

CHARTING CHINA'S EXPORT CONTROLS

PREDICTING IMPACTS ON CRITICAL U.S. SUPPLY CHAINS

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NBR SPECIAL REPORT #115 | JANUARY 2025

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*Predicting Impacts on
Critical U.S. Supply Chains*

*Emma M. Rafaelof, Taylore A. Roth, Mykael SooTho,
and John VerWey*

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This is the one-hundred-and-fifteenth NBR Special Report.

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EXECUTIVE SUMMARY

This report examines the existing export control regime of the People's Republic of China (PRC) and presents a methodology for anticipating and identifying future PRC controls on raw materials.

MAIN ARGUMENT

The PRC's export control regime has grown and formalized in recent years in response to an increasingly active and complex landscape of U.S. and allied export controls. The PRC's system of export controls has historically been piecemeal, and its administration poorly understood. Recent formalization of the system beginning in 2020 and escalating in 2023 is consistent with the PRC's increased exercise of lawfare and demonstrates greater regulatory capabilities. PRC authorities are able to weaponize supply chains by targeting specific critical minerals under new export controls.

POLICY IMPLICATIONS

- The PRC has gradually implemented and formalized export control measures, partly mirroring existing international frameworks. The country is relying further on a combination of these export controls and new legal mechanisms to retaliate against U.S. and allied technology protection measures.
- The PRC's use and calibration of retaliatory tools is dependent on several factors that can be subject to change, including the PRC's perception of U.S. goals and priorities.
- Continuous analysis of trade and investment data can provide some guidance and allow for government and business preparation ahead of anticipated changes in export controls in both the U.S. and China.

In December 2024 the People's Republic of China (PRC) announced an outright ban of gallium, germanium, and antimony exports to the United States.¹ The prohibition followed U.S. controls to stem the PRC's development of advanced semiconductors, with both actions representing a significant escalation in U.S.-China trade tensions. Steady adjustments to PRC export control regulations and legal mechanisms over the last few years have diversified the country's toolkit for engaging in strategic competition with the United States. The December 2024 ban was the next level of escalation from a July 2023 announcement that first developed controls on gallium and germanium. While U.S. export controls limiting PRC access to semiconductors have received substantial coverage in recent years, this action to unilaterally control several relatively obscure materials initially received limited attention. However, PRC controls on these critical materials, which are used in everything from wind turbine magnets to semiconductors, were followed later in the year by additional controls on high-end graphite and rare earth element permanent magnet manufacturing technologies. Notably, since PRC export controls on gallium were announced in July 2023, there have been zero recorded PRC-origin exports to any firm in the United States or the Netherlands, according to trade data available in September 2024.

U.S. and allied export control actions restricting PRC access to semiconductor technologies have raised the ire of PRC policymakers, and these seemingly retaliatory actions raise the possibility of future tit-for-tat exchanges. Taken together, changes in PRC export controls throughout 2023 represent a noteworthy shift in the country's economic statecraft: for the first time, the PRC government systematically employed its formal export control system to retaliate in response to U.S. and partner export controls it deems "unfair."

The PRC's updates to its export control regime in 2023 represented the most active year since its modern regime was established in the late 1990s. These retaliatory actions, along with new informational reporting requirements on exporters of other PRC-origin critical materials, suggest that additional export control actions are forthcoming and provide indications of an emerging PRC export control approach that incorporates short-term retaliatory actions and long-term strategic actions. These movements are in line with the PRC's inclination toward lawfare and the formalization of retaliatory and punitive actions, as well as with the long-standing but increasingly urgent drive for self-sufficiency and indigenous innovation. At the same time, the PRC is balancing these efforts with other economic policy priorities, many of which remain reliant on export growth.

The PRC export control bureaucracy is poorly understood; recent regulatory changes and control list updates are only available in Chinese, and assessment of how the PRC's overall regime compares with international regimes is lacking. This report describes the current PRC export control regulatory bureaucracy as well as recent changes the country has made to its control lists. The report also looks at the political economy of PRC export controls, characterizing how PRC firms have responded to these controls. Finally, it introduces a methodology to identify probable future changes to PRC controls.

The report proceeds as follows. The first section describes the PRC's current export control regulatory bureaucracy, surveying key regulatory institutions, the legal authorities they administer, their list-based control system, and a timeline of notable events. The second section then discusses recent PRC export control actions. This section details the 2023 controls on gallium, germanium,

¹ Amy Lv and Tony Munroe, "China Bans Export of Critical Minerals to U.S. as Trade Tensions Escalate," Reuters, December 3 2024, <https://www.reuters.com/markets/commodities/china-bans-exports-gallium-germanium-antimony-us-2024-12-03>.

high-purity graphite, rare earth element technologies, and aerospace equipment and summarizes notable requirements for reporting export information along with the application process for new export licenses. This section also highlights sub-commodities and specific countries that have been affected by these changes.

The third section draws on international trade data and Chinese open-source reporting to analyze how PRC firms have responded to recent export control actions. While much attention has been paid to the U.S. industry's response to U.S. export controls on the PRC, this section focuses on PRC firms' responses (or lack thereof) to domestic export controls.

The final section presents a methodology for anticipating and identifying future PRC controls on raw materials. This section concludes that future PRC export controls will likely focus on critical minerals and specific material processing equipment. In support of this methodology, the report draws on prior research by the National Bureau of Asian Research into supply chain chokepoints.

The PRC Export Control Administration

The PRC's stated approach to export controls is to regulate and facilitate trade, particularly in science and technology, while maintaining economic and national security. This approach, which was articulated in a 2021 white paper on export controls,² is reflected in a variety of regulations and laws. The PRC's regulations and laws surrounding export controls existed on paper in the 1960s and 1970s, but it was only during the period of reform and opening-up in the 1980s and through China's emergence as a major exporter that its system of controls began to receive greater scrutiny.³ International criticism of PRC sales of "sensitive nuclear and missile goods to aspiring proliferators" in the 1980s, combined with a changing consensus among PRC leaders that closer alignment with international nonproliferation export control norms was in the PRC's interest in the 1990s, resulted in the beginnings of today's regime.⁴

The PRC's current legal system for export controls began in 1994 with the passage of the Foreign Trade Law (FTL). In addition to the FTL, PRC export controls are governed by a series of regulations and laws that are in turn implemented by several lead government administrative agencies. These lead agencies collaborate with additional agencies that act in an advisory capacity to develop and update control lists as well as facilitate licensing decisions.

PRC export control activity has dramatically increased in recent years, but began in the late 1990s with the development of military- and WMD-related controls. PRC export controls in the 1990s focused on equipment, materials, and technologies related to nuclear, chemical, biological, and missile nonproliferation priorities as well as conventional arms and munitions. Though the PRC joined the Nuclear Suppliers Group in 2004, it is not a member of the Australia Group, the Missile Technology Control Regime, or the Wassenaar Arrangement. The PRC nonetheless maintains a series of export controls that align to varying degrees with the technologies controlled

² Ministry of Commerce of the People's Republic of China (PRC), "中国首次发布出口管制的白皮书" [China's First Published Export Control White Paper], December 30, 2021, <https://web.archive.org/web/20221022131834/http://exportcontrol.mofcom.gov.cn/article/gndt/202112/589.html>.

³ Evan S. Medeiros, *Chasing the Dragon: Assessing China's System of Export Controls for WMD-Related Goods and Technologies* (Santa Monica: RAND Corporation, 2005), xii, https://www.rand.org/content/dam/rand/pubs/monographs/2005/RAND_MG353.pdf.

⁴ *Ibid.*, xx, 9; and Chin-Hao Huang, "Bridging the Gap: Analysis of China's Export Controls against International Standards," Foreign and Commonwealth Office (UK), May 25, 2012, <https://www.gov.uk/government/publications/analysis-of-chinas-export-controls-against-international-standards/bridging-the-gap-analysis-of-chinas-export-controls-against-international-standards>.

by these international regimes.⁵ Following this period of activity in the 1990s and early 2000s, the PRC export control regime saw limited changes until 2018, when regulators began drafting the Export Control Law (ECL). Requiring two years for the drafting and deliberation process, when the ECL was finally adopted in October 2020, it demonstrated a clear shift in PRC thinking around export controls. Among the most notable changes was the addition of extraterritoriality and retaliatory measures. This section provides an overview of the PRC's relevant export control regulations and laws, including the ECL, as well as the regulatory and administrative agencies responsible for implementation.

Key Laws and Regulations

The PRC maintains a series of laws and regulations that directly and indirectly address export control considerations. The core of its export control legal system are the Foreign Trade Law and the Export Control Law. These two laws represent separate and distinct export control regimes within the PRC. The FTL generally covers exports of WMD-related technologies, while the ECL primarily covers dual-use items.⁶

Throughout the 1990s, the PRC established a series of regulations related to nuclear, chemical, biological, and missile technology export controls. In 1997 and 1998 the State Council of the PRC promulgated two orders (no. 230 and no. 245) governing nuclear export controls and export controls of nuclear dual-use technologies.⁷ Soon after export controls on nuclear technologies were first established in 1997, related controls on military exports were promulgated by the State Council via Order no. 234.⁸ Additional controls on commercial encryption technology, missile technology, and dual-use biological technologies occurred between 1999 and 2002.⁹ Following this initial period of activity from 1997 to 2002, PRC export control actions were relatively limited. While there were technical revisions and administrative updates, the fifteen years following the passage of the biological export controls in 2002 saw few substantive changes. However, beginning in 2018 with the introduction of the ECL (ultimately passed in 2020), a new period of activity was inaugurated that persists to date.

