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DISCUSSION PAPER

China's Rare Earth Monopoly: Implications for Western Security

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Abstract
The dominant position of Chinese suppliers on the rare earth market has led to security concerns in Western countries. This article examines the nature of rare earths, the sources of China's rare earth monopoly, and its strategic implications for the West, particularly in defence, technology, energy, and foreign policy. It highlights the challenges Western governments and industry face in reducing their dependence on China and developing alternative sources of rare earths. It concludes with a discussion of the ramifications and possible scenarios for Western governments, including the need for coordinated international action to address China's rare earth monopoly.

Keywords
China, geopolitics, rare-earth elements, security

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1. Introduction

The geopolitical and geo-economic rise of China in recent decades is an important topic in the foreign policy of Western actors, primarily the USA, and on the international stage as a whole. The tensions between the USA and China are becoming increasingly evident in economic matters and are gradually spilling over into political and military agendas. In recent months, tension between these two superpowers has been particularly apparent and visible, primarily due to their approach to Taiwan, where relations are still at a frosty point between the two states. President Donald Trump's trade war in 2017 contributed to the escalation of diplomatic ties. The result of the trade war was the imposition of tariffs on both sides on several trade items. However, tensions between China and the USA continue. In 2022, the Pentagon sent four ships, including an aircraft carrier, to the waters around Taiwan. At the same time, China was concerned about the visit of American Democratic politician Nancy Pelosi, who was at the time (in 2022) the Speaker of the House of Representatives. China's approach to the war in Ukraine also raises questions, as China is accused of supporting the Russian Federation. In January 2023, a four-star Air Force general, Minihan, expressed that he expects a military conflict with China within two years; by 2025 (Shepard 2023).

Recent years also highlight the issues of the interconnectedness of the modern world, where dependence can often be one-sided and replacing suppliers can be problematic. Weaknesses in the mentioned trade and supply chains were also revealed by COVID-19 pandemic, and the ongoing war in Ukraine also underscores these challenges. The United States and the European Union face similar challenges in the area of rare earth materials (White House 2021; European Commission n.d.).

At the beginning of the 21st century, China became the world's largest producer of rare earth elements. Australia, Brazil, India, Kazakhstan, Malaysia, Russia, South Africa, and the United States also extract and refine significant amounts of these materials (see Grasso 2013; Ferreira and Critelli 2022; Seligman 2022). China has rapidly become the global leader in the production, mining, and refining of rare earth elements. With increasing geopolitical disputes and associated uncertainties stemming from China's expansion, China's dominance in rare earth elements seems concerning (see Butler 2014; Htun 2023). The potential and utilization of rare earth elements should be kept in mind. Valerio Grasso (2013) already warned in 2013 that the entire world was becoming heavily dependent on Chinese supplies in this area, primarily concerning national security. Grasso emphasized that supply chains could negatively affect the strategic and defence planning of the United States. Rare elements are used in most critical infrastructure elements, and with technological advancements, dependence on these elements continues to increase. This pertains mainly to the energy sector, the IT sector, and the weaponry arsenal (see Grasso 2013; Butler 2014; Seligman 2022). Therefore, it can be inferred that dependence

on rare elements, in other words, on China, is becoming and could be a significant security issue in the future, as recognized by NATO in 2021.

During the year 2021, NATO officially recognized during its summit that the growing dependence on China in this area carries increased and continuously growing security risks (NATO 2021). China poses a threat not only from the perspective of national security and defence but also from an economic standpoint. Chinese dominance worsens and complicates the transition to clean energy plans. Vulnerability can be demonstrated by the example of China halting all rare earth supplies to Japan in 2010. Japan faced problems in most industrial sectors, rising prices, and difficulties in sourcing these materials from other producers (Ferreira and Critelli 2022; Kalantzakos 2017; Choong 2014). Despite the official recognition by NATO and an understanding of the seriousness of the situation, the supply of the Western world remains dependent on China.

The aim of the article is to discuss the security risk implications associated with the acquisition of rare earth materials by Western countries. The presented article is designed to present the basic issues related to rare earth materials and their importance for the defence and technological, energy and economic policies of Western countries, as well as challenges for foreign policies and to discuss potential takeaways and solutions for Western security architecture.

The article unfolds in a structured manner. Beginning with an introduction, it then delves into the world of rare earth elements, emphasizing their indispensable role in everyday life. The third section introduces the analytical concept shaping the research and explores specific sectors under investigation. Following this, the fourth section conducts a sectoral security analysis, leading to a discussion on potential policy solutions aimed at enhancing the resilience of Western countries concerning rare earth materials. The concluding sixth section summarizes the findings and proposes potential scenarios for future research.

2. Rare earth elements and their utilization

Rare earth elements, also known as rare earth metals, are composed of seventeen elements. These are elements with similar chemical attributes, specifically the following elements: scandium, yttrium, and the entire group of fifteen lanthanides, which are chemical elements with proton numbers ranging from 57 to 71.

