Beneficiation Mandates Meet Supply-Chain Security: African Export Bans on Unprocessed Critical Minerals and the Design of US Minerals Policy

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Abstract

Since 2020, a growing number of mineral-rich developing countries have banned or capped the export of unprocessed critical minerals to force processing onshore. Over the same period, the United States has adopted an unusually dense set of supply-chain instruments aimed at reducing reliance on Chinese processing. This included a section 232 negotiations over price floors, foreign-entity-of-concern restrictions on clean-energy tax credits, a USD 12 billion strategic minerals reserve, a successor to the Minerals Security Partnership, and bilateral minerals-for-investment agreements. This paper asks whether producer-country beneficiation mandates help or hinder US diversification. Using a simple location-and-ownership framework and descriptive evidence from four episodes, these include Indonesia's nickel ban, Zimbabwe's lithium restrictions, Namibia's 2023 ban and the Democratic Republic of the Congo's 2025 cobalt suspension and quotas, I show that bans have three distinct effects. They relocate processing to where the integrated value chain is profitable, withdraw supply where it is not, and, for dominant producers, raise world prices. In every case studied, the firms best placed to build the new processing capacity are Chinese incumbents, so bans have tended to relocate Chinese midstream capacity rather than diversify its ownership. Because US tax-credit eligibility turns on ownership rather than location, the interaction of the two policy regimes can leave US-eligible supply unchanged or lower. I argue that US policy should treat beneficiation mandates as a binding constraint to be designed around, not litigated against. I also outline instruments, open-access processing finance, conditional offtake, and coordinated price floors that would align the two objectives.

JEL codes: F13; F21; L72; O13; Q37; Q48

Keywords: critical minerals; export restrictions; beneficiation; industrial policy; supply-chain security; foreign entity of concern; Africa

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1. Introduction

The energy transition has turned a small group of minerals into objects of national security policy. Lithium, cobalt, nickel, graphite, manganese and the rare earth elements are indispensable to batteries, grid equipment and permanent magnets, and their processing is heavily concentrated. According to the International Energy Agency, the average market share of the largest refiner across key energy minerals rose from roughly 70 per cent in 2020 to about 72 per cent in 2025, and excluding rare earths, China's average share in refining rose over the last two years even as the United States and Malaysia made inroads in rare earth separation.[2] The number of mineral tariff codes subject to Chinese export controls has tripled since 2023.[3]

Washington's response has been one of the most active episodes of US minerals policy since the Second World War. In January 2026, the President issued a Section 232 proclamation finding that imports of processed critical minerals and their derivative products threaten national security and directing the Secretary of Commerce and the US Trade Representative to negotiate agreements with trading partners, including on price floors.[4] In February 2026, the Export-Import Bank approved a USD 10 billion loan that, together with nearly USD 2 billion in private capital, established a Strategic Critical Minerals Reserve known as Project Vault.[5] In the same month, the State Department launched the Forum on Resource Geostrategic Engagement (FORGE) as the successor to the Minerals Security Partnership and signed 11 new bilateral minerals frameworks.[6] The One Big Beautiful Bill Act of July 2025 conditioned the Section 45X, 45Y and 48E credits on the absence of "material assistance" from prohibited foreign entities, with Treasury guidance following in February 2026.[7] In December 2025, the United States and the Democratic Republic

[2]IEA (International Energy Agency). 2026d. *Global Critical Minerals Outlook 2026*. Paris: IEA. https://www.iea.org/reports/global-critical-minerals-outlook-2026/executive-summary; Reuters. 2026c. "US Invests in Critical Minerals but China Maintains Grip." 14 September. https://www.reuters.com/business/energy/us-invests-critical-minerals-china-maintains-grip--reeii-2026-09-14/.

[3]IEA, *Global Critical Minerals Outlook 2026*.

[4]White House. 2026. "Fact Sheet: President Donald J. Trump Directs Negotiations to Adjust Imports of Processed Critical Minerals and Their Derivative Products into the United States." 14 January. https://www.whitehouse.gov/fact-sheets/2026/01/fact-sheet-president-donald-j-trump-directs-negotiations-to-adjust-imports-of-processed-critical-minerals-and-their-derivative-products-into-the-united-states/.

[5]EXIM (Export-Import Bank of the United States). 2026. "Week in Review: Project Vault and the U.S. Strategic Critical Mineral Reserve." 6 February. https://www.exim.gov/news/week-review-project-vault-and-strategic-critical-mineral-reserve.

[6]US Department of State. 2026. "2026 Critical Minerals Ministerial." Office of the Spokesperson, 4 February. https://www.state.gov/releases/office-of-the-spokesperson/2026/02/2026-critical-minerals-ministerial.

[7]Baker Botts. 2026. "Treasury and IRS Provide Guidance Regarding Energy Tax Credit Limits on Provision of Material Assistance by Foreign Entities of Concern (FEOCs)." 17 February. https://www.bakerbotts.com/thought-leadership/publications/2026/february/treasury-and-irs-provide-guidance-regarding-energy-tax-credit-limits.

of the Congo (DRC) signed a Strategic Partnership Agreement granting US persons a right of first offer over a Strategic Asset Reserve of mineral projects.[8]

A parallel policy wave has been building in producer countries, and US policy discussion has largely ignored it. Mineral-rich developing countries are increasingly refusing to export unprocessed ore. Indonesia's 2020 nickel ore ban is the template.[9] Zimbabwe banned raw lithium ore exports in December 2022, suspended all raw mineral and lithium concentrate exports in February 2026, and has announced a full concentrate ban from January 2027.[10] Namibia's Cabinet prohibited the export of unprocessed lithium ore, cobalt, manganese, graphite, and rare earths in June 2023.[11] The DRC, which accounts for roughly three quarters of global mined cobalt, suspended cobalt exports in February 2025 and replaced the suspension with a quota system in October 2025.[12] Around twelve African countries now restrict unprocessed mineral exports, and in September 2026 Namibia's President told investors plainly that "you have to put up a processing plant in our country".[13] The OECD reports that export restrictions on industrial raw materials increased more than fivefold between 2009 and 2023, with 67 percent of cobalt trade affected by at least one restriction in 2021 to 2023.[14]

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[8]IEA (International Energy Agency). 2026b. "DRC-US Strategic Partnership Agreement." Policies Database. https://www.iea.org/policies/29541-drc-us-strategic-partnership-agreement.

[9]Guberman, David, Samantha Schreiber and Anna Perry. 2024. "Export Restrictions on Minerals and Metals: Indonesia's Export Ban of Nickel." Working Paper ICA-104. Washington, DC: US International Trade Commission. https://www.usitc.gov/publications/332/working_papers/ermm_indonesia_export_ban_of_nickel.pdf.

[10]Reuters. 2022. "Zimbabwe Bans Raw Lithium Exports to Curb Artisanal Mining." 20 December. https://www.reuters.com/world/africa/zimbabwe-bans-raw-lithium-exports-curb-artisanal-mining-2022-12-21/; Al Jazeera. 2026. "Zimbabwe Imposes Ban on Exports of All Raw Minerals and Lithium Concentrate." 25 February. https://www.aljazeera.com/news/2026/2/25/zimbabwe-imposes-ban-on-exports-of-all-raw-minerals-and-lithium-concentrate; Reuters. 2026b. "Zimbabwe to Introduce Lithium Export Quotas, Sets Conditions for Resumption of Shipments." 8 April. https://www.reuters.com/world/africa/zimbabwe-introduce-lithium-export-quotas-sets-conditions-resumption-shipments-2026-04-08/.

[11]Africa Legal. 2023. "Namibia Bans Export of Raw Lithium." 14 July. https://www.africa-legal.com/news/namibia-bans-export-of-raw-lithium/103216; IEA (International Energy Agency). 2026a. "Export Ban on Raw Materials (Namibia)." Policies Database. https://www.iea.org/policies/28970-export-ban-on-raw-materials.

[12]Cobalt Institute. 2026. *Cobalt Market Report 2025*. Prepared by Benchmark Mineral Intelligence. May. https://www.cobaltinstitute.org/wp-content/uploads/2026/05/Cobalt-Market-Report-2025.pdf.

[13]Semafor. 2026. "Namibia's President Eyes Local Mineral Processing." 25 September. https://www.semafor.com/article/09/25/2026/namibia-eyes-local-mineral-processing.

[14]OECD. 2025. "Export Restrictions on Critical Raw Materials Rise Sharply amid Growing Demand." Press release, 12 May. https://www.oecd.org/en/about/news/press-releases/2025/05/export-restrictions-on-critical-raw-materials-rise-sharply-amid-growing-demand.html; Kowalski, Przemyslaw, and Clarisse Legendre. 2023. "Raw Materials Critical for the Green Transition: Production, International Trade and Export Restrictions." OECD Trade Policy Papers 269. Paris: OECD Publishing. https://doi.org/10.1787/c6bb598b-en.

These two waves are usually discussed separately: the first as a question of US industrial and trade policy, the second as a question of development strategy and "resource nationalism." This paper argues that they now need to be analysed together, because each changes the returns to the other. Beneficiation mandates determine where the next unit of midstream processing capacity outside China will be built. US instruments determine whether the output of that capacity counts as secure supply. The central policy question is therefore whether producer-country export bans help or hinder US diversification away from Chinese processing, and how US instruments should be designed given that such bans are now a durable feature of the landscape.

