Rethinking Value Chain Upgrading and Value Capture in Mineral-Rich Countries

A Knowledge-Brief on Value-Addition and Value-Capture in the Copper Value Chain

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1. Introduction

Critical minerals (CMs) value chains are central to the global energy transition and the strategic development goals of economies worldwide, shaping industrial policy agendas in both the Global North and Global South.[1] While major Western economies have focused on friend-shoring and supply de-risking strategies such as the United States Inflation Reduction Act (2022) and the European Union Green Critical Minerals Act (2023) to secure stable mineral supply,[2] low-and-middle income countries (LMICs) with mineral deposits have pushed for critical-mineral-led industrialisation strategies that aim to “add value” and “upgrade” along different stages of the mineral value chain.[3]

Either through partnerships with major economies and international organisations or through resource-nationalist approaches, mineral-rich countries continue to pursue value addition, hoping to capture value from their resources and translate it into sustainable socioeconomic development.[4] However, broader structural challenges in CM global value chains (GVCs), such as ownership patterns and the control of capital by lead participants, limit LMICs' ability to translate resource wealth into sustainable industrial upgrading and economic development, making it increasingly important to assess these limitations and incorporate them into broader policy planning.

Using an assessment of the product complexity (PCI) of the copper value chain, and the economic complexity (ECI) of countries with major mineral reserves, this knowledge brief aims to show the following key messages:

1. Despite the rise in mineral demand, many low- and middle-income countries (LMICs) with critical mineral reserves lack the required productive capabilities to upgrade to downstream mineral processing and manufacturing, limiting their opportunities to participate in the value chain.
2. Creating value along a GVC is not the same as capturing it. While mineral-rich countries may be able to “add” value to the value chain as a whole, they may struggle to retain the benefits domestically.
3. Ownership patterns and governance structures within GVCs significantly constrain value-addition and value-capture opportunities for mineral-endowed countries as they establish governance and access to resources across the whole value chain.

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[1] D’Orazio, P. and Vasishtha, G. (2024). Critical minerals and the low-carbon transition: economic implications for emerging markets and developing economies.. https://doi.org/10.46855/energy-proceedings-11093

[2] Gereffi, G., Pananond, P., Tell, F., & Fang, T. (2025). Navigating industrial policy and global value chains in an era of disruptions. *Journal of International Business Policy*, *8*(3), 207-223. https://link.springer.com/article/10.1057/s42214-025-00223-9

[3] Brooks, S. M., & Voeten, E. (2025). Green Industrial Policy and the Geopolitics of Investment in Critical Minerals and Batteries. https://www.peio.me/wp-content/uploads/PEIO18/submission_52.pdf

[4] Anzolin, G., & Pietrobelli, C. (2025). Industrial policy along the mining value chain: a new taxonomy and case studies. *Journal of International Business Policy*, *8*(3), 373-390. https://link.springer.com/article/10.1057/s42214-025-00221-x

4. Technological change and industrial upgrading are long processes that the energy transition may outpace.

2. Analytical Framework and Methodology

This knowledge brief summarises the findings of a paper by Cuevas Verdin, Andrieu and Cullen (2025)[5] which assess the pre-conditions for participation and value-capture in the copper value chain using the Product Complexity Index (CPI), Economic Complexity Index (ECI), and corporate ownership.

Key Concepts

Global Value Chain: A globally dispersed and fragmented form of production in which firms and States engage in asymmetric trade relationships.[6][7][8]

Conditions of Production: concept stemming from the Marxian political economy referring to the material conditions needed to manufacture a product, such as raw materials, labour (skills), and infrastructure.[9]

Conditions of Circulation/Exchange: concept from the Marxian political economy referring to the rules in which trade occurs, which actors absorb the financial, social and ecological costs of the manufacturing and exchange.[10]

Product Complexity Index (PCI): Ranking of 1224 products developed by Hausman et al. (2014), which classifies products based on the level of productive capabilities and know-how required to manufacture them, with 1 representing the most complex product. In this context, it is a quantitative approximation of the conditions of production.[11]

Economic Complexity Index (ECI): Ranking that classifies countries based on their productive capabilities. It is measured based on the diversity of exports and the comparative complexity required to manufacture them.[12]

Value Addition vs Value Capture

A crucial distinction in the GVC literature is that creating value does not mean capturing it. Within a value chain, value is created through new productive activity that increases the generated value for the

[5] Cuevas Verdin, G., Andrieu, B., & Cullen, J. M. (2025). The Critical Minerals Value Addition Myth: Why Mineral-Rich Countries may Struggle to Realize Added Value. Available at SSRN 6135631. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=6135631

[6] Feenstra, R. C. (1998). Integration of Trade and Disintegration of Production in the Global Economy. *The Journal of Economic Perspectives*, *12*(4), 31–50. http://www.jstor.org/stable/2646893

[7] Gereffi, G. (1994) 'The Organization of Buyer-Driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks', in G. Gereffi and M. Korzeniewicz (eds), *Commodity Chains and Global Capitalism*, Westport: Praeger, pp. 95–122.