The FTL, which was first adopted in 1994 and subsequently revised in 2016 and 2022, empowers the PRC to restrict or prohibit the export of “relevant goods and technologies” for eleven specific reasons, including safeguarding national security, protecting human health or safety, and promoting the public interest, among others.¹⁰ In practice, the implementation

⁵ For additional historical context on PRC export controls, see Huang, “Bridging the Gap’: Analysis of China’s Export Controls against International Standards”; and Medeiros, *Chasing the Dragon*.

⁶ “China Revises Catalogue of Technologies Prohibited or Restricted from Export,” Covington, December 2023, <https://www.cov.com/en/news-and-insights/insights/2023/12/china-revises-catalogue-of-technologies-prohibited-or-restricted-from-export>.

⁷ The original text of Order no. 230, which was revised in 2006, is available at <https://web.archive.org/web/20240501183437/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/gzjgfwj/202111/440.html>; and the original text of Order no. 245, which was revised in 2007, is available at <https://web.archive.org/web/20240501183917/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/gzjgfwj/202111/445.html>.

⁸ The original text of Order no. 234 is available at <https://web.archive.org/web/20240501185246/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/gzjgfwj/202111/441.html>.

⁹ The original text of the Administrative Measures on Commercial Encryption is available at <https://web.archive.org/web/20240501185323/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/gzjgfwj/202111/442.html>; the original text of the PRC Export Control Measures on Missiles and Related Goods and Technologies is available at <https://web.archive.org/web/20240501185427/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/gzjgfwj/202111/443.html>; and the original text of the PRC Export Control Measures on Biological Dual-Use Goods and Related Equipment and Technologies is available at <https://web.archive.org/web/20240501185545/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/gzjgfwj/202111/444.html>.

¹⁰ See chap. 3, art. 15, of the Foreign Trade Law, which is available in Chinese at <https://web.archive.org/web/20240501193022/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfc/flfg/202404/991.html>.

of the FTL's export control provisions is accomplished via the publication of several guidance documents. The Catalogue of Technologies Prohibited or Restricted from Export (hereafter the Catalogue), jointly updated by the Ministry of Commerce (MOFCOM) and the Ministry of Science and Technology (MOST), is the FTL's primary implementing document.¹¹ First published in 2001, the Catalogue has only been updated three times (2008, 2020, and 2023).¹² Its control list takes a graded approach to controls, classifying exports into three categories: (1) unrestricted technologies whose export does not require a license, but may nonetheless necessitate registration or information reporting to Chinese authorities, such as the General Administration of Customs (GAC), (2) restricted technologies whose export requires a license, and (3) prohibited technologies that cannot be exported.¹³

In addition to the Catalogue, the FTL is implemented via regulations and measures that collectively describe and direct how the PRC export control administrative bureaucracy functions. Notable guidance documents include the Regulations for the Administration of the Import and Export of Technology,¹⁴ the Measures for the Administration of Technologies Prohibited or Restricted from Export,¹⁵ and the Measures for the Administration of Registration of the Contracts for Import and Export of Technologies.¹⁶ Collectively, these documents stipulate the process by which license applications are filed, reviewed, and granted (or denied), as well as the legal responsibilities, information reporting requirements, and roles and responsibilities of commerce departments in provinces, autonomous regions, and municipalities in export facilitation, among other things.

The ECL, which went into effect in December 2020, represented a holistic attempt to modernize the PRC's approach to export controls. The law consists of five chapters, including substantive changes to the PRC's control policies, measures, and lists (chapter 2), export control administration authorities (chapter 3), and fines and penalties for export control violations (chapter 4).¹⁷ Separate from the Catalogue under the FTL, MOFCOM and GAC jointly update the Catalogue for the Administration of Import and Export Licenses for Dual-Use Items and Technologies (hereafter the Dual-Use Catalogue).¹⁸ Since 2021, this catalogue has been updated annually and is jointly issued under ECL authorities alongside the "Measures for the Administration of Import and Export Licenses for Dual-use Items and Technologies."

Two provisions in the ECL that relate to extraterritoriality and retaliation represent noteworthy departures from prior PRC export control actions. First, the ECL dramatically extends the

¹¹ The original text of the Catalogue is available at <https://web.archive.org/web/20240305162751/http://www.mofcom.gov.cn/zfxgk/article/gkml/202312/20231203462079.shtml>.

¹² Jing Yunfeng, Li Jia Wang, and Hui Li Xinyan, "Revision of the Catalogue of Technologies Prohibited or Restricted from Export of the PRC," King and Wood Mallesons, October 15, 2020, <https://www.chinalawinsight.com/2020/10/articles/customs-business/revision-of-the-catalogue-of-technologies-prohibited-or-restricted-from-export-of-the-prc>.

¹³ Jing Zhang, Tamer A. Soliman, and Jennifer L. Parry, "China Proposed Changes to the 'Catalogue of Technologies Prohibited and Restricted from Export,'" Mayer Brown, February 28, 2023, <https://www.mayerbrown.com/en/insights/publications/2023/02/china-proposed-changes-to-the-catalogue-of-technologies-prohibited-and-restricted-from-export>.

¹⁴ The original text of the Regulations of the Administration of the Import and Export of Technology is available at https://web.archive.org/web/20240428075927/https://www.gov.cn/gongbao/content/2019/content_5468926.htm.

¹⁵ The original text of the Measures for the Administration of Technologies Prohibited or Restricted from Export is available at <https://web.archive.org/web/20240501220100/http://www.mofcom.gov.cn/article/swfg/fgdwmy/201805/20180502743968.shtml>.

¹⁶ The original text of the Measures for the Administration of Registration of the Contracts for Import and Export of Technologies is available at <https://web.archive.org/web/20200721024203/http://fms.mofcom.gov.cn/article/a/ae/200403/20040300198767.shtml>.

¹⁷ The original text of the Export Control Law is available at <https://web.archive.org/web/20221022131835/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfcg/flfg/202111/226.html>.

¹⁸ The original text of the Dual-Use Catalogue is available at <https://web.archive.org/web/20240305164817/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfcg/zcfcgzqd/202312/941.html>.

applicability of PRC export controls to include organizations and individuals outside the PRC itself. Article 44 states: “Organizations and individuals outside the territory of the People’s Republic of China that violate the relevant export control regulations of this Law, endanger the national security and interests of the People’s Republic of China, and hinder the performance of nonproliferation and other international obligations shall be dealt with in accordance with the law and held legally responsible.” More recently, in September 2024 the State Council released similarly broad guidance on the applicability of PRC export controls stipulating that export controls apply not just to citizens and “legal persons” but also to unincorporated organizations transferring dual-use items to foreign countries, organizations, or individuals. The new regulations also stipulate jurisdiction over dual-use items manufactured abroad that use or contain PRC-origin technologies, imitating the development of China’s own version of the U.S. Foreign Direct Product Rule (see **Table 1**).¹⁹ Finally, in addition to this extraterritoriality provision, the ECL also explicitly empowers the PRC to use retaliatory export controls. Article 48 states: “If any country or region abuses export control measures to endanger the national security and interests of the People’s Republic of China, the People’s Republic of China may take reciprocal measures against that country or region based on the actual situation.”

In addition to the FTL and the ECL, there are several laws that indirectly affect and relate to broader PRC export control goals. These include the 2015 National Security Law, the 2017 Nuclear Safety Law, the 2019 Cryptography Law, and the 2020 Biosafety Law.²⁰ In general, these laws stipulate that the relevant PRC state agencies take measures to control the transfer of technologies

TABLE 1 Comparison of export control systems in the United States and the PRC

Element	PRC	United States
<i>De minimis</i> threshold	N/A	Yes
Extraterritoriality	Yes	Yes
Foreign Direct Product Rule	Yes	Yes
Catch-all controls	Yes	Yes
Temporary controls	Yes	Yes
Deemed export	Yes	Yes

NOTE : On September 30, 2024, the State Council released updated dual-use item export control regulations. The new regulations outline MOFCOM’s jurisdiction over foreign-manufactured items that contain PRC-origin items. This new authority largely mimics the U.S. Foreign Direct Product Rule. See State Council (PRC), “中华人民共和国两用物项出口管制条例” [Regulations of the People’s Republic of China on the Export of Dual-Use Items], September 30, 2024, https://www.gov.cn/zhengce/content/202410/content_6981399.htm?mc_cid=945c152b01&mc_eid=cd1656a13c.

¹⁹ State Council (PRC), “Regulations of the People’s Republic of China on the Export of Dual-Use Items,” September 30, 2024, <https://www.lawinfochina.com/display.aspx?id=43751&lib=law>.