The paper builds on recent contributions to this series on industrial policy in renewable energy[15] and on carbon tariffs,[16] and extends that discussion upstream to the minerals on which clean-energy manufacturing depends. It also draws on my earlier policy research on African value addition in the e-mobility value chain.[17] I make three contributions. First, I set out a simple framework that separates the effects of an export ban into a location effect, a supply-withdrawal effect and a terms-of-trade effect and adds an ownership margin that is usually missing from the trade-policy literature on export restrictions. The framework shows why the same instrument can produce onshore processing in one country and mine closures in another, and why the ownership of the new capacity, not its location, determines whether it contributes to US objectives. Second, I assemble descriptive evidence from four episodes using public mirror trade statistics from UN Comtrade and documentary evidence on the firms that built or are building processing capacity. Third, I draw out implications for the design of FORGE, the Section 232 price-floor negotiations, Project Vault procurement, development finance and the foreign-entity-of-concern rules.

The main findings can be summarised briefly. Export bans do move processing onshore, where the integrated mine-to-intermediate value chain is profitable at the host country's processing cost;

[15] Gerarden, Todd D., Mar Reguant and Daniel Yi Xu. 2026. "The Role of Industrial Policy in the Renewable Energy Sector." In *Environmental and Energy Policy and the Economy*, vol. 7, edited by Matthew J. Kotchen, Tatyana Deryugina and Catherine Wolfram, 97–148. Chicago: University of Chicago Press. NBER Working Paper 34079. https://www.nber.org/papers/w34079.

[16] Brunel, Claire, and Arik Levinson. 2026. "Carbon Tariffs." In *Environmental and Energy Policy and the Economy*, vol. 7, edited by Matthew J. Kotchen, Tatyana Deryugina and Catherine Wolfram, 33–64. Chicago: University of Chicago Press. https://ideas.repec.org/s/ucp/epolec.html.

[17] Zongwe, Leezola R., Kasonde Chituta and Takudzwa Ndabvonga. 2025. *The Geopolitics of Critical Minerals in Africa: Redefining the Continent's Role in the E-mobility Value Chain*. Nairobi: Enzi Ijayo Africa Initiative and African Future Policies Hub. https://www.enziijayo.org/publications/the-geopolitics-of-critical-minerals-in-africa; Zongwe, Leezola R., and Francesca Manyonyi. 2026. "Can Africa Turn Critical Minerals into Green Industrialisation?" Oxford School of Global and Area Studies, 17 July. https://www.area-studies.ox.ac.uk/article/can-africa-turn-critical-minerals-into-green-industrialisation.

Indonesia and, more recently, Zimbabwe illustrate this. Where it is not, bans simply withdraw supply: China's recorded imports of lithium ores and concentrates from Namibia fell from about 106,000 tonnes in 2023 to under 1,000 tonnes in 2025, with no offsetting rise in processed lithium exports.[18] For a dominant producer, a quantitative restriction acts as a producer-imposed price floor; refined cobalt prices rose from about USD 10 to USD 25 per pound after the DRC's intervention.[19] Across all four cases, the firms that responded to beneficiation mandates by building capacity were overwhelmingly Chinese incumbents. The consequence is that bans have tended to relocate Chinese midstream capacity to producer countries rather than diversify its ownership, and under current US law the output of that relocated capacity remains ineligible for credit-supported US supply chains.

The policy implication is not that the United States should oppose beneficiation mandates. Opposition is unlikely to succeed: the mandates are embedded in the African Mining Vision and the African Union's 2024 Green Minerals Strategy, enjoy broad domestic legitimacy, and are increasingly written into statute.[20] Rather, the implication is that US instruments that currently target ownership and price should be complemented by instruments that target the location and openness of midstream capacity. I call agreements that leave behind processing capacity, skills and shared infrastructure "bridge deals," as opposed to "end deals" that conclude with extraction and export.[21] The paper argues that bridge deals financed and contracted by non-Chinese capital are the only configuration in which producer-country and US objectives are simultaneously met.

The remainder of the paper proceeds as follows. Section 2 describes the policy background in producer countries and the United States. Section 3 presents the conceptual framework. Section 4 presents the evidence from the four episodes. Section 5 discusses policy implications. Section 6 discusses limitations and a research agenda, and Section 7 concludes.

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[18] UN Comtrade. 2026. UN Comtrade Database, annual and monthly HS commodity trade by partner (reporters: China, United States; HS 2530.90, 2605.00, 2822.00, 2825.20, 2833.29, 2836.91, 8105.20). Accessed 29 September 2026. https://comtradeplus.un.org/.

[19] Reuters. 2026a. "Congo's Cobalt Curbs Expose China's Critical Metals Weak Spot." 25 February. https://www.reuters.com/markets/commodities/congos-cobalt-curbs-expose-chinas-critical-metals-weak-spot-2026-02-25/.

[20] ECFR (European Council on Foreign Relations). 2025. "From Ore to More: Mineral Partnerships for African Industrialisation." 28 August. https://ecfr.eu/publication/from-ore-to-more-mineral-partnerships-for-african-industrialisation/.

[21] Zongwe, Leezola R. 2026. "Can Namibia Turn China-EU Rivalry into Industrial Growth?" *African Business*, August. Summary available at https://www.linkedin.com/posts/enziijayoafrica_namibia-and-china-eu-rivalry-activity-7491065983139209217-R0it.

2. Policy Background

2.1 Why producer countries restrict unprocessed exports

The argument for beneficiation is old and familiar. Mineral exporters have long captured a small share of the value chain their resources feed. The IEA estimates that Africa, which produces around 70 per cent of global cobalt and three-quarters of global manganese, captures less than 1 per cent of the value generated by manufacturing clean-energy technologies and their components.[22] The development literature on commodity linkages argues that backwards and forward linkages from mining are neither automatic nor impossible, and depend on policy, capabilities and the technical characteristics of each value chain.[23] The broader resource-curse literature emphasises that the institutional setting in which rents are generated and distributed matters as much as the rents themselves.[24]

Recent enthusiasm for export bans also reflects a changed intellectual climate. The "new economics of industrial policy" has shown that some industrial policy episodes delivered large and persistent effects, and has shifted the burden of proof away from the presumption that such policies always fail.[25] Producer-country governments have noticed that the United States, the European Union and China now all practise explicit industrial policy in critical minerals and have drawn the obvious conclusion. Continental frameworks reinforce the point. The African Union's Green Minerals Strategy, launched in December 2024, aims to build value chains by "ensuring industrialisation through local beneficiation, green technology manufacturing, and mineral-based economic transformation".[26] Namibia's own Mineral Beneficiation Strategy (2021 to 2030) provides the domestic policy basis for its 2023 ban.[27] UNCTAD's February 2026 assessment

[22] IntelliNews. 2026a. "Africa's Push for Local Mineral Processing Reshapes Mining Investment." 17 September. https://www.intellinews.com/africa-s-push-for-local-mineral-processing-reshapes-mining-investment-468526/.

[23] Morris, Mike, Raphael Kaplinsky and David Kaplan. 2012. "'One Thing Leads to Another': Commodities, Linkages and Industrial Development." *Resources Policy* 37 (4): 408–416. https://ideas.repec.org/a/eee/jrpoli/v37y2012i4p408-416.html.

[24] van der Ploeg, Frederick. 2011. "Natural Resources: Curse or Blessing?" *Journal of Economic Literature* 49 (2): 366–420. https://doi.org/10.1257/jel.49.2.366.

[25] Juhász, Réka, Nathan J. Lane and Dani Rodrik. 2023. "The New Economics of Industrial Policy." NBER Working Paper 31538. https://doi.org/10.3386/w31538.

[26] ECFR, "From Ore to More."

[27] IEA, "Export Ban on Raw Materials (Namibia)."

identified 353 potential products across 23 sectors that Namibia could develop from existing capabilities, with potential for around USD 900 million in new activity and up to 26,400 jobs.[28]

The economic case against export bans is equally familiar. A ban lowers the domestic price of ore, transferring surplus from miners to domestic processors and to the state, and forgoing export revenue. The first-best instrument for promoting a downstream activity is a direct subsidy to that activity, not a trade restriction on its input.[29] Lederman and Barattieri[30] note that learning by doing can justify temporary support for downstream industries, but only if global demand for refined products grows enough to sustain those industries once support is withdrawn, and that export restrictions are not permitted under most interpretations of GATT Article XI. Empirical evidence on older African export controls is discouraging. Fliess, Idsardi and Rossouw[31] studied manganese in Gabon, lead in South Africa, copper in Zambia and chromite in Zimbabwe over more than twenty years and found no improvement in the revealed comparative advantage of processed products that were supposed to benefit, with some evidence that restrictions undermined overall industry performance. The IMF, while acknowledging Indonesia's investment gains, urged a cost-benefit framework and gradual phase-out, citing forgone revenue, misallocation, rent seeking and cross-border price spillovers.[32]

This paper takes no position on the domestic welfare calculus for producer countries, which depends on local conditions that are beyond its scope. It takes as given that beneficiation mandates are a durable feature of the policy environment and asks how they interact with US objectives. That framing is deliberate. For a US audience, the relevant question is not whether Namibia or Zimbabwe should ban raw exports, but what the United States should do given that they have.

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[28] UNCTAD. 2026. *Rapid Assessment of Value Addition and Diversification within and beyond the Critical Energy Transition Minerals Value Chain in Namibia*. Geneva: UN Trade and Development. https://unctad.org/publication/rapid-assessment-critical-energy-transition-minerals-value-chain-namibia; United Nations Namibia. 2026. "Beyond the Mine: How Namibia Is Mapping 26,400 New Jobs for the Next Generation." https://namibia.un.org/en/311622-beyond-mine-how-namibia-mapping-26400-new-jobs-next-generation.