[8] Coe, N. M., Dicken, P., & Hess, M. (2008). Introduction: global production networks—debates and challenges. *Journal of Economic Geography*, *8*(3), 267–269. http://www.jstor.org/stable/26161249

[9] Baglioni, E., & Campling, L. (2017). Natural resource industries as global value chains: Frontiers, fetishism, labour and the state. *Environment and Planning A: Economy and Space, 49*(11), 2437–2456. https://doi.org/10.1177/0308518X17728517

[10] Ibid

[11] Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). The atlas of economic complexity: Mapping paths to prosperity. Mit Press.

[12] Ibid

networks as a whole.[13] On the other hand, value capture refers to how value is retained and distributed among GVC participants, and the rules under which this occurs.[14] Therefore, participation in new segments of the value chain does not necessarily guarantee greater value capture that can be reinvested into objectives that create long-term benefits.

An example of this can be seen in the electric vehicle market (EV), which in 2023 had an estimated value of US$7,000 billion, unequally distributed across stages and GVC participants. According to estimates, the extraction of cobalt, lithium, and nickel used in EVs accounts for only 0.6% of value capture, and even when mineral smelting and processing are included, value capture reaches only 1.1%, as shown in Figure 1.

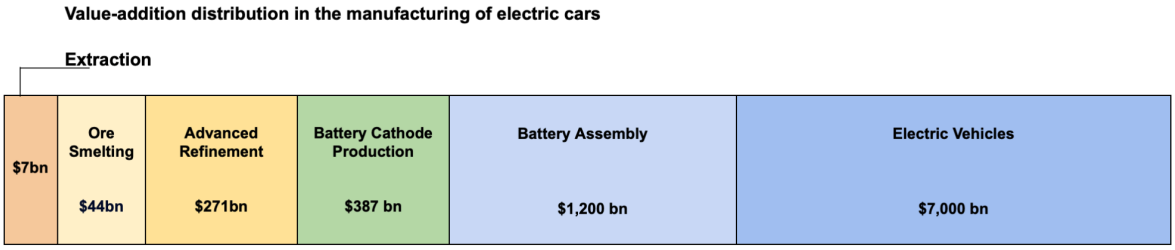


Figure 1: Value pool of the EV Value chain based on data retrieved by Heinrich Boll Stiftung Ecology Center in Pickles (2023).[15]

2.1 GVC Stages and the Complexity Requirements for Participation

The copper value chain, like many of the other critical minerals, is an additive one in which production is internationally fragmented across five main areas shown in Figure 2: 1) extraction, 2) processing, 3) component manufacturing, 4) product manufacturing and 5) recycling. While extraction and processing are concentrated in LMICs (Chile, DRC, Peru), value-added segments such as copper wire manufacturing are controlled by high-income countries like Germany, the United Arab Emirates and Canada.[16]



Figure 2. Stages of the CMs value chain. Excluding exploration and mining development services.

[13] Sako, M. and Zylberberg, E. (2017). Supplier strategy in global value chains: shaping governance and profiting from upgrading. Socio-Economic Review, 17(3), 687-707. https://doi.org/10.1093/ser/mwx049
Blome, C., Manning, S., & Schleper, M. (2022). The contest for value in global value chains: Correcting for distorted distribution in the global apparel industry. Journal of International Business Studies, 53(8), 1836-1840. https://doi.org/10.1057/s41267-022-00541-7

[14] Ibid

[15] Pickles, S. (2023, noviembre). *Value Addition in the Context of Mineral Processing* (E-paper). Heinrich Böll Foundation. https://www.boell.de/sites/default/files/2023-12/e-paper_value-addition-in-the-context-of-mineral-processing_endf2.pdf

[16] United Nations Conference on Trade and Development. (2025, May 1). *Global trade update (May 2025): Focus on critical minerals—Copper in the new green and digital economy*.https://unctad.org/publication/global-trade-update-may-2025-critical-minerals-copper#:~:text=Just%20one%20country%20%E2%80%93%20China%20%E2%80%93%20imports,are%20more%20complex%20and%20profitable.

