced challenges, one going bankrupt and the other temporarily losing its operating permit. When competitors fail, China steps in with equity and debt financing, taking over failed projects.[95]

China's aggressive exercise of market power favoring its domestic upstream and downstream industries has inevitably resulted in complaints before the World Trade Organization. In the early 2010s, the United States, European Union, and Japan challenged China's imposition of export quotas and duties on dozens of rare earth products and critical tungsten and molybdenum products, including the naturally occurring minerals and intermediate products that have been processed into concentrates, oxides, salts, and metals. China's export duties had increased from 10 percent to 25 percent, which—coupled with the elimination of VAT refunds on several rare earth products—resulted in foreign manufacturing industries paying 31 percent more than their Chinese industry competitors.[96] The complaint charged that

- China's imposition of export duties violated its explicit commitment in its WTO Accession Protocol not to apply export duties to the raw-material products at issue;
- China's imposition of export quotas violated its obligations under Article XI:1 of the General Agreement on Tariffs and Trade 1994 (GATT 1994) not to restrict exports; and
- China's imposition of export quotas on rare earths and molybdenum violated its obligations in its WTO Accession Protocol, requiring China to give all foreign enterprises and individuals, as well as all enterprises in China, the right to export most products.

China defended on the grounds that its imposition of export duties and export quotas was justified under exceptions in the GATT, specifically the export duties excepted under Article XX(b) of the GATT 1994 as environmental protection measures, and the export quotas excepted under Article XX(g) of the GATT 1994 as measures related to the conservation of exhaustible natural resources.

The WTO panel found that China's export duties and quotas breached WTO rules and that China had failed to justify its actions as conservation or environmental protection measures. The ruling was upheld on appeal in 2014.[97]

In response, China relaxed some of its trade restrictions. However, it continues to maintain tight control over rare earth exports. China has adjusted its tactics to manipulate supply and prices, employing broadly accepted methods of intervention that still favor its industry, while reducing the risk of another WTO challenge.

Export taxes or export duties are not expressly prohibited under international trade law, and are a common method for exporting countries to raise revenues or counteract the impacts of trading counterparty. During the early 2010s, when China was forced to reevaluate its strategy, export taxes were employed by ninety-three of 155 WTO member countries.[98] Yet, unless the country has few competitors, an exporting country imposing an export tax on commodities risks suffering a de-

93. Gustavo Ferreira and Jamie Critelli, "China's Global Monopoly on Rare-Earth Elements," *Parameters* 52, 1 (2022), 57–72, https://press.armywarcollege.edu/parameters/vol52/iss1/6/.

94. Juliane Proelss, Denis Schweizer, and Volker Seiler, "The Economic Importance of Rare Earth Elements Volatility Forecasts," *International Review of Financial Analysis* 71 (2020), https://www.sciencedirect.com/science/article/abs/pii/S1057521918306148.

95. James Kennedy, "China Solidifies Dominance in Rare Earth Processing," *National Defense Magazine*, March 21, 2019, https://www.nationaldefensemagazine.org/articles/2019/3/21/viewpoint-china-solidifies-dominance-in-rare-earth-processing.

96. Brigid Gavin, "China's Growing Conflict with the WTO: The Case of Export Restrictions on Rare Earth Resources," *Intereconomics* 48, 4 (2013), https://www.intereconomics.eu/contents/year/2013/number/4/article/chinas-growing-conflict-with-the-wto-the-case-of-export-restrictions-on-rare-earth-resources.html.

97. Appellate Body Report, China—Measures Related to the Exportation of Rare Earths, Tungsten, and Molybdenum, WT/DS431/AB/R, WT/DS432/AB/R, WT/DS433/AB/R (August 7, 2014), https://www.wto.org/english/tratop_e/dispu_e/431_432_433abr_e.pdf.

98. Olga Solleder, "Trade Effects of Export Taxes," Graduate Institute of International and Development Studies Working Paper, 2013, https://www.econstor.eu/bitstream/10419/77436/1/741215969.pdf.

Rare earth leaching pools in China. Image by Kevnmh via Creative Commons

crease in exports, a loss of market share, or retaliation by importing countries.[99] China possesses a near monopoly over rare earths supply. This hard-won market power enables China to generate elevated export tax revenues, which reinforces the already strong incentive to maintain its dominant position.

Following the WTO ruling against its export quotas on the grounds that they violated the terms of its accession to the WTO, China continued to limit exports by relying on its production quotas. Production quotas are common in the sustainable exploitation of any depletable resource, and the right to regulate national resources is a fundamental act of sovereignty under national public law. Production quotas are more logically justified under the conservation defense of Article XX(g) than an export quota. Also, importantly, prima facie, production quotas apply equally to domestic consumption and exports. WTO jurisprudence, however, will examine whether a production quota or any other measure indirectly restrict exports, and can find that it constitutes a trade restriction based on the "de facto nature" of its application.[100] However, a ruling finding that production quotas violate trade principles would expose many countries to the risk of legal challenges over their own production quotas. If, for example, the use of production quotas by the Organization of Petroleum Exporting Countries (OPEC) were successfully challenged, the consequences would be destabilizing for world markets and relations among exporting and importing countries. Perhaps for those reasons, OPEC's production quotas have never been challenged, despite tensions surrounding these quotas.[101]

In 2023, China introduced export restrictions on the critical minerals gallium, germanium, and graphite, followed by a complete ban on all exports of rare earth extraction and separation technologies, and later restrictions on manufacturing

99. Jeonghoi Kim, "Recent Trends in Export Restrictions," OECD Trade Policy Papers, July 19, 2010, https://www.oecd-ilibrary.org/docserver/5kmbjx63sl27-en.pdf.

