ESPON

Co-funded by the European Union
Interreg

REPORT //

STARTER. Task 1: The Territorial Impact of the European Union Critical Raw Minerals Act

Report on Scenario 1 July 2025

This Report is conducted within the framework of the ESPON 2030 Cooperation Programme, partly financed by the European Regional Development Fund.

The ESPON EGTC is the Single Beneficiary of the ESPON 2030 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

Coordination:
Centre of Economic Scenario Analysis and Research (CESAR)

Authors
Llano Verduras, Carlos; Pérez Balsalobre, Santiago; Steinberg Federico (CEPREDE)

Almazán-Gómez, Miguel Ángel (UNIZAR)

Information on ESPON and its projects can be found at www.espon.eu.
The website provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

ISBN: Click or tap here to enter text.

Printed in Click or tap here to enter text.

Printed on paper produced environmentally friendly

Layout and graphic design by BGRAPHIC, Denmark

Contact: info@espon.eu

REPORT //

STARTER. Task 1: The Territorial Impact of the European Union Critical Raw Minerals Act

Report on Scenario 1 // July 2025

Table of contents

List of figures and tables

List of figures

List of tables

Abbreviations

C2C	Country-to-country
CBAM	Carbon Border Adjustment Mechanism
ECRMA	European Union's Critical Raw Minerals Act
FTA	Free Trade Agreement
FDI	Foreign Direct Investment
ICIO	Inter-Country Input-Output tables
GDP	Gross Domestic Product
GEM	Global Extraction Method
GVA	Gross Value Added
GVC	Global Value Chain
HEM	Hypothetical Extraction Method
JRC	Joint Research Centre
MERCOSUR	Mercado Común del Sur (Argentina, Brasilia, Paraguay and Uruguay
OSA	Open Strategic Autonomy
R2R	Region-to-region
UNCTAD	United Nations Conference on Trade and Development
WIOD	World Input-Output Database
WTO	World Trade Organization

Abstract

The **ESPON STARTER project** examines regional implications of scenarios linked to **Open Strategic Autonomy (OSA)**, with a focus on strategic raw materials as defined in the **EU Critical Raw Materials Act (ECRMA)**. Recent disruptions—from Covid-19 and the war in Ukraine to escalating US-China rivalry—, and more recently the election of Donald Trump as US presidents, have prompted the EU to revise its stance towards globalization and pivot towards different aspects of **economic security and resilience. These priorities are now reflected in a variety of EU strategies and regulations that emphasize** themes such as **OSA, de-risking, and supply chain diversification**. Within this context, the **ECRMA** sets quantitative targets for securing access to strategic materials vital for Europe's green and digital transitions. The ECRMA sets ambitious targets to secure the supply of 16 strategic minerals crucial for the EU's industrial, technological, energy, and military capabilities, which are essential for achieving strategic autonomy.

This report presents an analysis of **Scenario 1 of Task 1**, which examines the **territorial impact** of substituting supply sources for the **16 strategic raw materials** prioritized by the ECRMA. The aim is to reduce external dependence and improve supply chain resilience, in line with guidance from the European Commission. To achieve this, the EU intends to seek new trading partners and strengthen economic relations with existing ones. By diversifying suppliers, reliance on current partners is decreased and economic security is enhanced against unexpected economic, geopolitical or regulatory shocks. It also sends a powerful political message: in a context of rising protectionism and aggressive unilateral economic nationalism from the US, the EU is committed to rules-based trade.

The report is divided into two sections: (i) Product-level analysis: This section aims to identify significant changes, risks and opportunities using key metrics from the ECRMA, including economic importance (EI), import substitutability indicators (SUBS), scarcity measures (SCARCE) and Herfindahl–Hirschman indexes (HHI).

(ii) Regional analysis: This section uses the EUREGIO-2017 dataset to simulate the territorial impact of substituting the identified strategic inputs. The country-product analysis concludes with a table identifying excessive dependence on current suppliers for each of the 16 SRMs, considering two alternative thresholds: 65% and 50%. Simulating the territorial effects of substituting potential alternative suppliers indicates that the impact on both GDP and employment is extremely limited at national and regional levels.

As expected, China and Russia are experiencing the largest reductions. However, other major trading partners, such as South Africa, Turkey, Canada, the United States and Norway, will also see a decline in export volumes to the European Union. The countries set to benefit most are Indonesia, Brazil, India, Mexico and Australia. In terms of the regional analysis, certain countries—such as the United Kingdom, Norway and Portugal—experience positive impacts across all regions. In contrast, most other EU regions exhibit slightly negative effects. Some countries, such as Spain, Greece and France, have regions with positive effects and others with negative effects. This heterogeneity can be explained by the actual sectoral and regional interconnection of these regions with current main suppliers and potential substitutes. The report concludes with methodological and policy implications.

In terms of policy recommendations, the report acknowledges that, although the European Commission's initiatives are vital, implementing them using real-world data and simulations poses significant methodological challenges. These include defining products, thresholds and transformation stages. These parameters are crucial in determining which countries emerge as dominant suppliers, some of which may also be viable alternatives. The report stresses the need for coordinated action that goes beyond market forces, using tools such as trade policy, incentives, and public procurement while avoiding protectionism. Flexibility in benchmarks such as the 65% rule, greater involvement of regional and industrial stakeholders, and cooperation with advanced democratic partners (e.g. the UK, Norway, Canada and Japan) are essential. Ultimately, achieving strategic autonomy requires not only trade diversification, but also domestic production, recycling, labour capacity and geopolitical intelligence, all within a cohesive, multi-scale and values-based framework.

Keywords

Strategic Raw Materials; Open Strategic Autonomy; Input-Output Analysis; Europe; Regions; Resilience

Highlights

- The ESPON STARTER project examines the regional implications of scenarios relating to the EU's pursuit of Open Strategic Autonomy (OSA), focusing particularly on the strategic raw materials outlined in the Critical Raw Materials Act (ECRMA).
- The ECRMA sets ambitious targets to secure the supply of 16 strategic raw materials (SRMs), which are essential for achieving strategic autonomy in Europe. This report presents an analysis of Scenario 1 of Task 1, which explores the territorial impact of substituting supply sources for the 16 strategic raw materials prioritised by the ECRMA.
- The analysis proceeds in two stages: (i) Product-level analysis, which aims to identify significant changes, risks and opportunities using key metrics from the ECRMA. (ii) Regional analysis, which uses the EUREGIO-2017 dataset to simulate the territorial impact of substituting the identified strategic inputs. The country-product analysis concludes with a table identifying the current main suppliers of each of the 16 SRMs, considering two alternative thresholds of 65% and 50%.
- The territorial effects of substituting potential alternative suppliers are extremely low at both the country and regional levels.
- The countries that would be affected the most in terms of GDP and employment are China and Russia. However, when applying the EC methodology strictly, other relevant countries, such as South Africa, Turkey, Canada, the USA and Norway, should also reduce their exports to the EU. The countries with the largest positive impacts are Indonesia, Brazil, India, Mexico and Australia.
- Regarding the regional analysis, all regions in some countries, such as the UK, Norway and Portugal, have a positive impact, while most others have a slightly negative impact. In some countries, such as Spain, Greece and France, some regions have positive effects and others have negative effects. This heterogeneity can be explained by the current sectoral and regional interconnection of these regions with main suppliers and potential substitutes.
- In terms of policy recommendations, the report identifies ECRMA as a critical step towards strategic autonomy. However, it highlights implementation challenges. Applying the strategy to real data is complex. Definitions, thresholds and transformation stages significantly influence dependency assessments.
- There is a need for policy coordination. Market forces alone would be insufficient to reach established goals, and effective de-risking would require incentives and public intervention. This is all within the context of the EU avoiding protectionism and remaining supportive of a rules-based international economic order.
- The analysis also suggests that there should be more flexibility in thresholds. Rigid benchmarks, such as 65%, should take into account geopolitical and supply chain context, as well as the role of specific 'friendly suppliers' (such as Canada), with a view to further integration with the EU..
- Finally, the strategy should extend beyond trade. Strategic autonomy depends on domestic production (where possible), recycling, labour force planning, geopolitical awareness, and efforts at global cooperation. Working with like-minded partners such as the UK, Norway, Canada and Japan (and, hopefully, the US) would be crucial in preventing fragmentation and increasing leverage, particularly with regard to China.

1 Introduction

The ESPON STARTER project aims to analyse the regional effects of Open Strategic Autonomy (OSA) scenarios. The project involves the following research areas: (i) Examining the impact of diversification benchmarks for strategic raw materials outlined in the EU's Critical Raw Materials Act (ECRMA). (ii)Assessing the regional effects resulting from concessions in Free Trade Agreements (FTAs), specifically those contributing to diversification targets for strategic raw materials. (iii) Translating exogenous shocks into policy recommendations and conducting regional-sectoral case studies to provide an in-depth analysis of the effects of these scenarios, considering endogenous characteristics, policies and industrial conditions.

This report corresponds to the first scenario of Task 1, which examines the territorial impact of the substitution scheme for country sources under the 16 strategic raw materials (SRMs). The aim is to reduce the EU's excessive dependence on certain countries and the associated risks, in line with the European Commission's recommendations.