To assess the complexity of production requirements across different stages of the copper value chain, we mapped the different stages (from copper ore extraction to advanced manufacturing and recycling) on the horizontal axis, and the complexity levels measured by the Product Complexity Index (PCI) on the vertical axis. The products on the x-axis are selected products used in the electric vehicle manufacturing. Overlaying this graph, we identified the top ten countries with the largest copper reserves (according to the 2025 US Geological Survey Summary) and ranked them by their Economic Complexity Index (ECI). While this is only an approximation of productive capabilities, this graph allows us to highlight where countries are more likely to participate in the value chain based on their current productive capabilities. While we recognise that the PCI and ECI values are not directly comparable in magnitude, they provide a proxy for illustrating "conditions of production" across the copper industry.

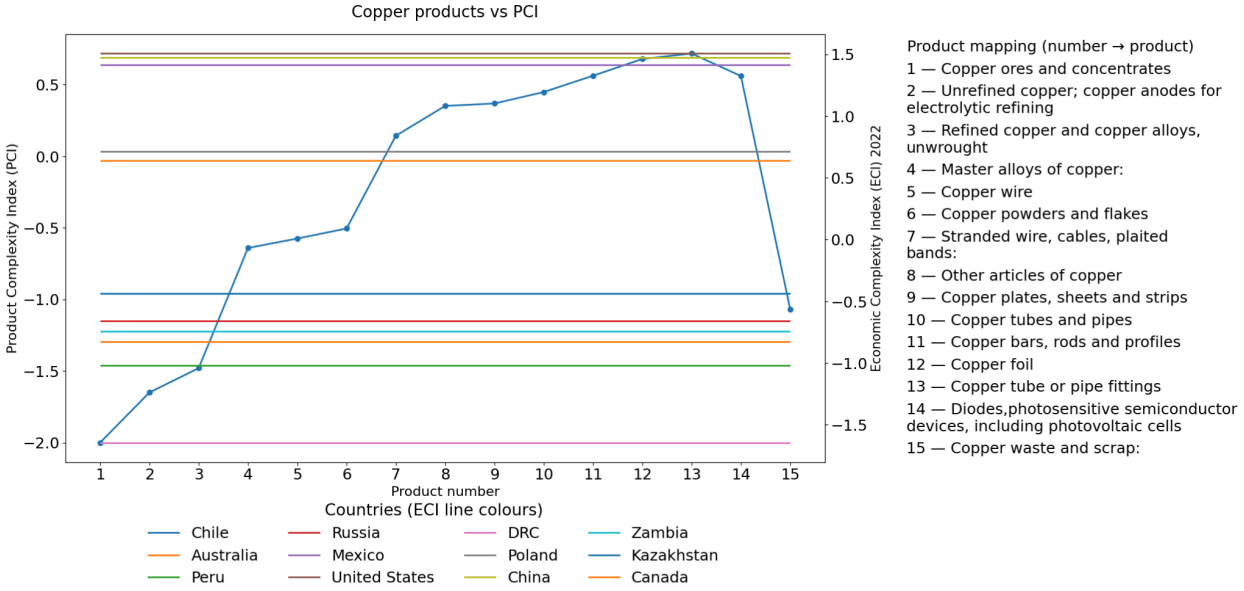


Figure 2. Graph comparing product complexity across electric vehicle value chain stages (PCI) with the economic complexity of top copper-reserve countries (ECI), illustrating feasible points of participation within the copper production systems.

Country	Economic Complexity Index (ECI) 2022	Mineral reserves measured in kilotons (kt)	Current capacity within the value chain[17]
Kazakhstan	-0.4352462	20000	Mineral extraction and with limited processing
Zambia	-0.74501723	21000	Mineral extraction
China	1.4706259	27000	All stages of the value chain
Poland	0.71279025	30000	Limited processing capacity
USA	1.5055896	48000	Component manufacturing capacity (4th Copper wire exporter)
Mexico	1.4144905	53000	Early Component Manufacture, (Important Exporter of Copper Mattes) and also participates in Copper Recycling
Russia	-0.6593752	61000	Mainly focused in copper processing
Peru	-1.0201774	92000	Mineral extraction and with limited processing
Australia	-0.8247082	97,000	Mineral extraction and processing

[17] UNCTAD. (2025). Global Trade Update - Focus on critical minerals: Copper in the new green and digital economy (UNCTAD/DITC/INF/2025/3). Retrieved from: https://unctad.org/publication/global-trade-update-may-2025-critical-minerals-copper

Chile	-0.43513533	200000	Mineral extraction and processing

Table 2. Summary of values of the graph along with the current capacity within the copper value chain.

