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Chokepoints in global supply chains: lessons
from rare earths and hard disk drives

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Chokepoints in global supply chains: lessons from rare earths and hard disk drives

Key takeaways

- *Concentration and limited substitutability can turn the efficiency gains from global supply chains into vulnerabilities. However, the consequences of chokepoints depend on their underlying nature.*
- *The rare earths industry illustrates a persistent dependence on concentrated processing capacity. By contrast, flexibility and effective crisis management can speed up recovery from a temporary disruption, as seen in hard disk drive production after the 2011 Thailand floods.*
- *Resilience measures should match the vulnerability: alternative capacity and technologies can address persistent dependencies, while inventories, supplier redundancy and geographical flexibility can cushion temporary disruptions.*

Global supply chains have delivered substantial efficiency gains through greater complexity and specialisation, but these features can also create vulnerabilities. When critical inputs are concentrated among a few firms or countries and cannot be easily replaced, disruptions in a small part of the supply chain can have wider production consequences.

Such vulnerabilities can become chokepoints whose consequences and policy responses depend on four factors. First, can buyers substitute another supplier or input? Second, is the disruption temporary or persistent? Third, are inventories or other buffers available? Fourth, can firms shift production, redesign products or develop new suppliers?

This Bulletin illustrates these issues through two contrasting cases. The first concerns rare earth elements (REEs)¹ and other critical minerals, where China's strong position means that trade restrictions can create persistent supply risks. The second examines the disruption of hard disk drive production caused by the 2011 floods in Thailand, an extreme but temporary shock from which production recovered relatively rapidly. Together, the two cases show why the appropriate response to a chokepoint depends critically on its underlying nature.

Critical minerals: a structural chokepoint

Demand for critical minerals has risen in response to the green and digital transitions. Some REEs are essential for permanent magnets used in electric vehicles, wind turbines and other clean energy technologies. REEs and minerals such as antimony, gallium and germanium are also important inputs into semiconductor production and, through this channel, into a wide range of products, including smartphones, medical devices, satellite communications, defence systems and artificial intelligence.

¹ REEs comprise a group of 17 elements that, despite their name, are relatively abundant in the Earth's crust. However, they are rarely found in concentrated, economically exploitable deposits and are difficult to separate because of their similar chemical properties.

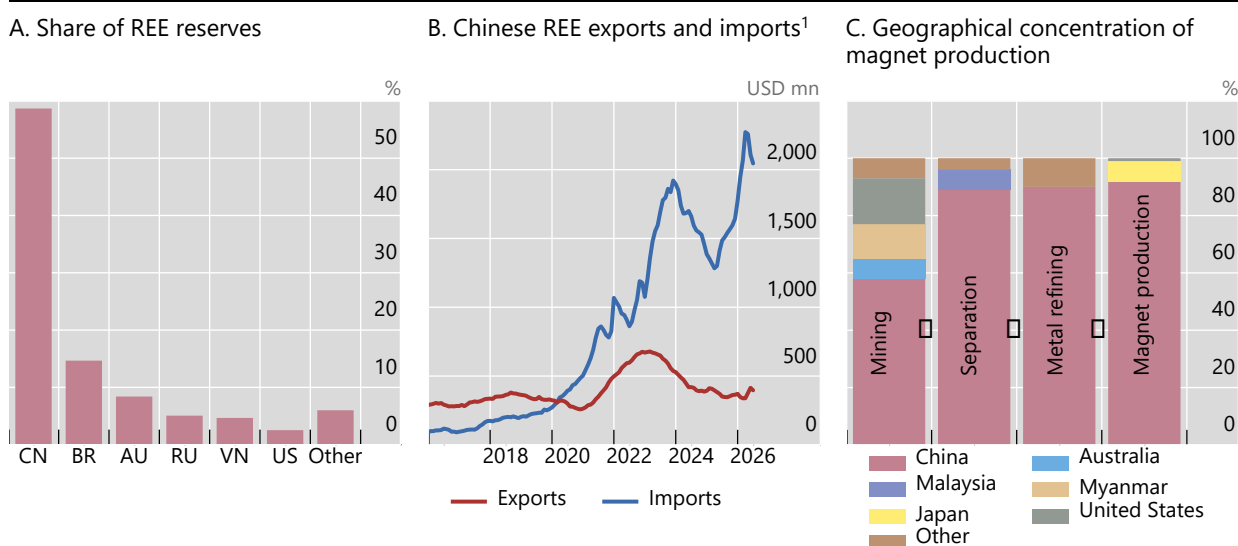
The principal vulnerability of REEs is not physical scarcity. Rather, the vulnerability is that production and, especially, processing capacity are highly concentrated. China has developed an integrated supply chain spanning extraction, separation, refining and manufacturing.