Rare earth elements can be divided into two groups: light rare earth elements and heavy rare earth elements. Light rare earth elements include lanthanum, cerium, praseodymium, neodymium, and samarium, with atomic numbers from 57 to 62. Light rare earth elements are more abundant than heavy ones. Heavy rare earth elements, with atomic numbers from 64 to 71 plus yttrium (39), are not as prevalent as light rare earth elements and are generally used in high-tech applications. Examples include erbium used

in fibre optics for communications, europium, and terbium used as phosphors (Grasso 2013; Hurst 2010).

These elements also play a crucial role in national security and military equipment. Specialized alloys are critical for weapon systems, and rare earth elements are important for all branches of the military, including the air force, ground units, and the navy (see Lu 2021; Butler 2014). Materials of rare earth elements form a group of elements that are essential for defence and national security. Rare earth elements are metals with a wide range of applications in modern technologies, and they are virtually irreplaceable. Without these materials, many advanced weapon systems used by modern armies would not be possible (see Runde and Hardmann 2023).

Their uniqueness lies in their exceptional properties such as magnetism, luminescence, and strength. However, despite the term "rare," they are relatively abundant in the Earth's crust. Rarity is associated with their extraction, as naturally occurring concentrations are low, making mining less profitable. Rare earth elements are also often dispersed and mixed with other minerals or are byproducts of mining other minerals. According to the US Geological Survey (2009), bastnäsite deposits are the most abundant source of rare earth elements. Bastnäsite deposits in China and the USA represent the largest percentage of economic resources of rare earth elements in the world (US Geological Survey 2009; see Mancheri 2012). Monazite deposits represent the second mineral where rare earth elements can be found. These deposits are primarily located in Australia, Brazil, China, India, South Africa, Sri Lanka, Thailand, and the USA (Hurst 2010).

One of the biggest challenges associated with rare earth materials is that they are often difficult and costly to mine. Many of the world's largest rare earth deposits are located in China, which has almost a monopoly on global supplies of these materials. This raises concerns about potential supply interruptions and scenarios where China could use its control over rare earth materials as a tool for economic or political pressure (see Htun 2023; Shen et al. 2018. Mancheri et al. 2019).

To address these issues, many countries are exploring ways to develop alternative sources of rare earth materials. This includes investments in the development of new mines and mining technologies, as well as recycling and reusing rare earth materials from existing electronic devices. Some countries are also researching ways to reduce their dependence on rare earth materials by developing new weapon systems and electronic devices that use alternative materials.

In conclusion, rare earth materials are critical for defence due to their use in advanced weapon systems and electronic devices. However, challenges in ensuring reliable supplies of these materials have raised concerns about potential supply disruptions and geopolitical instability. To address these challenges, it is important for countries to explore alternative sources of rare earth materials and reduce their dependence on these materials.

3. Conceptual framework for analysis

The Copenhagen School's framework (Buzan et al. 1998; Sheehan 2005; Dent 2010) for conceptualizing security sectors offers a comprehensive lens through which to examine the multifaceted dimensions of security. This paper utilizes the sectoral approach developed by the Copenhagen School scholars in order to analyse the security implications of rare earth materials for Western countries.

The framework is specifically aimed and narrowed. The framework for the security analysis of rare earth materials is centred on three pivotal sectors: energy, economic, and defence. The selection of these sectors is predicated on their critical significance to national security and economic vitality (see La Bruyere and Picaris 2022; Parman 2019). This deliberate focus serves to narrow the research scope, ensuring a more targeted and in-depth examination of the intersections between rare earth materials and these key domains.

The energy sector is paramount due to the integral role of rare earth elements in various clean energy technologies, including wind turbines, electric vehicles, and energy-efficient lighting (EIA 2021; Agamloh et al. 2020). Given the global emphasis on transitioning to sustainable energy sources, the security of rare earth materials becomes crucial for ensuring the reliability and resilience of these energy systems.

Economically, rare earth elements have become indispensable components in the manufacturing processes of numerous high-tech industries. Their inclusion in products ranging from electronics to medical devices underscores their economic importance. Examining the economic sector provides insights into the vulnerabilities and dependencies arising from the scarcity or disruption of rare earth material supplies, with potential ramifications for economic stability and growth (see La Bruyere and Picaris 2022).

The defence sector is inherently intertwined with national security, and rare earth materials play a pivotal role in the production of advanced defence technologies. Their application in missile systems, radar equipment, and advanced weaponry underscores the strategic importance of rare earth elements. A focused analysis of the defence sector allows for a nuanced understanding of the potential geopolitical implications and security vulnerabilities associated with the supply of rare earth materials (Butler 2014; Ferreira and Critelli 2022).