Results showed an increasing level of complexity at each stage, with a slight decline at the recycling stage. Countries showed consistent participation results across product and country complexity, except for Mexico. The country has a highly complex economy, with levels comparable to those of China and the United States, making it, in theory, capable of joining the highest-value-added stages of the value chain. This result highlights that even high levels of economic complexity alone do not guarantee value-chain participation or influence over the GVC governance or "conditions of exchange."

2.2 Capacity is not enough: the role of GVC governance and ownership

We evaluated "conditions of exchange" at the early stages of the value chain to better understand whether the ten major reserve-holding nations studied in the previous step can capture value at the right levels of complexity. Figure 3 shows mine ownership data, extraction volumes, global trade flows, and final copper consumption. This approach traces the flow of metals from the point of extraction through complex global supply chains to final consumer products by integrating corporate equity data from S&P Capital IQ Pro with the GLORIA multi-regional input-output database.[18]

Results revealed that GVC "lead participants" at the value-added sections of the value chain, such as Australia, Canada, Poland, China, the United States, and Russia, also have high ownership control in the upstream sectors.

Such levels of corporate control over copper extraction have a significant impact on the development of subsequent stages of the critical mineral value chain and on the conditions of trade and access to finance for LMICs.

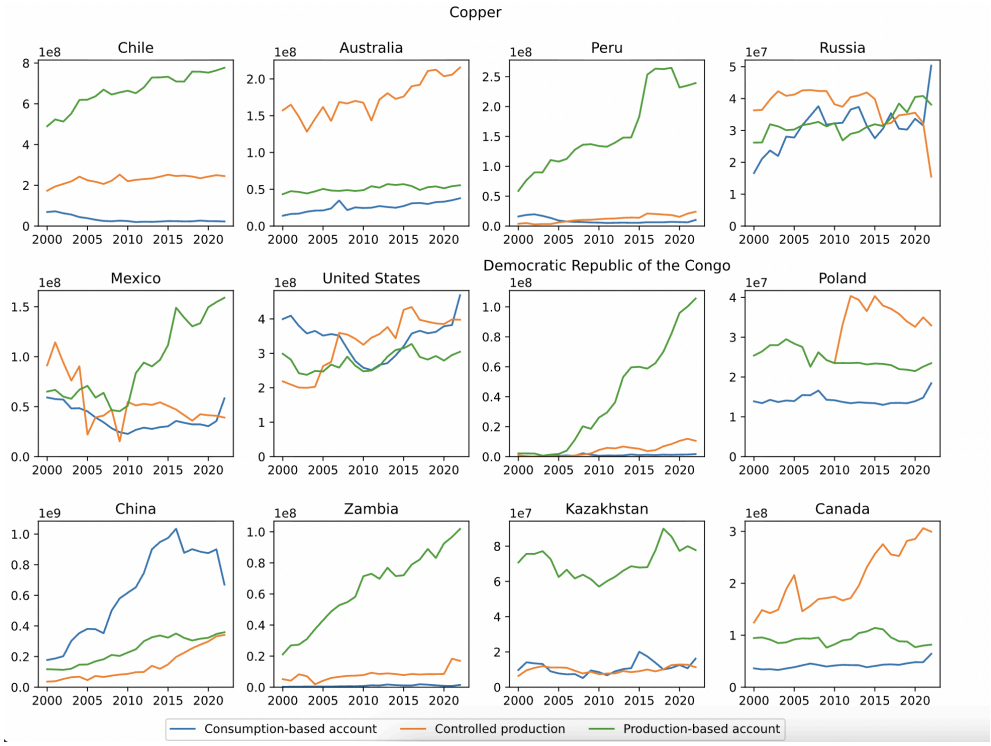


Figure 3. Consumption-based account, controlled production and production-based account of copper

[18]Andrieu, B., Cervantes-Barrón, K., Pant, R., Barzin, S., Heydari, M., Parpan, G., & Cullen, J. (2026). The impact of mine ownership on trade of metal ores. *Resources, Conservation and Recycling*, *225*, 108647.

3. Key Findings

1. Mineral-Rich Countries' Economic Complexity Profiles Are Diverse and Often Insufficient for Downstream Stages

The PCI analysis showed that, except for Mexico, LMICs with copper reserves can only participate in the extraction and processing sections of the value chain. While there is general optimism that rising demand and investment can lead to industrial upgrading, this process depends on long-term structural transformation, often influenced by domestic factors such as existing productive capabilities and international governance factors that determine access to finance and control over resources (ownership). Consequently, selective industrial policy and capability-aligned upgrading may lead to better outcomes than ambitious but unrealistic downstream strategies.

