Strategic Global Supply Chains, China and the Role of Critical Raw Materials for the European Union

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Executive summary

This study provides a data-driven assessment of the European Union's (EU) dependence on Critical Raw Materials (CRMs), focusing on its exposure to Chinese supply chains and identifying alternative sources to enhance Europe's strategic autonomy. It introduces a novel, empirically grounded framework that links detailed trade data with inter-industry production networks to quantify where Europe's vulnerabilities lie and how they propagate through the economy.

Analytical framework and approach:

The analysis builds on an integrated empirical framework that combines Eurostat COMEXT trade data with FIGARO input–output tables to map how deeply European industries depend on Chinese Critical Raw Materials (CRMs).

The framework rests on three key dimensions, which capture both the scale and the nature of Europe's strategic reliance :

Import dependence measures how directly EU sectors rely on Chinese inputs;

Exposure traces how potential disruptions to these inputs ripple through the wider economy via interconnected production chains;

Vulnerability assesses the economic significance of such disruptions by translating them into potential losses in output and welfare.

This approach moves beyond traditional trade analysis to provide a system-wide view of Europe's CRM risks. It highlights that the challenge is not only about sourcing but about how interlinked and economically consequential these dependencies have become. By turning detailed data into a quantified map of inter-industry risk, the study offers a solid evidence base for targeted policies that strengthen Europe's resilience and competitiveness.

Context and Policy Environment:

CRMs are essential to the EU's industrial base, particularly for the green and digital transitions. The European Critical Raw Materials Act (ECRMA, 2024) is the cornerstone of EU policy, setting diversification benchmarks for 2030: (i) at least 10% of annual consumption extracted domestically, (ii) 40% processed within the EU, (iii) 15% recycled, (iv) no more than 65% dependence on a single non-EU supplier. The ECRMA's structured framework aligns with the broader Open Strategic Autonomy (OSA) agenda, linking raw material security with competitiveness and sustainability. It distinguishes between Critical Raw Materials (CRMs), those with high economic importance and supply risk, and Strategic Raw Materials (SRMs), a subset essential to green, digital, and defence technologies such as lithium, nickel, gallium, and rare earths.

China's Strategy and EU Exposure:

China dominates the global CRM value chain, accounting for over 90% of rare earth refining, 70% of graphite, and 60–70% of lithium and cobalt chemical refining. Its industrial strategy combines state-owned enterprise control, subsidies, and an expanding export control regime covering high-impact materials such as gallium, germanium, graphite, and rare earths. This integration of mineral policy with national security gives China both economic and geopolitical leverage over global supply chains. As mineral policy becomes increasingly integrated into national security strategy, supply reliability now depends as much on geopolitics as on market forces

Empirical Findings:

Dependence:
Eurostat COMEXT data reveal that the EU sources more than 20% of its imports from China for twelve Critical Raw Materials (CRMs), and over 50% for five. When weighted by Member State imports, the average dependence rises further. China supplies over 20% of imports for eighteen CRMs and more than 50% for eleven, with arsenic, gallium, germanium, and magnesium showing dependence levels above 80%.

Supplier diversification across extra-EU partners is similarly limited: twenty-one CRMs are imported from four non-EU countries, while twelve display extreme concentration (HHI > 0.5), most notably beryllium, gallium, and magnesium.

These patterns highlight a structural vulnerability concentrated in a narrow set of high-leverage materials and supply relationships.

Exposure:
When trade dependencies are mapped onto the FIGARO input–output network, exposure extends well beyond direct importers. Industries such as automotive and batteries, electronics and semiconductors, renewable energy technologies and defence manufacturing rely heavily on CRM-intensive intermediate goods from China, revealing strong indirect dependencies that conventional trade metrics overlook.

Vulnerability:
Network-based propagation analysis indicates that even modest disruptions in high-impact CRMs (e.g. lithium, magnesium, rare earths) can trigger amplified output and welfare losses across European production networks. The results confirm that Europe's CRM dependence is systemic, affecting broad segments of its industrial base rather than isolated supply chains.

Using a Strategic Dependency Index (SDI) and input–output linkages, the study finds that supply disruptions in CRMs can ripple across industries far beyond direct importers. Sectors with the highest vulnerability include automotive and batteries, electronics and semiconductors, and renewable energy and defence manufacturing. Even modest supply shocks in high-impact materials can cause disproportionate production and welfare losses due to their critical role in downstream industries.

Policy Options

The evidence shows that the EU's vulnerability to Critical Raw Material (CRM) disruptions is systemic and multifaceted, extending beyond simple trade dependence. Addressing it will require a comprehensive policy mix that balances industrial investment, global partnerships, market design, and international engagement.

A coherent European strategy should build on the following complementary pillars:

1. **Strengthen and scale domestic capacity:** Expand sustainable mining, refining, and recycling within Europe to meet ECRMA targets, while improving regulatory predictability, access to finance, and community acceptance. Support regional clusters and cross-border infrastructure to reduce fragmentation across Member States.
2. **Diversify and deepen strategic partnerships:** Broaden cooperation with resource-rich and like-minded countries (e.g., Canada, Australia, Chile, Norway) through mutually beneficial supply agreements, joint ventures, and investment in midstream processing capacity abroad. Strengthen ties with emerging suppliers in Africa and Latin America under transparent, sustainability-based frameworks.
3. **Foster innovation and circularity:** Mobilise R&D and industrial alliances to improve material efficiency, develop recycling and substitution technologies, and integrate CRM recovery into broader circular-economy strategies. Support demand-side measures, such as eco-design standards and material passports, to reduce consumption intensity.
4. **Enhance market coordination and risk management:** Develop shared European stockpiling mechanisms, early-warning systems, and data platforms for CRM trade and inventories. Encourage public–private partnerships that improve transparency and risk-sharing across the value chain.
5. **Pursue calibrated international engagement:** Reinforce Europe's voice in global mineral governance through the WTO, G7, and OECD frameworks, promoting open, rules-based markets while managing strategic dependencies through constructive dialogue and diversification.

Together, these measures would enable the EU not only to mitigate short-term supply risks but also to shape a more resilient, competitive, and sustainable global position in the long-term transition to a green and digital economy.

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1. Introduction

Raw materials are fundamental to the European Union's economy. They supply the essential inputs for a wide spectrum of goods and technologies that underlie daily life and industrial competitiveness. As global demand accelerates and supply chains tighten, ensuring secure, sustainable, and uninterrupted access to these resources has become a strategic priority for the Union and its international partners. Moreover, reliable access to raw materials is also central to delivering the EU's twin green and digital transitions, supporting innovation and preserving Europe's position in global value chains.

Critical raw materials (CRMs) are especially significant, as they underpin production across virtually all sectors. Modern technologies depend on a growing number of these inputs: a smartphone may now contain up to fifty different metals that enable its compact size, low weight, and high functionality. CRMs are equally essential for clean energy technologies, forming the basis of solar panels, wind turbines, electric vehicles, and energy-efficient lighting. By linking industrial development, technological progress, and environmental sustainability, CRMs have become a cornerstone of the EU's strategic autonomy and long-term prosperity.

However, for many CRMs, the EU depends on China as the dominant supplier, including e.g. gallium (96%), magnesium metal (96%), and germanium (67%) (European Commission, 2020a). These materials are critical inputs for technologies that are central to the twin green and digital transition, and for key strategic sectors such as semi-conductors, automotive, defence, and aerospace. This extreme concentration increases the EU's exposure and vulnerability to both natural and geopolitical events and potentially endangers its autonomy, resilience, and growth.

In response, the European Commission developed its Open Strategic Autonomy (OSA) paradigm, aiming to safeguard the Union's strategic interests while remaining open to global trade, investment, and cooperation. Several legislative measures have since then been implemented under this umbrella, including e.g. the European Critical Raw Materials Act (ECRMA), the Chips Act, the Net Zero Industrial Act, and REPower EU.

By now, several initiatives exist to measure EU dependency on strategic goods, including both institutional and academic approaches. However, there is no comprehensive analysis of the vulnerability of EU value chains to China's dominance in CRMs. This study builds on existing insights from CRM dependence and uses detailed data with information on EU value chains to quantify dependence, identify exposure, and evaluate vulnerability to provide evidence-based policy recommendations.

Our empirical methodology integrates trade and input–output data at a highly disaggregated level. We combine Eurostat Comext trade statistics with sectoral input–output linkages from FIGARO to map the direct and indirect dependence of EU industries on Chinese critical raw materials. By applying network-based measures of exposure, concentration, and propagation, we distinguish between (i) *import dependence*—the degree to which EU sectors rely on Chinese inputs—and (ii) *value-chain vulnerability*—the extent to which shocks to these inputs could affect broader EU production through inter-industry linkages. This dual approach allows us to capture not only first-order supply risks but also systemic dependencies arising from the structure of European production networks.

The remainder of the report is structured as follows. Section 2 introduces the conceptual framework and data sources underpinning the analysis. Section 3 identifies the critical raw materials (CRMs) defined under the ECRMA and outlines their economic relevance. Section 4 documents the composition and evolution of CRMs in the EU, classifying them by economic importance and supply risk. Section 5 examines China's strategy, industrial policies, and governance mechanisms in the CRM domain, assessing their implications for EU strategic autonomy. Section 6 quantifies the EU's dependence on China across sectors and evaluates vulnerabilities along the value chain.

2. Conceptual framework and data sources

A growing policy and academic consensus recognises that *strategic dependence* cannot be captured by a single indicator. For the purposes of this study, three interrelated but distinct concepts are used: **dependence**, **exposure**, and **vulnerability**. Together, they describe the degree to which the EU economy relies on Chinese supplies of critical raw materials and the extent to which potential disruptions could affect European production, consumption, and welfare.

Dependence denotes the degree to which the EU's supply of a given input is concentrated in one or a few external partners. It is typically proxied by the share of imports from a third country or by a supplier-concentration index such as the Herfindahl–Hirschman index (HHI). High dependence signals limited supplier diversification and potential supply bottlenecks. Most existing quantitative metrics capture dependence, due to the widespread availability of international trade data at the detailed product level. However, these indicators do not allow an evaluation of the *indirect* or *total* exposure to CRMs in domestic value chains or differentiate between final and intermediate consumption of these materials.

Exposure measures the total (direct and indirect) reliance of EU consumption or production on imports from a third country as they propagate through global and local supply chains. It captures how a supply shock in one input, sector, or third country transmits through intermediate linkages to affect production or consumption elsewhere in the EU or within country boundaries. A sector with moderate direct dependence may still be highly vulnerable if its inputs are used extensively downstream in high-value activities. Existing metrics therefore combine product-level trade data with sectoral input-output tables to measure these direct and indirect impacts on local production and consumption. This necessarily entails some loss of detail, as the product-level trade data is much more granular than sector-level input-output information.

Vulnerability extends the analysis beyond direct dependence and total exposure. Whereas exposure quantifies how shocks to a third-country supplier would reverberate through EU production and consumption via intermediate linkages, vulnerability goes one step further by assessing the *economic impact* of such shocks once factors such as substitutability, demand preferences, and welfare effects from price changes are considered. These measures often combine data with economic modelling to recover dimensions that are not directly observable in the data but that critically affect welfare and resilience.

To translate these concepts into measurable indicators, the analysis integrates three complementary data layers:

1. **Trade layer**: Product-level import data from **Eurostat COMEXT** (Combined Nomenclature, CN 8-digit products) provide detailed information on yearly bilateral import flows and supplier concentration for each CRM-related product.
2. **Sectoral layer**: Each CN product is linked to its **NACE Rev. 2** sector using the official Eurostat correspondence tables. This enables aggregation of product-level exposure to the sector level.
3. **Value chains layer**: Sectoral linkages are taken from the **Eurostat FIGARO** input–output framework, which capture inter-industry dependencies across EU member states and the rest of the world.

These concepts align with the JRC's evolving *strategic dependence* framework and underpin the empirical approach adopted in this study. Together, they provide the analytical foundation for identifying which materials are deemed critical or strategic under EU policy, and for quantifying how dependence, exposure, and vulnerability shape economic outcomes. The next section examines how the European Commission defines Critical and Strategic Raw Materials (CRMs and SRMs) within the ECRMA and related initiatives.

Summary: Conceptual framework

This study distinguishes three interrelated concepts to assess the EU's reliance on Chinese supplies of critical raw materials:

- **Dependence** – the concentration of supply from a small number of external partners, measured through trade shares or supplier-concentration indices.
- **Exposure** – the total direct and indirect reliance that propagates through value chains, linking trade and input–output data.
- **Vulnerability** – the economic impact of potential disruptions, accounting for substitutability, demand preferences, and welfare effects.

These concepts, operationalised using international trade, sectoral, and input–output data, underpin the study's empirical analysis of the EU's strategic dependencies.

3. Identifying Critical Raw Materials in the EU

3.1 The EU institutional framework

Over the past two decades, the **European Commission** and the **Joint Research Centre (JRC)** have developed a systematic body of work assessing the European Union's exposure to **critical raw materials (CRMs)**. Established as a priority action under the EU Raw Materials Initiative (European Commission, 2008), the Commission has communicated successive lists of CRMs, which are updated at least every three years to reflect production, market, and technological developments (European Commission, 2011, 2014, 2017a, 2020a, 2023a).[1] This process has formalised a **criticality assessment methodology** covering a wide range of non-energy and non-agricultural raw materials. Over time, the methodology has evolved to incorporate dimensions of trade dependence (European Commission, 2017b), circularity and secondary use (European Commission, 2018), and recovery potential (Salminen et al., 2019), aligning with the Union's 2050 climate-neutrality goals (European Commission, 2020b). These assessments have consistently highlighted the growing dominance of China in several key inputs, notably rare earth elements, magnesium, tungsten, gallium, and graphite.

These assessments and monitoring efforts also connect to several recent legislative and strategic initiatives, designed to reduce external dependencies and strengthen the EU's industrial base, broadly framed under the **Open Strategic Autonomy (OSA)** paradigm. Outlined in the European Commission's Trade Policy Review (European Commission, 2021a) and the May 2020 European Council conclusions (European Council, 2020), and formalised in the EU New Industrial Strategy for Europe (European Commission, 2021b), OSA reflects the EU's objective to **maintain open markets while reducing strategic dependencies** on non-EU countries for critical goods in sectors such as clean energy, digital infrastructure, health, and defence. It recognises that access to CRMs is essential to the EU's ability to lead in strategic technologies, such as batteries, electric vehicles, wind turbines, semiconductors, and defence systems, many of which depend on a restricted set of raw materials sourced from a small number of non-EU suppliers.

Under the OSA umbrella, initiatives advancing this agenda include the European Green Deal and the **European Critical Raw Materials Act (ECRMA)** (European Parliament and Council of the European Union, 2024), which translate the Union's resilience ambition into concrete policy action; the Net-Zero Industry Act and the Chips Act, which aim to secure access to key technologies and industrial inputs; the Foreign Subsidies Regulation and the Anti-Coercion Instrument, which ensure fair competition and reciprocity in global markets; and the Single Market Emergency Instrument together with the Strategic Technologies for Europe Platform, which reinforce the Union's capacity to anticipate and respond to supply disruptions. Together, these instruments give practical effect to OSA by linking raw material security with industrial competitiveness, sustainability, and technological sovereignty.

The ECRMA, in particular, plays a central role in the implementation of the OSA agenda. Adopted by the European Parliament in April 2024, the ECRMA establishes a structured

[1] An overview of the successive lists and identified CRMs is available here: https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en.

framework to identify and monitor raw materials that are essential to the EU's industrial, digital, and green transitions. The ECRMA defines a *raw material* as "a substance in processed or unprocessed state used as input for manufacturing intermediate or final products", thereby excluding materials primarily used as food, feed, or combustion fuel. The related *raw materials value chain* includes "all activities involved in the exploration, extraction, processing, and recycling of raw materials". The ECRMA directly addresses these vulnerabilities through three mechanisms aligned with the principles of OSA:

1. **Defining Strategic Raw Materials (SRMs):** the ECRMA identifies SRMs with a forward-looking methodology in strategic sectors. By doing so, it establishes an adaptable framework to guide policy and investment decisions toward materials most critical for strategic technologies.
2. **Strengthening EU supply chains:** the ECRMA sets four diversification benchmarks for 2030, including targets for domestic extraction (at least 10% of EU annual consumption), processing (40%), and recycling (15%) of SRMs. It also calls for diversification of imports so that no single third country provides more than 65% of one raw material at any stage of the value chain.
3. **Establishing Strategic Projects and governance structures:** the ECRMA creates a framework to accelerate Strategic Projects across the raw materials value chain, streamlining permitting procedures, facilitating access to finance, and enhancing public-private coordination. It also establishes the European Critical Raw Materials Board, a governance mechanism to coordinate Member State efforts, conduct supply stress tests, and monitor the effectiveness of diversification strategies.

These measures jointly operationalise OSA in the domain of raw materials by fostering targeted industrial policies that preserve open trade while building resilient domestic capacities and strategic partnerships. It also reinforces the geopolitical dimension of EU industrial policy by promoting supply chain cooperation with like-minded partners through strategic partnerships and strategic trade agreements.

3.2 Complementary approaches to define strategic dependence

While the **ECRMA** provides a structured framework to identify CRMs from a predefined list of raw materials, it does not quantify the degree of strategic **dependence**, **exposure**, or **vulnerability** across sectors or supply chains. A growing academic and institutional literature has therefore sought to operationalise these dimensions using complementary data and methodologies. Although many of these studies extend beyond raw materials to other strategic goods, their insights are directly relevant for assessing the EU's economic dependencies. These dimensions have been approached empirically and theoretically across three interrelated levels as mentioned in previous section: dependence, exposure, and vulnerability.

Dependence is most commonly analysed using international trade data to measure supplier concentration and import reliance at the product level. Empirical studies by Bonneau and Nakaa (2020), Guinea and Sharma (2022), Arjona et al. (2023), Vicard and Wibaux (2023), and Berthou et al. (2024) quantify strategic dependence by tracing the origin and diversification of EU imports. The JRC (European Commission, 2024) proposes a composite autonomy index distinguishing between (i) provisional autonomy, based on net imports relative to total supply, and (ii) strategic autonomy, adjusted for supplier concentration. Arjona et al. (2024) further document the reallocation of EU imports toward intra-EU and trade-agreement partners, illustrating adaptive diversification patterns. At the firm level, Jaravel and Méjean (2021) exploit detailed French trade data to proxy demand concentration through the number of importing firms, although comparable micro data remain unavailable to researchers for most EU Member States.

Exposure examines how supply shocks propagate through global and domestic value chains beyond measures of import concentration. Some research integrates trade with domestic production data to proxy the role of strategic goods within domestic value chains (Amaral et al., 2022). Earlier assessments (European Commission, 2017a, 2020a, 2023a) focused on raw material exposure in technologies such as solar panels, wind turbines, and Li-ion batteries, using indicators of economic relevance, demand growth, production capability, and supply risk. Complementary data on links between fifteen European key technologies and critical or strategic raw materials are provided in Carrara et al. (2023), which maps material requirements across technological value chains. Network-based approaches extend this analysis by modelling how shocks propagate through global production linkages to quantify how disruptions in upstream inputs affect downstream industries, by combining import data with input-output tables, as in Baur and Flach (2022) for Germany and Berthou et al. (2024) across OECD economies. Alternative methodologies apply Large Language Models (LLMs) to reconstruct complex technological dependencies (Fetzer et al., 2024).

Vulnerability extends these analyses by considering the economic and welfare consequences of such dependencies once substitution, technological rigidity, and price shocks are accounted for. Consonni and Magerman (2025) use trade data to develop a Strategic Dependency Index that additionally incorporates product substitutability, consumer preferences, and a welfare-based assessment of international shocks. Magerman and Palazzolo (2025) develop a quantitative framework to evaluate supply chain risk and its welfare consequences using detailed RHOMOLO input-output tables for all EU NUTS2 regions.

Understanding exposure and vulnerability also requires **insight into the internal structure of value chains**. Most exporters sell the majority of their output domestically (Bernard et al., 2003), and most importers source inputs locally (Antràs et al., 2017). Customs or Intrastat data do not contain domestic trade flows, and while information on domestic firm-to-firm linkages is becoming more available for economic research (Pichler et al., 2023; Bacilieri et al., 2025), analysis is often constrained to individual countries. Value chains entail more than supplier-buyer transactions, including ownership linkages (Miroudot and Rigo, 2022) and contracts (Boehm and Oberfield, 2020). Yet neither trade nor input-output tables report ownership linkages, multinational activities, or the general role of heterogeneous firms in trade (UN, 2021).

Another strand quantifies **the role of value chains in explaining economic outcomes**. Several theory-consistent metrics characterize sector- and firm-level value chains, allowing for the identification of key players and the role of shock transmission, including value-added content of trade (Johnson and Noguera 2012), upstreamness (Antras et al., 2012), systemic risk (Diem et al., 2022) or Bonacich centrality (Acemoglu et al., 2012). They study welfare (Caliendo and Parro, 2015), labour markets (Caliendo et al., 2019), large shocks (Baqaee and Farhi, 2019), frictions (Baqaee and Farhi, 2020), and international trade (Baqaee and Farhi, 2024).

A final strand increasingly examines **how policy shapes dependence and vulnerability** within production networks. Studies explore industrial policy (Liu, 2019), trade policy (Lashkaripour and Lugovskyy, 2023), decoupling and supply-chain fragmentation (Eppinger et al., 2021), and monetary policy transmission (Rubbo, 2023). Few papers yet quantify the optimal policy mix for network resilience, with early contributions by Liu (2019), Lashkaripour and Lugovskyy (2023), and Magerman and Palazzolo (2025). Broader analyses of supply-chain disruptions and restructuring (Bonadio et al., 2021; Cajal-Rossi et al., 2023; Antràs et al., 2022; Grossman et al., 2023) highlight how geopolitical tensions, trade re-routing, and firm-level risk strategies jointly determine Europe's vulnerability to CRM supply shocks.