100. Paola Davide Farah and Elena Cima, "OPEC Production Quotas and the World Trade Organization," in Photini Pazartzis and Maria Gavouneli, eds., *Reconceptualising the Rule of Law in Global Governance, Resources, Investment and Trade* (Oxford, UK: Hart Publishing, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4043988.

101. Ibid.

Environmental impacts of illegal rare earths mining

Rare earths production, as carried out by Chinese companies operating domestically and abroad, is a source of environmental pollution through the various stages of the mining process, including extraction, processing, and waste disposal. Mining uses two methods: surface or hilltop mining followed by tank leaching and in-situ leaching, the latter commonly used by illegal mines. Leaching processes use chemicals such as sodium chloride and ammonium sulphate.[1]

Extraction process

- Chemical leaching: Many rare earth minerals are embedded in rocks and ores, requiring chemical leaching to extract them. This process involves the use of acids and other chemicals to dissolve the minerals from the surrounding rock. If not properly managed, the chemicals used in leaching can contaminate soil and water resources.
- Deforestation and habitat destruction: Mining operations often involve clearing large areas of land, leading to deforestation and habitat destruction. This loss of habitat can disrupt local ecosystems and threaten biodiversity.

Processing

- Chemical processing: Chemicals are used to separate and purify rare earth minerals from raw ore. This process generates large quantities of chemical waste, including toxic sludge and tailings, which can contain heavy metals and radioactive elements.
- Air pollution: Processing emits sulfur dioxide, nitrogen oxides, and volatile organic compounds. These emissions adversely impact human health and the environment.
- Water contamination: Wastewater from processing plants contains toxic chemicals and heavy metals that can accumulate in rivers, lakes, and groundwater, posing risks to aquatic ecosystems and human populations.

Waste disposal

- Tailings: Tailings from extraction and processing, if not properly managed, can leach harmful chemicals into the surrounding environment, contaminating soil and water.
- Radioactive waste: The processing of radioactive rare earth minerals, such as thorium and uranium, generates radioactive waste during mining and processing that poses serious environmental and health risks if not handled safely and securely.
- Health impacts: Exposure to pollutants from rare earth mining activities can result in adverse health effects for both humans and wildlife, including respiratory problems, neurological disorders, and increased cancer risks.

1. Packey and Kingsnorth, "The Impact of Unregulated Ionic Clay Rare Earth Mining in China."

equipment for permanent magnets.[102] Amid growing trade tensions in 2024, China outright banned all exports of gallium, germanium, and antimony to the United States, and in 2025 further tightened export controls over critical minerals vital for defense, electronics and energy applications.[103]

China's actions continue to be closely scrutinized by trade partners within WTO forums. International trade rules will remain an important tool for Western countries in responding to China's exercise of market power in rare earth elements and critical minerals.

3.4. Environmental, labor, and corruption issues

The environmental impacts of rare earth mining are significant. Producing one ton of rare earth oxide from ionic-adsorbed clays removes three hundred cubic meters of ground cover and soil, generates two thousand tons of tailings, and produces one thousand tons of wastewater containing heavy metals, often radioactive elements, and concentrated leaching chemicals.[104] With China's production quota at 240,000 tons of rare earths in 2023, the environmental impact of these numbers is staggering: 72 million cubic meters of disturbed ground, 480 million tons of tailings, and 240 million tons of wastewater. And these numbers do not account for the environmental impacts of illegal mining (see box).

China's rare earths industry has caused serious environmental pollution in nearly all nine provinces in which the industry primarily operates, and to all of China's major river systems.[105] China's largest rare earth mining operation, at Bayan-Obo near Baotou, Inner Mongolia, is an integrated complex of three open-pit mines with processing facilities, tailing ponds, and waste disposal. The Bayan-Obo deposit contains more than one hundred minerals, including fifteen rare earth minerals.[106] Nearly all rare earth ores contain thorium and other actinides. Radioactive elements and toxic chemicals expose workers during extraction and processing, and remain present in the tailing ponds—large artificial lakes—that allow pollutants to seep into the soil and water sources due to a lack of proper lining. The Bayan-Obo mine has polluted groundwater that will eventually pollute the Yellow River, China's second-longest river and a key source of drinking water for northern China.[107] Farms in the immediate area have experienced failed and mutated crops, and communities living near the mining operations suffer a variety of cancers and heightened mortality rates.[108]

Illegal mines, much smaller in size but numerous, are also a source of major environmental pollution. One example is in the city of Ganzhou, Jianxi province, where illegal and abandoned rare earth mines have caused soil, river, and groundwater contamination. Improper waste disposal and lax environmental regulations have resulted in the loss of wildlife habitat. Illegal mines have polluted more than one thousand rivers and streams in Ganzhou, which are tributaries of China's larger river systems. The most important of these are the Ganjiang River, which feeds the Yangtze River, and the Dongjiang River, a tributary of the Pearl River.[109]

Rare earth pollution of water and soil inevitably impacts food security, as seen in cases of river fish deaths, crop failures, and food contamination.[110] In 2011, China's General Administration of Quality Supervision found nineteen of eighty-five tea products contained excessive levels of toxic rare earths, including Lipton products produced and sold in China by Unilever, which determined that the rare earth metals had come from contaminated soil where the tea was grown.[111]

3.4.1. Human rights at home and abroad

The Rare Earth Industry Development Plan (2016–2020) specifically calls for the expansion of the rare earths mining industry in lower-income and indigenous communities. One of China's stated goals is to promote "win-win" outcomes, "promoting the transformation and upgrading of the resource real estate in-

102. Zhang, et al., "Key Changes and Updates to Chinese Export Controls in 2023"; Baskaran, "What China's Ban on Rare Earths Processing Technology Exports Means."