[29] Bhagwati, Jagdish, and V. K. Ramaswami. 1963. "Domestic Distortions, Tariffs and the Theory of Optimum Subsidy." *Journal of Political Economy* 71 (1): 44–50. https://doi.org/10.1086/258733.

[30] Lederman, Daniel, and Alessandro Barattieri. 2024. "The Double-Edged Sword of Export Bans on Critical Metals." World Bank, Let's Talk Development, 4 December. https://blogs.worldbank.org/en/developmenttalk/the-double-edged-sword-of-export-bans-on-critical-metals.

[31] Fliess, Barbara, Ernst Idsardi and Riaan Rossouw. 2017. "Export Controls and Competitiveness in African Mining and Minerals Processing Industries." OECD Trade Policy Papers 204. Paris: OECD Publishing. https://doi.org/10.1787/1fddd828-en.

[32] IMF (International Monetary Fund). 2023. *Indonesia: 2023 Article IV Consultation—Press Release; Staff Report; and Statement by the Executive Director for Indonesia*. IMF Country Report 23/221. Washington, DC: IMF. https://www.elibrary.imf.org/view/journals/002/2023/221/article-A001-en.xml.

2.2 Four episodes

Table 1 summarises the four episodes studied in this paper. They differ in the minerals covered, in the producer's share of world supply and in the design of the restriction, and those differences turn out to matter.

Table 1. Four export-restriction episodes

Episode	Instrument and timing	Producer share of world supply	Processing response	Ownership of new capacity
Indonesia, nickel	Ore export ban 2014; relaxed 2017; reinstated 1 January 2020	About 49% of mine output (2022)	Two smelters before 2014; at least 29 refineries by 2021; nickel exports USD 4.5bn (2019) to 19.6bn (2022)	Predominantly Chinese-owned or financed
Zimbabwe, lithium	Raw-ore ban December 2022; concentrate export suspension February 2026; producer quotas and 10% export tax from April 2026; concentrate ban from January 2027	Nearly 10% of world lithium (2025)	Concentrators at all six operating mines; first lithium sulphate plant (about 50 kt per year) shipped April 2026	Chinese firms involved in all six operating mines; sulphate plant closed to third-party ore
Namibia, lithium and other critical minerals	Cabinet ban on unprocessed lithium ore, cobalt, manganese, graphite and rare earths, 6 June 2023; ministerial discretion for small quantities	Small	No conversion capacity at scale; one Chinese-owned plant halted November 2024; pilot concentrate output at Uis	Mixed: Chinese (Xinfeng), UK-listed (Andrada), Japanese state partner in rare earths (Lofdal)
DRC, cobalt	Export suspension 22 February 2025; ARECOMS quotas from 16 October 2025 (96,600 t for 2026)	73% of mined cobalt (2025)	Hydroxide already produced onshore; no new refining step; domestic stockpiling; refined price roughly 2.5 times higher.	Quotas pro rata to historical exports; largest producer CMOC (Chinese) holds 39.5% of world output.

Sources: compiled by the author.[33]

Indonesia is the precedent that African governments explicitly cite.[34] Indonesia prohibited nickel ore exports in 2014, relaxed the ban in 2017 and reinstated it from 1 January 2020.[35] Before the first ban, Indonesia had only two nickel smelters; by 2021 at least 29 nickel refineries were operating, with dozens more planned, including hydrometallurgical plants producing battery-grade

[33]Guberman, Schreiber and Perry, "Export Restrictions on Minerals and Metals"; IMF, *Indonesia: 2023 Article IV Consultation*; CSIS (Center for Strategic and International Studies). 2024. "Diversifying Investment in Indonesia's Mining Sector." 7 November. https://www.csis.org/analysis/diversifying-investment-indonesias-mining-sector; Reuters, "Zimbabwe Bans Raw Lithium Exports"; Reuters. 2025a. "Zimbabwe to Ban Export of Lithium Concentrates from 2027." 10 June. https://www.reuters.com/business/energy/zimbabwe-ban-export-lithium-concentrates-2027-2025-06-10/; Reuters, "Zimbabwe to Introduce Lithium Export Quotas"; Al Jazeera, "Zimbabwe Imposes Ban on Exports"; Boston University Global Development Policy Center. 2026. "Zimbabwe's Lithium Pivot: Promises and Pitfalls of Mining." 23 March. https://www.bu.edu/gdp/2026/03/23/zimbabwes-lithium-pivot-promises-and-pitfalls-of-mining/; IntelliNews, "Africa's Push for Local Mineral Processing Reshapes"; Africa Legal, "Namibia Bans Export of Raw Lithium"; New Era. 2026. "Uis Demands N$300m from Xinfeng." https://neweralive.na/uis-demands-n300m-from-xinfeng/; African Green Minerals Observatory. n.d. "Namibia." Accessed 29 September 2026. https://www.africangreenminerals.com/countries/namibia; Cobalt Institute, *Cobalt Market Report 2025*; IEA (International Energy Agency). 2026c. "DRC ARECOMS Decision No. 004/2025 – Cobalt Quota System." Policies Database. https://www.iea.org/policies/29138-drc-arecoms-decision-no-0042025-cobalt-quota-system.

[34]Semafor, "Namibia's President Eyes Local Mineral Processing."

[35]Guberman, Schreiber and Perry, "Export Restrictions on Minerals and Metals."

intermediates.[36] Nickel exports rose from USD 4.5 billion in 2019 to USD 19.6 billion in 2022, and IMF staff estimated that higher prices could explain less than a third of this increase.[37] The investment was overwhelmingly Chinese: nearly half of the 2022 increase in foreign investment realisation came from China and Hong Kong,[38] and investment in mineral processing and manufacturing rose from USD 3.56 billion in 2019 to USD 10.96 billion in 2022, driven by Chinese financing.[39]

Zimbabwe holds Africa's largest lithium reserves and produced nearly 10 per cent of global lithium in 2025.[40] Its December 2022 ban prohibited the export of unprocessed lithium ore unless companies established local processing or obtained written permission.[41] The ban did not cover concentrates, and a surge in concentrator investment followed. Chinese private companies invested more than USD 1 billion in acquiring and developing Zimbabwean lithium projects after 2021 and are involved in all six operating lithium mines.[42] In June 2025, the government announced that concentrate exports would be banned from January 2027.[43] In February 2026, after reported stockpiles of ore were discovered at the Port of Beira in Mozambique, the government suspended all raw mineral and concentrate exports with immediate effect.[44] Shipments resumed in April 2026 under producer-specific quotas, subject to a 10 per cent export tax and written commitments to build lithium sulphate plants before 1 January 2027.[45]

Namibia's Cabinet approved the prohibition of exports of unprocessed crushed lithium ore, cobalt, manganese, graphite and rare earths on 6 June 2023, with ministerial discretion to permit small

[36] Guberman, Schreiber and Perry, "Export Restrictions on Minerals and Metals."

[37] IMF, *Indonesia: 2023 Article IV Consultation*.

[38] IMF, *Indonesia: 2023 Article IV Consultation*.

[39] CSIS, "Diversifying Investment in Indonesia's Mining Sector."

[40] Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."

[41] Reuters, "Zimbabwe Bans Raw Lithium Exports"; SCMP (South China Morning Post). 2022. "Export Ban Means Chinese Firms Will Have to Build Lithium Plants in Zimbabwe." 31 December. https://www.scmp.com/news/china/diplomacy/article/3205135/export-ban-means-chinese-firms-will-have-build-plants-zimbabwe-process-lithium.

[42] Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."

[43] Reuters, "Zimbabwe to Ban Export of Lithium Concentrates."

[44] Al Jazeera, "Zimbabwe Imposes Ban on Exports"; Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."

[45] Reuters, "Zimbabwe to Introduce Lithium Export Quotas"; IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."

quantities.[46] At the time, Namibia had no lithium processing plants.[47] The ban was a response in part to the Xinfeng affair, in which the Minister of Mines and Energy revoked the licence of a Chinese-linked company for alleged fraud in its application, only for the High Court to interdict the revocation on the ground that the Minister lacked the statutory power to revoke without approaching the court.[48] The ban was to be reinforced by a new Minerals Bill that would replace the Minerals (Prospecting and Mining) Act of 1992, but the bill was postponed in late 2025.[49] In August 2025, the ministry floated a requirement of 51 per cent Namibian ownership in new mining ventures, which the Chamber of Mines opposed, and the government later clarified that it had not adopted a fixed threshold.[50]

The DRC produced 73 per cent of global mined cobalt in 2025.[51] On 22 February 2025, it banned all cobalt exports for four months to reverse a price decline, extended the ban in June and September, and, from 16 October 2025, moved to a quota system administered by the Regulatory and Control Authority for Strategic Mineral Substances (ARECOMS).[52] The quota was set at 18,125 tonnes for the fourth quarter of 2025 and at 96,600 tonnes for 2026, comprising a base quota of 87,000 tonnes and a discretionary strategic quota of 9,600 tonnes, with quotas allocated pro rata to historical exports.[53] Implementation delays meant that shipments effectively stopped in the final quarter of 2025, and the first truck under the new system left in January 2026.[54]

The DRC case differs from the others because the DRC's motive was explicitly about price as well as processing. It is the only one of the four producers large enough to move the world price on its own. It is included because it shows what a quantitative restriction does when the restricting

[46] Africa Legal, "Namibia Bans Export of Raw Lithium."

