Beyond Rare Earths: Dual-Track Governance in China's Critical Minerals Strategy for Semiconductors and Clean Energy, 2010-2025

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(Dated: 17 November 2025)

While non-rare-earth minerals including lithium, cobalt, nickel, graphite, germanium and gallium are central to the energy transition and semiconductor manufacturing, they sit in fragmented regimes and have received little academic attention. I posit that China's approach to these minerals can be characterized as a dual-track governance, encompassing precision export licensing that turns midstream chokepoints into leverage and institution-building by way of BRI-style finance, ESG guidance, and standards that align other parties with PRC interests. This mixed-design study combines event-study evidence on the licensing shocks and export controls from 2023-2024 with comparisons of DRC cobalt and Argentina/Bolivia lithium joint ventures. This piece aims to distinguish coercion from order-shaping and identify where Western initiatives (e.g., MSP, FEOC) complement or collide with Chinese architectures.

I. INTRODUCTION AND BACKGROUND

A. EVs, semiconductors, and China's mineral hegemony

Fifteen years ago, the maximum range for an electric vehicle commercially available in the United Stated was under 100 miles, while today many models boast ranges upwards of 500 miles[1]. This development is a story of scientific achievement and engineering breakthroughs, but it is also a geopolitical story. Break open most EV batteries on the market today, and you'll find a $50-100$ kg graphite anode[2], 92% of which is produced in China's anode supply chain. And while each new generation of batteries has seen major changes to cathode design, each chemistry has remained tethered to Chinese-controlled nodes in the critical-minerals system. Roughly 60% of all nickel is now mined in Indonesia with the majority controlled by just two Chinese firms[3], cobalt is 74% mined in the DRC but almost entirely refined in China[4], and lithium is mined chiefly in Australia, Chile, and China yet more than 60% of refining occurs in China[5].

The power-electronics stack increasingly leans on gallium (for GaN) and germanium, and China controls about 99% of primary gallium production and more than 60% of refined germanium production[6]. These minerals and the problem of Chinese control over the supply chain are not limited to battery production. Indeed, the global energy transition and semiconductor manufacturing hinge on a set of non-rare-earth critical minerals — lithium, cobalt, nickel, gallium, germanium, graphite — over which China exerts outsized influence across mining, processing, and governance. Thus, while on the surface a technical story about materials and manufacturing, this is also an governance and geoeconomic story that leads us to ask who sets the rules that structure this dependence and how that structural position is used strategically.

B. Empirical puzzle

There have been significant scholarly and policy debates on rare earth elements (REE), particularly in the context of the 2010 Chinese embargo against Japan[7]. The REE episode is now viewed as the canonical case for debates centered on weaponized interdependence, coercive leverage, and vulnerabilities tied to concentrated supply. While this article will draw on that body of research as source of both inspiration and comparison, it focused instead on non-REE minerals, which are unique in that they are crucial to decarbonization and advanced manufacturing efforts but lie in more fragmented regimes and are relatively understudied in the field.

In the domain of non-REE critical minerals, China's recent behavior is fairly puzzling. On one hand, Beijing has targeted midstream chokepoints with the introduction of increasingly granular export controls and licensing requirements. In July 2023, it pushed through new licensing for gallium and germanium products effective that August[8], which were followed in December of that year by further licensing for graphite-anode materials[9]. Simultaneously, seemingly in an attempt to limit U.S. efforts to reduce reliance on China's manufacturing stack, Beijing supplemented their materials licensing measures with targeted restrictions focused specifically on extraction and processing technology[10]. Most of these restrictions were not walked back until the meeting between Xi Jinping and Donald Trump at the end of October 2025[11].

On the other hand, China has focused on presenting itself as a responsible creator of order in critical minerals. The China Chamber of Commerce of Metals, Minerals and Chemicals (CCCMC) has issued due-diligence guidelines that are clearly modeled in part on the frameworks from the Organization for Economic Co-operation and Development (OECD), signaling both autonomy and degree of isomorphism in norm diffusion[12]. Both the Green Belt and Road agenda and the

2022 joint Ministry of Commerce (MOFCOM) and Ministry of Ecology and Environment (MEE) guidelines on ecological and environmental protection for outbound investment work to explicitly align Chinese finance with community consultation, ecological due diligence, and host country law[13,14]. In this way, in both its rhetoric and increasingly in formal documents, Beijing seeks to depict its firms as stewards of sustainable development while presenting its outbound finance as a means of achieving a greener, more orderly globalization.

When viewed in tandem, these two sides of Chinese policy vis-a-vis non-REE critical minerals create the empirical puzzle of this article. How then should we make sense of a state that is simultaneously using precise export controls on gallium, germanium, and graphite in a way that resembles a system of coercive governance via chokepoints, while also promulgating Green BRI, MOFCOM–MEE environmental guidelines, and CCCMC due-diligence frameworks that both emulate and rival Western standards? Should we then view these export controls as merely episodic episodes of retaliation in the context of otherwise cooperative governance, or is the combination of the controls and standards manifestations better seen as a coherent strategy seeking to shape order in clean energy and semiconductors minerals?

C. Research question

This article addresses this puzzle by asking how China's strategy from 2010 to 2024 around the non-REE critical minerals central to clean energy and semiconductors combines export controls and outward-facing institutionalization and analyzing what this duality reveals about China's role in an international order that is increasingly plural and issue-specific.

To better answer this over arching question, this question and resulting analysis is broken down into two sub-questions:

- **Export controls and trade reconfiguration:** In what ways do Chinese export controls and licensing measures on gallium, germanium, graphite and related technologies serve to reconfigure patterns of trade? Do they simply depress volumes, or do they also induce partner switching, rerouting through third countries, and specification creep that allows for the relocation of chokepoints from raw materials to a narrowly defined set of intermediates?

- **BRI-era bundles and governance lock-in:** How do Chinese bundles of finance, offtake agreements and standards specifically related to cobalt and lithium projects in the Democratic Republic of Congo (DRC) and the Lithium Triangle result in governance outcomes that extend beyond individual projects? Under what conditions do these BRI-style bundles manage to entrench norms and flows aligned with the PRC, and when are they either constrained or redirected by a combination of competing Western initiatives and host-state politics?

Throughout this piece when I refer to resource security, I refer to domestic industrial upgrading, supply-chain resilience, and strategic leverage in clean-energy and semiconductor manufacturing[15]. I use global governance to mean the institutions and practices that allocate rights and responsibilities in these supply chains, including standards, ESG and transparency regimes, financing conditionality, and dispute-resolution mechanisms[16]. The core task then is to track how China's search for resource security interacts with and operates through new and existing governance structures.

D. Argument in brief

The central claim of this article is that China has a dual-track governance strategy in non-REE critical minerals, focused less on one-off coercion that on durable order-shaping.

> **Track 1 — governance-by-chokepoint:** In the first mode, Beijing makes use of precision export controls and licensing regimes to use midstream chokepoints as bargaining leverage. In thin value chains like gallium, germanium, and advanced graphite anode materials, China's production dominance becomes a form a structural power by way of technology controls, product-level specifications, and granular licensing.
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> **Track 2 — governance-by-institution:** In the second mode, China creates institutional frameworks that it then diffuses to urge firms and partner governments into norms preferred by the PRC. BRI-era finance packages, CCCMC due-diligence guidance, Green BRI principles, MOFCOM–MEE environmental guidelines, and other related standards documents together make up a governance structure that is outward facing by design. These instruments use ESG language to build packaged contract design, permitting practices, and offtake arrangements, increasingly interacting with Western club goods like the Minerals Security Partnership (MSP) and Foreign Entity of Concern (FEOC) rules.

This article argues that it is the union of these two tracks, rather than either individually, that serves to transform China's role in this governance sphere. Instead of categorizing export controls as ad-hoc retaliation and standards as window dressings, I show that these two tracks are mutually reinforcing. Export controls both highlight and help to create chokepoints. Likewise, institutionalized outward engagement pushes other parties into structures that preserve Chinese influence. The world is composed of overlapping domain-specific order, and China seeks not to build a single hierarchal architecture but rather to embed its preferred levers of influence directly into the supply chain.

To do this, in **Section 2**, I first review the relevant literature on plural and overlapping orders, modes of geoeconomic and structural power, soft law and standards, the use of export controls as a means of statecraft, and BRI-era mineral governance, situating the non-REE minerals domain within debates on alternative global orders and weaponized interdependence. This is followed by **Section 3**, which presents a explanation of the theoretical framework of dual-track governance, drawing on work of flexibility empowerment, structural power, and worlds of order to specify the mechanisms of each track and derive observable implications for trade rerouting, specification drift, offtake lock-in, and institutional feedbacks.

Section 4 provides a detailed accounting of the mixed method research design, explaining both the event study of Chinese export controls on gallium, germanium, and graphite as well as the bundle-tracing analysis of BRI-era cobalt projects in the DRC and lithium projects in the Lithium Triangle. The empirical findings from this work are presented in **Section 5**, showing the reconfiguration of trade patterns by export controls and the translation of bundles into govenance outcomes. I conclude in **Section 6**, exploring the implications for both IR theory and policy.