2. Ownership and GVC Structures Limit Value Capture for Most Mineral-Rich Countries: Value Addition does not equal value capture

Ownership analysis revealed that even in cases with high productive capabilities, extraction is often controlled by multinational companies headquartered in HICs, limiting the value redistribution that can be reinvested and directed towards LMIC value upgrading initiatives. Therefore, control at the extraction stage limits domestic reinvestment, technological learning, and strategic autonomy, crucial for value-upgrading initiatives and for value capture in downstream activities, even if achieved.

3. Time Constraints of the Energy Transition and Value Beyond Economic Terms

While mineral demand will increase during the energy transition decades, technological change, such as recent shifts in battery cathode chemistries, recycling, and second-life efforts, may reduce future demand for some minerals,[19] exposing countries to commodity busts and resource traps.
The duration of the CMs demand boom may not be sufficient to offset the economic, social, and environmental risks of rapid resource-led industrialisation. Such costs need to be compared to the promise of long-term socioeconomic development along the energy transition timeline.

4. Conclusion and Policy Implications

Despite the optimism surrounding the rise in demand for critical minerals, it is important to consider that CMs are part of broader GVCs in which participation depends on "pre-existing conditions of production and value capture on broader GVC "conditions of exchange."
GVC participation in itself may not lead to value capture as it is dependent on the "conditions of exchange" dictated by lead participants, in this case China and major Western economies, who not only retain control of the downstream stages of production, but also have major ownership of mines, and capital needed for value-addition initiatives.
Therefore, making CMs an opportunity in development requires significant changes to GVC governance, such as:

[19] Wesselkämper, J., Hendrickson, T., Lux, S., & Delft, S. (2025). Recycling or Second Use? Supply Potentials and Climate Effects of End-of-Life Electric Vehicle Batteries. Environmental Science & Technology, 59(30), 15751-15765. https://doi.org/10.1021/acs.est.5c01823

4.2.1 Trade and Investment Policy Flexibility

- Open space for industrial policy in trade agreements: Currently, many international trade agreements limit countries' ability to implement local content requirements, export controls, and technology transfer obligations.[20] Such restrictions should be limited or removed when extraction is aligned with energy transition goals.

4.2.2 Favourable International Development Finance

- Besides access to finance, countries with resources should be able to develop and benefit from their critical mineral sectors without incurring debt or coercive external pressures. Currently, a major component of green finance flows, from both major Western economies and China, is debt-based instruments, limiting countries' ability to capture value at the value-added stages of the value chain.[21] Furthermore, there have been reports of weaponised use of international aid by major economies to get mining concessions in LMICs.[22]

4.2.4 New International Regulations to Guarantee Responsible Corporate Ownership Structures and Transparency in Value Distribution

- Create flexible provisions for critical minerals in Investors-State Dispute Settlement (ISDS) mechanisms. Currently, ISDS limit governments' capacity to modify royalty regimes and beneficiation, even in contexts where extraction is happening to support the energy transition.
- Embed development requirements in ESG frameworks. Value distributions should be a central part of corporate social responsibility when it comes to critical minerals
- Align the Paris Agreement and other International Law Governance provisions with Critical Mineral Governance.
- Expand transparency initiatives and reporting requirements, such as EITI, to create a fairer level playing field for LMICs with mineral reserves.[23]

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[20] Tarh, B. (2018). Assessing the Paradox and Opportunities of Local Content Under the International Trade and Investment Legal Framework: A Lesson From Cameroon.. International Journal of Advanced Research, 6(11), 891-916. https://doi.org/10.21474/ijar01/8076
Collins, D. (2016). Government Procurement with Strings Attached: The Uneven Control of Offsets by the World Trade Organization and Regional Trade Agreements. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2747284

[21] Bracking, S. and Leffel, B. (2021). Climate finance governance: Fit for purpose?. Wiley Interdisciplinary Reviews Climate Change, 12(4). https://doi.org/10.1002/wcc.709

[22] Green, A. (February, 2026). "US accused of 'shameless exploitation' over proposed Zambian health aid deal."The Guardian. Retrieved from: https://www.theguardian.com/global-development/2026/feb/25/zambia-us-health-aid-deal-exploitation-mining-concessions-data-sharing-targets

[23] Tang, S., Elfenbein, D., & Pasipanodya, T. (2025). Self‐regulation, corruption, and competitiveness in extractive industries: Making transparency pay. Strategic Management Journal, 46(12), 2945-2974. https://doi.org/10.1002/smj.70001

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