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An Economic Perspective

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Abstract

This paper reassesses current anxieties about Critical Minerals (CMs), arguing that the dominant geopolitical narrative substantially overstates China's "weaponization" of its export position. Although China holds a large share of global CM mining and an even larger share of processing, these policies reflect standard Public Choice logic for a near-monopolist seeking to capture surplus through supply restrictions and higher prices. Episodes often described as geopolitical retaliation have been rare (though increasing) and economically limited. Comparing CM dependence to past commodity dependencies—especially oil—current risks are far smaller in macroeconomic terms, given the low import value of CMs relative to total trade. Using elasticity analysis and historical experience, we argue that market forces are already driving diversification and new supply. Fears that China's dominance poses a major long-run economic threat are thus overstated. Government responses—typically subsidies, tariffs, or strategic interventions—are costly and mostly unnecessary, except in narrowly defined military uses with limited substitution. Cross-national evidence indicates that China's behavior is typical of states with strong market power.

1 Introduction

"The Middle East has oil; China has rare earths"

(Deng Xiaoping)

Critical Minerals, or rare earths, are ubiquitous in our daily life. The benefits for increased productivity, and a cleaner environment are many. Additionally, many critical minerals (hereafter CM) are also used in military hardware as well as other dual-use technologies, including AI.[1]

[1] We adopt the term "critical minerals" (CM) to refer to a subset of mineral commodities that have acquired strategic, economic, or technological importance. Section 5 has a detailed discussion of the various definitions and lists by major countries. The Appendix presents the various minerals listed by country in tabular form.

While demand for various CMs has rapidly expanded across a wide range of industries, a large share of the mining and even larger share of the processing occurs in a single nation, China. As such, nearly all high-income countries are dependent on China for these CMs. This creates increased geopolitical risk to supply chains, and, of course, national defense concerns. While this dependency is in the headlines now, this it is not new. Awareness came to the forefront of the media in the wake of heightened political tensions between Japan and China in 2010 and a subsequent spike in the prices of certain CMs and short-term shortages. Japan is not the only one to experience such tensions: Australia, the US, the EU and others have all felt the pressure from the leverage China can employ in this key sector. Chinese exports of CMs are often seen as a weapon of trade and diplomacy. Chou (2025) from the Hudson Institute states that China,

"*…has long used its control over critical minerals and rare earths as a geopolitical weapon…*"

Though one cannot deny the important role CMs now play in geopolitical tensions, we feel that the interpretations have overstated China's use of its exports as a tool in international relations and forgotten or overlooked the greater motivation for Chinese government behavior, which began long before the rare earths tensions in 2010. Also, the current dependency on CMs has similarities but also stark differences from other resource dependencies, in particular, oil.

As argued in this paper, most of the actions taken by the Chinese central government can be best explained by standard tools in economics when a state is in the position of monopoly or near-monopoly control of a commodity. Narratives that frame China as having weaponized and politicized CM exports, either to punish or retaliate, are generally only correct in very recent years, and even when true, are typically quite small in scale and impact.[2] Such narratives are, in our view, all secondary in nature to the main goal: *to capture and monetize a portion of the non-pecuniary consumer surplus through restricted supply and higher prices for CM.*

In the second part of our analysis, the standard tools of economic analysis, namely, demand and supply elasticities, will be applied together with historical experience, to examine previous dependencies on other commodities. After first examining past dependency on oil, and its evolution throughout the 1980s, 1990s and up until the present day, the evolution of demand and supply responses in *lithium*, a prominent CM, will be examined to better assess the likely trajectory of this and other CMs. It appears that for the most part, market forces of supply and demand have responded and will continue to respond to allay most, if not all, of these fears. As such, governments intervention, often through wasteful subsidies, tariffs or other tools should be considered with a healthy skepticism.

Before proceeding to the analysis, it is important to note that the value of critical minerals as a share in total imports is somewhat small, both in absolute and relative terms. For example, the quantity of US oil imports peaked in 2005 and was valued at 264 *billion* dollars of petroleum products per year (source: fred.stlouisfed.org). In contrast, the US imported "only" 44 *billion*

[2] We will often use the term "China" to mean the Chinese government or some branch of it, unless otherwise described as a Chinese firm, industry, consumer, *etc*.

dollars worth of CMs in 2024.[3] While this figure is large and growing, it is still less than one-sixth of the US's peak imports of oil. Moreover, this *is only about 1% of total US imports* which are over *4 trillion dollars per year*. Contrast this with the late 1970s, where petroleum products accounted for as much as 15-20% of total US imports (Anderson, 1980).

The remainder of the paper is as follows. Section 2 gives a brief summary of the geopolitics of critical minerals. Section 3 provides more detailed summaries of critical minerals in several key suppliers in the industry, including China, but also Chile and others. Section 4 summarizes some responses taken by the governments of major importers to this critical mineral "threat". Section 5 describes the nature of the various critical minerals as defined by major countries around the world and then briefly discusses their role as an input in production, conceptually falling between pure energy such as oil, and specialized parts in a global value chain.

Section 6 contains the main analysis. This comes in two parts. First, the tools of Public Choice are applied to explain the rationale for China's restrictive critical mineral policies. The second half of Section 6 uses fundamental concepts of demand and supply to argue that while dependency on Chinese critical minerals is still high, it will likely not stay this way for long. This decline will largely occur with or without government actions. Section 7 summarizes the paper and offers some modest policy recommendations.

2 The Geopolitics of Critical Minerals

In this Section, a brief overview of the geopolitical literature on critical minerals is provided. For clarity, both the **alarmist** and the **moderate** discourses will be distinguished (albeit artificially).

First, at the **alarmist** level, the rhetoric often relies on hyperbole. Ivanov *et al.* (2025) claim that "Whoever controls critical minerals controls the global economy." STRATFOR (2019) proposes an even stronger assertion: "China and the United States engage in both a trade war that may soon be resolved and a tech war that will continue for decades."

These claims merit our scrutiny, even though a definitive judgment will only be rendered by historians in the distant future.

Is the first claim —that dominance over a subset of raw materials translates into control over the global economy— credible?

A historical perspective is necessary. As will be seen in Section 6, there is a certain commodity cartel that has —temporarily exerted— substantial influence over the world economy (and undeniably on world politics), namely OPEC (or OAPEC, to be precise). However, it would be an exaggeration to claim that OPEC has ever "controlled" the global economy.

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[3]Snoussi-Mimouni and Avérous (2024).

Indeed, although OPEC still commands over 75 percent of proven crude oil reserves and approximately 40 percent of global production, its influence has often been undermined by internal disagreements (*e.g.* Iran versus Iraq) and —even more damaging— strategic non-compliance (also known as 'shirking'). Furthermore, the geographic diffusion of oil reserves and the accelerating transition toward renewable energy sources are steadily eroding OPEC's structural power (Siripurapu and Chatzky 2022).

The second claim —that China and the United States are engaged in a trade and tech war (the latter lasting possibly for decades)— is even more complex to assess.

A frequently cited remark, attributed to Deng Xiaoping in 1992, encapsulates China's strategic posture: "The Middle East has oil; China has rare earths" (China National Radio 2007). This means that, very early on, China perceived its rare earth (and critical minerals) reserves as both economic and geostrategic assets.

Today, China accounts for approximately 70 percent of global rare earth production and, notably, nearly 90 percent of processing capacity (Ivanov *et al*. 2025). The longevity of this dominance is uncertain. Historical precedent suggests that monopolistic control over strategic commodities and technology typically provokes countermeasures. This is the "tit for tat" from the Mercantilist era in Europe (pre-Adam Smith), when "Governments also prohibited the export of tools and capital equipment and the emigration of skilled labor that would allow foreign countries, and even the colonies of the home country, to compete in the production of manufactured goods." (LaHaye 2025).

So, should China seek to weaponize its mineral advantages through export restrictions or non-market interventions, the likely result would be higher prices, which would incentivize new entrants, stimulate technological changes, and lead to the ensuing supply chains diversification — echoing the global response to OAPEC's attempts at market control in the 1970s (see Section 6).

On the other hand, the **moderate discourse** adopts a more careful tone. The geopolitical argument, in its most neutral form, goes as follows. First, the demand for rare earth elements is growing (for various reasons: technological changes, energy transition, *etc*.). Second, China is the dominant supplier, but faces a growing domestic demand which will constrain its future exports. Third, the US "will likely need to proactively intervene in the market to shift production dependence away from China." (STRATFOR, 2019). It is thus mainly about China (*vs.* the rest of the world).

This moderate discourse is analytically grounded. It avoids hyperbolic claims about "global domination" and forever "tech wars" mentioned in the alarmist approach. Instead, it emphasizes the importance of diversification, resilience, and autonomy.

A more detailed geopolitical analysis must also consider structural barriers. Two of them are often overlooked: first, regulatory and institutional constraints, and second, persistent market opacity.

Regulatory and institutional constraints often delay or block new mines and refineries. In developing countries, policy instability, corruption, and regulatory delays deter investment. Even in Canada, complex permitting involving federal, provincial, and Indigenous consultations makes projects costly, uncertain, and slow. Consequently, large, experienced, Canadian mining firms often redirect their capital to more accommodating jurisdictions (sometimes with disastrous results!). The Canadian firm 'Hudbay Minerals' learned this the hard way.[4]

Market opacity presents the second structural barrier. Many critical mineral markets lack transparent and standardized pricing and sourcing mechanisms. This complicates the investors' risk assessment.

In the case of lithium, for instance, the International Lithium Association (ILA, 2024) notes that "there is a perceived lack of price transparency in the market since the contracts are not public. This hinders the ability of investors to assess the risks and returns related to new projects." The gradual maturation of these markets brings a ray of hope. The ILA notes: "It should not be a surprise to learn that as the lithium market has expanded, new pricing mechanisms are emerging to cater to greater market liquidity.[5]

To summarize, whether in **alarmist** or **moderate** terms, the geopolitical approach to critical minerals remains overwhelmingly concerned with China. The **alarmist** view tends to overstate the implications of Chinese dominance, while the **moderate** discourse, though more pragmatic, often pays too little attention to institutional constraints and market opacity.

3 Further Geopolitical Considerations on China and Other Countries

China plays a central role in the geopolitics of critical minerals. Its position as the dominant producer, processor, exporter, importer, and consumer is central to this paper's analysis. However, there are other countries, besides China, where critical minerals play an important geopolitical role.

This Section delves deeper into China's recent geopolitical actions, then proceeds with a brief survey of three other countries (the Democratic Republic of Congo, Chile, and Mongolia) and the risks they pose.

3.1 *A Deeper Look at the Geopolitical Position of China*

China's rare earth dominance has long attracted scrutiny and geopolitical concerns. Yet, as will be argued in Section 6, claims about China's "strategic use" of CMs are overstated. Before analyzing China's motives, this Section reviews the origins of the trade frictions that surfaced more than 15 years ago and summarizes the state's dominant role in controlling CM output and sales—a system established well before the mid-2000s trade disputes.