II. LITERATURE REVIEW

A. From world order to material statecraft

While traditional frameworks of order have argued for single-hub models, recent work urges a move towards an environment of overlapping, issue-specific regimes. Johnston's debate on worlds

of order posits that rather than pursuing an overarching hegemonic architecture, great powers tend to seek nested, domain-specific orders[17]. This view fits well with the minerals domain made up of the overlapping but distinct systems of trade, standards, export controls, and development finance.

Economy reinforces this in her account of China's alternative order, arguing that Beijing uses institutional bricolage from standards setting to development lending to avoid frontal confrontation while securing strategic advantages[18]. Other authors complement this view of a blended Chinese power strategy, highlighting the deep pluralism in global order[19], the flexibility-empowerment nexus that enables rising powers to leverage informal club-like arrangements[20], and the ability of states to shpe markes via rules, standards and chokepoints as a structural power[21]. When taken together, these frameworks indicate a logic within the minerals regime where advantage comes not from monopolization alone but also a systemized approach to rules configuration exercised by embedding standards, export-licensing regimes, and concessional finance into the supply chain to create lock-in, veto points and path dependencies. This motivates an empirical inquiry into how China mixes rule-making and rule-exploiting in the non-REE critical mineral supply chain.

When taken together, these frameworks allow us to build a conception foundation for analyzing advantage accrual within the domain of mineral extraction and production. China achieves dominance through near monopoly on production paired delicately with rule configuration, working a preferred set of standards, licensing regimes, and concessional finance into the system of the supply chain. This body of research motivates empirical inquiry of China's blending of rule-making and rule-exploiting in non-REE supply chains.

B. Hardening soft law

A second area of research focuses on how soft-law instruments like ESG guidelines, standards, transparency regimes and investment principles now serve as a form of de facto governance in critical minerals.

The cornerstone for firm-level risk management has long been the OECD's Due Diligence Guidance, and it has gradually been expanded beyond conflict minerals to encompass broader ESG and traceability expectations[22]. The China Chamber of Commerce of Metals, Minerals and Chemicals (CCCMC) guidelines mirror this, adapting the template to firms and value chain realities relevant to China, signaling both autonomy as well as isomorphism in norm diffusion[12].

Standards often act as the central vector geoeconomic power. For most of the 20th and early 21st centuries, the U.S. dominated this game, but China appears to be taking steps to encroach on this hegemony[23]. In a concrete manifestation of this, China's Green BRI and the 2022 MOFCOM-MEE environmental guidelines align outward investment with ecological due diligence, community consultation, and host-country law[13,14].

In parallel, Western initiatives harden soft law into club goods. While OECD and CCCMC guidelines constrain themselves primarily to focusing on transparency and ESG aspects of governance, the Minerals Security Partnership — a coalition of 14 countries and the European Union working to secure supply chains for critical minerals — articulates an explicit intent to coordinate public finance and standards[24]. The U.S. has started the process of codifying market access constraints through the relatively new and unique Foreign Entity of Concern (FEOC) rules, operationalizing geopolitical screening within clean energy tax credits[25]. Technical assessments from the International Energy Agency (IEA) provide a synthesis of these governance moves with market structure, indicating that refining concentration rather than mining is the binding risk to supply chains[26,27].

In practice, these soft-law instruments function primarily as sources of strategic legitimation

and as reference points in contract and permitting disputes. Academic work has not suitably answered the question of how voluntary frameworks like Green-BRI and MOFCOM-MEE interact with binding subsidy and trade rules as well as with Western due diligence statutes to produce either standards convergence, mutual recognition, or competitive fragmentation.

C. Concentration and chokepoints

A third set of scholarship is used as the quantitative baseline for assessing the structure of the global minerals market and indentifying the location of chokepoints.

There are three canonical sources for process-level baselines. 1) The IEA's Global Critical Minerals Outlook 2025 provides quantified demand trajectories and concentration metrics at each step in the process from mining to refining, allowing for documentation of persistent trends like China's dominance in lithium chemicals ($\sim 70\%$ global output) and rising Indonesian primacy in nickel, even as ex-China refining projects grow from a low base[28]. 2) The USGS Mineral Commodity Summaries and accompanying technical reports provide series that satisfy the requirements of being long-run, country-level, and process-level necessary to anchor any original indicator work[29,30]. 3) Industry data, like Benchmark Mineral Intelligence, helps to clarify bottlenecks in the supply chain. For example, a Benchmark minerals report estimates that roughly 75% of the graphite anode supply chain sits in China, with strong lock-in effects for downstream cell makers[31].

D. Export controls as governance-by-chokepoint

Previous reviews indicate that China increasingly uses export controls and licensing rules to translate industrial capacity into strategic leverage. China's 2023 restrictions on gallium and germanium are framed as a test of reverse dependence and a probe of Western stockpile and substitution elasticities[32].

Given the small absolute tonnages, USGS characterizes the gallium/germanium value chains as thin, but noted the high mission criticality, amplifying the impact of licensing frictions[30]. Beijing's move to require licenses for certain anode materials including graphite introduces a level of administrative uncertainty that can make it hard for non-Chinese offtakers even absent any outright denials[33,34]. More recent analyses focus on an emergent, more systematic Chinese approach to outbound controls, linking measures to domestic capacity, retaliation signaling, and standards positioning[35]. As a corpus, the framing shifts from export bans as blunt tools to granular licensing and standards-based specifications as effective trade instruments.

This set of research helps us map the first half of the puzzle, describing how chokepoints are created, maintained and activated as well as the use of product definitions as governance tools.

E. BRI-era DRC cobalt complex

Parallel to discussion of China's export licensing is analysis of how China's development finance and corporate ecosystem work together to reshape upstream supply and local political economies.

In the DRC, AidData and related governance studies indicate that infrastructure for minerals package deals, loan renegotiations and cancellations, and off balance sheet guarantees have led to more consolidated Chinese commercial control, all the while creating leverage over production

schedules and offtake[36,37]. An Extractive Industries Transparency Initiative (EITI) report scrutinizing the Sicomines contract renegotiation brought light to how transparency mechanism can claw back fiscal space while maintaining entrenched offtake structures[38]. Carrai then situates the dynamics of this struggle within the broader context of US-China rivalry on the African Copperbelt and emergent corridors like Lobito[39]. She argues that the rivalry increasingly manifests via valuation of ERG, logistics, and traceability standards as opposed to pure ownership contracts.

A key empirical gap here is the interaction of these BRI-era contracts with new Western club goods like MSP and FEOC to alter the global governance equilibrium.

F. Lithium triangle

There is significant cross-validated reportage and industry filings indicating that Chinese firms are scaling stakes across brine and hard-rock projects in South America, particularly in the lithium triangle of Chile, Argentina, and Bolivia, pushing these projects forwards through joint-ventures (JVs) that blend capital, processing technology, and guaranteed offtake. The direct lithium extraction (DLE) demonstration reported by Eramet's Centanario and Argentina's wave of projects anchor expectations for non-Chinese brine growth, but refining gravity still pulls toward China[28,40].

Reuters and industry reports describe corporate consolidation moves within Lithium Argentina to integrate Salta basin assets and Ganfengs's commissioning at Mariana, both of which are consistent with China's playbook of basin-level control and midstream optionality[41–43]. In Bolivia, announcements of Chinese-led projects have led to major political upheaval, underscoring the political economy of often unmet promises of technology, where DLE and downstream integration are exchanged for market access and fiscal commitments under substantial policy risk[44**?** ,45].

Across the region, a number of policy analyses note that China's influence is not limited to its equity stakes, rather it extends to standard-setting and financing terms, with implications for the limitations of MSP-style initiatives in crowding in alternative capital[46–48].

G. Synthesis and researcheable gaps

Across this set of literature, there are two primary unexplored gaps.

The first is the controls-standards interface. How does granular export licensing for graphite or Ga/GaN precursors co-evolve with technical standards and product definitions? This has implications for the relocation of chokepoints from raw materials to intermediate specifications.

The second is the finance-governance interface. BRI-era resource packages in both the DRC and the Lithium Traingle have locked in offtake and processing locations, potentially leading to a more limited reach of MSP/FEOC-style clubs. In order to understand the BRI-era investment and subsequent Chinese commercial presence in the Lithium triangle, greater analysis of these loans and the resulting mineral supply chain is needed to see how export licenses and standards redefine tradability sets and how JV/offtake webs, transparency interventions, and club finance shift effective control without ownership changes.

These two interfaces help define the following theoretical framework describing China's dual-track governance strategy as well as motivating this article's mixed-method research design.

III. THEORETICAL APPROACH

A. Critical minerals as a world of order

I posit that China's non-REE minerals strategy is a dual-track governance marked by operation within a plural, domain-specific international order. Per Johnston's world of orders framework, contestation and compliance must be analyzed at the issue level rather than on a single, collapsed verdict on revisionism[17]. Following in this path, I treat critical minerals for semiconductors and clean energy as an institutional subdomain where we can see China acting as both rule-shaper through standards, guidance, and development finance and rule-exploiter through export licensing and domestic industrial policy.