China's dominance in the REE industry is not solely due to its abundant reserves, but also to its expertise derived from developing a highly integrated domestic supply chain. A typical REE supply chain involves several stages: extracting REEs from reserves, processing them to achieve the desired purity and integrating them into end-use technologies such as semiconductors and permanent magnets.

While China's reserves accounted for around 60% of the global total in 2025 (Graph 1.A), substantial reserves are also located in other countries. Moreover, China remains a net importer of REEs (Graph 1.B), as many countries send their raw ores to China for further processing.

China's dominance in the rare earth industry extends beyond mining

Graph 1



¹ Rare earth elements (REEs) defined as harmonised system (HS) 2846.

Sources: US Department of Energy (2022); US Geological Survey (2026); Chinese Ministry of Commerce.

This points to the importance of China's role beyond extraction. For example, in the production of NdFeB (neodymium–iron–boron) magnets, which are high-performance rare-earth permanent magnets made from neodymium, China's share of mining was around 58%. However, the country dominated the downstream stages, accounting for approximately 90% of global capacity in separation, metal refining and magnet manufacturing (Graph 1.C).

How did China achieve such strong dominance in the REE supply chain? Before the late 1980s, the United States was the world's leading producer of REEs. However, US firms were eventually driven out of the market by the influx of low-cost Chinese exports (Goldman (2014)). The economic advantages enjoyed by Chinese companies reflected several key factors.

First, state industrial policy played a key role. In 1985, REE exports became eligible for tax rebates of 13% for ores and 17% for metals (Shen et al (2020)). This initiative attracted numerous small producers, including illegal miners, to the sector. As a result, China's REE output surged, increasing more than sevenfold between 1985 and 1998. By the end of this period, China accounted for 85% of global REE production.

Second, weak environmental regulation facilitated growth during this period. Mining and processing REEs generate hazardous by-products. Foreign companies exploited China's lax regulations by setting up processing facilities within the country, transferring valuable technology in the process. For example, restrictions on radioactive waste disposal at Rhône-Poulenc's plant in France accelerated the relocation of

processing facilities to China (Shen et al (2020)). The lower environmental compliance costs also helped Chinese producers to undercut competitors.

Third, industry consolidation and innovation have strengthened China's position. Since the early 2000s, the sector has consolidated alongside increased investment in research and development. Large state-owned groups play a central role in the sector, working with local universities to advance extraction and separation technologies. Chinese entities accounted for 77% of global REE patent filings between 2014 and 2018, rising to 84% between 2019 and 2022 (Moving Targets Consulting (2026)).

