CRITICAL TIES, STRATEGIC RISKS: THE ROLE OF SEMICONDUCTORS AND RARE EARTH ELEMENTS IN THE SINO-US RELATIONSHIP

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Abstract

In an era marked by strategic decoupling and renewed great power rivalry, the US and China are navigating an intensifying tech rivalry. Co-dependencies in the critical areas of semiconductor production have the possibility of fostering innovation but also carry the risk of strategic vulnerability. This paper aims to examine the strategic interdependence between the US and China in key areas like critical rare earth elements and semiconductor technology. Employing the theoretical underpinnings of defensive neo-realism, the study seeks to examine the vulnerabilities and risks emanating from this kind of reciprocal reliance. It uses the qualitative approach to assess their respective state priorities and policy responses *in an attempt to mitigate the risks associated with mutual reliance in an anarchic international system, underscoring the principle of self-help. Findings of the study highlight the complexities arising from tech-decoupling and implications for the global technopolitical landscape.*

Key words: Semiconductors, Rare Earth Mineral, US-China Rivalry.

Introduction

The US and China have entered into a new phase of geo-political competition that is defined by a contest in the technology domain. Major break throughs and innovations in the tech industry are tied to digital supremacy and national security (*Semiconductors & Geopolitics*, n.d.). As both powers strive to achieve superiority in the global tech race, they are confronted by interdependencies on rival powers. Owing to the growing tensions between the two major powers, a Cold War 2.0 is underway wherein both sides are striving to upgrade their technological capabilities in support of their national economies and military modernization efforts.

The US has identified China as a rival and revisionist state that seeks to undermine the US-led global order. It accuses China of harbouring expansionist intentions to the detriment of regional peace and security in the Indo-pacific region. Consequently, successive US administrations have shifted their focus away from the Middle East and Europe towards the Indo-Pacific region to counter China's growing influence. In doing so, it has partnered with regional states by reviving past alliances and building new relationships. In order to cope with the scale of the China challenge, the US has encouraged regional states to collaborate with one another through multilateral arrangements that are spearheaded by the US. This is in contrast to the past US 'hub and spokes" model which emphasized US' bilateral alliances with regional states. The establishment of QUAD and AUKUS are two such initiatives that are indicate of the US approach towards the region. The US has tried to ally regional fears about China's growing dominance in the region by the establishment of coalitions and alliances and encouraged regional states to take greater responsibility in the security architecture of the region.

China, for its part has severely criticized the US for its "Cold War mentality" arguing that it is the single most destabilizing factor in the region that is stroking tensions between China and other Asian states. China continues to advocate the "Asia for Asians Approach" and emphasizes the need to engage in meaningful diplomacy to address all outstanding issues and conflicts. However, its stance on the Taiwan issue and the South China Sea has continued to raise apprehensions of regional states which are aggravated by its rapid military modernization and upgradation measures. Technology is at the heart of this rivalry. The US global leadership is driven by its technological supremacy. It has been the foundation of global tech innovations driving economic growth and development worldwide. Likewise, China has also been investing heavily in tech startups and incorporating technology-based solutions in its national policy frameworks. As the 'manufacturing hub' of the world, China has devoted significant funding towards research and development to become a leading power in the technology sector. Emerging technologies and Artificial Intelligence are fuelling the race for global supremacy in the contemporary era and shaping geo-political rivalries.

In context of the evolving technological competition, semiconductor chips have acquired considerable significance while Rare Earth Elements are essential to the production of these advanced semiconductor chips. The US leads in the production of semiconductor chips and controls the supply chains whereas China dominates the Rare Earth Minerals production. Owing to renewed patterns of rivalry between the two major powers, each side is striving to strengthen its domestic capabilities while reducing reliance on the other to minimize strategic risks (Brundage, 2023). Despite this, vital interests of both states remain deeply entwined especially across the intricate network of global value chains involving cutting-edge chips and critical raw minerals (CRM), hence making absolute decoupling both economically and technologically unfeasible (Jones et al., 2021).

This paper aims to explore the evolving nature of US-China tech rivalry in a globalized world. It analyses how efforts for technological decoupling related to semiconductors and Rare Earth Elements are underway in an era of rising strategic competition but remain constrained due to the interconnectedness of supply chains and production networks.

