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Capital in the Twenty-First Century:

Who Owns the Capital of Firms Producing Critical Raw Materials?

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ABSTRACT

This paper analyses who controls the capital of global listed companies involved in the mining of critical raw materials (CRM). While the very high geographical concentration of resources is well documented, the ownership interests in extractive companies is less so. Yet documenting the sources of control of mining companies is essential for assessing strategic dependencies. We contribute to fill this gap by developing a detailed database documenting the origins and characteristics of shareholders of global listed companies involved in the mining of cobalt, copper, lithium, nickel and rare earths. We designed several indicators for the sake of robustness, including production- and market capitalization-weighted holding rates, complemented by indicators focusing on majority holdings thresholds. In fact, holding shares above a certain threshold allows investors to exert a strong influence on the decisions of their executive boards. We highlight the discrepancy that can prevail between the geographical distribution of production and that of investors. We also document the preponderance of strategic investors like state-owned enterprises in the ownership of CRM firms. All indicators suggest that non-EU investors control a significant share of the capital of the leading CRM mining companies. Our results underpin the need to enhance the EU's strategic autonomy and suggest a need for a metal-specific strategy.

Keywords: Energy Transition, Critical Raw Materials, Geo-Economic Fragmentation, Ownership, Economic Security, Strategic Autonomy.

JEL classification: Q02, Q5, Q42, L72, G3, Q3.

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NON-TECHNICAL SUMMARY

The European Union (EU) has enacted recent legislation aiming at increasing the security of its supplies in critical raw materials (CRM) and make itself more strategically autonomous (Critical Raw Material Act, 2024). While the energy transition will require large quantities of CRM, mining and processing of CRM is geographically concentrated in countries that are geopolitically distant from the EU. For instance, 73% of all cobalt is mined in the Democratic Republic of the Congo (DRC), 69% of rare earth elements are mined in China and half of the global nickel supply is mined in Indonesia (USGS, 2023). The concentration of supply raises concerns that dominant countries may use their market position as leverage to pursue other strategic priorities, highlighting an urgent need to strengthen the EU's raw material strategy.

Against this backdrop, this paper analyzes who controls the capital of global listed companies involved in the mining of CRM. While the geographical concentration of resources is well documented, the ownership interests in extractive companies is less so. Yet documenting the sources of control of mining companies is essential for assessing strategic dependencies. We fill a gap in literature by designing a comprehensive database documenting the origin of shareholders of global listed companies involved in the mining of cobalt, copper, lithium, nickel and rare earths. We develop several indicators to map the geographical origin of capital-owners, including production- and market capitalization-weighted holding rates, complemented by indicators focused on majority holdings. All indicators suggest that non-EU investors control a significant share of the capital of CRM listed mining companies. Figure 1 summarises ownership rates by investor origin for the five selected metals.

Figure 1. Production-weighted holding rate in CRM mining companies

	China	United States	European Union	United Kingdom	Canada	Australia	Latin America	Africa
Cobalt	28%	12%	4%	5%	1%	6%	1%	16%
Copper	17%	27%	7%	8%	3%	5%	22%	2%
Lithium	19%	31%	2%	5%	1%	4%	20%	0%
Nickel	18%	16%	18%	5%	6%	8%	5%	3%
Rare earths	73%	15%	0%	2%	0%	6%	0%	0%

Note: The EU's holdings in the nickel mining sector, which includes an estimated 14% share for Russian investors, is closer to 4% when excluding European investors representing Russian interests. The EU's holdings in the cobalt mining sector, which includes an estimated 3% share for Russian investors, is closer to 1% when excluding Cypriot investors representing Russian interests.
Sources: Refinitiv and authors' calculations, data for 2022.

China's leading position is especially notable in the extraction of rare earths, cobalt and, to a lesser extent, lithium. By contrast, European investors hold limited stakes in CRM mining companies. The EU's relatively high stake in the nickel sector partly reflects investments located in Cyprus representing Russian interests. Besides China, investors from the United States also have significant holdings, especially in the lithium and copper sectors. Although Latin American investors hold a significant share of the capital of firms producing lithium and copper, they are underrepresented with respect to the region's share of global production. The weight of Australian investors is also relatively

limited for lithium, given the importance of the country's lithium resources. While Australia accounts for half of the world's lithium production (USGS, 2023), two of its biggest lithium mines are owned by Chinese companies. Hence, we highlight the discrepancy that can prevail between the geographical concentration of production and that of investors analysed through firm ownership. US investors, and, to a lesser extent, EU and UK investors, play a higher role in the copper and lithium supplies, compared with the production located in their respective countries. By contrast, Chinese investors have significant stakes in nickel and cobalt companies, while these minerals are predominantly mined in Indonesia for nickel and the DRC for cobalt. In contrast, for rare earths, production and capital ownership are aligned, with both the US and China being major producers and investors.

We also document the preponderance of strategic investors such as state-owned enterprises in the ownership of firms involved in the mining of rare earths, and, to a lesser extent, in the mining of cobalt, lithium and copper. Our results suggest that Chinese investors are overwhelmingly strategic investors, which concurs with literature. Strategic investors also play an important role in the exploitation of lithium and copper resources located in Latin America.

Overall, our analysis underpins the need to enhance the EU's strategic autonomy and suggests the need for a metal-specific strategy. In particular, the database could be valuable for informing investment decisions, should European entities wish to increase their shareholdings in major CRM firms.

Le capital au XXIe siècle : qui détient le capital des entreprises extractives de matières premières critiques ?

RÉSUMÉ

Cet article analyse la détention du capital des principales entreprises cotées impliquées dans l'extraction de matières premières critiques (MPC). Si la très forte concentration géographique des ressources est bien documentée, la question du contrôle du capital des entreprises extractives est en revanche peu explorée, alors même que cette question est cruciale pour évaluer les dépendances stratégiques. Nous avons construit une base de données détaillée documentant l'origine géographique et les caractéristiques des actionnaires des entreprises minières cotées de cinq MPC (cobalt, cuivre, lithium, nickel et terres rares). Par souci de robustesse, nous élaborons plusieurs indicateurs de détention du capital, tels que des indicateurs pondérés par la capitalisation boursière ou par la production mondiale de MPC. Pour compléter cette analyse, nous élaborons des indicateurs reposant sur des seuils de contrôle, notamment des seuils de détention majoritaire. Nous soulignons l'écart entre la distribution géographique de la production et celle des investisseurs. En outre, nous montrons la prépondérance des investisseurs stratégiques, tels que les entreprises d'État, dans la détention du capital des entreprises minières. Nos différents indicateurs concordent : les investisseurs extracommunautaires contrôlent l'essentiel du capital des entreprises extractives de MPC. Nos résultats mettent en évidence la nécessité de renforcer l'autonomie stratégique de l'UE et d'élaborer une stratégie adaptée à chaque MPC.

Mots-clés : transition énergétique, matières premières critiques, fragmentation géo-économique, actionnariat, sécurité économique, autonomie stratégique.

1 Introduction

The European Union (EU) has enacted recent legislation aiming at increasing the security of its supplies in critical raw materials and make itself more strategically autonomous (Critical Raw Material Act, 2024).[1] Moreover, the 'Fit for 55' strategy seeks to reduce the EU greenhouse gas emissions by 55% by 2030 compared with 1990 levels, while achieving climate neutrality by 2050. While recent crises have underlined EU strategic dependencies, the EU heavily relies on imports of critical raw materials from a limited number of third countries. While the CRM act sets out ambitious production and diversification targets, the EU accounts for only 2% of the world's mineral exploration investment (Hache and Normand, 2024), suggesting an urgent need to strengthen its raw material strategy. Mining and processing of CRM is geographically concentrated in countries that are not politically aligned with the EU. For instance, 73% of all cobalt is mined in the Democratic Republic of the Congo (DRC), 69% of rare earth elements (REE) are mined in China and half of the global nickel supply is mined in Indonesia, according to data from the U.S. Geological Survey (USGS, 2023). The geographic concentration of supply raises concerns that dominant countries may use their market position as leverage to pursue other strategic priorities (Buysse and Essers, 2023). In addition, a few mining companies wield control over a significant share of global production. For instance, respectively four and five companies control half of the supply of cobalt and nickel (IRENA, 2023). The concentration of supply makes the EU vulnerable to supply disruptions and geopolitical risks.

This paper analyzes who controls the capital of the main listed companies involved in the mining of CRM, a hitherto little explored area. While the geographical concentration of resources is well documented (Buysse and Essers, 2023; IRENA, 2023), the ownership interests in extractive companies is less so. While IEA (2024) assesses production by ownership for four CRM, it only focuses on the leading owner company's headquarter location and does not provide a comprehensive analysis of the shareholders of such companies. Yet documenting the sources of control of mining companies is essential for assessing strategic dependencies. Building on Leruth et al. (2022), we design a comprehensive database documenting the origin of shareholders of global listed companies involved in the CRM sector. We develop several indicators to map the geographical origin of capital-owners and the share of non-European investors. For each

[1] In this paper, "critical raw materials" refers to minerals and metals highly important as inputs for the energy transition, including but not limited to cobalt, copper, graphite, lithium, nickel and rare earth elements.

raw material, capital holdings by investors in each company are weighted by the share of the company's production in world production in 2022. We show that leading mining companies are mainly controlled by investors from outside the EU. We highlight the discrepancy that can prevail between the geographical concentration of production and that of investors. Results are robust to the use of alternative weighting schemes (production and market capitalization). We also analyze shareholdings thresholds to document the influence on executive boards of investors from countries geopolitically distant from the EU. Indeed, holding shares above a certain threshold (such as 50%) allows investors to exert a strong influence on the decisions of a corporation. Finally, we document the role of strategic investors.

The remainder of the paper is organized as follows. Section 2 presents the background and the motivation behind this work, specifically the strong mismatch between current CRM supply and foreseen demand, against the backdrop of geographically-concentrated production. In Section 3, we stress the role of firms concentration and capital control to better assess the CRM market structure. In Section 4, we construct a new database mapping the ownership of major mining companies and highlight our main results, based on several measures of geographical distribution of shareholders. Section 5 highlights policy implications. Section 6 concludes and sets out avenues for further research.

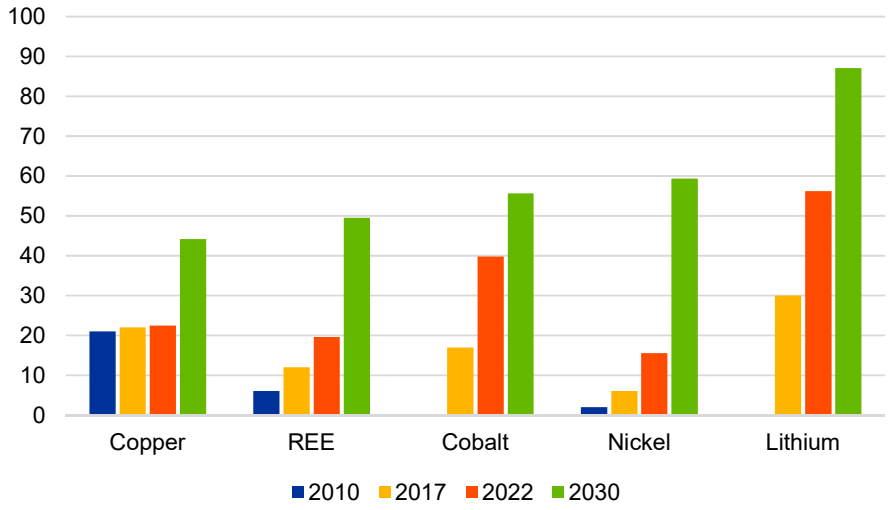
2 Risks to the EU's supply of critical raw materials

2.1 The energy transition will dramatically increase demand for critical raw materials

Technologies essential to the energy transition, such as wind turbines, fuel cells, batteries and power grids, require large quantities of certain raw materials, grouped under the term "critical raw materials" (CRM). Producing an electric car requires six times more CRM than a conventional vehicle, while producing energy from an onshore wind farm requires twice as many CRM as a nuclear power station (IEA, 2021). As a result, the build-out of clean energy technology and infrastructure will greatly increase demand for CRM. The technologies needed for the energy transition already account for a significant share of total CRM demand (Figure 1). This share is set to rise further: projections by the International Energy Agency (IEA, 2023) and the European Commission (EC, 2023a) suggest that the increase in global demand for CRM will be mainly driven by the roll-out requirements of electric vehicles and power grids. These

projections are subject to considerable uncertainty, such as that associated with the level of ambition of decarbonization policies and the difficulty in predicting technological developments or consumer preferences. Despite significant differences in the scope and volumes of projected demand, the EC and IEA projections concur on the overall assessment. The increase in demand for CRM would be particularly strong for copper, cobalt, lithium, nickel, natural graphite and rare earth elements[2] (see Appendix B, Figure B1). In the remainder of the paper, we focus on the aforementioned CRM for which demand is expected to grow fastest, suggesting supply tensions in the medium term.

Figure 1: Global demand for CRM due to the energy transition (% of total demand)



Note: energy transition technologies account for 56% of global lithium demand in 2022. This share is expected to reach 87% in 2030 under an ambitious climate transition scenario (Net zero CO_2 emissions by 2050). Neodymium demand is used as indicative for rare earth elements (REE). The five metals are ranked according to the relative values they are projected to reach by 2030.

Sources: IEA (2023) and authors' calculations.

2.2 The notion of criticality covers a wide range of risks

There is no universally accepted definition of critical materials. While a number of jurisdictions have drawn up lists of critical materials, the factors for determining criticality remain location-specific (IRENA, 2023).

The notion of criticality encompasses several risks. Some are economic in nature, reflecting

[2]Rare earths elements encompass some fifteen elements, which fall into two categories: "*heavy*" rare earths (dysprosium, erbium, europium, gadolinium, holmium, lutetium, terbium, thulium, ytterbium, yttrium) and "*light*" rare earths (cerium, lanthanum, neodymium, praseodymium and samarium) to which is also added scandium.

the concentration of supply and the market power of CRM suppliers. The mining of CRM is highly concentrated in specific countries. For example, 70% of cobalt is mined in the Democratic Republic of the Congo; 77% of natural graphite in China; 50% of nickel in Indonesia; 48% of lithium in Australia and 23% of copper in Chile (USGS, 2023). Mineral processing is even more concentrated, with China playing a dominant role (IRENA, 2023).