Rare earths came into the global spotlight during the alleged 2010 suspension of rare earth exports to Japan by China. Many suggested that these Chinese actions were in response to a fishing boat

[4] "Hudbay settles longstanding lawsuits related to Guatemala nickel mine" (www.mining.com 2024b).
[5] Section 6 will briefly examine the lithium market.

incident near the disputed *Senkaku* islands, a constant source of tension between China and Japan.[6] The story made a splash in the headlines and opinion columns of the New York Times and elsewhere.[7] This narrative has persisted. STRATFOR (2019) asserts that "China halted exports of rare earth ores, salts, and metals to Japan." The accuracy of this claim has been questioned, however.[8]

Early analysis of the Japanese import trade data suggests that, in fact, no such dramatic change (Smith and Armstrong 2013) occurred. Evenett and Fritz (2023) have also used detailed trade data from 2010 to 2019 and examined whether China selectively disrupted rare earth shipments to G7 countries and Australia. They concluded that, contrary to popular belief, Australia—not Japan—experienced the most significant declines in monthly Chinese rare earth exports over that period.

Nonetheless, one point is not disputed: China *did* impose export quotas. As Evenett and Fritz emphasize, "One matter is not in dispute as the facts were hashed out in disputes taken to the WTO: China *has used export quotas* and other export restrictions on Rare Earths" (2023, emphasis added).

But, in fact, China had been gradually restricting exports to Japan and the world *well before* that flare up. In seems that at least some in the media were aware that restricting exports was not new. An article in Japanese in the major newspaper the *Asahi Shimbun* dated Sept 30th, 2010 admits that China had been slowly restricting CM exports from at least 2008, *two years before the incident* (*Asahi Shimbun* 2010).

Notably, the 2010 incident also occurred before the rise of President Xi Jinping, who assumed office in 2013. During this earlier period, the Chinese leadership —from Jiang Zemin (1989–2002) to Hu Jintao (2003–2013)—had already introduced significant shifts in China's approach to its rare earths policy (Ministry of Land and Resources of the People's Republic of China 2008). These shifts have arguably intensified under Xi's more assertive geopolitical strategy. Whether these leadership changes are relevant is beyond the scope of this paper.

What may not be common knowledge to most casual observers of the rare earth trade friction saga is that management of a production cartel in CMs by the Chinese state started in the *1990s.* This active management by the state continues to this day. Export restraint policy is merely an *extension* of a much larger production restraint policies (akin to any cartel, such as OAPEC).

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[6] The collision on the high seas occurred on Sept 7th, 2010. The islands are referred to as *Diaoyu* in China and *Diaoyutai* in Taiwan.

[7] The western media seems to have taken up this narrative as early as Sept 23rd, 2010. From the New York Times, "*…Sharply raising the stakes in a dispute over Japan's detention of a Chinese fishing trawler captain, the Chinese government has blocked exports to Japan of a crucial category of minerals….Chinese customs officials are halting shipments to Japan of so-called rare earth elements, preventing them from being loading aboard ships at Chinese ports, industry officials said on Thursday."* (Bradsher 2010)

[8] Western authors such as Krugman (2010) wrote on the story in mid-October and strongly opined that the Chinese government explicitly or implicitly imposed export controls in response. Interestingly, Chinese sources tend to deny any specific Chinese response to this incident and attribute the origin of this narrative to the Japanese media (Wu 2010).

According to a very detailed report by the US Congressional Research Service (Morrison and Tang, 2012), since the early 1990s,

"…*the Chinese central government has been developing production plans for strategic commodities, including rare earths*" and "*China's Ministry of Land and Resources (MLR) issues production quotas to provincial governments, who then assign quotas to individual mining companies under their jurisdictions*."

Again, from Morrison and Tang, p. 13,

"*The Chinese central government has long envisioned a highly consolidated domestic rare earth industry controlled by a few large state-owned firms, which would enable the government to take control of the sector, specifically, to rein in 'oversupply' in the global market and stop price wars among the smaller suppliers in China."*

The overall goal since the 1990s was to create a government-led cartel in which it generally succeeded. For a brief period of time, the state actually subsidized (through export rebates) the exports of some rare earths, though in 2005, these rebates were rescinded. In the years that followed, various export licenses, export quotas and eventually export taxes were implemented to curb exports further. Export licenses were given to fewer and fewer firms, export quotas became stricter, and export taxes were first implemented in 2007 at 10% and rose, for some products to 25%. So, by the time the Japanese boating incident occurred in 2010, export restraints were deeply entrenched into China policy.

In recent years, China has ramped up its use of export controls as geopolitical tools. For example, on July 3, 2023, the Ministry of Commerce (MOFCOM) and the General Administration of Customs (GAC) announced new restrictions on the export of gallium, germanium, and related chemical compounds. As of August 1, 2023, all exporters must obtain licenses from MOFCOM before export (Wang and Zhang, 2023). New (albeit very narrow) restrictions on certain CMs to certain countries continue to this day.

While these actions made the headlines, *the economic impact thus far has been negligible* (Hendrix, 2024). It seems that these actions are more to gain diplomatic points than to inflict any real damage to the US or its allies. And, of course, deeper export restrictions would typically hurt the Chinese producers as much as the importing nations abroad that were targeted.

There is, of course, the broader challenge of *enforcing* export controls or sanctions. Hufbauer *et al.* (2009) *inter alia* have found that trade sanctions often fail to meet their objectives in a meaningful way due to either poor design or poor implementation.[9]

[9] See Hufbauer *et al.* (2009) for a comprehensive review of over 170 sets of sanctions around the world over the past 50+ years.

Industries have strong incentives to find alternative trade routes. For instance, Godek (2025) found that significant quantities of germanium are exported through indirect trade routes.[10] She noted that when Chinese exports of germanium to the US dropped to zero, exports to Belgium increased by approximately 224% in 2024 compared to 2022. The decline in exports to the US was nearly equivalent to the increase in exports to Belgium. She concluded that: "*China does have the ability to cut its exports, at least on paper, as evidenced by its zero reported exports to the United States. However, backdoor third-country channels have apparently allowed critical minerals to continue to flow to the United States*."

As noted above, China's policies towards CMs started *well before the US-China trade* war and before rare earth prices spiked in 2010. Recent actions to restrict germanium to the US are merely the frosting on the cake of a 30-plus year policy by the Chinese government, not of merely restricting CM exports, but rather a web of restrictions on overall output of these commodities in which they have acquired such a commanding market position.

Some may argue that these restrictions of CMs are done so as to give domestic champions such as BYD (a leading EV maker in China) a competitive advantage in EVs in the global market. This is very unlikely, or at least it is far from the main motivation. This is for two reasons. First, the actual costs of rare earths as a share of total production costs of EVs are tiny. Estimates for the cost of rare earths in an EV are "…less than a hundred dollars".[11] Since EV costs are in the tens of thousands of dollars, this will not give Chinese producers any cost advantage. The second is that these policies (to restrict exports of rare earths or CMs) began *before* BYD and others started selling EVs. BYD sold its first Hybrid plug-in 2008 and it first 100% EV in 2009, well after the export (and more importantly, production) restrictions began (Balfour 2008).

To be sure, the Chinese government will want to ensure that makers like BYD have a "steady" supply, thus the long-standing policy of curbing exports to make sure there is enough to meet domestic demand. But this is not massive industrial policy. It is a fine-tuning of a 30+ years policy of managing CM supply in China.

So, yes, the Chinese government, since 2008 at least, has been restricting exports. But this must be seen within the larger goal, which has always been to (optimally, from the government's point of view) to *limit total supply, not just exports*.

3.2 *Other Selected CM Exporting Countries and the Global Geopolitical Landscape*

When it comes to critical minerals, China is not the only country playing a vital role. Several other developing countries also possess significant reserves of critical minerals. Their geopolitical weight and impact vary widely. In this Section, the stance of three other countries towards its

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[10] China restricted germanium sales to the US late in 2024 (Baskaran and Schwartz 2024).
[11] See Owen (2024). Contrast this with the $7500/car subsidy the US was giving for EVs under the Biden administration.

critical minerals, namely, the Democratic Republic of Congo (DRC), Chile, and Mongolia will be examined.

The DRC accounted for 76% of global cobalt production in 2024 (USGS, 2025, p. 63). Approximately one-third of all cobalt is used in EVs to help increase energy density and maintain thermal stability.[12] However, governance risks and institutional weaknesses in the country (and its 26 provinces) discourage investment and limit long-term supply security. Therefore (and paradoxically) it is the DRC's political fragility that confers it its geopolitical importance.

On a different register is Chile, which holds (as of 2024) the world's largest known lithium reserves (Minerals Security Council [MSC], 2025, p. 111).[13] It is the second-largest global producer after Australia. In 2023, the Chilean government announced plans to *nationalize lithium production*. By 2024, a state-controlled entity was formed in partnership with the publicly listed Sociedad Química y Minera de Chile (SQM). The new joint venture is majority-owned (50 percent plus one share) by the state-run National Copper Corporation (CODELCO). Chile's President Gabriel Boric said that this initiative would "boost its economy and protect its environment" (Villegas and Scheyder 2023).[14] However, as McDermott (1999, p. 55) observes, this is a "monopoly creation to provide a stream of government revenue" which is a form of "fiscal mercantilism".

While China's Ministry of Land and Resources did not outright nationalize the critical minerals mining or processing firms, they did establish and still enforce an output cartel in critical minerals. This is effectively the same as a monopoly, and as will be argued in section 6, China and Chile's goals are essentially the same, *i.e.* "monopoly creation to provide a stream of government revenue".

Our final country example, Mongolia, combines weak institutions (as in the DRC) with "fiscal mercantilism" (as in Chile).[15] The government has made repeated amendments to the Minerals Law, introducing considerable legal and regulatory uncertainty. The latest amendment, adopted in April 2024, imposed *retroactive provisions* such as "non-compensated state participation," increased the mineral tax rate from 10% to 30%, and established state ownership quotas ranging from 34% to 50% for strategic mineral deposits (Articles 5.4 and 5.5, Dashnyam Partners LLC 2024). Here, not unlike the DRC, the geopolitical importance of Mongolia lies in its regulatory uncertainty.

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[12] Substitutes technologies for cobalt do exist and are growing. Also, among the CMs, cobalt has a fairly high rate of recycling, of about 15% (IRENA, 2024).

[13] Chile, Argentina and Bolivia are all part of the "Lithium Triangle." While Chile has the most production by far, all three have huge, untapped reserves. Bolivia's lithium is *entirely* owned and controlled by a state-owned company, the Yacimientos de Litio Bolivianos (YLB) under its Law 928 (IEA 2022); Argentina's lithium is more open to foreign investment (including Chinese investment), though certain rights go to provincial governments.

[14] China also invoked an environmental rationale for its defense in its WTO case on rare earth export constraints in 2012.

[15] Mongolia has an abundance of minerals (copper, gold) and fossil fuels (coal), most of which are exported in their raw form to China. As for rare earths, Mongolia is producing and exporting molybdenum (a critical mineral used in aerospace and green technology) and a few others, but it also has huge reserves of other (e.g. lithium) untapped, critical minerals. (USGS Minerals Yearbook 2023)

The main message of this Section is that, as the global demand for critical minerals grows, geopolitical risks—ranging from production (and export) restrictions (China), to resource nationalism (Chile), and institutional weaknesses (involuntary in Congo and 'planned' in Mongolia) — are influencing industrial strategy in both developed and developing economies.