[47] Africa Legal, "Namibia Bans Export of Raw Lithium."

[48] Africa Legal, "Namibia Bans Export of Raw Lithium."

[49] Cliffe Dekker Hofmeyr. 2026. "Critical Minerals, Critical Choices: Navigating US Tariffs, Chinese Dominance and African Sovereignty." Mining and Minerals Alert, 10 February. https://www.cliffedekkerhofmeyr.com/en/news/publications/2026/South-Africa/Mining-Minerals/mining-and-minerals-and-industrials-manufacturing-and-trade-alert-10-february-critical-minerals-critical-choices-navigating-us-tariffs-chinese-dominance-and-african-sovereignty.

[50] Cliffe Dekker Hofmeyr, "Critical Minerals, Critical Choices"; IntelliNews. 2026b. "Namibia Pushes Local Processing and Partnerships for Critical Mineral Investors." 28 September. https://www.intellinews.com/namibia-pushes-local-processing-and-partnerships-for-critical-mineral-investors-471584/.

[51] Cobalt Institute, *Cobalt Market Report 2025*.

[52] Cobalt Institute, *Cobalt Market Report 2025*; IEA, "DRC ARECOMS Cobalt Quota System."

[53] IEA, "DRC ARECOMS Cobalt Quota System."

[54] Reuters, "Congo's Cobalt Curbs Expose China's Critical Metals."

country is dominant, and because it is the country with which the United States has gone furthest in bilateral minerals diplomacy.

2.3 The US policy toolkit

Table 2 lists the principal US instruments now in force or under negotiation and identifies the margin on which each operates. The key observation is that US instruments operate on three margins: ownership (who controls the producing firm), price (the revenue a non-Chinese producer can expect) and access (whether US persons can buy or invest first). None operates directly on the processing location, which is the margin that beneficiation mandates target.

Table 2. US critical-minerals instruments and the margins on which they operate

Instrument	Date	Margin	Interaction with producer-country beneficiation mandates
Prohibited foreign entity and material assistance rules for §45X, §45Y and §48E (One Big Beautiful Bill Act; Treasury Notice 2026-15)	July 2025; February 2026	Ownership	Location-neutral: a Chinese-owned plant in a producer country is treated the same as one in China, so relocated capacity remains ineligible
Section 232 proclamation on processed critical minerals; negotiations on price floors	January 2026	Price	Floors on ore or concentrate cannot bind where exports are banned; floors on processed products can
Project Vault (US Strategic Critical Minerals Reserve; USD 10bn EXIM loan plus about USD 2bn private)	February 2026	Price and demand	Stockpiles held in the United States; procurement specifications could favour processed intermediates from mandate countries
FORGE (successor to the Minerals Security Partnership) and bilateral frameworks	February 2026	Coordination	Forum for aligning price floors and processing finance; no processing commitments to date
US-DRC Strategic Partnership Agreement	December 2025	Access	Right of first offer on Strategic Asset Reserve projects and marketed minerals; value-addition projects contemplated but non-binding
DFC finance, including USD 553m for the Lobito Atlantic Railway	2024–2025	Infrastructure cost	Lowers export logistics costs; does not directly finance processing

Sources: compiled by the author.[55]

The ownership margin is set primarily by the prohibited foreign-entity rules introduced by the One Big Beautiful Bill Act. For taxable years beginning after 4 July 2025, taxpayers are ineligible for

[55]Kirkland and Ellis. 2025. "One Big Beautiful Bill Act Brings Big Changes to Green Energy Tax Credits." August. https://www.kirkland.com/publications/kirkland-alert/2025/08/one-big-beautiful-bill-act-brings-big-changes-to-green-energy-tax-credits; Baker Botts, "Treasury and IRS Provide Guidance"; White House, "Fact Sheet: Processed Critical Minerals"; EXIM, "Week in Review"; US Department of State, "2026 Critical Minerals Ministerial"; IEA, "DRC-US Strategic Partnership Agreement"; DFC (US International Development Finance Corporation). 2025. "DFC CEO Ben Black Signs Loan Agreement for Lobito Atlantic Railway." Press release, 17 December. https://www.dfc.gov/media/press-releases/dfc-ceo-ben-black-signs-loan-agreement-lobito-atlantic-railway-securing; Oputu, Dafe, and Landry Signé. 2026. *Toward a U.S.-Africa Critical Minerals Investment Strategy: Tools, Priorities, and Trade-Offs*. Washington, DC: Brookings Institution. https://www.brookings.edu/wp-content/uploads/2026/07/CFF-paperV3-.pdf.

the Section 45X advanced manufacturing credit if they are prohibited foreign entities or receive material assistance from one.[56] A prohibited foreign entity generally includes a Chinese, Russian, North Korean, or Iranian entity, a 50 per cent or greater subsidiary of such an entity, or a "foreign-influenced entity," and Treasury's Notice 2026-15 sets out a material assistance cost ratio test and interim safe harbours.[57] These rules do not care where a plant is located. A lithium sulphate plant owned by a Chinese company counts as a foreign-entity supply whether it sits in Zhejiang or outside Harare.

The price margin is the subject of the Section 232 negotiations. The January 2026 proclamation instructs negotiators to work with allies to promote price floors for trade in processed critical minerals. It reserves the right to take further action if agreements are not reached within 180 days.[58] Project Vault operates on the same margin from the demand side, by creating a large, creditworthy buyer for stockpiled materials.[59] The proposed SECURE Minerals Act would add a USD 2.5 billion strategic resilience reserve.[60]

The access margin is the subject of bilateral agreements. The US-DRC Strategic Partnership Agreement requires the DRC to designate a Strategic Asset Reserve of mineral assets and exploration areas, gives US persons a right of first offer and a nine-month negotiating window, commits the DRC to provide US persons a right of first offer on marketed minerals destined for export, and sets five-year targets for the share of exports routed through the Sakania-Lobito corridor (50 per cent for copper, 90 per cent for zinc concentrate and 30 per cent for cobalt).[61] The agreement also contemplates "DRC Designated Strategic Projects" for industrial transformation and local value addition, to be financed by international and US institutions, but without binding processing commitments.[62] My earlier analysis with co-authors argued that these provisions add little to the DRC's existing beneficiation law and do not address armed-group financing or

[56] Kirkland and Ellis, "One Big Beautiful Bill Act."
[57] Baker Botts, "Treasury and IRS Provide Guidance."
[58] White House, "Fact Sheet: Processed Critical Minerals."
[59] EXIM, "Week in Review."
[60] Oputu and Signé, *Toward a U.S.-Africa Critical Minerals Investment Strategy*.
[61] IEA, "DRC-US Strategic Partnership Agreement."
[62] IEA, "DRC-US Strategic Partnership Agreement."

parliamentary oversight.[63] The US Development Finance Corporation's largest critical-minerals-related commitment remains its USD 553 million loan to the Lobito Atlantic Railway, which is transport infrastructure rather than processing.[64]

3. A Framework: Location, Supply and Ownership

This section sets out a deliberately simple framework to organise the evidence. The aim is not a general equilibrium model of mineral trade but a way of separating effects that are frequently conflated in policy debate.

3.1 Set-up

Consider a producer country h with an ore deposit of unit mining cost m. Ore can be converted into an intermediate product (for example spodumene concentrate into lithium sulphate or carbonate, or cobalt ore into hydroxide) at a rate of a units of ore per unit of intermediate. Processing can take place at home at unit cost c_h, including the annualised fixed cost of the plant and the local costs of energy, water, reagents and logistics, or abroad at an incumbent processing hub at unit cost c_c. The world price of ore is p_o and of the intermediate is p_i, respectively. In the absence of restrictions, and given the scale, clustering and learning advantages of the incumbent hub, $c_c < c_h$ for most minerals and most producer countries, so ore is exported and processed abroad. This is the pre-ban equilibrium for Namibian and Zimbabwean lithium, and for most DRC cobalt beyond the hydroxide stage.

Define the integrated margin at home as the profit per unit of intermediate from mining and processing in h:

$$V_h = p_i - \mathrm{a}\cdot\mathrm{m} - c_h$$

and the pre-ban margin from mining and exporting ore as $\mathrm{a}\cdot(p_o - \mathrm{m})$ per unit of intermediate-equivalent.

[63] Zongwe, Leezola R., Olivia Rumble and Inga Dyan. 2026. "Will the Minerals for Security Deal between US and the DRC Bring Lasting Peace?" *African Climate Wire*, 20 July. https://africanclimatewire.org/2026/07/will-the-minerals-for-security-deal-between-us-and-the-drc-bring-lasting-peace/.

[64] Oputu and Signé, *Toward a U.S.-Africa Critical Minerals Investment Strategy*; DFC, "DFC CEO Ben Black Signs Loan Agreement."

3.2 The location effect and the supply-withdrawal effect

An export ban removes the option to export. Mining continues only if the integrated margin is non-negative. Two cases follow.

If $V_h \geq 0$, the ban induces onshore processing. Surplus is transferred from the mining stage to the processing stage (the domestic ore price falls towards the level at which processors break even), and the host country gains processing activity. I call this the location effect.