Some CRM also suffer from significant geological limits. Known resources may prove insufficient to meet growing demand. In addition, raw materials production entails environmental risks, including pollution and pressure on water resources.

Geopolitical dynamics are a major source of risk to the supply of CRM, resulting from the heavy dependence on imports from a limited number of countries and state actors (IMF, 2023). Political instability in a producer country can lead to supply disruptions, particularly in the case of CRM concentrated among a few players, such as rare earth elements and cobalt. IRENA (2023) has identified six sources of geopolitical risks to the supply of CRM:

- **External shocks** which include natural disasters, pandemics, wars, mine accidents, etc.;
- **Resource nationalism** which can entail tax regime strengthening, royalty renegotiation, creation of state-owned mineral companies, nationalisation of critical material industries and restrictions on foreign investments;
- **Export restrictions** which can take the form of export quotas, export taxes, obligatory minimum export prices, or licensing. Incidences of export restrictions have grown five-fold over the past decade, according to Kowalski and Legendre (2023).
- The formation of **mineral cartels** that could potentially result from the high concentration of mineral production;
- **Political and social instability** in producing countries (including coups, labour strikes and civil wars), the majority of minerals being extracted in countries categorised as unstable in the Worldwide Governance Indicators;
- **Market manipulation**, including short squeeze,[3] can exacerbate price volatility and

[3] A recent example dates back to March 2022, when the London Metal Exchange suspended nickel trading after prices surged by over 270% over the course of three trading days. The price surge was attributed to a short squeeze. Large short positions had been built-up by a number of participants well before March 2022. Rising prices led to market participants facing rapidly growing margin calls, which prompted further buying to reduce risk, which in turn drove further price increases, while liquidity on the nickel market had declined (Wyman, 2023).

constrict supply. As mineral markets are narrow and lack liquidity, there are ample opportunities for traders to develop market-cornering positions (IRENA, 2023).

2.3 The EU's supply of CRM is vulnerable to geopolitical risks

The European Commission has identified 34 critical materials (EC, 2023b), selected on the basis of their economic importance for the EU and supply risk (see Appendix A).[4]

Geological, economic, and socio-environmental factors contribute to the concentration of CRM production outside Europe. This geographical concentration exposes the EU to potential supply disruptions and geopolitical risks.

We summarise the criticality of CRM for the EU along three dimensions (see Figure 2):

- **Supply risk**, measured by the degree of the EU's dependence on imports, which tends to be higher at the extraction stage;
- **Geological criticality**, assessed by the projected cumulative consumption of a raw material between now and 2050, in relation to currently known resources;
- **Geographical concentration of global CRM production (mining) and reserves**, assessed by the Herfindahl-Hirschman index (HHI). The HHI is a common measure of market concentration and is used to determine market competitiveness. The HHI is calculated by squaring the market share of each firm i competing in a market and then summing the resulting numbers:[5]

$$\text{HHI} = \sum_{i}^{n} (\text{Market share of country}_i)^2$$

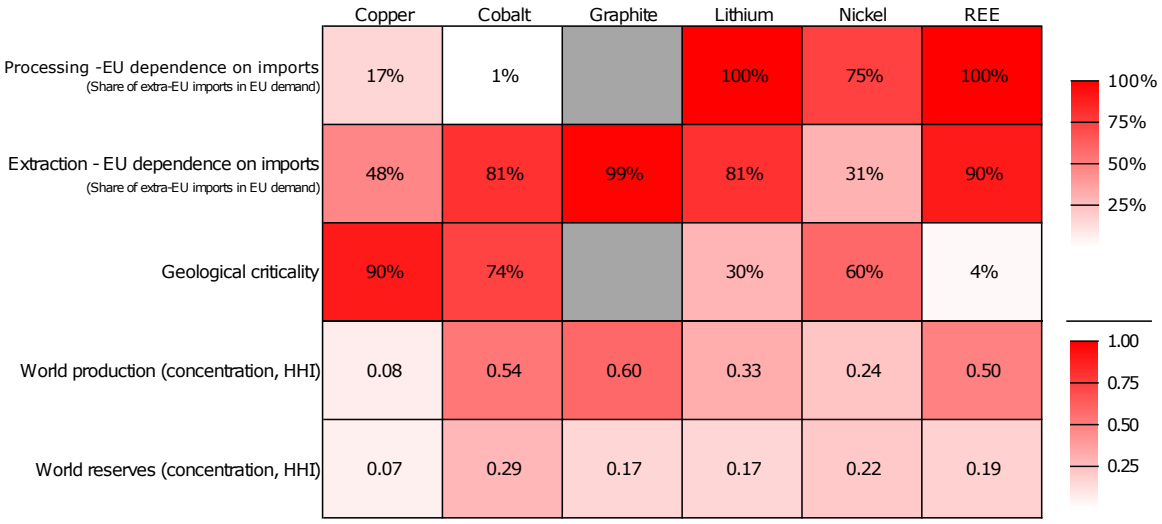
For example, copper, which is crucial for electricity grids, has low production and reserve concentration, limited EU import dependence, but high geological criticality. On the other hand, cobalt, which is essential for batteries and to produce super-alloys, exhibits highly concentrated production, significant EU import dependence, and extreme geological criticality. In contrast, lithium (essential for EV batteries) and rare earths (needed for magnets found inside wind

[4] The EC has also designed a narrower list of 16 raw materials regarded as *"strategic"*, taking into account both the importance of a raw material (i) for achieving the dual transition and (ii) for its security and space-related applications (EC, 2023b).

[5] Consequently, the Herfindahl-Hirschman index ranges from 0 (low concentration) to 1 (high concentration).

turbine generators) have concentrated production and high EU import dependence, but low geological criticality. Overall, reserves are more evenly distributed than production, opening opportunities to diversify the mining and processing of CRM in the long run.[6]

Figure 2: Economic and geological criticality and the European Union's dependence on imports



Note: the darker the red, the more concentrated the supply, the greater the EU's dependence on imports and the greater the geological criticality (missing data in grey).

HHI computed using data from the U.S. Geological Survey do not include the 'other countries' aggregate

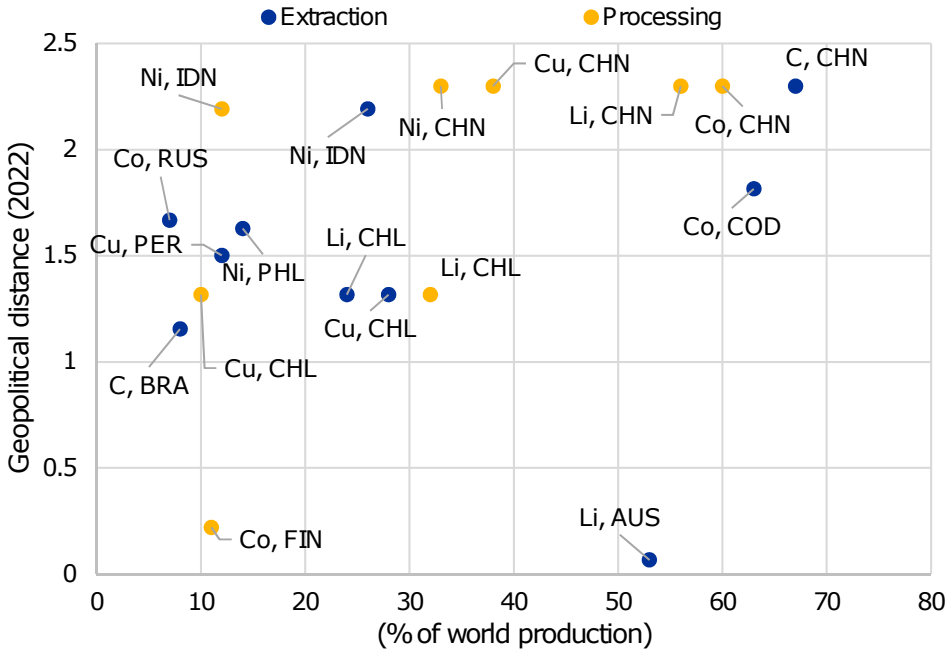
Sources: US Geological Survey, European Commission, IFP Energies nouvelles and authors' calculations (Faubert et al., 2023).

At the extraction stage, and even more so at the transformation stage, the production of CRM is highly concentrated in countries politically distant from the EU. Figure 3 illustrates the concentration of CRM extraction and transformation in relation to the geopolitical distance between the largest European economies (Germany, France, Italy and Spain) and CRM producers.[7] For some minerals such as natural graphite (C) or cobalt (Co), a significant share of global extraction is carried out by countries which are geopolitically distant from the European Union (China and, to a lesser extent, the DRC, which is beset by political instability and armed conflicts).

[6] In addition, large parts of the Earth's crust remain unexplored, opening opportunities for new discoveries (IRENA, 2023)

[7] Geopolitical distance is measured by differences in countries' voting patterns at the United Nations General Assembly (Bailey et al., 2017), using an indicator of "ideal geopolitical distance". This type of indicator, like the randomly corrected dyadic indicators (π-score and κ-score, Häge (2011)), has its limitations but is nonetheless widely used in literature. In particular, these indicators provide little information on regional disagreements between two states, since the UN focuses on global issues. Other indicators of geopolitical distance exist, but they are less widely used (den Besten et al., 2023). Therefore, UN vote-based measures are useful, provided that a state's position on global issues has an impact on the subject of interest.

Figure 3: Share of world production of EU imports (x-axis) compared with the geopolitical distance of CRM producers from the EU (y-axis).



Note: The geopolitical distance reflects state positions toward the US-led liberal order, based on a dynamic ordinal spatial model, using United Nations (UN) General Assembly votes as inputs. The indicator has no unit and ranges from 0 to 6. Only the two main producing countries are shown for each mineral and production stage. C denotes natural graphite, Co cobalt, Cu copper, Li lithium and Ni nickel. AUS stands for Australia, BRA for Brazil, CHL for Chile, CHN for China, COD for the Democratic Republic of the Congo (DRC), FIN for Finland, IDN for Indonesia, PER for Peru, PHL for Philippines and RUS for Russia.

Sources: Bailey et al. (2017), EC (2023b) and authors' calculations.

3 Firms concentration and capital control

3.1 Firms concentration and capital control

The geographical concentration of production is compounded by a concentration of firms controlling the supply of CRM, yielding oligopolistic market structures (IRENA, 2023). A handful of multinational companies and state-owned (SOEs) or -controlled enterprises dominate a considerable share of global production (Eyl-Mazzega and Mathieu, 2019). For instance, the top four mining companies control around 55% of cobalt output, while the top five mining companies control 80% of lithium global output (see Appendix C). The concentration of supply is even more pronounced for REE, where a single Chinese company controls more than 40% of global

output.

Alongside geographical, geopolitical or geological risks, understanding the capital structure of mining companies is important for documenting risks to the supply of critical metals.[8]

Table 1 illustrates the ownership structure of the top five lithium mining companies. Strategic entities control a significant share of the capital of two of the three largest companies (Chile's SQM and China's Ganfeng Lithium).[9] In particular, two strategic entities (Chile's Pampa Group and China's Tianqi Lithium) control half the capital of Sociedad Química y Minera (SQM), the world's second largest lithium company. In some cases, capital is concentrated among a limited number of large shareholders. For instance, five shareholders control more than half the capital of SQM and Pilbara Minerals. Top five investors come from a limited number of countries such as Australia, Chile and China. European investors play only a marginal role, occasionally appearing among the top 20 holders of capital in these companies.

Table 1: Ownership of the top 5 lithium mining companies

	Albemarle (US)	SQM (CL)	Ganfeng Lithium (CN)	Arcadium Lithium (JE)	Pilbara Minerals (AU)
% of global production	26%	23%	15%	11%	7%
% of shares held by strategic investors	0%	48%	38%	0%	9%
% of shares held by top 5 shareholders	27%	64%	35%	29%	54%
% of shares held by top 10 shareholders	37%	79%	37%	35%	64%
% of shares held by top 20 shareholders	48%	89%	41%	41%	67%
% of top 5 shareholders from Australia	100%	0%	0%	0%	89%
% of top 5 shareholders from China	0%	40%	100%	0%	0%
% of top 5 shareholders from Hong Kong	0%	0%	0%	0%	11%
% of top 5 shareholders from Latin America	0%	53%	0%	0%	0%
% of top 5 shareholders from the US	0%	0%	0%	100%	0%
% of top 5 shareholders from the UK	0%	8%	0%	0%	0%

Note: The country of incorporation is shown in brackets. AU refers to Australia, CL to Chile, CN to China, JE to Jersey and US to the United States.

Sources: US Geological Survey (global production), Refinitiv, annual mining company reports and authors' calculations.

[8]The ownership structure of a mining company can impact its risk tolerance (IRENA, 2023), with SOEs being more likely to invest in riskier environments. SOEs that may not be solely driven by profit motives may invest in environments that could be perceived as risky by public-listed companies (Elias T. Ayuk and Ekins, 2020). Chinese SOEs, for example, play an important role in Africa's mining industry, including in countries where weak governance might deter other investors.

[9]Strategic investors tend to invest in companies for strategic benefits rather than just financial returns (see section 4.5.2).

4 Who controls the capital of major mining firms?

Section 3 shows that the geographical concentration of production is compounded by a concentration of firms controlling the supply of CRM. Leruth et al. (2022) highlight the importance of understanding who controls the global supply chains of critical minerals and analyse how major shareholders can affect voting decisions in top mining companies involved in the mining of CRM. In the event of tensions over the availability of resources or geopolitical stress, shareholders in these companies could steer exports towards certain markets to the detriment of others. Analyzing the sources of control of mining companies is paramount for assessing the EU's vulnerability to geopolitical risks. In line with the existing literature (Gulley et al., 2019), we equate influence (or control) over production with ownership share.[10] To document the nationality of shareholders involved in the mining of CRM, we created a comprehensive database of global listed companies. This database is helpful for mapping the origin of decision makers and highlighting the dominant role of non-European investors in extractive companies.

4.1 Data sources

We used several data sources. Information on ownership comes from *Refinitiv Eikon* (hereinafter *Refinitiv*), a private database that records comprehensive financial information on listed companies.[11] Using Refinitiv and additional information from public sources, we selected companies producing one of the five selected critical raw materials. For each company, we retrieved data on capital holders, including details on share ownership and nationality. For subsidiaries or branches, we refer to the parent company's information. Parent firms generally maintain primary control over their branches. Additionally, the metal production data presented in companies' annual reports is consolidated at the parent company level.