103. Ibid; Gracelin Baskaran, "What China's Ban on Rare Earths Processing Technology Exports Means," Center for Strategic and International Studies, January 8, 2024, https://www.csis.org/analysis/what-chinas-ban-rare-earths-processing-technology-exports-means.

104. Packey and Kingsnorth, "The Impact of Unregulated Ionic Clay Rare Earth Mining in China."

105. Xiang Huang, et al., "Protecting the Environment and Public Health from Rare Earth Mining," *Earth's Future* 4 (2016), 532–535, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016ef000424; Liu, "Rare Earths: Shades of Grey."

106. "Bayan Oro Rare Earth Mine," NS Energy, May 10, 2020, https://www.nsenergybusiness.com/projects/bayan-obo-rare-earth-mine.

107. Huang, et al., "Protecting the Environment and Public Health from Rare Earth Mining."

108. Cecile Bontron, "Rare-Earth Mining in China Comes at a Heavy Cost for Local Villages," *Guardian*, August 7, 2012, https://www.theguardian.com/environment/2012/aug/07/china-rare-earth-village-pollution; Charles Kilby, "China's Rare Earth Trade: Health and the Environment," *China Quarterly* 218 (2014), 540–550, https://www.cambridge.org/core/journals/china-quarterly/article/abs/chinas-rare-earth-trade-health-and-the-environment/9A4380F05DDCDFFF75BA75AAF795ED6E.

109. Liu, "Rare Earths: Shades of Grey."

110. Ibid.; Bontron, "Rare-Earth Mining in China Comes at a Heavy Cost for Local Villages."

111. Jamil Anderlini, "Lipton Tea Faces Safety Scandal in China," *Financial Times*, November 11, 2011, https://www.ft.com/content/378f686e-0c55-11e1-8ac6-00144feabdc0.

A laborer works at the site of a rare earth metals mine at Nancheng county, Jiangxi province. REUTERS

dustry" by "promoting poverty alleviation in old revolutionary base areas, poverty-stricken areas, and ethnic minority areas in resource areas."[112]

However, in a country that does not guarantee a safe and healthy environment for all, rare earth environmental pollution raises human rights concerns, especially when polluting activities occur in poor, marginalized communities of ethnic minorities. Mining pollution can lead to displacement and loss of health, life, and livelihood, exacerbating poverty and inequality. Additionally, environmental pollution invariably results in labor rights violations, which, in the case of rare earths, has included unsafe working conditions, child labor, and exploitation of indigenous populations.[113]

Significantly, the resource bases are established in Inner Mongolia and Sichuan provinces, which are provinces with high proportions of ethnic minorities. Further, China is exploring rare earth resources in Tibet, and state enterprises mine critical minerals in Xinjiang, forcing prison workers to work in hazardous mine operations.[114]

China's expanding Belt and Road Initiative investments are exporting China's environmental, labor, and human rights practices globally. The London-based Business & Human Rights Resource Centre has identified 102 allegations of environmental and human rights abuses occurring in Chinese overseas rare earth and critical element investment projects under the Belt and Road Initiative across Asia and the Pacific, Africa, and Latin America between 2021 and 2022. These projects included Chinese direct investment in the exploration, licensing, mining, and processing of rare earths, lithium, and other elements critical to the transition to clean energy. A total of

112. "Rare Earth Industry Development Plan (2016–2020)."

113. Packey and Kingsnorth, "The Impact of Unregulated Ionic Clay Rare Earth Mining in China"; "Unpacking Clean Energy: Human Rights Impacts of Chinese Overseas Investment in Transition Minerals," Business & Human Rights Resource Centre, July 6, 2023, https://www.business-humanrights.org/en/from-us/briefings/unpacking-clean-energy-human-rights-impacts-of-chinese-overseas-investment-in-transition-minerals.

114. Amit Chaturvedi, "China Finds Rare Earth Deposits Along 1,000-km Himalayan Belt: Report," NDTV World, June 22, 2023, https://www.ndtv.com/world-news/china-discovers-potential-reserve-of-rare-earths-in-himalayas-report-4144120; "Forced Labor in China's Xinjiang Region," US Department of State, July 1, 2021, https://www.state.gov/forced-labor-in-chinas-xinjiang-region.

thirty-nine Chinese companies were implicated. More than half of the allegations involved environmental harms, in which water pollution, loss of access to water, and damage to wildlife and species habitat were common, and more than two-thirds involve human rights abuses against local communities and attacks against civil society organizations.[115]

Seventeen developing countries host these projects, with the greatest number of allegations occurring in Indonesia, Peru, the Democratic Republic of the Congo, Myanmar, Zimbabwe, Serbia, and Argentina.[116] Similar reports of Chinese-owned illegal mines expanding to Malaysia have similarly resulted in pollution and human rights abuses.[117] In one highly publicized incident in February 2025, a tailings dam breach at a Chinese-owned copper-mining operation in Zambia caused the catastrophic release of an estimated 50 million liters of acid waste into Zambia's Kafue River. This breach poisoned the country's most important river as far as sixty miles downstream, instantly killing its ecosystem and impacting some 20 million people who depend on it for irrigation, fishing, and hydropower.[118] The developing countries hosting these projects are institutionally weak, having lax environmental laws, disenfranchising communities and workers from seeking redress through the courts or other mechanisms, and suffering high to extreme levels of corruption.[119]

Worse, in the cases of Myanmar and the Democratic Republic of the Congo, illegal mining might be fueling civil conflict, as Chinese operators of illegal mines pay bribes to corrupt civilian or military leaders to use the land and permit violation of environmental and labor protections, the proceeds of which may be used to finance weapons purchases.[120]