Theoretical Framework

Defensive neo-realism is employed as a theoretical lens to analyze the ongoing technological rivalry between the US and China featuring semi-conductor chips and Rare Earth Elements. The defensive offshoot of neo-realism emphasizes the anarchic nature of the international system in which states are driven by the primary motive of seeking security in the absence of an over-arching central authority (Waltz 1979). Actions of one state to increase its security are perceived as measures aimed at undermining the security of others. This leads to a perpetual security dilemma where states cannot trust the intentions of others (Waltz 1979). Increase in the material capabilities of one state is perceived as threatening by the other and prompts counter-measures. In case of the US and China, the tech sector related to the semi-conductor production is bifurcated with the US exerting control over semiconductor design and supply chains and China maintaining authority over the processing and refinement of Rare Earth Elements. In order to secure themselves against potential vulnerabilities and disruptions, a process of targeted de-coupling is underway to reduce and diversify dependence. The study however argues that on account of mutual reliance in the supply chain system; absolute decoupling will not only be unfeasible but also counterproductive.

Research Methodology

This research is largely qualitative, descriptive and analytical focusing on strategic asymmetries in areas of interdependence between the US and China. It employs a comparative research approach to examine the relative strengths and weaknesses of both states in the global technopolitical landscape. China, for instance is regarded as a key supplier of Rare Earth Elements while the US is a leading force in chip design and manufacturing. Additionally, it also seeks to address the emerging vulnerabilities in their shared areas of concerns. This study combines the insights from primary data and existing literature. Primary data includes government documents, official statements and strategic whitepapers. Secondary data includes academic literature, policy papers, existing statistics and journal articles. This methodology provides a systematic comparison of their mutual capabilities in a highly competitive strategic environment.

China's Dominance in Rare Earth Elements

Rare Earth Elements (REE) are a set of 17 naturally occurring metallic elements that collectively share their chemical nature and are recognised as the fundamental bedrock of high-tech advancements. These elements include 15 lanthanide metals along with two additional elements scandium and yttrium and are typically found in the same geological mineral beds (*U.S. Geological Survey Releases 2022 List of Critical Minerals*, n.d.).

Contrary to common understanding, they are not naturally rare; indeed, they have significantly high abundance in the earth's crust, but are seldom found in concentrated forms which require specific extraction and refinement processes in order to obtain an isolated and usable rare element from within the mineral ores. In essence, the high cost of extraction and purification of these critical elements make them strategically rare and generate dependencies and vulnerabilities, given that extraction requires significant investments in critical infrastructure which is difficult to establish (Discovery Alert, 2025). More so, the environmental impacts of extraction and processing of these elements have also dissuaded western states from undertaking the refinement initiates, leaving it largely to China that has developed not only the requisite expertise but also strict compliance protocols that limit potential hazards.