²⁰ The original text of the National Security Law is available at <https://web.archive.org/web/20221022131834/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfg/flfg/202111/230.html>; the original text of the Nuclear Safety Law is available at <https://web.archive.org/web/20221022131835/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfg/flfg/202111/227.html>; the original text of the Cryptography Law is available at <https://web.archive.org/web/20221022131834/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfg/flfg/202111/229.html>; and the original text of the Biosafety Law is available at <https://web.archive.org/web/20221022131834/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfg/flfg/202111/228.html>.

whose export may compromise national security. For example, Article 63 of the Biosafety Law requires that “relevant departments of the State Council and relevant military agencies shall... strengthen control over the entry, exit, import, export, acquisition, manufacture, and transfer of organisms, biotoxins, equipment, or technologies that can be used in bioterrorism activities or manufacturing bioweapons.” In some instances, these laws also clarify technologies that are within the state’s export control jurisdiction. For example, Article 28 of the 2019 Cryptography Law explicitly notes that “cryptocurrencies are subject to export controls.”

Key Regulators

The ECL makes clear that all ultimate export control authority in the PRC resides with the State Council and the Central Military Commission (which are collectively referred to in the ECL as the “National Export Control Management Departments”).²¹ PRC export control laws and regulations are primarily implemented by MOFCOM, GAC, and MOST. MOFCOM serves as the central administrator of the PRC’s export control authorities, partnering with GAC to develop and implement dual-use controls and with MOST to develop the Catalogue of Technologies Prohibited or Restricted from Export. Unlike many Western countries that use Export Control Classification Numbers or an equivalent alphanumeric system, the PRC relies on customs codes to identify controlled technologies within the Dual-Use Catalogue (along with accompanying descriptions of technical control thresholds).²² GAC thus has an important role to play in terms of collecting information on PRC exports, both for customs purposes and for export control purposes. All of these entities report to the State Council, which is the named authority for export control matters in implementing regulations and laws and has delegated this authority to these three primary implementing agencies.

Importantly, other agencies, such as the Ministry of Industry and Information Technology, the State Administration of Science, Technology and Industry for National Defense, the State Atomic Energy Agency, and the Equipment Development Department of the Central Military Commission, also support specific export control implementation activities. For example, recent changes to export controls on specific classes of unmanned aerial vehicles were announced by MOFCOM and GAC in partnership with the Equipment Development Department of the Central Military Commission, which also plays a role in licensing decisions.²³ At the subnational level, the foreign trade and economic departments of provinces, autonomous regions, and municipalities are empowered to manage technology imports and exports in line with guidance from the national authorities.²⁴

Export Control License Application Reporting Requirements and Approval Process

The PRC MOFCOM export license application instructions for controlled products specify which local and national government agencies applicants should submit to and what information

²¹ See Article 5 of the Export Control Law.

²² “Decoding the New Chinese Export Control Law,” Baker McKenzie, June 2021, <https://www.bakermckenzie.com/en/-/media/files/insight/publications/2021/06/decoding-the-new-chinese-export-control-law.pdf>.

²³ Ministry of Commerce, “2023年第28号 关于对部分无人机实施临时出口管制的公告” [Order Number 28 of 2023 Announcement on the Implementation of Temporary Export Controls on Certain UAVs], July 31, 2023, <https://web.archive.org/web/20240501223621/http://exportcontrol.mofcom.gov.cn/article/zcfg/gnzcfcg/zcfggzqd/202307/872.html>.

²⁴ State Council, “中华人民共和国技术进出口管理条例” [Regulations of the People’s Republic of China on the Administration of Technology Import and Export], 2019, https://web.archive.org/web/20240428075927/https://www.gov.cn/gongbao/content/2019/content_5468926.htm.

and materials are required, while also providing answers regarding common application issues and applicant FAQs (see **Table 2**).²⁵ The inclusion of these common application issues (e.g., incomplete materials, lack of required signatures, and inconsistent contract numbers) suggests that PRC authorities are attempting to strike a balance by tightening restrictions without causing undue delays and economic harm to PRC exporters. The general application process is as follows:

1. Exporters complete applications and submit electronic documents via the MOFCOM online import and export control industry platform and simultaneously provide required paper documents to their local (provincial) MOFCOM.
2. Local MOFCOM authorities forward applications and materials to national-level MOFCOM authorities, who review them and then issue approvals or denials. In some cases, applications are passed on from MOFCOM to the State Council for final approval.
3. Central MOFCOM passes approvals back to local MOFCOM authorities, who then issue export approval licenses.
4. Exporters pick up their licenses and accompanying customs declarations certificates from their local MOFCOM locations.

The “Sensitive Items and Technology Export License Application Form” asks applicants to provide proof of export contracts, technical product specifications, and identifying information

TABLE 2 Export control application reporting requirements

Form name	Source of form	Form type	Required?
Sensitive items and technology export license application form	Issued by government departments	Paper	Yes
Identity certificates of the applicant’s legal representative, primary business manager, and person in charge	Prepared by applicant	Paper/electronic	Yes
The original export contract or agreement or a copy or scanned copy that is consistent with the original	Prepared by applicant	Paper/electronic	Yes
Technical description or inspection report of export items	Prepared by applicant	Paper/electronic	Yes
End-user and end-use certification (including Chinese translation)	Prepared by applicant	Paper	Yes
Description of importers and end users (including Chinese translation)	Prepared by applicant	Paper/electronic	Yes
Guarantee documents provided in accordance with Articles 1 to 3 of the above “Application Conditions”	Prepared by applicant	Paper/electronic	No
Other documents required by relevant State Council authorities	Prepared by applicant	Paper/electronic	No

²⁵ MOFCOM (PRC), “镓、锗相关物项出口许可办事指南” [License Application Instructions for Export of Gallium and Germanium Products], July 2023, http://egov.mofcom.gov.cn/xzxksx/18017/18017_11.pdf; and MOFCOM (PRC), “石墨物项出口许可办事指南” [License Application Instructions for Export of Graphite Products], October 2023, http://egov.mofcom.gov.cn/xzxksx/18017/18017_12.pdf.

about the importer, end user, and specific end use of the product. Interestingly, the End-User and End-Use Certification form requires signatures from both the importing company and MOFCOM authorities, who must attest that the end use of the product will not violate PRC law (see **Figure 1** below). While we did not observe any explicit justification or commentary on the rationale for requiring named MOFCOM authorities and company representatives, the measure imposes a clearer record of ownership and responsibility throughout the licensure process, as well as greater level of scrutiny, which may discourage corruption.

FIGURE 1 End-user and end-use certification required for export license applicants

<p>1. 企业版英文格式:</p> <p style="text-align: center;">End-User and End-Use Certificate _____(Date)</p> <p>Ministry of Commerce of P. R. China,</p> <p>We, _____(Company name and address), are the end-user of _____(Commodity name) purchased/leased (or other ways) from the Chinese company _____(Company name) under contract _____(Contract No.). We will only use the imported _____(Commodity name) for/in _____(End-use).</p> <p>We guarantee that we will not use the above-said _____(Commodity name) in any use other than we declared above, and we will not transfer the above-said _____(Commodity name) to any third party without the consent of the Chinese government.</p> <p style="text-align: right;">Signature (Handwriting) _____(Name in print) _____(Title) _____(Company name) Company Stamp</p>	<p>2. 政府版英文格式:</p> <p style="text-align: center;">End-User and End-Use Certificate _____(Date)</p> <p>Ministry of Commerce of P. R. China,</p> <p>This is to certify that _____(Company name and address) is the end-user of _____(Commodity name) purchased/leased (or other ways) from the Chinese company _____(Company name) under contract _____(Contract No.). The above-said company _____(Company name) will only use the imported _____(Commodity name) for/in _____(End-use). The above-said company guarantee that they will not use the above-said _____(Commodity name) in any use other than they declared above, and they will not transfer the above-said _____(Commodity name) to any third party without the consent of the Chinese government.</p> <p style="text-align: right;">Signature/Stamp _____(Name in print) _____(Title) _____(Name of the competent government departments)</p>
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Recent Changes in PRC Export Controls

Against the backdrop of increasing activity across the PRC export control regime described above, several actions taken by regulators in 2023 and 2024 stand out for their immediate market impact and as indicators of future evolutions in the PRC’s export control strategy. This section describes notable changes in PRC export control policies for specific critical minerals and materials and equipment used to process these materials. It also describes new information reporting requirements for PRC exporters and discusses their implications for probable future controls.