Due to its heavy rare earth element-rich soil and its proximity, Myanmar has been targeted by China's official and illegal mining operators. In Myanmar, China's state-owned China Nonferrous Metal Mining Group operates a rare earth Belt and Road project, and illegal Chinese-owned or Chinese-invested rare earth operations have been the subjects of reports of environmental damages and human rights abuses. Since China started cracking down on its own illegal mining industry, which was concentrated in southern China, illegal mining has been increasing in Myanmar's Kachin State, a conflict zone bordering China where the military has been accused of conducting a genocide of Kachin and Rohingya ethnic groups. Complaints include pollution of water, soil, and ecology, loss of endangered species and local livelihood, unsafe work conditions and extensive use of child labor, intimidation and harassment of local residents opposing mining, collusion with armed groups, and widespread corruption.[121] Rare earths produced in Myanmar are exported to nearby China for processing. China's regulation of its own industry appears to have caused the migration of illegal, low-cost rare earths extraction to Myanmar, extending China's official and unofficial rare earths supply chain.

3.5. China's domestic and international standards initiatives

Standardization can potentially expand China's influence in rare earths and critical minerals markets. China's government places great importance on standards development, both generally and specifically for rare earths, to achieve trade and regulatory objectives.

China's State Council has directed Chinese professionals to advance "China standards" to compete with or become international standards.[122] For rare earths, China's Rare Earth Industry Development Plan (2016–2020) calls for Chinese stakeholders to promote the internationalization of China's rare earth standards. Specifically, it mandates

> Focusing on the transformation and upgrading of the rare earth industry, strengthen the formulation of key rare earth standards, give full play to the role of enterprises, research institutions and intermediary organizations, enhance the influence of China's rare earth standards, promote Chinese standards to go global, and achieve the connection between domestic rare earth standards and international standards.[123]

To promote China standards, the State Council has directed its citizens to take leadership positions in international standards organizations, setting a goal of holding 50 percent of the leadership positions and technical committees of inter-

115. "Unpacking Clean Energy."

116. Ibid.

117. "From Malaysia to Myanmar: Paying a Price for World's Rare Earths Demand—Part 2/3: Power Scramble," CNA Insider, YouTube video, November 3, 2023, https://www.youtube.com/watch?v=HZaCzNlf7b0.

118. Kille and Zimba, "A River 'Died' Overnight in Zambia After an Acidic Waste Spill at a Chinese-Owned Mine."

119. "Unpacking Clean Energy"; "Corruption Perceptions Index," Transparency International, 2022, https://www.transparency.org/en/cpi/2022.

120. Maighna Nanu and Rory Wallace, "Increase in Rare-Earth Mining in Myanmar May Be Funding Junta," *Telegraph*, May 3, 2021, https://www.telegraph.co.uk/news/2021/05/03/increase-rare-earth-mining-myanmar-may-funding-junta; "From Malaysia to Myanmar."

121. "Unpacking Clean Energy."

122. "Five Year Plan for Development of the National Standardization System (2016–2020)," State Council, 89.

123. "Rare Earth Industry Development Plan (2016–2020)."

national standards organizations. The State Council explicitly recognizes that international standards organizations are a means to promote "China standards" by making "full use of" their leadership roles in international organizations, directing them to "absorb the strength of each party."[124]

In the case of rare earths, the Standardization Administration of China chairs two of the three International Organization for Standardization (ISO) Technical Committees developing standards relevant to rare earths and critical minerals—TC-298 for rare earths and TC-333 for lithium. Only TC-345 for specialty metals and minerals is not led by China.

China seeks to internationalize China's domestic standards to advance China's expansion in foreign investment under the Going Out policy and the Belt and Road Initiative. International adoption of Chinese standards enhances the reputation of China's companies, credentialling them in an apparent effort to associate "built to China standards" with quality. The State Council specifically directed that Chinese stakeholders engage in standards work.

> Establish a working mechanism for enterprises as the main body and relevant parties to participate in international standardization activities in collaboration, cultivate, develop and promote China's advantages, special technology standards to become international standards, serve our enterprises and industries Going Out.
>
> ***
>
> Deepen international cooperation in standardization. Actively play the role of standardization in supporting the "One Belt, One Road" strategy and promote connectivity among countries along the route in terms of policy communication, facility connectivity, and unimpeded trade.[125]

Beyond promoting Chinese companies doing business internationally, internationalization of Chinese domestic standards in the rare earths field extends the Chinese government's ability to influence the terms of trade. Chinese rare earths produced to internationalized standards will automatically enter world trade as compliant with prevailing standards. Chinese companies abroad can follow their customary practices and claim compliance with the accepted international standard. Conversely, countries importing Chinese rare earths will be obligated to enforce Chinese prohibitions on illegal rare earths production that cannot comply with these standards, thereby strengthening China's ability to influence international market prices for rare earths.[126]

3.5.1. Team China

Although China promotes a united approach to the internationalization of domestic standards, China's industry stakeholders may seek to advance their own competitive advantage through standards development.

According to China's Standardization Law, Chinese standards are divided into five categories: national standards, industry standards (sector or professional), local standards (applicable for province, autonomous region, and municipality levels), group standards (e.g., industry associations), and enterprise standards.[127]

While China's national, industry, and group standards are similar to international norms of standardization and generally support a degree of uniformity in practices across industry participants, local and enterprise standards are unique to China and are often used to advance parochial and commercial interests. Although local enterprise standards must not conflict, and must be at least as rigorous as applicable national compulsory standards, local and enterprise standards can be designed to codify certain conditions prevailing in a local area or require a proprietary process.[128] Notwithstanding the law's mandate to develop standards in a unified and transparent manner, China's five classifications of standards—especially local and enterprise standards—open the door to conflicting standards concerning the same subject matter among different levels of standards, localities, and even enterprises.[129]

In the cases of local governments and individual enterprises, the ability to adopt unique standards can be abused to block free competition in the marketplace favoring one region's or company's product. Indeed, when enterprises develop standards or when national or local governments initiate a standards-development effort for a technology, they are often developed by the leading company in the industry or particular technology for the purpose of protecting competitive advantage within both China's domestic market and export

124. "Five Year Plan for Development of the National Standardization System (2016–2020)."