4 Reducing the West's Strategic Dependence

In recent years, various industrialized countries have introduced a series of policy initiatives aimed at lessening their strategic dependence. These initiatives represent a response to China's dominant position in global critical mineral markets. They show a growing awareness of the geopolitical and economic drawbacks associated with concentrated supply chains. Several national policies are reviewed below.

4. 1 *Canada*

First, **Canada** launched its *Canadian Critical Minerals Strategy* in December 2022. After highlighting that "Canada is in the extremely fortunate position of possessing significant amounts of many of the world's most critical minerals as well as the workers, businesses and communities that know how to scale up our exploration, extraction, processing, manufacturing and recycling of those minerals." (Canada, 2022, p. 1), it stated its 'Vision' to become a leading global supplier of "responsibly sourced critical minerals and support the development of the domestic and global value chains for the green and digital economy."

The Canadian strategy is backed by CA$4 billion (approximately US$2.9 billion) in federal funding (Canada 2022, p. 2). Among its two main pillars are the "robust Strategic Innovation Fund" (p. 22) and the introduction of "tax incentives to stimulate mineral exploration" (p. 20).

4.2 *The European Union*

At the **European level**, the *Critical Raw Materials Act* (CRMA) was formally adopted by both the Council of the European Union and the European Parliament in April 2024 and entered into force the following month. The CRMA "sets benchmarks for domestic capacities along the strategic raw material supply chain to be reached by 2030: **10%** of the EU's annual needs for extraction; **40%** for processing, and **25%** for recycling. No more than **65%** of the EU's annual needs of each strategic raw material at any relevant stage of processing should come from a single third country." (European Commission 2024)

4.3 *The United Kingdom*

The **United Kingdom** unveiled its first *Critical Minerals Strategy* in 2022, with a scheduled review in 2025 by the incoming Labour government. "The strategy focuses on enhancing the resilience and security of the UK's critical mineral supply chains through diversification, innovation, and international partnerships." (UK Government 2022-2024).

4.4 *Japan*

After the 2010 “fishing boat incident”, **Japan** undertook significant efforts to reduce its reliance on Chinese rare earths. Barely a month after that incident, it established a JPY 100 billion (approximately US$1.2 billion) fund aimed at strengthening the various supply chains. This initiative included “five main pillars”: reduce the use of rare earths, invest in alternative technologies, promote recycling, secure overseas resources, and finally expand strategic reserves. As a result, “Japanese dependence on Chinese rare earths dropped from 90% at the time of the incident to 60% today. The consumption of rare earths in Japan is now half the level of what it was then” (Terazawa 2023).[16]

4.5 *The Multilateral Level and the G7*

At the **multilateral level**, the *Minerals Security Partnership* (MSP) is a broad international coalition comprising Australia, Canada, Estonia, Finland, France, Germany, India, Italy, Japan, Norway, the Republic of Korea, Sweden, the United Kingdom, the United States, and the European Union (represented by the European Commission). The MSP promotes intergovernmental coordination in foreign affairs, energy, mining, trade, and export finance (US Department of State 2025).

The MSP also engages with a wider circle of “countries with significant mineral reserves and those that aspire to move up the critical minerals value chain” (*ibid*)—designated as the “MSP Forum”. “Current members of the MSP Forum include Argentina, Democratic Republic of Congo, Dominican Republic, Ecuador, Greenland, Kazakhstan, Mexico, Namibia, Peru, Philippines, Serbia, Türkiye, Ukraine, Uzbekistan, and Zambia.” (*ibid*)

Finally, at the June 2025 **G7 Summit**, the leaders—while refraining from directly naming China—“recognize that non-market policies and practices in the critical minerals sector threaten our ability to acquire many critical minerals, including the rare earth elements needed for magnets, that are vital for industrial production.” (Canada 2025) In response, the G7 intended to “support the development of responsible critical minerals projects through direct partnerships with each other and by promoting private sector investment.” (*ibid*) These measures include “anticipating critical minerals shortages, coordinating responses to deliberate market disruption, and diversifying and onshoring, where possible, mining, processing, manufacturing, and recycling.” (*ibid*)

This brief overview indicates that some national policies are more aspirational than others. While some countries are focused on immediate results (*e.g.* Japan), others appear to prefer multilateral cooperation, dialogue, and joint initiatives. Here, we can look to history for precedents. Following the oil shocks in the 1970s and high dependence on Middle East oil, the wealthy importing nations created the International Energy Agency (IEA) in 1974 to act as a counterweight to OAPEC’s market power. Like the IEA, it remains to be seen whether a multi-government response will have

[16] This is, however, a contested statement. Fan, Omura and Roca (2023) and Armstrong, Solis, and Urata (2025) find, looking at the data from a different angle, that Japanese dependence has not fallen very much at all.

any success in reducing its dependence on a few dominant CM suppliers, or whether it will be market forces that make concerns today largely irrelevant.[17]

5 On the Concept of "Critical Minerals"

As seen in the previous Section, OECD countries have adopted institutions, frameworks, or outright policies to counteract the growing dependency on China, but also other countries. Time will tell whether such government-led efforts will succeed. But more than government intervention, as in global oil, market forces react in relatively predictable ways and over a fairly short time frame, such that what may have been a concern was overblown.[18] Section 6 will analyze current production and trade in CM markets through this economic lens. But first, CMs and their features as an input into production will be discussed.

In general, economists do not pay particular attention to the specific characteristics of the various commodities they study. They often abstract from mentioning goods, referring to them instead as "widgets" (a generic term) or, in the case of a composite basket of goods, as a "Hicksian composite commodity" (named after the British economist John Hicks). This simplification can lead to generalizable insights into markets, consumer behavior, and policy impacts. However, this abstraction proves unhelpful for our study. The specific characteristics of the commodities under consideration— the *critical minerals*—are not incidental; they are central to the problem at hand.

As briefly stated in the introduction, the term "critical minerals" (CM) is used to refer to a subset of mineral commodities that have acquired strategic, economic, or technological importance.

Over the past fifteen years, many countries have developed formal lists of critical minerals, typically also including the seventeen rare earth elements (REEs) and the six platinum-group elements (PGEs).

Unsurprisingly, there is no universally accepted or 'definitive nomenclature' for *critical minerals*. Rather, the classification of a mineral as "critical" varies by country, reflecting differing national priorities, industrial structures, and security concerns. For instance, uranium is considered critical in Japan but not currently by the US, and certainly not by the European Union. Conversely, molybdenum appears on Canada's critical list but not on that of the EU. The Appendix presents a comparative overview of national critical mineral lists. These reveal significant inter-country

[17] The IEA was established in 1974 and two of its original goals were to reduce oil dependency and the use of its emergency response preparedness system. The latter is a collective action arrangement where members states oil reserves can be called on to offset or otherwise stabilize oil supply disruption. According to the IEA, it has been used five (5) times, though the first of the five times was only in 1991 following the first Persian Gulf war (Iraq's invasion of Kuwait). This is 17 years after the IEA was founded. See https://www.iea.org/about/oil-security-and-emergency-response.

[18] At least for the US and Japan. In a sense, continental Europe (esp. Germany) switched its dependency from Middle East oil to cheap Russian oil. It benefitted for over two decades but is now paying the price for that dependency (Wintour 2022).

variation in nomenclature, underscoring the importance of national context, industrial structure, and geopolitical outlook in shaping mineral policy.

The example of uranium also illustrates a second key feature of *criticality*: it changes over time. Successive revisions of national lists tend to expand in scope, a trend shaped not only by shifting technological demands but also by policy incentives.

The designation of a mineral as “critical” is extremely valuable. Such a designation often allows access to various forms of government support, which might include fiscal incentives, public investment, and a favorable regulatory environment. Mining firms and downstream industrial actors whose operations involve minerals listed as critical are therefore direct beneficiaries of such public policies.

For example, President Biden invoked the 1950 *Defense Production Act* in March of 2022 for lithium, nickel, cobalt, graphite, and manganese for use in batteries in EVs and other ‘large-capacity batteries’ (Biden Whitehouse Archives 2022). In June 2025, President Trump also invoked the same *Act* to waive various legal requirements to “…help boost domestic production of critical minerals…” (Scheyder and Renshaw 2025).

The European Union and Japan have implemented similar measures, offering direct subsidies and other financial incentives to stimulate their critical minerals supply chains.

The *rationale* behind a country’s nomenclature for classifying a mineral as critical generally falls into two broad categories.

The first primarily relates to national security, a criterion prominently emphasized in US policy.

The second concerns the role played by a particular mineral in *selected* supply chains, particularly the ones related to emerging technologies such as electric vehicles, renewable energy systems, electronics, semiconductors, and advanced defense equipment.

When considering whether a mineral is critical in their nomenclature, governments look at factors such as the geographic distribution of reserves (domestic or foreign), import dependency, the reliability (or unpredictability) of foreign suppliers, and the availability (or absence) of viable substitutes.

At its core, the concept of criticality may be captured by a single economic notion: endowment. This applies to both net importers and exporters of minerals. For example, Japan’s designation of the seventeen rare earth elements and cobalt as “critical” is the direct consequence of its high dependency on these “inputs” for batteries, magnets, and other advanced technologies. In contrast, Canada includes potash and zinc on its list—not because of domestic consumption needs, but because it is a major producer and exporter of both.

Despite variation in national nomenclatures, one peculiarity stands out: virtually all of them include the seventeen rare earth elements and the six platinum-group elements.

Interestingly, the "rare" earths are not geologically scarce. As the US Geological Survey notes, "The rare earths are a relatively abundant group of 17 elements composed of scandium, yttrium, and the lanthanides." (USGS, *Rare Earths Statistics and Information*). The "rare" designation reflects not their abundance in the earth's crust, but the technical and environmental challenges associated with their extraction and, more importantly, their processing.

In recent years, China has not only dominated the mining of rare earths and other CMs but has also sought to tighten control over processing and refining technologies: for instance, in 2023, it imposed a ban on rare earth processing technologies (Liu and Patton 2023).

The technological capability to refine ('extract') CMs has itself become so strategic that one might refer to it as the "18th rare earth element." The economic logic applied to mineral commodities should likewise extend to *critical technologies* along the value chain.

6 On the Economics of Critical Minerals or "*Ipsa Historia Repetit*"

Having outlined the geopolitical dimensions of critical minerals, the analysis now turns to the economic aspects. As previously noted, supply-side actors—primarily China, but also countries like Chile—have, under various pretexts, imposed restrictions or limitations on output. Both demand and (alternate sources of) supply have responded and continue to respond. Sub-section 6.1 analyzes the behavior of state-controlled monopolists who are interested in maximizing pecuniary revenue(s) rather than what is best for society as a whole using the economic tools of Public Choice and microeconomic theory. Sub-section 6.2 will examine how markets have reacted when such cartels exert market power and raise prices. Elasticity will be used to analyze supply and demand responses. What emerges is a pattern of behavior that is, for the most part, rational and predictable. In this respect, the historical precedent of the oil crises beginning in the 1970s proves to be very relevant. Sub-section 6.3 briefly discusses, compares and contrasts CM use in the private and public (i.e. defense) spheres.

6.1 *Suppliers: A Public Choice Perspective*

We first examine the supply side of the market from a Public Choice and microeconomics framework. Spindler (2002) provides a Public Choice perspective on trade restrictions (tariffs, quotas, *etc*.) that is helpful to understand the current critical minerals strategy of China.