If $V_h < 0$, the ban does not induce processing. Mining stops, or ore is stockpiled in anticipation of an exemption or a price recovery, thereby withdrawing supply from the world market. I call this the supply-withdrawal effect. Because V_h depends on p_i, the same ban can produce the location effect at the top of a price cycle and the supply-withdrawal effect at the bottom.

This matters because lithium prices collapsed in exactly the period in which the African lithium bans were introduced. Chinese lithium carbonate prices fell by about 87 per cent from their late-2022 peak by the end of 2024.[65] A ban introduced in June 2023 therefore faced a sharply falling p_i, and V_h would have been negative for any greenfield processor facing typical African cost premia on energy, reagents and logistics. Namibia's Chamber of Mines has made exactly this point, identifying energy costs, water costs, logistics, deposit size and commodity prices as the determinants of processing viability.[66]

> **Proposition 1.** An export ban raises domestic processing if and only if the host country's integrated margin is non-negative at prevailing prices. When it is negative, the ban reduces world supply by the country's pre-ban exports, with no offsetting increase in processed exports.

3.3 The terms-of-trade effect

If the producer is large in the world market, withdrawing supply raises p_o and p_i. For a producer with share s of world supply facing world demand with elasticity ε, a restriction that reduces the producer's exports by a fraction x raises the world price by approximately $s \cdot x/\varepsilon$ in proportional terms, where ε is the absolute price elasticity of world demand and supply responses elsewhere are

[65] SMM (Shanghai Metals Market). 2025. "In 2024, Lithium Carbonate Futures and Spot Prices Both Plunge over 20%." 8 January. https://news.metal.com/newscontent/103125995-in-2024-lithium-carbonate-futures-and-spot-prices-both-plunge-over-20-leaving-miners-miserable-will-2025-bring-a-ray-of-.

[66] IntelliNews, "Namibia Pushes Local Processing and Partnerships."

ignored (a standard inverse elasticity approximation). For small producers such as Namibia, s is negligible, and the terms-of-trade effect can be ignored. For the DRC in cobalt, s is about three quarters,[67] and short-run demand is inelastic, so even a modest reduction in exports raises world prices sharply. A quantitative export restriction by a dominant producer is therefore, functionally, a producer-imposed price floor, and the rents accrue to whoever holds the export rights under the quota.

> **Proposition 2.** For a dominant producer, a quantitative export restriction raises world prices and transfers rents to quota holders. Whether those rents contribute to diversification depends on who holds the quotas.

3.4 The ownership margin

The trade literature on export restrictions typically stops at location. The policy question for the United States requires one more step: who builds and owns the onshore capacity?

Suppose there are two types of potential processors in h: an incumbent integrated firm I from the processing hub, and a non-incumbent firm N. For example, a US, Japanese, European or Gulf firm, or a local firm. Their unit processing costs in h are c_h^I and c_h^N. The incumbent has lower costs because it brings proven flowsheets, captive offtake into its own downstream operations, access to equipment and technicians, and finance from home-country lenders; and it often already owns the mine. So $c_h^I < c_h^N$. The non-incumbent also faces a higher cost of capital*, rN, on the plant's fixed cost, F. When the ban makes onshore processing necessary, the firm that builds the plant is the one with the higher integrated margin, which is typically* the incumbent.

The US prohibited-foreign-entity rules introduce a wedge. Output from I is ineligible for US credit-supported supply chains; output from N is eligible. Let π denote the premium an eligible producer earns per unit of intermediate, whether through a price floor, a guaranteed offtake, tax-credit pass-through or concessional finance. Then N builds the plant only if

$$p_i + \pi - a \cdot m - c_h^N - r^N \cdot F \geq \max\{0, p_i - a \cdot m - c_h^I\}$$

that is, only if the eligibility premium π exceeds the combined cost and financing disadvantage of the non-incumbent.

[67] Cobalt Institute, *Cobalt Market Report 2025*.

Proposition 3. Where the location effect operates, the ban relocates processing capacity but, absent an eligibility premium large enough to offset the incumbent's cost and financing advantage, the new capacity is owned by the incumbent and is ineligible under US rules. US-eligible supply is then unchanged, and falls if the ban also closes pre-existing export channels used by eligible buyers.

3.5 Bridge deals and end deals

The framework clarifies the typology used in the policy discussion. An end deal is an agreement that secures access to ore or concentrate for export. A bridge deal is an agreement that leaves behind processing capacity, skills and shared infrastructure.[68] In the notation above, bridge deals are instruments that raise V_h for eligible processors: by lowering c_h^N (shared power, water and rail), by lowering r^N (concessional or blended finance), or by raising π (guaranteed offtake at floor prices). One further feature matters: whether the processing capacity is open to third-party ore. A plant that processes only its owner's ore does little for other miners in the host country, who continue to face $V_h < 0$ on their own. An open-access or toll-processing plant converts the location effect from a firm-level to a country-level outcome.

The framework yields three testable predictions for the episodes studied below. First, where integrated margins were negative, bans should be followed by export collapses with no substitution into processed exports (Proposition 1). Second, where the producer is dominant, restrictions should be followed by large price rises with rents accruing to quota holders (Proposition 2). Third, where onshore processing did emerge, it should be owned predominantly by incumbents from the dominant processing hub (Proposition 3).

4. Evidence from Four Episodes

4.1 Data

The trade evidence uses UN Comtrade mirror statistics, specifically China's reported imports by partner, because China is the destination for nearly all of the exports in question and because producer-country reporting is incomplete or delayed.[69] I use HS 2530.90 (mineral substances not elsewhere specified, which for Namibia and Zimbabwe consists overwhelmingly of lithium ores

[68] Zongwe, "Can Namibia Turn China-EU Rivalry into Industrial Growth."

[69] UN Comtrade, database extract, accessed 29 September 2026.

and spodumene or petalite concentrates), HS 2836.91 (lithium carbonate), HS 2825.20 (lithium oxide and hydroxide), HS 2833.29 (other sulphates, which includes lithium sulphate), HS 8105.20 (cobalt mattes and other intermediate products, under which China records DRC cobalt hydroxide) and HS 2605.00 (cobalt ores and concentrates). I also report US imports from the same partners in the same product lines. Mirror statistics have well-known limitations: they record shipments by date of arrival rather than departure; they can misattribute the origin of goods transshipped through third countries such as Mozambique; and HS 2530.90 includes some non-lithium minerals. The figures should be read as indicative orders of magnitude rather than precise volumes. Firm ownership and plant capacity are taken from company announcements, government notices and press reports cited in the text.

Table 3. China's recorded imports from Namibia, Zimbabwe and the DRC, selected lines, 2021–2025 (thousand tonnes, net weight)

Partner and product	2021	2022	2023	2024	2025
Namibia, lithium ores/concentrates (2530.90)	0.0	72.8	105.6	13.7	0.6
Namibia, lithium carbonate/hydroxide/sulphate	0.0	0.0	0.0	0.0	0.0
Zimbabwe, lithium ores/concentrates (2530.90)	0.0	62.2	404.7	1,259.2	603.5
Zimbabwe, lithium carbonate/hydroxide/sulphate	0.0	0.0	0.0	0.0	0.0
DRC, cobalt intermediates (8105.20)	304.7	355.1	387.0	628.2	306.6
DRC, cobalt ores/concentrates (2605.00)	19.0	26.3	16.6	0.4	0.1
US imports, all above lines, from the three countries (USD million)	0.00	0.09	0.01	0.00	0.00

Source: UN Comtrade data, China as reporter (mirror data); final row, United States as reporter.[70] HS 2530.90 is mineral substances n.e.s., which for Namibia and Zimbabwe consists overwhelmingly of lithium ores and concentrates. Processed lithium combines HS 2836.91, 2825.20 and 2833.29. DRC cobalt intermediates (HS 8105.20) are reported in gross product weight. Mirror data are subject to timing, transhipment and classification errors; 2025 values may be revised.

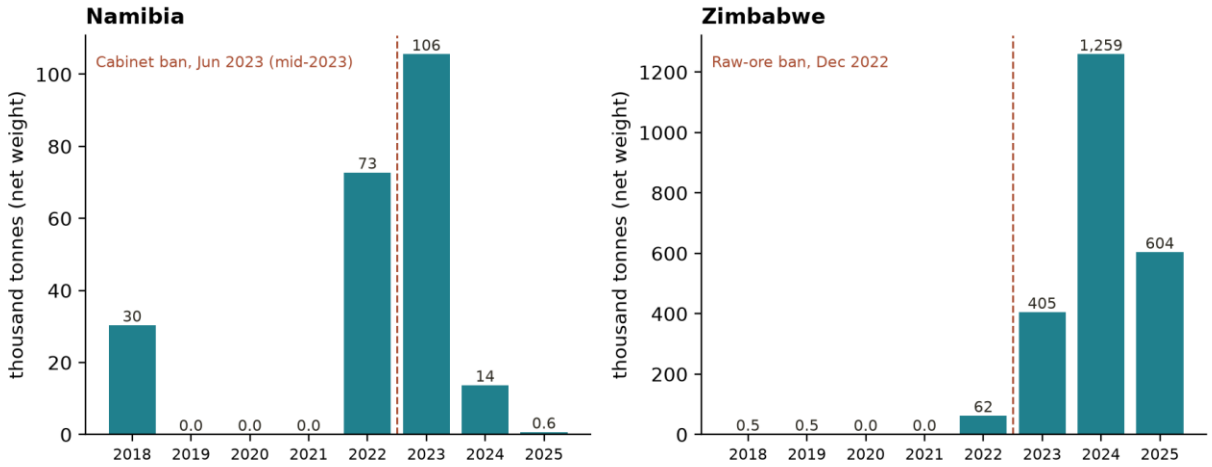
4.2 Namibia: supply withdrawal without substitution

Namibia is the cleanest illustration of Proposition 1. China's recorded imports of HS 2530.90 from Namibia were 72,800 tonnes in 2022 and 105,600 tonnes in 2023, reflecting the ramp-up of small lithium operations around Uis and Karibib (apart from an isolated 30,000 tonnes in 2018, recorded flows before 2022 were negligible). They fell to 13,700 tonnes in 2024 and 600 tonnes in 2025 (Table 3 and Figure 1). The value of these flows fell from USD 37.8 million in 2022 to less than USD 0.1 million in 2025. There is no offsetting increase in recorded Chinese imports of lithium

[70] UN Comtrade, database extract, accessed 29 September 2026.

carbonate, lithium hydroxide or lithium sulphate from Namibia in any year; the processed lithium lines for Namibia are empty.[71]

Figure 1. China's recorded imports of lithium ores and concentrates (HS 2530.90) from Namibia and Zimbabwe, 2018–2025



Source: UN Comtrade data, China as reporter.[72] Dashed lines mark the Namibian Cabinet ban (June 2023) and the Zimbabwean raw-ore ban (December 2022). Note the different vertical scales.