125. Ibid.

126. Mancheri, et al., "Effect of Chinese Policies on Rare Earth Supply Chain Resilience."

127. "Standardization Law of the People's Republic of China," National People's Congress, May 17, 2017, Article 2, https://share.ansi.org/Shared%20Documents/News%20and%20Publications/Links%20Within%20Stories/China%20Standardization%20Law_English%20translation_SESEC_5.17.2017.pdf.

128. Ibid., Article 21.

129. Ibid., Article 5. The problem of conflicting standards was recognized in: "Notification Regarding Further Standardization Reform," State Council, 2015.

markets.[130] In the case of enterprise standards, these are largely internal standards, and may contain information that is regarded as trade secrets and, thus, not released to the public or outside the organizations.[131]

3.5.2. Transparency

The transparency and openness of China's domestic standard setting raises issues for how it might use its leadership positions in rare earths, lithium, and other areas.

In the United States and OECD countries, standards are meant to promote the goals of safety, reliability, and performance. Pursuit of these goals requires an open and transparent process.

The "Measures for the Administration of the China National Standardization Technical Committee" mandate that "A technical committee shall carry out work in a scientific, rational, open, fair, standardized and transparent manner."[132]

In practice, however, Chinese technical committees do not operate in an open or democratic manner but, rather, are often controlled by the dominant central state-owned enterprise.[133] Further, enterprise-level standards are by their nature secret, which reduces transparency and leads to the fragmentation of standards.

In this environment, perhaps unsurprisingly, China has failed to report thousands of its mandatory standards to the World Trade Organization as required by the terms of the accession protocol.[134]

When one departs from the pursuit of common goals like safety, lack of transparency is to be expected if standards development instead prioritizes the goals of a dominant state enterprise advancing its competitive advantage, "Team China" expanding its franchise across the developing world, or, worse, state enterprises evading regulation.

130. Craig Hart and Jiahui Ying, "Let a 100 Standards Bloom: Standards Setting for Carbon Capture, Use and Storage Technologies in China," US Department of Energy, 2017 (unpublished).

131. Ibid.

132. "Measures for the Administration of the China National Standardization Technical Committee," State Administration for Market Regulation 31, 6 (2020).

133. This statement is based on several interviews conducted by the author with members of Chinese standard-setting committees.

134. "Ninth Annual Transitional Review Mandated in Paragraph 18 of the Protocol of Accession of the People's Republic of China," World Trade Organization, 2011; "Trade Policy Review: China," World Trade Organization, 2011.

Laborers work at a site of a rare earth metals mine at Nancheng county, Jiangxi province. REUTERS

4. China's strategic goals, their implications, and the US response

China orchestrates a whole-of-government response, which encompasses the party, government at all levels, state-owned industry, state-owned or state-controlled policy and commercial banks, the military, industry, and research institutions. This cannot be readily matched by Western countries because they lack the control that China possesses through party leadership embedded throughout these organizations and direct ownership of industry.

China's efforts to ensure that its own rare earths demand is satisfied now and into the future, to nurture the expansion and protect the profitability of its domestic rare earths and rare earths-dependent industries, and, ultimately, to provide China with enduring technological superiority to ensure its economic and military competitiveness throughout this century. These have distorted the operation of global rare earth markets and enabled China to pursue its own foreign policy goals at the expense of the sustainable development and ethical governance of countries where China invests in mining projects—and to the detriment of the rules-based international order.

More specifically, the net effect of China's actions has been to shield China's domestic rare earth production from true market forces, sustaining market primacy through price setting and evangelization of Chinese-led supply chain standards; misallocate resources and damage the environment, both at home and in countries where it establishes mining operations; and enlarge China's position in economic competitiveness and foreign policy as directed by Beijing.

Critically, each facet of China's strategy has significant implications for rare earth markets, favoring China's own domestic industry and extending its influence over global rare earth supply chains, negatively affecting the economic and national security of the United States and its partners and allies.

4.1. Shielding domestic supply chain inputs and outputs from market forces

China's relationship to markets fundamentally differs from that of traditional market economies. In capitalist countries, market forces operate to set the prices for inputs and outputs, and, in doing so, allocate resources efficiently based on economic principles.

In contrast, China's state controls all domestic input and output prices to which central SOEs are exposed, shielding them from true market forces. In China, prices of key inputs are not determined by market forces but are instead negotiated among key government and industrial stakeholders, including the NDRC and its Pricing Department, the MIIT, and, in the case of rare earths, the major state-owned rare earth conglomerates. By controlling the supply chain from raw ore and processing equipment to processed metals and finished products like magnets, the government and industry players are able to use markets as a tool to pursue desired price outcomes as empowered by China's share of global markets. Beyond direct price setting, China can also use its Rare Earth Strategic Reserve to make purchases and sales in the open market that can raise or lower prices, giving priority of supply to China's state enterprises. This tool has an immediate benefit in that it permits China to tip the scales when needed to ensure that China's state enterprises out-compete Western competitors, yet it also affords Beijing considerable agility to adapt to new supply chain patterns and market conditions.