By honing in on these three interconnected sectors, the research gains specificity and depth, facilitating a comprehensive analysis of the intricate relationships between rare earth materials, national security, and economic resilience. This targeted approach enables a nuanced exploration of the multifaceted challenges and opportunities arising from the utilization and supply of rare earth elements within these critical domains.

4. Security sectoral analysis and implications for Western security

The demand for strategic and critical materials is poised to escalate, particularly due to their role in enhancing or enabling the performance of environmentally friendly "green" technologies such as electric vehicles, wind turbines, and advanced batteries. A recent report from the International Energy Agency (2021) highlights this phenomenon, stating that "A typical electric car requires six times the mineral inputs of a conventional car, and an onshore wind plant requires nine times more mineral resources than a gas-fired plant."

The challenges and opportunities within strategic and critical material supply chains epitomize the intense geopolitical competition of the 21st century. The intricate nature, global reach, and cross-disciplinary aspects necessitate a comprehensive approach by the European Union and United States, involving collaboration with allies, partners, and stakeholders from the private and non-profit sectors.

Western countries heavily depend on Chinese rare earth materials for their defence industry due to limited domestic production and challenges in developing alternative sources. China's abundant rare earth reserves and low production costs have enabled it to capture a significant share of the global market (Kennedy 2019; Gulley et al. 2018; Schmid 2019; Hudson 2022). In comparison to China, Western nations, facing environmental regulations and complex extraction processes, have struggled to compete. As a result, they have become highly reliant on Chinese supplies, creating vulnerabilities in various sectors, including soft and hard security. Reliance on a single source increases the risk of supply disruptions due to trade disputes, export restrictions, or geopolitical tensions (Schmid 2019; Shen et al. 2018). Thus, China's control over rare earth materials gives it potential leverage to manipulate prices or restrict access to critical components (Schmid 2019).

4.1. Economic Sector

The use and distribution of rare earth elements present a significant problem for the USA and its allies, as the USA, despite "owning" deposits on its territory, has significantly lost its own production and has become dependent on rare earth element imports from China. This dependence reached up to 80% of rare earth element imports from China in 2020, and the European Union is similarly dependent, up to 90%, also on China (see Ferreira and Critelli 2022; European Commission n.d.). However, this high dependence can severely impact national security in case of supply disruptions from China, as previously experienced by Japan.

For approximately four to five decades, China has been formulating national strategic programs and building facilities dedicated to the rare earth element sector (see Kalantzakos 2017). These efforts later included the securitization of trade and supply routes, which can be demonstrated by China's efforts to create new international

communities and entities: BRICS, the Asian Development Bank, and more. China has, therefore, not only focused on domestic policies and processes but also on international politics, with these efforts becoming more evident since the 1990s (see Kalantzakos 2017). Rare earth elements also feature in China's "Made in China 2025" strategy, designating the sector as key and strategic for technology, security, and national defence (see La Bruyere and Picaris 2022). The ultimate outcome of China's efforts is that it currently controls up to 90% of processing capacities worldwide (see Ferreira and Critelli 2022; Yao 2022). Additionally, China also controls most transportation routes and supply chains. With its production and associated position, China can influence markets and globally manipulate rare earth element prices. Unlike other countries, China can accumulate rare earth elements for its strategic stockpile and artificially increase or decrease production, which can be used as a tool in foreign policy. We have already seen such an event, among other things, in the past decade. From 2010 to 2011, there was a significant increase in prices due to a dispute between China and Japan, as mentioned earlier. This example illustrates how these elements can be used as leverage in international politics and also shows the vulnerability of other, especially Western, countries to supply disruptions (see Butler 2014). This, of course, directly impacts the defence capabilities of individual states whose military is practically dependent on these materials.

If we take a closer look at production itself, for example, the Bayan Obo mine produced up to 45% of the world's rare earth element production in 2007. Ferreira and Critelli indicate up to 50% to 60% in recent years (Chengyu 2008; Ferreira and Critelli 2022). Currently, China is the world leader in rare earth element production, mining, and refining. It is estimated that China is responsible for approximately 70% of global mining. Other sources state that China is responsible for about 63% of all mining but processes up to 80% and even 90% of all magnetic components (see Yao 2022). A White House (2021) report states that China controlled 55% of global rare earths mining capacity in 2020 and 85 percent of rare earths refining.

In addition to its own deposits, China is working to secure additional deposits as part of its foreign policy, as mentioned earlier. For example, Chinese investments in Myanmar, which is the third-largest producer of rare earth elements, with over 50% of its exports going to China (see Subramanian 2021). Hurst (2010) argues that states with such a descriptor of "rare" supply its justified importance. Their geographic deposits are mainly located in vulnerable and less stable countries, which mostly maintain very good foreign relations with China or China maintains significant influence over them by other means.