The argument is further structured by two additional strands. First, deep pluralism implies that there exist multiple, non-disjoint governance logics with significant conditions of interdependence[19]. In this kind of setting, rising powers like China seek instruments that maximize issue and governance flexibility in their favor[20]. Second, working off of Strange's framework, the center of geoeconomic influence in these supply chains is structural power over knowledge and production networks[21]. Control over midstream processing, process know-how, and quality specifications is crucial to this power. Economy's account of an alternative order built from development finance, narrative legitimation, and technical standards provides the large-scale template that this project brings into the minerals domain[18].

When viewed together, these perspectives support the claim that non-REE critical minerals form world of order with distinct rules, players, and playbooks. Instead of abstractly arguing over whether China is a revisionist power or seeking to maintain the status-quo, the task at hand is to explain how Beijing uses export controls, designed standards, and finance plus offtake bundles to directly shape its existence within this subdomain. We can define a parameter space of control methods, which flexibility empowerment suggests Beijing will seek to keep as broad as possible to preserve optionality. Within this space, China charts paths that allow it to toggle between cooperation and pressure as circumstances demand. This instrument space, however, is constrained by the broader environment that it exists in. As deep pluralism implies, Chinese practices here do not simply replace Western frameworks. Rather, they coexist with and often intersect regimes like OECD due diligence, MSP, and FEOC screening.

Within this world of orders, critical minerals for semiconductors and clean energy are a particularly useful subdomain when it comes to inferring the set of methods employed by Beijing. The chains are thin and very specialized, so they are very susceptible to chokepoint politics, yet they are also subject to increasing layers of soft law, ESG guidance, and club-based coordination. The fact that the domain of non-REE critical minerals is both structurally vulnerable and institutionally dense means that they are optimal for observing China's blending of rule-making and rule-exploiting, and the country's use of material statecraft to shape this specific order rather than a single architecture across orders.

B. Defining dual-track governance

a. Core claim. China uses a dual-track strategy in non-rare-earth minerals whereby 1) precision export controls convert midstream chokepoints into bargaining leverage, creating a form of governance-by-chokepoint[32,33,35], while 2) institutionalized outward engagement socializes other countries and firms to PRC-approved norms in sourcing, ESG, and contract design[12–14]. The union of these two tracks is a strategy focused on translating production dominance into durable

order-shaping rather than episodic coercion.

I designate this configuration dual-track governance. Many states occasionally use export controls or issue ESG guidelines, but it is rare that the systematically employ both in concerted strategy. China employs these instruments in tandem to pursue a defined direction. One track capitalizes on discrete chokepoints to turn turns structural advantages in processing and technology into leverage. The other track builds and diffuses a set of institutional frameworks that yield normalization of Chinese roles and standards in the same chains.

Dual-track governance builds on Strange's account of structural power[21]. In thin, very specialized supply chains, China's control over production networks, technical knowledge, and quality specifications allow it to leverage markets without depending on visible, continuous coercion. While the mechanisms differ across the tracks, all are grounded in the logic that a small targeted intervention can have an out-sized effect as it works through existing concentrated structures.

b. Track 1: export-control track (governance-by-chokepoint). The set of granular controls and licensing friction that China uses to transform midstream dominance into bargaining leverage define the first track. In analyzing this mode, we should understand export controls as tools of governance rather than simple bans. Beijing controls the ease of access for foreign firms to critical intermediate inputs such as gallium, germanium, and advanced graphite anode materials with a careful combination of licensing requirements, technology-transfer controls, and finely sliced product definitions.

The specialized and critical nature of the gallium, germanium, and battery-grade graphite supply chains means that very small changes in licensing requirements or product definitions can create significant downstream adjustments. The governance effects of the methods on this track can be seen through three channels:

- **Partner switching —** When facing licensing shocks, importers respond by either rerouting trade through intermediaries or by shifting marginal volumes to alternative suppliers. This then creates new dependencies on specific transit hubs and trading partners even if aggregate volumes stay the same.

- **Specification redefinition —** Chinese authorities can easily move chokepoints from raw materials to processed intermediates by tightening or reclassifying HS codes and technical specifications. Even if other countries develop basic extraction capacity, this specification creep allows China to preserve leverage.

- **Administrative uncertainty —** Uncertainty can be created through delays, documentation demands, and discretionary enforcement. This allows China to structure bargaining, forcing firms and governments to adjust their investment plans and political positions to stay on the right side of relatively opaque licensing practices.

c. Track 2: institutional track (governance-by-institution). The second track is institutional and outward-facing. In order to socialize norms and lock in flows, China uses a combination of joint ventures, BRI finance and policy guidelines like CCCMC due diligence, Green BRI principles, and MOFCOM–MEE environmental guidelines. Beijing is thus able to shape practices around permitting and contracting, push a narrow definition of responsible conduct, and structure risk allocation between host states, Chinese firms, and third parties.

This governance by institution is built on the following:

- **Financing bundle —** China bundles concessional and policy-directed finance with equity stakes, long-term offtake agreements, and occasionally requirements for downstream pro-

cessing in China to shape the physical direction of mineral flow and the legal and institutional landscape to favor them in the creation of future contracts.

- **Guidelines and soft-law templates —** CCCMC guidelines, Green BRI documents, and MOFCOM–MEE guidance build a unique framework specific to Chinese outbound investment, adapting ESG and due-diligence language but distinct in nature. While formally voluntary, this framework still provides reference points for use in disputes and serves as de-facto standards in the bureaucracy of the host state.

- **Joint ventures and technology partnerships —** China has structured JVs, especially in the DRC and the Lithium Triangle, specifically to combining capital, process know-how, and midstream technology. This allows the JVs to act as a means of diffusing technical standards and business practices aligned with those of China, also serving to shape domestic politics of resource governance by creating local stakeholders that are invested in the success of the Chinese led model.

This set of methods allows for faster initial ramp up, as bundles help move projects more quickly from announcement to production, especially in contexts with limited state capacity. It also creates stickier flows to Chinese refineries, as long-dated offtake clauses and Chinese dominance of refining technology make it harder for host states or other buyers to move from mineral extraction to technology fabrication in a way that avoids Chinese chokepoints.

Employed in tandem, these two tracks allow China to embed leverage in both the material and institutional fabric of the non-REE critical mineral supply chain. Where governance-by-chokepoint constrains the options and costs available to foreign actors at critical nodes, governance-by-institution shapes the surrounding landscape of rules and expectations where those actors plan and negotiate. These mechanisms mean that the abstract ideas of structural power and worlds of order can be observed in trade data and contract structures.

C. Observable implications

1) Controls → rerouting: After shocks in export-licensing, there should be clear evidence of persistent partner switching (third country involvement) and specification creep (product definition tightening), not merely level drops[30,32]. Partner switching should be visible through increased shares through specific Southeast Asian or European countries, even if ultimate consumption remains elsewhere. While aggregate exports may remain non-trivially positive, the destination concentration should rise. Specification creep will be evident in relative shift in the diversity or mix of the HS codes for the relevant products, presenting as either consolidation to a smaller set of codes or as a relative shift in quantities of exports under two HS codes.

2) Finance → offtake lock-in: JV equity, syndicated debt, and offtake clauses in BRI-era projects (DRC cobalt and Lithium Triangle) should predict a period of more stable China-bound flows through the price cycle relative to EPC-only models[36,37,39]. Renegotiation episodes like contract revisions and debt re-profiling in bundled projects can adjust fiscal terms, but they should ultimately preserve core offtake and processing arrangements, as governance outcomes are posited to be stickier than headline ownership percentages. Regulatory debates and changes within the host country should explicitly or implicitly reference Chinese derived ESG templates in tension and in combination with Western frameworks.

D. Alternative explanations

This framework of dual-track governance does not claim that ambitions to shape order drive all variation in Chinese behavior or supply-chain outcomes. Thus we must consider three alternative frameworks:

- **Pure retaliation or coercion —** If export controls have no broader governance ambition and are interpreted as one-off retaliatory moves in response to U.S. or allied actions, we would expect to see short-live controls, sharp level effects, and limited institutional follow through.
- **Pure resource scarcity —** If Chinese policies are driven entirely by domestic industrial upgrading and resource-security concerns, with any governance effects simply by-products, we should see export controls and finance bundles that are highly sensitive to domestic capacity and industrial policy cycles, but not linked systematically to any outward norm diffusion.
- **Host agency and domestic politics —** If outcomes in the DRC and Lithium Triangle simply reflect host-country politics, bureaucratic capacity, or ideological preferences, with Chinese instruments adapting to rather than structuring governance trajectories, we would predict varied patterns of engagement that track domestic coalitions more closely than the presence or absence of bundled Chinese engagement.

IV. RESEARCH DESIGN AND METHODOLOGY

A. Mixed-method strategy and case logic

I combine two methods to explore the governance vs resource strategy question: 1) quasi-experimental inference on the effects Chinese export controls in thin, mission critical value chains on trade; 2) focused comparison of BRI-era minerals governance in the Lithium Triangle (Argentina, Bolivia, Chile) and the DRC. The quantitative components serve as an anchor for magnitudes and timing, while the qualitative components enable us to identify mechanisms and institutional pathways.