In markets in which China accounts for a small, non-controlling market share, the impact of Chinese protective pricing policies and subsidies is felt directly by Chinese consumers. But in rare earths markets where Chinese producers enjoy a controlling share of global production, Chinese state intervention in setting prices is passed onto consumers globally. Through price manipulation, China has altered the competitive playing field. By keeping rare earth prices unsustainably low through oversupply, new entrants struggle to compete against China's rare earth complex. Once competitors fail, China raises prices, exercising its oligopolistic market power. At other points, China has raised prices or constrained supply for geopolitical gain, such as with Japan in 2011 or the United States over the past two years.

Implication: China's dominance over the global rare earth supply chain shields it from the market instability that its competitors face and creates supply risks for countries that are, by necessity, overly reliant on Chinese supply chains. China's ability to influence prices and restrict supply or access to processing enables it to undercut emerging firms and counter Western efforts to stand up competitors. Consequently, it is improbable in the near term for Western supply chains to break free from dependence on China acting through market forces alone. The United States and its allies must effect a structural shift in global rare earths supply chains.

4.2. Evangelizing China-led supply chain standards

China's market supremacy also allows Beijing to propagate its practices, norms, and standards internationally, especially to Belt and Road countries in which China has invested in mining and supporting infrastructure projects.

Mining projects worldwide have historically been criticized for exploitation and environmental damage, but China's investments in rare earth and critical mineral extraction in developing countries involve particularly harmful practices that exacerbate environmental degradation, exploit labor, and fuel corruption. Environmentally, Chinese mining operations frequently disregard local regulations, leading to severe deforestation, water pollution, and habitat destruction. These practices not only threaten biodiversity but also endanger the health and livelihoods of local communities. Labor practices in these mining projects are often exploitative, with workers facing poor working conditions, low wages, and inadequate safety measures. Host governments are frequently either too weak to monitor and address harmful Chinese practices or complicit in them. China's involvement in these sectors is frequently marked by corrupt dealings, where local officials are bribed to overlook violations and grant favorable terms, undermining governance and perpetuating economic inequality.

Examples of China's practices in rare earth mining include the following.

- China's rare earths industry and China's larger mining industry have been major polluters of local communities throughout China, often in the poorest regions, contributing to poverty and preventing these communities from raising themselves out of poverty.
- China's policies of expanding rare earths to ethnic minority regions, especially regions such as Tibet and Xinjiang, raise human rights concerns when these industries requisition land and pollute communities.
- Illegal mining, both domestically and in countries where China is investing, is propagating environmental disasters internationally. In the cases of Myanmar and the Democratic Republic of the Congo, illegal mining is fueling civil conflict.[135]

A second emerging theme is Beijing's growing leadership in industrial standard setting across the rare earth element supply chain. This leadership is driven by China's significant investments in rare earth extraction and processing technologies, human capital, and intellectual property within the rare earths sector. Beijing is actively leading global standard-setting efforts governing rare earths through the ISO, attempting to shape international norms for a wide range of rare earths issues, including product quality and testing procedures, as well as supply chain governance, traceability, transparency, and sustainability. China's leadership role in standard setting will enable it to define the future of the global rare earth element market.

As a consequence, Beijing is able to use its existing leadership of the supply chain to establish "rules of the road" that secure and reinforce its dominant position into the future, while also limiting scrutiny of Beijing's conduct in the supply chain. It is

135. Nanu and Wallace, "Increase in Rare-Earth Mining in Myanmar May Be Funding Junta"; "From Malaysia to Myanmar."

essential that the United States and its allies fully engage in international standard-setting proceedings in order to ensure the integrity of resulting standards.

Implications: Due to China's dominance in standard-setting and foreign mining projects, its leadership on supply chains will remain entrenched even if the West manages to diversify supply chains. New market entrants will still be vulnerable to the rules, norms, and prices dictated by China.

Therefore, diversifying sources for rare earths is insufficient for countering China's dominance in rare earth element supply chains. A more comprehensive approach is essential to truly increasing security, including reforming market governance to ensure fairness, investing in human capital, and establishing more robust multilateral norms around labor, transparency, and environmental protections.

4.3. Assuring competitiveness in industrial and foreign policy

Finally, China's control over rare earths and other critical minerals supply enables China to use these resources as a tool of economic statecraft for geopolitical gain, both generally in pursuit of its broad foreign policy goals and specifically to ensure industrial competitiveness. Several examples already point to this, the most notable of which was China's embargo of rare earth exports to Japan in 2011 following a dispute over the Diayaou-Senkaku islands. More recently, in 2019, China threatened to leverage rare earths by restricting their export during a trade dispute with the United States. In 2023, China escalated matters by imposing a series of export restrictions on germanium and gallium equipment for rare earth separation and processing, and equipment for manufacturing permanent magnets in response to export controls on high-value semiconductors by the United States, Japan, and the Netherlands. In 2024 and 2025, China further restricted export of critical minerals vital to defense, chip manufacturing, and other industries.

Given the importance of rare earth elements to vital technologies for advanced manufacturing and military applications as well as for dual-use technologies, China's controlling share in these metals, its efforts to restrict access to technologies for separation and processing of these metals, and its restrictions on export of technologies for the manufacture of critical end products such as permanent magnets give China leverage over industries that are critical to future US and allied economic competitiveness and national security. The use of rare earth elements in permanent magnets makes them critical for electric motors essential not only for electric vehicles but also for wind turbines, advanced robotics, aerospace applications, and military technologies like precision-guided munitions. All of these applications are crucial to the future of transportation, renewable energy, industrial growth, and national security. Even ordinary domestic priorities, such as job creation in the manufacturing sector, are vulnerable to Beijing's decisions over the production and distribution of rare earth elements.