He starts with a traditional partial equilibrium (see Figure 1 below), with price (P) represented on the vertical axis (and measured in $ per unit), a horizontal axis measuring quantity (per time), a standard downward sloping demand curve, and a constant marginal cost (representing the competitive, constant return, horizontal supply curve).

Equilibrium is achieved when demand intersects with supply, and marginal cost equals price. The equilibrium output is q_c, and the equilibrium price is p_c.

In this initial scenario, the total welfare is equal to the consumer surplus (which is given by the triangular area under the demand curve and bounded by the horizontal supply curve and the vertical axis). The rectangular area under the marginal cost (p_c) and bounded by the vertical axis and the equilibrium output (q_c) is both the total revenue and the total cost.

While consumer surplus is a conventional welfare metric used in standard "welfare analysis" in economics, Spindler emphasizes its *notional character*: it lacks monetary representation and is not recorded as part of national accounts.[19] As he notes, "it would be nowhere counted as part of net wealth" (Spindler 2002, p. 24). Nevertheless, it is expressed in comparable units (*e.g.* dollars).

The introduction of output restrictions—whether through production quotas, or monopolistic rights or even export quotas—alters this equilibrium. China's Ministry of Land and Resources' coordinated and controlled restraint of the critical mineral producing firms' output detailed in Section 3.1 is a perfect example of this theory in practice. For expositional clarity, Spindler assumes a halving of output in the post-restriction regime. The new equilibrium entails a higher price (p_m, with $p_m > p_c$), reduced quantity (q_m, with $q_m < q_c$), and a redistribution of welfare. Whereas in the initial condition, it was assumed that the supplier or suppliers had no market power, we now assume that single firm or a few firms acts as a monopoly or cartel. As argued earlier, China's management of CM output functions essentially like a cartel. Now, Price is no longer equal to MC (the initial perfect competition case), but rather, the monopoly sets quantity where Marginal Revenue is equal to MC. The dotted line represents the MR curve in the monopoly case.

Crucially, during this process of restricted output and higher process, some or all of the consumer surplus is transferred to the owner of the tariff/quota/monopoly rights. There is also a net welfare loss for society as a whole (consumer and producer), as the loss to the consumer is less than the gain to (monopolistic) producer. This societal loss is the so-called "deadweight loss" (*a.k.a.* the Harberger Triangle, named after the famous American economist Arnold Harberger). This loss is represented by the triangle in Figure 1 whose base is the length q_m to q_c.

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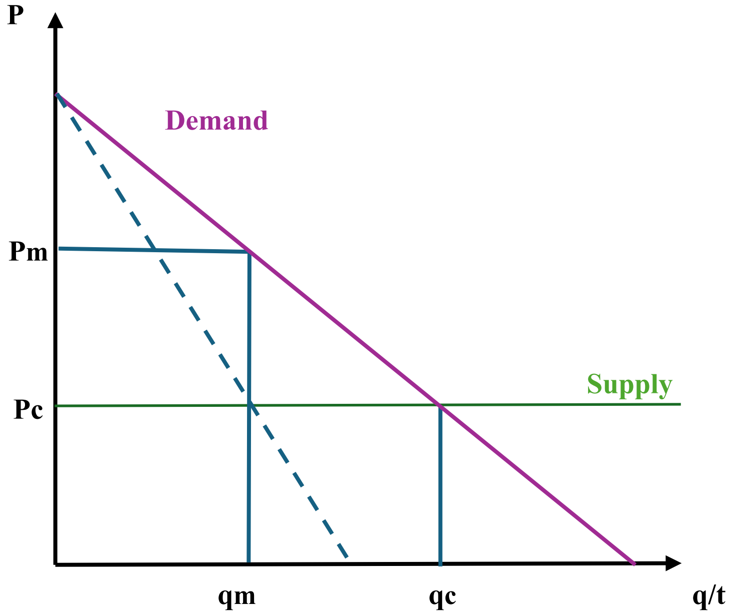
[19] Consumer surplus (and Producer Surplus) are fundamental concepts in the so-called welfare analysis in economics. Consumer Surplus, loosely speaking, represents the difference between a consumer's willingness to pay and the price actually paid (and then aggregated across the quantity purchased by all consumers). Simplifying a bit, we could say that if a person's maximum willingness to pay for a certain good was $100, but the market price was $60, their Consumer Surplus would be $40. If the price falls further, say to $50, their total Consumer Surplus would increase by another 10 dollars. But, of course, they do not actually receive $10. This is what Spindler means by a "notational" gain or increase, rather than a pecuniary gain such as profits of a firm or revenue for the government.

Figure 1: Diagram for section 6.1 (based on Spindler, 2002)



Spindler notes that government-imposed output restrictions capture and transform some consumer surplus (which, as he reminds us, is *notional*) into tax revenues or profit for domestic producers, or some combination (Spindler 2002, p. 27). Further, measured, *taxable* wealth is increased in the process. Consumers, whether they be foreign or domestic, are worse off. But this loss of the Consumers, since it not monetary and does not enter in the GDP, may be ignored by the government running the monopoly/cartel as well. Some private citizens may, however, benefit from the restricted output of the monopoly/cartel if they own shares in the firm or are otherwise "factor" owners. That is, if those that supply labor to (*i.e.* work for) the cartelized firms may enjoy higher wages.

Using the redistributive implications of these restrictions, we can now use his framework to understand China's (and Chile's, as we will see) rare earth policy.

Before output restrictions are imposed by China, the consumer surplus from rare earth extractions is accrued to foreign and domestic (Chinese) consumers. At that stage, the Chinese government and Chinese mining firms and any citizens (as share (or factor) owners of the rare earth mining companies) do not benefit.[20]

[20] Prior to output restrictions, the government does not benefit at all. The mining firms will only receive "normal" profits, just making enough to pay market prices for their factors (capital, labor, *etc*.). There will be no monopoly profits or "rents", as they are often called in economics.

Thus, Chinese output (and concomitantly, any trade restrictions) restrictions are a rational, *wealth-maximizing* behavior which have three consequences:

First, *a redistributive effect*: they transfer a part of the consumer surplus to the Chinese state (and to some extent to Chinese citizens as factor or share owners of the mining and/or mineral processing firms).

Second, the *monetization* of the *notional* consumer surplus: they capture and transform a part of the consumer surplus from a *notional* concept into *tax revenues*.[21]

Finally, *a market rationalization*: These output (and trade) restrictions largely eliminate the pre-cartel price competition amongst Chinese mineral firms, and therefore avoids the previous (pre-cartel) "race to the bottom" in prices which squandered of producers' surplus. This is because the cartel, through its allocation of output quotas is essentially creating fixed market rights for each firm. (Spindler and de Vanssay 2000, p. 8).

These interventions, while redistributive, also raise complex questions regarding their longer-term impact on technological competitiveness and dynamic comparative advantage. A full treatment of those issues is beyond the scope of this Section.

Viewed through Spindler's framework, output and export restrictions (in the Chinese case) or a nationalization (*e.g.* Chile, see Sub-section 3.2) serves to capture and monetize a share of the consumer surplus from various rare earths (in the Chinese case) or lithium (in the Chilean example), which never showed up in the national accounts (GDP) and was previously dissipated through market competition of the firms.

In doing so, China (or Chile) adopt a *de facto* monopolistic approach that enhances their national welfare, narrowly defined, albeit at the expense of global, and often domestic, consumers.

Such policies may also generate positive spillovers for other producers that should not be discounted. From the literature on partial cartels, we know that output restrictions by a major producer can raise world prices, thereby benefiting even non-cartel producers (d'Aspremont *et al.*, 1983). Thus, China's restrictive policies today are planting the seeds for their supply competitors of tomorrow.[22]

Nonetheless, the standard issues concerning the efficiency of state-owned, or otherwise state-controlled (via the state-led cartel) enterprises and the potential for rent-seeking behavior remain ever present.

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[21] Either through direct output taxes which are often employed on natural resources, or simply higher tax revenues from the higher profits made by the firms under the higher price and lower output regime of the restrictive cartel.

[22] Some observers claim that China engages in global predatory dumping to maintain its monopoly, "*For decades, China has used the tactic of dumping excess critical minerals onto the market to drive prices down to force mining companies in the rest of the world out of business to eliminate any competition*" (Kim and Madhani 2025).

Viewing state-led CM policies through this lens is often more useful and powerful than merely focusing on the effect on global exports. The primary goal is to restrict output and maximize monetary wealth. Selective export controls are secondary and subservient to this primary goal.

6.2 *Demand and Supply Responses*

In response to unreliable suppliers—whether at the production or processing stages—along with export restrictions, price opacity, selective embargoes, and other restrictive practices, importers and consumers of critical minerals have started to strengthen their supply chains and reduce their dependencies. This reduction in dependency flows through several channels as will be seen below.

Strategic Dependencies and Historical Context

Even though it has been more than fifty years, the 1973 oil crisis and the lessons learned from that episode remain highly relevant to the present analysis.

After the October 1973 Yom Kippur War and US military support for Israel, the Organization of Arab Petroleum Exporting Countries (OAPEC) imposed an oil embargo on the US, while also cutting deliveries to the EEC, Japan, and Canada (Office of the Historian, accessed July 15, 2025; Schramm 2024, p. 59). The embargo lasted until March 1974, driving oil prices from $2.90 to $11.65 per barrel (Federal Reserve History, accessed on July 15, 2025).

The parallel with critical minerals is striking: a dominant supplier reduces, or threatens to reduce, deliveries to Western countries that have become structurally dependent on those resources.

Interestingly, during the 1973 oil crisis, EEC member states failed to coordinate a common response to address the oil supply emergency. The formation of the International Energy Agency (IEA) in 1974 was a response, but the IEA was largely ineffective in this role as discussed in Section 4. A similar institutional shortcoming also became evident in 2022 with respect to the 2022 natural gas crisis (post-Ukraine invasion), when the European Union "s*truggled to find a common crisis response and largely refrained from supranational cooperation and capacity-building to deal with the energy challenges. Their failure to overcome collective action problems led to suboptimal policy outcomes*…" (Schramm 2024, p. 67).

Thus, meaningful responses to these supply shocks did not originate from collective political action or rhetorical displays of Western solidarity. Rather, they emerged through slow economic adjustment processes (including trial and error)—where *market mechanisms*, new supplier incentives, and long-term technological shifts played a central role. As we shall see, economic logic unfolded *over time*.

Elasticities and Substitution: Demand Side

We start with the standard concept of elasticities.[23] In his well-known study, Cooper (2003) estimated both the short-run and long-run *price elasticities of demand* (PED) for crude oil in 23 countries. He found that all estimated short-run elasticities for oil demand were highly price-*inelastic*, but that all long-run elasticities were much larger. For example, for the US, Cooper found the short-run price elasticity for the US to be -0.05 (very inelastic) but in the long run, this rose eight-fold to -0.45. Empirical studies for energy, but also other more mundane goods, typically find that long-run price elasticities are much larger, *i.e.* far more responsive. Consumers and firms do not suffer high prices forever. In energy markets, consumers reduce use of costly sources, substitute cheaper ones, and improve efficiency. At the same time, firms try to meet that demand by developing alternative products, or more efficient products which use the expensive good. All of this increases the responsiveness and ultimately decreases the demand for the original product.