We cover the period spanning from 2004 to 2022, at a quarterly frequency. For the sake of robustness, we cross-checked wherever possible the information retrieved from *Refinitiv* with the shareholding data published in the annual reports of extractive companies.

As a robustness check, we also compared our selection of companies involved in the extraction of CRM with literature. A scarce literature focuses on the market structure of mining firms

[10] Control refers to the ability to direct the management and policies of an organization, through ownership of voting securities or otherwise.

[11] Hence, our database does not cover artisanal and small-scale mining (ASM), which is estimated to account for 15% to 20% of the DRC's total cobalt production (Barazi et al., 2017). The share of ASM cobalt production in the DRC's for a given year is highly variable, depending on developments in the industrial cobalt mining sector.

operating in the CRM sector (IRENA, 2023; Buysse and Essers, 2023; Leruth et al., 2022). For the top largest producers, our results concur with other papers. For instance, our ranking of Glencore, China Molybdenum (CMOC) and Eurasian Group as the biggest producers of cobalt is in line with other publications. On the contrary, differences can be sizeable for second-order producers. Such discrepancies may reflect the fast-evolving environment of the CRM industry.[12] Differences may also arise from different interpretations of the ownership structure of companies.[13]

Data from *Refinitiv* is supplemented by information on mineral production at the firm-level, derived from companies' annual reports and cross-checked with public sources such as the United States Geological Survey (USGS). Many mining companies form joint ventures to share the high costs and risks associated with mining operations.[14] In this case, the company's production is calculated pro rata to the share held in the joint venture that governs the mine's operation.

Our database covers a large share of world output (see Appendix D, table D2). This proportion ranges from 63% for cobalt to 90% for rare earths, when we look at publicly-traded companies only. Alternatively, when considering a larger database including non-quoted firms, the coverage rate improves by several percentage points mainly for copper and cobalt, reaching 88% and 90% respectively.[15]

4.2 Caveats

4.2.1 Difficulties in accessing non-listed firm data

Data on ownership provided by the data supplier *Refinitiv* focuses only on listed companies (see section 4.1). Market data is characterised by its availability and reliability, but, on the other hand, a significant part of extractive companies are not publicly traded and are classified as 'private firms'. By not seeking public funding, these companies can avoid disclosing financial

[12] Faced with a sharp rise in CRM demand, the mining landscape is rapidly re-configuring. For example, BHP, a prominent Anglo-Australian mining company is divesting its oil and gas portfolio, repositioning itself as a mining enterprise focused on the energy transition (see: "BHP's offloading of oil and gas assets shows the global market has turned on fossil fuels", accessed 28 December 2023). Increasing demand for CRM is also attracting interest from entities outside their conventional purview. Tesla, the U.S. electric vehicle manufacturer, is establishing a lithium refinery in Texas (see: "Tesla Might Enter Mining Business After All, As It Mulls Sigma Lithium Buyout", accessed 28 December 2023)

[13] For example, Talison Lithium, which operates the Greenbushes massive field (Western Australia), is a joint venture between Albemarle (US) and Tianqi Lithium (CN). We distinguish between these two entities in our analysis, while Leruth et al. (2022) refers only to Talison Lithium in its assessment.

[14] For instance, Rio Tinto declares more than fifty managed and non-managed joint ventures as at 31 August 2023, see: "Joint Venture Beneficial Ownership", Rio Tinto (accessed 23 May 2024).

[15] Although more exhaustive, this broader database is not available in time series.

and operational information, thereby evading costly transparency. This is especially relevant when mining companies face scrutiny over social, health, and environmental issues.

As a result, some developments in the sector may remain below radar, whether market data is only used as a proxy of CRM market power (section 4.3.1). This is the case in the nickel sector, where production is heavily concentrated in Indonesia and extraction is carried out by non-listed companies.

4.2.2 Difficulties in identifying all shareholders

There is one important limitation to the completeness of information available on *Refinitiv*. The percentage of investors for whom information on capital ownership is available varies from company to company, and over time. Ownership is rarely identified for 100% of the shares. Although *Refinitiv* aims to identify as many shareholdings as possible using multiple sources and methods (including shares held by global mutual funds), it is not possible to identify all private or retail shareholders below the notifiable disclosure threshold who, in aggregate, may hold a sizeable proportion of a company's shares.

4.2.3 Difficulties in identifying the ultimate holder

Data on capital ownership may underestimate the share of Russian holdings in extractive companies. These assets are partly held in offshore centres, whereas *Refinitiv* only provides the nationality of first holders (as opposed to ultimate owners). When such offshore centres are located in the EU, this can lead to overestimating the ownership rate of EU investors. This is particularly problematic for the nickel industry[16] and, to a lesser extent, for cobalt and copper.[17] At first glance, our results suggest limited Russian ownership in extractive companies (see Section 4.3 below). By contrast, Leruth et al. (2022) consider that there is strong evidence that the two main investors of GMK Norilskiy nikel are controlled by Russian interests.[18] For the sake of consistency and simplicity, in the remainder of the document, we do not identify the nationality of the ultimate investor, unless there is a serious doubt, in which case we provide specific details.

[16] According to USGS (2023), the Russian Federation accounts for nearly 7% of global production through the company GMK Noril'skiy nikel'.

[17] Less than 5% of global production for both minerals.

[18] Interros Ltd., incorporated in Cyprus and Aktivium, incorporated in the Netherlands account for nearly 84% of the capital of GMK Norilskiy nikel, representing 15% of the total mining sector involved in nickel.

4.3 Measuring the geographical distribution of shareholders

We developed two indicators to measure the geographical distribution of shareholders. The first indicator highlights changes in share ownership over time (section 4.3.1). The second indicator is static. It shows the share of investors from different regions as a percentage of world production in 2022 (section 4.3.2). Both indicators suggest that leading mining companies are mainly controlled by investors from outside the EU.

4.3.1 Capitalization-weighted holding rates and changes in capital ownership over time

First, we consider the share of capital in companies i extracting metal m held by investors from country j, out of the total capital of all companies extracting metal m (see Equation 1):

$$AhR_{j,m} = \frac{\sum_i^n K_{j,i,m}}{\sum_i^n K_{i,m}} \tag{1}$$

with:

- $AhR_{j,m}$ the average holding rate of investors from country j for metal m.
- $K_{j,i,m}$ the capital of company i belonging to investors from country j.
- $K_{i,m}$ the total capital of company i extracting metal m.
- n the number of firms producing metal m.

For all selected critical raw metals except rare earths, China's dominance is relatively recent (Figures 4 to 8).

For **cobalt**, China had limited holdings in cobalt-producing companies until 2013, when that share started to rise steeply. The rise of China reflects its increasing role as an important source of outward foreign direct investment in the aftermath of the global financial crisis, especially for mineral resources and infrastructure in Africa (Gulley et al., 2019).[19] In particular, China's CMOC has acquired increasing stakes in the Tenke Fungurume mine, the second largest cobalt

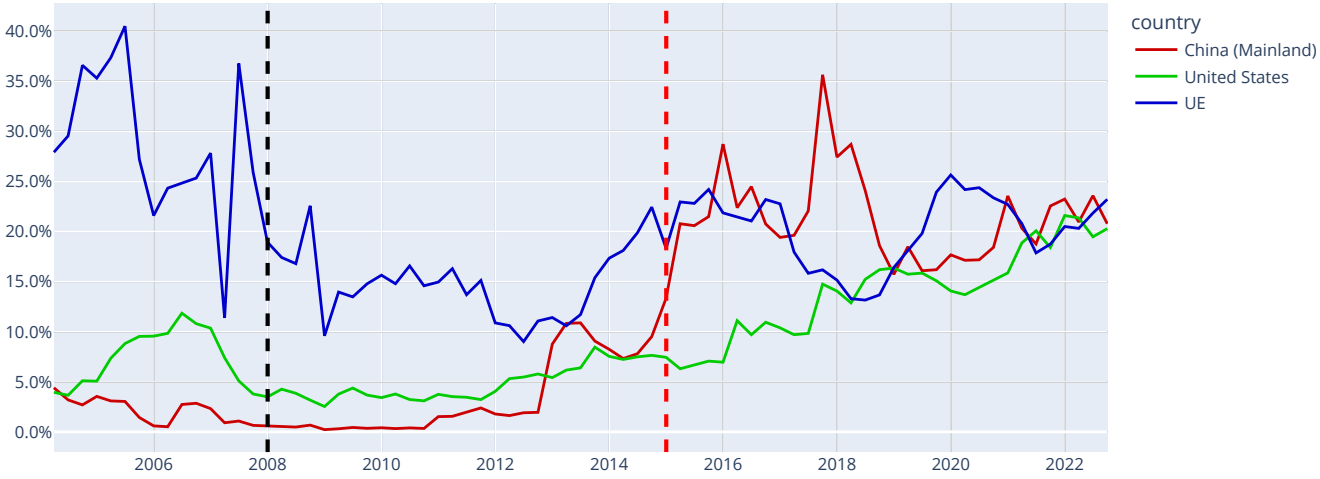
[19] Gulley et al. (2019) document how the China's Going Out Strategy encouraged Chinese companies to expand outward foreign direct investment in companies, assets and infrastructure that produce minerals critical to China's strategic development plans. The 'minerals for infrastructure' deal between China and the DRC is an example of China's resource-seeking behaviour via the Going Out Strategy. In this deal, Chinese state-owned banks provided favorable loans to the DRC government for infrastructure, in exchange for access to copper and cobalt mineral development rights.

mine in the world, from 2016 onwards.[20]

According to our estimates, China's investors owned one-fifth of the capital of cobalt-producing companies in 2022. Similarly, the share values belonging to US investors in cobalt-producing companies have grown from 5% to 20% between 2004 and 2022. This reflects a growing interest in mining activities among investment and fund managers, mirroring the relative decline of South American investors in the mining sector.

Contrasting with the US and China's rising appetite for cobalt-mining firms, the share of European capital-owners has slightly declined from 35% of the capital of cobalt-producing companies in the early 2000s to one-fifth in 2022. However, the seemingly resilience of the European position in the cobalt sector conceals a likely slump in European investment in this area. Indeed, once the holdings of Cypriot investors representing Russian interests are excluded, the share of European investors in cobalt companies drops to 4% (see section 4.2).

Figure 4: Share of capital held by Chinese, US and EU investors in firms producing cobalt as a percentage of total capital of mining companies in the cobalt sector



Note: The first vertical bar refers to the start of the 2008 financial crisis, while the second one accounts for the launch of the Chinese "Belt and Road Initiative" (BRI). The BRI is a global infrastructure development strategy adopted by the Chinese government in 2013 with the aim of investing in more than 150 countries and international organizations (Jones and Zeng, 2019).

Sources: Refinitiv and authors' calculations.

In contrast with other metals, changes in the ownership of **copper** companies are less pronounced (Figure 5). Since 2008, the EU holding rate in copper firms has hovered around 5%,

[20] In 2016, CMOC acquired the 56% stake of Freeport McMoran in Tenke Fungurume Mining. In 2019, CMOC ended up with an 80% stake in Tenke Fungurume Mining.

while US and China holdings have fluctuated respectively between 20-30% and 10-15%. This relative stability masks a rapid reconfiguration in the sector. Since 2004, the copper mining sector has undergone a dual evolution. On the one hand, it has significantly consolidated, with major companies merging to enhance their market position and operational efficiency. On the other, new players have emerged, amid sustained demand.[21] This has resulted in a few large players dominating the market,[22] coupled with a multitude of new "small" entrants.[23]

The modest but significant share held by the EU primarily reflects the activity and ownership of Poland's copper mines. More recently, the influence of German investors has risen. German investors are becoming the largest EU holders of capital in copper extraction companies.

In China, ownership is multifaceted, based on long-standing holdings in regional players (for example, Jiangxi Copper Co Ltd), in regional players that have emerged more recently (for example, CMOC Group Limited), or leading international players that have more recently been added to China's portfolios (for example, Rio Tinto).

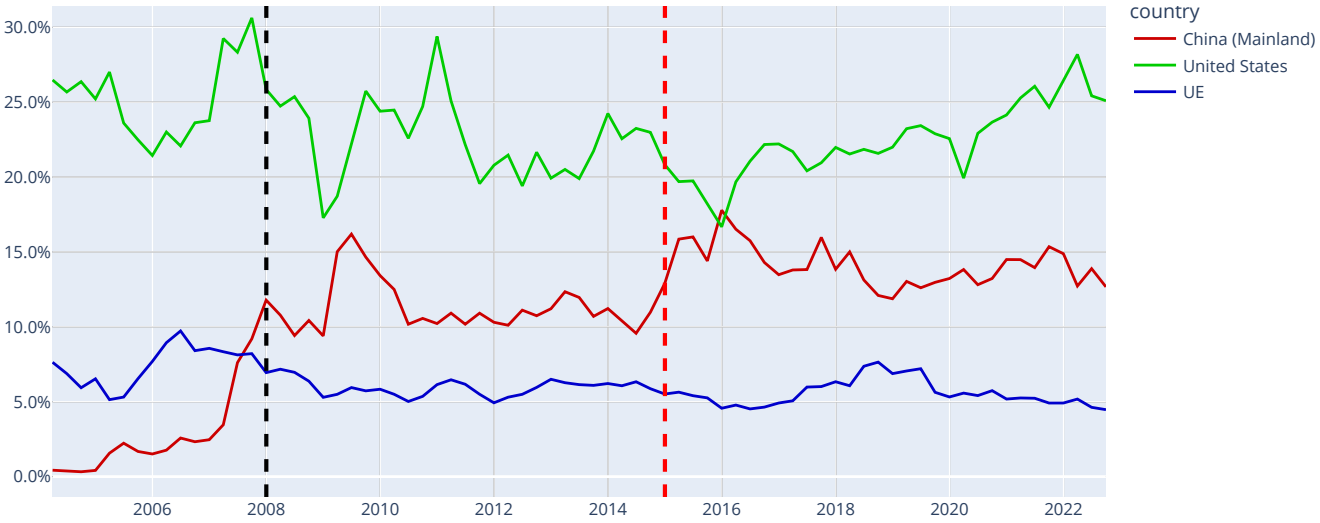
In the US, investment patterns are more regular, with the long-standing presence of large institutional investors such as BlackRock and The Vanguard Group.