The case selection follows a simple logic. The DRC is cobalt-heavy and has featured some of the earliest and most significant cases of infrastructure for minerals and resource backed deals, and there have been multiple cycles of transparency interventions and equity renegotiations like Sicomines. On the other hand, the Lithium Triangle has brine and hard-rock projects, both state-dominant and JV-heavy policy models, and intense Western discourse on alternative supply chains and derisking. These cases work well together to provide variation in host-country governance and project structures, but they keep China central in terms of downstream processing and offtake.

B. Export controls design

a. Events and outcomes. The primary events examined are the July 2023 gallium and germanium licensing, and the October 2023 announcement and December 2023 effectiveness of graphite licensing[32,33]. The December 2024 U.S.-targeted bans, and January 2025 controls on extraction/processing technologies[35] are not included as data is only available through December

2024. As explained above, the testable outcomes are CN-origin exports by HS6 code and partner, partner-switch indices, and announcement-window price responses.

In the current draft, I implement the trade analysis in two steps. I first build monthly series from 2018 to 2024 for total Chinese exports and destination-specific exports at the HS6 level for gallium, germanium, and graphite-related codes as well as selected comparison commodities. I then compute the following descriptive indicators: monthly export values and volumes, simple year-on-year changes and unit-value series. These are visualized as stacked monthly shares, time-varying HHIs, and unit-value plots around the control events. Planned analysis of destination shares and Herfindahl indices of partner concentration has been curtailed by access limitations for destination-specific data.

b. Data. I rely on UN Comtrade monthly data from 2018 to 2024 for treatment commodities, supplementing with U.S. import and price context from USITC briefs, structural characteristic and substitutes from USGS OFR 2024-1057, baseline concentration from IEA 2025[28–30,32]. While thin tonnages may imply large percentage swings, inference emphasizes composition rerouting and persistence over levels. As graphite licensing is widely assessed as "country-agnostic with a presumption of approval," I choose to treat any administrative frictions like longer lead times or documentation as part of the treatment[33,34].

C. 2) BRI-era Minerals Governance — Structured Comparison

Note - this section is still in progress. I have gathered a preliminary data set for this, but data limitations and slow-downs in coding on the track 1 analysis took many more days than anticipated. The methods below are a refined version of those described in my proposal, but no results will be included for this track. Apologies for this absence.

a. Cases and Scope. I will compare a) DRC cobalt complexes including the Sicomines, Tenke, and CMOC/Huayou portfolios with b) Lithium Triangle projects including Mariana and PPG consolidation in Argentina and CBC-YLB DLE plants in Bolivia. The scope of this is from 2008-2024, as 2008 marked the initial loan from CHEXIM that was later canceled in order to push through the DRC cobalt agreement. This selection encompasses variation in host-state institutions, stability, and finance-ownership-offtake bundle[36,39,41–44].

b. Coding Scheme. For each project-year, I will track the following:

- Ownership/finance: equity shares, policy bank vs SOE commercial vs syndicated, debt terms.
- Offtake: existence, volume caps, pricing formula.
- Technology/process: DLE vs evaporation (for Lithium), hybrid flowsheets, on-site energy. Standards/ESG: explicit references to OECD,CCCMC/host law. Institutional events: EITI audits, renegotiations, approvals.

These allow me to track commissioning lead times, shipping routing shares at country level, and renegotiation frequency and fiscal outcomes[12,22,38].

I construct my dataset through a combination of hand-coding and GPT-4 API calls of Aid-Data reports, EITI documents, company filings, and reputable media sources. The dimensions above are coded coarsely. For example: "policy-bank led" vs "SOE commercial" vs "mixed," or "explicit CCCMC reference" vs "OECD/host-law reference" vs "no explicit standards reference." For offtake arrangements, I look for the existence of long-term agreements and broad volume or

duration ranges, so these are coded as binary variables. Where loan agreements and shareholder agreements are confidential, as is often the case, I use secondary sources to infer the separability of equity, concessional finance, and offtake.

c. Inference. For each project, I will analyze whether equity+debt+offtake bundles precede or accompany stable China-bound flows and faster ramp trajectories, versus state-dominant models that may have higher policy and technology risk[41,43,44,47]. I will then match the patterns across cases, evaluating whether BRI-era governance claims like win-win and reliable partner narratives correlate with measurable institutional outcomes like fewer permitting delays prior to auditing and the scope of renegotiation post-audit[39]. Alternative explanations such as price cycle, grade, and chemistry are explicitly controlled for quantitatively and using public technical reports.

D. Scope, implementation, and limitations

Once I obtain destination-level data, mine-level shipment destinations will be proxied by country-level exports. The analysis will necessarily abstract from environmental externalities except as they enter governance via ESG conditionality as signaled in guidance and permitting. Scenario-dependent demand projections from IEA will be used descriptively with sensitively bands[26–28].

The current draft should be viewed as a partial implementation of the broader design described here. Due to the data limitations and access constraints detailed above, the analysis below is limited to the trade side of the dual-method research strategy. This analysis itself is limited due to lack of partner-level data in this implementation of my code. This will hopefully be rectified by the final draft.

V. PRELIMINARY RESULTS FOR TRACK 1 ANALYSIS

A. Monthly value and share

I construct a monthly panel of Chinese exports of critical-mineral–related products from 2018 through 2024 using UN Comtrade's v1 HS6 database. The unit of observation is a reporter–HS6–month tuple. I restrict the reporter to China (reporterCode = 156) and use world-aggregate exports (partnerCode = 0). For each HS6 code and month, Comtrade reports a customs value in current U.S. dollars and a physical quantity. In the v1 API the value field is primaryValue. I treat primaryValue as the export value and netWgt as the physical quantity in kilograms, and filter to monthly observations (YYYYMM).

The commodity universe is defined by an HS6–to–"material group" mapping that draws on the battery, semiconductor, and export-control literatures. Each HS6 line is assigned to exactly one of twelve material groups: aluminum, copper, graphite, lithium, manganese, nickel, silicon, cobalt, rare earths, gallium, germanium, and anode materials (graphite-based active materials and precursors).

The primary intent in the selection of these materials is the approximation of the functional categories in EV and semiconductor supply chains, not to reconstruct the full periodic table. The gallium, germanium, and anode HS6 lines map onto the gallium, germanium, and graphite controls explained above.

For each group g and month t, I aggregate the values and quantities across the HS6 codes in

that group as

$$\text{value}_{g,t} = \sum_{h \in g} \text{value}_{h,t} \qquad \text{qty}_{g,t} = \sum_{h \in g} \text{qty}_{h,t}$$

If we let the total basket exports at time t be $\text{value}_{\text{tot},t} = \sum_g \text{value}_{g,t}$, we can define each group's share of the tracked basket as

$$\text{share}_{g,t} = \frac{\text{value}_{g,t}}{\text{value}_{\text{tot},t}}$$

Figure 1 plots $\text{value}_{g,t}$ in levels while Figure 2 plots $\text{share}_{g,t}$. The stacked value plot in Figure 1

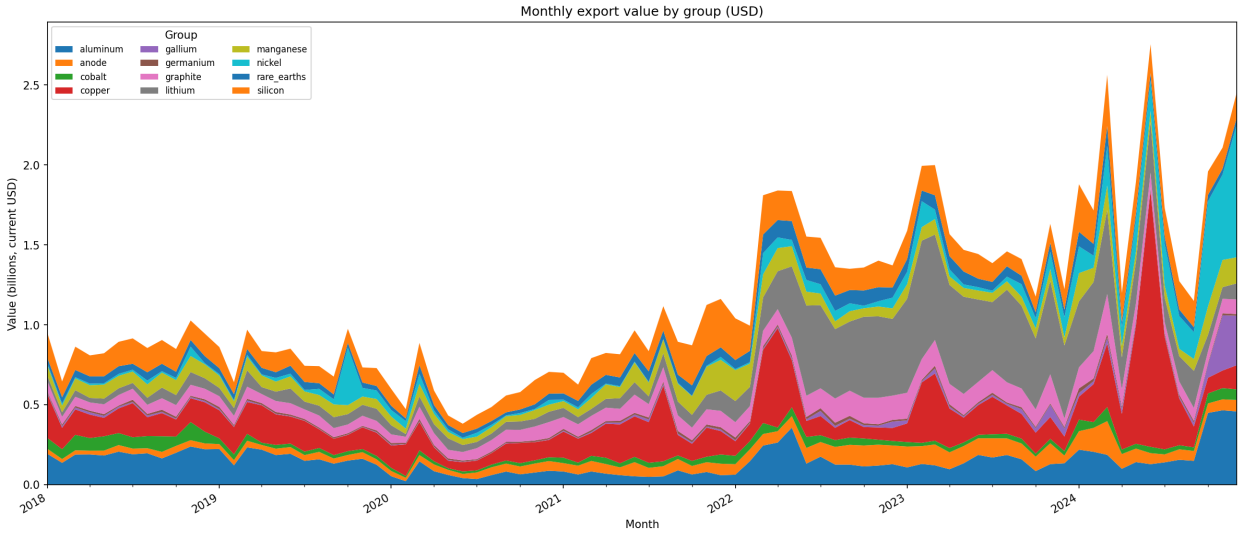

FIG. 1: Monthly value of exports by group.

has three distinct features of note. The first is the clear COVID shock. Monthly exports of the tracked materials hover around USD 0.6–0.9 billion in 2018–19, collapse briefly in early 2020, and then recover to a much higher steady-state from 2021 of around USD 1.2 and 1.8 billion per month with two pronounced spikes beyond USD 2.5 billion in 2023–24.