The remainder of the report is structured as follows: The sub-chapters in Section 1 provide an overview of the background and policy context. Section 2 describes the methodology and data used. Section 3 presents the results at country and regional levels. Section 4 suggests possible policy implications. Finally, Section 5 summarises the key findings and provides concluding reflections. The document is complemented by an Annex.

1.1 Background and policy context

In recent years, the EU has faced several unexpected shocks, including the disruption to global supply chains caused by the pandemic, the economic, energy and political consequences of the Russian invasion of Ukraine, increased US-China rivalry and the risk of global economic fragmentation. These shocks have undermined the liberal, rules-based order that the EU had long relied upon, replacing it with geopolitical rivalry and weakened multilateralism. Donald Trump's return to the White House in January 2025, along with his new tariffs, has introduced further uncertainty to the global trading system (Baldwin, 2025). The new US president has questioned the security umbrella protecting Europe and targeted the European economy directly. In response to these challenges, the EU has reluctantly adapted its policies to the new geoeconomic reality and has recently been forced to refine its foreign policy tools, particularly in the spheres of trade and the economy.

Key themes now shaping Europe's economic and trade policies include open strategic autonomy (OSA), energy and economic security, supply chain resilience, and de-risking — not only from China, but also from the US. Unlike the US, which has adopted a protectionist and isolationist stance, the EU remains committed to free trade agreements — preferably multilateral, but also bilateral — to mitigate risks, reduce vulnerabilities and secure critical resources from allied or like-minded countries. At the same time, the EU is adopting a more assertive stance, moving away from an overly optimistic view of globalisation, and developing tools to defend itself against external coercion and unfair competition, while using trade policy to combat climate change and promote European values.

The EU has also developed an economic security strategy that is aligned with the US and Japan, but which takes a less confrontational approach towards China given the strong economic ties that some member states, such as Germany, have with China. This strategy includes more sophisticated screening of inward investment, export controls, and protection against technology transfers. Following the recommendations of the Letta and Draghi reports, the EU is also strengthening its industrial policy to spearhead the green and digital transitions, particularly in sectors such as semiconductors, biotechnology, electric vehicles, artificial intelligence and quantum computing. However, these efforts have revealed a shortage of critical raw materials, which complicates the transition.

The various official documents outlining these evolving policies will have significant economic and redistributive impacts across the EU, making it essential to assess their effects and ensure cohesion among member states.

Consequently, the concepts of 'geopolitical Europe' and 'strategic autonomy' have become pivotal in EU policy discussions[1]. In 2019, EC President Ursula von der Leyen emphasised the need for a 'Geopolitical Commission' to address global instability, while in 2020, European Council President Charles Michel promoted 'European Strategic Autonomy'. The 2021 EU Trade Policy Strategy introduced the OSA concept, which aims to balance trade openness with autonomy. Scholars and academics have linked this shift to a more protectionist 'Fortress Europe' approach, highlighting the role of industrial policy in achieving strategic autonomy (Scott Lavery, 2023; Wigger, 2023). However, since Donald Trump's election, the EU has emphasised its commitment to an open, rules-based trading system by accelerating the negotiation and ratification of free trade agreements.

OSA refers to Europe's ability to govern itself without external interference, thereby ensuring resilience, security and prosperity (Tocci, 2021). Autonomy is a means to this end, not a goal in itself, enabling the EU to act independently while collaborating with global partners on an equal footing to shape global governance and reinforce interdependence.

A key element of EU autonomy is increasing resilience, which prompted the EU to pass the Critical Raw Materials Act (ECRMA) in 2024. The ECRMA aims to ensure the EU has access to a secure and sustainable supply of critical raw materials, enabling Europe to meet its 2030 climate and digital objectives. The Act sets ambitious targets to secure the supply of 16 strategic minerals that are crucial for the EU's industrial, technological, energy and military capabilities.

To mitigate the vulnerabilities associated with these minerals, the ECRMA promotes strategies such as diversifying suppliers, enhancing resource efficiency, recycling, and exploring material substitutes. Key actions include forming strategic alliances with like-minded countries to secure access to raw materials while maintaining autonomy; fostering internal cohesion to enable coordinated action; negotiating favourable terms with external suppliers; and investing in research and development to identify alternative materials.

This report focuses on the trade dimension of the issue, leaving the exploration of mining and recycling for further research.

1.2 Research design

In order to reduce its excessive reliance on a small number of countries for the supply of critical raw materials to European industries, the European Union is seeking to establish new trade partnerships. By diversifying its suppliers, the EU can reduce its reliance on existing sources and enhance its economic resilience in the face of unforeseen economic, geopolitical or regulatory shocks. This scenario analyses the EU’s current dependence on 16 strategic raw materials and assesses the potential economic impact of sourcing from a more diverse and geopolitically aligned group of suppliers.

The analysis proceeds in two stages:

- Product-Level Analysis: This phase evaluates the current status of strategic raw materials across Europe and identifies major risks and opportunities. The analysis uses key metrics set out in the EU Critical Raw Materials Act (ECRMA), such as economic importance (EI), import substitutability indicators (SUBS), scarcity measures (SCARCE) and Herfindahl–Hirschman indexes (HHI), to provide a thorough assessment of the strategic importance of each material.
- Counterfactual simulations: Using the EUREGIO-2017 dataset, this phase will simulate the territorial impact of substituting the critical inputs that have been identified. This exercise will produce two types of analysis: one at the national level and one at the regional (subnational) level. This will allow for a more nuanced understanding of how potential economic effects are distributed spatially. In particular:
  - Through the simulations, we will map increases and decreases in trade flows across affected sectors, considering Europe to be the central import market and the rest of the world to be the supplier. This

[1] The EU has been refining its conceptualization of Strategic Autonomy in the last years. A concept originated in the defense sphere and first mentioned in official documents in 2013 was later extended to the field of foreign policy with the 2016 EU Global Strategy and then entered the economic field in 2020, rebranded “Open Strategic Autonomy”.

analysis will help us to identify the countries most impacted by shifts in sourcing patterns, and will provide insights into how the global trade landscape is changing as critical inputs are substituted.

- The country-level analysis will be complemented by an assessment of the regional effects resulting from the replacement of current source countries with alternative suppliers capable of meeting European demand. This analysis will capture the territorial dimension of shifts in trade and highlight the potential economic impact on different European regions.

Two main data sources are employed in this study:

- For the Product–Country Analysis, the primary source is the BACI dataset (developed by CEPII and based on WTO, OECD, and UNCTAD trade data), which provides detailed international trade flows at the product and country levels.
- The simulation phase is based on the EUREGIO-2017 dataset, which enables territorial-level analysis across European regions.

1.3 Literature review

Several reports from European institutions, including the European Commission and the Joint Research Centre (JRC), have identified critical raw materials, assessed potential shortages and evaluated their impact on the green and digital transitions (see the European Commission's Raw Materials Information System, 2023). Key references include the methodologies used to identify these materials and assess associated dependency risks (European Commission, 2021; Arjona et al., 2023).

Recent scientific studies have made significant contributions to this field. For example, Borin et al. (2023) use an Italian foreign transaction dataset to map vulnerabilities at firm level and examine the potential economic impact of supply reductions due to fragmentation. This methodology is being used by several European Central Banks and is a key reference for the ESPON-STARTER fourth case study. Ioannou et al. (2023) explored the implications of the ECRMA for European monetary policy, and Firgo et al. (2024) proposed a framework for prioritising reshoring activities by identifying import dependencies and risks. They provided an example from an Austrian region.

Baldwin et al. (2023) analysed global value chain disruptions, focusing on links that expose supply chains to shocks, and on the need for policies that target individual products rather than entire sectors. Their research reveals that US exposure to foreign suppliers, particularly those in China, is greater than traditional trade data suggests, although macro-level exposure remains modest, with over 80% of US industrial inputs being sourced domestically. The authors' main conclusion is that concerns about supply chain disruption and the corresponding policies should focus on specific products rather than the manufacturing sector as a whole.

Additionally, a growing body of literature is addressing the economic impacts of geoeconomic fragmentation. For instance, Attinasi et al. (2023) use Baqaee and Farhi’s (2023) model to quantify the consequences of a scenario involving global trade fragmentation. Similarly, Javorcik et al. (2022) examine the costs of friend-shoring. Other studies utilise multi-country, multi-sector models (Eppinger et al., 2021; Góes and Bekker, 2022; Felbermayr et al., 2023; Campos et al., 2023), alongside large macroeconomic models (OECD, 2020; Chepeliev et al. 2022), input-output models using the hypothetical extraction method (Almazán et al., 2024; Wu et al., 2021; Giammetti et al., 2021) and CGE models (Lim et al., 2021).