[21] Demand for copper is highly volatile, often experiencing significant short-term declines, as evidenced by price fluctuations (ECB, 2018). In the long run, given its wide range of uses, from wiring to wind turbines, electronics or construction, the overall demand for copper is expected to grow steadily.

[22] In 2022, the 10 largest copper-producing companies are estimated to account for two-thirds of the total market capitalization of copper companies.

[23] For example, Tibet Huayu Mining Co Ltd, founded in 2002, was listed on the Shanghai stock exchange in 2016 and reached a market capitalisation of $1.4 billion in 2022 (which can be compared with Rio Tinto's market capitalisation of $90 billion).

Figure 5: Share of capital held by Chinese, US and EU investors in firms producing copper as a percentage of total capital of mining companies in the copper sector



Note: The first vertical bar refers to the start of the 2008 financial crisis, while the second one accounts for the launch of the Chinese "Belt and Road Initiative".

Sources: Refinitiv and authors' calculations.

New **lithium** deposits have been discovered and developed worldwide over the last twenty years. Australia, in particular, has seen rapid growth and has become the largest producer of lithium. Although the country is not the largest holder of companies active in the lithium sector, its share has risen significantly, from around 1-2% in 2004 to almost 8% at the end of 2022. Concurrently, long-standing Latin American producers such as Chile, Argentina and Bolivia (also known as the "Lithium Triangle") have expanded operations (Heredia et al., 2020). Despite the rise in production, in relative terms, South American holdings in lithium companies have somewhat declined over the years.[24] The relative decline of South America reflects China's spectacular rise in the lithium sector, from a stake close to zero in 2004 to almost 20% by 2022, driven by the rapid expansion of Ganfeng Lithium Group Co, which accounted for up to 15% of global lithium production in 2022 (see Appendix C). Its main shareholder, Aluminum Corporation of China Ltd, has expanded sharply its participation in various mining firms.[25]

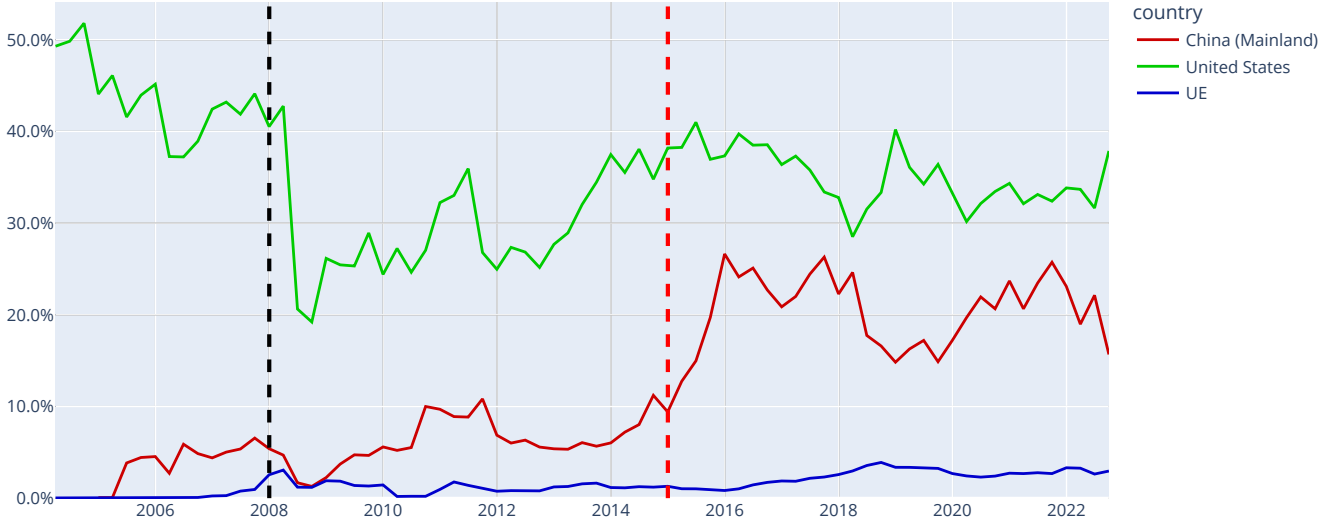
Although extremely modest, the share of lithium companies owned by European investors has grown steadily over the past decade. This reflects growing EU investments in Albemarle, a

[24] Chilean investors are the main shareholders in the lithium sector, primarily through Pampa Group's holdings in SQM (see section 4.2).

[25] Also known as Chinalco, Aluminum Corporation of China Ltd is also the largest identified shareholder of copper mining companies in China. Chinalco is also a leading producer of rare earths (see Appendix C).

leader in lithium production, with investors from Sweden being the EU's largest EU investors in 2022. The rise of Sweden coincides with the Swedish company Northvolt lithium-ion battery plant's intention to secure its lithium supplies.

Figure 6: Share of capital held by Chinese, US and EU investors in firms producing lithium as a percentage of total capital of mining companies in the lithium sector



Note: The first vertical bar refers to the start of the 2008 financial crisis, while the second one accounts for the launch of the Chinese "Belt and Road Initiative".

Sources: Refinitiv and authors' calculations.

The **nickel** mining landscape has undergone significant changes since 2004, with the entry of new players and the formation of strategic partnerships. Notably, automakers and battery manufacturers have been seeking to secure a stable supply of nickel.

China's holdings' rate in nickel firms spiked in 2014, before declining somewhat in subsequent years (Figure 7). This coincided with the launch of a comprehensive Indonesia's nickel strategy, which aims to develop a fully integrated value chain around nickel.[26] However, the decline in Chinese investor ownership since 2014 is a distorted picture of Indonesia's new strategy, as Chinese interests are large and expanding in the Indonesian nickel sector. Notably, numerous mining projects have been launched in Indonesia in recent years, primarily through unlisted companies, which are not included in our estimates.[27] Therefore, figure 7 shows a biased change

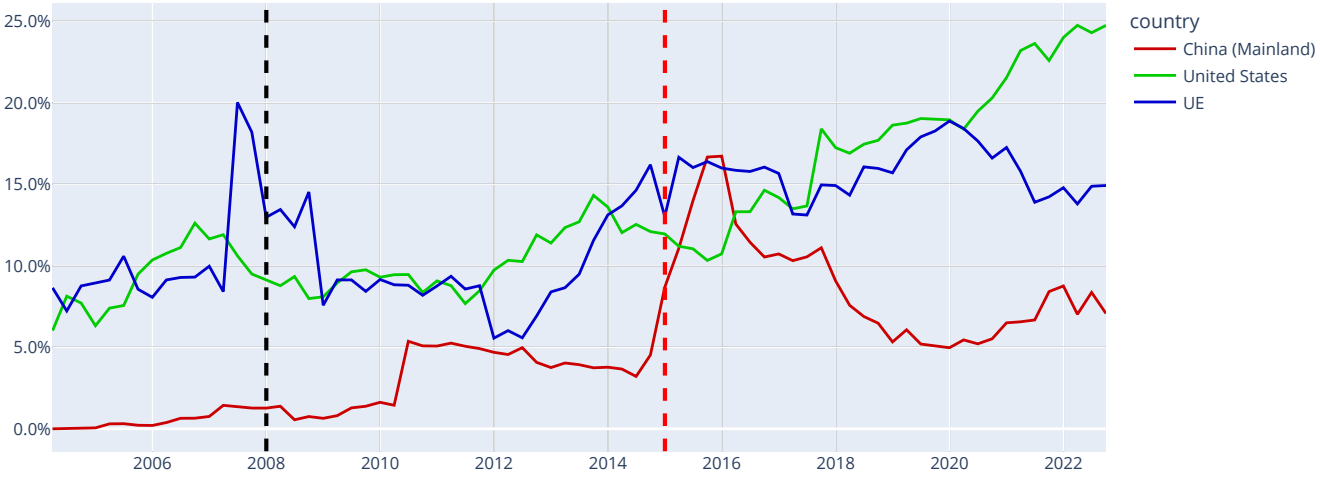
[26] See for instance: "Indonesia's Nickel Industrial Strategy", 8 December 2021, Center for Strategic and International Studies (CSIS). The Indonesian strategy includes a ban on unprocessed nickel ore initially imposed in 2014 (with a temporary lift and subsequent re-imposition in 2020).

[27] Chinese investors acquire substantial stakes in these projects through joint ventures, see for instance: "Indonesia's Nickel Bounty Sows Discord, Enables Chinese Control", 21 March 2024, United States Institute of Peace.

in Chinese interests in the nickel sector, which we seek to correct with a production-weighted approach in section 4.3.2.

The high and increasing share of EU holdings since 2012 very likely reflects Russian assets in this sector (see section 3.1). Excluding these assets, EU holdings are within a range of 4% to 6% of the total capitalization since 2010, with a declining trend since then. This decline likely reflects the difficulties of the company Eramet.[28] However, Eramet remains one of the few companies in this sector partly owned by a European state, with the French Government owning close to 30% of Eramet's capital.

Figure 7: Share of capital held by Chinese, US and EU investors in firms producing nickel as a percentage of total capital of mining companies in the nickel sector



Note: The first vertical bar refers to the start of the 2008 financial crisis, while the second one accounts for the launch of the Chinese "Belt and Road Initiative".

Sources: Refinitiv and authors' calculations.

In 2004, China was already a major player in **rare earths** mining. Its dominance has only increased since then. By the mid-2010s, China was producing over 80% of the world's rare earth elements. Accordingly, 80% of the capital of rare earths companies belonged to Chinese investors from 2007 to 2020 (see Figure 8). In response to China's dominance and the 2010 supply scare, several countries, including the United States, Australia, Canada, started developing rare earth mining projects. Notable projects include:

- **Mountain Pass Mine** (US): this mine was restarted by MP Materials after being closed

[28] While the company lost market share (see: "Indonesia to wipe out global nickel rivals, warns French miner Eramet chief", Financial Times, 15 February 2024), international investors gradually replaced historical ones, (see: "Les déboires du milliardaire français Romain Zaleski", Le Monde, 5 October 2013).

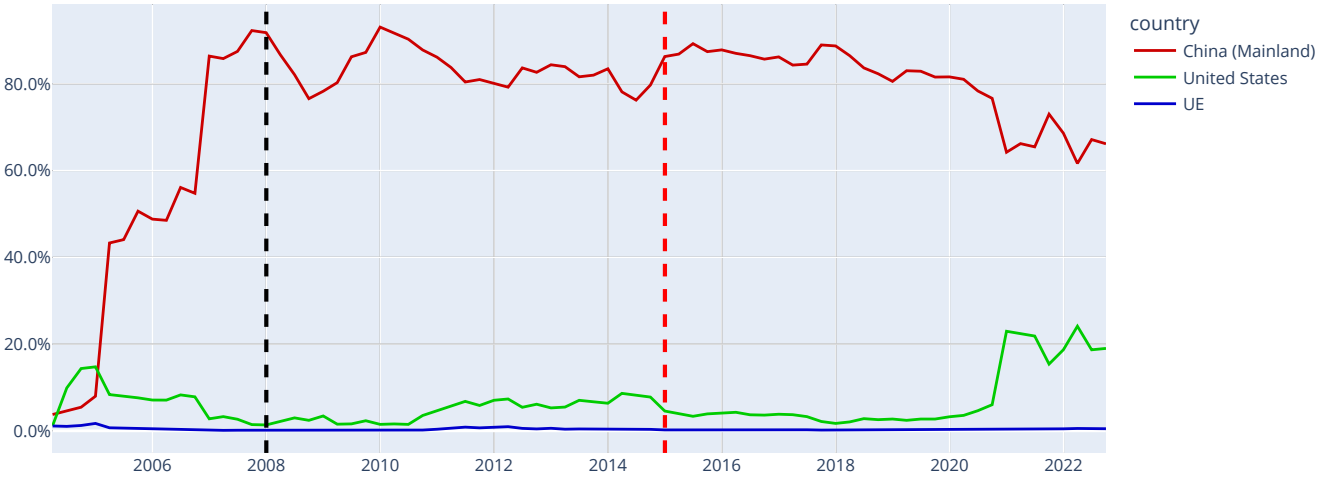
in 2002.

- **Lynas Corporation** (Australia): Lynas is now one of the few significant producers of rare earths outside China, operating the Mount Weld mine.
- **Canada** and **South Africa** are also exploring and developing rare earth projects.[29]

As a result of recent investments (in particular in Mountain Pass Mine), US shareholdings of rare earths mining companies has recently increased, accounting for 20% of the capital of REE-producing firms. On the other hand, the development of projects in Canada, South Africa and Australia, although visible in the increase in capital held by these countries, still represents modest amounts and is unlikely to put an end to China's dominance.

European countries are absent from the capital ownership of REE extractive companies. This could change in the years to come with the recent discovery of large rare earth deposits in Sweden that are to be exploited by LKAB, a 100% state-owned Swedish mining company.[30]

Figure 8: Share of capital held by Chinese, US and EU investors in firms producing rare earth elements as a percentage of total capital of mining companies in the rare earth elements sector



Note: The first vertical bar refers to the start of the 2008 financial crisis, while the second one accounts for the launch of the Chinese "Belt and Road Initiative".

Sources: Refinitiv and authors' calculations.

To sum up, China's dominance is particularly marked for rare earths throughout the period. While the ownership of other CRM extractive companies is less concentrated, the EU lags behind

[29] See, for instance in Canada: "Nechalacho Project, Canada" or in South Africa: "Rainbow, Bosveld to develop South Africa rare earths project" (accessed 26 May 2024).

[30] See: "Sweden discovers biggest rare earths deposit in EU", Financial Times, 12 January 2023, (accessed 26 May 2024)

the United States and China. This is particularly the case for lithium and copper, for which the EU share has remained stable in recent years, contrasting with growing holdings by Chinese and US investors.

All in all, ownership rates calculated using Equation 1 present both benefits and limitations. The main benefit stems from the availability of data, providing an overview of the evolution of capital ownership over time. However, data from *Refinitiv* have some limitations. First, the database contains very little metal production data. The only production data available on *Refinitiv* is for copper, and only partially. Second, non-listed companies are not available in *Refinitiv*, thereby leading to underestimating the market influence of some nationalities. For instance, Gécamines, a State-owned company located in the Democratic Republic of the Congo (DRC), is a major non-listed firm operating in the cobalt sector.[31] Hence, investors from DRC are not represented in the database. To address this caveat, we added unlisted companies when calculating an alternative indicator (see Equation 2 in subsection 4.3.2). Another limitation, independent of the data provider, pertains to the accounting treatment of companies producing several metals. For instance, the Anglo-Australian conglomerate Rio Tinto engages in the production of multiple critical materials, making it challenging to distinguish the separate contributions of copper, nickel or lithium to the firm's total capitalization. As a result, the importance of Rio Tinto across these three sectors may be overestimated, leading to biases in the description of holdings provided by Equation 1.