The second notable feature is that the composition of this growth is highly uneven, with the early value stack dominated by copper, aluminum, and silicon, but starting after 2020, the contributions of lithium, graphite, and nickel grow rapidly. By 2022–23, lithium and graphite together occupy a large fraction of the upper half of the stack, with nickel also contributing meaningful slices. While anode materials are almost absent in the beginning, they too thicken appreciably post pandemic.

Third, there are a set of discrete episodes where one or two groups temporarily almost entirely dominate the basket. The most dramatic of these cases in the middle of 2024, when copper's slice balloons, driving a overall increase in the stack height.

The share plot in Figure 2 makes this reweighting even more clear. While copper starts as the single largest share in 2018, with cobalt, lithium, manganese, and silicon each capturing meaningful but smaller slices, copper's share gradually declines, while the share of lithium steadily rises, and by 2022–23 lithium has become one of the largest components of the basket in share terms. 2021-22 also mark an expansion of the share of graphite and anode materials, while cobalt and manganese shrink as a share of the basket even though their absolute values does not decline.

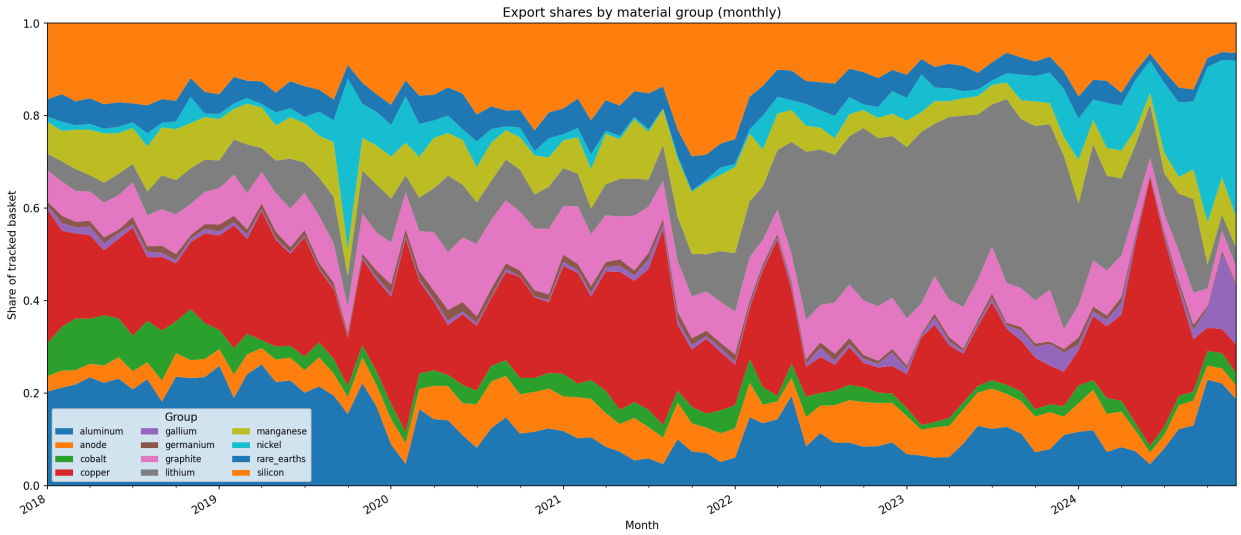

FIG. 2: Monthly share of exports by group.

B. Annual growth

In order to examine annual trends, I sum over months to obtain group year totals

$$\text{value}_{g,y} = \sum_{t \in y} \text{value}_{g,t} \qquad \text{qty}_{g,y} = \sum_{t \in y} \text{qty}_{g,t}$$

and compute the compound annual growth rates between 2018 and 2024

$$\text{CAGR}_g^{\text{qty}} = \left(\frac{\text{qty}_{g,2024}}{\text{qty}_{g,2018}} \right)^{1/(2024-2018)} - 1$$

with an analogous definition for values. These CAGRs are plotted against size of the export market in Figure 3. These annual quantity trends allow us to examine which materials are becoming more central. As we see in Figure 4, Aluminum, silicon, and manganese cluster at high size but low single-digit growth, while copper sits slightly above them with a quantity growth rate on the order of 15–20 percent per year. Nickel and lithium are the standouts in this analysis, as both are large by 2024 and exhibit quantity CAGRs on the order of 30–65 percent. While smaller in absolute value, gallium and graphite also show elevated CAGRs of roughly 40 percent and 10 percent respectively.

These can be seen as evidence that the composition of China's export basket is gradually tilting towards groups like lithium, nickel, graphite, gallium, and anode materials that are relevant to battery and semiconductor production, while export levels of base metals like aluminum, copper, and silicon stay relatively constant. This also outlines the importance of the export control cases analyzed later. They are not peripheral to the overall trade bundle, rather they operate in segments that are both fast-growing and increasingly central.

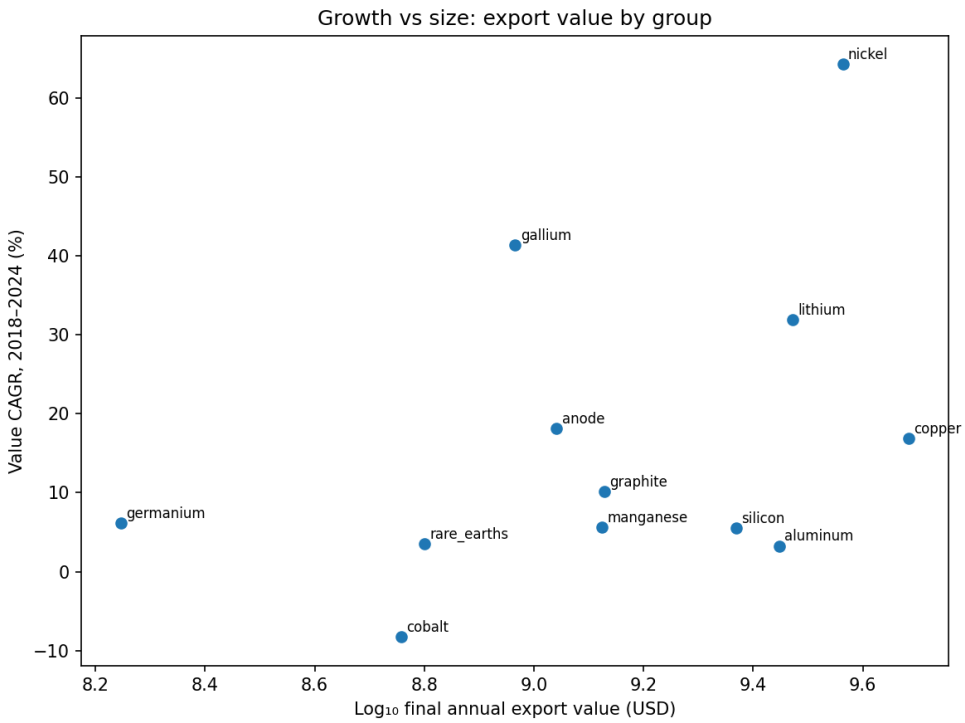

FIG. 3: Growth-size scatter plot showing Compound Annual Growth Rate (CAGR) versus average value for each material group.