Gallium and Germanium

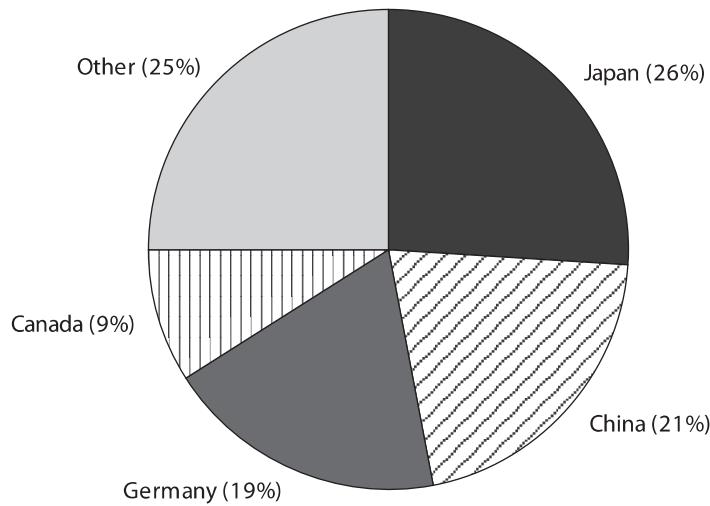
On July 3, 2023, MOFCOM and GAC issued a set of new dual-use export controls on gallium and germanium metals and related compounds. Industry commentators largely characterized these new restrictions as retaliatory to U.S. export controls on the PRC’s semiconductor manufacturing ecosystem beginning in October 7, 2022.²⁶ Subsequently, in December 2024 PRC authorities doubled down on these germanium and gallium restrictions by implementing an outright export ban on these and other materials critical to U.S. supply chains for “dual military and civilian uses,” just one day after new U.S. restrictions were imposed to curb China’s capability

²⁶ Alexander Holderness et al., “Understanding China’s Gallium Sanctions,” Center for Strategic and International Studies (CSIS), July 7, 2023, <https://www.csis.org/analysis/understanding-chinas-gallium-sanctions>.

to produce advanced semiconductors.²⁷ As of 2023, the PRC accounted for approximately 98% and 60% of global gallium and germanium production capacity, respectively.²⁸ These materials are used in advanced microelectronics, enabling radiation tolerance and other key properties. MOFCOM and GAC’s announcement contained a list of items to be controlled, which included microelectronic-specific products such as gallium nitride and gallium arsenide wafers, germanium ingots, germanium epitaxial growth substrates, germanium oxide, and germanium tetrachloride.²⁹

From a whole-of-supply-chain perspective, the PRC’s export controls have the greatest impact on upstream gallium and germanium supply, which has caused ripple effects throughout downstream supply chains for gallium and germanium wafers. While China produces approximately 98% of the world’s gallium, it lacks significant capacity to convert the metal into downstream semiconductor products. This is reflected in U.S. Geological Survey data showing that between 2019 and 2022 only about 21% of gallium metal imports came directly from the PRC (see **Figure 2**). China’s small share of U.S. imports is even more pronounced for gallium arsenide wafers, which the United States imports far more of than gallium metal (see **Figure 3**). In 2022, only about 6% of U.S. gallium arsenide wafers came directly from China according to U.S. trade data. Rather than direct export, PRC relies on intermediary German and Japanese companies like Freiburger and

FIGURE 2 Composition of U.S. gallium metal imports, 2019–23



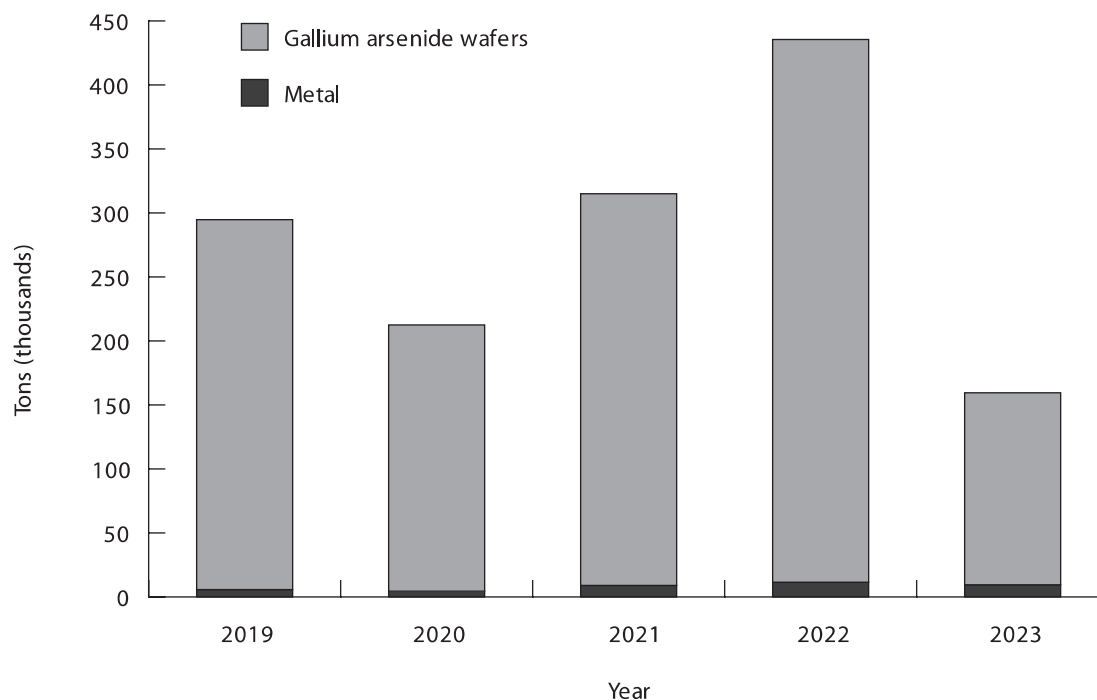
SOURCE: U.S. Geological Survey, “Gallium,” <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-gallium.pdf>.

²⁷ Gracelin Baskaran and Meredith Schwartz, “China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet amidst Escalating U.S.-China Tech War,” CSIS, December 4, 2024, <https://www.csis.org/analysis/china-imposes-its-most-stringent-critical-minerals-export-restrictions-yet-amidst>; and “Commerce Strengthens Export Controls to Restrict China’s Capability to Produce Advanced Semiconductors for Military Applications,” U.S. Bureau of Industry and Security, December 2, 2024, <https://www.bis.gov/press-release/commerce-strengthens-export-controls-restrict-chinas-capability-produce-advanced>.

²⁸ U.S. Geological Survey, “Gallium,” January 2024, <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-gallium.pdf>; and Critical Raw Materials Alliance, “Germanium,” <https://www.crmalliance.eu/germanium>.

²⁹ Ministry of Commerce and General Administration of Customs (PRC), “商务部 海关总署公告2023年第23号 关于对镓、锗相关物项实施出口管制的公告” [Announcement No. 23 of 2023 of the Ministry of Commerce and the General Administration of Customs on the Implementation of Export Controls on Gallium and Germanium Related Items], July 3, 2023, <http://m.mofcom.gov.cn/article/zwgk/gkzcfb/202307/20230703419666.shtml>.

FIGURE 3 Composition of U.S. gallium imports, 2019–23



SOURCE: U.S. Geological Survey, “Gallium.”

NOTE: The majority of U.S. gallium imports are in the form of gallium-based wafers produced in third countries like Germany and Japan.

Sumitomo to process and manufacture raw gallium into wafers that are ultimately exported to the United States. However, this still affords the PRC leverage to disrupt U.S. microelectronics supply chains by excluding U.S. end users from export licenses granted to Japanese and German wafer manufacturers.

The PRC’s sudden reduction in gallium and germanium exports to the United States highlights critical supply chain vulnerabilities and has necessitated alternate sourcing where possible. According to the U.S. Geological Survey, U.S. companies are currently recovering germanium-containing zinc from mines in Alaska and Tennessee, while a major zinc smelter in Tennessee produces germanium leach concentrates from zinc concentrates, bringing U.S. germanium import reliance to below 50%.³⁰ However, the United States currently has few options for accessing raw gallium outside of the PRC, as it lacks any domestic production and does not maintain a government stockpile. Domestic recycling capacity to recover gallium is minimal, with only one company in New York recovering gallium through reprocessing gallium arsenide-based devices.³¹

Given the PRC’s significant supply curtailment, companies are considering new investments to expand gallium and germanium extraction and refining. Nyrstar Zinc, the Tennessee zinc

³⁰ U.S. Geological Survey, “Germanium,” January 2024, <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-germanium.pdf>.