On the other hand, alternatives are difficult to reach for several reasons. Aside from China's dominance and its well-developed network in foreign policy, these investments are costly and building complete infrastructure from scratch is technologically demanding. Moreover, material acquisition is an environmentally damaging process

involving the use of toxic chemicals, which subsequently generate a large amount of waste. Given the various restrictions and standards of Western countries, it doesn't seem like a feasible option for them to challenge China's position or that of its allied states.

Therefore, it cannot be expected that any global player, meaning a state, can build its own infrastructure in the short term and challenge China's monopoly. China's competitiveness is also disrupted by its non-transparency, as it has long been subsidizing its state-owned enterprises, and pricing in China is not as transparent as in the free market economies of the West. Ferreira and Critelli (2022) state that China artificially allowed Chinese processors access to cheap materials to maintain high prices of rare earth elements without jeopardizing itself.

Although China only recently began to strengthen its control over the industry, atypical for Western states, it quickly became an entity with a very strong position in the international community. Nevertheless, we can still observe China's efforts to secure access to essential elements, especially in its foreign policy. In recent years, China has been using its control over the rare earth element market as a political tool, threatening to restrict exports to other countries during diplomatic disputes. The Chinese monopoly allowed prices for various rare earth materials from 2009 to 2011 to be increased by hundreds of percent and export quotas for many of these products as well. This led to a major change in the dynamics of the rare earth markets. This has led to concerns from other countries about their dependence on China for these critical elements (see Ferreira and Critelli 2022).

4.2. Energy sector

The use of rare earth elements (REEs) in the energy sector has profound implications for Western countries. These 17 chemically similar elements, encompassing the lanthanides and a few others like scandium and yttrium, are integral to numerous advanced technologies, particularly in the realms of renewable energy sources and electric vehicles. This subsection delves into the role of REEs in the energy sector and the far-reaching geopolitical consequences for Western nations.

Rare earth elements are indispensable in the energy sector, especially in the development of renewable energy technologies. The global transition to a more sustainable and eco-friendly energy future hinges on a stable and secure supply of REEs. As Western countries progressively reduce their reliance on fossil fuels and embrace renewable energy sources, they become increasingly dependent on these elements. For instance, the magnetic properties of neodymium and praseodymium are crucial in the development of electric vehicle (EV) motors (Agamloh et al. 2020). With the rapid expansion of the EV market, the demand for these REEs is expected to skyrocket.

Elements such as neodymium, praseodymium, and dysprosium are pivotal in the creation of high-strength magnets used in wind turbine generators. Additionally,

elements like europium and terbium find applications in phosphors, which are integral to energy-efficient lighting technologies like compact fluorescent lamps and light-emitting diodes (LEDs).

Clean energy solutions such as solar photovoltaic plants, wind farms, and electric vehicles fundamentally diverge from their fossil fuel-based counterparts in terms of resource requirements (EIA 2021; Agamloh et al. 2020; Ashby 2013). In essence, the construction of solar PV plants, wind farms, and EVs demands a more substantial quantity of minerals than their traditional counterparts. To illustrate, the mineral inputs necessary for manufacturing a typical electric car surpass those required for a conventional car by a factor of six (EIA 2021; Agamloh et al. 2020). Similarly, the mineral resources needed for the establishment of an onshore wind plant are nine times greater than those for a gas-fired plant (EIA 2021). This notable difference underscores the resource-intensive nature of clean energy technologies.

The transition towards a clean energy paradigm is poised to trigger a substantial surge in the demand for critical minerals, propelling the energy sector into a prominent role within mineral markets. A noteworthy trend has emerged since 2010: the average amount of minerals essential for generating a unit of power capacity has surged by 50% (EIA 2021; Ashby 2013). Historically, until the mid-2010s, the energy sector constituted a minor fraction of total mineral demand for most resources. However, with the accelerating momentum of energy transitions, clean energy technologies are rapidly emerging as the most swiftly expanding sector of demand.

This escalation aligns with the increasing prominence of renewables in new investments. As the share of renewable energy in new projects has risen, so too has the demand for minerals, underscoring the intricate relationship between the transition to clean energy and the heightened requirement for key resources.

In a trajectory aligning with the goals of the Paris Agreement, particularly in the International Energy Agency's Sustainable Development Scenario (SDS), the share of total demand for minerals is anticipated to undergo a profound transformation. Over the next two decades, clean energy technologies are projected to claim more than 40% of total demand for copper and rare earth elements, 60–70% for nickel and cobalt, and an astonishing nearly 90% for lithium (EIA 2021).

Remarkably, electric vehicles and battery storage, integral components of the clean energy landscape, have already superseded consumer electronics as the primary consumers of lithium (EIA 2021). Furthermore, they are poised to surpass stainless steel, traditionally a major consumer, to become the foremost end user of nickel by the year 2040 (EIA 2021). This seismic shift underscores the pivotal role of the energy sector in reshaping mineral markets and emphasizes the transformative impact of the clean energy transition on global resource dynamics.