C. Basket diversity

To quantify the concentration across the material groups, I calculate the commonly used Herfindahl–Hirschman index over group shares,

$$HHI_t^{\text{group}} = \sum_g \text{share}_{g,t}^2$$

and its inverse,

$$N_t^{\text{eff}} = \frac{1}{HHI_t^{\text{group}}}.$$

This inverse can be seen as the effective number of material groups in the basket at time t. The group-level HHI can be seen in Figure 4, while Figure 5 stacks each group's squared share $s_{g,t}^2$ which by construction sum vertically to HHI_t^{group}. Zooming out to the level of broad material categories, we see in Figure 4 that concentration is moderate but is punctuated by sharp spikes. For most of 2018–23 the index oscillates around 0.15, implying an effective number of roughly six or seven equally-sized groups. The noticeable bumps in late 2019 and early 2020, when the index approaches 0.2, coincide with months when copper and nickel briefly take unusually large shares of the basket. The broader trend of this is clear as the increase in share of lithium pushes the index upward from 2021 through late 2023. In early 2024, however, the index drops, revealing a surprisingly diversified export mix. The jump in mid 2024 corresponds to the copper super-episode explained above. When we look at the group-specific contributions in Figure 5, we see again that aluminum and copper compose most of the baseline index early on, while lithium's

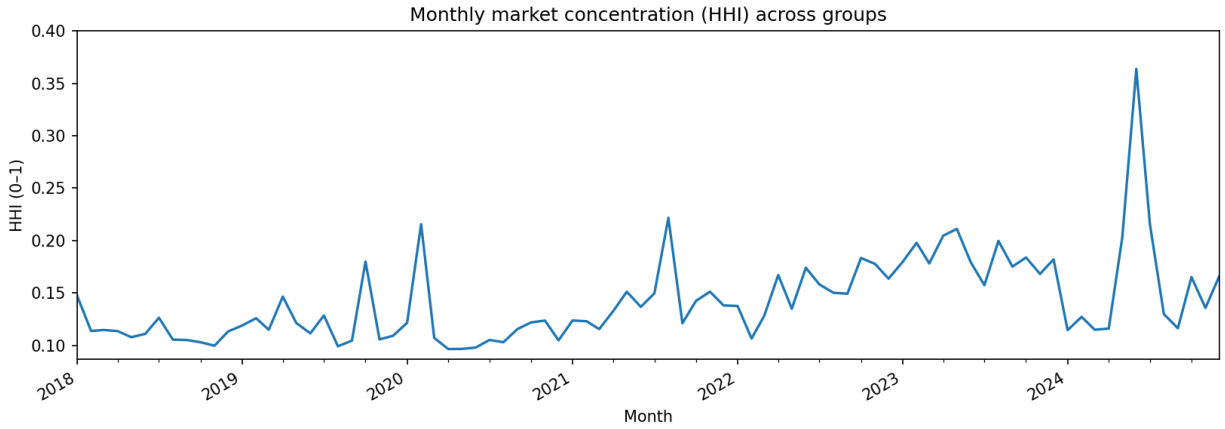

FIG. 4: Monthly Herfindahl-Hirschman Index (HHI) for the aggregated group-level exports. The inverse of this value is interpreted as the effective number of groups in the market.

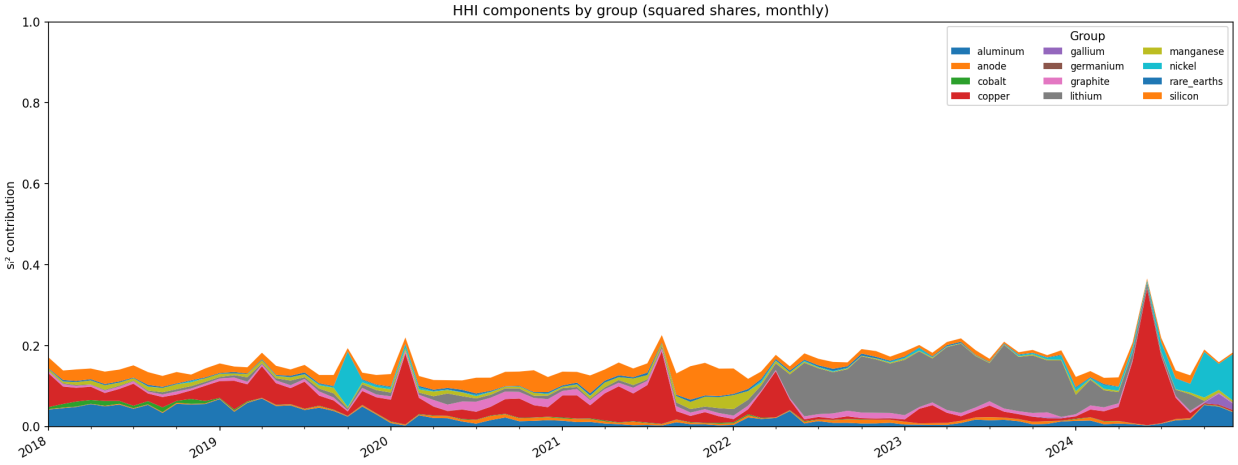

FIG. 5: Components of the Monthly Herfindahl-Hirschman Index, stacking the squared export share ($s^2_{g,t}$) of each material group. The vertical sum of all components equals the total HHI_t^{group}.

squared share grows substantially in 2022-23. The late-2019 and early-2020 bumps in the HHI map almost entirely onto copper and nickel, while the mid-2024 spike is overwhelmingly copper's squared share.

D. Group-level HS6 concentration

Within each of these groups, I also examine product line concentration at the HS6 level. If we let $s_{g,h,t} = \text{value}_{h,t}/\text{value}_{g,t}$ denote the share of group g's exports in month t that is HS6 h, then we can compute

$$HHI_{g,t}^{\text{HS6}} = \sum_{h \in g} s_{g,h,t}^2 \qquad \text{and} \qquad N_{g,t}^{\text{eff-HS6}} = \frac{1}{HHI_{g,t}^{\text{HS6}}},$$

where the inverse acts as an effective number of HS6 lines within group g at time t. Figure 6 plotes the annual averages of $N_{g,t}^{\text{eff-HS6}}$. We see here in Figure 6 that aluminum is essentially a

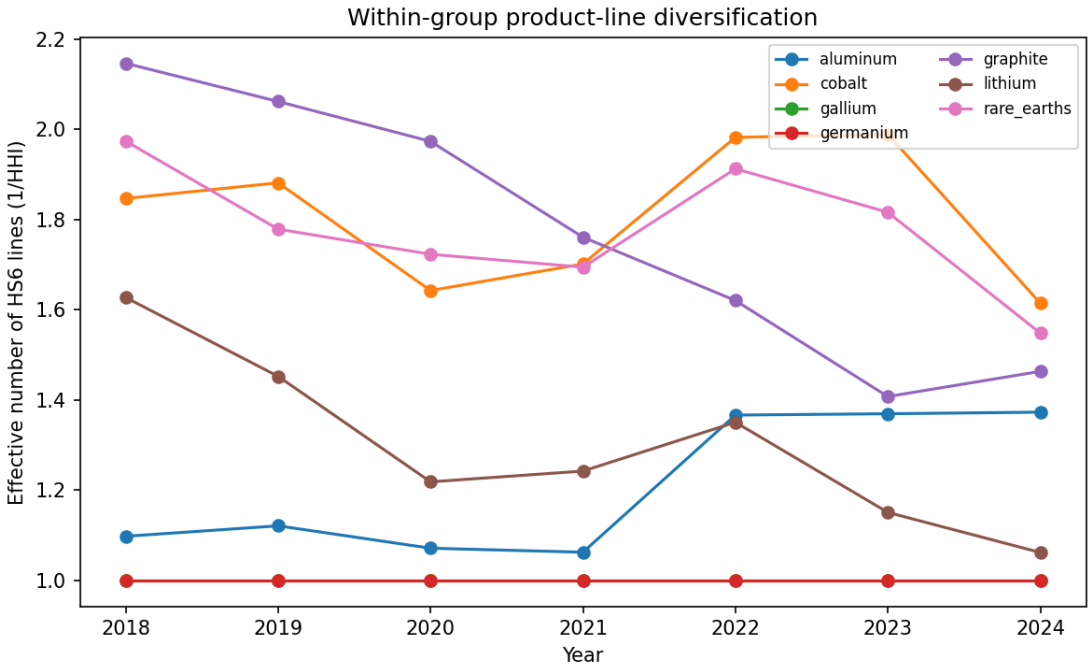

FIG. 6: Annual average of the effective number of HS6 lines per material group ($N_{g,t}^{eff-HS6}$), where a higher number indicates less product-line concentration within the group.

one-line export until 2021, experiencing very modest diversification across unwrought, alloyed, and semi-processed forms after 2022. Meanwhile, cobalt exhibits real but shallow diversification that appears to reverse by the end of the period in question, and lithium becomes less diverse in a relatively monotonic fashion.

Crucially for the event study below, we see that gallium and germanium are pure single-line exports, sitting exactly on top of each other at 1 every year. Graphite, however, tells a much more interesting story. Initially spread across about 2.1 effective HS6 lines in 2018, it reconcentrates monotonically to roughly 1.4 by 2023, with only a slight rebound to 1.5 in 2024.

While the group-level exports appear diversified across broad materials, the actual internal HS6 data is fairly thin. This structural thinness is exactly what makes HS6-based licensing a powerful tool of governance, as a small number of tariff codes can reach a large fraction of relevant trade.

E. Price-volume regimes

Finally, I construct group-level unit values

$$p_{g,t} = \frac{\text{value}_{g,t}}{\text{qty}_{g,t}}$$

and use them to characterize price volume regimes. Within each group, I calculate the correlation between $\log(\text{qty}_{g,t})$ and $\log(p_{g,t})$ as well as the average absolute monthly percentage change in unit value:

$$\overline{\Delta p_g} = \frac{1}{T-1} \sum_{t>1} \left| \frac{p_{g,t} - p_{g,t-1}}{p_{g,t-1}} \right|$$

These two statistics are used in Figure 7.