³¹ U.S. Geological Survey, “Gallium.”

smelter mentioned above, has announced plans to construct a \$150 million gallium- and germanium-processing facility that could recover an estimated 40 tons of gallium and 30 tons of germanium per year. Once financing for the plant is secured, the company estimates that the project could take roughly two years to complete and commence refining.³² Nyrstar has also announced that it is exploring new gallium and germanium mining projects in Australia and Europe. While the U.S. government could support the project via a funding mechanism like the Department of Defense Manufacturing Capability Expansion and Investment Prioritization Office's Defense Production Act authorities, new entrants into the gallium market face the possibility that PRC producers could dump their supply on the market, undercutting the profitability of nascent competitors.³³ PRC-induced gallium price volatility largely drove the shuttering of gallium operations in Germany, Kazakhstan, and Hungary between 2013 and 2016.³⁴ As such, potential new entrants into the gallium market note that price supports for both gallium and ancillary mineral markets like aluminum could be necessary to sustain new operations.³⁵

Graphite

On October 20, 2023, MOFCOM announced new dual-use controls on graphite products including high-purity (purity >99.9%), high-strength (flexural strength >30 megapascals), high-density (density >1.73 grams per cubic centimeter) artificial graphite materials and their products, as well as on natural flake graphite and its products (e.g., spheroidized graphite and expanded graphite).³⁶ This announcement came within a week of the United States' announcement that it would tighten controls on semiconductors, updating its rule from October 2022. The most recent PRC restrictions on gallium, germanium, and other so-called superhard materials imply that graphite exports, though still permitted with export licenses, will be subject to greater scrutiny.³⁷

The PRC's export controls on graphite serve as a stark reminder of the country's leverage within clean energy supply chains, as graphite is a key material used in battery anodes. While the PRC has approved some graphite exports since implementing new license requirements, the ongoing disarray within gallium and germanium supply chains signals Beijing's willingness to use controls to retaliate against U.S. and allied policy decisions. As of 2023, the PRC dominated global graphite production, accounting for around 77% of global supply. By contrast, the United States is 100% reliant on imports of graphite, primarily from the PRC, Mexico, and Canada.³⁸ Rising demand for lithium-ion batteries, coinciding with intensifying concerns about overreliance on the PRC, has spurred numerous U.S. government investments in domestic graphite mining projects. In July

³² Christian Brown, "Nyrstar Zinc in Clarksville Could Become Nation's Top Source of 2 Key Minerals after China Cuts Off Supply," *Clarksville Now*, September 25, 2023, <https://clarksvillenow.com/local/nyrstar-zinc-in-clarksville-could-become-nations-top-source-of-2-key-minerals-after-china-cuts-off-supply>.

³³ Title III of the Defense Production Act gives the president authority to create incentives for the development or expansion of capacity in critical technologies through mechanisms such as loans, loan guarantees, purchase commitments, and grants or subsidies. U.S. Office of the Assistant Secretary of Defense, "Defense Production Act Title III," <https://www.businessdefense.gov/ibr/mceip/dpai/dpat3/docs/DPA-TitleIII-Overview.pdf>.

³⁴ U.S. Geological Survey, "Gallium"; and Cora Jungbluth and Thieß Petersen, "More and More? Why Chinese Overcapacities Are a Significant Challenge for the EU," *Global Europe*, September 13, 2024, <https://globaleurope.eu/europes-future/more-and-more-why-chinese-overcapacities-are-a-significant-challenge-for-the-eu>.

³⁵ Solomon Cefai, "A Make-or-Break Year for Non-Chinese Gallium Market: 2024 Preview," *Fastmarkets*, December 18, 2023, <https://www.fastmarkets.com/insights/a-make-or-break-year-for-non-chinese-gallium-market-2024-preview>.

³⁶ MOFCOM and GAC (PRC), "商务部 海关总署公告2023年第39号 关于优化调整石墨物项临时出口管制措施的公告" [Announcement No. 39 of 2023 of the Ministry of Commerce and the General Administration of Customs on Optimizing and Adjusting Temporary Export Control Measures on Graphite Items], October 20, 2023, <http://m.mofcom.gov.cn/article/zcfb/zcdwmy/202310/20231003447368.shtml>.

³⁷ Baskaran and Schwartz, "China Imposes Its Most Stringent Critical Minerals Export Restrictions."

³⁸ U.S. Geological Survey, "Graphite (Natural)," January 2024, <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-graphite.pdf>.

2023, the Department of Defense announced that it had entered into a \$37.5 million agreement using Inflation Reduction Act funding to assist U.S. company Graphite One with the development of a graphite mining, refining, and recycling operation in Washington State.³⁹ Months later, in November 2023, the Department of Defense announced another \$3.2 million award to South Star Battery Metals Corporation to support its production of coated, spherical, purified graphite in Alabama.⁴⁰ According to the U.S. Geological Survey, three additional U.S. companies are exploring or developing graphite mining projects in Alabama, Montana, and New York, and additional plants to produce spherical graphite are under early development.⁴¹

Rare Earth Technologies

The PRC's controls on critical minerals have already generated supply chain shocks throughout global markets. Similarly, its controls on rare earth mining, processing, and utilization technologies enhance the country's control over all stages of the rare earth supply chain. In their December 2023 update of the Catalogue, MOFCOM and MOST added and amended several items related to rare earths on both the restricted and prohibited technology export lists. China has controlled rare earth technologies since 2003 through a slew of restrictions on extraction, separation, and processing technologies. The 2023 update expands the list of restricted rare earth technologies and includes language on specific technologies related to the production of neodymium magnets. The technologies newly prohibited from export include rare earth refining, processing, and utilization technologies (e.g., rare earth extraction and separation technology; preparation technology of samarium cobalt, neodymium iron boron, and cerium magnets; and preparation technology of rare earth calcium oxyborate). Technologies newly restricted from export include rare earth mining and smelting technologies (except for those already prohibited from export).

Amid a global push to diversify the supply of rare earth minerals, the PRC is solidifying the regulatory tools to defend its leadership in rare earth mining, separation, and refining, in which it accounts for approximately 58%, 89%, and 90% of global capacity, respectively.⁴² While this dominance within rare earths is partially attributable to its lax environmental standards, inexpensive labor costs, and industrial subsidies, China has also developed strong technological capabilities. Because it has been the world's primary rare earth-processing hub for decades, its companies have honed separation and refining processes and technologies amid fierce domestic competition. For example, 98% of global patents for "ionic rare earth leaching," a controlled chemical extraction process technology, have been granted to PRC assignees.⁴³

New export prohibitions on neodymium magnet "preparation technology" similarly target a market where the PRC maintains a dominant share. According to the U.S. Department of Energy, as of 2020 the PRC accounted for 92% of global magnet manufacturing.⁴⁴ Despite this manufacturing dominance, PRC rare earth magnet manufacturers have not yet fully indigenized

³⁹ "DOD Enters Agreement to Expand Capabilities for Domestic Graphite Mining and Processing for Large-Capacity Batteries," U.S. Department of Defense, Press Release, July 17, 2023, <https://www.defense.gov/News/Releases/Release/Article/3459556/dod-enters-agreement-to-expand-capabilities-for-domestic-graphite-mining-and-pr>.

⁴⁰ "DOD Enters Agreement to Expand Domestic Graphite Supply Chain," U.S. Department of Defense, Press Release, November 29, 2023, <https://www.defense.gov/News/Releases/Release/Article/3600429/dod-enters-agreement-to-expand-domestic-graphite-supply-chain>.

⁴¹ U.S. Geological Survey, "Graphite," 2024, <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-graphite.pdf>.

⁴² U.S. Department of Energy, "Rare Earth Permanent Magnets: Supply Chain Deep Dive Assessment," February 24, 2022, <https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf>.

⁴³ This information was accessed on July 10, 2024, from the Digital Science database under a license agreement.

⁴⁴ U.S. Department of Energy, "Rare Earth Permanent Magnets."

their supply chains and continue to rely on foreign technologies for certain high-end processes. For example, they rely on core technology patents from Japanese firms like Hitachi Metals to produce and sell magnets to patent-protected markets such as the United States, Europe, and Southeast Asia.⁴⁵ Similarly, Chinese neodymium magnet manufacturers continue to rely on Japanese and German machine tools for key magnet manufacturing processes like near-net shaping and grain refinement. These processes are critical for developing high-end magnets for advanced applications like robotics and large-scale offshore wind turbines.⁴⁶ Despite having a much smaller manufacturing footprint, Japan maintains a technological edge in this space, suggesting that neodymium magnet production technology is not a chokepoint technology that China can use to damage competitors.

Given the breadth of competing technologies in both the United States and Japan, China's prohibition on exports of neodymium magnet production technology could damage the global ambitions of Chinese companies. For example, prior to the prohibitions, Chinese magnet company JL Mag had announced plans to invest \$100 million in a facility in Mexico to convert scrapped alloy into neodymium magnets.⁴⁷ With the investment still pending, the new prohibitions could force the company to maintain the majority of its manufacturing processes in China, with the Mexican facility adding limited value. Ultimately, the controls curtail Chinese magnet companies' ability to maintain proximity to key industries outside China like electric vehicles and wind power. As the United States and European Union invest in developing alternative supply chains for these technologies, including through the implementation of mineral-sourcing requirements for components, China's prohibitions create space for non-Chinese magnet manufacturers to potentially gain ground in new markets.

PRC Firms' Compliance with and Response to Export Controls

Following the announcement of new export license requirements for germanium, gallium, and graphite products, PRC exports of these products surged and then fell precipitously. PRC suppliers and foreign purchasers likely sought to respectively offload and stockpile these products prior to licensure implementation dates (see **Figures 4** and **5**). The trade data shows that for all affected materials, PRC exports have largely resumed after the implementation of the new licensure requirements. As of September 2024, the PRC's exports of wrought gallium have increased above their pre-export control levels, while exports of wrought germanium have also largely recovered. This signals that PRC gallium and germanium exporters might now be completing a backlog of orders upon receiving license approval from MOFCOM.