China ensures that a large share of rare earth-related manufacturing remains within its borders through a two-tiered tax and pricing system for rare earth elements that offers lower costs for domestic manufacturers. This approach promotes an investment-driven economy, in contrast to the consumption-driven models of most advanced Western economies. Additionally, by keeping rare earth manufacturing within its borders, China maintains economic leverage by being deeply integrated into global supply chains, thus serving both its domestic and foreign policy objectives.

As the world transitions to a net-zero energy system, China's state-sustained control over the rare earth elements supply chain and competitive advantage over downstream intermediate product manufacturing ensures that it will retain a larger global share of advanced manufacturing. China's position affords it a robust strategic buffer in its decision-making in international affairs, such as if it adopts a more aggressive stance in the South China Sea or toward its policy of reunification with Taiwan. When responding to these challenges, advanced economies will be forced to consider the economic toll of being separated from China's rare earth complex, highlighting the formidable system of economic leverage China has constructed through long-term strategic, state-driven investment.

Implications: China's control over rare earths supply could be used to its advantage in a confrontation with the United States or its allies. This leverage could be wielded in a trade war, in a direct armed conflict, or to influence the United States' response to a third-party crisis, such as one in the Taiwan Strait. This scenario remains a significant concern demonstrating the urgent need for supply chain diversification.

The implications of China's leverage are profound and far reaching. Without countermeasures, China's dominance will continue to shape global supply chains and geopolitical dynamics, posing significant risks to economic and national security interests in the United States, European Union, and beyond. Moreover, if China's dominance in rare earths is not countered effectively, the longer-term risks of China controlling the United States and allied energy transition is stark—China could dictate the pace and terms of the global shift toward sustainable energy, entrenching its influence over critical future technologies and potentially exercising economic leverage over global energy markets more broadly.

4.4. Response

China's successes in rare earths are worthy of study, and perhaps even emulation, where serviceable. In emulating China's state-led policies, however, a key part of the United States' strategy must be to "do better," especially in areas of environment and worker protections, and as investors in foreign countries.

Responding to China's domination of rare earths requires the United States and allies to develop their own long-term strategy. These efforts should focus on three priorities to secure the rare earths supply chain, including

- investment in diverse and resilient supply chains;
- technological leadership across the value chain in extraction processing, developing substitutes, and recycling; and
- the sustainability of the energy transition in terms of resource management, governance, and environmental or worker protections.

4.4.1. Diversifying rare earths supply chains

- Counter China's expansion in foreign investment by forming alliances and offering alternative investment options to countries with rare earth deposits committed to sustainable development of those resources, and adopt extraction, processing, and waste-management practices that are safe for workers, surrounding communities, and the environment. An approach that champions rule of law and human rights principles and accords with corporate environmental, social, and governance principles will best secure host country support, laying the groundwork for responsible partnerships that provide sustainable benefits for host countries and local communities.[136]
- Promote investment of patient capital in rare earths. The Minerals Security Partnership—established in 2022 by the United States, European Union, United Kingdom, Australia, Japan, India, and other countries—offers the potential to support coordinated investment in sustainable production and procurement, and collaborative research, that can form the basis of a financially sustainable response to counter China's market dominance.
- Build on the re-shoring and friend-shoring movement, establishing a rare earths supply chain supported by investing in a coalition industrial ecosystem that drives demand through high-value, high-volume downstream manufacturing, for products including wind turbines and electric vehicles, which require rare earths for motors, drive trains, batteries, electronics, and hydrogen storage. This action will ensure that consistent offtake is available for rare earth supply projects located outside of China and outside of the governance of Chinese entities.
- Establish coalition government procurement commitments and facilitate private-sector supply agreements to help ensure that supply-side cooperation is supported by sustained demand. The procurement system should be designed to ensure that domestic and coalition demand supports allied suppliers at reasonable cost, utilizing the United States' system of national defense contracting as a model, in order to ensure that the industry can survive market manipulation or other offensive pricing strategies. Building procurement around government and private demand for rare earths can help stabilize diversified mining ventures.
- Establish a system of rare earths reserves among the United States, partners, and allies in the event of extended emergency or trade crises. Reserves can also help moderate Chinese price manipulation. An allied reserve system should focus on the high-value heavy rare earth elements and other critical minerals that are vulnerable to supply shortages with significant economic impacts.
- Enhance non-rare earth value chains to broaden the rare earths extraction ecosystem and increase opportunities for the retrieval of rare earths as byproducts of other mining and production processes.

4.4.2. Back up supply chain diversification efforts with competitive financial commitments

- Commit significant financial resources, including equity and debt financing, to support acquisition of rare earths and critical minerals assets, ensuring a timeline competitive with China. China's Belt and Road Initiative lending and grants exceeded $1.3 trillion from 2000 to 2021 across all sectors. In the mining sector alone, China entered into 284 unique lending transactions or grants valued at $90 billion in investment in mining and processing, increasing to $198 billion, counting related infrastructure (in 2021 constant dollars).[137] These figures do not include foreign investments made by China's state-owned industry or China's domestic investments and subsidies to its critical minerals industries. Additionally, China-financed foreign infrastructure projects required only 2.7 years to issue loans, in contrast to World Bank and regional multilateral development bank lending requiring five to ten years to reach financial close.[138] The Belt and Road Initiative's vast scale, speed in lending, and rapid impact have made China the wor-

136. For example, application of the Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America (the Escazu Agreement) to rare earth extraction projects will require changes to mining practices in mineral-rich Latin America that protect human rights and accord with ESG principles. See: Owen Pell, "The ESG Triangle: How Lithium Mining in Latin America Could Point the Way Toward Long-Term Environmental and Social Value Strategies," in Sophia Kalantzakos, ed., *Critical Minerals, the Climate Crisis and the Tech Imperium* (Berlin: Springer, 2023).