Together, these complementary approaches operationalise the concepts of dependence, exposure, and vulnerability outlined in **Section 2**, providing the analytical basis for the empirical mapping in subsequent sections.

Summary: Identifying CRMs in the EU

The European Commission and the Joint Research Centre (JRC) have, since 2008, developed a structured framework to identify and monitor **Critical Raw Materials (CRMs)**, using indicators of **economic importance** and **supply risk**. This framework underpins the EU's broader policy of **Open Strategic Autonomy (OSA)**, which aims to maintain open markets while reducing strategic dependencies in key sectors such as clean energy, digital technologies, and defence. The **European Critical Raw Materials Act (ECRMA)** (2024) translates these goals into concrete targets for domestic extraction, processing, and recycling, alongside diversification of imports.

Recent research has expanded how the EU's strategic dependence on third countries for critical raw materials can be quantified.

- **Dependence** studies measure supplier concentration and import reliance using detailed trade data, highlighting how EU sourcing remains concentrated for several key inputs despite gradual diversification.
- **Exposure** research links trade and production data to trace how supply shocks propagate through global and domestic value chains, identifying which sectors and technologies are most affected by upstream disruptions.
- **Vulnerability** analyses assess the welfare and resilience implications of such shocks once substitutability, technological rigidity, and price effects are considered.

Together, these approaches translate the ECRMA's qualitative framework into quantitative measures, allowing policymakers to evaluate where the EU's critical dependencies lie, how they spread through production networks, and which sectors would face the greatest risks under adverse supply conditions.

4. Critical and Strategic Raw Materials in the ECRMA

This section presents the list of Critical Raw Materials (CRMs) and Strategic Raw Materials (SRMs) established under the European Critical Raw Materials Act (ECRMA) and the most recent 2023 assessment. These assessments identify materials that are essential to the EU's economy and industrial base, forming the foundation for policies aimed at strengthening resilience and reducing strategic dependencies. While the ECRMA provides the official list of CRMs and SRMs, it does not quantify the Union's dependence on individual supplier countries (e.g., China), the degree of exposure or vulnerability. These aspects are analysed in the following sections. Details of the methodology on the CRM and SRM indicators are provided in **Appendix A**.

4.1 Methodology and classification

The ECRMA establishes a structured and transparent framework for identifying CRMs and SRMs. This framework builds on the European Commission's long-standing criticality assessment methodology developed in cooperation with the Joint Research Centre (JRC), in consultation with the Ad Hoc Working Group on Defining Critical Raw Materials, a sub-group of the Raw Materials Supply Group expert group. It evaluates the economic and technological importance of individual materials and their associated supply risks, providing the analytical foundation for the Union's raw-materials policy. The assessment screens several candidate raw materials to classify them as potential CRMs or SRMs.

Critical Raw Materials (CRMs) are identified based on two quantitative indicators that must jointly exceed their respective thresholds: **economic importance** ≥ 2.8 and **supply risk** ≥ 1. The *economic importance indicator* measures the contribution of a material to EU value added, computed from the share of each material used across NACE 2-digit industries. It also incorporates a substitution index reflecting the feasibility of replacing the material with alternative inputs in its main applications. The *supply risk indicator* captures concentration in global and EU sourcing using the Herfindahl–Hirschman Index (HHI). It combines information on production and import dependence, weighted by the degree of EU import reliance. The measure further adjusts for *end-of-life recycling rates* and the *substitution index*, so that materials with low recycling potential or limited substitutes are rated as more critical.

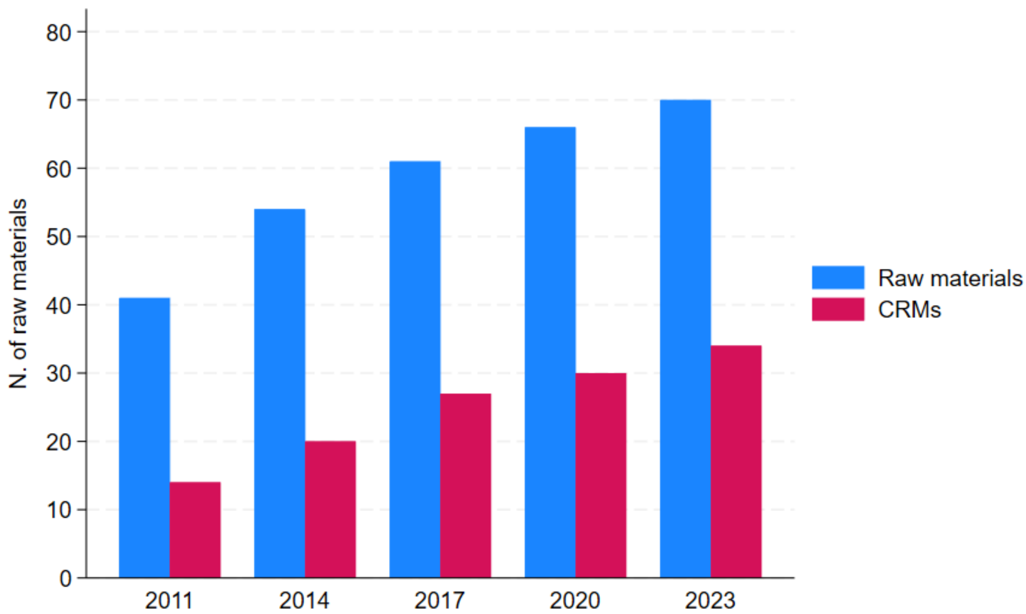
Strategic Raw Materials (SRMs) form a subset of CRMs that are deemed essential for the green and digital transitions, as well as for defence and aerospace industries. SRMs are selected based on three criteria: **strategic importance**, **forecast demand growth**, and **difficulty of scaling up supply**. *Strategic importance* is measured on the use intensity of each material in strategic technologies (e.g., batteries, wind turbines, semiconductors, defence systems). *Forecast demand growth* is calculated as the ratio of projected global demand to current global annual production. The *difficulty of scaling up supply* is proxied by current output levels, reserves-to-production ratios, and project lead times to increase supply capacity. Unlike CRMs, SRMs are not defined by fixed numerical threshold. Instead, the evaluation relies on expert judgment and forward-looking modelling of technological trends and supply constraints.

This two-tier classification serves distinct purposes. The CRM list ensures broad monitoring of materials with high economic relevance and supply risk, while the SRM list prioritises those materials most critical for the EU's strategic objectives under the OSA agenda. Together, they provide a structured basis for quantifying Europe's **dependence**, **exposure**, and **vulnerability** to disruptions in critical material supply.

4.2 Composition and evolution of CRMs

Since the launch of the EU Raw Materials Initiative in 2008, the European Commission has conducted periodic assessments to update the list of CRMs. These updates, published in 2011, 2014, 2017, 2020, and 2023, reflect changes in industrial demand, global market dynamics, technological developments, and trade patterns. **Figure 1** shows the evolution of all raw materials assessed and those identified as critical. Over this period, the CRM list has expanded substantially, from 14 materials in 2011 to 34 in 2023. The **share of CRMs in the total assessed materials rose from 34% to nearly 50%**, signalling the EU's increasing structural dependence on a broader range of inputs.

Figure 1: Total number of raw materials and CRMs (2011-2023).



Source: Study on the CRMs for the EU (European Commission, 2023).

The enlargement of the list mirrors both evolving industrial needs and shifting geopolitical realities. **Several materials identified as critical in 2011**, such as antimony, cobalt, tungsten, and the rare earth elements, **remain on the list today**, underscoring their persistent importance for EU manufacturing and energy technologies. Others, like bauxite, lithium, and copper, have been added in response to the accelerating demand associated with the green and digital transitions.

At the same time, a small number of materials were removed, including indium and natural rubber, either because supply risks eased or because their economic importance declined relative to other inputs. Beyond quantitative expansion, the 2023 assessment introduced a major qualitative shift with the formal distinction between CRMs and SRMs, the latter representing a forward-looking subset tied to the Union's strategic objectives, particularly in clean energy, digital infrastructure, and defence.

Overall, the continuous refinement of the list demonstrates **the adaptability of the EU's criticality methodology** and its capacity to respond to new technological dependencies.

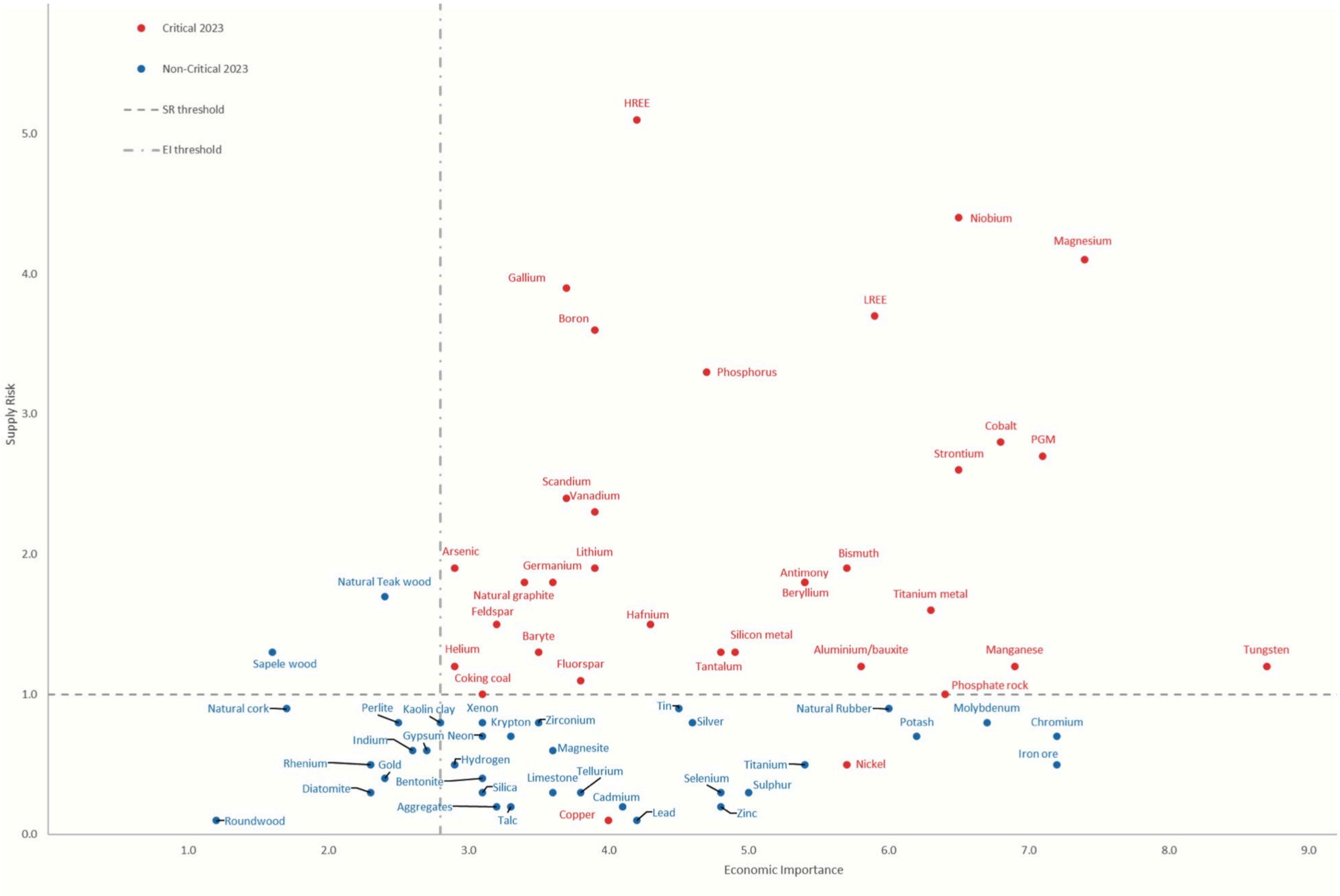
4.3 Mapping CRMs by economic importance and supply risk

Figure 2 positions all assessed raw materials according to their 2023 values for *economic importance* and *supply risk*. Materials exceeding both thresholds (economic importance ≥ 2.8, supply risk ≥ 1) are classified as CRMs and are highlighted in red. The 2023 assessment screened a total of 87 individual raw materials, consisting of 67 single materials and three material groups: ten heavy rare earth elements (HREEs), five light rare earth elements (LREEs), and five platinum-group metals (PGMs). Out of these, 34 materials met the criteria for classification as CRMs.

Materials with the **highest supply risk** include **heavy rare earth elements, niobium, magnesium, and gallium**, reflecting the strong geographic concentration of their global production. Materials with the **highest economic importance** include **tungsten, magnesium, platinum group metals, and manganese**, which are integral to EU manufacturing, renewable energy, and mobility sectors.

Two materials, **nickel and copper**, fall slightly below one threshold but are nevertheless classified as critical due to their additional strategic importance as SRMs. This highlights the tension between economic relevance and supply concentration and reinforces the need for a multidimensional approach that jointly considers dependence, exposure, and vulnerability when assessing material criticality.

Figure 2: Economic importance and supply risk for (non-)critical raw materials (2023).



Source: Study on the CRMs for the EU (European Commission, 2023).

4.4 The 2023 list of CRMs and SRMs

Table 1 summarises the **34 CRMs and 16 SRMs** identified by the European Commission in 2023 under the ECRMA. The table illustrates that SRMs constitute a subset of CRMs, reflecting materials of both high economic importance and strategic relevance.

Materials such as **copper, gallium, germanium, graphite, lithium, magnesium, manganese, nickel, platinum-group metals, silicon metal, titanium, and tungsten** meet both definitions and are therefore of the **highest strategic concern** for the European Union. These materials are critical not only because of their high economic importance and elevated supply risk, but also because they underpin key strategic technologies, but also because they underpin strategic technologies such as batteries, permanent magnets, semiconductors, hydrogen electrolysers, and renewable energy components central to the twin green and digital transitions.

A smaller group of materials, **bismuth, boron, and cobalt**, also appear in both categories but are differentiated by *application-specific grades* (for instance, battery-grade versus metallurgy-grade). This growing functional differentiation underscores that strategic dependence may hinge not only on a material itself but also on the availability of processing capacity for specific high-purity or technology-grade forms.

Conversely, several materials, e.g. **antimony, rare earths in non-magnet uses, niobium, vanadium, phosphate rock**, are classified as CRMs, but not as SRMs. While economically important and subject to supply risk, they are less directly tied to the EU's strategic technology base or defence applications. Nevertheless, their continued inclusion as CRMs signals the need for continued monitoring and evaluation on substitution, recycling, and diversification potential.

Taken together, Table 1 shows that the overlap between the CRM and SRM lists concentrates on metals and minerals central to **electrification, renewable energy, digitalisation, and defence systems**, areas that are expected to drive raw material demand over the coming decade. The distinction between CRMs and SRMs serves a dual policy purpose:

- **Prioritisation** – focusing resilience and investment measures on SRMs that are simultaneously critical and strategic;
- **Comprehensiveness** – maintaining a wider monitoring scope for CRMs to anticipate emerging dependencies as technologies evolve.

Overall, the 2023 lists confirm a structural shift in the EU's materials landscape: the core of strategic dependency now lies in a narrow set of energy-transition and digital-technology inputs, underscoring the need for coordinated action across trade, industrial, and innovation policies under the Open Strategic Autonomy framework. The next section examines the geographical dimension of these dependencies, with a particular focus on China's dominance in the production and export of critical and strategic raw materials.

Table 1: Most recent list of critical and Strategic Raw Materials in the ECRMA.

Raw material	Critical	Strategic
Antimony	✓	
Arsenic	✓	
Bauxite / Alumina / Aluminium	✓	
Baryte	✓	
Beryllium	✓	
Bismuth	✓	✓
Boron	✓	✓ (metallurgy grade)
Cobalt	✓	✓
Coking Coal	✓	
Copper	✓	✓
Feldspar	✓	
Fluorspar	✓	
Gallium	✓	✓
Germanium	✓	✓
Hafnium	✓	
Helium	✓	
Heavy Rare Earth Elements	✓	
Light Rare Earth Elements	✓	
Lithium	✓	✓ (battery grade)
Magnesium	✓	✓ (metal)
Manganese	✓	✓ (battery grade)
Natural Graphite	✓	✓ (battery grade)
Nickel	✓ (battery grade)	✓ (battery grade)
Niobium	✓	
Phosphate Rock	✓	
Phosphorus	✓	
Platinum Group Metals	✓	✓
Rare Earth Elements (Nd, Pr, Tb, Dy, Gd, Sm, Ce)	✓	✓ (for magnets)
Scandium	✓	
Silicon Metal	✓	✓
Strontium	✓	
Tantalum	✓	
Titanium Metal	✓	✓
Tungsten	✓	✓
Vanadium	✓	

Source: European Commission (2023a).

Summary: Critical and Strategic Raw Materials in the ECRMA

The **ECRMA** establishes a unified framework for identifying **Critical Raw Materials (CRMs)** and **Strategic Raw Materials (SRMs)** based on economic importance, supply risk, and forward-looking strategic relevance.

CRMs are defined by quantitative thresholds for economic importance (≥ 2.8) and supply risk (≥ 1), providing a broad monitoring base for materials essential to EU industry.

SRMs form a focused subset of CRMs selected for their pivotal role in the green, digital, and defence transitions, assessed through indicators of strategic importance, demand growth, and scalability of supply.

Between **2011 and 2023**, the CRM list expanded from **14 to 34 materials**, reflecting both changing industrial needs and evolving geopolitical dependencies.

The **2023 classification** confirms that Europe's structural vulnerabilities are concentrated in a narrow group of metals and minerals, such as **lithium, nickel, copper, gallium, germanium, magnesium, graphite, and rare earth elements,** that are indispensable for electrification, renewable energy, semiconductors, and defence systems.

The **CRM–SRM distinction** serves two complementary policy functions:

- **Prioritisation** – focusing resilience and investment measures on SRMs that are simultaneously critical and strategic;
- **Comprehensiveness** – maintaining wide monitoring coverage to anticipate emerging dependencies as technologies evolve.

Collectively, these measures anchor the EU's strategy to reduce **dependence**, manage **exposure**, and mitigate **vulnerability** in raw-material supply chains, thereby operationalising **Open Strategic Autonomy (OSA)** in the field of resource security.

5. China's role in Critical Raw Materials

The production, refining, and processing of many Critical Raw Materials (CRMs) are highly geographically concentrated, creating significant supply risks for countries such as the EU that depend heavily on their imports.[2] Among global suppliers, **China occupies a dominant position across multiple stages of the value chain**, from extraction and refining to downstream manufacturing, making it the central hub in several CRM supply chains.

5.1 Position in global CRM supply chains

China is the world's leading supplier of clean energy technologies and a net exporter for many of them. It holds **at least 60% of global manufacturing capacity** for mass-produced clean-energy technologies, such as **solar photovoltaic (PV) systems, wind turbines, and batteries**, and **around 40% of electrolyser production** (International Energy Agency, 2023). The EU remains a net importer for most of these technologies, particularly solar PV modules, battery components, and fuel cells.

Beyond final goods, China also dominates the **midstream processing and refining** stages of critical materials. It performs about **90% of global rare earth refining** and accounts for **60–70% of lithium and cobalt chemical refining**, with even higher shares in **graphite anode materials**, essential for nearly all electric vehicle batteries. Moreover, China holds around **half of global investment value in planned lithium chemical plants**, reflecting its vertically integrated industrial ecosystem, cost advantages, and extensive state support (International Energy Agency, 2023).

Despite this strength, China depends on imports of several unprocessed ores, such as cobalt from the Democratic Republic of the Congo and lithium from Chile and Australia, illustrating its dual role as both a **dominant processor and a dependent importer**. To mitigate these upstream risks, Chinese firms have systematically invested in mining assets across Africa, Latin America, and Southeast Asia, as well as in overseas refining and downstream facilities, securing long-term access to raw material inputs. Between 2018 and 2021, Chinese companies invested USD 4.3 billion in lithium assets, more than double the combined investment of firms from the United States, Australia, and Canada over the same period.

Recent global shocks, including the COVID-19 pandemic, the Russian invasion of Ukraine, and surging demand for clean energy technologies, have dramatically affected CRM markets. Between 2019 and 2022, the average **price of lithium increased fourfold**, while **cobalt and nickel roughly doubled** in price (International Energy Agency, 2023). These developments **reversed a decade-long decline in battery costs**: battery prices rose nearly 10% globally in 2022. Similarly, prices of key industrial inputs such as solar-grade polysilicon, copper, and steel roughly doubled between early 2020 and mid-2022, increasing the cost of solar modules by 25% and wind turbines by up to 20% outside China.

[2] The Raw Materials Information System of the European Commission provides a comprehensive and detailed overview of these production and technology profiles.