From a policy perspective, Baldwin (2025) has analysed the probable future evolution of the global trading system following Donald Trump's election as US president and his introduction of aggressive tariffs. Finally, analyses of various Free Trade Agreements (FTAs) being developed by the EU with strategic partners, such as MERCOSUR (Burrell et al., 2011; Timini & Viani, 2020), and specific countries, such as Korea, India and Chile (Su, 2018; Khorana & Perdikis, 2010; Roy & Mathur, 2016; Dür, 2007; Jean, Mulder & Ramos, 2014), are also available. However, the timing, potential impact and focus of these papers suggest a lesser interest than previous literature, which often emphasised political economy and regulatory frameworks rather than the economic impact of these agreements. Many of these agreements are still under negotiation or awaiting ratification and implementation. In any case, it is undeniable that the EU has recently accelerated several trade negotiations, from India to Indonesia, and is deepening its ties with the UK and Canada, in order to confront growing American protectionism. The EU has also made strategic political moves in an attempt to lead the reform of the global trading system, and more broadly, the rules-based order in a post-American world (Politico).

2 Overview of Methodology

As discussed above, the aim of this report is to create plausible scenarios addressing the territorial impact of the de-risking process suggested in the ECRMA. To do so, we use robust quantitative frameworks that analyse spatial and sectoral interactions within and between European countries, with a focus on NUTS 2 regions.

This section details the methodologies and secondary data sources used for analysis. Our approach combines two different layers, one applied at the country-to-country level (C2C), and the other at the region-to-region level (R2R):

- For the C2C analysis, we deploy a trade analysis following the European Commission methodology to identify strategic raw materials and the main source countries.
- The R2R analysis relies mainly on the latest version of the multi-regional input-output table (EUREGIO-2017), developed by teams from this consortium in collaboration with the JRC under the ESPON-IRIE project.

While the C2C analysis provides updated and detailed insights into global trade, the regional analysis using EUREGIO-2017 will offer in-depth assessments of direct, indirect, and induced effects for Europe's 297 regions (EU27 + UK, Norway, Iceland, Switzerland, and Liechtenstein) across 64 sectors. The results are then presented through figures, tables and maps, illustrating the national and sub-national exposure to the shocks considered.

2.1 Indicators to identify risks of provision

Due to the complex nature of defining risk and dependency in academic literature, evaluations of strategic dependence have adopted various perspectives, combining complementary risk indicators. In line with the approach adopted by the European Commission (European Commission, 2021), it is not feasible to define the level of dependence using a single measure. Therefore, we use a set of key indicators that collectively assess different dimensions of risk. The indicators used in the analysis are described below and are all aligned with the criteria identified in recent European reports.

Concentration of extra-EU imports: The Herfindahl–Hirschman Index (HHI) measures the degree of concentration of imports of a given material from non-EU countries. A high HHI value indicates significant import concentration from a limited number of supplier countries, thereby increasing the risk of supply disruption if issues arise with these predominant suppliers. For example, an HHI approaching 1 indicates almost exclusive reliance on a single country. According to the methodological framework used by the Commission, high concentration risk is identified when the HHI surpasses the 0.4 threshold.

$$HHI_{ip} = \sum_{j=1}^{n} (S_{ijp})^2$$

Where S_{ijp} is the market share of the extra EU supplying country "j" in country "i" imports of the strategic product "p", and "n" is the total number of extra EU supplying countries.

Scarcity or dependence on extra-EU imports: The second indicator measures the proportion of a product's total supply that comes from outside the EU. It calculates the proportion of total imports (the sum of intra-EU and extra-EU imports) that extra-EU imports represent. A high value for this ratio indicates that the EU relies primarily on external sources to meet demand, suggesting shortages or a high degree of external dependence. According to European Commission reports, a value above 50% is considered critical, meaning that more than half of a material's availability comes from outside the EU.

$$SCARCE_{ip} = \frac{M_{ip}^{Extra}}{M_{ip}^{Total}}$$

Where M_{ip}^{Extra} refers to the extra EU import value of country "i" for the strategic product "p" and M_{ip}^{Total} to the total import value of the specific country for the strategic product.

Import substitutability: The third indicator assesses the EU's ability to replace its current imports from third countries with domestic production in the event of a trade disruption. As detailed production data is sometimes incomplete, a proxy based on a comparison of the volume of extra-EU imports and EU exports (within and outside the EU) of the same product is used instead. High values of this ratio suggest that there is insufficient domestic production capacity to replace external supplies in the short term. According to the European Commission's methodology, if the volume of extra-EU imports exceeds the total export volume (i.e. if the value is greater than 1), the product indicates a high level of vulnerability in the event of an external shock.

$$SUBS_{ip} = \frac{M_{ip}^{Extra}}{X_{ip}^{Extra} + X_{ip}^{Intra}}$$

Where the aggregation $X_{ip}^{Extra} + X_{ip}^{Intra}$ refers to the total export value for the strategic product "p" done by the country "i".

As mentioned, previous studies (European Commission, 2021; Borin et al., 2023). consider a product to be critical or to have a high dependency on it if the three conditions mentioned above are satisfied. That is, HHI>0.4; $SCARCE$>0.5, and $SUBS$>1. In our case, we will maintain these limits, and in our methodology, we will consider the product criticality to be "high" if they are met. However, we add a more flexible scenario, which we call "Medium," in the case that HHI>0.25; $SCARCE$>0.4 but maintaining $SUBS$>1. If the three conditions are not satisfied, we consider that the country has "Low" critical risk.

In the subsequent phase of our analysis, we calculate a metric of **Economic Importance** (European Commission, 2020) for the different raw materials, specific to each country. This analysis aims to ascertain the economic significance of these raw materials in the production chains of each European nation. The indicator is computed as follows:

$$EI_{ip} = \frac{\sum_{is}(A_{is} \cdot Q_{is}) \cdot SI_{EI}}{\max Q_{is}} \cdot 10$$

Where, A_{si} refers to the percentage of final use of a raw material (6-digit product) in a 2-digit sector of NACE "s". Q_{si} is the value added of the sector belonging to the NACE and SI_{EI} being the substitution index of the raw material in relation to the economic importance. In previous works SI_{EI} take values in the range of 0.8 to 1. Given the challenges associated with calculating this indicator using the available data, we conservatively assign a value of 1 to all products, considering this value to represent the worst-case scenario. Finally, the result is called by dividing by the maximum value of 2-digit sector NACE and multiplied by 10.

2.1.1 Trade data

For this analysis, we used the BACI database. Created by the French Research Institute CEPII, BACI is a detailed international trade database. It provides annual trade data for around 200 countries. The data is categorised into over 5,000 products using a six-digit code from the Harmonised System (HS). For each pair of countries trading a product, BACI shows the trade value in US dollars and the quantity traded in metric tons. For this report, we use data covering the period from 2019 to 2023.

BACI is developed by harmonising and reconciling country-reported trade statistics from the United Nations Comtrade database. Each bilateral trade flow is usually reported twice: once as an export by the origin country, and once as an import by the destination country. However, these 'mirror' reports often differ due to valuation and reporting discrepancies. BACI's methodology addresses these inconsistencies by estimating and deducting CIF freight costs from import values, thereby converting them to an FOB basis. It also evaluates the reliability of each country's reporting to ensure that both sides of each trade flow are appropriately weighted when averaged into a single reconciled figure. This process generates a clear and consistent set of trade values and quantities for each combination of exporter, importer and product. Thanks to this careful harmonisation methodology and the extensive scope of the database, BACI is an invaluable tool for analysing international trade, export performance and the impact of trade policy.

For this study, 184 HS6-2007 products were selected, based on the JRC document on Trade Codes for the Raw Materials Information System for the 16 strategic products covered in the report (Georgitzikis, K. 2023). These products are classified, based on the same document, into two categories. The first is the Extraction/Mining stage. The second is all other stages. Table 4 in the Annex includes the complete information about the products and categories included in the report.

2.2 Multiregional Input Output Modelling

In the final stage, a regional impact analysis will be carried out to study the effect that substitution movements located in the previous stages would have on each European region. The impact of reducing imports without substitution will also be analysed, in order to identify the regions most affected by higher supply risks for each product-country. This will be done using the trade data from the previous stages.

Please note that the impact at the sector-country level is calculated as a percentage. To allocate the impact at the sector-region level, the percentage for each country in each sector is applied to the regions.

$$A_{sc} = A_{sr} \; \forall \, r \in c$$

Subindex c depicts the country and subindex r depicts the region. In this way, the direct commercial impact is assumed to be a demand shock that provokes direct and indirect effects on socioeconomic variables. These impacts are calculated using the input-output framework.

Input-output analysis models the direct and indirect effects of economic shocks across all sectors. The development of multi-regional input-output (MRIO) databases has transformed IO analysis by providing insights into global trade flows and value chains at a country-to-country level (Lenzen et al., 2013; Merciai & Schmidt, 2018; Remond-Tiendrez & Rueda-Cantuche, 2019; Stadler et al., 2018; Tukker & Dietzenbacher, 2013; Wood et al., 2014).

The ESPON-IRIE project has contributed to this by creating EUREGIO-2017, which builds on the EUROSTAT-supported FIGARO framework (Remond-Tiendrez and Rueda-Cantuche, 2019). This framework provides detailed sector-to-sector and region-to-region comparisons within Europe and other countries at the NUTS-2 level for all EU27 countries, including the UK, Norway, Iceland, Switzerland and Liechtenstein — a total of 297 NUTS-2 regions. Unlike previous EUREGIO approaches (Thissen et al., 2019, 2018, 2013), this study's EUREGIO-2017 framework employs the latest coherent FIGARO figures at the country-to-country level as constraints.