4.3.2 Production-weighted holding rate

Equation 1 has the benefit of showing changes in shareholdings' patterns over time. However, it may over-represent companies producing multiple minerals. To address this caveat, we compute an average holding rate weighted by the share of annual firms' production in global production[32] of metal m in 2022 (see Equation 2):

$$PWhR_{j,m} = \sum_{i}^{n} s_{i,m} * k_{j,i} \tag{2}$$

with:

- $PWhR_{j,m}$ the production-weighted holding rate of investors from country j for metal m.

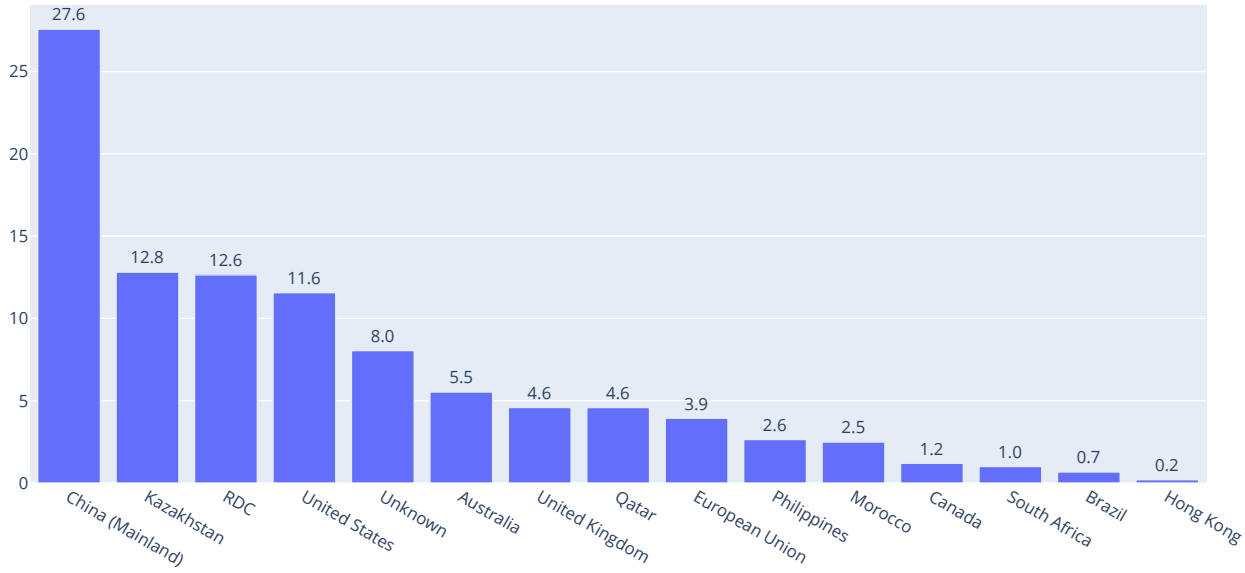
[31] It accounts for 10% of world cobalt production.

[32] Global production data are taken from the U.S. Geological Survey.

- $s_{i,m}$ the share of company i in the global annual output of metal m.
- $k_{j,i}$ the share of the company's capital i, owned by investors from country j.
- n the number of firms producing metal m.

Figure 9 illustrates the production-weighted holding rate of firms producing cobalt.[33]

Figure 9: Production-weighted holding rate for firms producing cobalt



Sources: Refinitiv, U.S. Geological Survey and authors' calculations.

The production-weighted holding rate is highest for China (27.6%), followed by Kazakhstan (12.8%), the Democratic Republic of the Congo (12.6%) and the United States (11.6%). The capital of mining companies therefore appears to be concentrated in the hands of investors from countries geo-politically distant from the EU (see Figure 3).[34] Assuming that individual investors align themselves with the geopolitical position of their home government, the EU access to CRM could be stymied in the event of geopolitical tensions with such countries.

Figure 10 summarises ownership rates by investor nationality for the five selected metals. Investors from China exhibit a high holding rate for all five metals. China's leading position is especially notable in the extraction of rare earths, cobalt and, to a lesser extent, lithium. China's

[33] See Appendix D, Figures D2 to D6 for copper, lithium, nickel and rare earths.

[34] For instance, Kazakhstan is within Russia's sphere of influence, while both Russia and China exert increasing influence in the DRC.

predominance in rare earths is consistent with the scale of its production. Indeed, China accounts for around 70% of the mine production of rare earths according to data from the US Geological Survey (USGS).

Besides China, investors from the United States also have significant holdings, especially in the lithium and copper sectors.

Latin American investors hold a significant share of the capital of firms producing lithium and copper, reflecting the geographical concentration of resources in this region.[35] However, Latin American investors are underrepresented with respect to the region's share of global production. Indeed, a third of the world's lithium mine production takes place in Latin America, mainly in Chile and, to a far lesser extent, Argentina and Brazil. In addition, Chile, Peru and, to a far lesser extent, Mexico, all three represent close to 40% of global copper mine production.

The weight of Australian investors is also relatively limited for lithium, given the importance of the country's lithium resources. While data from the US Geological Survey suggest that Australia produces half of the world's lithium production, two of Australia's biggest lithium mines, Greenbushes and Mt Marion, are 26% and 50% owned by Chinese companies (Tianqi Lithium and Ganfeng Lithium respectively).[36]

With the exception of nickel, the EU's holding rates for the different metals are below 10%, even dipping as low as 2% for lithium and rare earths. The noteworthy statistic regarding the EU's holding rate in the nickel sector (19%) is however partly driven by investments located in Cyprus representing Russian investors (see also Appendix D, table D1).[37]

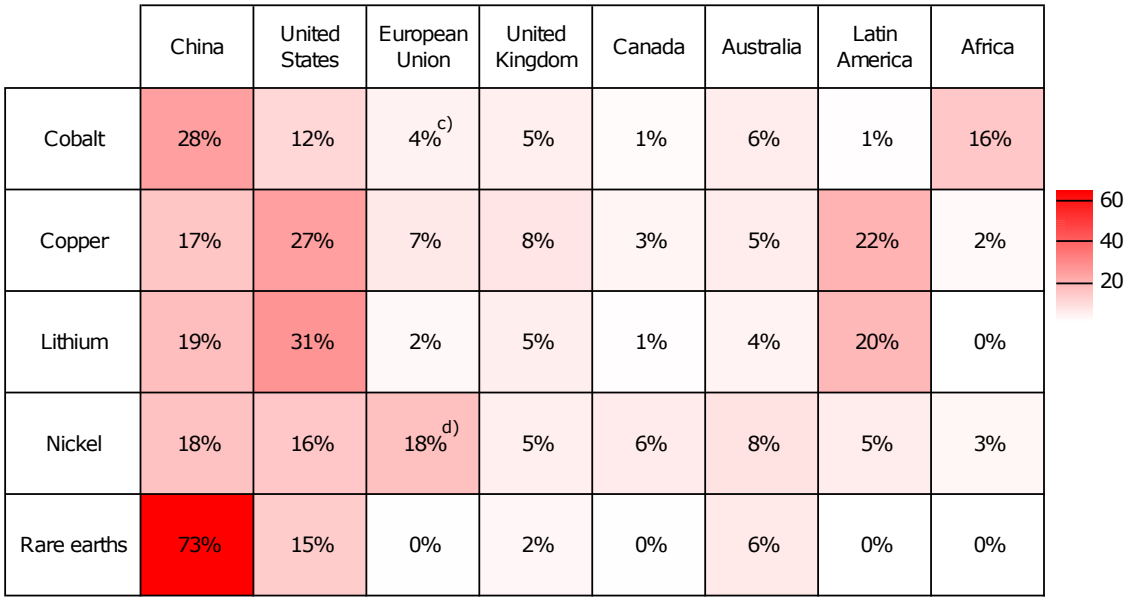
Overall, the position of the European Union in the ownership of companies producing critical metals is far below that of other major economies.

[35] Investors from Chile own a large share of SQM, the world's second-largest lithium mining company. In addition, the government of Chile has recently formed an entity to keep a majority stake in domestic lithium production. See: "Chile forms state-controlled entity with SQM to control domestic lithium production", The Energy Storage Report 2024, January 4, 2024.

[36] See: "Lithium miners plead 'foreign entity' case to US over China links", Financial Review, May 21, 2024.

[37] See: "A Chypre, argent sale et fortunes russes continuent de narguer l'Europe", Le Monde (accessed 12 February 2024)

Figure 10: Production-weighted holding rate in selected regions



Note: c) The EU's holdings in the cobalt mining sector, which includes an estimated 3% share for Russian investors, is closer to 1% when excluding European investors representing Russian interests. d) The EU's holdings in the nickel mining sector, which includes an estimated 14% share for Russian investors, is closer to 4% when excluding Cypriot investors representing Russian interests (see section 4.2).

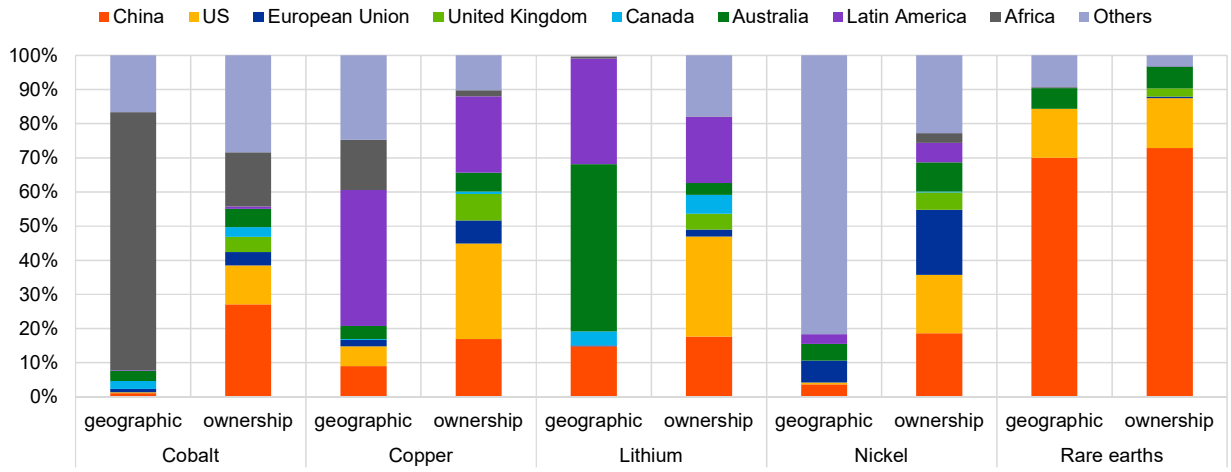
Sources: Refinitiv and authors' calculations.

As a robustness check, we compare the results obtained using Equation 1 (i.e. the share of capital held by investors as a percentage of total capital of mining companies, see 4.3.1) and Equation 2, i.e. the production-weighted holding rate (see Figure D1 in Appendix D). Both methods provide relatively consistent estimates. Nevertheless, some differences arise in the holdings of Chinese investors in the nickel sector and African investors in the cobalt sector. For example, Chinese investors hold 18% of the nickel sector when weighted by production, compared with 8% when weighted by capitalisation, due to the role played by unlisted Indonesian companies in nickel production. In Africa, the holding rate in the cobalt sector is 16% when the holding is weighted by production, compared with 3% when it is weighted by capitalisation, due to the role played by Gécamines, a non-listed state-owned company operating in the DRC.

Figure 11 highlights the discrepancy that can prevail between the geographical concentration of production and that of investors. The concentration in the mining sector appears different when analysed through the perspective of firm ownership. US investors, along with those of the EU and the UK to a lesser extent, play a significant role in the copper and lithium supplies, compared with the production of their respective countries. Meanwhile Chinese investors have

a greater role in nickel and cobalt production, even though these minerals are predominantly mined in other regions, such as Indonesia for nickel and the Democratic Republic of the Congo for cobalt. In contrast, for rare earths, production and capital ownership are aligned, with both the US and China being major producers and investors.

Figure 11: Geographic concentration of production and ownership



Note: Nickel production is geographically concentrated in Indonesia, resulting in a substantial contribution from the 'Others' category in the bar chart that breaks down nickel production by region.

Sources: US Geological Survey, Refinitiv and authors' calculations.

4.4 Control and concentration indicators

In this subsection, we focus on shareholdings thresholds (20% and 50%) to document the influence of investors from specific countries on executive boards. In fact, holding shares above a certain threshold allows investors to exert a strong influence on the decisions of their respective executive, especially if the rest of the shareholder base is diluted. Corporate charters often require a simple majority of 50.1% to approve most decisions.

A threshold rate of control ThR is defined as the share of world production of metal m controlled by investors from country j when capital ownership exceeds threshold t (see Equation 3):

$$ThR_{j,m,t} = \frac{\sum_{i,k_{j,i}>t}^{n} Y_{i,m}}{Y_{tot,m}} \tag{3}$$

with:

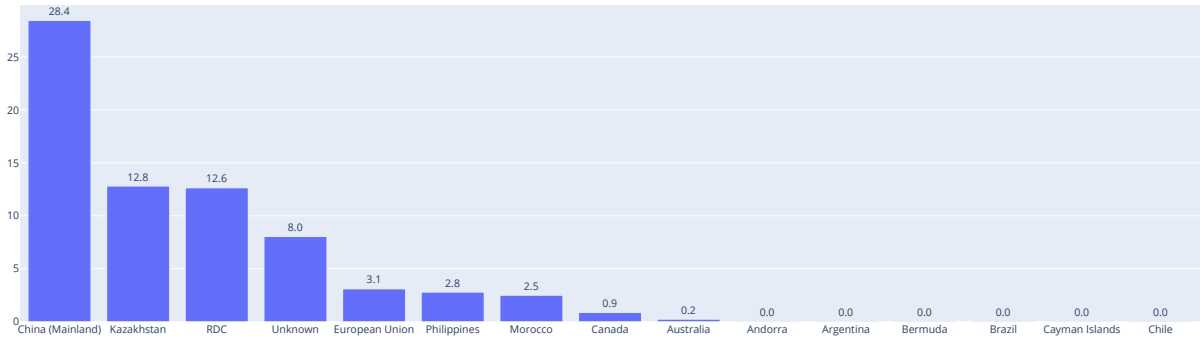
- $ThR_{j,m,t}$ the threshold holding rate of investors from country j, metal m and holding

threshold t.