137. Author's analysis based on the AidData Global Chinese Development Finance Dataset 3.0.

138. Parks, et al., "Belt and Road Reboot."

ld's largest official creditor to the developed world, conferring tremendous influence with the Global South.

Meeting China's challenge and diversifying supply chains will require a substantial commitment of financial resources, including equity and debt financing, deliverable on a time frame competitive with China.

4.4.3. Technological leadership across the value chain

- Substantially increase investment in R&D in rare earths, rare earth substitutes, and technologies reducing the use of rare earths, on either a US or coalition basis in which R&D efforts are coordinated and innovation is shared among its members.
- Establish collaborative rare earths research programs, bringing together US and coalition country universities, national laboratories, and industry to conduct research and development of extraction, processing, recycling, and waste-management technologies across all of the seventeen rare earths elements, with the goal of improving both cost and environmental performance.
- Invest in recycling and reclaiming critical minerals in onshore facilities, enabling the exploitation of the large volumes of rare earths and critical minerals embedded in existing products, rather than exporting materials back to China as scrap.

4.4.4. Secure a sustainable and well-governed energy transition

- Develop and adopt international standards for rare earths and critical minerals extraction and processing, concerning the pollution of land, water, and air, along with waste management and worker safety. The International Organization for Standardization's Technical Committee 298 for rare earth elements and Technical Committee 333 for lithium have established a joint working group dedicated to developing such standards.
- Streamline approval time and reduce investment risks for appropriately sited and designed extraction and processing operations, while strengthening site selection and standards at home and abroad.
- Support China in shuttering its illegal rare earths trade by working to block illegal imports, which undermine prices for all producers alike, conditioned upon China increasing transparency and cooperating in bringing its rare earth industry into compliance with trade and environmental norms domestically and abroad.
- Implement a sustainable approach to rare earth investment in developing countries that screens the almost six hundred rare earth deposits based on economic and environmental sustainability standards, only developing sites that can be selected and then designed to avoid and reduce environmental harms and protect ecosystems.[139]

139. Golev, et al., "Rare Earths Supply Chains."

5. Conclusion

Starting at least as early as the 1980s, China recognized in rare earths an opportunity to gain significant global economic and geopolitical influence. Through a concerted, whole-of-government strategy, including the natural advantage of holding one-third of rare earth reserves, China overtook the United States in rare earths production. China now dominates the entire rare earths value chain and—through ongoing planning, policymaking, and investing domestically and abroad—China has made clear it intends to further deepen and broaden its already firm grip on the sector and in associated advanced technologies.

China's unrivaled position in rare earths and the leverage this provides have profound implications for the energy transition, energy security, and, relatedly, national security both domestically and globally. The United States and its allies and partners must respond with their own robust, assertive vision and long-term strategy. This will require countering the highly effective, reinforcing aspects of China's strategy that shield its domestic industry from true market forces, propagate its standards and practices internationally (particularly those that harm the environment and communities), and leverage its supply chain dominance to achieve China's industrial and foreign policy objectives.

To compete with the complicated and massive rare earths apparatus that China has built over decades, the United States must mirror aspects of China's approach with a methodical, long-term, encompassing strategy of its own. It must invest heavily with partners and allies in resilient supply chains, a system of reserves, and research and development on all aspects of rare earths, including substitutes, to gain technological leadership that counterbalances China's dominant position. Where the United States must diverge from China's approach is through an uncompromising insistence on improved stewardship of the environment and protection for workers and communities where rare earths are mined. In this way, the United States can become a standard bearer, leader, and partner of choice in the responsible development of rare earths resources, their usage, and the energy transformation.

If the United States and its allies fail to take these actions to counter China's dominant position in rare earths, China will not only control these vital minerals, but will also hold a potentially decisive advantage in the technologies of the future.

Appendix: Selected rare earths policies

2002 NDRC Notice on Issuing the "Interim Regulations on the Administration of Foreign Investment in Rare Earth Industry"

Ministry of Commerce (2008) Technical Guide for Export of Rare Earth New Material Products
(出口商品技术指南稀土新材料制品)

Several Opinions of the State Council on Promoting the Sustained and Healthy Development of the Rare Earth Industry (National Development and Reform Commission 2011 No 12)
[国务院关于促 进稀土行业持续健康发展的若干意见 (国发 (2011) 12号]

Ministry of Environment (now Ministry of Ecology and Environment) (2011) GB 26451-2011 Emission Standard of Pollutants for Rare Earth Industry (稀土工业污染物排放标准)

2012 Notice of the MIIT on Checking and Governing Rare Earth Illegal and Violating Acts

Opinions of the General Office of the State Council on Accelerating the Construction of Important Product Traceability Systems (Guobanfa [2015] No. 95)
[(国务院办公厅关于加快推进重要产品追溯体系建设的意见) [国办发 (2015) 95号]

2015 Notice on Implementing the "Reform of Rare Earth, Tungsten and Molybdenum Resource Taxes on Ad valorem Tax."

2015 Evaluation Index System of Clean Production in Rare Earth Smelting Industry

2015 MIIT "Access Conditions for Rare Earth Industry"

National Mineral Resources Plan (2016–2020), [全国矿产资源规划（2016－2020年）]

Regulations of the Ministry of Industry and Information Technology [2016] No. 319: Rare Earth Industry Development Plan (2016–2020)
[工信部规 (2016) 319号: 工业和信息化部关于印发稀土行业发展规划（2016－2020 年)]

Notice of the State Council on the Publication of "Made in China 2025"
[国务院关于印发 (中国制造2025) 的通知]

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