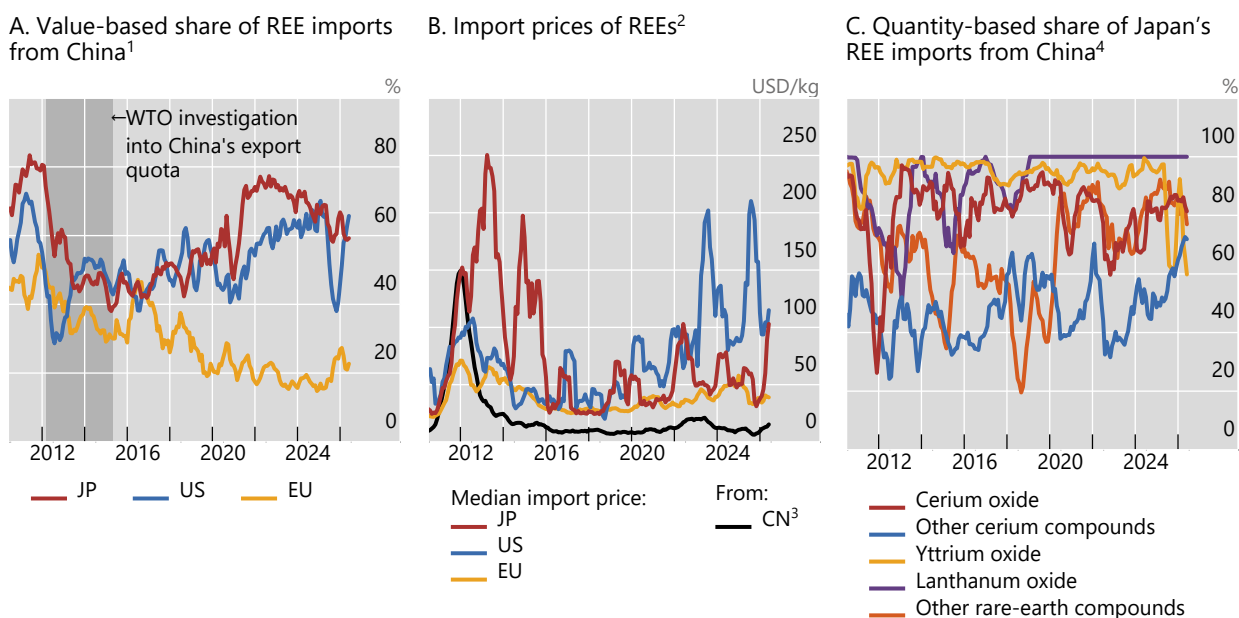
Finally, economies of scale and by-product recovery reinforce China's advantage. Gallium, for example, is produced mainly as a by-product of aluminium bauxite processing. China's scale in aluminium production and its specialised processing capabilities contributed to it accounting for 99% of worldwide primary low-purity gallium production in 2025.

Diversification can reduce dependence, but at a cost

Concerns about dependence on Chinese REEs are not new. By the late 2000s, Japan, the United States and, to a lesser extent, the European Union relied heavily on Chinese imports (Graph 2.A). In 2010, the US Department of Energy's first critical materials strategy highlighted disruption risks and limited availability of substitutes (US Department of Energy (2010)). Around the same time, a diplomatic incident involving a Chinese trawler and the Japan Coast Guard led China to impose a de facto restriction of REE exports to Japan.² In response, the Japanese government supported diversification, recycling and technologies to reduce rare earth use, helping to reduce China's share of Japanese REE imports from around 80% to as low as 40% in mid-2010s (Terazawa (2023)).

Diversifying import sources increases costs and is not always possible

Graph 2



¹ Based on HS 2846; six-month moving averages. REE = rare earth element; WTO = World Trade Organization (see also footnote 2). ² Defined as value of imports divided by quantity; six-month moving averages. ³ Simple average of the three economies.

⁴ The five categories shown are the most disaggregated REE product categories available in the trade data published by Japan's Ministry of Finance.

Sources: Eurostat; Ministry of Finance Japan; US International Trade Commission.

² In early 2012, the European Union, Japan and the United States jointly filed a dispute settlement case with the World Trade Organization (WTO) against China's export restrictions on rare earths, tungsten and molybdenum. The WTO ultimately ruled that China's trade practices violated international trade rules, and China lifted the export restrictions in 2015.

This experience demonstrates that diversification is possible but also highlights its limits. First, alternative supply can be more expensive. Import prices paid by Japan, the United States and the European Union for non-Chinese REEs have generally been substantially higher than prices for Chinese supplies (Graph 2.B). Second, substitutability varies substantially across individual minerals. Even after years of diversification, Japan remains almost entirely dependent on China for some products: all its lanthanum oxide imports, used in high-end optical glass, originate there (Graph 2.C). Third, diversification may itself be vulnerable to common shocks. During the Covid-19 pandemic, disruptions to production outside China contributed to a renewed increase in Japan's reliance on Chinese supplies.

Private sector mitigation actions when substitutes are limited

When substitution is difficult, inventories can provide an important first line of defence. Following China's October 2025 announcement of licensing requirements for certain REEs and artificial diamonds used in microelectronics, artificial diamond exports rose to nearly four times their normal monthly level as buyers brought purchases forward, before returning towards previous levels when implementation was postponed (Graph 3.A).