Monthly data sharpen the picture. Recorded arrivals from Namibia were concentrated in October and November 2022, January 2023 and May 2023, the last immediately before the Cabinet decision, and after June 2023 arrivals were sporadic: about 25,000 tonnes in December 2023 and 13,000 tonnes in October 2024, consistent with shipments under ministerial exemptions or delayed arrival of earlier consignments, and close to zero in other months.[73] The obvious confounder is the price collapse. Lithium prices fell by about 87 per cent from peak to trough,[74] and some of the decline in Namibian shipments would have happened without a ban. But the comparison with Zimbabwe, which faced the same price shock, is instructive: Chinese imports from Zimbabwe of the same HS line rose from 62,200 tonnes in 2022 to 1.26 million tonnes in 2024. The difference is that Zimbabwe's 2022 ban allowed concentrate exports and was followed by large concentrator investment. In contrast, Namibia's 2023 ban covered crushed ore at a time when no Namibian concentrate or conversion capacity of scale existed.[75] In the notation of Section 3, Namibian

[71] UN Comtrade, database extract, accessed 29 September 2026.
[72] UN Comtrade, database extract, accessed 29 September 2026.
[73] UN Comtrade, database extract, accessed 29 September 2026.
[74] SMM, "Lithium Carbonate Futures and Spot Prices."
[75] Africa Legal, "Namibia Bans Export of Raw Lithium."

operations faced a sharply negative V_h because they would have had to finance both concentration and conversion onshore at the bottom of the price cycle.

The firm-level record is consistent with this reading. The one operation that built a processing plant, Xinfeng Investments, is Chinese-owned; a Namibian newspaper reports ownership of 85 per cent, 10 per cent by two Chinese nationals, and 5 per cent by a Namibian partner, and a plant valued at around N$600 million.[76] The Mining Commissioner halted its operations in November 2024 due to illegal mining, and the local community has since demanded compensation and binding benefit-sharing agreements.[77] Andrada Mining, a UK-listed company, produced its first lithium concentrate from a pilot plant at Uis in late 2023, with expected output of up to 250 tonnes per month.[78] Lepidico's Karibib project was designed to ship concentrate to a chemical plant in Abu Dhabi,[79] a configuration that is in tension with the ban's objective.

Namibia's case also carries a lesson about sequencing. The ban preceded the legal and infrastructural preconditions for onshore processing: the replacement Minerals Bill has been postponed, ownership rules remain in flux, and the UNCTAD assessment explicitly identifies reliable energy supply, transport infrastructure, industrial zones, testing laboratories and finance as preconditions.[80] The 2025 proposal of a 51 per cent local ownership threshold, later softened, added uncertainty at precisely the moment when investors had to decide whether to build.[81] The rare earths project at Lofdal, developed with Japan's JOGMEC, is the principal example of non-Chinese capital committed to a Namibian critical-minerals project; it is expected to produce around 2,000 tonnes of total rare earth oxide per year, including dysprosium and terbium, which are among the elements most exposed to Chinese export controls.[82]

From a US perspective, the Namibian ban has so far neither helped nor hurt directly, as the United States has not been importing Namibian lithium. Recorded US imports of the relevant lines from Namibia are effectively zero throughout the period (Table 3). But the ban has removed a potential

[76] New Era, "Uis Demands N$300m from Xinfeng."
[77] New Era, "Uis Demands N$300m from Xinfeng."
[78] African Green Minerals Observatory, "Namibia."
[79] African Green Minerals Observatory, "Namibia."
[80] Cliffe Dekker Hofmeyr, "Critical Minerals, Critical Choices"; United Nations Namibia, "Beyond the Mine."
[81] Cliffe Dekker Hofmeyr, "Critical Minerals, Critical Choices."
[82] African Green Minerals Observatory, "Namibia."

source of feedstock for non-Chinese processors elsewhere, and it has not yet produced the onshore capacity that would give eligible buyers something to purchase. Namibia was also a partner in the Minerals Security Partnership, alongside the United States, the European Union, Japan and others,[83] whose successor is FORGE, so channels for coordination already exist.

4.3 Zimbabwe: relocation of Chinese midstream capacity

Zimbabwe illustrates Proposition 3. Its December 2022 ban on raw ore exports, which left concentrate exports open, coincided with the most rapid expansion of lithium mining in Africa's history. National production rose from just over 20,000 tonnes in 2020 to more than 826,000 tonnes in 2023,[84] and Zimbabwe exported 1.128 million tonnes of spodumene concentrate in 2025, about 15 per cent of China's lithium concentrate imports.[85] China's recorded imports of HS 2530.90 from Zimbabwe rose from 62,200 tonnes in 2022 to 404,700 tonnes in 2023 and 1.26 million tonnes in 2024 (Table 3 and Figure 1). The recorded figure for 2025 in the Comtrade release is lower than the Zimbabwean export figure, likely reflecting differences in timing, transhipment, and reporting, and should be treated with caution.

The investment response was almost entirely Chinese. Chinese private firms invested more than USD 1 billion after 2021 and are involved in all six operating lithium mines.[86] The principal firms are Zhejiang Huayou Cobalt at Arcadia, Sinomine at Bikita, Yahua at Kamativi, Chengxin Lithium and Tsingshan.[87] Huayou commissioned a USD 300 million concentrator at Arcadia in 2023 and a USD 400 million lithium sulphate plant with an annual capacity of around 50,000 tonnes, which made Africa's first commercial shipment of lithium sulphate in April 2026.[88] Sinomine has announced a USD 500 million lithium sulphate plant at Bikita.[89]

The Zimbabwe case therefore shows the location effect operating as intended from the host country's perspective: concentration and, increasingly, first-stage chemical conversion are moving

[83] White and Case. 2024. "Critical Minerals Supply Chains: The Minerals Security Partnership and Trade." 7 October. https://www.whitecase.com/insight-our-thinking/critical-minerals-supply-chains-minerals-security-partnership-and-trade.

[84] Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."

[85] Reuters, "Zimbabwe to Introduce Lithium Export Quotas."

[86] Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."

[87] Reuters, "Zimbabwe to Introduce Lithium Export Quotas."

[88] Reuters. 2025b. "Huayou to Start Zimbabwe Lithium Sulphate Production in Early 2026." 16 October. https://www.reuters.com/world/africa/huayou-start-zimbabwe-lithium-sulphate-production-early-2026-2025-10-17/; IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."

[89] Al Jazeera, "Zimbabwe Imposes Ban on Exports."

onshore. But two features limit the benefits for both Zimbabwe and US diversification. First, the new capacity is owned by incumbents in the dominant processing hub, so, under the prohibited foreign entity rules, its output remains a foreign-entity supply irrespective of location. Second, the Huayou sulphate plant cannot accept material from third-party miners.[90] In the language of Section 3.5, it is a closed-access plant: it moves Huayou's own processing onshore. Still, it does not solve the processing problem for other Zimbabwean producers, who in June 2026 asked the government for an additional six months to complete their own facilities.[91]

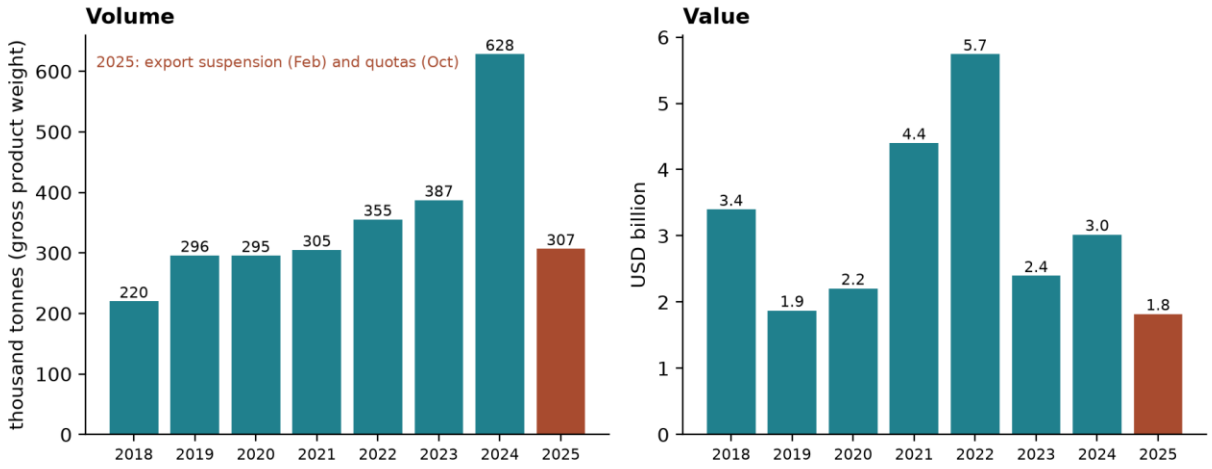
The February 2026 suspension also illustrates the enforcement problem that attends every beneficiation mandate. The government cited "continued malpractices" and leakages, reported stockpiles of ore at Beira, and a legal framework still rooted in the 1961 Mines and Minerals Act, with the 2025 replacement Bill unenacted.[92] A household survey of communities around the six operating mines found that 94 per cent of respondents felt mining companies did not value their input.[93] Onshore processing is not by itself evidence of broader developmental gains.