In other words, Rare Earth Materials are essential in order to secure smooth transition to so-called green energy. Examples of mineral-based clean technologies

include rare earth elements for permanent magnets in electric vehicles and wind turbines; battery grade cobalt, lithium, manganese, nickel, and graphite for vehicle batteries and grid storage; gallium and many other materials for semiconductors used in LEDs and power electronics used in wind and solar systems; and magnesium and aluminium for vehicle light weighting.

Therefore, the energy security is a growing concern for Western nations as they seek to decrease their dependence on fossil fuels and mitigate the impact of climate change. However, the shift to renewable energy sources comes with its own set of security challenges. The critical importance of REEs in these technologies means that Western countries have become heavily reliant on imports of these materials. The majority of these imports come from China, which has a dominant position in the REE market. This heavy reliance on a single source, especially one that may not always be considered a reliable and politically aligned partner, exposes Western nations to vulnerabilities in their energy supply chains.

The geopolitical implications of this reliance on China for rare earth elements are significant. China's dominance in the REE market provides it with considerable geopolitical leverage (see Dong 2020). In the past, China has used this position to exert influence and make political statements, including threats to restrict exports to countries that do not align with its political objectives.

Western countries, including the United States and members of the European Union, must grapple with the strategic vulnerabilities associated with depending on a single, potentially unreliable source for critical materials. These vulnerabilities extend beyond energy security to encompass broader geopolitical implications. They must consider the risks and develop strategies to secure a stable supply of REEs, either by diversifying sources or investing in domestic production and recycling.

In conclusion, the utilization of rare earth elements in the energy sector is central to the development of renewable energy technologies. As the world seeks to transition towards a greener energy future, it becomes imperative for Western nations to address these challenges and secure a stable supply of rare earth elements. To mitigate these risks, Western nations should explore alternatives, strengthen their domestic capabilities, and engage in international cooperation to ensure a reliable and resilient supply of these critical materials in the pursuit of a sustainable energy future.

4.3. Military Sector

China's dominance in the global rare earth materials market has significant security implications for Western countries, particularly in the defence sector. The dependency creates a precarious situation where a disruption in the supply chain could compromise defence capabilities and impact national security. The potential for disruptions or manipulation in the supply of rare earth materials poses a significant risk to the defence

sector of Western countries. China's monopoly allows it to exert control over the global market and influence supply chains. In times of geopolitical tensions or conflicts, China could exploit its position by limiting or manipulating the supply of rare earth materials, thereby compromising the production and maintenance of advanced defence systems (CSIS 2019; Butler 2014). Such actions could erode the technological advantage and military capabilities of Western nations, affecting their ability to protect national interests. These materials are essential for advanced defence technologies, including precision-guided munitions, radar systems, and communication devices (Parman 2019; Butler 2014). Reliance on Chinese supplies makes Western countries vulnerable to potential supply chain disruptions and manipulation, which could have severe consequences for their defence capabilities and national security (CSIS 2019).

Rare earth materials play a crucial role in defence due to their integral use in the production of advanced weapons systems (see Runde and Hardman 2023). In the intricate framework of the defence industrial base, the strategic integration of critical materials stands as a linchpin, facilitating not only the operational capabilities of the allied NATO forces but also fostering the expansion and enhancement of military assets. These materials serve as the backbone, enabling the seamless execution and endurance of military operations, while concurrently propelling the production and evolution of cutting-edge military technologies (Runde and Hardman 2023; White House 2021). Essentially, the reliance on strategic and critical materials is not merely a logistical necessity but a key determinant in maintaining and bolstering technical dominance over adversaries. By leveraging these materials, military forces can stay at the forefront of technological advancements, ensuring a decisive edge in the evolving landscape of modern warfare.

A historical lens underscores the significance of these materials, revealing that nations devoid of such strategic foresight have found themselves compelled to make compromises in operational performance and suboptimal allocations of capital. This, in turn, has been a contributing factor to the historical defeats of industrialized nations on the battlefield (White House 2021). In essence, the prudent utilization of strategic and critical materials within the defence industrial base is a proactive measure that not only safeguards the efficacy of military operations but also positions nations strategically to navigate the complexities of contemporary warfare with a marked advantage over potential adversaries. For example, neodymium is essential for manufacturing powerful magnets employed in missile guidance systems, and europium is a key component in producing red phosphors utilized in night vision goggles (Butler 2014).

Beyond weaponry, rare earth materials are vital for defence through their involvement in electronic device manufacturing. Yttrium, for instance, is crucial in creating superconductors, which find application in various electronic devices, ranging from radar systems to communication equipment (see Hurst 2010). The absence of these

materials would impede the production of essential electronic devices crucial for contemporary defence operations.