Substitution generally involves replacing one critical mineral by another mineral (critical or not). However, for economists, substitution may hold a deeper meaning. An industry may invest more in new technology (and therefore *less* in new mineral acquisitions), so that in the end, each 'widget' is produced using less (critical) minerals and more technology. This industry has *substituted* technology for critical minerals.

The analogy with 1973 oil crisis is obvious. Over time, car makers produced more economical cars, with ever more sophisticated internal combustion engines. They *substituted* technology for oil consumption. Today, automakers are developing electric motors that use fewer—or even eliminate—rare earth magnets (Reuters 2021). Even so, these results confirm that price sensitivity and substitution exist across sectors. Industry experts concur that substitution will continue for most rare earths (Gardiner *et al*., 2024).

Cooper, whose study spanned from 1971 to 2000, also estimated *income* elasticities of demand for oil, *i.e.,* the percent increase in consumption for a one percent increase in income or GDP. He found they were around unity (1.0) for the US and other countries. This has been fairly constant over time, but here too, we find that the income elasticities for oil and other fossil fuels have fallen. A recent study by Helmi *et al.* (2024) estimated the income elasticities of oil demand in 21 OECD countries and found them to be, on average a very low 0.12. Other studies have found somewhat larger income elasticities, but all of them have unity as an upper bound. For example, Narayan and Smyth (2007) estimated the income elasticities for a panel of countries to be 1.01, while Dargay

[23] There are many types of elasticities in the economics literature. Fortunately, a general, actionable, definition is available: an elasticity measures the % change in the dependent variable divided by the % change in the independent variable. So, when calculating an elasticity, the first step is to identify the dependent and independent variables. In the case of the Price Elasticity of Demand (PED), the quantity demanded depends on the price level. So, the quantity demanded is the dependent variable and the price level the independent variable. Similarly, in the case of the income elasticity of demand (IED), the quantity demanded is the dependent variable and the income level the independent variable.

and Gately (2010) reported an income elasticity of 0.80. Liddle and Parker (2022) estimated the income elasticities for oil to be slightly less than 1.0.

While there are few careful elasticity estimates for CMs, there are many estimates for other non-fossil fuel minerals. Fernandez (2018), for example, estimated income elasticities of seven major metals—steel, aluminum, copper, lead, nickel, tin, and zinc— She found that, except for steel (the only metal above that is *not* a CM), the income elasticities were generally less than one. This means that as income goes up by one percent, the demand for a *specific* mineral goes up by less than that amount. This is a strong indication that substitution (due to technical change, for instance) is possible and can unfold over time. Also, greater efficiency in use of the input can reduce consumption of the energy or mineral despite rapid income growth.[24] However, as we will see below with lithium (a CM) and other CMs, the income elasticity tends to first be much *greater* than one, but then falls to less than one, or even *negative*. But first, we will discuss market responses on the supply side.

Reducing country-specific dependence: The Price Elasticity of Supply (PES)

In addition to the above responses by consumers to high and volatile CM prices originating in China, new suppliers of the *existing* CMs are also emerging as alternative, non-Chinese, sources. This will bring about: 1) a reduction in high prices through a direct reduction of monopoly power and; 2) a reduction in the dependency on and vulnerability to a single country. High prices should draw out new sources of supply, but the speed of the response is unclear. This information is captured in the price elasticity of supply (PES) --- the percent increase in supply to a 1% percent price rise.

In other well-studied extraction industries such as oil and natural gas, the PES in the very short run, say, one month, is virtually zero (Kilian 2022). However, in the long run, the PES is much larger. Estimates of US price elasticities of supply of natural gas by the US Energy Information Administration, for example, were found to be 0.11 in the short-run (months) and 0.50 in the longer-run (several years) long-run US. Of course, over a long enough horizon, the PES will be over unity or even infinite as alternate sources come 'online', with some long run estimates as high as 6, for example (Vipin 2014).

Historically, the price elasticity of supply was having an impact in the 1970s. In response to high oil prices, offshore oil in the North Sea and the Gulf of Mexico became economically viable (along with advances in drilling technologies, spurred by the high process) in 1975. In the longer run, alternative sources with new technology, for example, from Canadian "oil sands" become viable.[25]

[24] The IEA and others find that the US generally achieves "2% energy intensity improvement" each year. See the IEA's energy intensity tracker at: https://www.iea.org/data-and-statistics/data-tools/energy-efficiency-progress-tracker last accessed November, 13, 2025.
[25] Like offshoring drilling, extracting oil from the "sands" in Canada began the late 1960s, but was not really economically viable until another technologically revolution occurred in 2001 (Cross 2021).

Establishing new mining and processing sites for CMs involves overcome numerous, onerous and time-consuming regulatory barriers. This is true for fossil fuels as well, but more so for CMs, which also must be processed, another phase with huge regulatory hurdles as well as NIMBY concerns.[26] The US abandoned its critical minerals processing industries years ago, for cost considerations (China can do it much cheaper), but also due to environmental regulations and "NIMBY" considerations, more generally. While it is unclear exactly how long it will take for additional full-scale mining and processing to come "online" in the US and elsewhere, this is already occurring in lithium as will be discussed below.

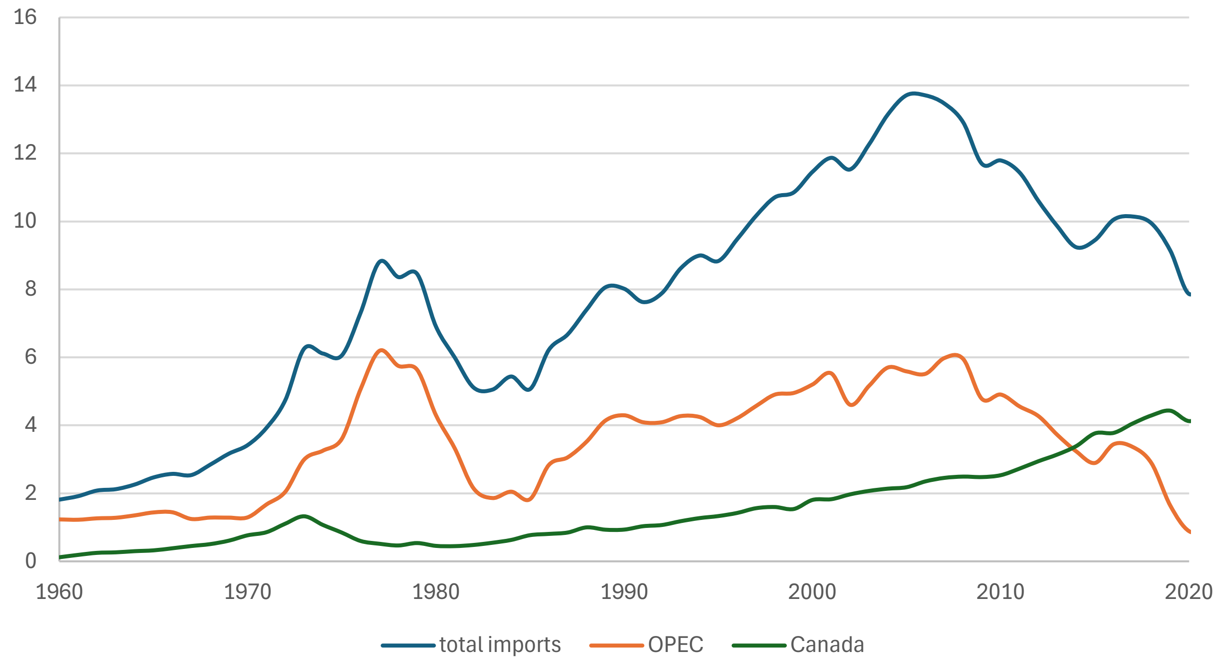
The historical market response in global oil

If we look at the most important energy commodity, oil, overall demand for energy has risen as GDPs around the world grow and many emerging economies are now as energy-hungry as the US, Japan and Europe. But this huge increase in *energy* demand has been met, thanks to the emergence of substitute sources of energy (nuclear, natural gas, coal, renewables, …). As a result, the IEA (International Energy Agency) noted (IEA 2025, p. 13), "Oil's share of total energy demand fell below 30% for the first time ever, 50 years after peaking at 46%." Higher oil prices eventually led to a reduction in demand. This is also occurring in the various CM markets as will be discussed below.

Following the 1973 oil crisis, non-OPEC members (Canada, US, Norway, *etc*.) ramped up oil production (undoubtedly benefitting from the cartel's 'supply management' effort, see d'Aspremont *et al.*, 1983). As we can see in Figure 2, while dependency on OPEC was nearly 70% for US (and similar figures for other OECD members) in the 1970s, this dropped sharply to a low of 36 or 37% in the early 1980s, mainly due to offshore oil. Imports rose as the economy continued to grow, but dependency only rebounded to 45% or so for the next 20 years.

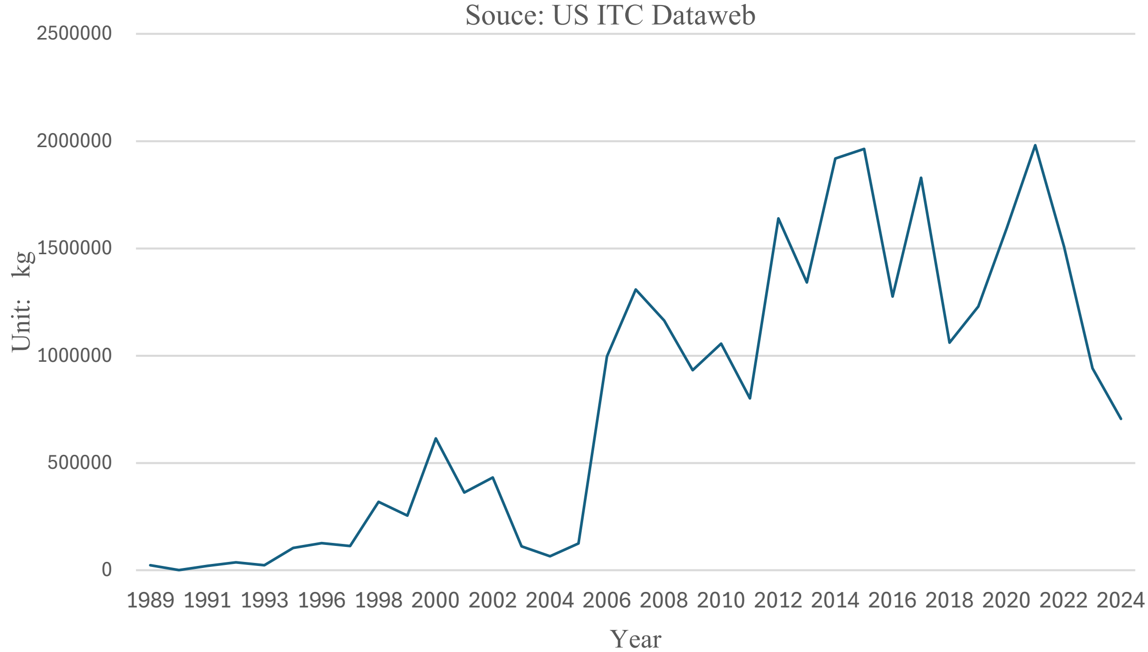
[26] Crude oil must also be processed, but unlike the processing of CMs, North America has no shortage of oil refining capacity.