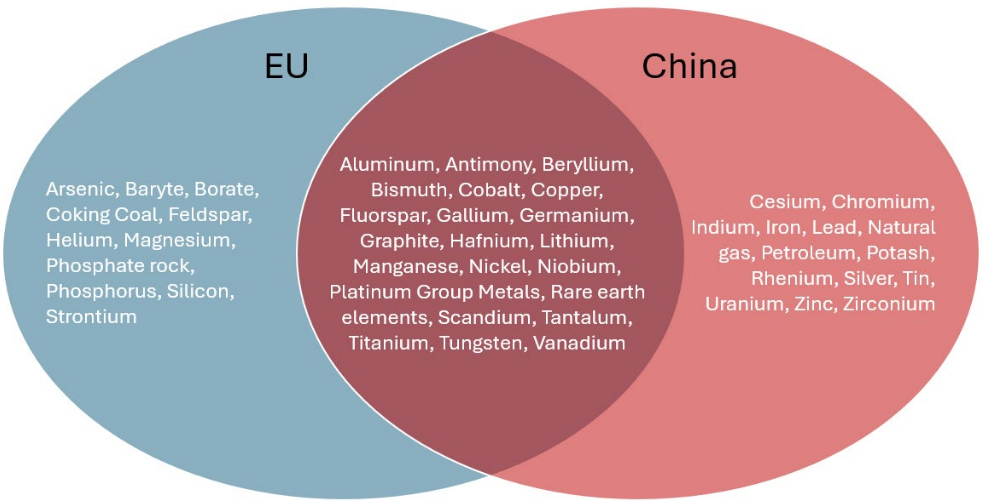
These dynamics underscore the degree to which China's production concentration and policy decisions can influence global markets. Temporary export restrictions or production cuts have previously caused price surges in rare earths and magnesium, highlighting how tight market structures can transmit shocks through international supply chains.

5.2 China's strategy on critical and strategic minerals

In recent years, Chinese authorities have sought to systematise the definition and monitoring of strategic critical minerals. Scholars at the Chinese Academy of Geological Sciences, a government think tank under the administration of the Ministry of Land and Resource, define them as "minerals crucial to the national economy, indispensable to strategic emerging industries, and endowed with geopolitical significance" (Wang and Yuan, 2022). Drawing from the National Mineral Resource Plan (2016–2020) and the 2018 List of Strategic Critical Minerals for a New Era, they identify minerals central to the **Made in China 2025** industrial programme.[3]

Table 2 lists China's recognised CRMs, indicating whether each mineral is explicitly linked to a Made in China 2025 priority industry in Wang & Yuan (2022). While the list overlaps partially with the EU classification (see **Figure 3**), it highlights a much broader scope, covering both advanced-technology inputs and base industrial materials. Most are produced domestically, while only a limited subset, such as oil, natural gas, potash, and uranium, remains primarily import-dependent.

Figure 3: Overlap between China's and EU's strategic critical minerals.



Source: Authors own calculations based on ECRMA and Li et al. (2023).

[3] An updated version of the National Resource Plan for 2021-2025 has been devised but not publicly disclosed. Local government versions of the plan reference the national plan, but potential updates to the list of strategic minerals remain undisclosed. Chinese researchers generally revert to the above mentioned pre-2020 documents.

Table 2: Chinese Critical Raw Materials.

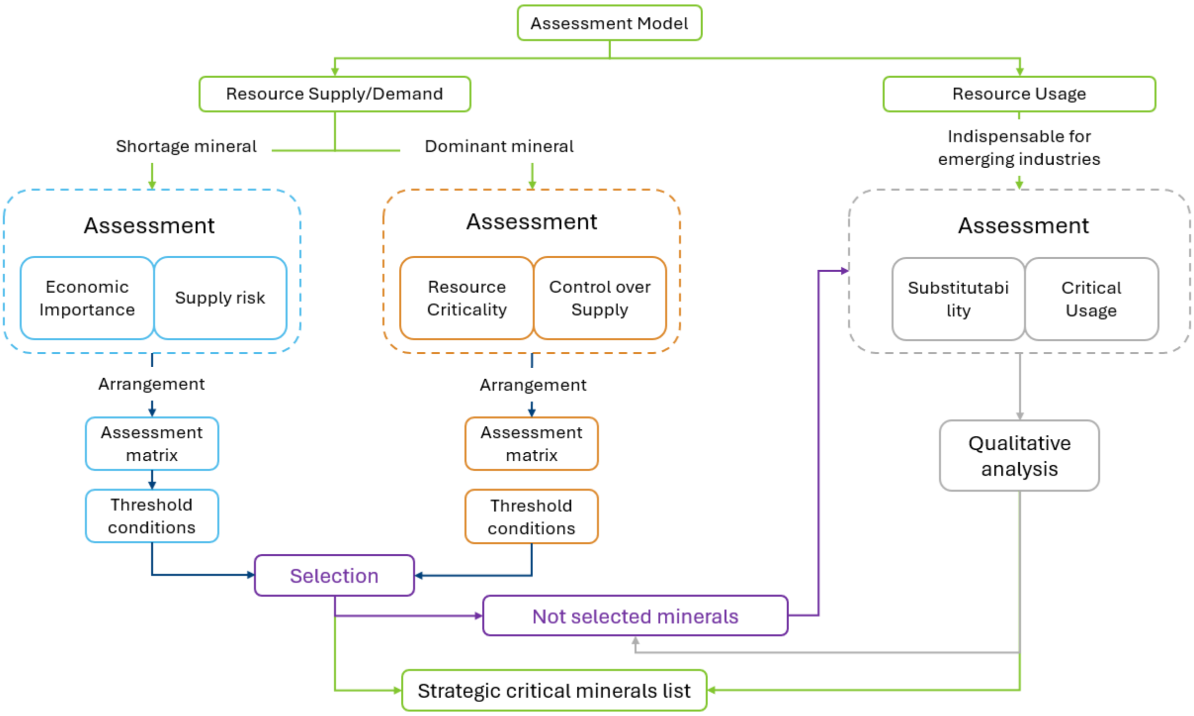
Chinese Name	English Name	Made in China 2025
镍	Nickel	Yes
钨	Tungsten	Yes
锡	Tin	No
钼	Molybdenum	Yes
锑	Antimony	No
钴	Cobalt	Yes
锂	Lithium	Yes
铀	Uranium	No
铁	Iron	Yes
铬	Chromium	Yes
铜	Copper	Yes
磷	Phosphorus	Yes
金	Gold	No
锆	Zirconium	Yes
铝	Aluminium	Yes
稀土	Rare earths	Yes
石油	Petroleum (crude oil)	No
天然气（页岩气,煤层气）	Natural gas (Shale & CBM)	No
煤炭	Coal	No
钾盐	Potash	No
铍	Beryllium	Yes
铌	Niobium	Yes
钽	Tantalum	Yes
硒	Selenium	No
铼	Rhenium	Yes
钒	Vanadium	Yes
镓	Gallium	Yes
锗	Germanium	Yes
铟	Indium	Yes
石墨	Graphite	Yes

Source: Wang and Yuan (2022).

Building on this framework, Li et al. (2023) propose a refined classification distinguishing between **shortage** and **dominant** strategic minerals (see **Figure 4**). *Shortage minerals* are those where domestic supply is insufficient relative to demand, exposing China to import dependence and potential vulnerability. *Dominant minerals* are those where China possesses a resource-endowment advantage, global markets rely on Chinese supply, and the country wields potential control power (潜在控制力) in international trade.

This methodology further evaluates minerals according to (i) the criticality of the resource (measured by inclusion in major countries' official CRM lists) and (ii) China's degree of control, captured by a composite index combining global export share, production share, and domestic reserves. Minerals are also linked to **strategic emerging industries** (战略性新兴产业), a key pillar of China's industrial policy since 2010. These industries, such as electric vehicles, solar photovoltaics, and advanced materials, are viewed as domains where China can leapfrog technologically advanced economies. Ensuring secure access to their raw material inputs is therefore seen as essential for achieving technological self-reliance. **This concept, unique to the Chinese framework, introduces an explicit coercive dimension to mineral policy, framing CRMs as both economic inputs and instruments of geopolitical influence.**

Figure 4: Assessment method of the Chinese Academy of Geological Sciences.



Source: Li et al. (2023).

Li et al. (2023) identify **31 strategic critical minerals**, listed in **Table 3**. The materials are divided into energy, metallic, and non-metallic categories. Many overlap with the EU's CRM and SRM lists, though China's coverage is broader: it includes widely used base metals (copper, iron, zinc) and fossil fuels (oil, gas, coal) for which China remains highly import-dependent. The distinction between shortage and dominant minerals is fundamental: it defines both external vulnerabilities (e.g. oil, natural gas, uranium) and potential levers of power (e.g. tungsten, rare earths, gallium, graphite).

Table 3: China's Strategic Critical Minerals.

Category	Count	Shortage minerals	Dominant minerals
Energy minerals	3	Oil (petroleum), natural gas, uranium.	
Metal minerals	25	Iron, manganese, chromium, copper, aluminium, nickel, cobalt, lithium, beryllium, niobium, tantalum, zirconium, hafnium, platinum-group metals, rhenium, cesium, scandium.	Vanadium, tungsten, antimony, bismuth, rare-earth elements, gallium, germanium, indium.
Non-metallic minerals	3	Potash.	Fluorite (fluorspar), graphite.

Source: Li et al. (2023).

This classification provides the analytical foundation for China's resource-security policy, which combines **domestic control of dominant minerals** with **outward investment in shortage minerals**, thereby extending its influence across global supply chains. It also embeds resource management within the country's broader industrial planning architecture, linking the raw-materials sector directly to national goals of **technological advancement, resilience, and strategic autonomy**.

5.3 Integration of CRMs into China's industrial and security policy

Since the founding of the People's Republic of China in 1949, mineral resources have occupied a central place in the country's industrialisation strategy. During the Mao era, critical raw materials were viewed as strategic assets for achieving self-sufficiency in defence and heavy industry. With the reforms initiated under Deng Xiaoping, raw materials acquired a **geopolitical dimension**. Deng famously declared in 1992 that "the Middle East has oil, China has rare earths" (中东有石油，中国有稀土), symbolising the perception of **critical minerals as a pillar of national strength and autonomy**.

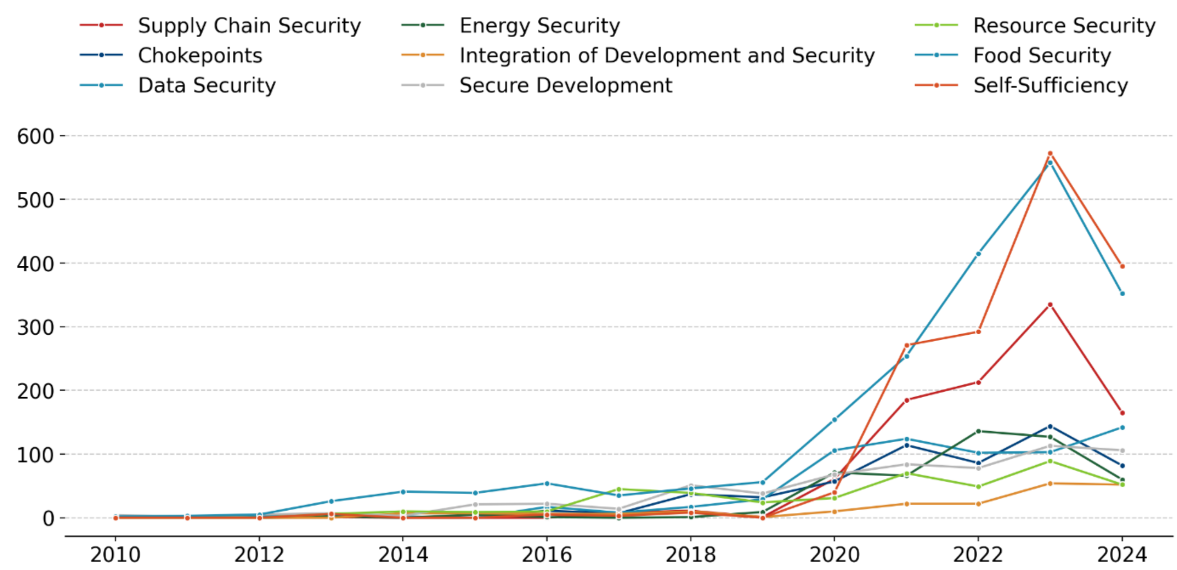
Technically, raw materials were categorised as foundational industries (基础产业), together with energy, transport, communications, and agriculture, forming the backbone of China's national economic security. This framing persisted in central government communications until the mid-2000s. In the contemporary policy lexicon, strategic critical minerals (战略性关键矿产资源) are those that form part of "industries representing the lifeline of the national economy and affecting the livelihood of the people" (国民经济是国家命脉, 关系民生的领域). These sectors are typically **dominated by state-owned enterprises** (SOEs), reflecting the constitutional principle that mineral resources belong to the state. Under the Mineral Resources Law, ownership rests with the State Council, which regulates exploration, extraction, and reserves on behalf of the people.

China's modern approach to critical raw materials is embedded in a broader political economy of **self-reliance and strategic security**. Historically, the Chinese state has regarded exposure to foreign powers with caution, shaped by a long tradition of Sino-centrism and a desire for autonomy in the control of key resources. This sentiment was reinforced by the "century of humiliation" (1842–1949), when forced market openings and colonial incursions left a deep legacy of vulnerability. Even as China embraced reform and globalisation, this experience continued to inform a persistent perception that dependence on foreign technologies and inputs constitutes a potential strategic threat (Wang, 2012).

Under President Xi Jinping, this logic has crystallised into a doctrine of **comprehensive self-sufficiency**. The "great rejuvenation of the Chinese nation" places control over strategic inputs (technologies, energy, and raw materials) at the centre of national security. Industrial policy support for the electric-vehicle sector, for example, is explicitly justified as a means to reduce dependence on imported oil, which still accounts for roughly 70% of consumption (Wang et al., 2023). Yet China's development model continues to exhibit the "two ends outside" pattern (资源和市场 两头在外), in which both resources and final markets lie abroad. Between 2013 and 2019, value added in Chinese manufacturing rose by roughly 50%, while value added in mining fell by 30%, illustrating the gap between industrial expansion and raw material supply.

The 2019 U.S. restrictions on Huawei and subsequent export-control measures on semiconductors and advanced machinery (Newman & Farrell, 2023) reinforced Beijing's conviction that **technological and resource security are inseparable**. As shown in **Figure 5**, references to "security," "self-sufficiency," and "resource security" in central policy documents have surged since 2016, reaching record levels after 2021. The official narrative of "great changes unseen in a century" (百年未有之大变局) now underpins a broad securitisation of economic policy, extending explicitly to mineral resources.

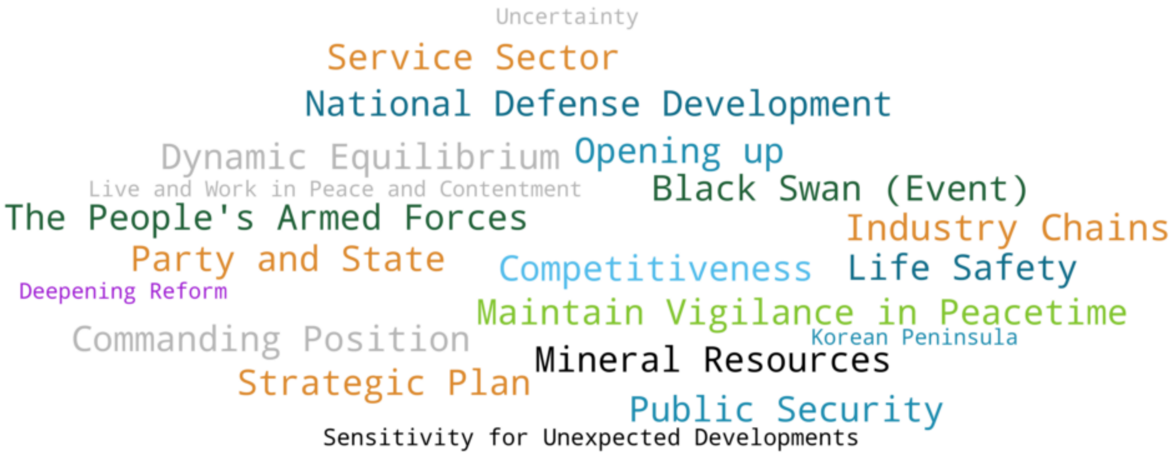
Figure 5: Mentions of security-related keywords in non-normative central policy documents.



Source: Schindowski, Zenglein, and Groenewagen-Lau (mimeo).

China's "dual-circulation" development model (以国内大循环为主体、国内国际双循环相互促进的新发展格局) embodies this shift. It prioritises the domestic market as the main growth driver while maintaining selective openness to foreign investment. The goal is to strengthen internal resilience, mitigate supply-chain vulnerabilities, and reduce reliance on external demand. Within this framework, the principle of integrating development and security (统筹发展与安) promotes "bottom-line thinking" and preparedness for systemic shocks through crisis-management and early-warning mechanisms. Mineral resources feature prominently in this doctrine (see **Figure 6**).

Figure 6: Keywords in policy documents on "integration of development and security".



Note: Keywords are considered more important the higher the absolute number of appearances is and the closer these keywords are to other frequent keywords.

Source: Schindowski, Zenglein, and Groenewagen-Lau (mimeo).

By embedding mineral-resource governance into its broader security framework, China has transformed CRMs from purely industrial inputs into instruments of **strategic resilience and geopolitical leverage**. This integration sets the stage for a comprehensive system of legal, financial, and administrative policy instruments, through which Beijing coordinates domestic control and international influence.

5.4 Policy instruments and governance

China's mineral resource strategy combines **industrial policy, state ownership, and an increasingly security-driven governance** framework. Since 2020, this approach has been formalised under the "**dual-circulation**" development model and the principle of "integrating development and security", which emphasises crisis readiness, supply-chain resilience, and self-reliance.

Strategic materials and institutional reforms

The 2024 revision of the Mineral Resource Law strengthened the role of strategic minerals in national planning and state oversight. The State Council maintains a confidential list of strategic critical minerals, while provincial governments have been granted broader authority to coordinate extraction, transport, and emergency supply. Geological surveys for strategic minerals are mandatory before major construction projects, and mineral reserves may not be overlaid with other infrastructure. The National Security White Paper (May 2025) further elevated minerals to the status of national-security assets, establishing the objective of a comprehensive strategic-material reserve system. Resource policy has become increasingly linked to energy-security goals, seeking to reduce dependence on imported oil and gas while expanding renewable-energy production. Yet this shift introduces new vulnerabilities in transition materials such as lithium, cobalt, nickel, and rare earths (Escobar et al., 2025). The resulting "transition-materials strategy" emphasises domestic production and stockpiling of critical inputs for solar, wind, and battery technologies.

Geo-economic and trade Instruments

In parallel, Beijing has broadened its **toolbox of geo-economic instruments** (Medeiros & Polk, 2025), which now includes:

- the *Unreliable Entities List*;
- the *Anti-Foreign Sanctions Law*;
- the *2024 Tariff Law*;
- cybersecurity and merger-review mechanisms; and
- an expanded *export-control regime* covering selected CRMs.

Export controls have become a cornerstone of China's economic statecraft, see **Table 4**. Licensing requirements for **gallium and germanium** were introduced in July 2023 (effective 1 August 2023), followed by new controls on **graphite** in October 2023 (effective December 2023). Although presented domestically as national-security measures, these restrictions reveal the **policy risk at the midstream stage**: small-volume inputs with few substitutes can transmit shocks rapidly through global value chains. As of 2025, all CRMs on China's export control list are considered "dominant minerals". Furthermore, except for Fluorspar and Vanadium, all materials identified by the Chinese Academy for Geological Sciences as "dominant" find themselves on China's export control list.

Table 4: Timeline of export CRM export control measures.

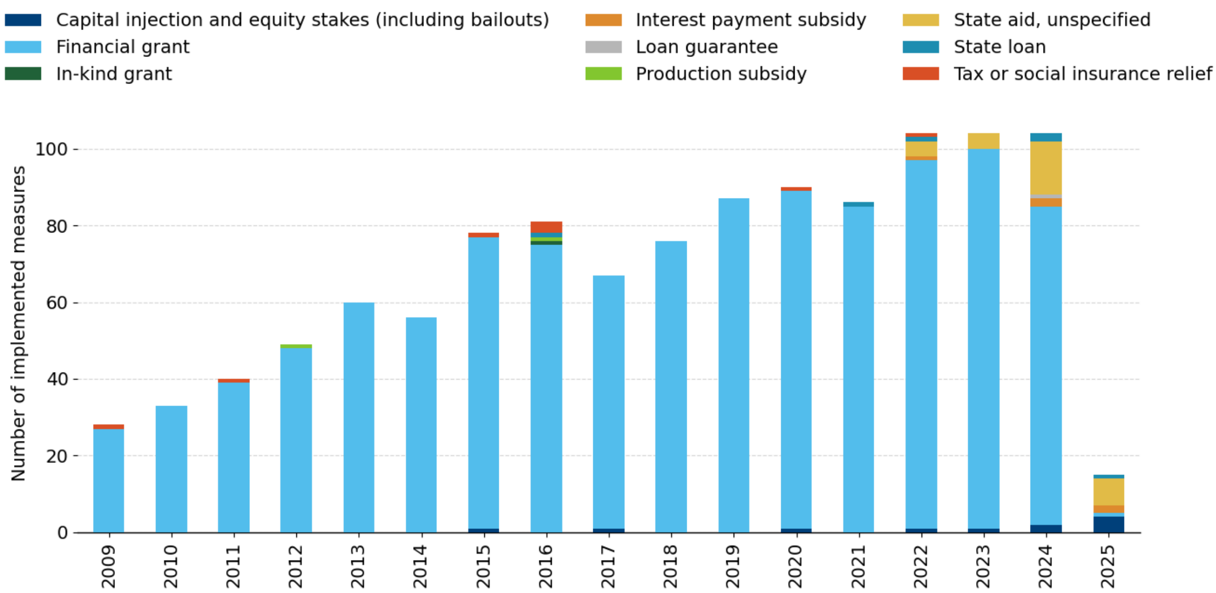
Date	Raw Material(s)	Content
9/1/2010	Rare earths	China suspends rare-earth shipments to Japan.
5/20/2015	Rare earths, tungsten, molybdenum	WTO ruling (WTO DS431/432/433 rulings) against China's export quotas on rare earths, tungsten, and molybdenum.
12/1/2020	—	China's Export Control Law enters into force.
8/1/2023	Gallium, germanium	Export licensing requirements introduced.
10/20/2023	Graphite	Licensing introduced for sensitive graphite grades.
12/21/2023	Rare earths	Ban on export of rare-earth processing and magnet-making technologies.
9/15/2024	Antimony	Antimony added to export controls under a dual-use rationale.
12/1/2024	Dual-use materials (various)	Regulations issued on Export Control of Dual-Use Items and dual-use control list.
12/3/2024	Antimony, gallium, germanium, graphite	China bans exports of antimony, gallium, and germanium; tightens checks on graphite exports.
2/4/2025	Tungsten, tellurium, bismuth, indium, molybdenum	Export controls implemented.
4/4/2025	Samarium, gadolinium, terbium, dysprosium, lutetium, scandium and yttrium	Export controls imposed on 7 out of 17 medium and heavy rare earths.
10/9/2025	Holmium, erbium, thulium, europium and ytterbium	Export control on five additional rare earths. Also covers rare earth-related processing technology and equipment.