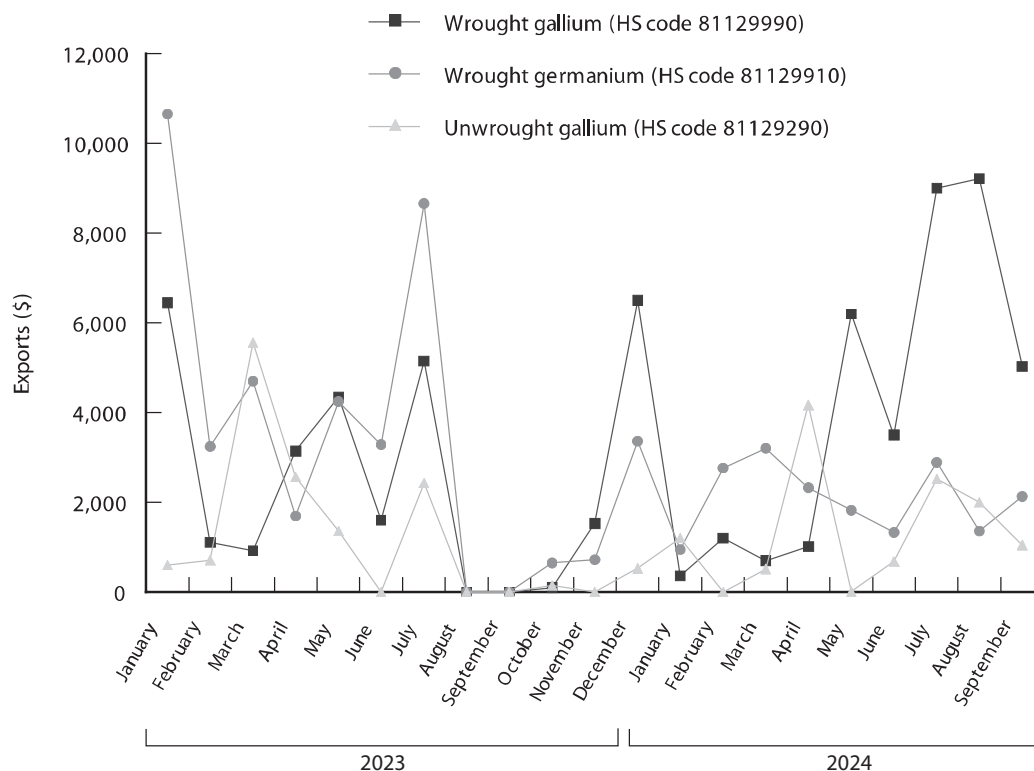
There are other notable changes to PRC exports in the wake of the new restrictions. While the PRC has resumed gallium and germanium exports to the world market, it had yet to export any gallium or germanium to the United States or the Netherlands in 2024 at the time of writing, suggesting that the PRC is retaliating against coordinated semiconductor manufacturing controls implemented by the United States, Japan, and the Netherlands. MOFCOM's approval or

⁴⁵ “钕铁硼 头豹词条报告系列” [Neodymium Magnets—LeadLeo Report Series], LeadLeo, August 21, 2023, https://pdf.dfcfw.com/pdf/H3_AP202310121601272719_1.pdf?1697140431000.pdf. The top assignees for neodymium magnet patents are all Japanese. They include Semiconductor Energy Laboratory, Hitachi, Mitsubishi Electric, Panasonic, and Denso, according to Digital Science's Dimensions database.

⁴⁶ Trivium China, “Chinese Policy Discourse: Clean Energy Technology Chokepoints,” February 19, 2024, 22.

⁴⁷ Dou Shicong, “China's JL Mag to Build USD100 Million Rare-Earth Magnet Recycling Facility in Mexico,” Yicai Global, September 13, 2022, <https://www.yicai.com/news/china-jl-mag-to-build-usd100-million-rare-earth-magnet-recycling-facility-in-mexico>.

FIGURE 4 Chinese exports of germanium and gallium, 2023–24



SOURCE: General Administration of Customs (PRC), via Global Trade Tracker.

denial of export licenses is likely heavily dependent on the recipient country, given that gallium and germanium exports to Germany, Russia, Belgium, and Japan have all resumed following implementation of the license requirements.

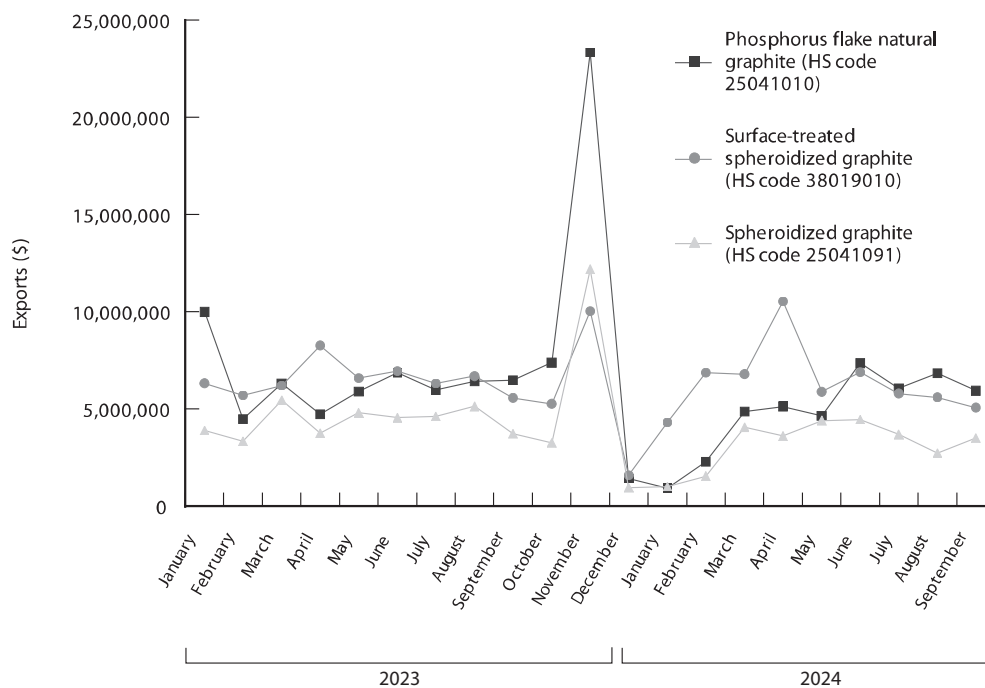
The PRC’s graphite exports appear to have been somewhat less negatively affected by the new requirements. Unlike germanium and gallium, PRC graphite exports to all countries, including the United States, have largely recovered to their prior levels, suggesting that graphite export licenses have thus far been treated with a presumption of approval, according to statistics from GAC.

PRC officials and international media outlets have confirmed that some PRC firms have successfully applied for new export licenses.⁴⁸ For example, Beijing Tongmei, a Chinese subsidiary of the U.S. semiconductor company American Xtal Technology (AXT), reportedly received licenses to export gallium and germanium substrates to “certain customers.”⁴⁹ However, all of AXT’s manufacturing operations are located in China, and these local manufacturers could

⁴⁸ “China Approves Export Licences for Chip Materials Gallium, Germanium,” Reuters, September 21, 2023, <https://www.reuters.com/markets/commodities/china-has-issued-some-export-licences-gallium-germanium-2023-09-21>; and Joe Cash and Siyi Liu, “China Approves First Graphite Export Permits after Rule Change,” Mining.com, December 14, 2023, <https://www.mining.com/web/china-has-approved-a-number-of-export-permits-for-graphite>.

⁴⁹ “Tongmei Receives Initial Export Permits from China’s Central Ministry of Commerce for Gallium Arsenide and Germanium Substrates,” AXT, September 20, 2023, https://investors.axt.com/Investors/news/news-details/2023/Tongmei-Receives-Initial-Export-Permits-from-Chinas-Central-Ministry-of-Commerce-for-Gallium-Arsenide-and-Germanium-Substrates/default.aspx?mc_cid=0ea2bdb82d&mc_eid=cd1656a13c.

FIGURE 5 Chinese exports of newly controlled graphite items, 2023–24



SOURCE: General Administration of Customs (PRC), via Global Trade Tracker.

NOTE: This figure shows PRC changes in the three HS codes that exhibited the greatest change in export volumes following the announcement of new controls. In total, the PRC announced export controls on graphite affecting six HS code categories: 25041010 (phosphorus flake natural graphite), 25041091 (spheroidized graphite), 38011000 (artificial graphite), 38019010 (surface-treated spheroidized graphite), 38019090 (graphite or other carbon n.e.c.), and 68151900 (other graphite or other carbon products for nonelectrical purposes).

ultimately be denied licenses if their products are meant for U.S. end users, especially if they are affiliated with the U.S. defense industrial base.

A handful of PRC subject matter experts have provided varying assessments of the overall impact of the new trade restrictions on affected PRC firms. In an interview with the *Global Times*, a researcher at the International Mining Research Center of China’s Geological Survey (a sub-organ of the Ministry of Natural Resources) posited that the PRC remains in an advantageous position with respect to germanium and gallium, owing to the high concentration of domestic mining and production of the materials.⁵⁰ In another article, an unnamed securities analyst from prominent PRC supplier Chihong Zinc and Germanium noted that the company focused primarily on domestic production and sales, meaning that export restrictions would have relatively little impact.⁵¹ In contrast, the article noted that between 2019 and 2021 as much as 60% of Beijing

⁵⁰ Fan Wei et al., “中国镓锗出口管制影响有多大” [What Is the Impact of China’s Gallium and Germanium Export Controls], *Global Times*, July 4, 2023, <https://world.huanqiu.com/article/4Da1y0dxiYs>. Assessments and narratives appearing in the *Global Times* should be analyzed with some skepticism, as the outlet is nonauthoritative and tends to produce articles with a highly nationalistic bent.