It is also important to note that the EUREGIO-2017 framework captures not only sector-region-to-sector-region flows within Europe, but also sector-region-to-sector-country flows with other countries, including the US, China, Japan and Russia. Considering sector-region-to-sector-country flows enables a more detailed analysis of economic relationships and dependencies between regions and third countries, thereby enhancing the accuracy and completeness of impact analyses (Miller and Blair, 2009). Consequently, this framework is the most comprehensive and up-to-date multi-sectoral, multi-regional framework currently available for Europe.

Once the database is described, some insights about the multiregional and multisectoral input output framework are needed. First, let's $\mathbf{Z}$ depict a block matrix with $\mathbf{Z^{rs}}$ matrices that capture the inter-industry relations between regions r and s. So, each submatrix $\mathbf{Z^{rs}}$ is a n-by-n matrix where n is the number of sectors accounted. The matrices on-diagonal ($\mathbf{Z^{rr}}$) capture the domestic intermediate flows (intraregional intermediate flows). By contrast, all off-diagonal matrices ($\mathbf{Z^{rs}}\ \forall\ \mathrm{r} \neq \mathrm{s}$) contain the inter-industry interregional flows where $\mathrm{Z_{ij}^{rs}}$ is the value of the production generated by sector i in region r that is being used as an intermediate input by sector j in region s (interregional inter-industry flow). The gross output of each industry is depicted by a column vector $\mathbf{x}$. Then, dividing each element of the intermediate inputs matrix ($\mathrm{Z_{ij}^{rs}}$) by the gross output of the sector j of the region s ($\mathrm{x_j^s}$) we obtain the matrix of technical coefficient, in matrixial form: $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$. Each element of this matrix ($\mathrm{A_{ij}^{rs}}$) informs us about the requirements that has the industry j of region s from the industry i from region r to produce an output of 1 monetary unit (one million Euros in our case). Let's call the matrix of value-added generated as $\mathbf{M}$, where each component $\mathrm{M_{cj}^s}$ depict the component c of value-added (gross operating surplus, compensation of employees, taxes, etc.) associated to industry j from region s. For the lack of simplicity let's assume there are no other components on the supply side and to aggregate the matrix $\mathbf{M}$ to obtain a row vector called $\mathbf{m}$ ($\mathrm{m_j^s} = \sum_c \mathrm{M_{cj}^s}$). Then, dividing the $\mathbf{m}$ vector element by element by the gross output, we obtain, for each sector of each region the share of value-added over the total output, let's call this vector as $\mathbf{v}$. Note that this vector ($\mathbf{v}$) is a vector of value-added requirement per unit of output. Finally, the final demand matrix, usually called $\mathbf{Y}$, is also a block matrix of matrices $\mathbf{Y^{rs}}$ where each component $\mathrm{Y_{id}^{rs}}$ represent the final demand that makes the agent d (households, government, NPISHs, etc.) of region s from industry i of region r. Let's also aggregate all columns in the final demand matrix to obtain a column vector ($\sum_{sd} \mathrm{Y_{id}^{rs}} = \mathrm{y_i^r} \rightarrow \mathbf{y}$), then, the main equations are the following:

$$\mathrm{x} = \mathrm{Ax} + \mathrm{y} \quad \leftrightarrow \quad \Delta\mathrm{x} = (\mathrm{I} - \mathrm{A})^{-1}\Delta\mathrm{y}$$

$$\Delta \mathrm{m} = \hat{\mathrm{v}}(\mathrm{I} - \mathrm{A})^{-1}\Delta \mathrm{y}$$

Where $\Delta \mathrm{y}$ is a vector of N-by-R elements, where *N* depict the number of sectors considered and R is the number of regions considered. Each element of this vector ($\Delta \mathrm{y}_{\mathrm{is}}$) represents the shock in monetary units:

$$\Delta y_{si} = A_{si} * EXP_{si}^{EU}$$

Where EXP_{si}^{EU} is the exports (in million euros) to the European Union of sector *s* from region *i*. Here fist equation depicts the changes in the gross output, meanwhile second equation depicts the changes in the value-added. Note that the Leontief model is a linear model, so, percental changes in the output depict the same percental variation in the value-added (or employment) at the sector-region level ($\frac{\mathrm{x}_{\mathrm{i}}^{\mathrm{r}*} - \mathrm{x}_{\mathrm{i}}^{\mathrm{r}}}{\mathrm{x}_{\mathrm{i}}^{\mathrm{r}}} = \frac{\mathrm{m}_{\mathrm{i}}^{\mathrm{r}*} - \mathrm{m}_{\mathrm{i}}^{\mathrm{r}}}{\mathrm{m}_{\mathrm{i}}^{\mathrm{r}}}$).

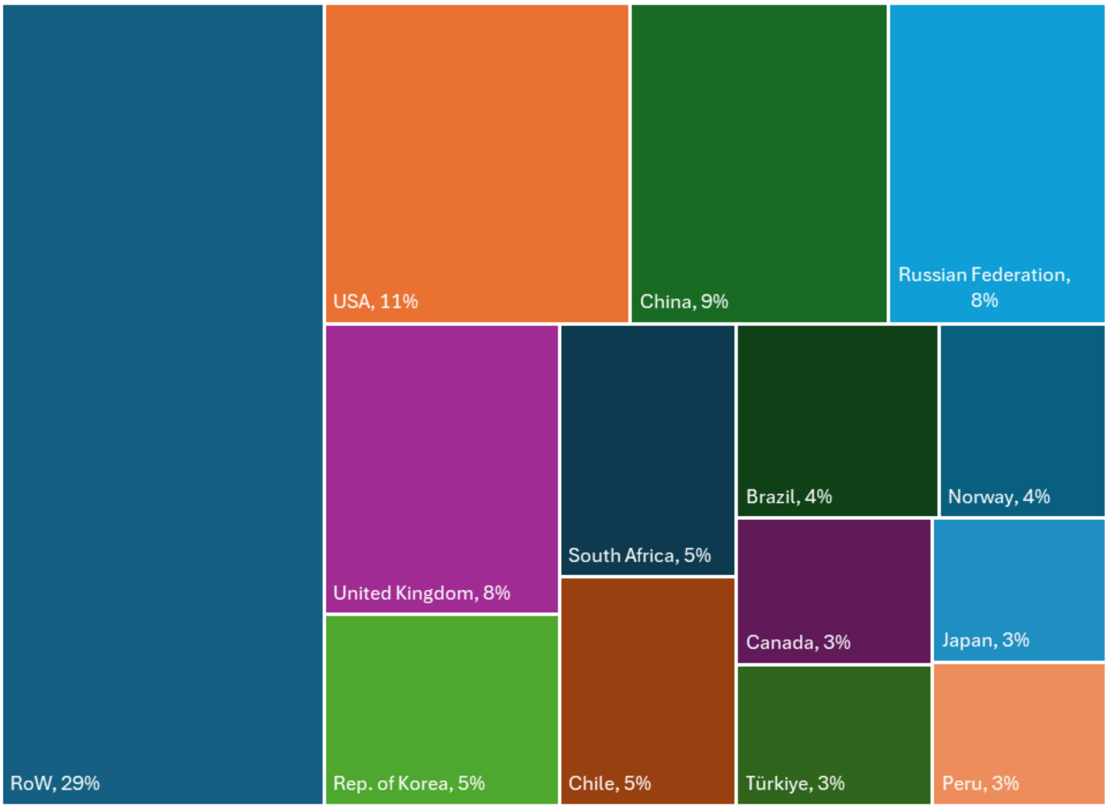
3 Results

This section is divided into two parts. In the first part (Section 3.1), we provide a descriptive analysis of the main results obtained in the country trade analysis described previously, in which we applied the EC methodology to identify the various degrees of dependency on EU provision of the 16 SRM. The second part (Section 3.2) analyses the results of the simulations conducted with EUREGIO-2017 with respect to the reduction in dependency identified in Section 3.1. These results are presented at country (world) and regional (EU27+EEA) levels, considering various situations and economic units (e.g. value added and employment).

3.1 Country Trade Analysis: identifying dependencies

As discussed in previous sections, this study focuses on 184 six-digit HS products classified as strategic by the European Commission. **Figure 1** shows the main suppliers of these products to the EU in monetary terms. During the study period, the three main suppliers of these products were the United States, China and the Russian Federation. Together, these three countries accounted for one-third of imports of these 184 products. The United Kingdom, the Republic of Korea, South Africa and Chile also stand out.