Source: Global Trade Alert Database.

Subsidies and state Influence

State ownership and industrial subsidies further reinforce China's control over strategic sectors. Financial grants and equity injections, often channelled through **state-owned or provincial funds**, target large conglomerates in energy, mining, and materials. Data from the Global Trade Alert Database (**Figure 7**) indicate a **sharp post-2020 increase** in disclosed subsidies, although overall support remains partly opaque due to declining transparency and limited publication of non-normative policy documents (von Carnap, 2024). In practice, China's ownership of land, banks, and major upstream firms enables **policy steering without formal announcements**, meaning that standard monitoring tools likely underestimate the true scale of state intervention.

Figure 7: Implemented Subsidies to Critical Minerals, China.



Source: Global Trade Alert Database.

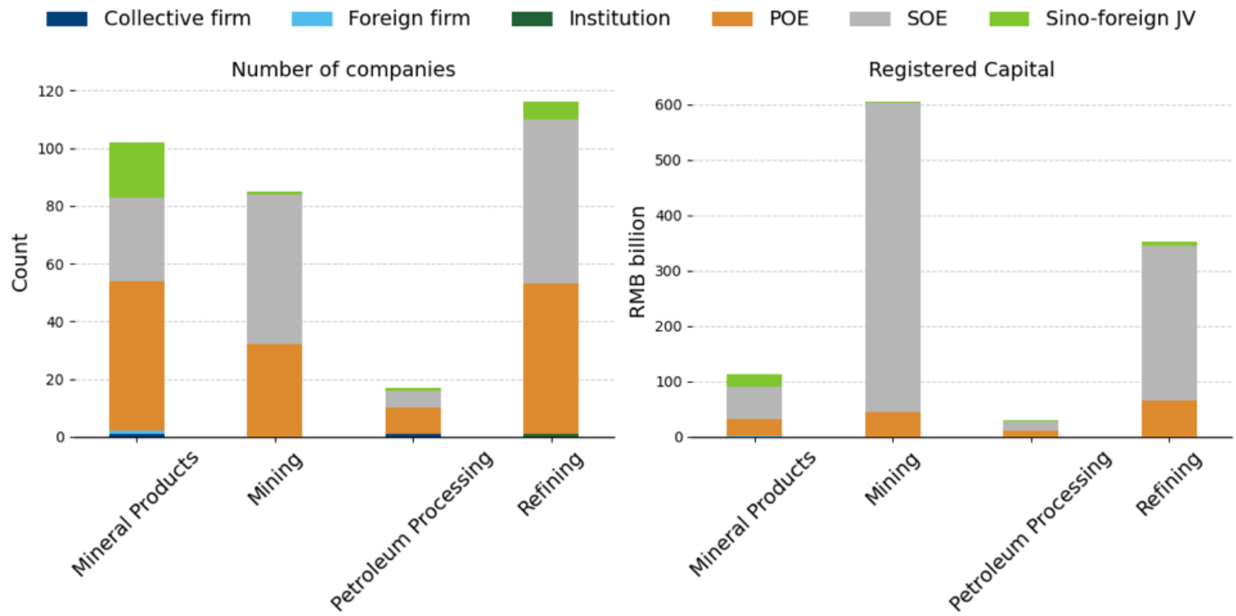
Next to the updating of government regulation, SOEs will play a major role in using China's CRM leverage to pursue geopolitical interests. SOEs are part of the government's control over the factors of production and their function as the *ruling foundation of the party* (执政基础) has been reemphasized under Xi Jinping. Through the most recent wave of SOE reform from 2015 onwards, SOE's management teams have become more closely tied to the company-internal party organization, which now participates directly in strategic decision-making and the appointment of important personnel (Beck and Brødsgaard, 2022). China's promotion of a *modern industrial system with Chinese characteristics*[4] (中国特色现代化企业制度) further states that the essential guiding role of SOEs should be strengthened through an increased presence in supply chains, especially in upstream segments.

Mineral resources are emblematic of this. Based on publicly listed firms along the mineral resource value chain in China, private firms take a considerable share in the number of companies but are overshadowed by SOEs in terms of registered capital (**Figure 8**). As of 2024, capital registered in mineral-related industries was roughly 1.097 trillion RMB (€132.19 billion), representing 12.13% of total registered capital. In some CRMs sub-industries, companies have also been consolidated into a few large conglomerates since the early 2000s. For instance, out of 67 granted licenses in rare earths mining in 2012, six large companies emerged by 2016, which were further consolidated into the two now dominant rare earth mining firms. The China Northern Rare Earth Group is solely responsible for mining light rare-earths, China Rare Earths Group is permitted to mine heavy rare earths on top of that[8]. This

[4] https://www.gov.cn/zhengce/202505/content_7025304.htm.

will grant the CCP the ability to influence global prices and thus render any de-risking strategy particularly costly.

Figure 8: Listed firms active in minerals resources by ownership type, 2024.



Source: Authors' calculations based on CSMAR.

Together, these instruments form a comprehensive governance framework that integrates CRMs into China's industrial and security architecture. The system combines domestic control, through legal, administrative, and financial mechanisms, with external leverage exercised via export controls and strategic subsidies. By embedding mineral policy within its wider national-security doctrine, Beijing seeks simultaneously to secure upstream supply, maintain dominance in midstream processing, and preserve strategic influence over global markets, all under the overarching objective of national self-reliance and resilience.

5.5 Implications for the EU risk profile

China's control over CRMs creates structural asymmetries in the global economy that directly affect the EU's industrial and strategic security. The combination of extensive refining capacity, state-backed industrial coordination, and export-control instruments grants Beijing both market power and political leverage over midstream supply chains on which the EU depends. While Europe remains a principal consumer of clean energy and advanced manufacturing inputs, it lacks domestic refining capacity for most CRMs and relies heavily on Chinese intermediate products such as lithium carbonate, cobalt sulphate, and rare earth oxides.

This concentration of processing activities in China magnifies vulnerability at the **midstream stage**, where substitution options are limited and switching costs are high. Even temporary Chinese export restrictions on small-volume, high-leverage inputs (for example gallium, germanium, or graphite) can disrupt production across multiple EU sectors, from semiconductors and batteries to renewable-energy technologies. Because these materials enter European value chains indirectly through complex intermediate goods, the resulting risks are systemic rather than confined to individual import flows.

The **integration of mineral governance into China's security architecture** further heightens exposure. Instruments such as the *Mineral Resource Law* (2024), the *National Security White Paper* (2025), and the expanding export-control regime blur the boundary between economic management and national-security policy. As a result, supply chain reliability is now contingent on political relations and internal Chinese policy priorities rather than solely on market dynamics. For the EU, these developments translate into a dual challenge: maintaining access to essential inputs while mitigating growing strategic dependence on a single supplier. Understanding where and how such dependencies are embedded within European production networks is therefore critical. The following section maps these dependencies quantitatively, tracing China's weight across the EU's CRM supply chains and identifying the sectors most exposed to potential disruption.

Summary: China's Role in Critical Raw Materials

Global dominance: China is the leading actor across critical-raw-material (CRM) value chains. It accounts for roughly 90 % of global rare-earth refining, 60–70% of lithium and cobalt chemical processing, and at least 60 % of manufacturing capacity for clean-energy technologies such as solar PV, wind turbines, and batteries.

Dual position: While China dominates midstream processing, it remains import-dependent for several unprocessed ores (notably cobalt, lithium, and nickel). To mitigate this, Chinese firms have secured upstream access through extensive overseas investments in Africa, Latin America, and Southeast Asia.

Strategic framing: Minerals have been viewed as pillars of national strength. Under Xi Jinping, this logic has evolved into a doctrine of comprehensive self-sufficiency, linking mineral policy directly to technological autonomy, energy security, and national resilience.

Policy instruments:

- **Legal tools:** export controls, licensing regimes, and security reviews.
- **Geo-economic tools:** the *Unreliable Entities List*, *Anti-Foreign Sanctions Law*, *2024 Tariff Law*, and targeted export restrictions (e.g. gallium, germanium, graphite).
- **Financial and industrial tools:** extensive subsidies and state-directed credit to energy and materials conglomerates.

Strategic intent: China's CRM policy combines domestic control with external leverage, securing upstream supply, maintaining midstream dominance, and exercising influence over global markets.

Implications for the EU: Europe's dependence on Chinese refining and intermediate materials creates structural vulnerability at the midstream stage, where substitution is limited and policy risk is high. As mineral governance in China becomes fully securitised, **supply reliability** increasingly depends on **political relations** rather than **market forces**.

6. Mapping EU dependence on China in CRMs

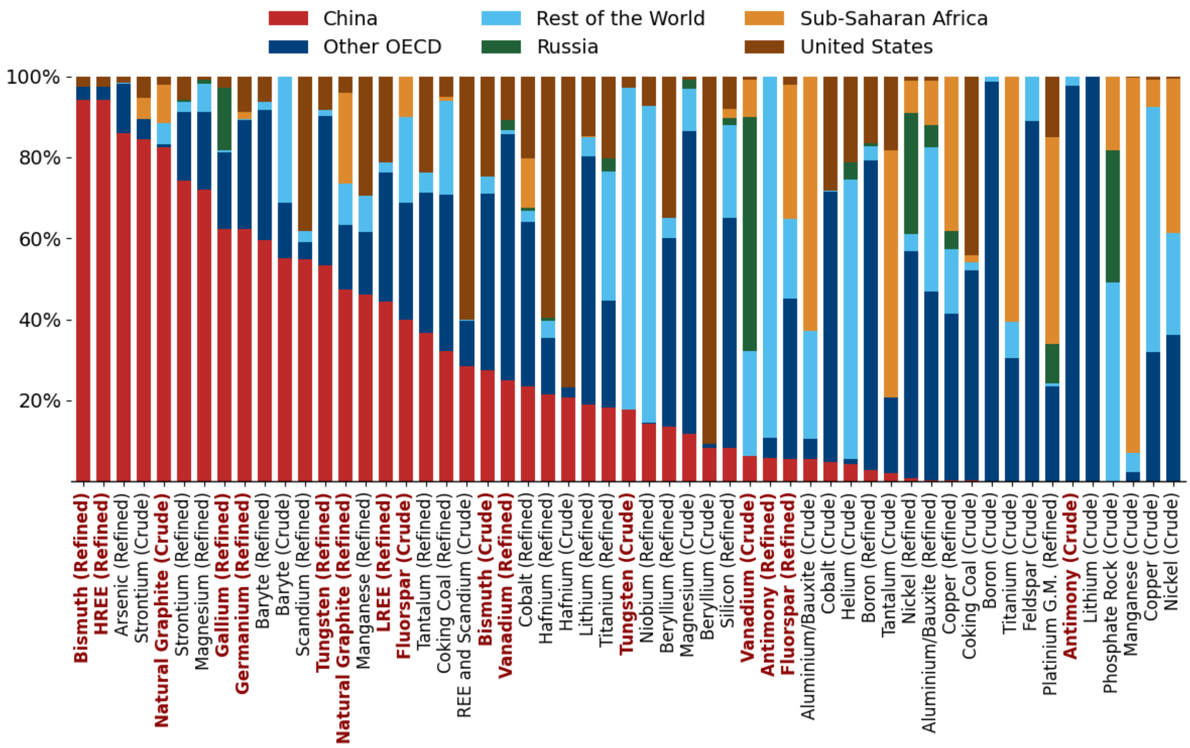
This section quantifies how Europe's dependence on China for critical raw materials (CRMs) translates into measurable economic exposure. While Section 5 examined China's strategy and industrial dominance, the present analysis shifts the focus to the EU. Using detailed trade data (Eurostat COMEXT) and product-level mappings under the ECRMA, we identify where European supply relies most heavily on Chinese inputs and where supplier concentration limits diversification options. Combining trade data with input-output tables (Eurostat's FIGARO), subsequent analysis traces how these dependencies can propagate through downstream industries and value chains. We close with an analysis of economic vulnerability.

6.1 Patterns of EU-China trade and import concentration

This subsection quantifies the EU's **direct import dependence** on China for CRMs and the **degree of supplier concentration** across extra-EU partners. Dependence is measured as the share of EU CRM imports originating from China, while concentration is assessed using the Herfindahl–Hirschman Index (HHI) to capture the number and diversification of extra-EU suppliers. Both indicators are computed for each CRM and for all CN-8-digit products classified under the ECRMA list.

As shown in **Figure 9**, EU import dependence is particularly high for minerals that China itself classifies as *dominant*, including **bismuth (refined)**, **heavy rare earth elements (refined), gallium (refined), germanium (refined)**, **tungsten (refined)**, and **natural graphite (crude and refined)**. For these materials, China supplies more than half of total EU imports, underscoring its pivotal role in global refining capacity. Other CRMs such as **magnesium** and **strontium** also show high import concentration from China but are *not* designated as dominant in China's own classification, indicating that European vulnerabilities extend beyond those officially recognised by Beijing.

Figure 9: EU import shares for critical raw materials in 2024.

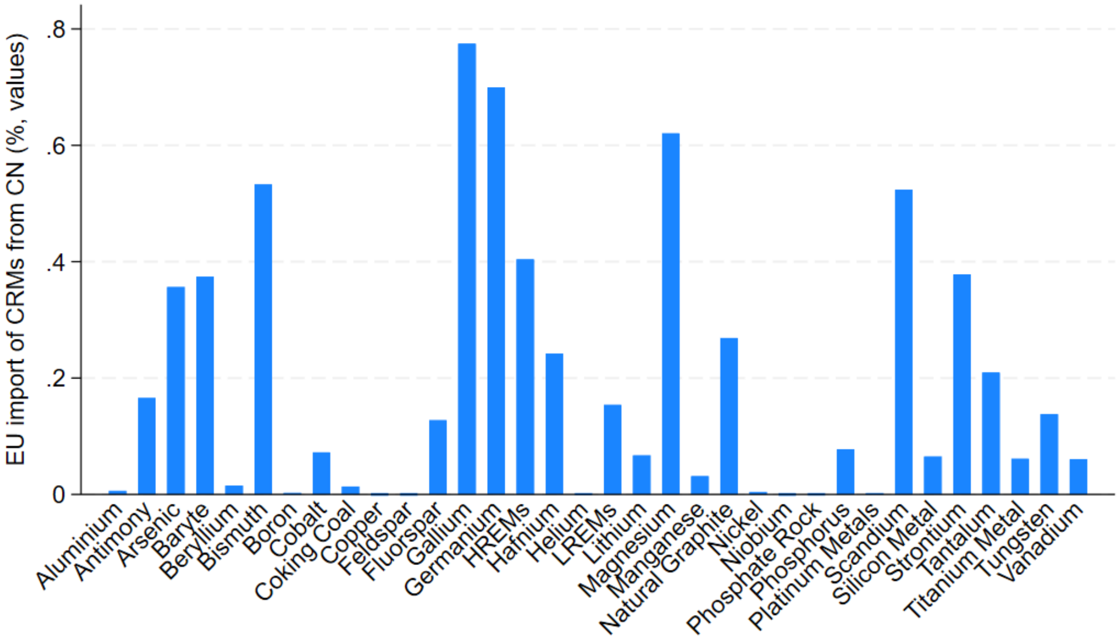


Note: CRMs included in this graph are those covered by the 2023 ECRMA. Raw materials in red are dominant minerals according to the Chinese Academy of Geological Sciences.

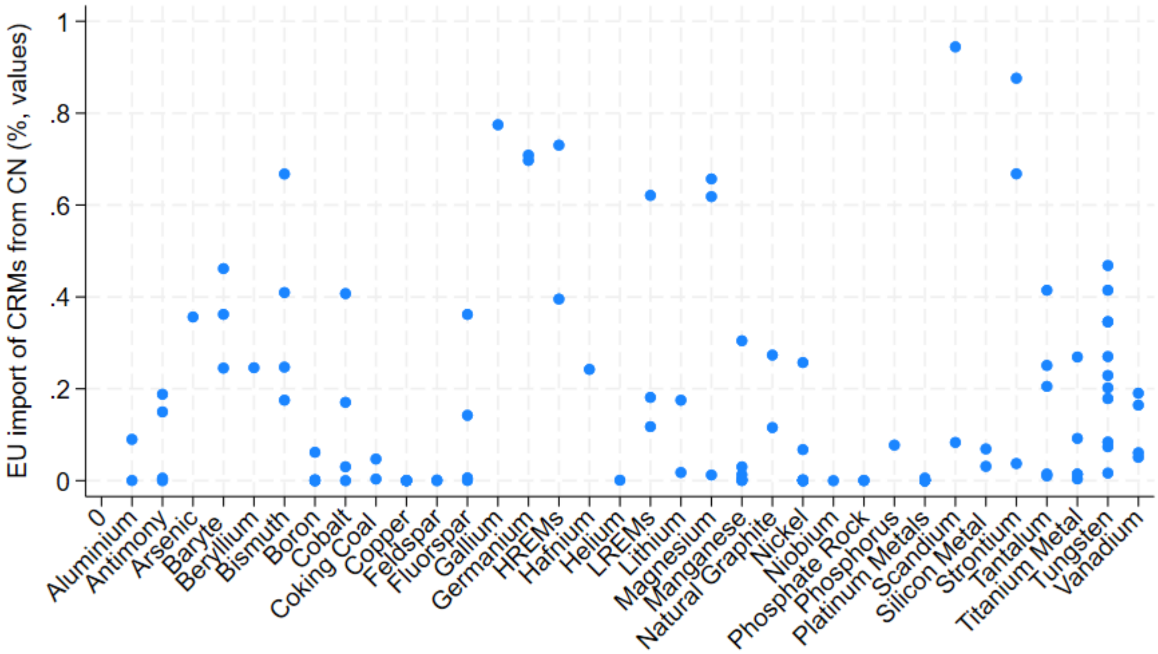
Source: Authors calculations using Eurostat Comext.

Using Eurostat COMEXT data, **Figure 10** reports the EU-wide import share from China for each CRM listed in the ECRMA. **Panel (a)** reports the aggregate EU-27 share, while **Panel (b)** disaggregates results by CN8 product within each CRM. Overall, the EU imports **more than 20% of its supply from China for twelve CRMs**, and **over 50% for five**, notably **gallium** and **germanium**, where Chinese shares exceed 70%. At the product level, dependence is even more pronounced: **35 CN8 products** record Chinese import shares above 20%, and **11 products**above 50%, particularly **processed scandium (94%)**, **strontium (88% and 67%)**, **gallium (77%)**, and **heavy rare earth materials (74%)**. This disaggregation highlights how headline CRM-level indicators can obfuscate deeper vulnerabilities in specific refined or intermediate materials.

Figure 10: Import share of CRMs from China for the EU in 2022.



Panel (a)



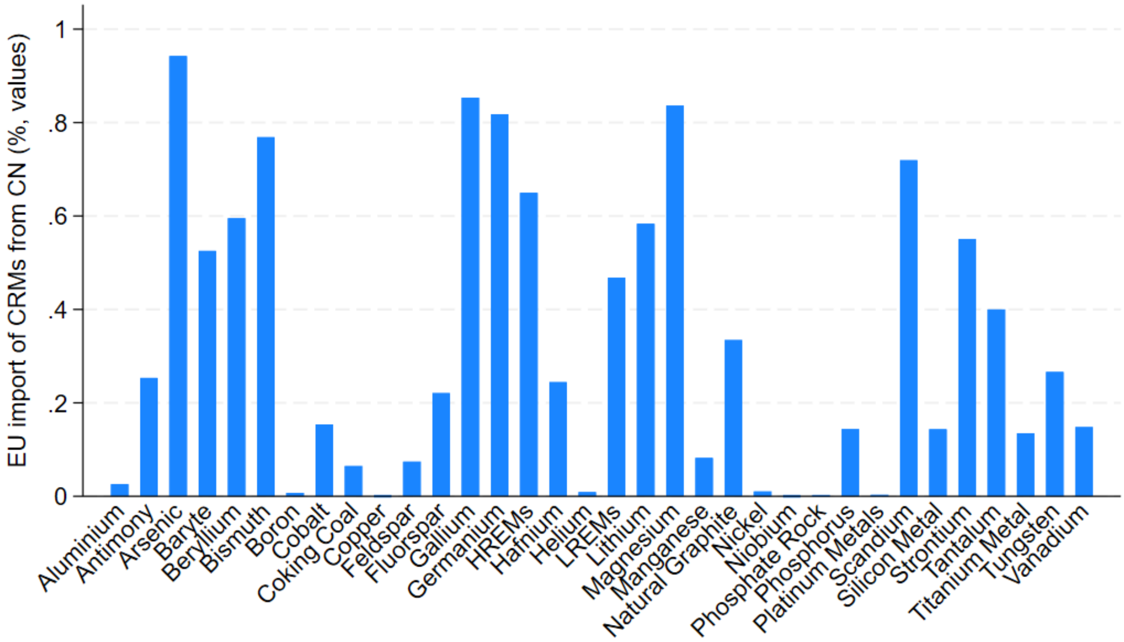
Panel (b)

Source: Authors calculations using Eurostat Comext.