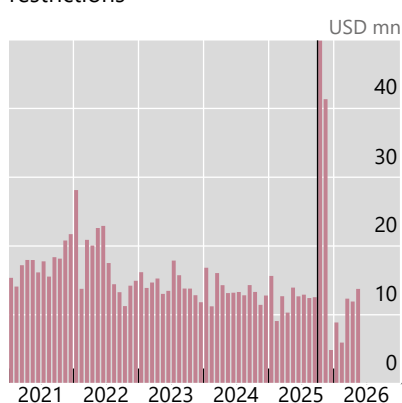
Trade rerouting and transshipment can also ease supply constraints. For example, after China announced its new licensing scheme, exports of yttrium compounds to ASEAN (Association of Southeast Asian Nations) countries rose sharply (Graph 3.B),³ while US data suggest that some may have subsequently reached the United States through the region (Graph A1.B in the online annex).

However, such responses have clear limits. Inventories eventually run down, while governments can tighten enforcement against the circumvention of trade restrictions. One example is gallium, a critical input for military equipment such as proximity sensors and radio-frequency electronics. In December 2024, China added gallium to the list of minerals subject to export controls. An inter-agency crackdown on

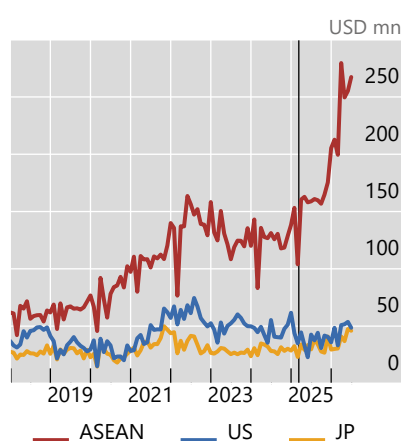
Stockpiling and changes in trade routes can provide relief but with limits¹

Graph 3

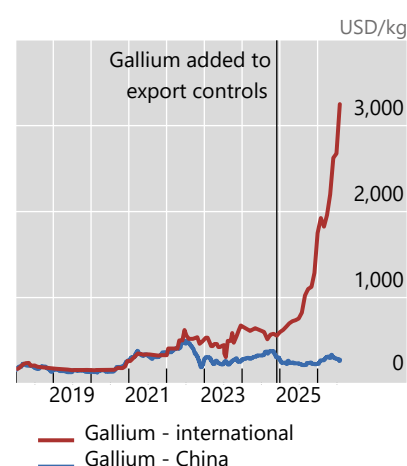
A. Stockpiling artificial diamond exports from China ahead of restrictions²



B. China's yttrium compound exports indicate transshipment³



C. Gallium prices skyrocket as Chinese export controls bite



¹ Vertical lines represent the dates when restrictive trade measures were announced. ² Includes HS 68042110; 71051020; 84798999. ³ Includes 28053017; 28469011; 28469019; 28469026; 28469028; 28469036; 28469039; 28469046; 28469048; 28469099; 38249999; 84869091. ASEAN = Association of Southeast Asian Nations.

Sources: Chinese Ministry of Commerce; US International Trade Commission; LSEG.

³ Chinese yttrium export figures are derived from publicly available data reported under eight-digit Harmonised System codes, aligned with the 10-digit codes specified in the Chinese Ministry of Commerce announcement of the implementation of export controls on yttrium. Although these aggregates may include exports of other rare-earth compounds, data based on a narrower definition also support the possibility of transshipments.

smuggling and transshipment initiated in May 2025 brought China's exports of unwrought gallium to a halt (Graph A2.A in the online annex). As exports dwindled, gallium prices outside China diverged sharply from those quoted in Shanghai (Graph 3.C).

Natural disasters: a temporary chokepoint

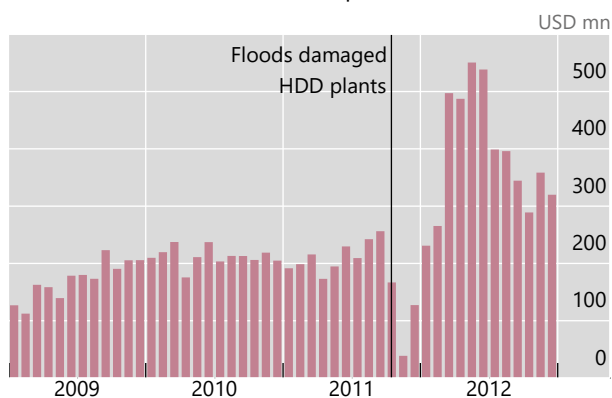
A very different type of chokepoint emerged during the severe floods that affected Thailand in the second half of 2011. At the time, Thailand accounted for around 40% of global hard disk drive (HDD) production. The floods severely disrupted Thailand's HDD manufacturing, resulting in a 55% year-on-year fall in HDD production in the fourth quarter of 2011. The disruption quickly propagated through global computer supply chains and exports (Graph 4.A).