These materials are pervasive across the spectrum of national security and military equipment, featuring prominently in systems like missile guidance and night vision technology. Their indispensability is underscored by their role in sustaining operations for the U.S. Armed Forces and allied militaries, contributing to the expansion and advancement of military technology to maintain a strategic edge over adversaries. History has demonstrated that the lack of these strategic and critical materials forces industrialized nations into compromising performance and making suboptimal capital allocations, factors that have historically contributed to their defeat on the battlefield.

Each branch of the military uses ammunition that contains rare earth elements, especially in "smart-bombs." Rare earth elements are also found in fighter jet engines and other aviation components. They play an important role in guidance systems, satellites, ammunition, naval air defence, and communication systems (see Lu 2021; Butler 2014). For example, the F-35 fighter jet relies heavily on rare earth minerals, requiring approximately 400 kilograms of these materials for its construction (see Science History Institute 2020).

The U.S. Department of Defence has recognized the strategic importance of rare earth materials and the risks associated with relying on China's monopoly, prompting efforts to diversify supply sources and develop domestic production capabilities (White House 2021). China's dominance in the rare earth materials market has been attributed to its vast reserves, low production costs, and control over the global supply chain (Schmid 2019; Htun 2023). The limited domestic production in Western countries, coupled with strict environmental regulations and complex extraction processes, has hindered their ability to compete with China. As a result, Western countries find themselves heavily reliant on Chinese supplies, making them susceptible to potential supply disruptions, price manipulation, and geopolitical pressures.

5. Policy implications

Rare earths find applications in both commercial and defence sectors, with the majority of their domestic utilization being attributed to commercial purposes. Rare-earth elements, possessing diverse applications in business and technology, are considered strategic resources.

Even though, the connection between economic security and national security is not universally agreed upon, the global dominance of China in the rare-earth market poses a vulnerability for, among others, economic, energy and military sectors in the Western nations, making them susceptible to potential political and economic aggression from China. Western nations should, thus, view control over the supply chains as a matter of utmost concern, mirroring the significance it holds for the Chinese government. To

control the supply chain and gain a particular control of REE market, this paper suggests four policy approaches that lead to short as well as long term solutions.

First, the countries must focus on building recycling programs. Globally, the reuse and recycling of products containing rare-earth elements are still at relatively low levels. The potential embedded in existing products or waste streams remains largely untapped (Beattie 2020). This limited reuse is primarily attributed to factors such as low market prices, logistical challenges, high initial setup costs, and environmental concerns associated with recycling programs. Notably, the use of toxic substances and the substantial energy requirements for separating rare-earth elements from recycled materials contribute to the hesitancy in embracing recycling initiatives.

Recycling alone is unlikely to bridge the significant demand-supply gap in the near future, given Beijing's control over pricing (Ferreira and Critelli 2022). To address this challenge, the Western allies need to focus on creating enduring incentives for long-term recycling programs and explore alternative sources that are less susceptible to China's temporary price manipulations. Also, this tool should be considered as the complementary and not as issue-solving policy.

As indicated, securing a stable and sustainable supply of critical minerals necessitates a focus on efficient utilization and reuse. This efficiency can be attained through various means, such as reducing content in products, minimizing material waste in manufacturing processes, reusing postproduction waste, and implementing recycling practices at the end of a product's life. These enhancements and innovations not only contribute to resource sustainability but can also enhance the cost-competitiveness of products.

Second, national stockpiles serve as a strategic tool to address the challenges posed by Chinese dominance in rare earth elements. By accumulating reserves from diverse sources, countries can reduce dependency on a single supplier, particularly China. These stockpiles act as a buffer during supply disruptions or geopolitical tensions, ensuring a stable supply for crucial industries.

Allocating portions of national stockpiles to critical sectors such as defence and technology further guarantees a reliable supply in challenging circumstances. Simultaneously, investments in domestic production contribute to the establishment of a more robust and self-reliant supply chain.

Collaborative efforts with like-minded nations strengthen the collective ability to counter Chinese dominance. Shared stockpiles and coordinated strategies enhance overall resilience. Strategic management of national stockpiles involves regular assessments to adapt to changes in technology, consumption patterns, and geopolitical developments.

Investing in research and development initiatives, focusing on recycling and alternative technologies, reduces reliance on specific rare earth elements and contributes to long-term sustainability and security. Engaging in international agreements to regulate

the production and trade of rare earth elements provides a framework for fair and secure access to these critical resources.

In essence, a comprehensive strategy that combines stockpiling, diversified sourcing, domestic production, and international collaboration enhances a nation's resilience against disruptions and reduces dependence on a singular dominating supplier.