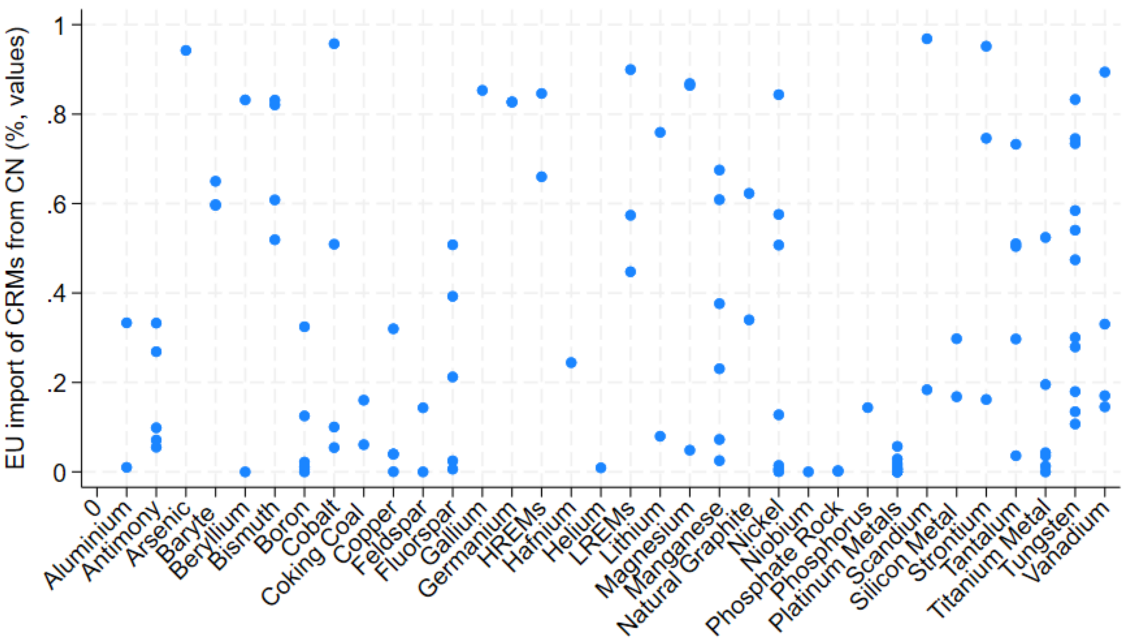
Country-specific patterns reinforce this picture. **Figure 11** presents average import shares from China across Member States, weighted by each country's contribution to total EU imports of a given CRM. The average import share exceeds 20% for **18 CRMs** and 50% for **11 CRMs**. Dependence surpasses 80 % for **arsenic, gallium, germanium, and magnesium**. These values are systematically higher than those obtained for the EU aggregate because intra-EU trade inflates total import volumes and thereby reduces measured extra-EU dependence. The country-average measure therefore provides a more accurate picture of actual reliance on Chinese inputs in national consumption and production structures. At the product level (**Panel**

(b)), the average Chinese import share exceeds 50% for **38 CN8 products**, and 80% for **15 products**, notably **arsenic (94%)**, **processed scandium (97%)**, **processed strontium (95%)**, and **processed cobalt (96%)**.

Figure 11: Average import share of CRMs from China for EU countries in 2022.



Panel (a)

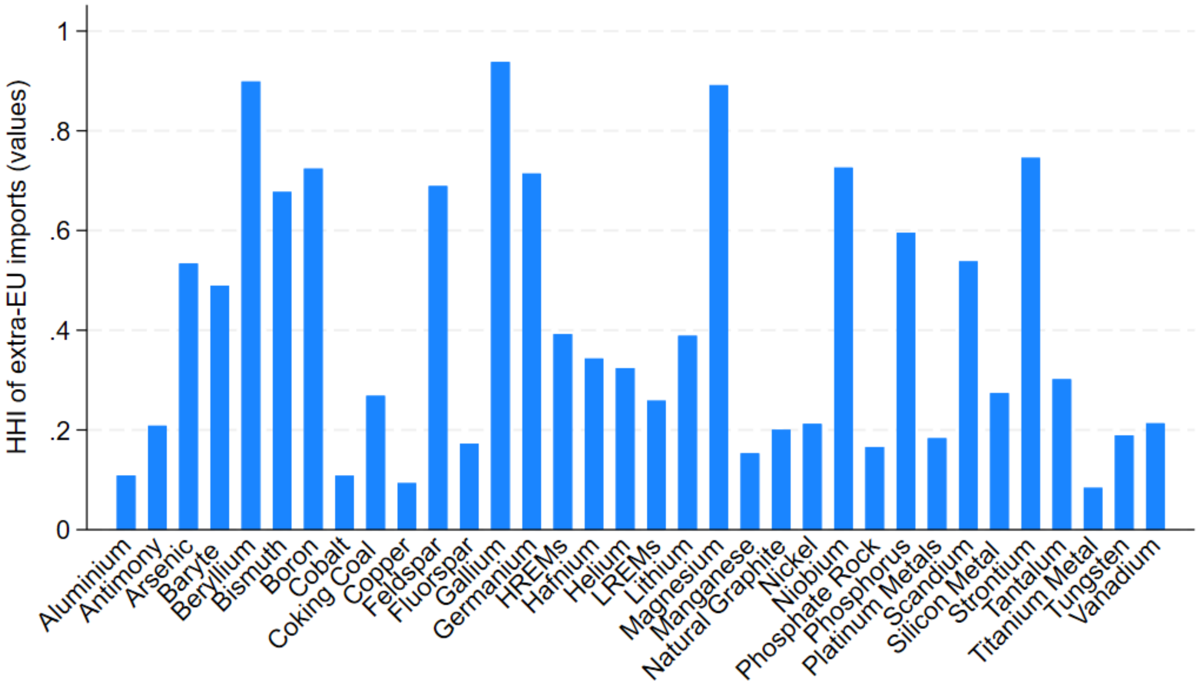


Panel (b)

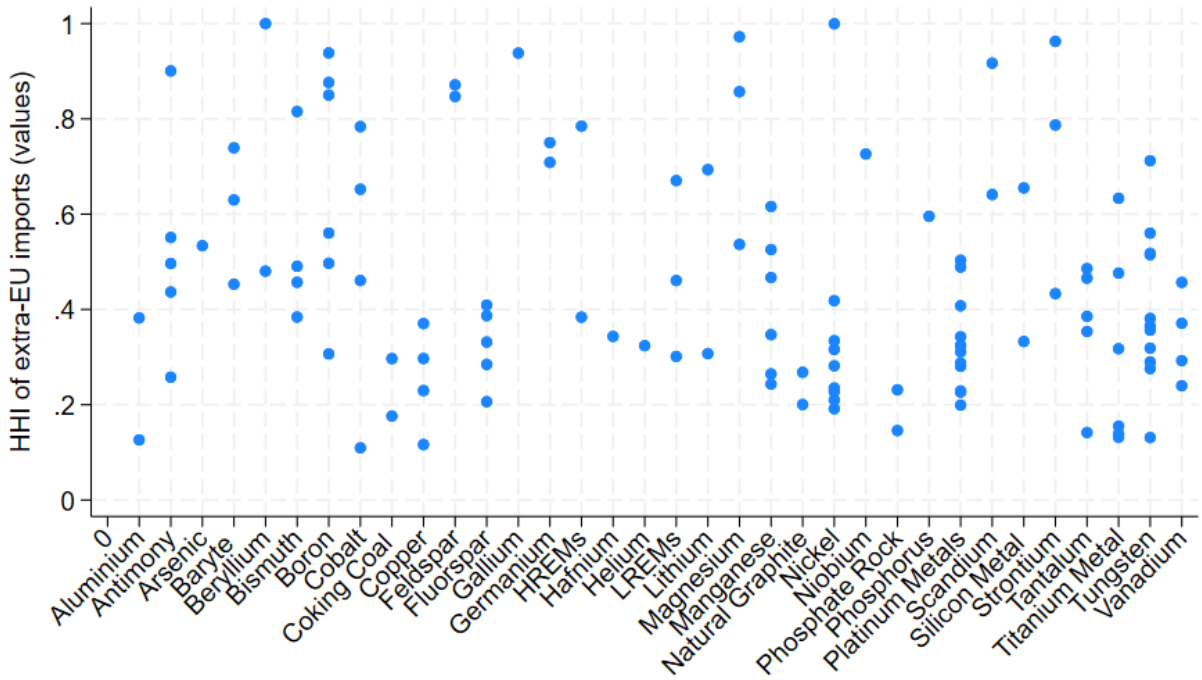
Source: Authors calculations using Eurostat Comext.

Supplier diversification is equally limited. **Figure 12** shows the concentration of EU CRM imports across all extra-EU partners. **Panel (a)** presents the concentration of EU CRM imports across all extra-EU suppliers in 2022. The HHI exceeds 0.25 for **21 CRMs**, implying that these materials are sourced from fewer than four countries on average. For **12 CRMs**, the HHI surpasses 0.5, indicating extreme concentration and sourcing from fewer than two countries. This pattern is most acute for **beryllium, gallium**, and **magnesium**. Product-level results in **Panel (b)** reveal that even CRMs appearing diversified in aggregate, such as **antimony, cobalt, manganese,** or **nickel**, contain specific products that are highly concentrated. Hence, aggregate indicators can underestimate supply-chain fragility where individual products are dominated by single suppliers.

Figure 12: Concentration of EU imports of CRMs across extra-EU suppliers in 2022.



Panel (a)

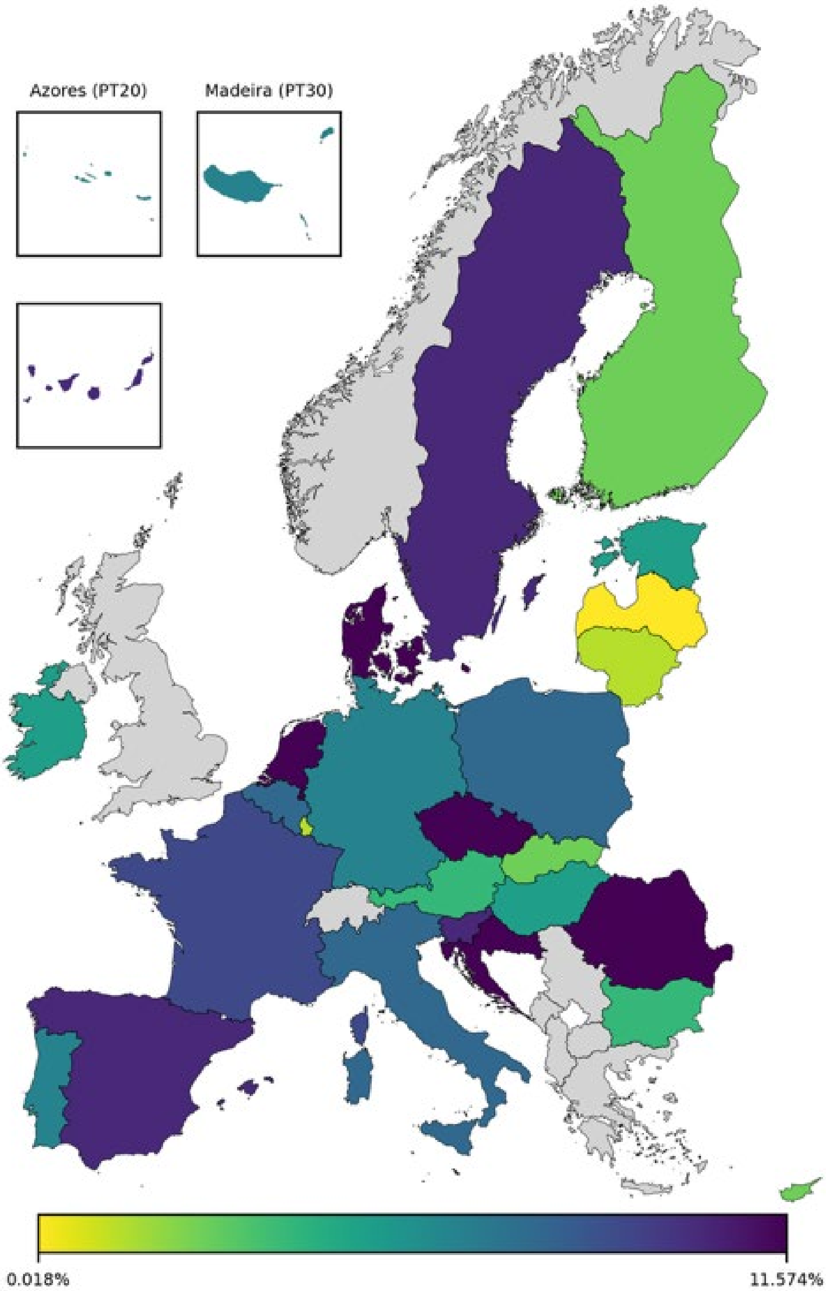


Panel (b)

Source: Authors calculations using Eurostat Comext.

Finally, **Figure 13** maps the import share of all CRMs from China by Member State, revealing stark heterogeneity, from over 11 % of total imports in Romania to below 0.1 % in Estonia. Detailed product-specific maps are provided in **Appendix B**. These differences reflect national industrial structures and the spatial clustering of CRM-intensive sectors such as automotive manufacturing, electronics, and renewable-energy equipment.

Figure 13: Import shares from China by EU country (all CRMs).



Source: Authors calculations using Eurostat Comext.

Taken together, these results confirm that the EU's dependence on China is **concentrated in a small group of high-leverage materials**, particularly refined **gallium, germanium, graphite, and rare-earth elements**, where Chinese suppliers account for more than half of EU imports.

For several Member States, **effective dependence exceeds 80 %**, especially in countries with strong manufacturing specialisation in **automotive, electronics, and renewable-energy equipment**. The geographical pattern of dependence is highly uneven—ranging from more than **11 % of total CRM imports from China in Romania** to **less than 0.1 % in Estonia**—reflecting structural differences in industrial composition and trade orientation across the Union. High HHI values further indicate **limited diversification potential**, as most CRMs are sourced from only a few non-EU partners. While these findings capture **direct import dependence**, the next subsections extend the analysis to **sectoral exposure** and **structural vulnerability**, tracing how such dependencies propagate through European value chains.

6.2 Sectoral exposure across EU value chains

While Section 6.1 quantified the EU's direct import dependence on China for individual CRMs, this subsection examines how those dependencies translate into **sectoral exposure** within European production networks. Exposure captures the extent to which EU industries rely on Chinese-origin CRMs as essential inputs, focusing on downstream sectors central to the green and digital transitions.

We combine **Eurostat COMEXT** import data with the **Eurostat FIGARO** input–output tables o trace the flow of CRMs across industries. Each CRM is mapped to its principal downstream applications and corresponding NACE Rev. 2 sectors (**Table 5**), weighted by sectoral consumption intensity and value added. This concordance enables us to identify the sectors most exposed to Chinese supply disruptions and to distinguish **direct exposure** (through raw-material imports) from **indirect exposure** (through embedded intermediate goods).

To capture the degree of market dependence, we compute the import-penetration ratio, defined as the value of imports of a specific good from China divided by total domestic expenditure on that good. Higher values indicate greater market concentration and stronger Chinese market power. Because detailed data on domestic CRM expenditure at the product level are scarce, we aggregate at the sectoral level using the FIGARO input-output tables for each Member State.

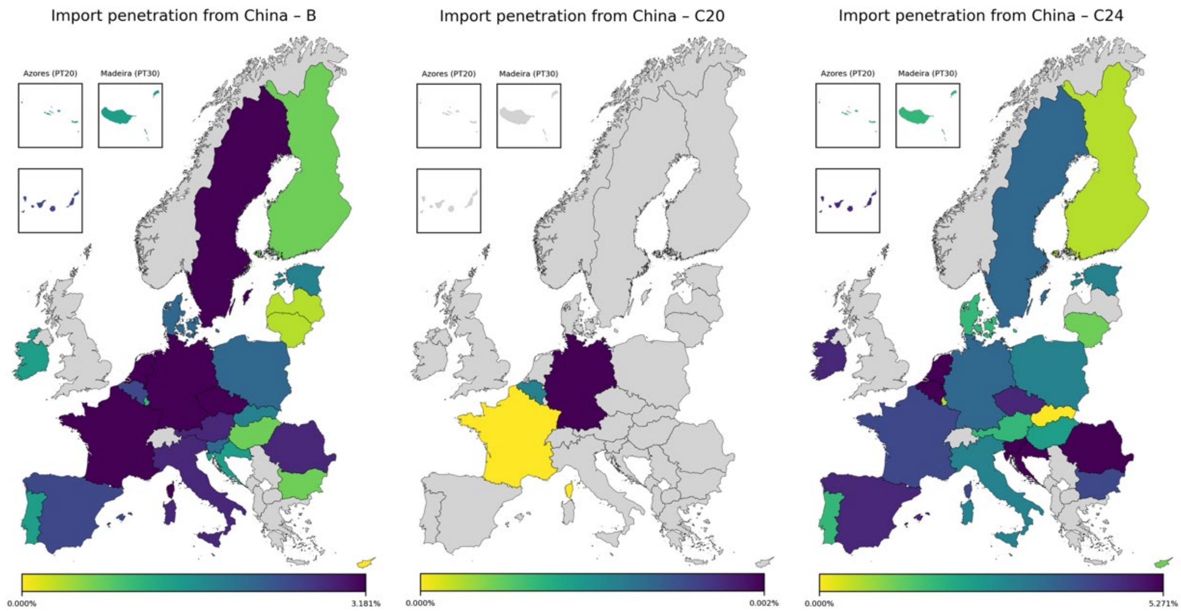
Table 5: CRM-sector concordance.

NACE code	CRMs
B (Mining and quarrying)	Antimony, Arsenic, Baryte, Beryllium, Boron, Coking Coal, Feldspar, Fluorspar, HREMs, Helium, LREMs, Lithium, Natural Graphite, Niobium, Phosphate Rock, Scandium, Strontium, Tantalum, Tungsten
C20 (Manufacture of chemicals and chemical products)	Phosphorus
C24 (Manufacture of basic metals)	Aluminium, Bismuth, Cobalt, Copper, Gallium, Germanium, Hafnium, Magnesium, Manganese, Nickel, Platinum Metals, Silicon Metal, Titanium Metal, Vanadium

Source: Authors own calculations based on Comext and FIGARO data.

Figure 14 presents the sectoral aggregation of CRM import penetration across EU member states. The results reveal substantial cross-country heterogeneity in import concentration patterns. Sector C24 (Manufacture of Basic Metals) exhibits the highest Chinese import penetration (around 5.2%), indicating significant market concentration across multiple EU countries. In contrast, sector C20 (Manufacture of Chemicals and Chemical Products) displays minimal Chinese import penetration, with only three countries (France, Belgium, and Germany) reporting measurable CRM imports. Notably, sector C20 contains only phosphorus among the CRMs, which accounts for this limited import profile.

Figure 14: Import penetration ratio from China by EU country (NACE B, C20, C24).



Source: Authors own calculations based on Comext and FIGARO data.

CRM exposure is **highly concentrated in four strategic value chains**:

1. **Automotive and battery manufacturing**: dependent on *lithium, cobalt, nickel, manganese,* and *graphite*. China's dominance in battery-grade lithium carbonate, cobalt sulphate, and anode materials links European e-mobility directly to Chinese processing capacity.
2. **Semiconductors and electronics**: reliant on *gallium, germanium, indium,* and *rare-earth magnets*. These inputs are critical for wafers, LEDs, and optoelectronic components, where Chinese firms occupy dominant positions in the global refining and separation stages.
3. **Renewable-energy equipment**: notably *rare-earth elements, copper, silicon,* and *aluminium*. Wind-turbine generators and solar photovoltaics depend on neodymium–iron–boron magnets and polysilicon, both industries in which China controls over two-thirds of global capacity.

4. **Defence, aerospace, and advanced materials**: reliant on *tungsten, titanium, beryllium,* and *high-purity aluminium*. These materials have few substitutes and are embedded in high-performance alloys and guidance systems, rendering these sectors structurally exposed to Chinese supply disruptions.

Across these value chains, dependence on China often coincides with **low substitutability and high technological specificity**, amplifying exposure even where overall trade volumes are modest. Moreover, intra-EU specialisation patterns reinforce these asymmetries: Member States with strong automotive and renewable-energy clusters, such as Germany, France, and Spain, are more exposed to lithium and rare-earth inputs, whereas those with electronics and semiconductor industries, such as the Netherlands, Ireland, and Austria, are more dependent on gallium, germanium, and indium.

In sum, sectoral mapping shows that the EU's exposure to Chinese CRMs is **concentrated, asymmetric, and technologically strategic**. The most exposed sectors—batteries, semiconductors, renewables, and defence—are precisely those underpinning Europe's green and digital transitions as well as its security capabilities. As a result, any disruption in Chinese supply of refined or processed CRMs could propagate rapidly through European production networks. The next subsection develops **structural-vulnerability indicators** to assess how dependence and exposure interact to generate systemic risk across EU industries.