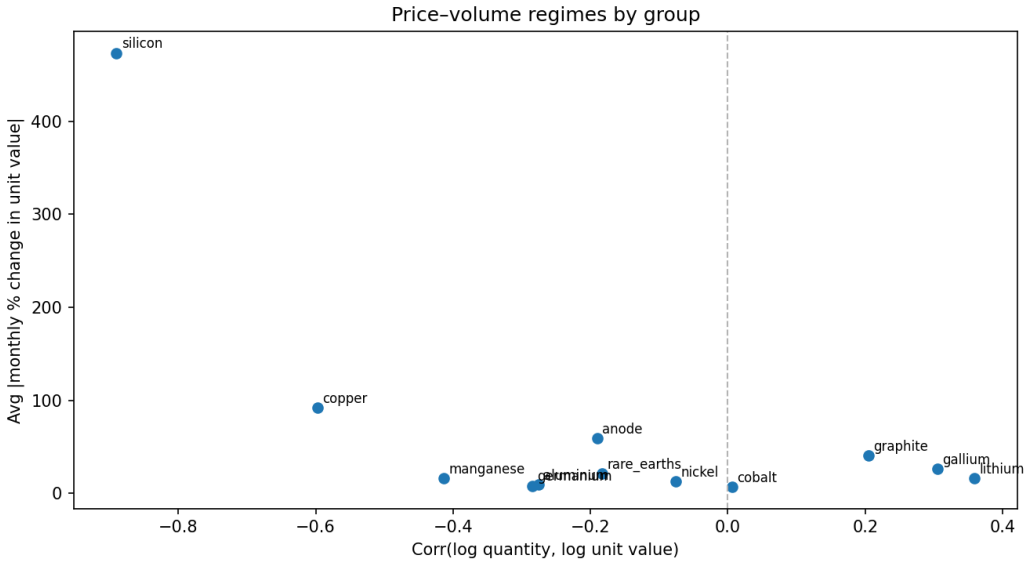

FIG. 7: Scatter plot characterizing price-volume regimes for each group. The axes show the correlation between log quantity and log unit value, and the average absolute monthly percentage change in unit value.

We see here in Figure 7 a sketch of two distinct price–volume regimes. Aluminum, copper, manganese, silicon, germanium, and rare earths all exhibit negative correlations, meaning that months with high export volumes tend to have low unit values and vice versa. The volatility of materials within this set is varied. While manganese, germanium, aluminum, and rare earths have modest volatility, copper has unit-value volatility near 100 percent, consistent with the pronounced boom–bust episodes in the value plot. On the other hand, lithium, gallium, and graphite show positive price–volume correlations, indicating scarcity dynamics or market control rather simple supply expansion.

This behavior is mirrored when we look at the raw data of value-vs-unit value. For gallium and graphite, episodes of high export value coincide with elevated unit values, especially around the licensing periods, but for aluminum and copper, volume peaks occur at flat or declining unit prices. This matters from a governance perspective. If China introduces licensing into a market that is already in a positive positive price–volume regime (like gallium), it will serve to amplify scarcity rents and China's bargaining position, even if the aggregate exports do not fall significantly. Licensing in a more traditional, commodity-like segment operates more as a quantity brake.

F. Export-control events

This period from 2018 to the end of 2024 contains two salient episodes of export control. The first is the July 2023 licensing requirement on gallium and germanium related exports, and the second is the graphite licensing regime announced in late 2023 and implemented that December[49]. While both measures were formally agnostic to destination country, they are widely seen as reponses to control by the U.S. and allies on advanced chips and supply-chain security[50,51].

To best study these episodes, I construct event-time series, choosing the effective licensing month t_0 (August 2023 for gallium/germanium and December 2023 for graphite) and define $\tau = t - t_0$. For each group, I compute level indexes, which are the export value or quantity normalized such that the pre-event mean is 100. I also calculate share indexes, which are share$_{g,t}$ normalized in the same way. Formally, for any outcome $y_{g,t}$, we can write the index of that outcome as

$$\tilde{y}_{g,\tau} = 100 \times \frac{y_{g,t_0+\tau}}{\bar{y}_{g,\text{pre}}},$$

where $\bar{y}_{g,\text{pre}}$ is the mean of $y_{g,t}$ over the pre-event window. These normalized indices are used in the below.

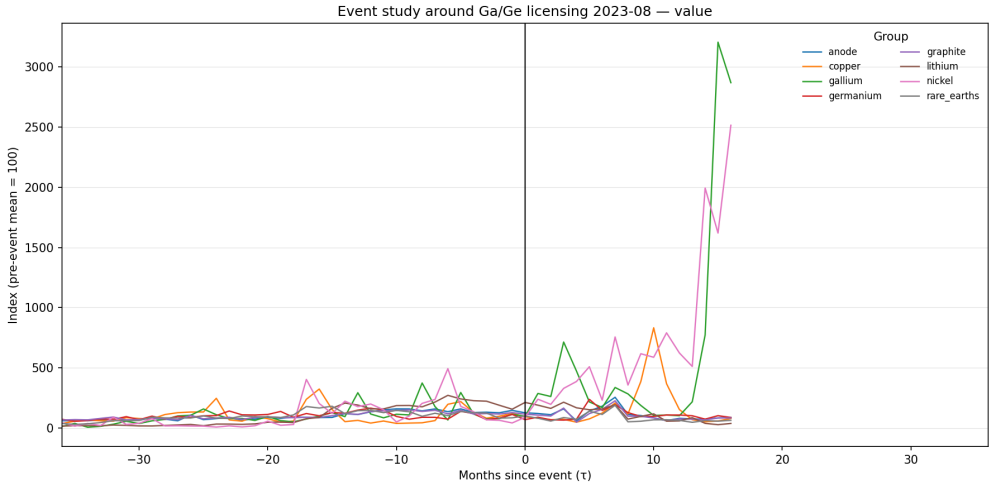

FIG. 8: The impact of the July 2023 gallium and germanium licensing requirements on export value.

a. Gallium/germanium licensing. Figure 8 is the value-indexed event lot for the July 2023 gallium and germanium licensing. We can see here that these measures served not to choke off gallium but rather to reorganize its export. After a brief medium sized bump a few months after the event caused by international buyers rushing to stockpile gallium before the implementation date, roughly a year after the rules come into effect, gallium export levels spiked sharply to roughly 20 times the pre-licensing average. In a sector dominated by a single HS6 line, this jump reflects tighter control over that chokepoint, rather than broad-based expansion of production. China inserts itself between foreign buyers and the HS6 line, allowing volumes and prices to rise together. This looks more like a rent-bearing gate than any sort of effective sanction. Alternatively, this spike can be viewed as reflecting increased demand in anticipation of the further tightening of these controls put in place in December 2024, though this seems less likely, as these further controls were not widely expected prior to December[52].

Germanium, however, exhibits a flat profile, and its export values never rise or fall meaningfully from the pre-event band. This asymmetry between the behavior of the two minerals covered by the same licensing notice suggests that China uses the control instrument selectively within the legal umbrella, pushing hard on gallium, where the downstream dependence is strongest, while leaving germanium on a sort of autopilot. The licensing regime is thus an allocation rule of where to exert administrative effort in addition to being a legal category.

Nickel's immediate and relatively motononic rise following the licensing implementation pro-

vides a picture as to how allocation works in practice. The simplest explanation here is that nickel is a close component in many battery and alloy related applications, sharing logistical and trading channels with the controlled products. As licensing pushes up gallium supply, nickel demand increases commensurately due to co-use in EV battery systems and similar energy devices. This also helps explain the initial 2 month lag of the first nickel peak behind that of gallium. As China's export basket, while diverse at the material level, is thin at the HS6 level, it can exert this kind of shadow licensing where pressure spills over onto nearby, formally uncontrolled lines to reshape the network more broadly.

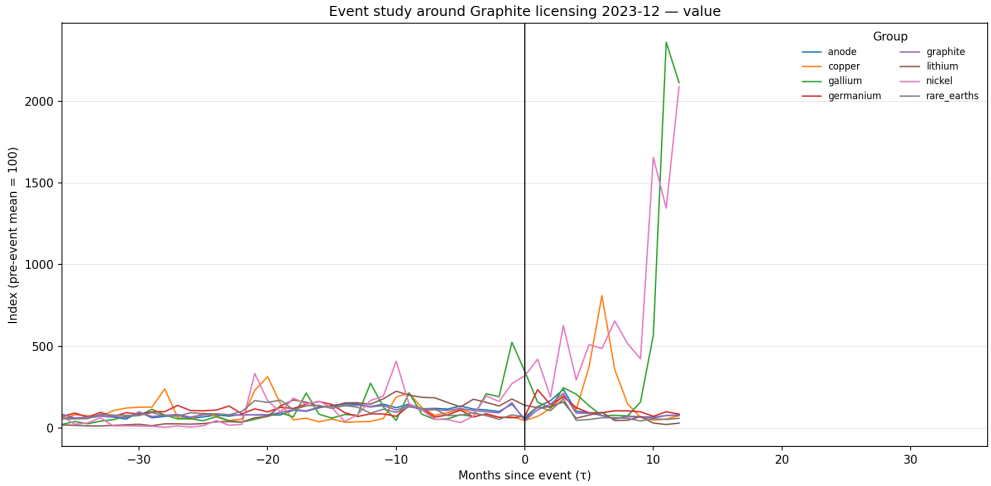

FIG. 9: The impact of the December 2023 graphite licensing regime on export value.

b. Graphite licensing. The plot of graphite value-index for the December 2023 measures in Figure 9 is much more consistent with a typical clampdown. Before the implementation of the licensing regime, graphite exports were at a relative 2x high over the 2018-22 average. After implementation, this fell quickly to roughly 15% of that level within six months, briefly recovering before falling further. As graphite is a multi-line export with an effective HS6 count that has been drifting down over time, unlike gallium, this change in value post event is hard to read as anything other than a deliberate pinching off of aggregate supply. Licensing is not used to reprice a thin, speculative flow, rather it is used to place a ceiling on the export volume of a key component of EV batteries.