- $k_{j,i}$ the share of company's i capital owned by investors from country j.
- $Y_{i,m}$ company's i production of metal m.
- $Y_{tot,m}$ the world output of metal m.[38]
- n the total number of firms in the sector producing metal m.

First, we consider a 50% threshold, allowing a majority control of companies.[39]

Figure 12: Share of world cobalt production accounted for by companies more than 50%-owned by investors from a specific country



Sources: Refinitiv and authors' calculations.

Figure 12 suggests that shareholders exercising majority control over cobalt-producing companies originate from countries geopolitically distant from the EU. Companies more than 50%-owned by Chinese investors account for 28% of global cobalt production, whereas companies more than 50%-owned by investors from the EU account for only 3% of global cobalt production. By contrast, U.S. investors only own minority interests in cobalt-producing companies, suggesting limited ability to influence management committee decisions. Such figures put into perspective other estimates indicating a larger U.S. share in such companies (sections 4.3.1 and 4.3.2).

Appendix D provides information for the lower, 20%, threshold. Figure D1 shows that companies in which U.S investors hold more than 20% of shares account for more than 29% of world cobalt production, compared to a lower 12% average holding rate (computed based on Equation

[38] Source: U.S. Geological Survey.

[39] Appendix D shows results for copper, lithium, nickel and rare earths (see Figures D2 to D6).

2, see section 4.3.2 above). However, for geographical areas displaying limited ownership rates (computed based on Equation 2), such as the EU, the threshold approach based on Equation 3 does not change the picture. For instance, companies in which the EU holds more than 20% of shares represent only 3% of global cobalt production (i.e. close to the EU average holding rate of 4% for cobalt, see Figure D2).

Appendix D provides information for other metals. Regarding **copper** (see Figure D3), the 50%-threshold approach suggests that companies majority-owned by investors from the US and China each account for 15% of world copper production, followed by companies more than 50%-owned by investors from Chile and Mexico, which represent each close to 12% of world copper production.

Companies more than 50%-owned by investors from the U.S., Chile and China respectively account for 35%, 23% and 20% of world **lithium** production (see Figure D5). Companies more than 50%-owned by Chinese investors account for 74% of world **rare earths** production (see Figure D6), confirming the predominance of Chinese investors in this sector.

4.5 Concentration and characteristics of shareholders of CRM firms

4.5.1 Herfindahl–Hirschman Index

This paragraph illustrates the concentration of the nationalities of shareholders of firms extracting CRM. The Herfindahl–Hirschman Index (HHI, Herfindahl (1950); Hirschman (1945)) is widely used for assessing market concentration,[40] although subject to criticism, particularly for its difficulty in reflecting the market power of stakeholders.

We assess a Herfindhal–Hirschman index HHI_m for metal m based on the geographic origin of investors, calculated by squaring the market capitalization share of each investing country j and then summing the resulting numbers (see Equation 4):

$$HHI_m = \sum_{j}^{n} \left(\frac{k_{j,m}}{k_m} \right)^2 \tag{4}$$

with:

- HHI_m the Herfindahl–Hirschman Index of metal m, based on the geographic origin of

[40] For instance, Mignon et al. (2024) show that the HHI indicator calculated at the producing countries level is a fitting measure of the criticality of raw materials and highlight how changes in market concentration measured by the HHI can affect metal prices.

investors.

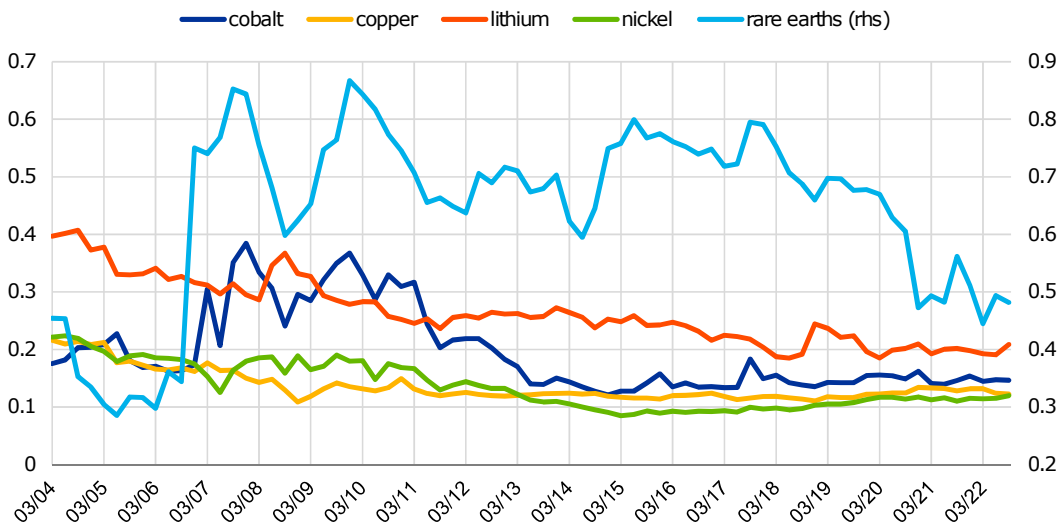
- $k_{j,m}$ the total shares of companies producing metal m held by investors from country j.
- k_m the total market capitalization of firms producing metal m.

Using the shareholdings' database, Figure 13 illustrates the evolution of the HHI calculated for the different metals. From 2004 onwards, we find a downward trend in HHI across metals. The downward trend highlights the appetite of a growing number of investors from a large number of countries for the CRM market. The sharp contraction of the HHI for rare earths since 2020 highlights the rise of US investors, at the expense of China (see Figure 8).

At the end of 2022, the rare earths' extraction industry emerges as the most concentrated, followed by lithium, while cobalt, copper and nickel sectors exhibit comparatively lower concentration levels. These figures can also compare with those presented by Mignon et al. (2024), who conducted their analysis on a per-country basis using the production figure of the U.S. Geological Survey. Some of their results align with ours. Thus, for copper, rare earths and nickel, we evidence a decrease in the market-firm concentration of these sectors, along with Mignon et al. (2024). However, our analysis diverges for cobalt and lithium. According to Mignon et al. (2024), there is a significant increase in the HHI for these sectors. This indicates that, at the country level, production of lithium and cobalt is getting more concentrated, while the number of geographical investors is expanding. As regards cobalt, Campbell (2020) highlights how ownership of resources in the DRC has broadened over time with Gécamines sharing mines' control with firms like China Moly, Glencore, and Randgold, whilst production concentration grew.[41]

[41] In 2017, 60% of world cobalt production was mined in DRC, against 70% in 2022 USGS (2018, 2023).

Figure 13: Herfindahl–Hirschman index for the main CRM producing sectors



Note: This figure displays HHI indices computed at the geographic ownership level, ranging between 0 and 1. The figure shows the indicator for cobalt, copper, lithium and nickel on the left-hand axis and for rare earths on the right-hand axis.

Sources: Refinitiv and authors' calculations.

4.5.2 Role of strategic investors

In this paragraph, we document the role of strategic investors and their share in the capital of CRM mining companies. Strategic investors typically have a medium to long-term interest in the industry or market in which the company operates. Their investment behaviours are diverse. For example, strategic investors may aim to create synergies, enhance their own business operations, gain access to new technologies, markets, or products, and secure supply chains. Unlike purely financial investors, strategic investors are not solely driven by the prospects of immediate financial returns. Strategic investors such as state-owned enterprises (SOEs) can pursue geopolitical goals. Other strategic investors seek to wield decision-making power within the companies they control, enabling them to implement long-term development strategies. This category of investors includes, but is not limited to, founding families, board members, or management teams.

Table 2 illustrates the weight of strategic investors in capital ownership. Our analysis relies on the identification of strategic investors as established by *Refinitiv*. It includes those investors who exceed the holding disclosure threshold, thus owning a significant share of the mining firms and are distinct from investment managers, brokerage firms, or funds, as their involvement is

intertwined with the strategic control of the companies.

All columns of Table 2 but the last one show, for each metal m, the share of capital of CRM mining companies belonging to strategic investors from a specific country j, expressed as a percentage of the total market capitalization belonging to all investors (strategic and non-strategic) from country j (see Equation 5):

$$s_{j,m} = \frac{\sum_i^n K_{i,j,m,s}}{\sum_i^n K_{i,j,m}} \tag{5}$$

with:

- $K_{i,j,m,s}$ the capital of company i involved in metal m, strategically held (s) by investors from country j;
- $K_{i,j,m}$ the total capital of company i involved in metal m held by all investors (whether strategic or not) from country j.

Our results suggest that Chinese investors are overwhelmingly strategic investors, which concurs with literature (IRENA, 2023). For instance, strategic investors account for respectively 100%, 86% and 77% of Chinese investors' holdings in firms extracting copper, REE and lithium. Strategic investors also play an important role in the exploitation of lithium and copper resources located in Latin America. Indeed, strategic investors account for respectively 100% and 67% of Latin American investors' holdings in firms extracting copper and lithium.

Overall, the last column of Table 2 confirms the predominance of strategic investors for rare earths companies, which are largely owned by Chinese investors. Strategic investors also own about a third of the capital of firms involved in the mining of cobalt, lithium and copper.

Table 2: Share of strategic investors in CRM mining companies in 2022

	China	US	EU	UK	Canada	Australia	Latin America	Africa	**Total**
Cobalt	48%	0%	93%	3%	0%	99%	2%	0%	**41%**
Copper	100%	0%	0%	1%	0%	37%	100%	0%	**31%**
Lithium	77%	0%	0%	6%	0%	0%	67%	9%	**34%**
Nickel	0%	0%	80%	10%	0%	38%	2%	18%	**25%**
REE	86%	12%	0%	0%	0%	4%	0%	0%	**62%**
Total	**75%**	**1%**	**75%**	**5%**	**0%**	**46%**	**59%**	**12%**	**33%**

Note: Strategic investors account for 86% of Chinese investors' holdings in the rare earths sector. Strategic investors account for 62% of all investors' holdings in the rare earths sector.

Sources: Refinitiv and authors' calculations.

5 Policy implications

As the supply of critical raw materials is confronted with rising geopolitical risks, analyzing the sources of control of mining companies underpins the need to enhance the EU's strategic autonomy.

Although the EU's CRM Act aims to reduce strategic dependencies (see Appendix A) by diversifying the EU's imports, it does not address vulnerabilities associated with the concentration of mining capital. Indeed, the CRM Act sets diversification targets at producer country level.[42] Such targets do not address concentration risks linked to capital ownership.[43] However, assessing concentration in the mining sector through shareholdings data shows a very different picture compared with the geographical mine location. Our database could be useful for identifying vulnerabilities linked to capital ownership and for refining diversification targets.

The CRM Act also aims to improve EU's capacities for extraction, processing and recycling of critical raw materials. Developing the European mining industry will require substantial funding (Hache and Normand, 2024) from private sources. In light of the EU's commitment to strengthen its economic security, assessing the sources of control of European mining companies is paramount for gauging supply and geopolitical risks in the EU. Against this background, our results suggests a need for increased transparency regarding the sources of control of new mining projects announced in the EU. Additionally, this database could also be instrumental in guiding investment decisions, should European entities seek to increase their shareholdings in major CRM firms.

6 Conclusions

The EU has set ambitious targets to reduce its strategic dependencies and diversify its CRM suppliers. Against this backdrop, this paper analyzes controlling interests in CRM mining companies.

We developed a detailed database documenting the origins and characteristics of investors involved in the CRM sector. We designed several indicators for the sake of robustness, including

[42] The share of a third country in the EU's supply should not exceed 65% at any stage of the value chain (which is currently the case for more than half of all strategic raw materials (Grohol and Veeh, 2023).

[43] In addition, generic targets set in the CRM Act pose further challenges, such as measuring the achievement of diversification targets on an EU-wide scale and finding alternative suppliers. See Hache and Normand (2024) for an analysis of the CRM Act.

production- and market capitalization-weighted holding rates, complemented by indicators focused on majority holdings. All indicators suggest that investors from outside the EU control a significant share of the capital of the leading CRM mining companies. We also document the preponderance of strategic investors in the ownership of firms involved in the mining of rare earths, and, to a lesser extent, in the sectors of cobalt, lithium and copper.

Several caveats should be borne in mind when interpreting our results. First, ownership is rarely identified for all shares. Indeed, the percentage of investors for whom information on ownership is available varies from company to company as well as over time. Second, information on the ultimate owners of shares is not available. Hence, our estimates are a proxy of the geographical distribution of shareholders. Third, the heterogeneity of shareholders should be taken into account when inferring geopolitical risks from ownership data. While we can assume that strategic entities such as SOEs are aligned with the geopolitical stance of the home country, this is not necessarily the case for individual shareholders. Despite these limitations, our database provides an overview of ownership interests in listed CRM companies, against a backdrop of increasing geopolitical risks. The database could be helpful for informing investment decisions, should the EU wish to increase its shareholdings in major CRM firms.

On the whole, our analysis underpins the need to enhance the EU's strategic autonomy and suggests a need for a metal-specific strategy. The production of certain metals is likely more subject to investor pressure given the greater footprint of strategic investors, limiting investment opportunities for new entrants. On the other hand, historical patterns highlight strategies that may prove effective: the market share growth of China and the US in certain metals is more attributable to the emergence of new players than to acquiring stakes in existing companies.

Avenues for future research include analyzing investors' strategies in the CRM sector, exploring decision-making processes, risk management approaches, and the impact of geopolitical factors on investment decisions. Future research would also benefit from better taking into account the heterogeneity of investors (eg. fund investors, including ETFs, or strategic investors), by exploring the drivers of strategic *vs* non-strategic investment decisions (eg. profitability considerations as opposed to concerns over securing resources).