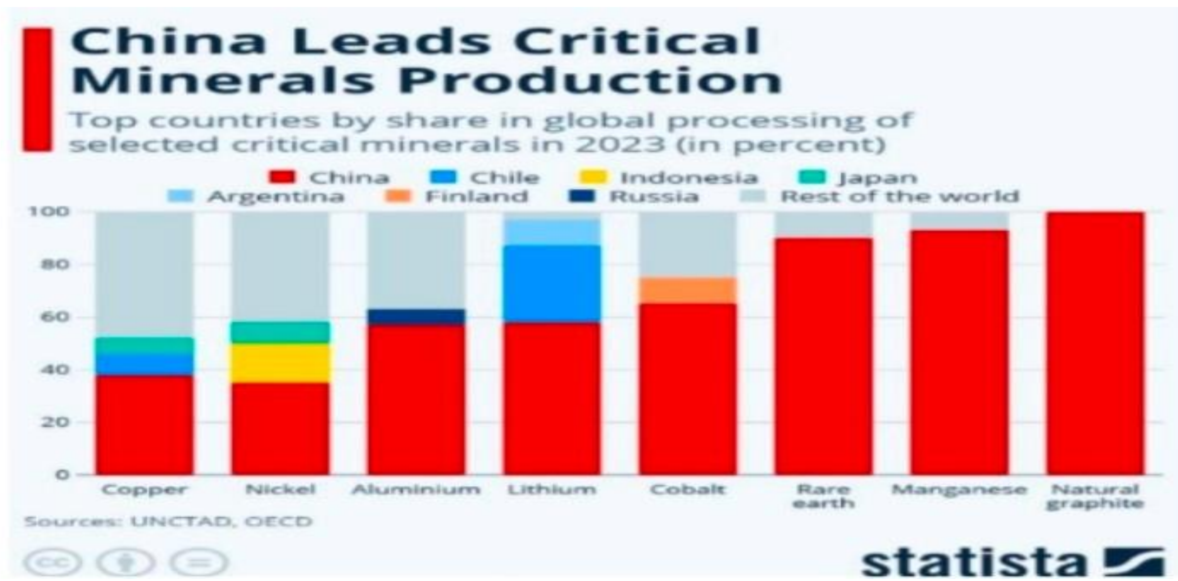
Rare Earth Elements play an indispensable role in modern industrial and technological spheres. They are essential metals used in a wide range of applications like green technology, electronics, defence systems, radar systems, solar panels, computer hard discs, medical devices, fiber optics and automotive industries. Their distinct electro-magnetic and catalytic properties make them crucial for designing and fabricating high-quality equipment(CAPS India, 2025). For instance, Dysprosium and Yttrium are heavy rare earth elements used in electric vehicles and wind turbines, amplifying their durability and efficiency (Cowle, 2025). In parallel, Neodymium is a critical light-rare earth element that is used in different areas ranging from mobile phones and medical equipment to electric vehicles. (Cowle, 2025) In addition, Praseodymium is a highly significant mineral that is widely used in aircraft engines and permanent magnets (*The Praseodymium (PR) Market | SFA (Oxford)*, n.d.).

Additionally, they have strategic importance for advanced industries vital to national defence. Their specific characteristics facilitate miniaturization and upgrading of modules, resulting in more optimized and compact devices. Samarium, for example is a heavy rare earth element that has applications in heat resistant metallic alloys, essential for defence and aerospace industries (*The*

Samarium (SM) Market | SFA (Oxford), n.d.). Similarly, Terbium is a heavy rare earth element that is alloyed with other rare minerals to maximize its capacity and efficiency for storing bulk of data in hard drives for purposes of reading and writing data operations. (Discovery Alert, 2025)

The worldwide critical raw material (CRM) sector is a broader category comprising minerals that are considered to have strategic and economic viability. This sector is heavily monopolized by China which possesses over 37% of proven rare earth reserves, nearly 69% of production output, and over 90% of purification capacity. In addition, China's low productivity costs and advanced refineries contribute to its overarching dominance (Statista 2025). A report published by United Nations Conference on Trade and Development reflects China's leading role in rare earths refinement and processing. Although, the mining of these minerals take place in different geographical zones, but China presently accounts for two-third of worldwide refining and processing outputs. In particular, it is accountable for purification of nearly 90% of rare earth minerals and 100% of naturally occurring graphite (Baskaran 2024).

Figure 1: China Leads Critical Minerals Production



Source: Anna Fleck, "China Leads Critical Minerals Production," Statista, July 31, 2024, https://www.statista.com/chart/32748/top-countries-processing-critical-minerals

One of the leading rare earth production firms in Beijing is China Rare Earth Group, a state-owned mega firm established in 2022, which controls at least 60-70% of raw mineral production and contributes approximately 30-40% in global supply (Briefing 2022). The second leading rare earth giant in China is the Northern Rare Earth Group High-tech Co. Ltd, which is currently operationalized in inner Mongolia and specifically deals with mining and refining of critical raw minerals. ("Invest in China | investinchina.chinadaily.com.cn," n.d.) In 2024, CNREG initiated the world's largest, rare earths refining plant, Northern Rare Earths Green Smelting Upgrade and Transformation Project' in Baotou ("Baotou, China," n.d.). This facility has been regarded as a "Quality Powerhouse Enterprise' because it incorporated environmentally friendly technologies and solidified China's standing as the very first nation in implementing safety standards for rare earths purification and processing. In parallel, it has reserved 5% of shares in research and development sector, hence forging innovation. Moreover 80% of rare minerals mining process within this plant have been digitised, underscoring its commitment to modernization. (Times, n.d.) As the concentration of production, refinement and processing of rare earths in China has solidified its role as a steady supplier, this has also created potential dependencies and vulnerabilities for buyer states that rely on this valuable resource. China's control over the critical industry allows for its to leverage critical earth materials as a strategic weapon, enabling it to exert significant geopolitical pressure by restricting supply of these metallic minerals (Darabshaw 2025).