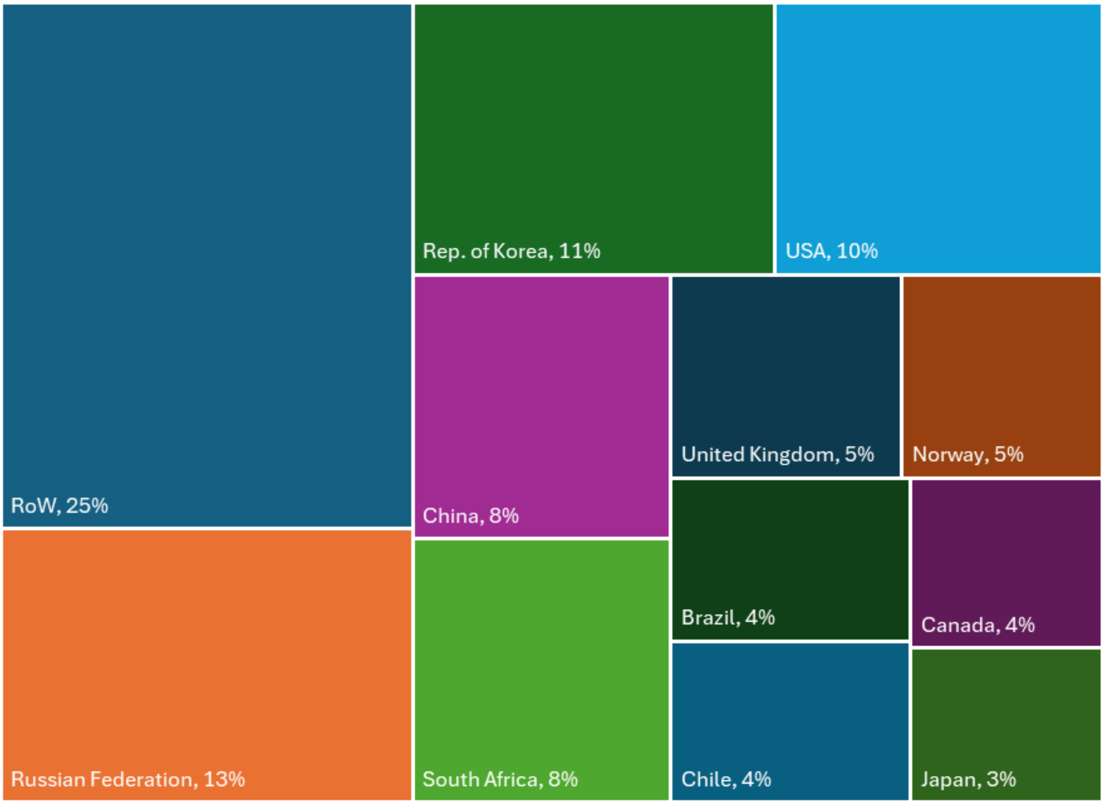
Figure 1. Share of EU imports value of the strategic materials (2019-2023)



Source: Own elaboration with BACI data

Figure 2 offers a complementary view, including the level of risk posed by each European country for each selected product in the analysis. This changes the picture, showing greater dependence on many of the highlighted countries. For example, the Russian Federation now accounts for 13% of European imports from countries with medium- or high-risk products. Similarly, the Republic of Korea now ranks second, having increased by 11%. The United States and China rank at 10% and 8%, respectively. South Africa also climbed to 8%. Together, these countries account for 50% of imports of medium- and high-risk products.

Figure 2. Share of EU imports value of the strategic materials with Medium or High risk (2019-2023)



Source: Own elaboration with BACI data

When evaluating these indicators collectively for EU countries (**Table 1**), considerable heterogeneity in import risk levels is observed. Overall, around 24% of total EU imports are classified as high risk, with an additional 14% classified as medium risk. However, there are notable disparities among individual countries. For example, up to 95% of Hungary's imports are classified as high risk, whereas Italy's figure is significantly lower at 6%.

It is important to consider these dependencies from multiple perspectives, bearing in mind that the current analysis measures imports in monetary terms. This approach is affected by unit values and the heterogeneous quantities of different products traded (even by the joint effect). Therefore, the analysis is complemented by the distribution of HS6 strategic products according to their respective risk categories for each country. Consequently, countries such as Spain, which appear relatively low-risk in monetary terms, reveal that nearly a third of the examined strategic products are classified as medium- or high-risk. Conversely, Hungary's initial high-risk import share of 95% decreases to 15% in a product-specific analysis. This highlights that certain items can disproportionately influence the overall risk profile when measured in monetary terms, despite the presence of many dependent products. Conversely, Ireland has more than 50% of strategic products showing medium or high risk, making it the country with the highest number of products with extensive dependencies. Considering this discrepancy, **Figure 3** shows the average risk of countries computed using two different statistical indicators. First, we calculated the weighted average of the three dependency indicators, weighting them by the level of extra-UE imports of each HS6 product. These results are shown in the left-hand panels. Additionally, we present the results using an arithmetic average to provide a comprehensive analysis of countries exposed to criticalities. The results of these arithmetic averages are shown in the panels on the right.

Table 1. Country profile by level of risk using alternative measures

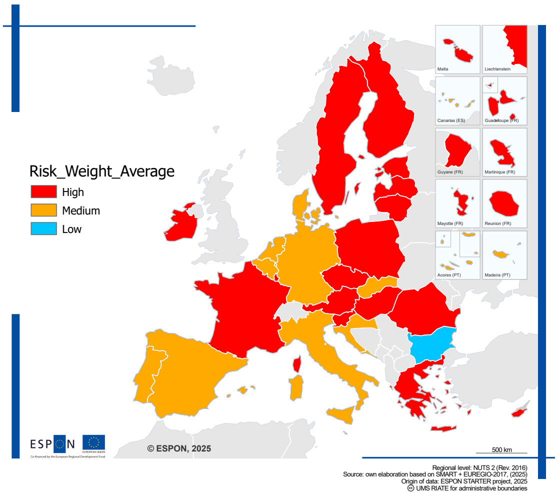
	Share of import values by level of risk			Share of HS6 products by level of risk		
	Low	Medium	High	Low	Medium	High
Hungary	4%	1%	95%	78%	8%	15%
Malta	17%	4%	79%	72%	5%	23%
Latvia	24%	1%	75%	72%	4%	24%
Poland	24%	4%	72%	68%	11%	21%
Luxembourg	27%	0%	73%	85%	1%	15%
Slovenia	30%	19%	52%	74%	8%	18%
Cyprus	32%	12%	57%	69%	5%	26%
Ireland	33%	13%	54%	49%	13%	38%
Greece	36%	4%	60%	77%	3%	20%
Finland	42%	9%	48%	75%	7%	18%
Austria	44%	36%	20%	83%	8%	10%
Estonia	45%	18%	37%	79%	5%	16%
Sweden	46%	30%	25%	79%	7%	15%
Romania	49%	6%	45%	81%	5%	13%
Lithuania	50%	7%	43%	80%	4%	16%
Portugal	53%	3%	44%	84%	3%	13%
Czechia	58%	7%	35%	78%	7%	15%
Germany	61%	29%	9%	81%	8%	11%
EU	62%	14%	24%	77%	7%	16%
France	62%	9%	29%	86%	7%	8%
Slovakia	63%	15%	22%	83%	6%	11%
Denmark	70%	9%	21%	81%	7%	12%
Netherlands	71%	5%	24%	73%	9%	18%
Croatia	73%	1%	26%	81%	7%	11%
Belgium	74%	10%	17%	79%	6%	15%
Italy	77%	16%	6%	77%	12%	11%
Bulgaria	85%	3%	13%	76%	6%	18%
Spain	87%	6%	7%	76%	8%	16%

Source: Own elaboration with BACI data

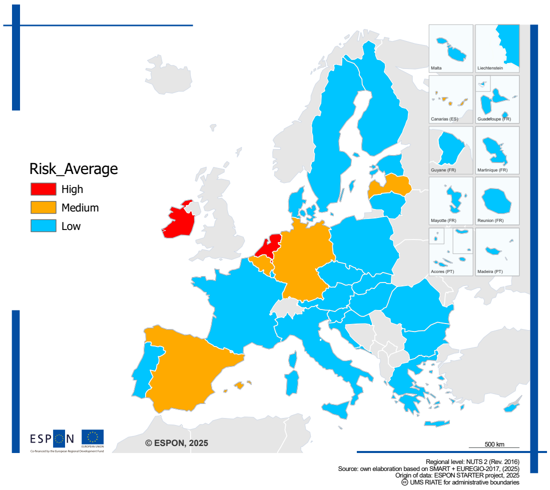
We summarize this information in **Figure 3**. The information within the figure is divided in two ways. Each row contains information on a group of products. The first row (Panels A and B) contains details of all the HS6 products referenced in the report. The second and third rows divide the products according to the stage to which they belong, using the aforementioned criteria. Thus, the second row (panels C and D) shows information relating to stage 1 (extraction/mining), while the third row (panels E and F) shows information relating to stages 2 (intermediate, final and recycling). The resulting indicators are shown in columns depending on the statistical indicator used to summarise the information. The first column shows the summarised information based on a weighted average of the different HS6 products according to the value of their extra-EU imports. The second column uses an arithmetic mean to give all products equal weight and analyse these risks more extensively.