FIGURE 2: US Petroleum Imports (millions bbl/day)
data source: www.eia.gov



OPEC dependency dropped even further in the mid-2002 as imports from Canada (primarily through the now-profitable oil "sands") increased. Finally, US oil dependency has virtually disappeared due to the profitability of domestic (US) fracking and other methods to extract less accessible oil (and gas). In 2019, the US became a net exporter of energy overall and *also a net exporter of petroleum products* (EIA 2024). The situation is very different for the EU, Japan and Korea, but they also experienced large decreases in dependencies over time.

FIGURE 3: US Imports of Lithium Oxide and Hydroxide
Souce: US ITC Dataweb



Lithium

This paper cannot examine every critical mineral, but briefly considers lithium, a CM which plays a huge role in everyday consumer goods as well as in military hardware. The world is heavily dependent on Australia (and Chile) for the raw lithium and China for the processing of that lithium into lithium hydroxide for use in the ubiquitous Li-ion batteries. These batteries, in turn are used in household appliances and most Electric Vehicle (Tesla, Nissan's Leaf, *etc*.) batteries. Much of any country's military arsenal (*e.g.* drones, torpedoes, targeting systems, *etc*.) is reliant upon lithium as well.

Similar to oil, there are several ways in which the world is already moving away from Chinese lithium dependence, namely: 1) moving away from lithium altogether as the main technology (in batteries); 2) expanding non-Chinese supplies of lithium, and ; 3) expanding non-Chinese processing of lithium.

Demand for Lithium

Figure 3 shows that, like oil in the 1970s, lithium dependency had a sharp rise, but now appears to be falling. Looking at the US import data, lithium hydroxide has seen a steady, and at times rapid, rise since the first economically viable Li-ion batteries were introduced by Sony in 1991. Indeed, from 1994 to 1995 US "Lithium oxide and hydroxide" imports trebled, and then doubled again over the next five years. The Li-ion battery superseded the previous dominant technology for rechargeable batteries like NiCad (Nickel-Cadmium) and NiMH (Nickel-Metal Hydride) (Olabi *et al.* 2023).

If we look at the period from 1995 to 2015, lithium imports from the world grew by 500-600%. This works out to be an average of 9% growth rate per year. Over the same period, US GDP (income) grew by about 2 or 3% per year. Thus, a back of the envelope calculation for the income elasticity of demand for lithium would be 3 or even 4. Recall that this is much higher than the income elasticity for oil and other energy products which is typically unity (one) or even a bit lower. But, importantly, notice that lithium hydroxide imports peaked in 2015 and 2021, just short of 2 million kgs/year. Since 2021, imports are on a sharp and steady decline. It has not rebounded in the post-Covid years and continues to decline. This implies that the income elasticity of demand for lithium is now *negative*. As US GDP rises, total demand for lithium is falling.

The falling relative demand for lithium is not limited to the US. CATL, a major Chinese EV maker and the largest battery maker for EVs in China, plans to release a new EV with Sodium-ion batteries this year (as of this writing in late 2025). The new battery just passed an important national government safety in early September of 2025 (Liu 2025). Sodium, unlike lithium, is very cheap and relatively available around the world. In summary, the days of Li-Ion batteries and therefore dependence on China for processed lithium hydroxide, may be numbered (Phogat *et al.* 2024).

Lithium: supply response

Australia is already a major lithium producer, but it exports most of its lithium to China for processing. However, in 2022, Australia began expanding its domestic lithium processing industry. The operation was expected to ramp-up to "…50,000 tonnes per annum" in 2025 (Australia's Critical Minerals Strategy Report 2023) and it seems to be on target. A single plant alone would produce roughly 5% of the world's battery-grade lithium (Covalent Lithium 2025).

In the US, several efforts are underway. For example, South Korea's POSCO plans to start a lithium processing plant in Utah in 2026 (POSCO Group Newsroom 2025). Thus, both demand and supply have been and will continue to respond to high prices in lithium and other CMs.

6.3 *Substitutability of CMs in the Defense Industry*

The above discussion of response to current high dependencies on CMs has largely been with a view toward the private market and private market goods (EVs, consumer electronics, *etc*.). However, the Center for Strategic and International Studies (CSIS) (Baskaran and Schwartz 2025) *inter alia* argue that governments have been slow to act to the CM dependency on China in the defense industry (F-35s, submarines, Tomahawk missiles, *etc*.) and that "*the United States is a long way off from meeting the DOD's goal for a…supply chain independent of China*" (Baskaran and Schwartz 2025). This is a large component to the "alarmist" view.

While the "optimal" level and readiness of the military is far beyond the purview of this paper, there are a few insights that economics can provide on the subject.

First, is this a serious problem? Naturally, it is. If the military needs a certain component to make a particular weapons system, there may be no quick substitute and it could spell disaster. For the consumer, it is simply an inconvenience, or higher costs. For example, if a particular type of EV cannot be made or purchased, then the consumer can buy another EV with a different battery, or buy a gasoline-powered automobile instead. There may be no ready substitute for an F-35 in the time of war. Most defense systems are capital goods rather than consumables, and both weapons and ammunition can be stockpiled. So, presumably the US and other nations are (constantly) rethinking optimal stockpiles, and also switching to systems less reliant on a single country (China.) Thus, though the US may have been slow to act, there is still time to accelerate the pace in finding alternatives.

Let's take a look at *dysprosium*, which is a critical mineral on every country's list (see the detailed Critical Mineral lists in the Table in the Appendix).

Dysprosium is considered "critical" due to its importance in high-tech applications, particularly in *permanent magnets*. And certain types of permanent magnets are indispensable to many weapon systems. The main source of dysprosium is China (Booten *et al.* 2020).

Dysprosium helps permanent magnets work at high temperatures. Permanent magnets (and therefore dysprosium) are also in great demand for the same reasons in EVs, turbines, and many military weapons.

The search for alternative supplies and other efforts (technical solutions) to diversify the supply chain began in 2020, if not sooner (Booten *et al*. 2020).

Following the 2025 (temporary) export ban by China, many private firms are continuing to ramp up mining and processing of dysprosium of other rare earth magnets technology in response to consumer and defense-related demand. For example, the Texan firm Noveon Magnetics announced a multi-year supply agreement with General Motors to supply rare earth magnets to support a wide range of vehicle components (Noveon Magnetics 2025). Other new suppliers are coming from Australia, Estonia and Vietnam as well. While it is difficult to say if these new sources will come online "fast enough", it is interesting to note that government researchers (*e.g.* the US Dept. of Energy) seem to *consistently underestimate* the power of the market and predict shortages without them actually occurring.[27]

Thes shifts will not happen overnight.[28] This is a common feature of all the economic adjustments mentioned in the paper. Changes will unfold over time.

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[27] From the same DOE-funded report in 2020 (Booten *et al.*) "The elements *(authors: dysprosium, etc.)* cited as critical or near critical remain so today; however, major shortages have not occurred between the publishing of the DOE report (2011) and the present. Nevertheless, even the most optimistic estimates in the report still suggest supply shortages could occur…before 2030."

[28] The US government (perhaps slower than they should) has been shifting away from China-based sources for its military; this will only continue (Emont *et al.* 2025).

7 Conclusion and the Road Ahead

While the dependency on Chinese CMs may now seem staggering, with 70-90% of CM's (processed or otherwise) originating in China, there are grounds for a cautiously optimistic view. This is based on economic fundamentals about how markets respond and how government-controlled monopolists behave. These same fundamentals can be confirmed in past evolutions in fossil fuel dependencies as well as in the current CMs developments.

Setting important national defense aspects aside, the view that China is using CMs as a strategic export tool is off target. Admittedly, China has been using them as a diplomatic tool in recent years, but the actual economic impact has been tiny. The main goal has been (since Deng Xiaoping), and will continue to be, limiting supply to maximize revenue for the Chinese state-run cartel. The main goal for the main actors in Chinese CMs, as well as Chile and others, is to profit from its monopoly position *while it still can.*

The current critical mineral dependency has similarities, but also key differences with oil dependency.

As with the rise of OPEC in the 1970s, the market will respond to high prices and high volatility of CMs from China, DRC (cobalt) and others. High prices will spur more supply in new, non-China locations. This is already happening. Demand will continue to respond as well, both by finding non-Chinese sources of the same material, but also importantly by switching to substitute CMs (also non-China) or radically different technologies all-together (such as Sodium-ion batteries for EVs).

Many governments have also responded. However, there is limited basis for optimism regarding the success of a coordinated response. Just as the IEA was largely ineffectual, the effect of multilateral coordination by governments will also be limited. Government subsidies and eased regulation in the mining and processing of CMs will, of course, bring more alternative CMs online. Whether this intervention is necessary, or if the market forces would do it on its own is another matter, and that analysis is beyond the scope of this paper.

However, when considering the national defense arguments for less dependency on CMs, governments, especially the US, may very well want to accelerate alternative, "onshore" supply chains. This should only apply to the defense industry, not to EVs, smartphones and other consumer electronics. The market can and will sort that out or pay the price when each new disruption takes place.

Current dependency on CMs differs from past oil dependency in its scale, if not scope. The actual dollar amount on CM imports is only a fraction of the amount spent on oil in the past. China or other CM monopolies can disrupt supply chains for a time, in certain products, but for the most part, the economies can adapt, and weather the storm. Supply chain disruption during the covid pandemic were far worse than anything a CM disruption would entail. Also, any radical tightening of Chinese (or other) CM exports would be met by an equally sharp response by the US and perhaps others. It is very unlikely China would want to go down that road. Indeed, such a strategy runs counter to the CM cartel's primary goal of maximizing profits, as argued in this paper.

Lastly, as the dollar amounts of CMs are relatively small, if China doubled, tripled or even quadrupled the price of its CMs, the effect on the US deficit would barely be noticeable. Huge price hikes or export bans would cause shortages and delays, but they would not shut down the economy or cause nationwide price hikes and inflation as was the case with oil in the 1970s.

As seen from our investigation of oil and now with lithium, what goes up, usually comes down. Short-run price hikes and supply disruptions, while frustrating for certain sectors, will not bring the US, Japanese or EU economies to a halt. If firms and consumers do not like to pay high prices and face uncertainty, they will adjust or diversify sources. Firms have been surprisingly reluctant to reduce dependency from China in the last decade. The cost advantages have simply been too attractive to ignore. But this applies to many inputs, not just CMs, as evidenced by the various shortages during the covid pandemic. There is no reason, *per se,* to be particularly panicked about CMs.

In summary, despite the splash in the news that each new diplomatic jab China makes when restricting this rare earth or that, it is, for the most part, just that. It is unlikely that China will escalate the current trade war through radical critical mineral restrictions. It simply isn't in their interest.