A notable example of resource nationalism was evident in China's rare earth embargo on Japan in 2010 that drastically impacted its high-tech sector and disclosed the risks associated with a concentrated mineral supply chain (*How Japan Strengthened Its Rare Earth Minerals Supply Chain*, 2025). At present, the US is heavily dependent on China for its rare earth minerals requirement with over 70% of its rare earth imports originating from China in 2024. California's Mountain Pass Mine is the only facility in the US that is responsible for mining rare earths and is vital for domestic rare earths production (*World Economic Forum*, n.d.) In total, the US possesses 11.6% of rare earth reserves and ranks second to China but lacks the specific infrastructure needed for refining and processing of raw minerals, compelling it to export the extracted material from California's Mountain Pass mine to China (Statista, 2025).

The supply concentration of the rare earth elements exposes the US to geo-political risks. Critical resources especially for military grade equipment and advanced computing capabilities allow China to exert influence over US semiconductor supply chains. Restrictions on rare earth minerals essential for the processes of doping, etching and polishing could disrupt semiconductor manufacturing, slowing or effectively halting manufacturing (Tan et al., 2025). Following the Trump Administration's decision to impose a tax credit of 145% on imported goods, China tightened the export of rare earth elements like germanium, gallium, antimony and graphite which the US heavily relies on for chip fabrication. This calculated counter-retaliation by Beijing underscores its ability to weaponize rare earth minerals supply chain by reinforcing strategic leverage and geoeconomic dominance in an integrated international economy. (Tan et al., 2025) Therefore, in context of the simmering tensions and growing discord between the US and China over trade, both sides are using their relative advantages in the tech domains to influence the outcome of the negotiations. In case of any conflict involving the two disputing parties, either side could weaponize their advanced capabilities with regards to semiconductor production to inflict considerable damage to the other side (Tan et al., 2025).

U.S. Dominance in Semiconductor Design and Software

Semiconductors are mainly the silicon or germanium-based microchips that can conduct electricity under suitable conditions. These miniature chips are used in a wide range of electronic devices and are identified as the foundational components of electronic and digital technology. (McCallum, 2025) In the current dynamics, semiconductor chips are considered not just an economic tool but also a powerful means of strategic influence that determines state security, geopolitical leverage and tech superiority (*Chip War,* 2022). Additionally, their versatile applicability in both military and civilian domains have placed them at the centre of technopolitical contestation. In essence, they are recognized as the prime assets of modern economic and defence systems (Shivakumar and Wessner 2024).

Acknowledging their indispensable significance in an interconnected and globalized world, acquisition to semiconductor technology and software is redefining the technopolitical landscape by deepening innovation gaps between the established power i.e. the US and the rising power, China (The Belfer Center for Science and International Affairs, n.d.). By virtue of the Chips and Science Act, 2022 the US has allocated approximately $13 billion for generating next generation semiconductor technology. In designing cutting-edge chip, American firms like Nvidia and Qualcomm are at the leading edge by developing high-tech chips that drive everything from smartphones to artificial intelligence system (The Belfer Center for Science and International Affairs, n.d.). These breakthroughs are complemented by the superiority of American based software companies like Cadence and Synopsys, which deliver a sensitive Electronic Design Automation (EDA) software, which is utilized in manufacturing complex and sophisticated chips containing numerous electronic components, thereby enhancing miniaturization and efficiency within electronic devices (Costa, 2025).