Figure 3. Risk by country and stage

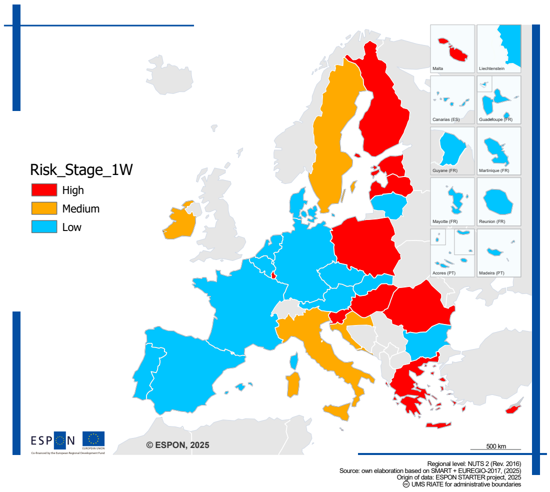
Panel A: Overall (Stages 1+2) Risk, weighted by imported value



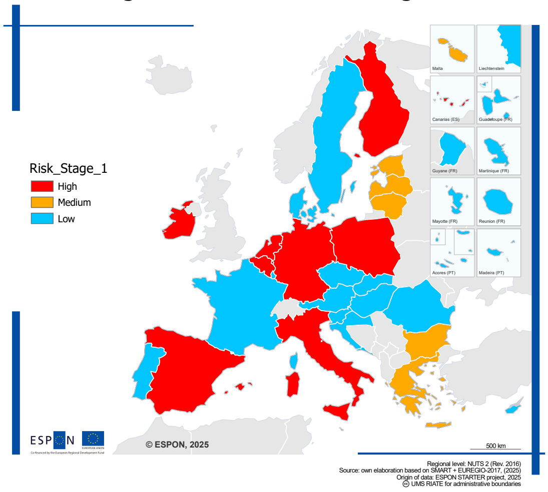
Panel B: Overall (Stages 1+2) Risk, Arithmetic average



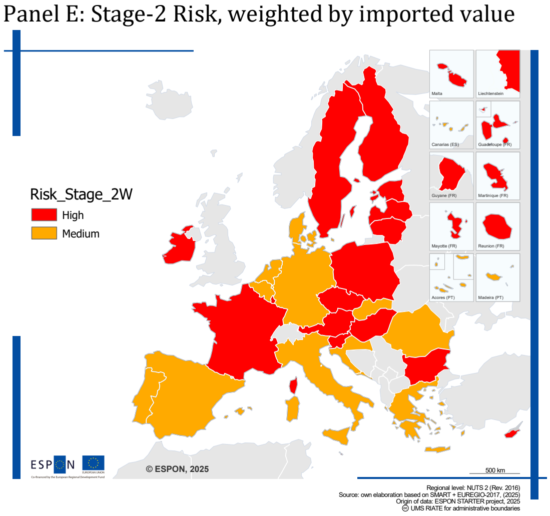
Panel C: Stage-1 Risk, weighted by imported value



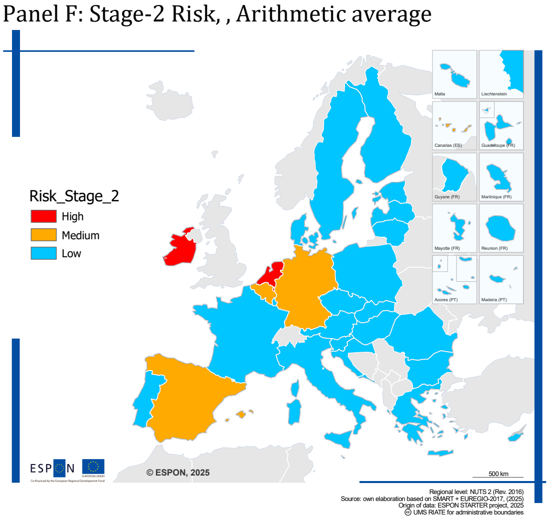
Panel D: Stage-1 Risk, Arithmetic average



Panel E: Stage-2 Risk, weighted by imported value



Panel F: Stage-2 Risk, , Arithmetic average



Source: Own Elaboration
Note: Stage 1 refers to HS6 products in the Extraction/Mining stage. Stage 2 refers to HS6 products in the Intermediate/Final/Recycling stage.

As the results show, risk levels vary greatly depending on the statistical indicator or strategic product considered. Starting with the analysis of Panels A and B, the discrepancy between the two maps is striking, and is closely related to what was shown in **Table 1**. When the average value of extra-EU imports of these products is considered (Panel A), a high level of overall risk is observed. Of particular note is the high concentration of risk in Eastern Europe. Only one country shows a low risk for strategic products, regardless of the statistical indicator used: Bulgaria. In contrast, Ireland shows high dependence when considering both the extent (Panel B) and the value (Panel A) of its external imports from the EU. Simultaneously, three countries demonstrate consistent medium risk: Germany, Belgium and Spain. The Netherlands stands out with a high risk when all products are considered equally, although this decreases when the value of imports of these products is considered. Latvia also stands out with a medium risk when considering the average of all products (Panel B); this situation is exacerbated when the risk is weighted by the value of extra-EU imports, elevating it to the high category (Panel A). When all products were considered unweighted, all other countries presented a low risk. However, their situation worsens when the value of imports is considered. It is important to highlight that the results shown in Panel B of **Figure 3** for the overall arithmetic mean (Stages 1+2) are partially conditioned by the scarcity indicator (all countries exceed the value of 1 in the substitution indicator and the minimum in the HHI is 0.38), the average of which is 0.35. Up to eight countries are located between this average and the limit of 0.4 imposed for the medium-risk category. Similarly, in the weighted indicator, the substitutability and concentration indicators show a high correlation with the aforementioned indicators, but the scarcity indicator increases, which explains the large jump that occurs in many countries from one panel to another.

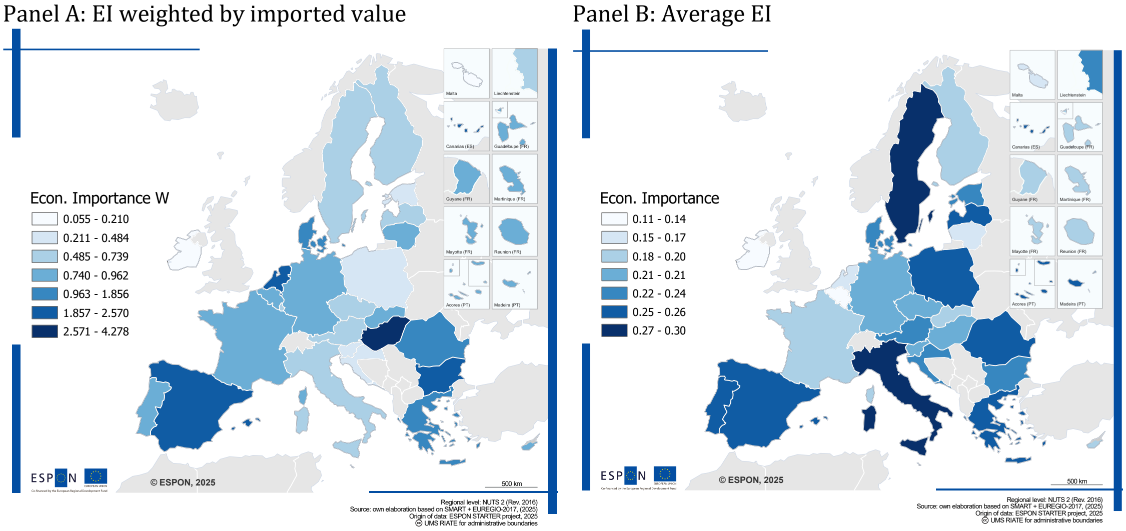
When products are disaggregated into different subgroups, new weaknesses emerge. In the case of products related to the extraction/mining stage, the weaknesses appear to be concentrated in Eastern Europe when using the weighted risk indicator (see Panel C). However, countries such as Spain, Germany and Italy appear to have significant weaknesses due to their dependence on products that are not widely imported, as can be seen in Panel D. It is notable in this panel that Bulgaria is beginning to show minor weaknesses in products that are not widely imported, placing it at medium risk. Nevertheless, there is little correlation between these panels and those shown in Panels A and B.

Conversely, the risk correlation is almost perfect when considering the intermediate, final and recycled product stages, with a few exceptions. Notably, the risks at this stage are evident in a number of products that are imported more frequently. It is interesting to note that when the two stages are considered separately, the situation in Bulgaria changes radically, with a high risk associated with the products of this stage.

Figure 4. Economic importance (EI) of SRM by country

Panel A: EI weighted by imported value

Panel B: Average EI



Source: Own elaboration

Additionally, **Figure 4** analyses the average economic importance of the strategic raw materials by country. As before, the results are shown in Panel A, with the average results weighted according to extra-EU imports of strategic HS6 products. Panel B, on the other hand, shows the simple arithmetic average of the economic importance of all products for each country. This dual approach enables us to consider both the risk associated with each country's level of import dependence and the overall economic significance of the different strategic products within their respective economies. One notable case is Ireland. Although the country exhibited high levels of risk in the various SRMs considered, its economic importance is the lowest in the EU. Conversely, these SRMs appear to be of great importance to the Bulgarian economy despite presenting low risk. Looking at Panel A, the economic importance of these SRMs is evident in Southeast European countries, as well as in large economies such as Portugal, Spain, France, Germany, Belgium and the Netherlands. Conversely, these SRM products appear to have little economic importance in Northeastern Europe when their importance is weighed against the level of extra-EU imports.