Appendix : Summary Table of Critical Minerals by Country

Mineral	***CAN***	***EU list***	***India***	***JP List***	***US List***	***REE***	***Plat.***
Aluminum	**Y**	**Y**	N	N	**Y**		
Antimony	**Y**	**Y**	**Y**	**Y**	**Y**		
Arsenic	N	**Y**	N	N	**Y**		
Barite	N	**Y**	N	**Y**	**Y**		
Bauxite	N	**Y**	N	N	N		
Beryllium	N	**Y**	**Y**	**Y**	**Y**		
Bismuth	**Y**	**Y**	**Y**	**Y**	**Y**		
Borate	N	**Y**	N	N	N		
Boron	N	**Y**	N	**Y**	N		
Atmospheric Carbon ('C')	N	N	N	**Y**	N		
Cadmium	N	N	**Y**	N	N		
Cerium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Cesium	**Y**	N	N	**Y**	**Y**		
Chromium	**Y**	N	N	**Y**	**Y**		
Cobalt	**Y**	**Y**	**Y**	**Y**	**Y**		
Cooking Coal	N	**Y**	N	N	N		
Copper	**Y**	**Y**	**Y**	N	N		
Dysprosium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Erbium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Europium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Feldspar	N	**Y**	N	N	N		
Fluorspar	**Y**	**Y**	N	**Y**	**Y**		
Gadolinium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Gallium	**Y**	**Y**	**Y**	**Y**	**Y**		
Germanium	**Y**	**Y**	**Y**	**Y**	**Y**		
Graphite	**Y**	**Y**	**Y**	N	**Y**		
Hafnium	N	**Y**	**Y**	**Y**	**Y**		
Helium	**Y**	**Y**	N	N	N		
High Purity Iron Ore	**Y**	N	N	N	N		
Holmium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Indium	**Y**	**Y**	**Y**	**Y**	**Y**		
Iridium	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**
Lanthanum	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Lithium	**Y**	**Y**	**Y**	**Y**	**Y**		
Lutetium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Magnesium	**Y**	**Y**	N	**Y**	**Y**		
Manganese	**Y**	**Y**	N	**Y**	**Y**		
Molybdenum	**Y**	N	**Y**	**Y**	N		
Neodymium	**Y**	**Y**	**Y**	N	**Y**	**Y**	
Nickel	**Y**	**Y**	**Y**	**Y**	**Y**		

Niobium	**Y**	**Y**	**Y**	**Y**	**Y**		
Osmium	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**
Platinum	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**
Palladium	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**
Phosphate	N	**Y**	N	N	N		
Phosphorus Rock	**Y**	**Y**	**Y**	N	N		
Potash	**Y**	N	**Y**	N	N		
Praseodymium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Promethium	**Y**	**Y**	**Y**	**Y**	N	**Y**	
Rhenium	N	N	**Y**	N	N		
Rhodium	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**
Rubidium	N	N	N	**Y**	**Y**		
Ruthenium	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**
Samarium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Scandium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Selenium	N	N	**Y**	**Y**	N		
Silicon Metal	**Y**	**Y**	**Y**	**Y**	N		
Strontium	N	**Y**	**Y**	**Y**	N		
Tantalum	**Y**	**Y**	**Y**	**Y**	**Y**		
Tellurium	**Y**	N	**Y**	**Y**	**Y**		
Terbium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Thallium Sulfate	N	N	N	**Y**	N		
Thulium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Tin	**Y**	N	**Y**	N	**Y**		
Titanium	**Y**	**Y**	**Y**	**Y**	**Y**		
Tungsten	**Y**	**Y**	**Y**	**Y**	**Y**		
Uranium	**Y**	N	N	**Y**	N		
Vanadium	**Y**	**Y**	**Y**	**Y**	**Y**		
Ytterbium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Yttrium	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
Zinc	**Y**	N	N	N	**Y**		
Zirconium	N	N	**Y**	**Y**	**Y**		
Total	54	56	51	54	50	17	6

Sources: from various government sources described below.

In 2024, **Canada**'s critical minerals list identified **34** critical minerals and metals. They were chosen based on some criteria (essential to Canada's economic security, a reasonable likelihood of being produced in Canada, *etc.*). Actually, it is 32 critical minerals and metals *plus* the 17 rare earth elements, *plus* the 6 platinum group metals (platinum, palladium, rhodium, ruthenium, iridium, and osmium). Note that, just like in the European list, scandium is mentioned twice (once in the list itself, and once as part of the rare earths elements). The Canadian list thus contains a total of 54 critical minerals. (See www.canada.ca last accessed December 12, 2025.)

The fifth **European list** (2023) of "Critical Raw Materials" includes 56 CRMs (up from 36 CRMs in 2011). Source: European Commission: "Critical raw materials - Fifth list 2023 of critical raw materials for the EU". March 16th, 2023.

India also released its list of 30 critical minerals in 2023, (India - Ministry of Mines 2023).

Japan has also its Critical Minerals list with 31 metals *plus* platinum-group elements and rare earth elements, as provided by the Ministry of Economy Trade and Industry of Japan (METI 2020). Uranium was conspicuously added in 2024. Japan doesn't have a domestic uranium production, despite hoping to rely more on nuclear energy in the future (www.mining.com, 2024a).

Finally, for **the United States**, in 2022, the USGS published a list of 50 "Critical minerals" (see USGS 2025).

Declaration of Interest

None

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References

Armstrong, S., M. Solís and S. Urata. 2025. "Economic Security and New Industrial Policy." *Asian Economic Policy Review* 20, 2: 265-275. https://doi.org/10.1111/aepr.12502

Anderson, G. H. 1980. "Turnabout in US Merchandise Trade." Federal Reserve Bank of Cleveland, Economic Commentary 6/2/1980. https://www.clevelandfed.org/publications/economic-commentary/1980/ec-19800602-turnabout-in-us-merchandise-trade

Asahi Shimbun. 2010. 朝日新聞「レアアース禁輸解除　中国、姿勢軟化の動き」September 9. Also published in English on September 30, 2010 "China Rescinds its Ban on Rare Earth Metal

Exports."http://www.asahi.com/special/senkaku/TKY201009280494.html?msockid=3ad0fac4f838622d02acec00f98863ea.

Balfour, F. 2008. "China's First Plug-in Hybrid Car Rolls Out." *Bloomberg Business.* December 15. https://www.bloomberg.com/news/articles/2008-12-15/chinas-first-plug-in-hybrid-car-rolls-outbusinessweek-business-news-stock-market-and-financial-advice.

Baskaran, G., and M. Schwartz. 2024. "China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet Amidst Escalating US-China Tech War." December 4. https://www.csis.org/analysis/china-imposes-its-most-stringent-critical-minerals-export-restrictions-yet-amidst.

Baskaran, G., and M. Schwartz. 2025. "The Consequences of China's New Rare Earths Export Restrictions." April, 14. CSIS. https://www.csis.org/analysis/consequences-chinas-new-rare-earths-export-restrictions.

Biden Whitehouse Archives. 2022."Memorandum on Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as amended". March 31. https://bidenwhitehouse.archives.gov/.

Booten, C., M. Mann, A. Momen, and O. Abdelaziz. 2020. "Critical Material Supply Chain Analysis: Magnetocalorics." Technical report, Clean Energy Manufacturing Analysis Center (CEMAC under US Dept of Energy). https://www.energy.gov/eere/buildings/articles/critical-material-supply-chain-analysis-magnetocalorics.

Bradsher, K. 2010. "In Dispute, China Blocks Rare Earth Exports to Japan." *The New York Times*. September 23. https://www.nytimes.com/2010/09/23/business/global/23rare.html.

Choe, B. J. 1990. "The metals price boom of 1987-89: the role of supply disruptions and stock changes." *The World Bank Policy Research Working Paper Series* 542:25. http://documents.worldbank.org/curated/en/846221468766203401.

Chou, W. 2025. "China's Bureaucratic Playbook for Critical Minerals." Hudson Institute, July 9. https://www.hudson.org/supply-chains/chinas-bureaucratic-playbook-critical-minerals-control-technology-transfer-william-chou.

d'Aspremont, C., A. Jacquemin, J. J. Gabszewicz, and J. A. Weymark. 1983. "On the Stability of Collusive Price Leadership." *Canadian Journal of Economics* 16, no. 1: 17-25. https://doi.org/10.2307/134972.

Canada: "The Canadian Critical Minerals Strategy." 2022. https://www.canada.ca/content/dam/nrcan-rncan/site/critical-minerals/Critical-minerals-strategyDec09.pdf.

Canada (Prime Minister). 2025. "G7 Critical Minerals Action Plan." June 17.https://www.pm.gc.ca/en/news/statements/2025/06/17/g7-critical-minerals-action-plan.

China National Radio. 2007. 邓小平南巡时指出：中东有石油，中国有稀土 [Deng Xiaoping Noted during his Southern Tour: The Middle East has Oil; China has Rare Earths]. https://nm.cnr.cn/nmzt/60dq/tjnmg/20070412/t20070412_504442760.html.

Cooper, J. C. B. 2003. "Price Elasticity of Demand for Crude Oil: Estimates for 23 Countries." *OPEC Review* 27, no. 1:1-6. https://doi.org/10.1111/1468-0076.00121.

Covalent Lithium. 2025. "Covalent Lithium Achieves First Product at Kwinana Lithium Hydroxide Refinery." August 14. https://www.covalentlithium.com/news/covalent-lithium-achieves-first-product-at-kwinana-lithium-hydroxide-refinery.

Cross, P. 2021. "A National Project: How Oils Sands Investment and Production Benefit Canada's Economy." A MacDonald-Laurier Institute (MLI) publication April. 20210414_Innovation_and_the_oil_sands_Cross_PAPER_FWeb.pdf.

Dargay, J. M., and D. Gately. 2010. "World oil demand's shift toward faster growing and less price-responsive products and regions." *Energy Policy* 38, no. 10: 61-6277. doi:10.1016/J.ENPOL.2010.06.014Corpus ID: 154132746.

Dashnyam Partners LLC. 2024. "Recent Amendments to the Minerals Law of Mongolia." May 19. https://dplaw.mn/recent-amendments-to-the-minerals-law-of-mongolia/?utm_source=chatgpt.com.

Energy Information Agency (EIA). 2024. "US Energy Facts Explained." July 25. https://www.eia.gov/energyexplained/us-energy-facts/imports-and-exports.php.

Emont, J., Somerville, H., and A. MacDonald. 2025. "China Is Choking Supply of Critical Minerals to Western Defense Companies." *Wall Street Journal* August 3. https://www.wsj.com/world/asia/china-western-defense-industry-critical-minerals-3971ec51?msockid=3ad0fac4f838622d02acec00f98863ea.

European Commission. 2023. "Critical Raw Materials- Fifth List 2023 of Critical Raw Materials for the EU." March 16. https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en.

European Commission. 2024. "European Critical Raw Materials Act." https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan/european-critical-raw-materials-act_en ,

Evenett, S., and J. Fritz. 2023. "Revisiting the China–Japan Rare Earths Dispute of 2010." *VOX Eu/CEPR*. July 19. https://cepr.org/voxeu/columns/revisiting-china-japan-rare-earths-dispute-2010 .

Fan, J. H., A. Omura, and E. Roca, E. 2023. "Geopolitics and Rare Earth Metals" in *European Journal of Political Economy* 78, 102356. https://doi.org/10.1016/j.ejpoleco.2022.102356.

Federal Reserve History. "*Oil Shock of 1973-74*." https://www.federalreservehistory.org/essays/oil-shock-of-1973-74.

Fernandez, V. 2018. "Price and Income Elasticity of Demand for Mineral Commodities" *Resources Policy* 59, December :160-183. https://doi.org/10.1016/j.resourpol.2018.06.013.