6.3 Vulnerability of EU dependency on Chinese CRMs

This subsection assesses the **vulnerability** of the EU's dependence on Chinese critical raw materials (CRMs) by linking the ECRMA framework to recent empirical measures of external supply risk. While Sections 6.1 and 6.2 examined import dependence and sectoral exposure, vulnerability captures the *potential welfare loss* that would arise from disruptions or price shocks in extra-EU sources, particularly China.

To quantify this dimension, we draw on the **Strategic Dependency Index (SDI)** developed by *Magerman and Consonni (2025)*. The SDI measures the sensitivity of EU consumer-price indices to hypothetical price shocks originating in specific source countries. It embeds substitution elasticities across both goods and supplier countries within a welfare-based index, thereby quantifying how a given shock would affect aggregate EU welfare through import prices.

In a counterfactual scenario involving a **10 % price increase** on goods imported from all extra-EU countries, such as might result from new tariffs or geopolitical disruptions, the SDI estimates how much the EU price index would rise and how large the resulting welfare loss would be. Products with a high SDI are therefore those for which European consumers and producers face limited substitution possibilities across suppliers or goods, and where supply concentration magnifies exposure to external shocks.

Table 6 reports the Top 30 CN8-level products ranked by SDI in 2019, alongside standard indicators of concentration (HHI), extra-EU import share, and the ratio of extra-EU imports to EU exports. Several **CRMs feature prominently**, including *aluminium ores and concentrates*, *unwrought manganese*, *aluminium oxide*, and *antimony*, confirming that material inputs occupy a central place among Europe's most vulnerable import dependencies.

Although not all CRMs appear directly in the top list, many record SDI values in the **top quartile of the full product distribution**, notably *titanium, nickel, copper,* and *magnesium*. The absence of certain CRMs such as *beryllium, gallium,*and *nickel* from the Top-30 reflects the methodology's product-level aggregation: when imports originate from only a few extra-EU countries, the combined price-shock effect may appear smaller than in product groups with more numerous sources. Moreover, some CRMs, particularly *cobalt, strontium, light and heavy rare-earth elements*, are excluded from the SDI sample because their CN8 codes change over time, and the index requires consistent product codes for longitudinal estimation.

The SDI complements the dependency and exposure measures presented earlier by translating trade structure into **potential welfare impact**. Three main insights emerge:

1. **High vulnerability in metals and ores:** Aluminium and manganese stand out as critical inputs with both high SDI values and high import concentration, underscoring Europe's structural exposure to supply disruptions in Chinese-dominated markets.
2. **Hidden vulnerabilities through substitution limits:** CRMs that appear moderately dependent in trade data (e.g. titanium, nickel, copper) still exhibit high welfare sensitivity, revealing that diversification potential is more limited than import shares suggest.
3. **Data and structural gaps:** Some of the most strategic CRMs (cobalt, rare earths, gallium) are under-represented in the SDI due to data limitations, implying that the *true extent of vulnerability is likely understated*.
4. In summary, the vulnerability analysis confirms that **EU dependency on Chinese CRMs carries measurable welfare risks**, particularly in base-metal and energy-transition inputs. When combined with the results from Sections 6.1 and 6.2, the SDI evidence suggests that the **EU's supply security challenge is not only about import concentration, but also about the limited substitutability of Chinese-origin materials**.

Table 6: Top 30 products by Strategic Dependency Index (SDI) at CN8 level, 2019.

#	Product	SDI	HHI	Share of extra-EU imports	Extra-EU imports/ EU exports
1	Aluminium ores and concentrates	.748	.367	.919	39.3
2	Raw furskins of lamb (ex. Astrakhan, Caracul, Persian, etc..)	.702	.488	.608	11.2
3	Unwrought manganese; manganese powders	.672	.778	.588	11.3
4	Linseed (excl. for sowing)	.627	.380	.649	12.7
5	Collections and collector's pieces (zoological, botanical, mineralogical, etc..)	.617	.570	.926	1.8
6	Reeds, rushes, osier, raffia, cereal straw, lime bark and other vegetable materials	.604	.446	.650	4.0
7	Aluminium oxide	.575	.354	.255	.538
8	Natural calcium phosphates and natural aluminium calcium phosphates, ground	.567	.344	.957	40.8
9	Tobacco refuse	.563	.1243	.592	3.7
10	Fresh, chilled or frozen reindeer meat and edible offal thereof	.537	.966	.243	4.5
11	Unwrought antimony; antimony powders	.524	.288	.934	30.8
12	Natural gum Arabic	.508	.537	.616	.866
13	Non-agglomerated iron ores and concentrates "ECSC"	.500	.211	.764	30.4
14	Natural calcium phosphates and natural aluminium calcium phosphates, unground	.458	.224	.917	286.3
15	Crude palm oil	.421	.153	.915	256.1
16	Anhydrous ammonia	.399	.250	.705	21.5
17	Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution	.382	.251	.348	2.3
18	Cork waste; crushed, powdered or ground cork	.364	.401	.133	1.3
19	Technically specified natural rubber "TSNR"	.360	.208	.746	94.9
20	Bamboos	.346	.789	.852	19.8
21	Bran, sharps and other residues of wheat	.336	.233	.097	.238
22	Lead waste and scrap	.333	.347	.242	1.9
23	Greasy shorn wool, incl. fleece-washed wool, neither carded nor combed	.332	.340	.952	7.2
24	Parachutes, incl. dirigible parachutes and paragliders, and rotochutes	.325	.161	.803	1.3
25	Prepared or preserved tunas, skipjack or other fish of genus Euthynnus	.315	.094	.359	1.9
26	Metaldehyde, hexamethylenetetramine and similar products	.314	.304	.284	.950
27	Basketwork, wickerwork and other articles	.304	.429	.701	9.0
28	White sugar, containing in dry state>= 99,5% sucrose	.299	.105	.182	.640
29	Noils of wool or of fine animal hair, non-carbonized	.295	.218	.642	14.9
30	Cocoa beans, whole or broken, raw or roasted	.295	.288	.824	54.5

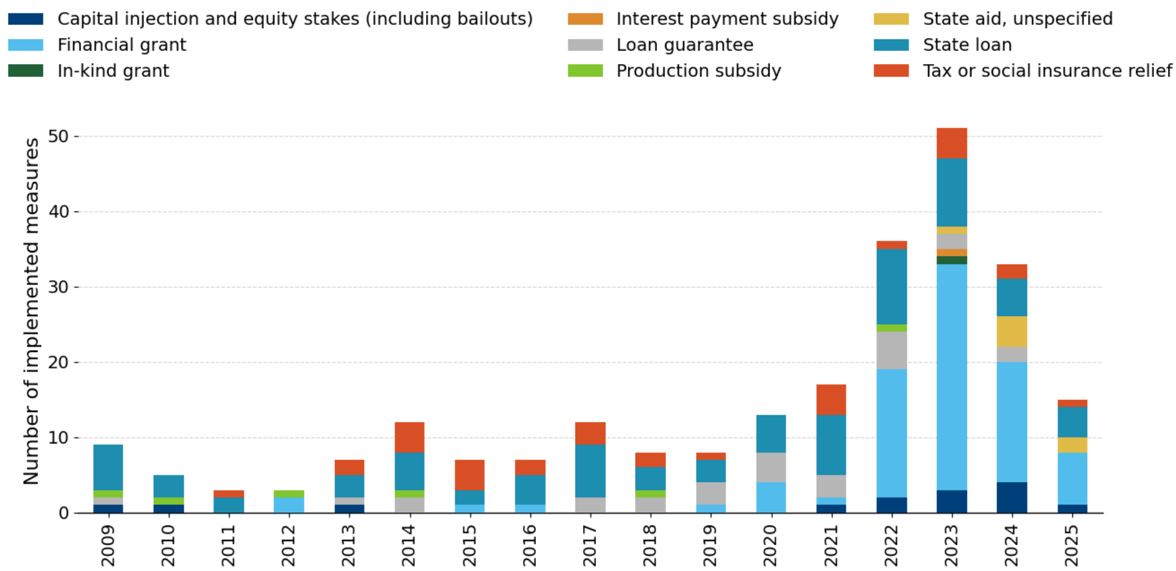
Source: Consonni and Magerman (2025).

6.4 EU policy reactions and comparative statecraft

The sharp increase in critical-raw-material (CRM) dependencies revealed during the pandemic and the energy crisis has triggered a notable rise in **state intervention on both sides of the Eurasian divide**. Since 2021, the European Union has progressively expanded its policy toolkit for securing CRM supply, while China has intensified its use of subsidies, export controls, and other geo-economic instruments. Together, these developments reflect a wider global shift towards the securitisation of industrial policy.

Since 2021, EU-level and national governments have introduced a wave of **subsidy schemes and state loans** targeting CRM extraction, recycling, and processing. According to the *Global Trade Alert* database, the number of new or modified EU subsidy measures **rose sharply in the post-pandemic years**, mirroring support provided under the Green Deal Industrial Plan and various national green-transition programmes (**Figure 15**). Unlike China, EU support instruments rely more heavily on **state-backed loans and guarantees** rather than direct grants. The intensity of intervention peaked in 2022 and has since moderated as temporary crisis measures expired.

Figure 15: Implemented Subsidies to Critical Minerals, EU.

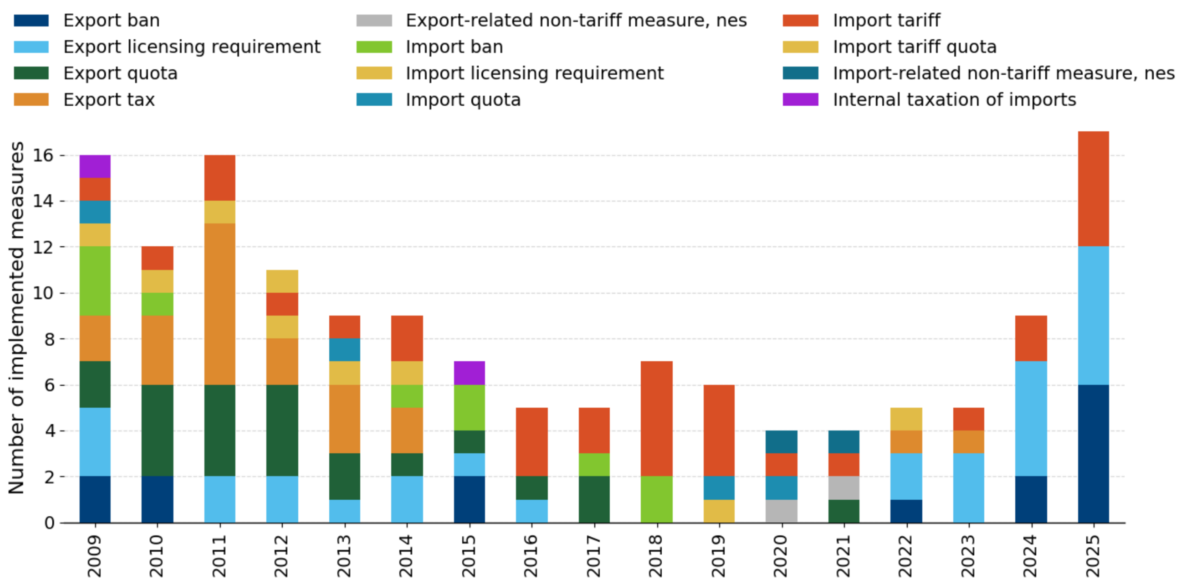


Source: Authors calculations on the Global Trade Alert Database.

Parallel to its internal-market measures, the EU has also started developing an **external economic-security toolkit**. This includes the *Anti-Coercion Instrument*, the *Foreign Subsidies Regulation*, and the ECRMA, all aimed at enhancing the Union's capacity to monitor, mitigate, and respond to strategic dependencies. While the ECRMA focuses on diversifying supply and promoting recycling, the other instruments introduce defensive trade capabilities to counteract coercive actions by third countries.

China, in turn, has **consolidated its dominance** in CRM markets through a sophisticated mix of industrial policy, export licensing, and coercive trade practices (**Figure 16**). Since 2023, Beijing has implemented new export-licensing requirements on **gallium, germanium, graphite, and bismuth**, all minerals where EU dependence is particularly high. These controls—officially justified on national-security grounds—function as tools of *geo-economic leverage* over downstream industries globally. More broadly, China's export-control regime has become an integral part of its industrial-policy architecture, complementing subsidies, tax incentives, and strategic-reserve policies discussed in Section 5.

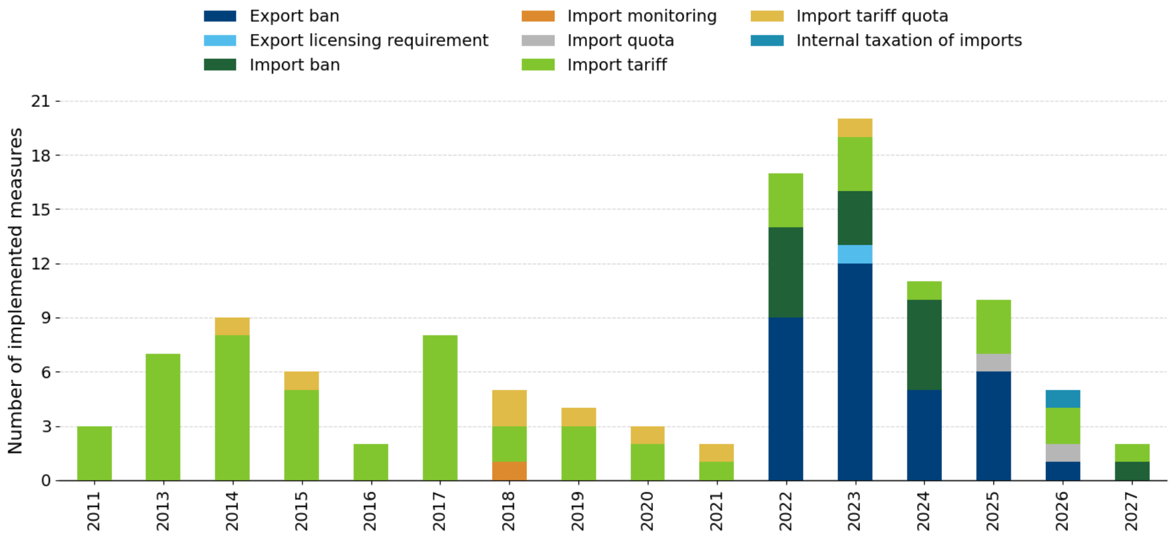
Figure 16: Implemented Import and Export Restrictions in Critical Minerals, China.



Source: Global Trade Alert Database.

EU data indicate a moderate but growing resort to **export bans and trade restrictions**, though these remain limited in scope and primarily directed at **Russia** following its invasion of Ukraine (**Figure 17**). The EU has so far applied these instruments with caution in the CRM domain, focusing instead on **positive-supply measures** (investment, diversification, recycling) rather than coercive trade tools. By contrast, China's export controls directly target the **bottleneck stages** of global value chains, magnifying policy risk for the EU and other import-dependent economies.

Figure 17: Implemented Import and Export Restriction in Critical Minerals, EU.



Source: Global Trade Alert Database.

Summary: EU dependence, exposure, and vulnerability to Chinese CRMs

Dependence:

- The EU relies heavily on China for a narrow group of high-leverage CRMs.
- China supplies over **50% of EU imports** for **gallium, germanium, graphite, bismuth, tungsten,** and **rare-earth elements**.
- Product-level data reveal even stronger dependence in refined materials (e.g. processed scandium 94%, strontium 95%, cobalt 96%).
- Import-source concentration is high: for **21 CRMs**, the Herfindahl–Hirschman Index (HHI) > 0.25, implying sourcing from fewer than four countries.

Exposure:

- Chinese CRM inputs are deeply embedded in four strategic EU value chains:
    1. **Automotive and batteries** – lithium, cobalt, nickel, manganese, graphite.
    2. **Semiconductors and electronics** – gallium, germanium, indium, rare-earth magnets.
    3. **Renewable energy equipment** – rare earths, silicon, copper, aluminium.
    4. **Defence and aerospace** – tungsten, titanium, beryllium, high-purity aluminium.
- Exposure is **technologically specific and regionally uneven**: Germany, France, and Spain are most reliant on battery materials, while the Netherlands, Ireland, and Austria depend more on semiconductor inputs.

Vulnerability:

- Welfare-based indicators such as the **Strategic Dependency Index (SDI)** confirm that several CRMs, especially **aluminium, manganese, antimony, nickel, titanium, copper,** and **magnesium**, generate high vulnerability to external price shocks.
- Limited substitutability amplifies welfare losses even where trade dependence appears moderate.
- Data gaps for CRMs with changing CN8 codes (e.g. cobalt, rare earths, gallium) likely **understate the true vulnerability** of EU industries.

Policy reactions:

- **China** integrates CRMs into a coercive statecraft toolkit combining **export controls, subsidies, and strategic reserves**.
- **The EU** adopts a defensive strategy centred on **subsidies, diversification, recycling,** and new regulatory instruments (ECRMA, Anti-Coercion Instrument, Foreign Subsidies Regulation).
- EU measures remain largely **market-based and resilience-oriented**, while China's are **restrictive and leverage-oriented**, reflecting an asymmetry in policy capabilities.

Overall assessment:

The EU's dependence on Chinese CRMs is **narrow but deep**, concentrated in a small set of materials that underpin its **green, digital, and defence transitions**. These dependencies translate into **high exposure and vulnerability**, especially where production networks rely on refined intermediates with few substitutes. While the EU has begun to respond through industrial-policy integration and strategic diversification, China's use of export controls and targeted subsidies continues to shape global CRM markets—underscoring the need for **systemic resilience measures**.

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Appendices

A. Methodology to identify CRMs in the ECRMA

ANNEX I - Strategic raw materials

1. The strategic importance shall be determined on the basis of the relevance of a raw material for the green and digital transition as well as defence and aerospace applications, in accordance with the following criteria:
   (a) the amount of strategic technologies using a raw material as an input;
   (b) the amount of a raw material needed for manufacturing relevant strategic technologies;
   (c) the expected global demand for relevant strategic technologies.

2. The forecasted demand growth ($D_{F/C,\tau}$) shall be calculated as follows:

$$D_{F/C,\tau} = \frac{DF_{\tau}}{GS_{\tau_0}}$$

   where DF_{τ} is the global annual demand forecast for a raw material in year *τ*, and $GS_{\tau o}$ is the global annual production of a raw material for a reference period τ_0 .

3. The difficulty of increasing production shall be determined taking into account at least:
   (a) the current global annual production scale of a raw material;
   (b) the reserves-production ratio of a raw material, based on known reserves of economically extractable geological resources and current global annual production;
   (c) lead-times for new projects increasing supply capacity, when reliable information is available.

ANNEX II - Critical raw materials

1. The economic importance (*EI*) of the assessed raw material is calculated as follows:

$$EI = \sum\nolimits_{s} (A_s * Q_s) * SI_{EI}$$

   where *s* denotes the NACE (2-digit level) sectors of the economy; A_s is the share of end use of the assessed raw material in a NACE (2-digit level) sector (using Union values when available, global shares otherwise); Q_s is the value added of the relevant sector at the NACE (2-digit level), as a share of the total economy; SI_{EI} is the substitution index related to economic importance.

2. The substitution index of the assessed raw material related to economic importance (SI_{EI}) is calculated, based on its most relevant industrial applications, as follows:

$$SI_{EI} = \sum_{i} \sum_{a} SPP_{i,a;EI} * Sub\_share_{i,a} * Share_{a}$$

   where *i* denotes an individual substitute material; *a* denotes an individual application of the raw material; $SPP_{i,a;\,EI}$ is the Economic Importance performance parameter of each substitute material, *i*, compared to the assessed raw material, based on technical performance, including functionality, and cost performance, for each application, a; $Share_a$ is the share of the raw materials in an end-use application; $Sub\_share_{i,a}$ is the sub-share of each substitute material within each application.

3. The supply risk (SR) of the assessed raw material is calculated as follows:

$$SR = \left[\left(HHI_{WGI,t_c}\right)_{GS} * \frac{IR}{2} + \left(HHI_{WGI,t_c}\right)_{EU\_sourcing} * \left(1 - \frac{IR}{2}\right) \right] * (1 - EoL_{RIR}) * SI_{SR}$$

where GS denotes the global annual production of the assessed raw material; $EU\_sourcing$ denotes the actual sourcing of the supply to the Union, i.e. Union domestic production plus Union imports from third countries or from OCTs; HHI is the Herfindahl-Hirschman Index (used as a proxy for concentration of supply across countries); WGI is an index based on the scaled World Bank Worldwide Governance Indicators (used as a proxy for country governance); t_c is the trade parameter adjusting WGI, which shall be determined taking into account potential export taxes (possibly mitigated by a trade agreement in force), physical export quotas or export prohibitions imposed by a country, c; EoL_{RIR} is the end-of-life recycling input rate, meaning the ratio of secondary material inputs (recycled from old scrap) to all inputs of a raw material (primary and secondary); SI_{SR} is the substitution index related to supply risk; IR is import reliance.

4. The import reliance, IR, of raw materials is calculated as follows:

$$IR = \max\left\{0;\ \frac{Import - Export}{DomesticProduction + Import - Export}\right\}$$

5. The Herfindahl-Hirschman Index (HHI_{WGI}) of the assessed raw material is calculated as follows:

$$HHI_{WGI,t_c} = \sum_{c} (S_c)^2 * WGI_c * t_c$$

where c denotes the countries supplying the assessed raw material; S_c is the share of country c in the supply (GS or $EU\_sourcing$) of the assessed raw material; WGI_c is an index based on the scaled World Bank Worldwide Governance Indicators of country c; t_c is the trade parameter of a country adjusting the WGI, which shall be determined taking into account potential export taxes (possibly mitigated by a trade agreement in force), physical export quotas or export prohibitions imposed by a country c.