⁵¹ Chen Jialan, “中国管制镓、锗出口，各方影响几何？” [China Controls the Export of Gallium and Germanium—What Impact Will It Have on All Parties?], *China Business Times*, July 8, 2023, <https://news.sina.cn/gn/2023-07-08/detail-imyzzrfv7549416.d.html>.

AXT's income came from export sales, implying that the export restrictions would have a chilling impact on that U.S.-headquartered company.

Other PRC experts noted that some PRC companies might feel the negative impacts through diminished export earnings. One securities analyst from Yunnan Germanium Industry Co., China's largest germanium supplier, observed that the company was actively communicating with relevant PRC authorities on the new measures, and that they were unable to assess the ultimate market reaction or price increases.⁵² Post-implementation, the export restrictions have had divergent impacts on the market prices of the affected materials. Gallium and germanium prices have trended upward, whereas graphite prices experienced only a slight upward blip, followed by a relative decrease in line with the previous trend, likely driven by a general oversupply of graphite in the saturated market for electric vehicles.⁵³ Thus, PRC gallium and germanium suppliers that are unable to receive export licenses might temporarily weather reduced exports by selling domestically at a higher price per volume, while PRC graphite suppliers facing the same limitation could be more negatively affected as prices remain flat or decrease.

Anticipating PRC Controls and Lawfare

In December 2023 the PRC announced a series of new requirements for monitoring information on exports, which were perceived by industry analysts as a potential precursor of new controls.⁵⁴ Such efforts to gather more information on the effect of current and prospective controls are ultimately driven by three motivations: (1) to improve economic policy planning to bolster affected industries, (2) to refine its implementation and enforcement capabilities, and (3) to prepare responses to future U.S. and allied export controls. This section proposes a methodology to predict the likelihood of controls on certain goods, as well as briefly reviewing other tools in the PRC's retaliatory toolbox.

Likelihood of Future Controls

The passage of the ECL and subsequent modification of the export control regime is part of a broad push within the PRC bureaucracy to encourage the adoption of more formal legal and regulatory tools to be utilized in the administration of various systems. The provisions of these new mechanisms often remain vague, creating flexibility for follow-on regulations, standards, and guidelines. The PRC has sought to adopt these new rules in part to develop greater internal clarity among interdepartmental responsibilities, but establishing these rules also lends a degree of formality and perceived legitimacy to punitive actions that in earlier years the PRC might have carried out through more informal mechanisms or administrative punishments. Beijing has demonstrated greater willingness to use these new tools as a response to foreign actions that threaten its economic and national security interests, even when such actions may support compliance with international laws or laws of a company's domiciled country. This form of lawfare

⁵² Chen, "中国管制镓、锗出口，各方影响几何?"

⁵³ "Gallium Prices for the Last 2 Years," Daily Metal Price, <https://www.dailymetalprice.com/metalpricecharts.php?c=ga&u=kg&d=480>; U.S. Geological Survey, "Germanium"; and Sybil Pan, "Natural Graphite under Pressure from Synthetics, amid Oversupply, Slow Trade Flows," Fastmarkets, April 10, 2024, <https://www.fastmarkets.com/insights/natural-graphite-under-pressure-from-synthetics-amid-oversupply-slow-trade-flows>.

⁵⁴ Eric Hendrich, "China Demands More Information on Rare Earth Exports," Rawmaterials.net, November 7, 2023, <https://rawmaterials.net/china-demands-more-information-on-rare-earth-exports>; and Eric Hendrich, "China: New Export Regulations for Tungsten, Antimony, and Silver," Rawmaterials.net, November 13, 2023, <https://rawmaterials.net/china-new-export-regulations-for-tungsten-antimony-and-silver>.

and weaponization of supply chains has also been part and parcel of Beijing's more frequent and flagrant economic coercion.

Given the broad applications for minerals across different emerging technology areas, this section's analysis of the potential for certain minerals to be subject to PRC retaliatory controls relies on a national security lens to narrow the scope of priority technologies that the PRC is likely to target based on greatest U.S. vulnerabilities. While the methodology is not statistically rigorous, it can provide useful guidance in understanding PRC and U.S. policy priorities on critical minerals and support general predictions regarding the specific minerals that could be targeted in the future. The ranking in **Table 3** is based on international trade data and the following scoring system that relies on the U.S. Herfindahl Hirschman Index as well as related metrics regarding PRC market data:⁵⁵

- *PRC dominance in extraction or production.* Even for materials where the PRC lacks natural reserves, it is frequently dominant in the extraction of these materials around other parts of the globe.
 - over 75% dominance, +5
 - over 50% dominance, +3
 - over 25% dominance, +1
- *PRC dependence on exports overseas.* Policymakers in Beijing will want to avoid applying restrictions to exports that have few alternative destinations because PRC companies might be unable to sell to markets other than the United States or U.S. allies with more advanced manufacturing economies.
 - exports at least 75% of production, -5
 - exports at least 50% of production, -3
 - exports at least 25% of production, -1
- *Impact on U.S. priorities.* The U.S. government has several lists and other published policy statements indicating areas of strategic importance, including critical defense materials and technologies. The U.S. government also publicly acknowledges its financial support for priority industries, such as those stemming from Title III of the Defense Production Act. Beijing is more likely to target these identified priority areas for the U.S. government.
 - presence on National Defense Stockpile critical materials list, +3⁵⁶
 - presence on Defense Logistics Agency strategic materials list, +3
 - target of U.S. government investments of at least \$10 billion, +5
 - target of U.S. government investments of at least \$5 billion, +4

⁵⁵ The Herfindahl Hirschman Index is a measure of market concentration. It is calculated by squaring the share of each supplier in a given market and then adding them together. The index varies between 0 and 1, indicating perfect diversification and total monopolization, respectively. The higher the score, the more concentrated the market for a particular commodity. A commodity with a high index is likely produced by only a few countries. The index increases both as the number of countries supplying a commodity decreases and as the disparity between those countries' market share increases. UN Conference on Trade and Development, "Indicators Explained #1: Export Market Concentration Index," June 12, 2018, https://unctadstat.unctad.org/EN/IndicatorsExplained/statie2018d1_en.pdf.

⁵⁶ This methodology gives critical minerals and materials on the National Defense Stockpile and Defense Logistics Agency lists high priority because they must pass a high bar of criticality. Due to their perceived criticality, these minerals and materials may also be recipients of U.S. government investments. The criteria for minerals or materials to be listed in the National Defense Stockpile are as follows: "materials that (a) would be needed to supply the military, industrial, and essential civilian needs of the United States during a national emergency, and (b) are not found or produced in the United States in sufficient quantities to meet such need." As of the end of 2023, the National Defense Stockpile contained \$1.3 billion in total assets, including \$912.3 million of stockpiled material. Cameron M. Keys, "Emergency Access to Strategic and Critical Materials: The National Defense Stockpile," Congressional Research Service, CRS Report for Congress, R47833, November 14, 2023, <https://crsreports.congress.gov/product/pdf/R/R47833>.

- target of U.S. government investments of at least \$1 billion, +3
- target of U.S. government investments of at least \$500 million, +2
- target of U.S. government investments of at least \$50 million, +1
- *Chokepoints.* PRC attempts to leverage U.S. supply chain dependencies are likely to target commodity chokepoints where there is a high degree of market concentration and few alternative suppliers.⁵⁷
 - U.S. Herfindahl Hirschman Index equal to or above 0.25 and PRC market share above 33%, +5
 - U.S. Herfindahl Hirschman Index equal to or above 0.15 and PRC market share above 20%, +3
 - PRC market share equal to or above 10%, +1

TABLE 3 Anticipated minerals controls

Mineral	Dominance	Export dependence	U.S. priority	Chokepoint	Score
Graphite	5	-1	8	5.0	17.0
Manganese	3	0	9	5.0	17.0
Rare earth elements	5	-1	8	5.0	17.0
Cobalt	3	0	9	3.0	15.0
Germanium	3	-1	11	1.0	14.0
Nickel	0	0	9	5.0	14.0
Tungsten	5	0	6	3.0	14.0
Antimony	3	-1	7	3.0	12.0
Magnesium	5	-3	6	3.4	11.4
Lithium	5	-5	11	0.0	11.0
Quartz	0	-1	6	5.0	10.0
Chromium	0	0	7	3.0	10.0
Copper	3	0	6	1.0	10.0
Gallium	3	-1	6	1.0	9.0
Tantalum	5	-3	6	1.0	9.0
Titanium	3	-3	6	2.0	8.0

NOTE: Graphite export controls were implemented in October 2023. Germanium export controls were implemented in July 2023. The PRC announced new antimony export controls on August 15, 2024, while this report was under development. On this, see Ministry of Commerce and General Administration of Customs (PRC), “商务部 海关总署公告2024年第33号 关于对锑等物项实施出口管制的公告” [Ministry of Commerce and General Administration of Customs Announcement No. 33 of 2024 Announcement on the Implementation of Export Controls on Antimony and Other Items], August 15, 2024, https://www.mofcom.gov.cn/zwgk/zcfb/art/2024/art_a4711acb06364199a3c5a06d7f2be6d8.html.