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Appendix A Critical raw materials for the EU

The EU assessment of Critical Raw Materials (CRM) was launched in 2008 as part of the EU Raw Materials Initiative (RMI), a diversification strategy aimed at securing the supply of non-energy raw materials for EU industrial value chains. The EU list of critical raw materials (CRM) is updated every three years. The number of CRM identified increased from 14 in 2011 (when the list was first established) to 34 in 2023 (see Table A2). Critical materials are selected on the basis of two criteria (EC, 2023b):

- **Economic importance** for the EU, computed on the basis of the value added of the corresponding EU manufacturing sectors, corrected by a substitution index;
- **High supply risk**, defined on the basis of global and European supply concentration, weighted by a governance performance index, corrected by recycling and substitution parameters.

The EC also identified strategic raw materials (such as cobalt, copper, lithium, nickel, graphite and rare earths, see Table A1) in 2023.[44]

Table A1: Critical and strategic raw materials (in italic) for the EU (2023).

aluminium/bauxite	coking coal	lithium	phosphorus
antimony	feldspar	LREE	scandium
arsenic	fluorspar	*magnesium*	*silicon metal*
baryte	*gallium*	*manganese*	strontium
beryllium	*germanium*	*natural graphite*	tantalum
bismuth	hafnium	niobium	*titanium metal*
boron/borate	helium	*PGM*	*tungsten*
cobalt	*HREE*	phosphate rock	vanadium
copper	*nickel*		

Note: Light rare earths elements (LREE) account for cerium, lanthanum, neodymium, praseodymium and samarium. Scandium is considered as a REE, but is not included neither in HREE nor in LREE. Heavy rare earths elements (HREE) account for dysprosium, erbium, europium, gadolinium, holmium, lutetium, terbium, thulium, ytterbium and yttrium. Copper and nickel do not meet the CRM thresholds, but are included as Strategic Raw Materials.
Source: EC (2023b).

[44] Strategic importance depends on the importance of a raw material for achieving the twin transition and for its defence and space applications, considering: (a) the quantity of strategic technologies using a raw material as an input; (b) the quantity of a raw material needed to produce relevant strategic technologies; (c) the expected global demand for the relevant strategic technologies.

To tackle these issues, the European Parliament and the Council adopted the Critical Raw Material Act in mid-December 2023, that came into force in the first quarter of 2024.[45]
The CRM Act sets benchmarks along the strategic raw materials value chain and for the diversification of the EU supplies, with the following objectives:

- at least 10% of the EU's annual consumption for extraction;
- at least 40% of the EU's annual consumption for processing;
- at least 15% of the EU's annual consumption for recycling;
- no more than 65% of the EU's annual consumption from a single third country.

[45] See: Critical Raw Materials Act, European Commission, EC website (accessed 25 April 2024)

Table A2: Successive EU lists of critical raw materials

	2011	2014	2017	2020	2023
aluminium					Strategic
antimony	Critical	Critical	Critical	Critical	Critical
arsenic					Critical
baryte			Critical	Critical	Critical
bauxite				Critical	Critical
beryllium	Critical	Critical	Critical	Critical	Critical
bismuth			Critical	Critical	Strategic
boron/borate		Critical	Critical	Critical	Strategic
chromium		Critical			
cobalt	Critical	Critical	Critical	Critical	Strategic
coking coal		Critical	Critical	Critical	Critical
copper					Strategic
fledspar					Critical
fluorspar	Critical	Critical	Critical	Critical	Critical
gallium	Critical	Critical	Critical	Critical	Strategic
germanium	Critical	Critical	Critical	Critical	Strategic
hafnium			Critical	Critical	Critical
helium			Critical		Critical
HREE	Critical	Critical	Critical	Critical	Strategic
indium	Critical	Critical	Critical	Critical	
lithium				Critical	Strategic
LREE	Critical	Critical	Critical	Critical	Strategic
magnesite		Critical			
magnesium	Critical	Critical	Critical	Critical	Strategic
manganese					Strategic
natural graphite	Critical	Critical	Critical	Critical	Strategic
natural rubber			Critical	Critical	
nickel					Strategic
niobium	Critical	Critical	Critical	Critical	Critical
PGM	Critical	Critical	Critical	Critical	Strategic
phosphate rock		Critical	Critical	Critical	Critical
phosphorous			Critical	Critical	Critical
scandium			Critical	Critical	Critical
silicon metal		Critical	Critical	Critical	Strategic
strontium				Critical	Critical
tantalum	Critical		Critical	Critical	Critical
titanium				Critical	Strategic
tungsten	Critical	Critical	Critical	Critical	Strategic
vanadium			Critical	Critical	Critical
Total	**14**	**20**	**27**	**30**	**34**

Critical: Strategic:

Note: PGM refer to platinum group metals.

Sources: European Commission and authors' representation.

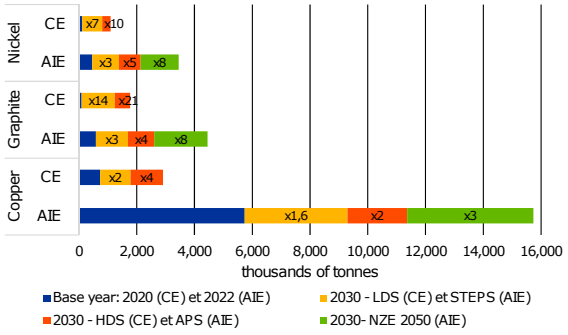
Appendix B Projected demand for critical raw materials

Demand for critical raw materials is projected to rise dramatically. The International Energy Agency (IEA, 2023) and the European Commission (EC, 2023b) have drawn up projections for the twin transition-induced increase in global CRM demand for 2030 and 2050 (EC) and for the years 2025 to 2050 (IEA).

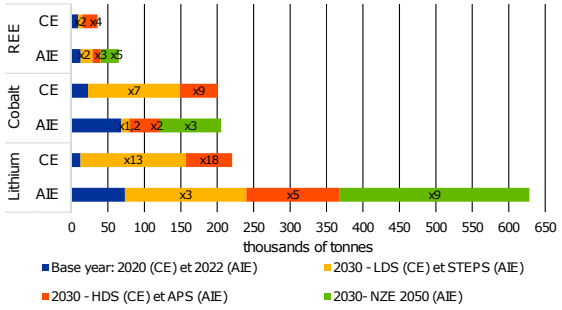
Despite significant differences in the scope and amounts of estimated world demand, the EC and IEA projections concur with the general outlook. The increase in global demand for CRM, driven mainly by the needs of electric vehicle deployment and power grids, is expected to be particularly strong for the copper, cobalt, lithium, nickel and graphite needed to produce them. Figure B1 shows large differences between the initial level of global demand estimated by the two institutions (IEA and EC), starting from the base year (2020 for the EC and 2022 for the IEA).

Figure B1: Demand projections to 2030 of CRM induced by the energy transition (IEA) and the green and digital transitions (EC), in thousands of tonnes per year and in deviation from actual levels.

(a) copper, graphite and nickel



(b) lithium, cobalt and rare earths



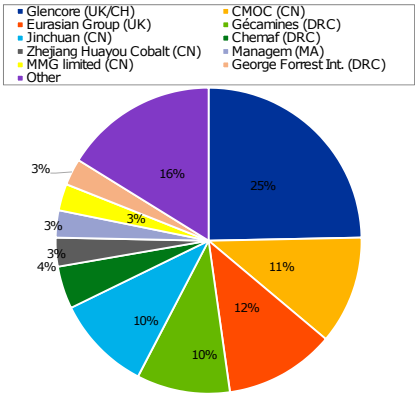
Note: For each institution, a range of projections is presented. The EC has developed two scenarios: (i) Low Demand Scenario (LDS) and (ii) High Demand Scenario (HDS). The IEA (2023) developed three scenarios: (i) Stated Policies Scenario (STEPS, lower bound); (ii) Announced pledges scenario (APS); and (iii) Net Zero Emissions by 2050 (NZE) scenario. For rare earth elements, an aggregate is provided directly by the IEA, while the world demand estimated by the EC for four minerals (dysprosium, neodymium, praseodymium and terbium) is summed.

Sources: EC (2023b), IEA (2023) and authors' calculations.

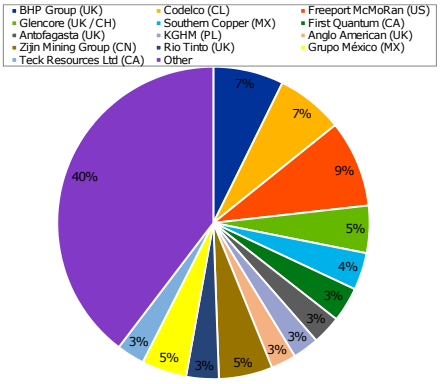
Appendix C Supply concentration of critical raw materials

Figure C1: Market share of major mining companies (% of global output)

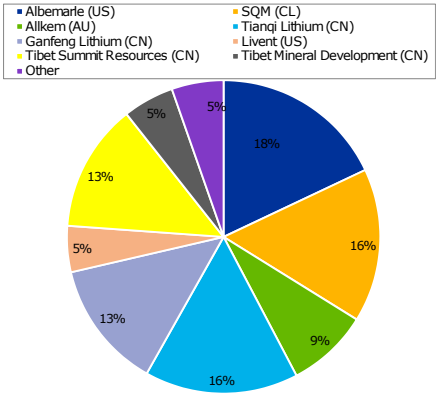
(a) Cobalt



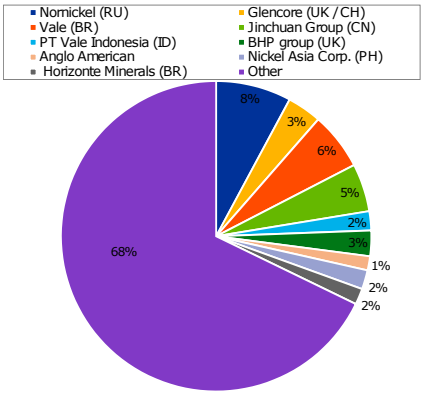
(b) Copper



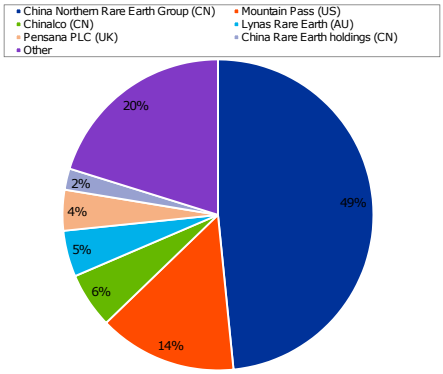
(c) Lithium



(d) Nickel



(e) Rare earths



Note: percentage of global output in 2022; country of incorporation in brackets.

Sources: Refinitiv, annual reports of mining companies and authors' calculations.

Appendix D Ownership interests in mining companies

Comparing the average holding rate and the production-weighted holding rate

We compare the share of capital held by investors as a percentage of total capital of mining companies, see 4.3.1) and the production-weighted holding rate. The right-hand heatmap shows the average holding rates at the country level, as specified in subsection 4.3.1 ("Non-weighted"). Conversely, the left-hand figure displays the production-weighted holding rate, as described in subsection 4.3.2 (so called "Weighted").

Figure D1: Holding rates in selected regions

(a) Non-weighted

	China	United States	European Union	United Kingdom	Canada	Australia	Latin America	Africa
Cobalt	22%	21%	21%[a)]	6%	1%	5%	10%	3%
Copper	14%	26%	5%	12%	3%	5%	16%	3%
Lithium	20%	34%	3%	7%	1%	7%	17%	4%
Nickel	8%	24%	15%[b)]	11%	2%	8%	6%	7%
Rare earths	66%	20%	0%	2%	1%	8%	0%	0%

(b) Weighted

	China	United States	European Union	United Kingdom	Canada	Australia	Latin America	Africa
Cobalt	28%	12%	4%[c)]	5%	1%	6%	1%	16%
Copper	17%	27%	7%	8%	3%	5%	22%	2%
Lithium	19%	31%	2%	5%	1%	4%	20%	0%
Nickel	18%	16%	18%[d)]	5%	6%	8%	5%	3%
Rare earths	73%	15%	0%	2%	0%	6%	0%	0%

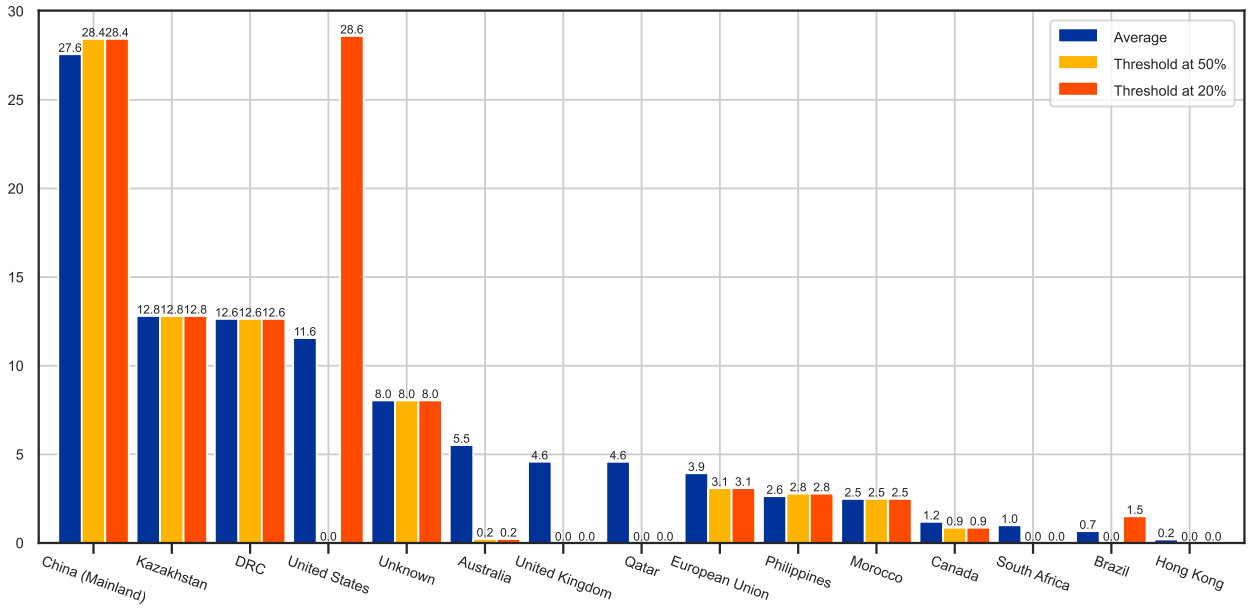
Note: a) The EU's ownership in the cobalt mining sector, which includes an estimated 17% share for Russian investors, is closer to 4% when excluding Cypriot investors representing Russian interests. b) The EU's ownership in the nickel mining sector, which includes an estimated 10% share owned by Cyprus-registered Russian investors, is closer to 5% when excluding European investors representing Russian interests. c) The EU's ownership in the cobalt mining sector, which includes an estimated 3% share for Russian investors, is closer to 1% when excluding Cypriot investors representing Russian interests. d) The EU's ownership in the nickel mining sector, which includes an estimated 14% share for Russian investors, is closer to 4% when excluding European investors representing Russian interests. (see section 4.2).