6. The substitution index of the assessed raw material related to supply risk (SI_{SR}) is calculated as follows:

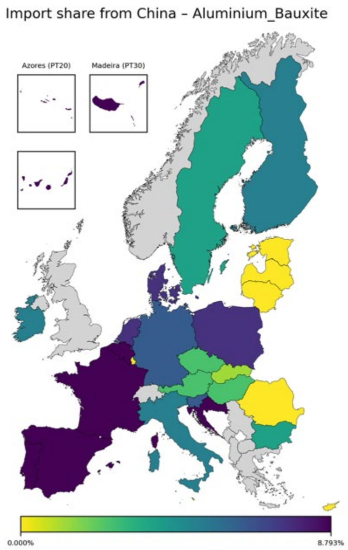
$$SI_{SR} = \sum_{i}\sum_{a} SPP_{i;SR} * Sub\_share_{i,a} * Share_a$$

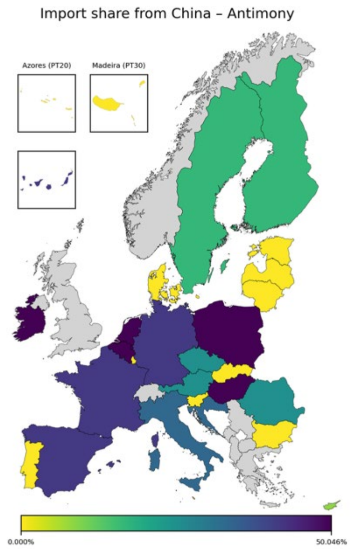
where i denotes an individual substitute material; a denotes an individual application of the candidate material; $SPP_{i;\,SR}$ is the Supply Risk performance parameter of each substitute material, i, based on its global production, criticality and economic significance (primary product, co-product, by-product); $Share_a$ is the share of the candidate materials in an end-use application; $Sub\_share_{i,a}$ is the sub-share of each substitute material within each application.

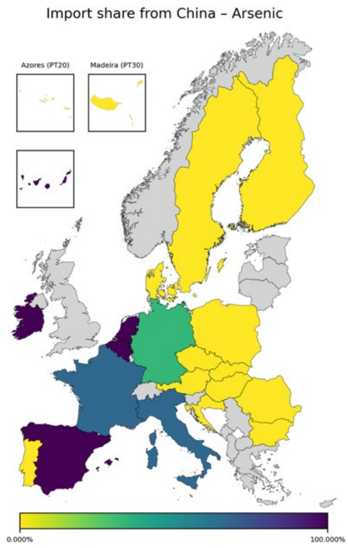
7. Where structural or statistical changes affect the measurement of economic importance and supply risk horizontally for all assessed materials, the corresponding values shall be corrected to offset such changes. The calculations of the formulas shall be based on an average of the most recent five years for which data is available. The priority, quality and availability of data shall be taken into account.

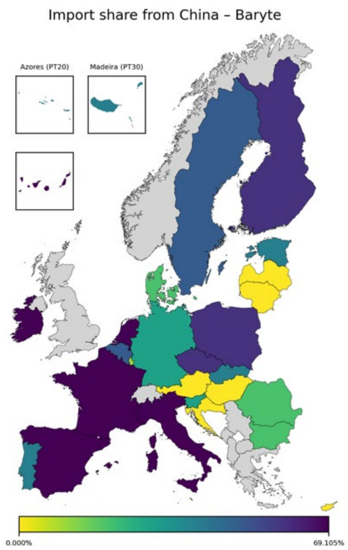
B. CRM import dependency on China

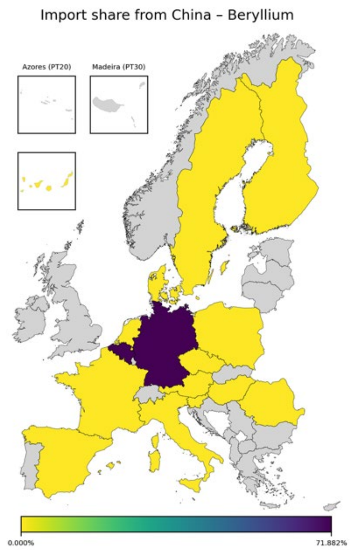
Import shares by CRM

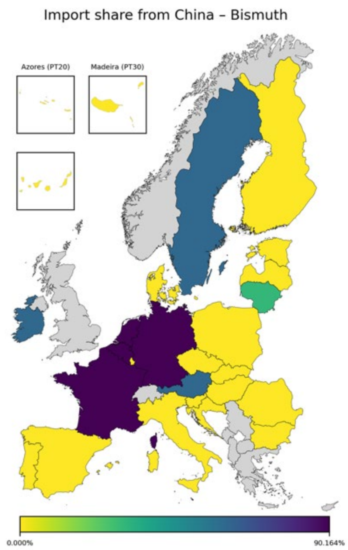




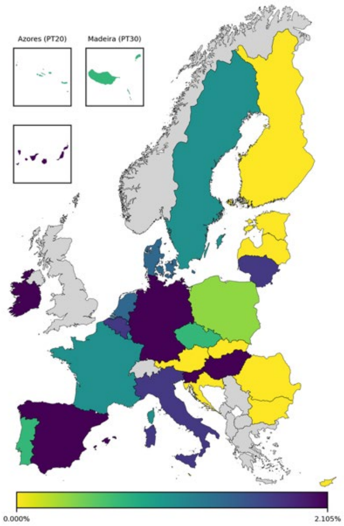




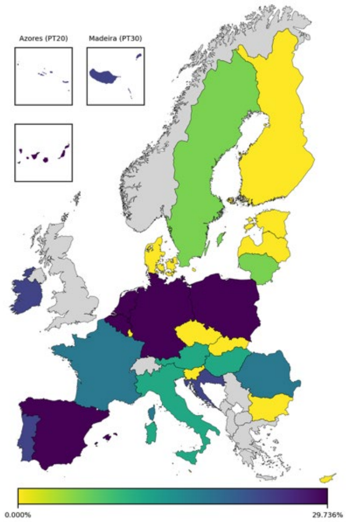




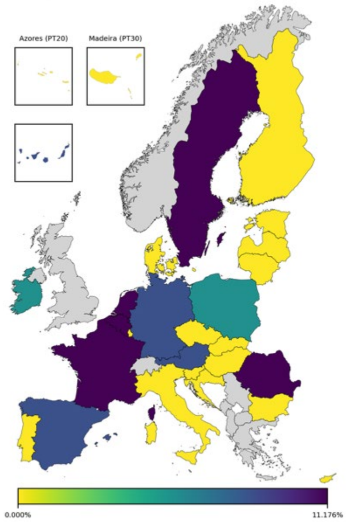
Import share from China – Boron



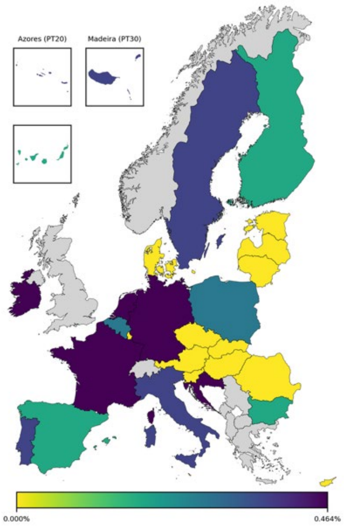
Import share from China – Cobalt



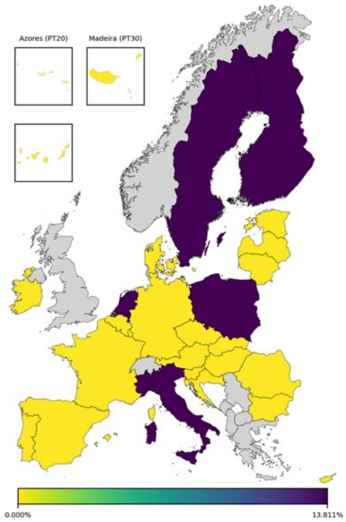
Import share from China – Coking Coal



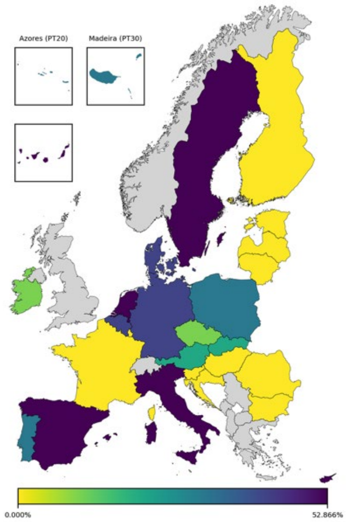
Import share from China – Copper



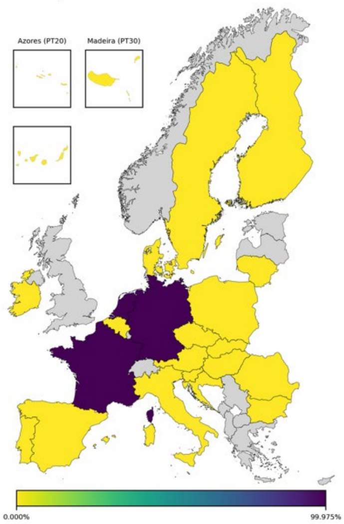
Import share from China – Feldspar



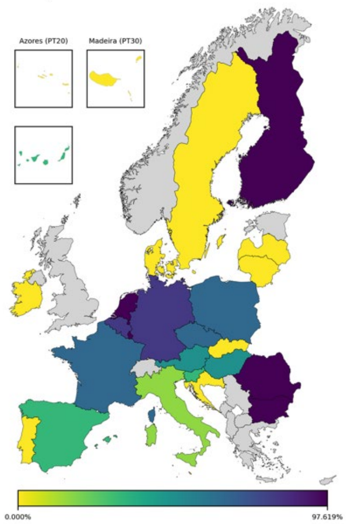
Import share from China – Fluorspar



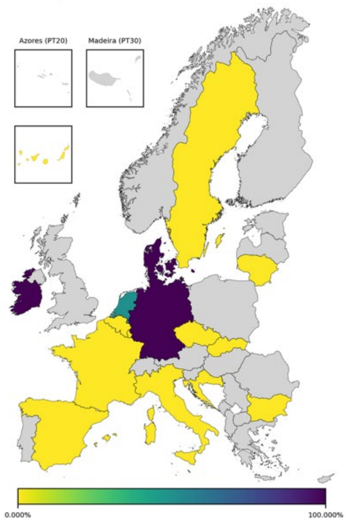
Import share from China – Gallium



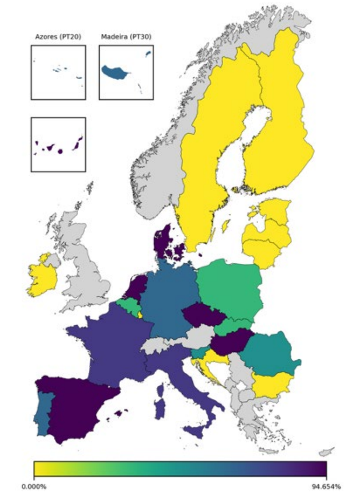
Import share from China – Germanium



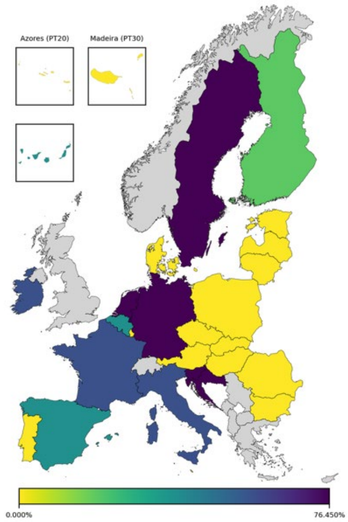
Import share from China – Hafnium



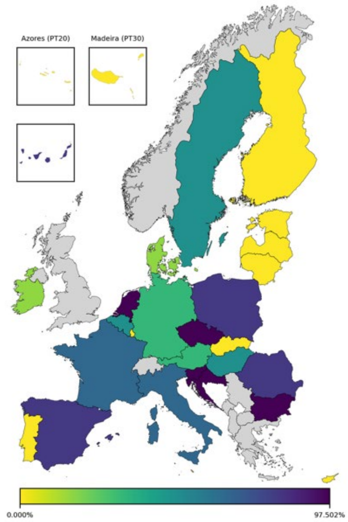
Import share from China – Heavy Rare Earth Metals



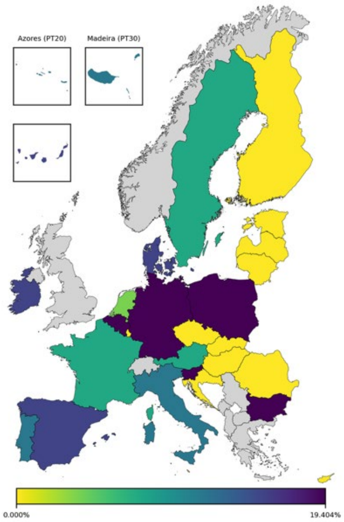
Import share from China – Lithium



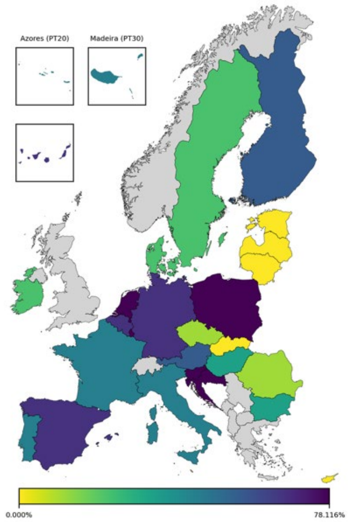
Import share from China – Magnesium



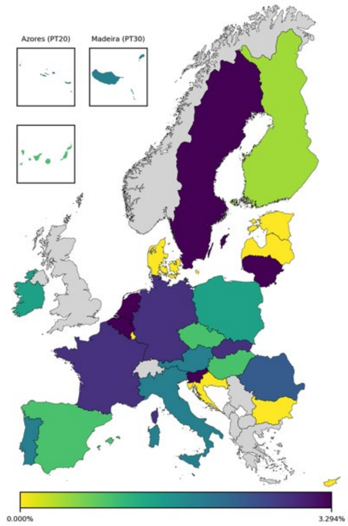
Import share from China – Manganese



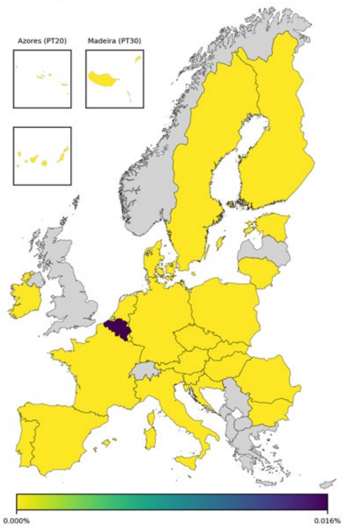
Import share from China – Natural Graphite



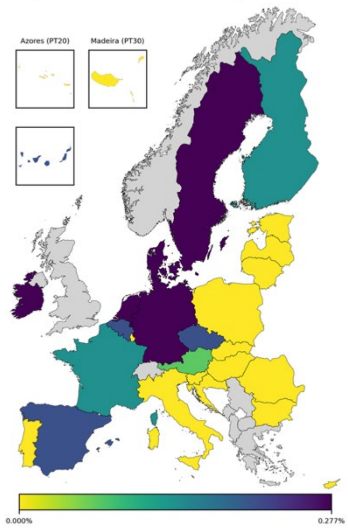
Import share from China – Nickel



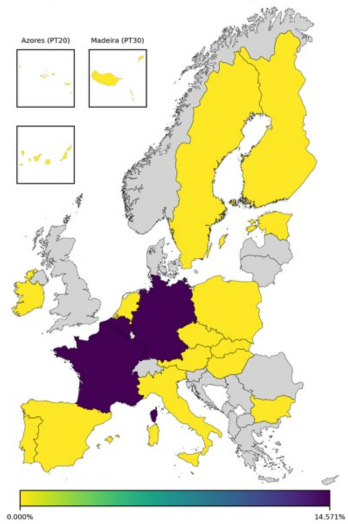
Import share from China – Niobium



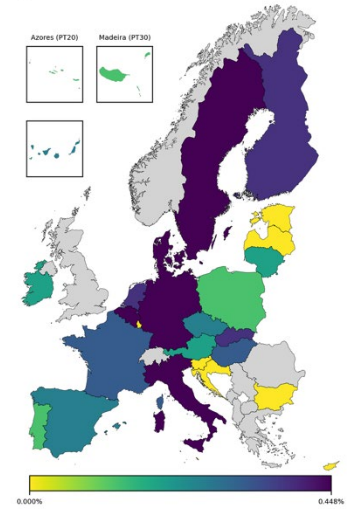
Import share from China – Phosphate Rock



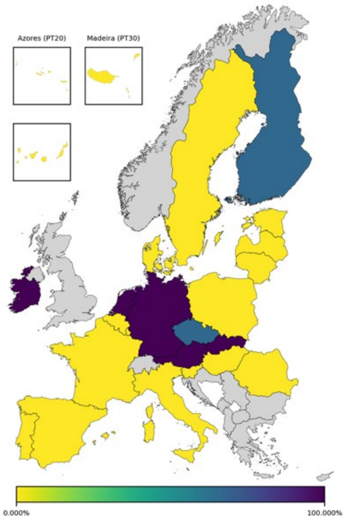
Import share from China – Phosphorus



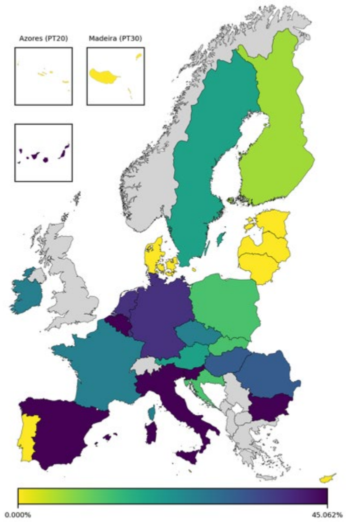
Import share from China – Platinium Group Metal



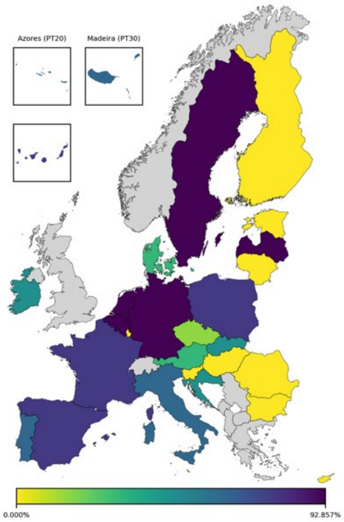
Import share from China – Scandium



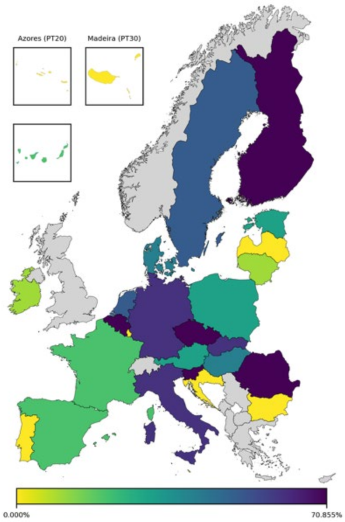
Import share from China – Silicon Metal



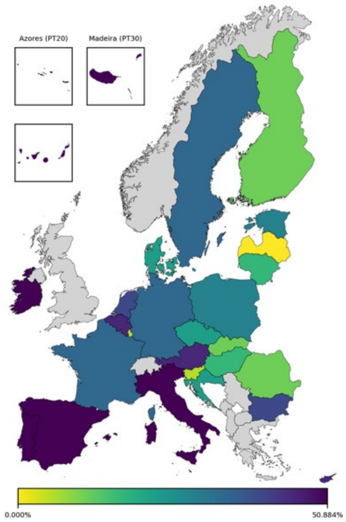
Import share from China – Strontium



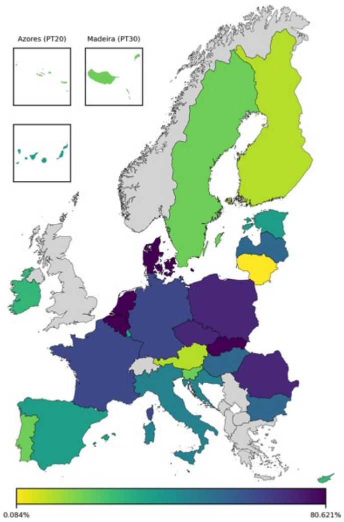
Import share from China – Tantalum



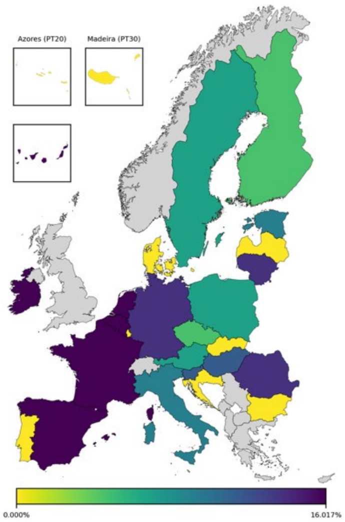
Import share from China – Titanium Metal