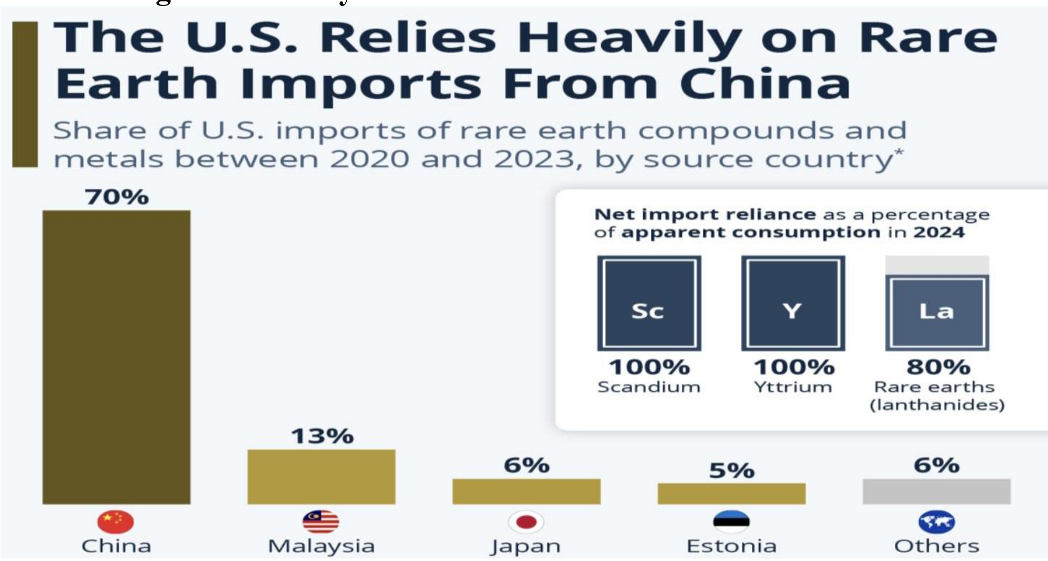
China on the other hand is heavily dependent on the US for state-of-the-art-semiconductor technology to fulfil its domestic demands (Borak & Borak, 2021). But China's strategic approach of civil-military fusion which incorporates semiconductor technology in military applications has raised concerns in the US regarding the potential misuse of its chip technology in advancing and modernizing China's military forces. Additionally, China's requirements of joint ventures for sharing technical expertise are mandatory for foreign companies in exchange for their operationalization in China but its weak intellectual property regulations have resulted in IP theft and extraction of critical technological information from foreign firms (Borak & Borak, 2021). Consequently, these developments have prompted action from the US to restrict the exports of EDA software and cutting-edge semiconductor chip technology to China to curb its technological aspirations and military modernization (Matsakis, 2024). The US opts for a competitive coexistence strategy vis-à-vis China that aims to restrict its access to US-based advanced technology, which in turns limits the ability of China to nurture its own domestic semiconductor manufacturing capacity (Sullivan, 2025). Taken collectively, these measures aim to restore the US leadership in the technological domain by restricting China's development in critical areas related to semi-conductor production and application in strategic areas (*Everything You Need to Know*

About the U.S. Semiconductor Restrictions on China, n.d.).

Strategic Vulnerability and Policy Responses

Undoubtedly, the interdependence between the US and China in the semiconductor industry creates interwoven patterns of cooperation and vulnerability (Allison et al., 2021). Complex interdependencies in varying sectors and stages of manufacturing offer a conducive environment for cooperation, however when such interlinkages are associated with rival and confrontationist actors, the opportunities for cooperation may turn into strategic risks with each side using it's economic heft to influence desired outcomes (CSET, 2023). Given the significance of semiconductors in the contemporary economic, political and strategic domains, China's control over Rare Earth Elements and the US superiority in semi-conductor design and supply chains showcases such patterns of mutual reliance and strategic risks (CSET, 2023). In the aftermath of the October 2022, export restrictions limiting access to advanced semiconductor chips, China responded by tighter governmental controls over the export of Rare Earth Elements. Each export order now requires a one-time approval with complete details of the end user, meanwhile the US has been strictly monitoring any transfer of advanced semi-conductors to China through direct and indirect avenues leading to sanctions and barring future cooperation with parties that are involved in violations (CSET, 2023). China's decision to impose export controls on gallium and germanium in 2023 were considered retaliatory moves in response to the restrictions. Both earth elements are crucial for semiconductors used in defence production. An analysis of emerging trends indicates strategic de-coupling as a result of rising geo-political tensions between the US and China (CSET, 2023). Efforts for limiting dependencies and seeking autonomy in the semiconductor industry illustrate how previous cooperation in strategic sectors can witness significant steps towards disassociation. Such developments can be viewed through a broader lens in context of the US efforts to constrain the rise of China and maintain its global supremacy given that the future of the international order will to a great extent be determined by technological supremacy (Grant, 2025). By recognizing the ramifications of critical minerals dependency on its geopolitical adversary, the US has introduced legislative measures focusing on securing the mineral supply chain by accelerating local rare earths production and processing in pursuance of its national interest. In 2022 former US President Biden's Administration decided to upsurge the domestic mining, refining and processing of key minerals like nickel, cobalt, lithium and graphite which are central to both economic and military grade technologies (*Biden Invokes Defense Production Act to Shore up Raw Materials for Clean Energy*, 2024). In the present context, the US continued reliance on China for 70% of its rare earth imports has compelled US President Trump to prioritize domestic mineral mining and processing. The Administration has directed funding to the California's Mountain Pass Mine for revitalizing refining and processing facilities for light critical minerals hence, encouraging domestic rare earths supply chains (Renshaw & Scheyder, 2025)