Third, the states with rare earth reserves should support this specific domestic industry. A comprehensive strategy is essential for the Western allies to produce the necessary component parts for both the military complex and the growing green economy. For example, United States has the potential for developing domestic refining and manufacturing capabilities (Ferreira and Critelli 2022). It will essentially shift the dependency risk to other stages of the supply chain. The pressing need for building domestic value-added refining, metal production, and alloying capacity is underscored by two highly likely scenarios, emphasizing the urgency of simultaneous growth in domestic mining and manufacturing capabilities.

China can either reduces or increases domestic production and both scenarios can bring particular challenges. The first one will mean the shift of Chinese position as a major consumer of raw REE while decreasing its own production. To meet demand, China may need to boost imports of REE concentrates or establish mining operations globally to mitigate environmental concerns. This scenario intensifies global competition for these raw materials, reducing availability for refiners outside China, including those in the United States.

The second option could adversely affect Western mining operations that rely on China as a major export market. Outside China, there are very few smelters and processors capable of producing REE oxides and metals (Ferreira and Critelli 2022). To ensure a stable destination market for Western mining operations and attract investor financing in this inherently risky sector, establishing a vertically integrated sector in the Western countries, notably in US, becomes crucial. Nevertheless, expanding refining capacity would require significant investments to catch up, rebuild a skilled labour force, and establish a comprehensive research infrastructure.

Lastly, geopolitical partnerships offer a strategic avenue for addressing the challenges posed by Chinese dominance in the rare earth elements market. Through collaboration, nations can diversify their sources of these critical resources, reducing dependence on a single dominating player like China. Shared stockpiles become a tangible manifestation of this collaboration, ensuring that partner countries have a collective reservoir to draw from during periods of supply disruptions.

According to the US Geological Survey (2020), most of the reserves of rare elements are located in China and in other friendly countries such as Vietnam, Brazil, Russia and India. Only in other places can we find states from the imaginary Western world, namely Australia and the USA. And it is here that it is necessary to perceive the fact that Brazil, India and South Africa together with Russia, and precisely China, form the

BRICS grouping, and a certain degree of cooperation between these states can be assumed even in the field of rare elements, which would facilitate the approach of China or Russia compared to others - Western competitors. China's foreign policy in Central Asia can be perceived in a different way, where, among other goals, mineral wealth is in the interest (see Frough 2016; Hynek 2020; Juza 2016). Although China has had access to Afghanistan's mineral wealth for a long time, immediately after the withdrawal of Western troops, China began negotiating with the Taliban to strengthen its access to rare earth deposits (see Frough 2016; Blumenthal et al. 2022). It secures similar approaches on the African continent and in the surrounding Asian countries. Securing access to mineral wealth is not only eliminated for rare elements, but also for gas, oil and other raw materials (see Hynek 2021).

Therefore, joint investments in domestic production facilities, facilitated by geopolitical partnerships are inevitable to strengthen the ally's resilience. By pooling resources and expertise, countries within these partnerships can collectively navigate market fluctuations and geopolitical pressures.

Geopolitical partnerships also wield diplomatic influence, providing a collective stance to negotiate fair trade practices and market access for rare earth elements. The combined weight of partner nations enhances their bargaining power. Additionally, these partnerships can advocate for and contribute to the development of international regulations governing the production and trade of rare earth elements. Such regulations foster transparency and fair practices, reducing the risk of monopolistic control.

Strategic alliances formed within geopolitical frameworks, specifically focused on securing critical resources like rare earth elements, bolster the overall geopolitical position of partner nations. This mutual support contributes to a more balanced and resilient global economic landscape. Transparent supply chains, advocated for and established through these partnerships, enable tracking the flow of rare earth elements and ensure ethical and sustainable practices throughout the supply chain.

Geopolitical partnerships also provide a platform for joint crisis management and response planning. In the face of supply disruptions or geopolitical tensions, coordinated efforts within the partnership framework can help member countries effectively navigate and mitigate the impact of such crises. By fostering collaboration through geopolitical partnerships, nations can collectively diminish the influence of any single dominating supplier, such as China, and create a more robust and secure global rare earth elements landscape.

6. Conclusion

China is the world's largest producer of rare earth elements, currently supplying over 80% of the global demand. This dominance has made China a significant player in the global rare earth market, providing the country with substantial economic and

geopolitical leverage. Western countries' dependence on China for rare earth element supplies can pose a serious problem, a concern that was officially acknowledged at the NATO summit in 2021. In April 2020, China sent a message that it needed to increase the global supply chain's reliance on it and develop strong retaliatory and deterrent capabilities against disruptions from foreign parties. Recently, China has also threatened to limit rare earth exports in response to the export of weapons by the American company Lockheed Martin to Taiwan. In 2020, President Xi Jinping even warned the USA that in the event of a trade war, China would cut off the supply of rare materials to the USA, which are crucial for its technological development (Ferreira and Critelli 2022). In other words, China threatened to apply the same approach in foreign policy as it did against Japan.