4.4 The Democratic Republic of the Congo: a producer-imposed price floor

The DRC illustrates Proposition 2. After the February 2025 suspension, China's recorded imports of cobalt intermediates (HS 8105.20) from the DRC fell from 628,000 tonnes gross weight in 2024 to 307,000 tonnes in 2025, and their value fell from USD 3.0 billion to USD 1.8 billion (Table 3 and Figure 2). Shipments came to a near standstill in the fourth quarter of 2025 as the quota system was implemented.[94] Global mined cobalt output was roughly flat at 270,000 tonnes in 2025, but the effective supply available outside the DRC fell to about 183,000 tonnes as material accumulated in domestic stockpiles.[95]

[90] IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."
[91] IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."
[92] Al Jazeera, "Zimbabwe Imposes Ban on Exports"; Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."
[93] Boston University Global Development Policy Center, "Zimbabwe's Lithium Pivot."
[94] Reuters, "Congo's Cobalt Curbs Expose China's Critical Metals."
[95] Cobalt Institute, *Cobalt Market Report 2025*.

Figure 2. China's recorded imports of cobalt intermediates (HS 8105.20) from the DRC, 2018–2025



Source: UN Comtrade data, China as reporter.[96] 2025 is highlighted: the DRC suspended cobalt exports on 22 February 2025 and moved to quotas from 16 October 2025.

Prices responded as the framework predicts for a dominant producer. Cobalt metal prices rose from near nine-year lows of about USD 24,300 per tonne at the start of 2025 to about USD 53,000 by the end of December.[97] The CME-refined cobalt price rose from about USD 10 per pound in early 2025 to USD 25 per pound, and the "payable" on cobalt hydroxide, the share of the metal price paid for intermediate content, rose from about 55 per cent to an unprecedented 100 per cent.[98] Chinese stocks were drawn down: more than 3,250 tonnes of cobalt metal, 37 per cent of the total, left warehouses registered with the Wuxi exchange at the end of January 2026.[99]

Two points follow for US policy. First, the DRC has done unilaterally something the Section 232 proclamation asks US negotiators to achieve through agreement: it has put a floor under the price of a critical mineral whose low price had been driving non-Chinese producers out of the market. The Centre for Strategic and International Studies had argued for a US cobalt price floor for precisely this reason.[100] Second, the distribution of the resulting rents depends on the allocation of quotas. Quotas are allocated pro rata to historical exports, with carve-outs for the state-owned

[96] UN Comtrade, database extract, accessed 29 September 2026.

[97] Investing News Network. 2026. "Cobalt Market 2025 Year-End Review." 13 January. https://investingnews.com/daily/resource-investing/battery-metals-investing/cobalt-investing/cobalt-market-update/.

[98] Reuters, "Congo's Cobalt Curbs Expose China's Critical Metals."

[99] Reuters, "Congo's Cobalt Curbs Expose China's Critical Metals."

[100] CSIS (Center for Strategic and International Studies). 2025. "Stabilizing Cobalt Markets: A Price Floor for U.S. Minerals Security." https://www.csis.org/analysis/stabilizing-cobalt-markets-price-floor-us-minerals-security.

Entreprise Générale du Cobalt.[101] The largest producer, CMOC, produced 117,500 tonnes in 2025, 39.5 per cent of the global total; with Glencore and ERG, the three largest firms accounted for more than 78 per cent of DRC production.[102] A pro rata quota therefore allocates the largest share of the new rents to a Chinese-controlled firm. The US-DRC agreement's right of first offer operates only on newly designated projects and marketed minerals, so it does not alter this distribution in the short run.[103]

The DRC restrictions also illustrate a limitation of the location effect. The DRC already produces cobalt hydroxide onshore; the binding constraint is the step from hydroxide to refined cobalt sulphate or metal, for which China accounted for 78 per cent of global output in 2024.[104] A BloombergNEF study cited by Oputu and Signé[105] estimated that a 10,000-tonne battery precursor facility would cost about USD 39 million in the DRC, compared with USD 112 million in China and more than USD 120 million in the United States. If those estimates are even roughly right, the DRC is a location where V_h for the next processing step could be positive for an eligible processor with access to reliable power and finance, which is exactly the configuration that US instruments do not currently target.

4.5 Indonesia: the template and its ownership problem

Indonesia is the case that best demonstrates both the power of the location effect and the ownership problem. The ban worked on its own terms: Indonesia became the world's dominant nickel processor, with nickel exports rising more than fourfold between 2019 and 2022.[106] Top refiners, Indonesia for nickel and China for the other key energy minerals, accounted for over three-quarters of the growth in refined supply over the last two years.[107] But the capacity is predominantly owned or financed by Chinese firms.[108] Under current US rules, much of Indonesia's battery-grade nickel

[101] IEA, "DRC ARECOMS Cobalt Quota System."
[102] Cobalt Institute, *Cobalt Market Report 2025*.
[103] IEA, "DRC-US Strategic Partnership Agreement."
[104] Reuters, "Congo's Cobalt Curbs Expose China's Critical Metals."
[105] Oputu and Signé, *Toward a U.S.-Africa Critical Minerals Investment Strategy*.
[106] IMF, *Indonesia: 2023 Article IV Consultation*; Guberman, Schreiber and Perry, "Export Restrictions on Minerals and Metals."
[107] IEA, *Global Critical Minerals Outlook 2026*.
[108] CSIS, "Diversifying Investment in Indonesia's Mining Sector"; IMF, *Indonesia: 2023 Article IV Consultation*.

is therefore treated as foreign-entity supply, and the country's greatest industrial policy success has concentrated rather than diversified the ownership of nickel processing.

For African governments, the Indonesian model is attractive because it worked. For US policymakers, it is a warning: the combination of a beneficiation mandate and the absence of competitive non-Chinese processing finance produces relocation, not diversification. The African bans are, in effect, Indonesia's policy applied to minerals and countries where the United States still has an opportunity to shape the outcome.

4.6 Summary of the evidence

The four episodes line up with the three propositions. Where the integrated margin was negative (Namibian lithium, 2023 to 2025), the ban withdrew supply without substitution into processed exports. Where the producer was dominant (DRC cobalt, 2025 to 2026), the restriction raised world prices sharply, and rents flowed to quota holders, principally large incumbents. Where the location effect operated (Indonesian nickel and Zimbabwean lithium), Chinese incumbents overwhelmingly owned the new capacity and, in the Zimbabwean case at least, were closed to third-party ore. In no case did a beneficiation mandate by itself generate processing capacity that would be eligible under current US rules. It is equally true that in no case did US instruments offer non-Chinese processors a premium large enough to compete. The evidence is descriptive, and the counterfactuals are uncertain, but the pattern is consistent across very different minerals, market structures and policy designs.

5. Implications for US Policy

5.1 Treat beneficiation mandates as a constraint, not a target

The first implication is strategic. US policy has so far treated producer-country beneficiation mandates, where it has considered them at all, as an obstacle to access. The Section 232 framework, the right of first offer in the DRC agreement and the design of Project Vault are all instruments for securing access to materials. But the evidence suggests that producer countries will increasingly refuse to supply ore on end-deal terms. Around 12 African countries now restrict unprocessed exports; Mozambique's June 2026 Mining Law generally prohibits raw or semi-processed exports

absent an approved processing plan;[109] and Guinea is requiring gold to be refined domestically.[110] The relevant question for the United States is no longer whether processing moves to producer countries, but who will own and finance it when it does.

Challenging mandates under GATT Article XI is unlikely to be productive. Such challenges would be slow and would place the United States in opposition to a policy that enjoys broad legitimacy in producer countries and continental endorsement through the African Mining Vision and the Green Minerals Strategy. They would also concede the processing investment to incumbents while the litigation proceeds. A more productive approach is to design US instruments so that the most attractive way for a producer country to satisfy its own mandate is through eligible capital.

5.2 Close the eligibility gap with processing finance located in producer countries

Proposition 3 implies that the binding constraint on eligible onshore processing is the gap between the incumbent's and the non-incumbent's integrated margins. US instruments can close that gap by lowering c_h^N and r^N or by raising π. At present, the largest US development finance commitment in African critical minerals is for rail,[111] and the largest domestic instrument, Project Vault, finances stockpiling in the United States.[112] Neither lowers the cost of building midstream capacity where beneficiation mandates require it.