Sources: Refinitiv and authors' calculations.

Holding rates

For each of the Figures D2 to D6, we present on the one hand, the capital ownership rate weighted by production (blue bar, see section 4.3.2), and on the other hand, the 20% and 50% ownership threshold rates (red and yellow bars respectively, see section 4.4).

Figure D2: Holding rates in the cobalt sector for different shareholding thresholds

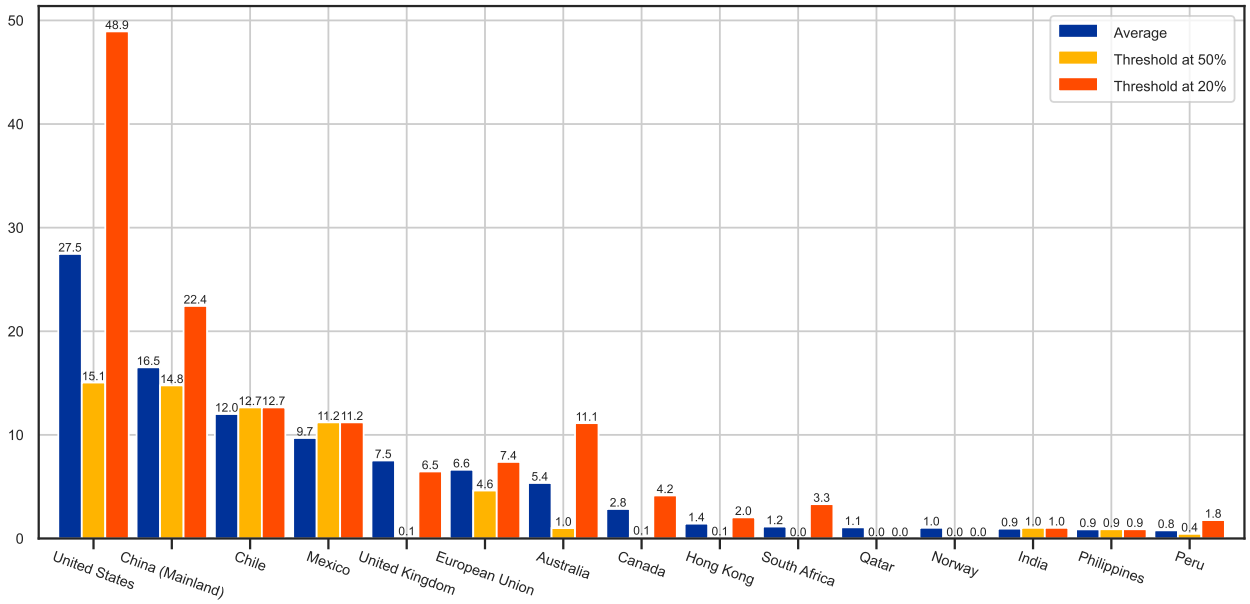


Notes: the average holding rate (blue bars) refers to the indicator computed using Equation 2, whereas the two other indicators rely on Equation 3, with t corresponding to either 20% (orange bars) or 50% (yellow bars).

The "average" holding rate (blue bars) suggests that 27.6% of the capital of cobalt-producing companies belongs to investors domiciled in China. Companies in which more than 50% of the capital is owned by Chinese investors account for 28.4% of world cobalt production (yellow bars). Companies in which Chinese investors own more than 20% of the shares account for 28.4% of world cobalt production (orange bars).

Sources: Refinitiv and authors' calculations.

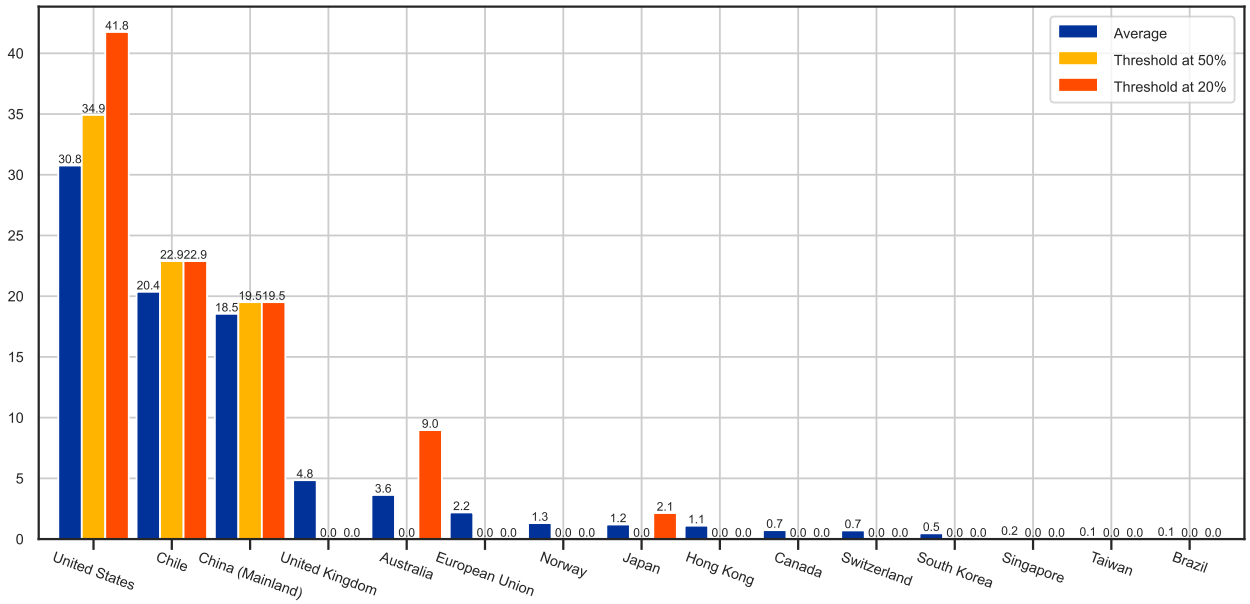
Figure D3: Holding rates in the copper sector for different shareholding thresholds



Note: for the reading of the figure, refer to figure D2.

Sources: Refinitiv and authors' calculations.

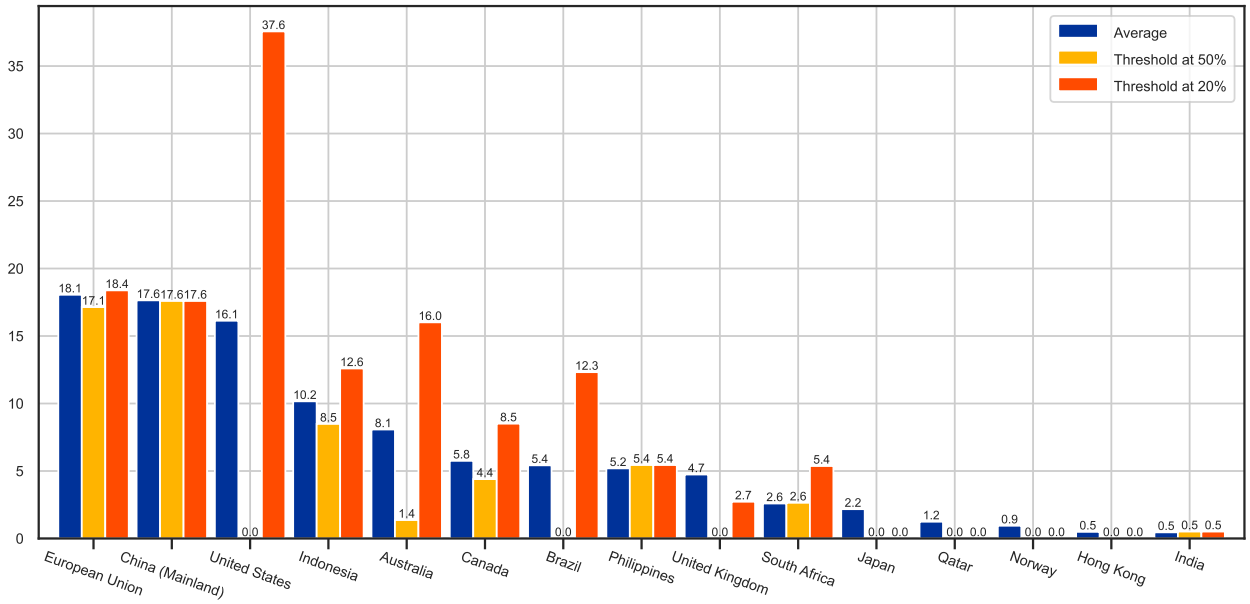
Figure D4: Holding rates in the lithium sector for different shareholding thresholds



Note: for the reading of the figure, refer to figure D2.

Sources: Refinitiv and authors' calculations.

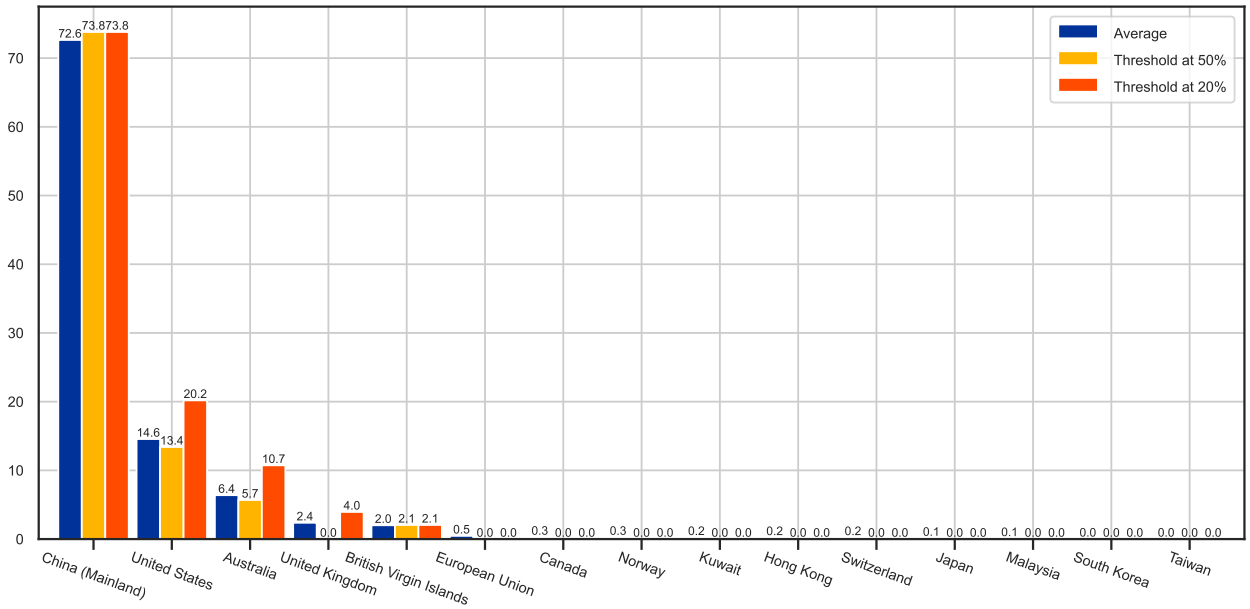
Figure D5: Holding rates in the nickel sector for different shareholding thresholds



Note: for the reading of the figure, refer to figure D2.

Sources: Refinitiv and authors' calculations.

Figure D6: Holding rates in the rare earths sector for different shareholding thresholds



Note: for the reading of the figure, refer to figure D2.

Sources: Refinitiv and authors' calculations.

Table D1: Production-weighted holdings rates of mining companies by EU countries

	Co	Cu	Li	Ni	REE
DE	0.3	0.7	0.2	0.5	0.2
FR	0.3	0.4	0.5	2.0	0.1
IT	0.1	0.1	0.1	-	-
ES	0.1	0.2	-	0.1	-
NL	1.4	0.6	0.5	6.8	0.1
PL	-	3.2	-	-	-
BE	-	0.1	-	-	-
SE	-	0.4	0.2	0.1	-
AT	-	-	-	-	-
IE	0.1	0.2	0.4	0.1	0.1
DK	-	0.1	0.2	0.1	-
FI	-	0.1	0.1	-	-
CZ	-	-	-	-	-
RO	-	-	-	-	-
PT	-	-	-	-	-
GR	-	-	-	-	-
HU	-	-	-	-	-
SK	-	-	-	-	-
LU	-	0.5	0.1	0.4	-
BG	-	-	-	-	-
HR	-	-	-	-	-
LT	-	-	-	-	-
SI	-	-	-	-	-
LV	-	-	-	-	-
EE	-	-	-	-	-
CY	1.6	-	-	7.8	-
MT	-	0.1	-	-	-
EU	**3.9**	**6.6**	**2.2**	**18.1**	**0.5**

Note: countries are sorted in descending order based on their nominal GDP level. Co denotes cobalt, Cu copper, Li lithium, Ni nickel and REE rare earths elements.

Sources: Refinitiv and authors' calculations.

Coverage ratios

Table D2 documents the completeness of our ownership database for each of the five selected metals. The first column shows the share of world production covered by the capitalization-weighted ownership indicator (see Equation 1). The second column shows coverage ratios for the production-weighted holding rate (see Equation 2).

Table D2: Coverage ratios of the ownership capitalization- and production-weighted indicators, (% of world production)

Metal	Method 1	Method 2
Cobalt	63%	90%
Copper	82%	88%
Lithium	90%	90%
Nickel	65%	68%
Rare earths	90%	90%

Note: This table shows the share of world metal production (computed using data from the U.S. Geological Survey) covered by the companies included in our database.

Method 1 refers to the average holding rates where market capitalisation is not weighted by the level of production (section 4.3.1). Method 2 refers to the production-weighted average holding rates (section 4.3.2).

Sources: Refinitiv, U.S. Geological Survey and authors' calculations.