When the arithmetic mean of economic importance is calculated, considering all products equally (Panel B), the profile of European countries changes. While Southeast European countries such as Spain and Portugal maintain a high level of economic importance for these SRMs, several Northeast European countries such as Sweden, Poland, Latvia and Estonia have joined them. Italy is also a noteworthy case. Although it displayed low economic importance in Panel A, it now shows a high value, demonstrating that a wide variety of these SRMs are important to its economy, even though it does not import them intensively. Conversely, the values obtained by other countries, such as France, the Netherlands, Belgium, Hungary and Slovakia, are now lower. It is therefore evident that, while some SRMs are highly relevant to the economies of these countries due to intensive imports from non-EU countries, the rest of these products do not appear to have a major impact on them.

The ECRMA sets ambitious goals in terms of international trade and supply for non-EU partners. Specifically, it stipulates that the EU should not depend on any single third country for more than 65% of its supply of each strategic raw material at any stage of processing. The next table shows the main current providers and the potential alternative sources needed to fulfil the ECRMA requirement, based on an independent analysis of the different HS6 products considered in the study. For simplicity, the HS6 results have been grouped according to the 16 strategic raw material categories to which they belong.

The analysis of **Tables 2 and 3** highlights critical insights into EU strategic dependencies on specific inputs and potential pathways for reducing these dependencies below the European Commission's defined threshold of 65%. **Table 2** focusses on the "Extraction & Mining" stage will **Table 3** focusses on all the others.

Table 2. Key and alternative country sources by each SRM group (Stage Extration/Mining)

SRM	Main Suppliers	Potential Substitutes	Others
Bismuth	No supplier with concentration >65%		
Boron	Türkiye	United Kingdom	
Cobalt	No supplier with concentration >65%		
Copper	No supplier with concentration >65%		
Gallium	No supplier with concentration >65%		
Germanium	No supplier with concentration >65%		
Lithium	No supplier with concentration >65%		
Magnesium metal	Norway	United Kingdom	Canada; Brazil
Manganese	No supplier with concentration >65%		
Natural Graphite	No supplier with concentration >65%		
Nickel	No supplier with concentration >65%		
Platinum	No supplier with concentration >65%		
REE	No supplier with concentration >65%		
Silicon metal	Brazil	Norway	India; Ukraine
Titanium metal	No supplier with concentration >65%		
Tungsten	No supplier with concentration >65%		

Regarding the EU's imports at the 'Extraction & Mining' stage of these strategic raw materials, **Table 2** shows that only three products are highly vulnerable: boron, magnesium metal and silicon metal. The main suppliers of these products are Turkey, Norway and Brazil, respectively, with all surpassing the 65% import concentration threshold. When it comes to potential substitutes, our decision is based on the current structure of EU importers. To reduce the concentration of imports from Turkey of boron, for example, the simplest alternative would be to increase imports from the United Kingdom. For magnesium metal, the main alternative is again the United Kingdom, though Canada and Brazil are also possible sources. Finally, for raw silicon metal products, Norway would be the main source of substitution. India and Ukraine could also supply some of these products.

Turning to the 'Intermediates & Final' stage of the supply chain, **Table 3** shows a different situation. At this more advanced stage of product transformation, only four products (gallium, natural graphite, titanium metal and tungsten) do not present a situation of non-dependence in terms of the necessity to search for new importers. All the other SRMs show high levels of dependency, above the official threshold of 65% concentration in a single supplier.

Table 3. Key and alternative country sources by each SRM group (Stage Intermediate and Final)

SRM	Main Suppliers	Potential Substitutes	Others
Bismuth	Rep. of Korea	Japan	
Boron	China; Türkiye	Rep. of Korea; USA	United Kingdom; Japan
Cobalt	Bosnia Herzegovina; Russian Federation; China; Rep. of Korea	Indonesia; India; Japan	USA; India; Switzerland; Mexico
Copper	Bosnia Herzegovina; China; Türkiye; Viet Nam; South Africa	Rep. of Korea; Uzbekistan; United Kingdom; Türkiye	India; USA
Gallium	*No supplier with concentration >65%*		
Germanium	China; Rep. of Korea	Japan	
Lithium	Israel; Chile; Rep. of Korea; China	USA; Argentina; Japan	United Kingdom; Jordan
Magnesium metal	China	Israel; Türkiye; United Kingdom	Canada; Brazil
Manganese	Russian Federation; China	Türkiye; South Africa	Egypt; Indonesia
Natural Graphite	*No supplier with concentration >65%*		
Nickel	United Kingdom; Russian Federation; Bosnia Herzegovina; USA	Indonesia; India	Japan; Brazil
Platinum	Japan	United Kingdom	USA; India; South Africa
REE	China	USA	Canada; Thailand; United Kingdom; Türkiye
Silicon metal	USA	Singapore	Japan; Norway
Titanium metal	*No supplier with concentration >65%*		
Tungsten	*No supplier with concentration >65%*		

Source: Own elaboration.

Three names stand out among the products from these intermediate and final stages: China, the Russian Federation, and the Republic of Korea. They are the main importer of many HS6 products, with shares exceeding 65% across the different strategic material groups. In terms of substitutes, Japan, India and Indonesia are notable. As discussed in previous sections, this concentration limit is directly linked to the risk indicators previously calculated. In particular, the 65% limit is strongly related to the previously calculated high criticality level.

As a robust check, and in line with the medium criticality level mentioned above, subsequent simulations will also consider an alternative scenario in which the limit is set at 50% instead of 65%. In other words, no single country would supply more than half of a single strategic material (SRM).

3.2 Scenarios

Based on the results presented in Table 2 and 3, we simulate the territorial impact of a shift from the current situation of dependency for each of these 16 SRM to an alternative supplier where each of these items would be supplied below the 65% (or the alternative 50% threshold) in the next future (2030). To do so, we proceed in the following way:

- First, we identify the value of Extra-EU imports to be reduced for each of the HS6 products that belong to the 16 SRM categories and the countries with excessive dependency (>65%).
- Similarly, we identify the potential alternative supplier according to the value of their exports for each of these 16 SRM to the EU. Such values are based on the actual trade data from BACI (2019-2023)
- Then, we translate these values of country-product trade shifts into percentage changes of trade-changes at the country-sector level in the EUREGIO-2017 input-output table. According to the previous sections, these trade shifts will generate effects on the world output, which can be split into national and sub-national impacts, measured in terms of Value Added, Employment and CO2 emissions.

When computing this simulation, we consider **two scenarios:**

- **Scenario A (Baseline):** in this scenario, we strictly consider the official threshold defined by the EC (to keep supply of each SRM below 65% threshold for every HS6 product of the 16 SRM). A total of 27 HS6 products that belong to 12 SRM categories exceed this 65% threshold. As has been commented, when doing so, we consider as potential alternative suppliers those other countries that are actually exporting such 16 SRM to the EU. This baseline scenario is the one that can be more easily implemented with the time line considered by the EC (2030), since it do not imply searching for a completely new provider, something that might cause additional effects related to changes in prices, quality, degree of standardization of the product, low level of substitutability with the one provided by the main supplier, etc.
- **Scenario B (Alternative)**: in this scenario, we reduce the official threshold from 65% to 50%. By lowering this threshold, the number of HS6 products showing excessive dependence increases to 61 and the 16 SRM categories.