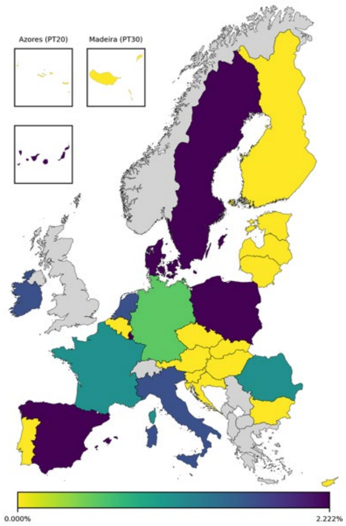
Import share from China – Tungsten

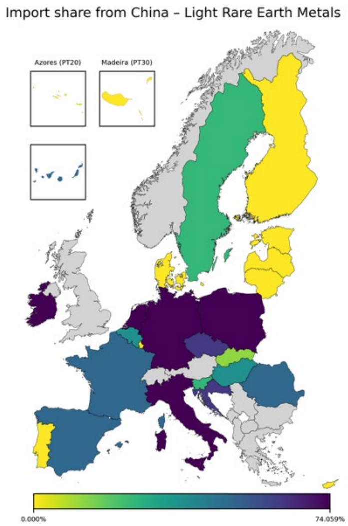


Import share from China – Vanadium

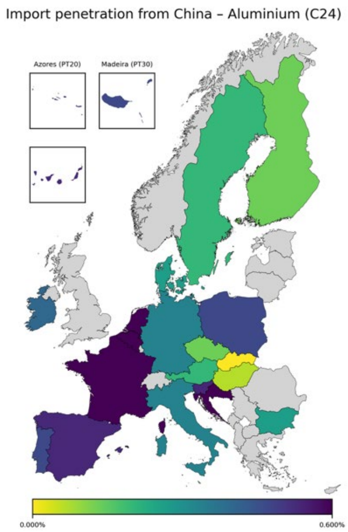


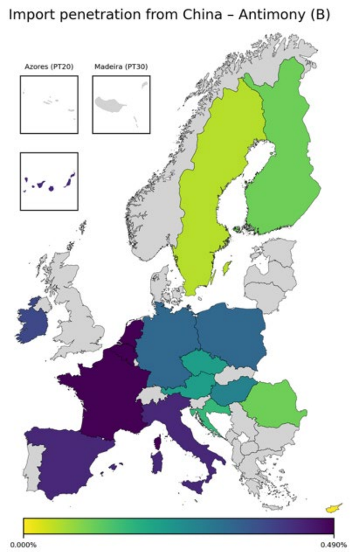
Import share from China – Helium

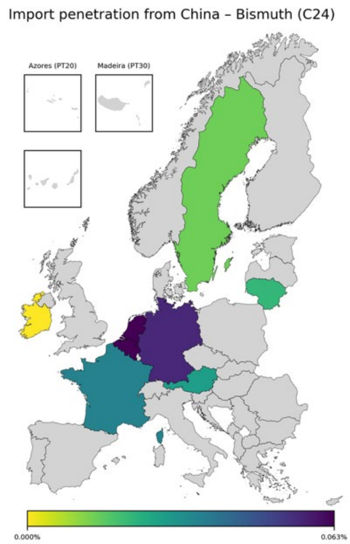




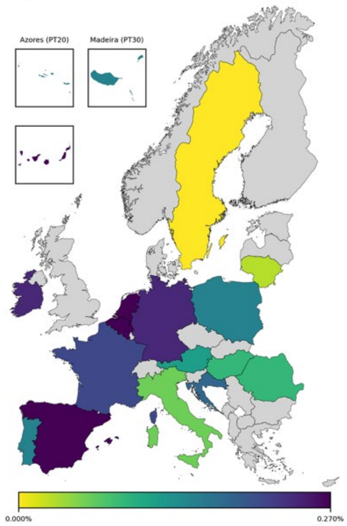
Import penetration ratios by CRM



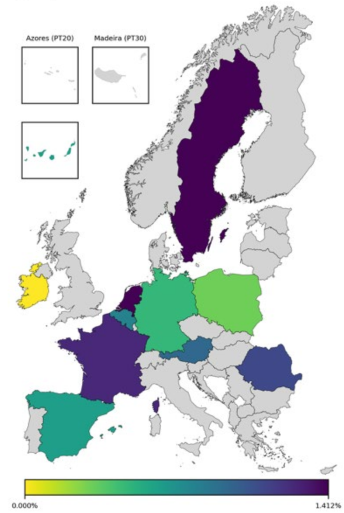




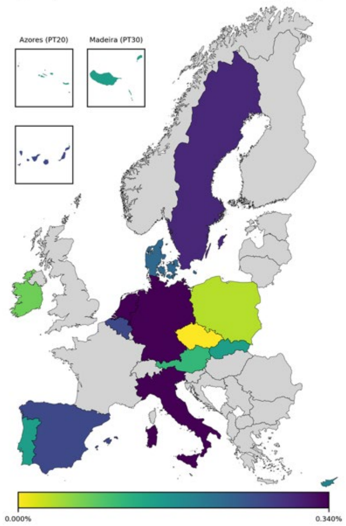
Import penetration from China – Cobalt (C24)



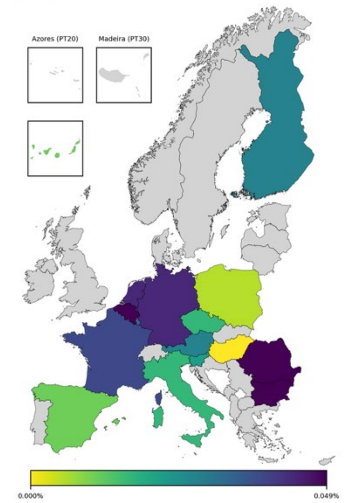
Import penetration from China – Coking Coal (B)



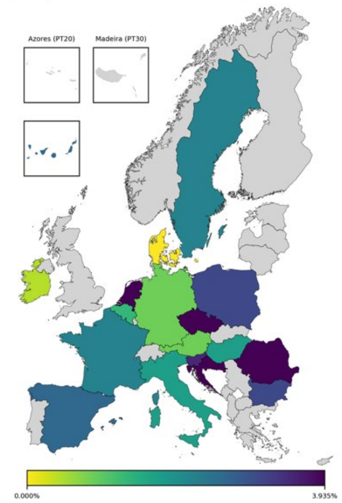
Import penetration from China – Fluorspar (B)



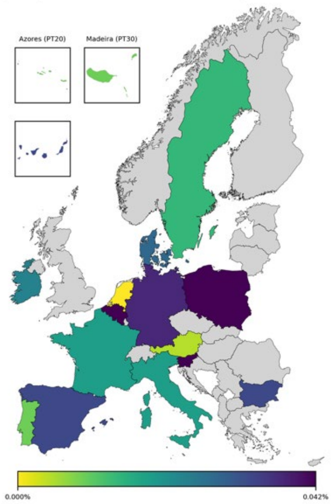
Import penetration from China – Germanium (C24)



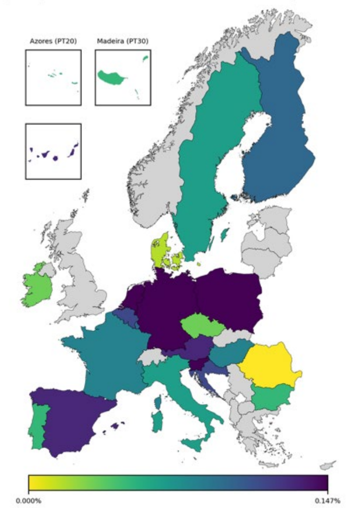
Import penetration from China – Magnesium (C24)



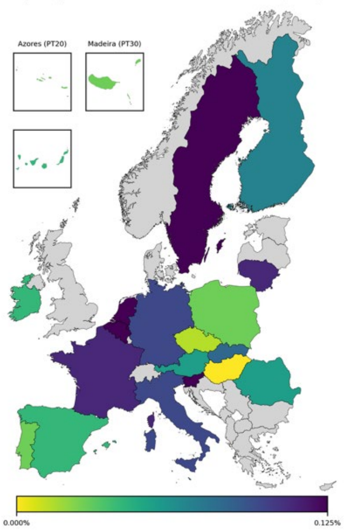
Import penetration from China – Manganese (C24)



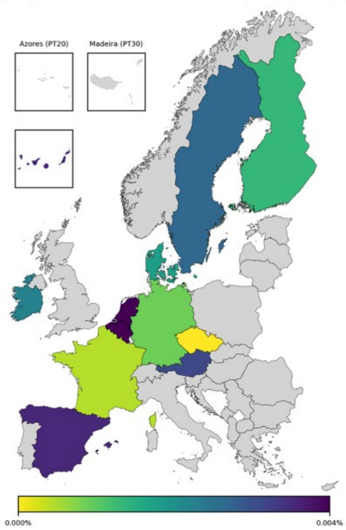
Import penetration from China – Natural Graphite (B)



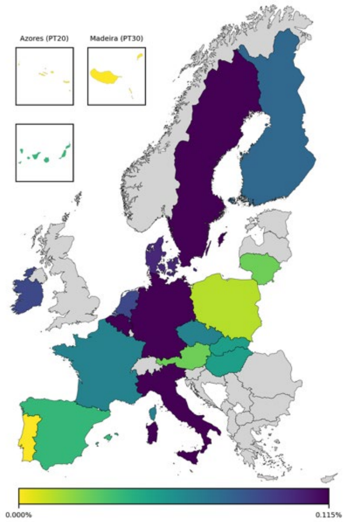
Import penetration from China – Nickel (C24)



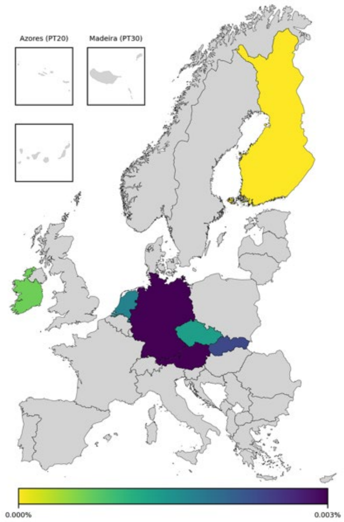
Import penetration from China – Phosphate Rock (B)



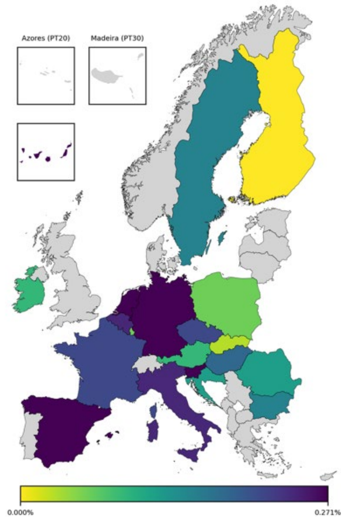
Import penetration from China – Platinum Metals (C24)



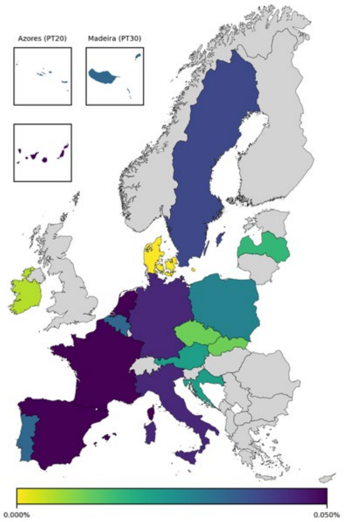
Import penetration from China – Scandium (B)



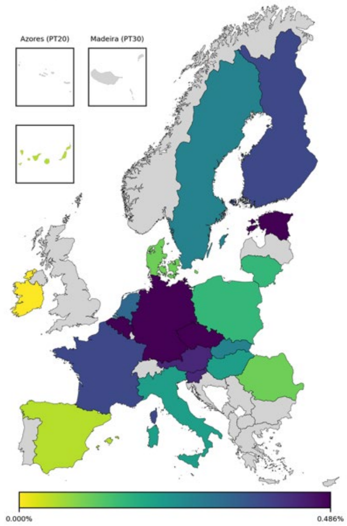
Import penetration from China – Silicon Metal (C24)



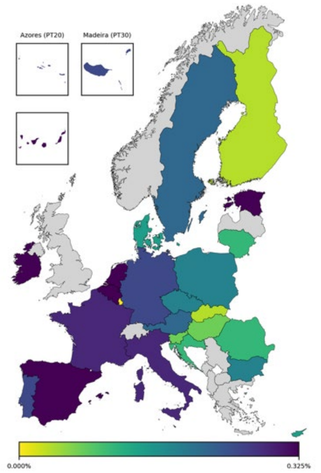
Import penetration from China – Strontium (B)



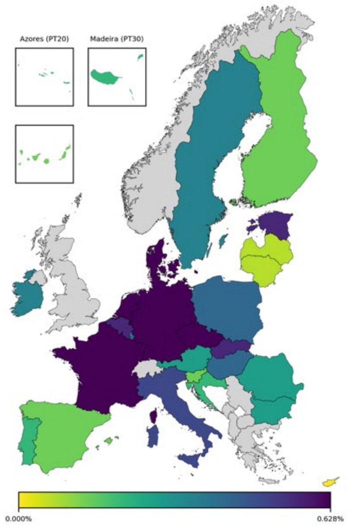
Import penetration from China – Tantalum (B)



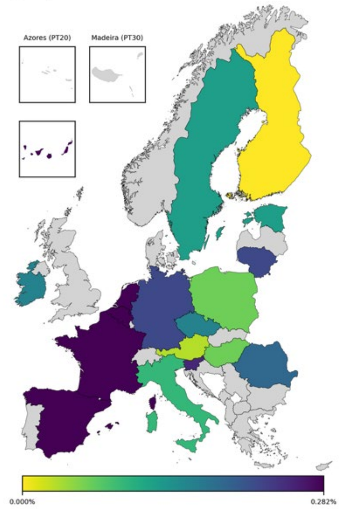
Import penetration from China – Titanium Metal (C24)



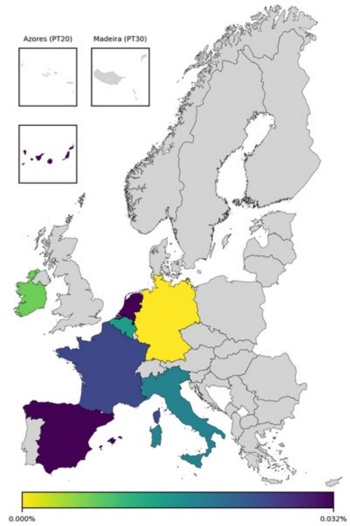
Import penetration from China – Tungsten (B)



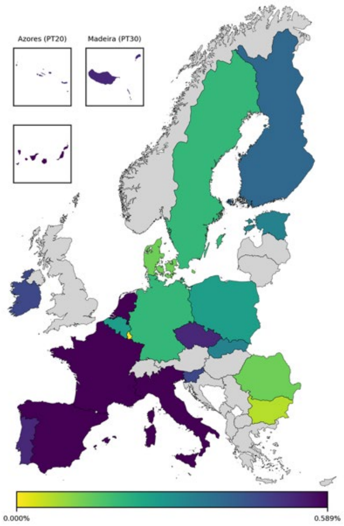
Import penetration from China – Vanadium (C24)



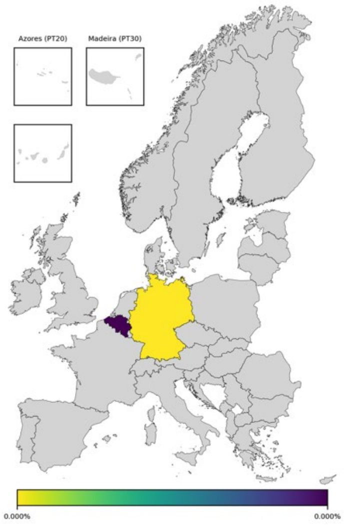
Import penetration from China – Arsenic (B)



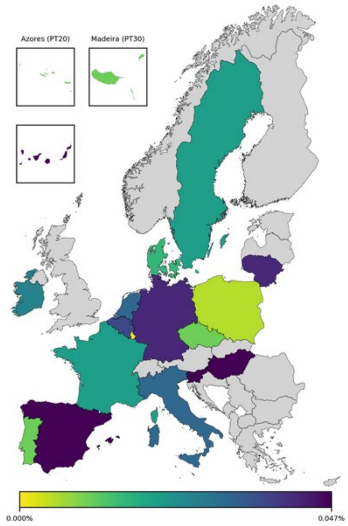
Import penetration from China – Baryte (B)



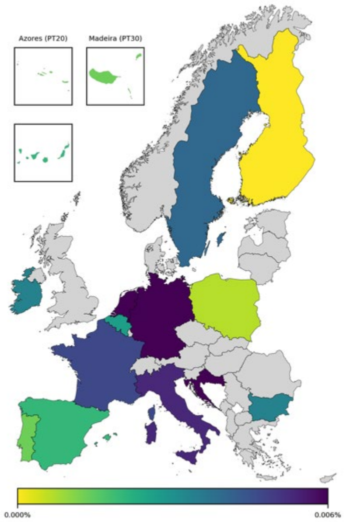
Import penetration from China – Beryllium (B)



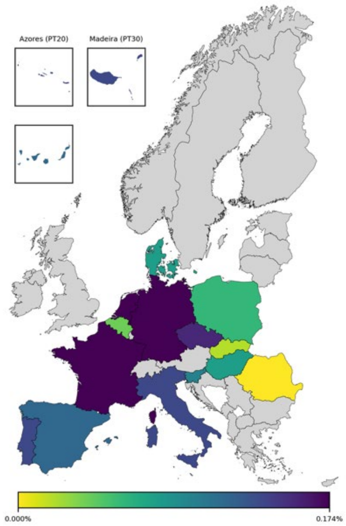
Import penetration from China – Boron (B)



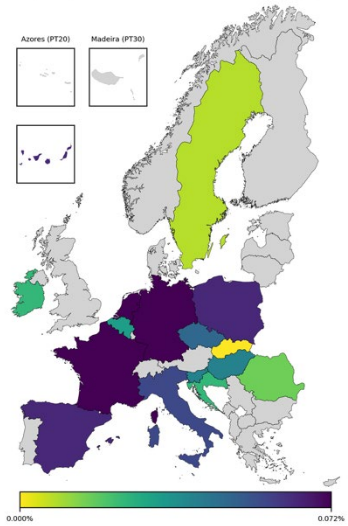
Import penetration from China – Copper (C24)



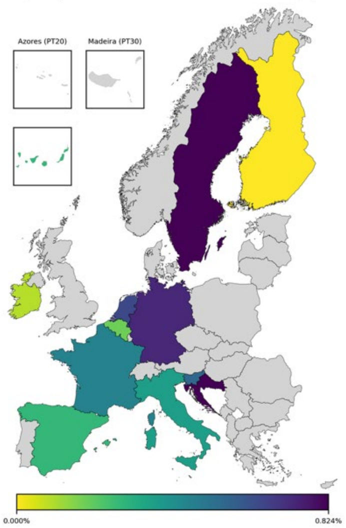
Import penetration from China – HREMs (B)



Import penetration from China – LREMs (B)

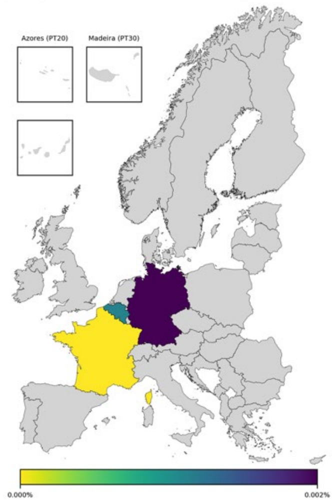


Import penetration from China – Lithium (B)

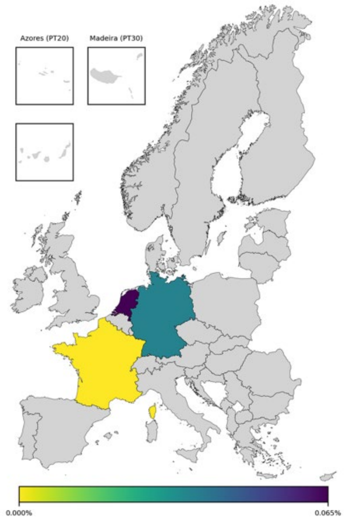


Import penetration from China – Niobium (B)

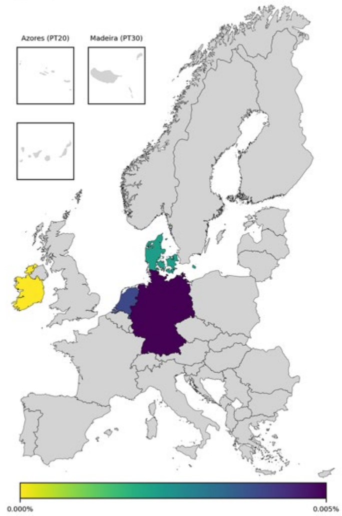
Import penetration from China – Phosphorus (C20)



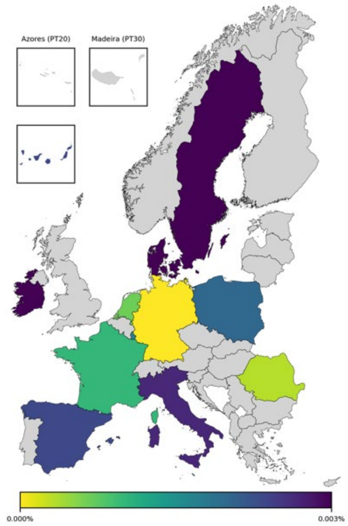
Import penetration from China – Gallium (C24)



Import penetration from China – Hafnium (C24)



Import penetration from China – Helium (B)



Import penetration from China – Feldspar (B)