In this case, mitigating the chokepoint disruption depended on restoring existing capacity quickly rather than seeking alternative sources of supply. Western Digital's Thai factories, which together supplied roughly one quarter of global HDDs, illustrate this process. The floods paralysed these factories, reducing shipments from 52.2 million units in the fourth quarter of 2010 to 28.5 million a year later. Nevertheless, production restarted within 46 days (Lau and Wongsurawat (2013)).

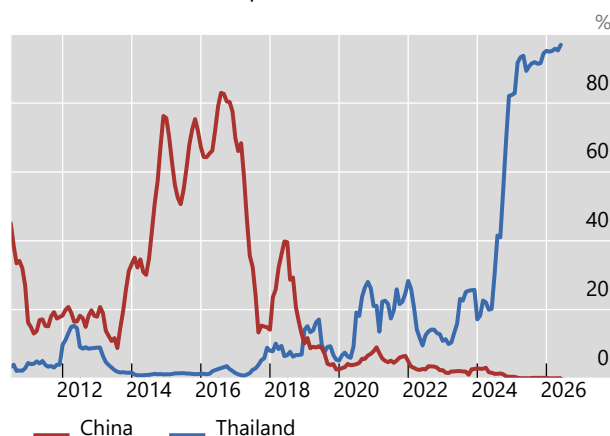
Swift post-flood recovery in hard disk production and Thailand's growing role in global supply

Graph 4

A. Thai hard disk drive (HDD) exports



B. Share of US HDD imports from China and Thailand



Sources: Thai Customs Department; US International Trade Commission.

Several factors enabled the rapid resolution of the chokepoint disruption, reflecting the producer's strong incentives to restore production. Western Digital shifted some capacity to Malaysia and drew on inventories relocated to safer sites before the floods. Its enterprise risk management framework also encouraged suppliers to maintain capacity across multiple locations, reducing the risk of a single point of failure. Retaining all 38,000 employees on 75% of their normal salaries ensured that an experienced workforce was available when factories reopened, while transparent communication helped manage the expectations of customers and investors. Thailand subsequently strengthened its role in global HDD production and in recent years has become an increasingly important source of US HDD imports (Graph 4.B).

Implications

Chokepoints are an inherent feature of specialised global supply chains. The efficiency gains generated by concentration, scale and clustering can also create vulnerabilities when critical inputs or production processes become difficult to replace.

The examples described in this Bulletin show that chokepoints require different responses. Some chokepoints have relatively limited aggregate economic significance but are strategically important. For example, estimates indicate that a complete one-year Chinese embargo on gallium exports would reduce US GDP by about \$3.1 billion, or only 0.01% of GDP (Nassar et al (2024)). This underscores an important distinction: an input may be highly concentrated and strategically important without necessarily posing a large aggregate macroeconomic risk.

Other chokepoints, however, can have broader economic effects.⁴ China's position in rare earths and other critical minerals reflects a structural vulnerability rooted in downstream processing, technological expertise and economies of scale. Diversification is possible but costly and time-consuming, while inventories offer only temporary relief. By contrast, the Thailand floods temporarily disrupted a concentrated HDD cluster, but firms mitigated the shock by shifting production, using redundant suppliers, retaining workers and managing the crisis effectively.

The broader policy lesson is therefore that economic resilience should not be equated mechanically with reshoring or eliminating concentration. Doing so can sacrifice substantial gains from specialisation without necessarily providing proportionate protection against shocks. Instead, governments and firms should identify which chokepoints create material economic vulnerabilities and choose resilience measures according to the nature of the risk.

For persistent structural dependencies, this may justify investment in alternative capacity and technologies. For temporary disruptions, inventories, redundancy and preparedness may be more efficient. The challenge is not to remove every chokepoint, but to strike an appropriate balance between the efficiency of global supply chains and their capacity to absorb shocks.

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⁴ See Alshehri et al (2026) for an analysis of the factors which determine the economic effects of chokepoint disruptions.