When viewed together, these two episodes suggest that export control is used in two distinct ways in China's minerals strategy. Gallium licensing converted a structurally thin chokepoint into a managed scarcity regime. This raised both volumes and scarcity rents, deepening China's control over the bottleneck. On the other hand, when applied to graphite, the same tool was used simply as a means of stemming the much larger flow. This indicates that China has a degree of willingness to trade off ner term export revenue for downstream leverage. The asymmetry in the responses of these value indices is not noise. It instead provides a window into how Beijing segments the domain into lines it wants to monetize, lines it wants to lightly police, and line it wants to bluntly weaponize.

VI. SYNTHESIS, CONTRIBUTION AND CONCLUSION

This article presents a preliminary set of evidence on how China uses critical mineral licensing to reshape the broader structure of its trade within the domain. The results elucidate four emerging patterns: 1) the significant growth of exports of battery and semiconductor related materials like lithium, nickel, graphite, and gallium, 2) the thinness of the HS6 structure means a few tariff lines carry the majority of flows, 3) licensing of gallium transforms a single-line chokepoint into managed scarcity regime with rising volume and prices across multiple materials, and 4) China uses graphite licensing as a more traditional commodity brake on aggregate exports.

Within this work, destination-level concentration, robustness analysis vis-a-vis alternative groupings, and a fuller identification strategy remain to be completed, so the claims here must be viewed as provisional. However, the results already demonstrate that China's export controls are distinctly non-traditional, focused more on partitioning the domain into diverse lines of advantage than shutting off trade wholesale. These claims will be tested more rigorously in the final version of the paper, exploring the implications for U.S. and allied supply chain strategy.

REFERENCES

[1]U.S. Department of Energy and U.S. Environmental Protection Agency, "Fuel economy website: Datafiles," https://www.fueleconomy.gov/feg/download.shtml (2024), accessed October 10, 2024.

[2]European Carbon and Graphite Association (ECGA), "Graphite in batteries: Info sheet," https://ecga.net/wp-content/uploads/2023/02/Graphite-in-batteries_Infosheet_final.pdf (2023), accessed October 10, 2024.

[3]Reuters, "Chinese firms control around 75% of indonesian nickel capacity, misc finds," (2025), accessed 17 November 2025.

[4]VisualCapitalist, "Visualizing cobalt production by country in 2023," https://www.visualcapitalist.com/visualizing-cobalt-production-by-country-in-2023/ (2024), accessed October 10, 2024.

[5]International Energy Agency (IEA), "Energy technology perspectives 2023: Clean energy supply chains," https://www.iea.org/miscs/energy-technology-perspectives-2023 (2023), china accounts for 60–70% of global lithium refining capacity. Accessed October 10, 2024.

[6]Center for European Policy Analysis (CEPA), "China, gallium, and germanium: The minerals inflaming the global chip war," https://cepa.org/article/china-gallium-and-germanium-the-minerals-inflaming-the-global-chip-war/ (2023), accessed October 10, 2024.

[7]S. Evenett and J. Fritz, "Revisiting the china–japan rare earths dispute of 2010," https://cepr.org/voxeu/columns/revisiting-china-japan-rare-earths-dispute-2010 (2023), accessed October 10, 2024.

[8]M. Blackwood and C. DeFilippo, "Germanium and gallium: U.s. trade and chinese export controls," Executive Briefing on Trade EBOT — March 2024 (U.S. International Trade Commission, 2024) the views expressed solely represent the authors' research and not the U.S. ITC or the U.S. government.

[9]E. Benson and T. Denamiel, Critical Questions (Center for Strategic and International Studies) (2023), accessed: YYYY-MM-DD.

[10]S. Liu and D. Patton, Reuters (2023), accessed: YYYY-MM-DD.

[11]K. Bradsher, The New York Times (2025), accessed: YYYY-MM-DD.
[12]China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters (CCCMC), "Chinese due diligence guidelines for responsible mineral supply chains," (2015).
[13]ClientEarth, "China clarifies its vision for a green belt and road initiative," (2023).
[14]MOFCOM and MEE, "Guidelines for ecological environmental protection of foreign investment and cooperation," (2022).
[15]S. A. H. Shekarabi, R. K. Mavi, and F. R. Macau, Global Journal of Flexible Systems Management (2025), 10.1007/s40171-025-00458-8, accessed October 10, 2024.
[16]M. Cate, ResearchGate Preprint (2022), accessed October 10, 2024.
[17]A. I. Johnston, International Security (2019).
[18]E. C. Economy, Foreign Affairs (2024).
[19]B. Buzan and Y. Zhang, International Affairs (2024).
[20]E. C. Heldt and A. Mährenbach, Global Policy (2018).
[21]S. Strange, *States and Markets* (Continuum, 1996).
[22]OECD, "Oecd due diligence guidance for responsible supply chains of minerals from conflict-affected and high-risk areas," (2016).
[23]T. Büthe and W. Mattli, *The New Global Rulers: The Privatization of Regulation in the World Economy* (Princeton University Press, 2011).
[24]Minerals Security Partnership, "Joint statement of the msp principles' meeting," (2024).
[25]U. D. of the Treasury, "Internal revenue bulletin 2024–09: Feoc guidance (2024–09094)," (2024).
[26]International Energy Agency, "Clean energy supply chains: Vulnerabilities and resilience," (2023).
[27]International Energy Agency, "Mining and materials production — energy technology perspectives 2023," (2023).
[28]International Energy Agency, "Global critical minerals outlook 2025," (2025).
[29]United States Geological Survey, "Mineral commodity summaries 2025," (2025).
[30]United States Geological Survey, "Gallium and germanium: Supply chain basics and policy relevance (ofr 2024-1057)," (2024).
[31]B. M. Intelligence, "Infographic: China controls three-quarters of graphite anode supply chain," (2023).
[32]R. Team, "China's germanium and gallium export restrictions: Consequences for the united states," (2023).
[33]R. Team, "China's new graphite restrictions," (2023).
[34]S. Ethanolwala, Chemical & Engineering News (2023).
[35]H. Riggs and colleagues, "Hidden reach: Export controls and china's critical materials strategy," (2025).
[36]AidData, "Power playbook: How countries navigate china's development finance," (2024/2025).
[37]AidData, "Chasing copper and cobalt: China's mining operations in peru and the drc," (2023).
[38]EITI International Secretariat, "Sicomines: How the eiti in drc helped secure $4 billion in additional revenue," (2024).
[39]M. A. Carrai, Global Policy (2025).
[40]Eramet, "Centenario lithium project: Investor presentation," (2023).
[41]R. Staff, "China's ganfeng starts lithium production at argentina's mariana project," (2025).
[42]M. Staff, "Ganfeng and lithium argentina merge salta projects," (2025).
[43]L. A. . Ganfeng, "Joint venture announcement: Pozuelos–pastos grandes and related assets,"

(2025).
[44]R. Staff, "Bolivia says china's cbc to invest $1 billion in lithium plants," (2025).
[45]T. D. Staff, The Diplomat (2023).
[46]C. on Foreign Relations, "China's growing influence in latin america," (2025).
[47]I.-A. Dialogue, "Lítio en américa latina: Tendencias y riesgos," (2025).
[48]I. for Energy Research, "China issues new rules on exports of ev batteries and materials," (2025).
[49]M. Risse, ""a widening net: A short history of chinese export controls on critical raw materials and their usage"," Blog Post/Analysis (Global Trade Alert, 2025) accessed: YYYY-MM-DD.
[50]C. Combs, ""gaming out china's next export controls on critical minerals"," Research Note (Trivium China, 2024) accessed: YYYY-MM-DD.
[51]A. Nath and J. D. Bean, "China's critical mineral export controls: Background & chokepoints," Background Paper No. 32 — Technology Policy (ORF America, 2025) accessed: YYYY-MM-DD.
[52]S. Godek, "China's germanium and gallium export restrictions: Consequences for the united states," Issue Brief – China Program, Asia Indo-Pacific (Stimson Center, 2025) accessed: YYYY-MM-DD.