Figure 2: Heavy Reliance of the United States for Rare Earth's on China



Source: Felix Richter, "The U.S. Relies Heavily on Rare Earth Imports from China," Statista, Apr 14, 2025, https://www.statista.com/chart/34301/us-rare-earth-imports/

In an effort to secure alternative Rare Earth Elements' supply chain, the US officially amended the Defence Production Act in 2024 in order to designate Australia as a 'domestic source' for critical minerals vital for radar systems, semiconductor chips, missile systems and EV batteries. The specific designation is confined to the closest allies of the United States. The shift is noteworthy because it authorizes U.S. Department of Defence to invest in Australia's critical mineral programs that are essential to US national defence thereby strengthening the allied supply chain while minimizing dependency on adversarial nations (*Critical Minerals, Clean Energy and a US Compact*, n.d.).

China, on the other hand, is actively engaged in acquiring semiconductor self-sufficiency in its strategic attempt to build an all Chinese-centered supply chain. For this purpose, China has launched the Made in China 2025 Initiative which aims to narrow the technological gap with the US. This initiative set the ambitious goal of achieving 70% self- sufficiency in microchip fabrication by the end of 2025 (Institute for Security and Development Policy, 2018). Consequently, one of the major objectives of this initiative was to reduce reliance on foreign technology and to bolster China's ability to produce advanced chips to address production needs (*Made in China 2025*, 2016). However, owing to the sanctions imposed by the US, the self-sufficiency rate reached only 23% in 2023, highlighting a major gap in the attainment of the target (Staff, 2025). In order to address this issue, China officially launched the third phase of the 'Big Fund' which is also known as the National Integrated Circuit Industry Investment Fund, in May 2024. Within this phase, China committed to invest approximately $47.5 billion in domestic chip fabrication, development of semiconductor equipment locally and promotion of research and development (R&D) in modernizing semiconductor technology (Joane, 2024). The most recent assessments indicate that China has achieved nearly 30% self-sufficiency in semiconductor industry. In essence, China's new policy underscores long-term resilience and tech autonomy in the microchip supply chain (CSET, 2023).

Conclusion

The intensifying rivalry between the US and China especially in the technological domains on account of distinctive strengths in semiconductor production have led to the rise of two possibilities: The first, "absolute decoupling" which calls for profound bifurcation leading to the creation of distinct global technological ecosystems that are incompatible with each other (CSET, 2023). The other, referred to as "targeted decoupling" which argues for selective cooperation and limited separation in sensitive technological areas where strategic concerns are more pronounced. The likelihood of the second form of decoupling is more likely and currently underway. Most analysts argue that a complete bifurcation is neither viable nor entirely possible given the integrated nature of the globalized economy wherein the US and China are leading actors in international manufacturing networks (Rao, 2024). Consequently, the possibility of targeted decoupling may prevail in critical areas like state-of- the-art-semiconductor technology, under strict regulations. In this scenario, the prospect of strategic competition is likely to prevail with limited cooperation hence, avoiding the complete economic severance (CSET, 2023). In order to mitigate the risks associated with decoupling, it is essential to prioritize the diversification of supply chain, foster collaboration to manage supply chain resources and focus on strengthening resilience for sustaining technological growth rather than resorting to absolute decoupling (*China Risk Analysis Advisory Services - Pamir Consulting*, n.d.).

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