It is also necessary to consider the conflict in Ukraine, where the importance of modern technology on the battlefield becomes evident. A modern army is characterized by its technological sophistication and equipment. Although NATO armies are likely at the pinnacle of the technological pyramid among armies, the situation could change rapidly if China interrupts or disrupts rare earth element supplies, over which it currently holds a de facto global monopoly. It's important to keep in mind that most armies are undergoing significant modernization. All efforts to develop the technological capabilities of NATO armies, expand military capacities, and overall modernize could be jeopardized by China, perceived as a competitor to Western countries. As the only global actor remaining outside the conflict in Ukraine, China could emerge from the situation as the ultimate winner. NATO members support Ukraine's struggle with weapon and material deliveries, so China can take advantage of the situation and emerge stronger because it has the tools to further weaken the overall rearmament and technological development of the West. In this situation, it is important to consider the broader geopolitical context, where China has serious disputes with the USA and other European countries, such as Lithuania, regarding Taiwan. This is also a reason why the situation in Ukraine could ultimately favour China to strengthen its position at the expense of others.

In a holistic analysis of the situation, it's also essential to note that the USA, a key NATO actor, imports up to 80% of rare earth elements from China, and the European Union imports even more (US Geological Survey 2020; European Commission n.d.). The USA has already taken steps to restore and secure supplies and increase domestic rare earth element production, as well as develop alternative sources of these critical elements. One example is the Mountain Pass mine in California, which is currently the only functioning rare earth metals mine in the United States. The mine was closed in 2015 due to bankruptcy but was reopened by a new owner in 2018. The US government has also invested in research and development of new technologies for mining and processing rare earth elements; however, as previously mentioned, similar capacity development requires time and significant financial investments. Therefore, international coordination and mutual support among European states and the USA will be crucial for future development.

Overall, this research has provided a comprehensive examination of the implications of Chinese dominance in rare earth elements for Western countries, particularly within the energy, economic, and military sectors. The findings underscore the intricate challenges posed by China's control over the market, revealing vulnerabilities and dependencies that extend across critical domains.

In the energy sector, the significance of REE in clean energy technologies highlights a potential risk to the Western transition towards sustainable energy sources. China's dominance in REE production introduces uncertainties in the reliability and resilience of these technologies, prompting a reconsideration of strategies for ensuring long-term energy security.

Economically, the study elucidates the far-reaching impacts of Chinese dominance on high-tech industries. Western countries, heavily reliant on manufacturing processes, face economic vulnerabilities stemming from supply chain disruptions and market uncertainties. This necessitates a recalibration of economic strategies to mitigate risks associated with dependence on a single dominant supplier.

Within the military sector, the strategic importance of rare earth elements in advanced defence technologies exposes Western nations to geopolitical vulnerabilities. China's control over the supply of rare earth materials raises concerns about the security of defence systems and the potential leverage that could be exerted in geopolitical contexts. Addressing these vulnerabilities requires a nuanced approach that integrates security considerations into defence planning and procurement.

The article also provides the reader with potential policy solutions, concerning short- and long-term options. The paper recommends and advocates for a paradigm shift towards sustainable practices, emphasizing the importance of recycling as a means to enhance resource efficiency and reduce dependency on external suppliers. Reuse and recycling of products containing rare earth elements emerges as a viable strategy to mitigate environmental impacts and promote a circular economy.

National stockpiles are identified as a strategic tool to buffer against supply disruptions and geopolitical uncertainties. Developing and maintaining reserves of rare earth materials not only safeguards critical sectors but also ensures a stable supply in the face of market fluctuations or geopolitical tensions.

The support of the domestic rare earth industry is highlighted as a cornerstone of resilience. Policy recommendations underscore the significance of investing in mining, refining, and manufacturing capabilities to enhance self-reliance, stimulate economic growth, and establish a robust and resilient supply chain.

Geopolitical partnerships are emphasized as a key strategy to diversify sources and reduce dependence on a single dominating supplier. Collaborative efforts with other nations are seen as a means to strengthen access to rare earth materials, foster technological innovation, and present a unified front in negotiating fair trade practices on the global stage.

In conclusion, China's dominance in the rare earth element market has provided the country with significant economic and geopolitical leverage. In the future, it will be important for NATO and European Union member states to build infrastructure for acquiring these materials and, most importantly, to develop foreign policies to secure materials from third parties, including supply and transit countries. Collectively, the findings emphasize the urgency for Western countries to diversify their sources of rare earth materials, invest in domestic mining and refining capabilities, and foster international collaborations to enhance resilience. Mitigating the implications of Chinese dominance necessitates a strategic and coordinated effort across governmental, industrial, and research sectors. The research presented herein provides a foundation for future policy discussions and strategic initiatives aimed at securing the Western nations against the challenges posed by the current dynamics in the rare earth elements market.

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