The first recommendation is therefore that DFC and EXIM prioritise equity, blended finance, and political risk insurance for eligible midstream plants located in producer countries that have adopted beneficiation mandates, beginning with lithium sulphate and carbonate in Zimbabwe and Namibia, and with cobalt sulphate or precursor production in the DRC and Zambia. The cost estimates in Oputu and Signé[113] suggest that the capital requirement per plant for early midstream steps is modest relative to the scale of Project Vault. The Atlantic Council's task force has similarly called for a DFC with greater flexibility and risk tolerance in this sector.[114]

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[109] IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."

[110] IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."

[111] DFC, "DFC CEO Ben Black Signs Loan Agreement"; Oputu and Signé, *Toward a U.S.-Africa Critical Minerals Investment Strategy*.

[112] EXIM, "Week in Review."

[113] Oputu and Signé, *Toward a U.S.-Africa Critical Minerals Investment Strategy*.

[114] Atlantic Council. 2026. "Critical Minerals Task Force." Africa Center. https://www.atlanticcouncil.org/programs/africa-center/critical-minerals-task-force/.

5.3 Make offtake and price floors conditional on processing location and openness

The second recommendation concerns the design of price-floor agreements and Project Vault procurement. A price floor or guaranteed offtake raises π for eligible producers. As currently framed, those instruments would reward eligible ore, concentrates, and processed material. In countries with beneficiation mandates, eligible ore cannot be exported, so a floor on ore is worthless there and a floor on processed products is the only one that can bind. Aligning the floor with the mandate costs the United States little and turns the mandate from an obstacle into an advantage: the producer country's ban eliminates the incumbent's option to ship ore to its home processing hub, and the US floor raises the return to the eligible processor that builds onshore.

I further suggest that US-supported plants be required to offer open-access or toll processing to third-party miners on published terms. This is the feature that most clearly distinguishes a bridge deal from a closed, firm-specific relocation. It would make US-supported plants attractive to host governments, since it solves the processing problem for small and medium producers who cannot build their own plants, and it would expand the pool of eligible feedstock. The contrast with the Huayou plant in Zimbabwe, which cannot accept third-party material,[115] is the clearest argument for the design.

5.4 Coordinate with dominant producers on price, and attend to who holds the rents

The DRC episode shows that a dominant producer can unilaterally impose a price floor. The US interest is broadly aligned: a higher and more stable cobalt price supports the viability of non-Chinese producers, which is the stated purpose of the Section 232 price-floor negotiations.[116] The third recommendation is that the United States treat the DRC's quota system as a potential component of a price-floor arrangement rather than as a supply disruption to be resisted. The Strategic Partnership Agreement already contemplates a coordinated Strategic Minerals Reserve in the DRC, and the DRC established a strategic reserve for cobalt, managed by ARECOMS, in April 2026.[117]

[115] IntelliNews, "Africa's Push for Local Mineral Processing Reshapes."

[116] White House, "Fact Sheet: Processed Critical Minerals"; CSIS, "Stabilizing Cobalt Markets."

[117] Cobalt Institute, *Cobalt Market Report 2025*.

Coordination should, however, attend to the distribution of quota rents. Under pro rata allocation, the largest share of rents flows to the largest historical exporters.[118] A US-supported arrangement could seek to link a portion of future quota allocations, or the discretionary strategic quota, to onshore processing by eligible firms, so that the price floor finances the next processing step rather than simply enriching incumbents.

5.5 Reconsider the treatment of location in the foreign-entity rules

The prohibited foreign entity rules are designed to prevent US tax credits from subsidising supply chains controlled by adversary governments. That objective is legitimate, and I do not argue for weakening the ownership test. But the rules currently treat a Chinese-owned plant in Zimbabwe identically to a plant in China, and a joint venture with a producer-country state enterprise identically to any other entity depending solely on ownership percentages. Two modest refinements are worth considering. First, Treasury could clarify how the "foreign-influenced entity" test applies to joint ventures in which a producer-country government or local investors hold significant stakes, since local ownership requirements increasingly accompany beneficiation mandates.[119] Second, Congress could consider whether processing in countries party to FORGE or bilateral minerals frameworks should be eligible for a transitional safe harbour when ownership is diluted below control thresholds within a defined period. Both refinements would create an incentive for incumbents to share ownership of onshore plants with eligible partners, which is itself a form of diversification.

5.6 Recognise the costs of poorly sequenced bans

Finally, US policymakers should recognise that poorly sequenced bans are costly for everyone. Namibia's ban removed supply without creating processing capacity, and Zimbabwe's abrupt 2026 suspension disrupted shipments of about 15 per cent of China's lithium concentrate imports.[120] In a market in which non-Chinese processors are struggling for feedstock, these are losses. The United States has an interest in helping producer countries design bans that are credible, time-bound and paired with processing finance, because such bans are more likely to produce the eligible capacity the United States wants. Technical assistance in drafting licensing conditions,

[118] IEA, "DRC ARECOMS Cobalt Quota System"; Cobalt Institute, *Cobalt Market Report 2025*.

[119] Semafor, "Namibia's President Eyes Local Mineral Processing"; IntelliNews, "Namibia Pushes Local Processing and Partnerships."

[120] Reuters, "Zimbabwe to Introduce Lithium Export Quotas."

open-access requirements and transparent quota rules is cheap relative to the other instruments in Table 2, and it is precisely the kind of cooperation that the FORGE framework and the bilateral memoranda of understanding were designed to support.[121]

Table 4 summarises the options discussed in this section.

Table 4. Policy options for aligning US instruments with beneficiation mandates

Option	Margin in framework	Problem addressed	Main risk
DFC and EXIM equity, blended finance and risk insurance for eligible midstream plants in mandate countries	Lowers c_h^N and r^N	Incumbent cost and financing advantage (Proposition 3)	Fiscal exposure; project and country risk
Condition price floors and Project Vault offtake on processed products from mandate countries	Raises π	Floors on ore cannot bind where exports are banned	Higher unit cost than buying raw material
Open-access or toll-processing requirement for US-supported plants	Raises V_h for third-party miners	Closed, firm-specific relocation	Complexity of tolling terms and ore pricing
Coordinate with dominant producers' quotas; link strategic quotas to eligible onshore processing.	Redistributes quota rents	Rents flowing to incumbents (Proposition 2)	Perception of cartel support; trade-law challenge
Clarify prohibited foreign entity treatment of producer-state joint ventures; transitional safe harbour for ownership dilution.	Narrows the ownership wedge	Ownership-only eligibility test	Evasion through nominal dilution
Technical assistance on ban design: sequencing, time limits, transparent quotas	Reduces supply withdrawal	Poorly sequenced bans (Proposition 1)	Sovereignty sensitivities

Note: notation refers to the framework in Section 3. c_h^N is the non-incumbent processing cost in the host country, r^N its cost of capital, π the eligibility premium and V_h the integrated margin.

6. Limitations and a Research Agenda

This paper is intended to frame a policy question and to organise the available evidence, not to deliver causal estimates. Several limitations should be noted. The trade evidence relies on mirror statistics that are subject to timing, transhipment and classification errors, and the 2025 figures in particular may be revised. Each episode is confounded by large and simultaneous price movements, notably the lithium price collapse. The set of episodes is small and was not randomly selected. Firm ownership is inferred from public sources that may not capture beneficial ownership or financing relationships.

[121] US Department of State, "2026 Critical Minerals Ministerial."

A fuller empirical treatment is feasible. First, a difference-in-differences or synthetic control design could compare restricting and non-restricting producers of the same mineral, using monthly customs data for China, the European Union, Japan, Korea and the United States as destinations, and separating ore, concentrate and processed product lines. Mali, Nigeria and Ghana for lithium, and Zambia and Indonesia for cobalt, are natural comparison units. Second, a plant-level dataset of announced, under-construction and operating midstream facilities in Africa, coded by ownership, financing source, capacity, openness to third-party feed and eligibility under US rules, would allow direct measurement of the ownership margin. Third, the framework in Section 3 could be calibrated to estimate the eligibility premium π required to make non-incumbent processing viable in specific locations, using published cost estimates and prevailing price floors. That calculation would allow a direct comparison of the fiscal cost of location-sensitive US instruments with the cost of the stockpiling and tax-credit instruments already in place.

7. Conclusion

Beneficiation mandates and US supply-chain policy are two responses to the same underlying fact: processing of the minerals that the energy transition depends on is highly concentrated, and the concentration has become a source of both economic rents and geopolitical leverage. Producer countries have responded by trying to capture more of the processing stage; the United States has responded by trying to secure supply from firms it does not regard as adversaries. The evidence in this paper suggests that the two responses have so far operated at cross purposes. Bans have moved processing onshore where it was profitable, withdrawn supply where it was not, and raised prices where the producer was dominant. Still, the capacity they have attracted has been built by the incumbents whose dominance the United States is trying to reduce.

This is not inevitable. The margin on which the two policy regimes can be aligned is the location and openness of midstream capacity owned and financed by eligible firms. Instruments that make it cheaper for such firms to build open-access processing plants in producer countries, and that make US price floors and offtake conditional on that processing, would convert beneficiation mandates from an obstacle into an advantage for US diversification. They would also give producer countries what their mandates are meant to achieve. The alternative is for the United States to secure access agreements for ore that producer countries will not export. At the same

time, Chinese incumbents are building the plants those countries require; the outcome the evidence suggests is currently on course.

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