⁵⁷ If a commodity meets one but not both requirements for a given score, it is scored at the lowest level at which both requirements are met.

PRC retaliatory measures have generally been designed to respond directly to U.S. actions on the basis of sectors or technologies targeted by a U.S. policy action. The materials listed are used in different combinations across critical technologies that include batteries, semiconductors, aerospace craft, electric vehicles, ammunition, and a range of metallurgy applications that support advanced manufacturing.

Alternative tools to export controls. The PRC's responses to U.S. and allied export controls have largely centered on use of its maturing export control system, but the government has also been building an arsenal of other economic policy tools to retaliate. The PRC could weaponize its exports through use of the Unreliable Entity List (UEL) and hamper activities of foreign companies and their employees through use of the Anti-Foreign Sanctions Law (AFSL). The PRC has also used antimonopoly and security investigations to retaliate against foreign companies that the government sees as particularly complicit in disadvantaging Chinese companies through compliance with U.S. sanctions and export controls.⁵⁸

Unreliable Entity List. In 2019, MOFCOM announced the creation of the UEL following U.S. placement of various PRC-headquartered entities, including Huawei Technologies, on its Entity List. Where the U.S. Entity List is explicitly tied to its export control regime and the Export Administration Regulations, the PRC Unreliable Entity List is administered more independently, and its authority is based on the FTL, the Antimonopoly Law, and the National Security Law.⁵⁹ This UEL is also administered by MOFCOM. Entities placed on the UEL may be subject to the following conditions in the PRC: import and export restrictions, investment ban, limitations on personnel entry or travel within borders, revocation of personnel work authorization or residency, and fines matching the severity of the circumstances.⁶⁰

Use of this tool to date has been directed at individual entities that support U.S. weapons sales to Taiwan, meaning that these firms are already prolific U.S. government defense suppliers that conduct very limited to no business in the PRC. In other words, the use of this sanctions tool has been largely symbolic with little economic effect on either the PRC or the listed entities.⁶¹

Anti-Foreign Sanctions Law. In 2021, Beijing published the AFSL, essentially in response to various U.S. and allied measures to combat forced labor and human rights issues in the PRC. The AFSL bars both PRC and foreign entities operating within PRC borders from enforcing discriminatory foreign sanctions levied against the PRC. Under the law, the PRC can take a range of punitive measures against organizations and their employees, such as deportation or revocation of visas or entry, asset freezing or seizure, or prohibition of transactions with other entities in the PRC. To date, the AFSL has been used against U.S. and European lawmakers, advocates, or researchers focused on human rights in Hong Kong, Xinjiang, and Tibet.

The UEL and the AFSL are designed for use against specific entities and individuals. The PRC government appears to be careful in its use of both mechanisms to underscore its policy redlines regarding foreign support of Taiwan, Hong Kong, and Xinjiang. Use of these tools to respond to other perceived commercial and economic threats would signal a significant shift in its policy

⁵⁸ U.S.-China Economic and Security Review Commission, "2023 Annual Report to Congress," November 2023, chap. 2, section 1, https://www.uscc.gov/sites/default/files/2023-11/Chapter_2_Section_1--Chinas_Increasingly_Global_Legal_Reach.pdf.

⁵⁹ Ministry of Commerce (PRC), "商务部:中国将建立不可靠实体清单制度" [Ministry of Commerce: China Establishes Unreliable Entity List System], May 31, 2019, <http://www.mofcom.gov.cn/article/i/jyj/e/201905/20190502868927.shtml>.

⁶⁰ *Ibid.*

⁶¹ "China Sanctions Lockheed Martin, Raytheon over Taiwan Arms Sales," Reuters, February 16, 2023, <https://www.reuters.com/business/aerospace-defense/china-imposes-sanctions-lockheed-martin-raytheon-over-taiwan-arms-sales-2023-02-16>.

priorities and send a stark message to foreign businesses. With PRC policymakers attempting to maintain the appearance of an open environment for foreign investment, the use of such formal tools to intimidate companies is likely to remain limited.

Antimonopoly investigations and security reviews. PRC authorities have a history of using antimonopoly authorities to target individual foreign companies and have expanded this toolset to cybersecurity and supply chain security reviews. On December 9, 2024, the State Administration for Market Regulation announced an antimonopoly investigation into U.S.-based Nvidia Corp. Nvidia is the leading producer of graphics processing units, the most advanced of which are prohibited for export to China. The investigation, which could result in fines of up to \$1 billion, is widely viewed as a retaliation against the December 2024 U.S. export controls on advanced-node integrated circuits. As part of the probe, Chinese authorities are investigating Nvidia's acquisition of Israeli firm Mellanox Technologies, despite having approved the deal when it took place in 2020.⁶² In May 2023 the Cybersecurity Administration of China determined that U.S. chip producer Micron had failed its April 2023 cybersecurity review and prohibited further acquisitions of Micron products from Chinese government procurement. The move was widely seen as retaliation for October 2022 U.S. and allied semiconductor export controls.⁶³ PRC authorities appear to be targeting specific U.S. companies through these reviews not only because of their compliance with U.S. laws but also because of their role in Chinese supply chains, where removing them could further PRC self-sufficiency.

Key Takeaways

The PRC export control regime has evolved dramatically after a period of stability following its emergence in the late 1990s, with the most significant actions taking place within the past few years, clearly in retaliation to U.S. policies and those of other perceived adversaries. The PRC's Export Control Law encompasses a range of dual-use products and commodities, widening the scope of strategic trade controls from the PRC's Foreign Trade Law, which contained narrow restrictions on the export of military equipment and technologies. The PRC is also adopting lawfare beyond export controls (e.g., the Unreliable Entity List and Anti-Foreign Sanctions Law) to enable greater flexibility in responding to U.S. policies it deems threatening.

PRC authorities seek to balance the retaliatory effect of new export controls with their deleterious impact on PRC firms. The materials subject to most recent PRC export controls (e.g., gallium, germanium, and graphite products) were almost certainly selected in retaliation to U.S. technology export restrictions and intended to undermine U.S. national security goals. However, the level of detail found in PRC export license application guidelines for these newly affected goods—particularly the extensive description of common issues with applicant materials—suggests that MOFCOM and other PRC export authorities do not want these restrictions to cause undue harm to PRC firms. While trade data illustrates that PRC exports of newly controlled commodities have largely resumed after a short decline, a survey of PRC industry experts offered mixed assessments on whether PRC firms would be able to weather resulting market turbulence.

⁶² Che Pan and Ann Cao, "Nvidia Faces US\$1 Billion Fine If China Probe Finds Violation of Antitrust Laws," *South China Morning Post*, December 9, 2024, https://sc.mp/pjac9?utm_source=copy-link&utm_campaign=3290190&utm_medium=share_widget.

⁶³ Matthew Reynolds, "Micron Aggression: The Right Response to Beijing's Ban on the U.S. Chipmaker," CSIS, June 22, 2023, <https://www.csis.org/analysis/micron-aggression-right-response-beijings-ban-us-chipmaker>.

Future PRC export controls are likely to continue targeting commodities for which PRC firms maintain significant supply chain advantages and which are critical to U.S. technology and national security strategies. The commodities subject to recent rounds of PRC export controls are characterized by a set of common traits: (1) PRC enterprises have dominant or near-monopoly positions in their supply chains, (2) they are of high strategic or economic importance to the United States and are explicitly identified in U.S. national security policy documents, (3) they are solely or primarily sourced globally from the PRC, and (4) they have alternate export markets outside the United States.

A methodological approach to identifying such goods using trade data and policy analysis gives U.S. and allied policymakers a first-pass prediction of commodities likely to be restricted in the future. The methodology developed in this report demonstrated some merit, identifying antimony as a top potential target in the report's draft stage. On August 15, 2024, the PRC placed controls on antimony. In a press statement, MOFCOM asserted that the new restrictions were “in order to safeguard national security and interests, and fulfill international obligations such as nonproliferation.”⁶⁴ This justification lends the restrictions an air of legitimacy, but their effect is highly concentrated on the United States and its allies. Use of the methodology identified in this report can provide guidance to U.S. and allied policymakers to anticipate PRC reactions to new security and trade restrictions. Ideally, this could also provide the lead time necessary to explore alternative sources or approaches.

⁶⁴ MOFCOM and GAC (PRC), “商务部 海关总署公告2024年第33号 关于对锑等物项实施出口管制的公告” [Ministry of Commerce and General Administration of Customs Announcement No. 33 of 2024 Announcement on the Implementation of Export Controls on Antimony and Other Items], August 15, 2024, https://www.mofcom.gov.cn/zwgk/zcfb/art/2024/art_a4711acb06364199a3c5a06d7f2be6d8.html.



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