Gardiner, N. J., S. M. Jowitt, and J. P. Sykes. 2024. "Lithium: Critical, or not so Critical?" *Geoenergy* 2, no. 1: geoenergy2023–045. https://doi.org/10.1144/geoenergy2023-045.

Godek, S. 2025. "China's Germanium and Gallium Export Restrictions: Consequences for the United States" in *Stimson (Issue Brief)*. March 19. https://www.stimson.org/2025/chinas-germanium-and-gallium-export-restrictions-consequences-for-the-united-states/.

Helmi, M. H., *et al.* 2024. "Time-varying Income and Price Elasticities of Oil Demand in OECD Countries." *International Journal of Energy Economics and Policy.* 14, no. 6: 303-311. https://doi.org/10.32479/ijeep.15895.

Hendrix, C. S. 2024. "China's Export Controls on Critical Minerals aren't Starving the United States—at least so far." October 31. Peterson Institute for International Economics (PIIE). Washington, D.C. https://www.piie.com/blogs/realtime-economics/2024/chinas-export-controls-critical-minerals-arent-starving-united-states.

Hufbauer, G., J. Schott, K. Elliott, and B. Oegg. 2009. *Economic Sanctions Reconsidered*, 3rd Edition. Peterson Institute of International Economics. Washington, D.C. https://cup.columbia.edu/book/economic-sanctions-reconsidered/9780881324129/.

India - Ministry of Mines, Press Release. 2023. "Thirty Critical Minerals List Released." July 24. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1942027.

International Energy Agency (IEA). 2022. "Law No 928: Law of the National Strategic Public Company for Bolivian Lithium Deposits- YLB" https://www.iea.org/policies/16654-law-no-928-law-of-the-national-strategic-public-company-for-bolivian-lithium-deposits-ylb.

International Energy Agency (IEA). 2025. "Global Energy Review 2025" https://www.iea.org/reports/global-energy-review-2025/oil

International Lithium Association (ILA). 2024. "What is the Price of Lithium?" https://lithium.org/what-is-the-price-of-lithium/ .

IRINA. 2024. "Critical Materials: Batteries for Electric Vehicles." International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Sep/IRENA_Critical_materials_Batteries_for_Evs_2024.pdf.

Ivanov, H., T. Zenou, and M. Qvortrup. 2025. "Geopolitics of Critical Minerals." in *The Henry Jackson Society*. February. https://henryjacksonsociety.org/publications/the-geopolitics-of-critical-minerals/.

Kilian, L. 2022. "Understanding the Estimation of Oil Demand and Oil Supply Elasticities." *Energy Economics* 107 105884. https://doi.org/10.1016/j.eneco.2022.105844.

Kim, S. M., and A. Madhani. 2025. "Trump Signs Rare Earths Deal with Australian Prime Minister as a Way to Counter China." PBS.org. October 20. https://www.pbs.org/newshour/politics/trump-signs-rare-earths-deal-with-australian-prime-minister-as-a-way-to-counter-china.

Krugman, P. 2010. "Rare and Foolish." *The New York Times*. Oct. 18, Section A, Page 35. https://www.nytimes.com/2010/10/18/opinion/18krugman.html.

LaHaye, L. 2008. "Mercantilism." in *The Concise Encyclopedia of Economics, Library of Economics and Liberty*. https://www.econlib.org/library/Enc/Mercantilism.html.

Liddle, B., and S. Parker. 2022. "One More for the Road: Reconsidering whether OECD Gasoline Income and Price Elasticities have Changed over Time. *Energy Economics*, 114, 106280. https://doi.org/10.1016/j.eneco.2022.106280.

Liu, M. 2025. "CATL's Naxtra Sodium-ion Battery Passes New National Safety Standards, Ready for Mass Production." *Car News China*. September 8. https://carnewschina.com/2025/09/08/catls-naxtra-sodium-ion-passes-new-national-safety-standards-ready-for-mass-production/.

Liu, S., and D. Patton. 2023. "China Bans Export of Rare Earths Processing Tech over National Security." Reuters. December 21. https://www.reuters.com/markets/commodities/china-bans-export-rare-earths-processing-technologies-2023-12-21/.

McDermott, J. 1999. "Mercantilism and Modern Growth." *Journal of Economic Growth*. 4: 55–80. https://doi.org/10.1023/A:1009878625417.

METI, Agency for Natural Resources and Energy. 2020. "Japan's New International Resource Strategy to Secure Rare Metals." July 31. https://www.enecho.meti.go.jp/en/category/special/article/detail_158.html.

Mining.com. 2024a. "Japan Adds Uranium to Critical Minerals List." February 1, https://www.mining.com/japan-adds-uranium-to-list-of-critical-minerals/.

Mining.com. 2024a. "Hudbay Settles Longstanding Lawsuits Related to Guatemala Nickel Mine." October 7. https://www.mining.com/hudbay-settles-longstanding-lawsuits-related-to-guatemala-nickel-mine/.

Ministry of Land and Resources of the People's Republic of China. 2008. 全国矿产资源规划（2008～2015） "National Mineral Resources Plan (2008–2015)". https://dnr.yn.gov.cn/html/2009/guotuzhishi_0120/11901.html

Narayan, P. K., and R. Smyth. 2007. "A Panel Cointegration Analysis of the Demand for Oil in the Middle East." *Energy Policy*, 35: 6258-6265. https://doi.org/10.1016/j.enpol.2007.07.011.

The New York Times. 2023. "Sweden Discovers a Rare Earth Bonanza." January 13. https://www.nytimes.com/2023/01/13/business/sweden-rare-earth-minerals.html.

Noveon Magnetics. 2025. "Driving American Industry: General Motors and Noveon Magnetics Sign Multi-year Agreement to Deliver American-made Rare Earth Magnets." August 6. https://www.prnewswire.com/news-releases/driving-american-industry-general-motors--noveon-magnetics-sign-multi-year-agreement-to-deliver-american-made-rare-earth-magnets-302522804.html.

Office of the Historian. "Oil Embargo, 1973–1974." in *Milestones in the History of U.S. Foreign Relations*. https://history.state.gov/milestones/1969-1976/oil-embargo.

Olabi, A. G., Q. Abbas, P. A. Shinde, and M. A. Abdelkareem. 2023. "Rechargeable Batteries: Technological Advancement, Challenges, Current and Emerging Applications." *Energy*. 266. 126408. https://doi.org/10.1016/j.energy.2022.126408.

Owen, W. 2024. "The Misleading Prices of Rare Earths." December 5. https://www.globalminingreview.com/mining/05122024/the-misleading-prices-of-rare-earths/

Phogat, P., S. Dey, and M. Wan. 2024. "Comprehensive Review of Sodium-Ion Batteries: Principles, Materials, Performance, Challenges, and Future Perspectives." *Materials Science and Engineering B*. 312. 117870. doi: 10.1016/j.mseb.2024.117870.

POSCO Group Newsroom. 2025. "POSCO Holdings Sets Out to Demonstrate DLE Tech in the US, Speeds Up Lithium Supply Chain in North America." July 15. https://newsroom.posco.com/en/posco-holdings-sets-out-to-demonstrate-dle-tech-in-the-u-s-speeds-up-lithium-supply-chain-in-north-america/.

Reuters. 2021. "Automakers Cutting Back on Rare Earth Magnets." July 19. https://www.reuters.com/business/autos-transportation/automakers-cutting-back-rare-earth-magnets-2021-07-19/.

Scheyder, E., and J. Renshaw. 2025. "Exclusive: Trump Set to Waive some Legal Requirements to Boost Critical Minerals." Reuters. June 03. https://www.reuters.com/world/us/trump-expected-waive-defense-production-act-requirements-boost-critical-minerals-2025-06-03/.

Schramm, L. 2024. "Some Differences, Many Similarities: Comparing Europe's Responses to the 1973 Oil Crisis and the 2022 Gas crisis." *European Political Science Review* 16, no.1: 56-71. doi:10.1017/S1755773923000255.

Siripurapu, A., and A. Chatzky. 2002. "OPEC in a Changing World." *Council on Foreign Relations* (CFR), March 9. https://www.cfr.org/backgrounder/opec-changing-world.

Smith, A., and S. Armstrong. 2013. "Did China Really Ban Rare Earth Metals Exports to Japan?" *East Asian Forum*. August 18. https://eastasiaforum.org/2013/08/18/did-china-really-ban-rare-earth-metals-exports-to-japan/.

Snoussi-Mimouni, M., and S. Avérous. 2024. "High Demand for Energy-related Critical Minerals Creates Supply Chain Pressures." WTO blog article. Jan 10th. https://www.wto.org/english/blogs_e/data_blog_e/blog_dta_10jan24_e.htm.

Spindler, Z. A., and X. de Vanssay. 2000. "A Public Choice Perspective on Cartels." *Journal of Public Finance and Public Choice* 18, no. 1 : 3-22. https://doi.org/10.1332/251569200X15665365495005.

Spindler, Z. A. 2002. "The Wealth of Nationals versus the Wealth of Nations: A Public Choice Perspective" *Economia* (Yokohama National University) 53, no. 1:21-30. https://www.econ.ynu.ac.jp/hus/econ/26406/.

STRATFOR. 2019. "The Geopolitics of Rare Earth Elements." in *WorldView*. April 8. https://worldview.stratfor.com/article/geopolitics-rare-earth-elements.

Terazawa, T. 2023. "How Japan Solved its Rare Earth Minerals Dependency Issue" in *World Economic Forum*. October 13. https://www.weforum.org/stories/2023/10/japan-rare-earth-minerals/.

UK Government (2022-2024) "Collection Critical Mineral Supply Chains." https://www.gov.uk/government/collections/critical-mineral-supply-chains.

United States Geological Survey (USGS) "Mineral Commodities Summary (MSC)", various years, https://www.usgs.gov/centers/national-minerals-information-center/mineral-commodity-summaries.

United States Geological Survey (USGS). 2025. "About the List of Critical Minerals. https://www.usgs.gov/programs/mineral-resources-program/science/about-2025-list-critical-minerals.

US Government (State Department) Minerals Security Partnership, https://www.state.gov/minerals-security-partnership, accessed on June 16, 2025.

Villegas, A., and E. Scheyder. 2023. "Chile Plans to Nationalize its Vast Lithium Industry." Reuters. April 21. https://www.reuters.com/markets/commodities/chiles-boric-announces-plan-nationalize-lithium-industry-2023-04-21/.

Vipin, A. 2014. "Estimates of the Price Elasticities of Natural Gas Supply and Demand in the United States." Munich Personal RePEc Archive https://mpra.ub.uni-muenchen.de/54232/1/MPRA_paper_54232.pdf.

Wang, A., and W. Zhang. 2023. "China Slaps Export Restrictions on Two Critical Metals" in *Global Policy Watch*. July 6. https://www.globalpolicywatch.com/2023/07/china-slaps-export-restrictions-on-two-critical-metals/.

Wintour, P. 2022. "'We were all wrong': how Germany got hooked on Russian energy." *The Guardian*, June 2. https://www.theguardian.com/world/2022/jun/02/germany-dependence-russian-energy-gas-oil-nord-stream.

Wu, J. 2010. (*Original in Chinese)* "The 'rare earth controversy' as a diversion of attention?" *Zhongguo Qiyejia* (Chinese Entrepreneur). 20: 22.