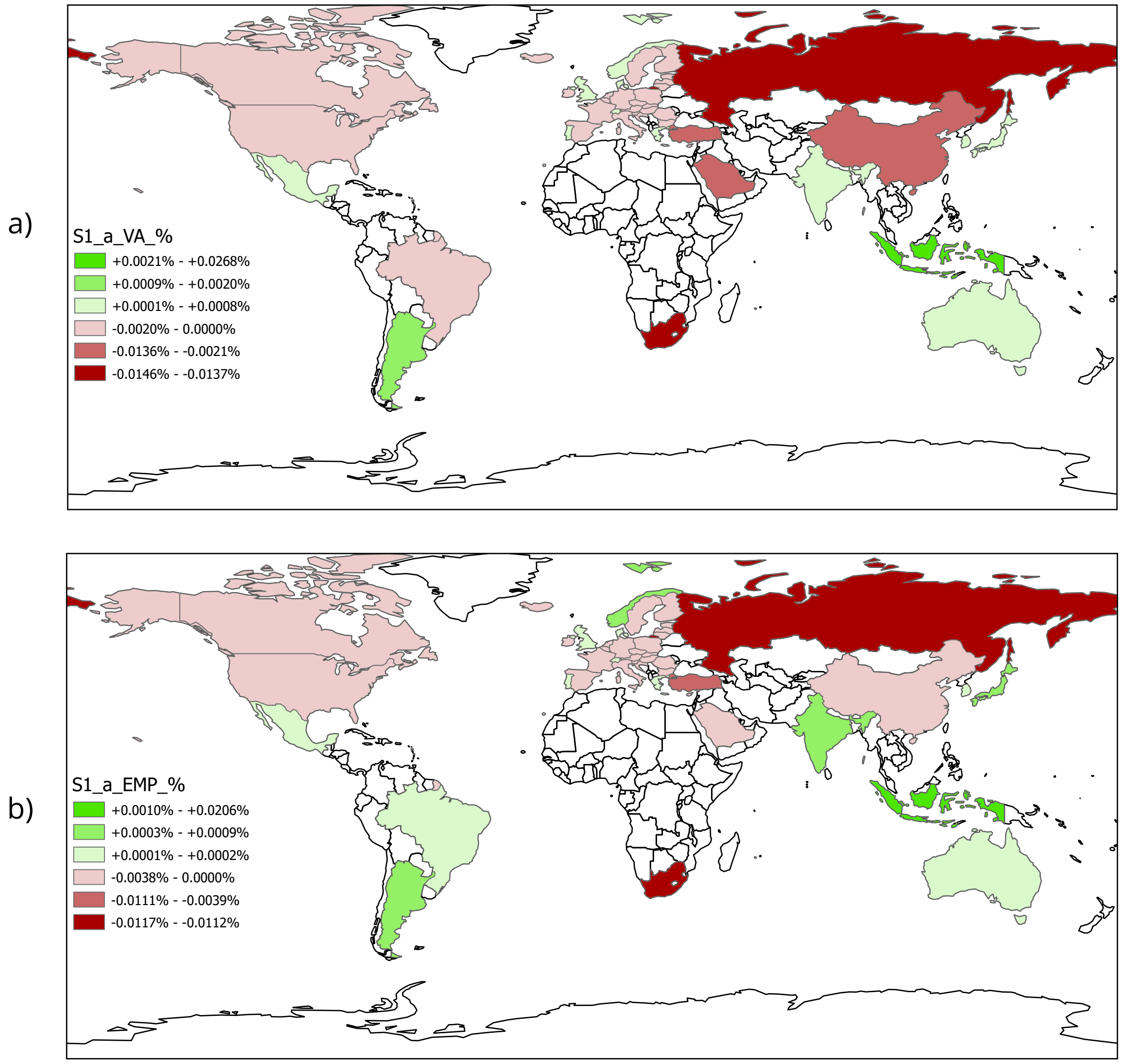
In this report, we interpret the 'spirit of the OSA and the ECRMA' rather than the EC's technical methodology. In cases where Russia or China are not the main suppliers, we do not consider these two countries as potential new providers, but as potential alternative providers.

Additionally, this type of analysis can be expanded by considering alternative cases, such as increasing the number of potential providers or filtering this list based on the trustworthiness (friendship) of the relationship with the EU in the present and future years. In this regard, one option would be to expand the scope of potential alternative suppliers to include not just those currently exporting 16 SRM to the EU, but all potential providers worldwide. This alternative scenario could incur additional costs due to the need to establish new supply channels and make additional investments in infrastructure, such as transportation networks, logistics interconnections and platforms. It could also lead to more disruptive changes resulting from competition with third countries, such as competing with the US and other hub countries that depend heavily on the same products. Similarly, it could be worthwhile excluding certain 'friendly' countries from the list of 'excessive' suppliers of certain products (e.g. Canada, Norway, Turkey), or narrowing the list of potential alternative suppliers to avoid countries that could cause more problems than the current excessive supplier.

3.2.1 Country results

Figure 5 shows two world maps displaying the total effects of the simulation for **Scenario A (baseline)**, which considers the official threshold used by the EC (65%). The results obtained based on EUREGIO-2017 are reported in panels a) and b), in terms of Gross Value Added (GDP) and employment, respectively. In general, the effects are extremely low for all countries, including those most affected by the process of detachment from the EU (e.g. China and Russia). The results in both panels are similar in that all the impacts concentrate on extraction and energy sectors and their subsequent transformation processes. These are sectors where employment intensity is considerably lower than in the services sector. Focusing on country heterogeneity, it is evident that the largest negative impacts arise in countries identified in Tables 3 and 4 as excessive suppliers, considering the prudent threshold of 65%. China, Russia and South Africa, but also Turkey, Canada, the USA and Norway. Conversely, the countries with the largest positive impacts are those identified as potential alternative suppliers who are already exporting each of the 16 SRMs to the EU27, such as Indonesia, Brazil, India, Mexico and Australia.

Figure 5. Baseline: world effect of a shift in the EU provision of SRM. Threshold: 65%



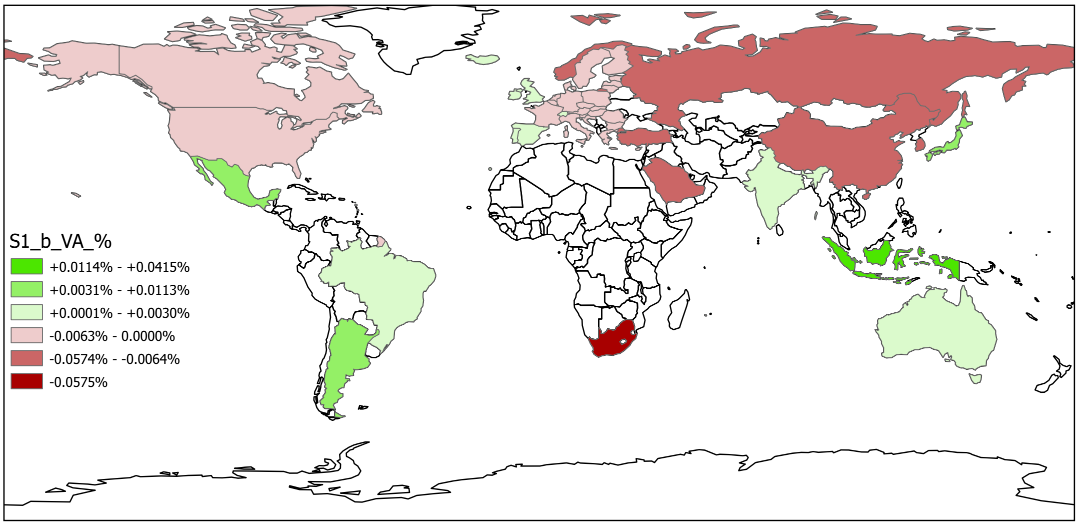
Source: Own elaboration.

Additionally, **Figure 6** shows two world maps displaying the total effects of **Scenario B (alternative)**, which considers a lower threshold of 50%. The results obtained also correspond to the impacts in terms of VA (Panel

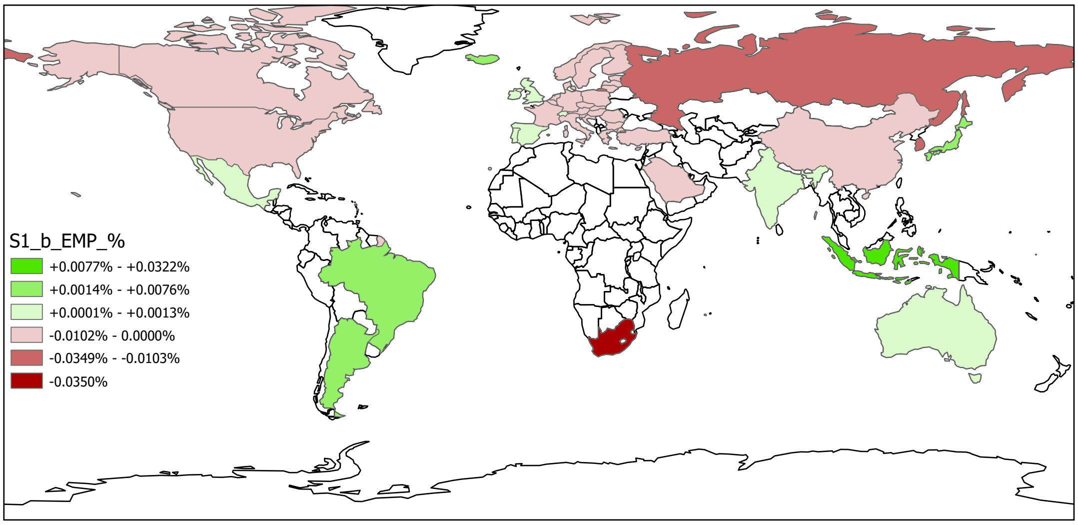
A) and employment (Panel B), as calculated using the EUREGIO 2017 model. As expected, the impacts remain very low and the territorial heterogeneity is very similar to that considered in the baseline scenario: negative impacts still concentrate in China, Russia, South Africa, Turkey, Canada, the USA and Norway, while positive effects concentrate in Indonesia, Brazil, India, Mexico, Australia, etc.

Figure 6. Alternative: world effect of a shift in the EU provision of SRM. Threshold: 50%

a)



b)



Source: Own elaboration.

3.2.2 Regional results

This section focuses on the regional results within Europe, considering the 297 NUTS 2 regions included in EUREGIO-2017. As with the previous world maps, the following maps consider the impacts for the baseline scenario (**Figure 7**), taking into account VA (Panel A) and employment (Panel B), as well as the alternative scenario (**Figure 8**), with the threshold lowered to 50% for each of the 16 SRMs.

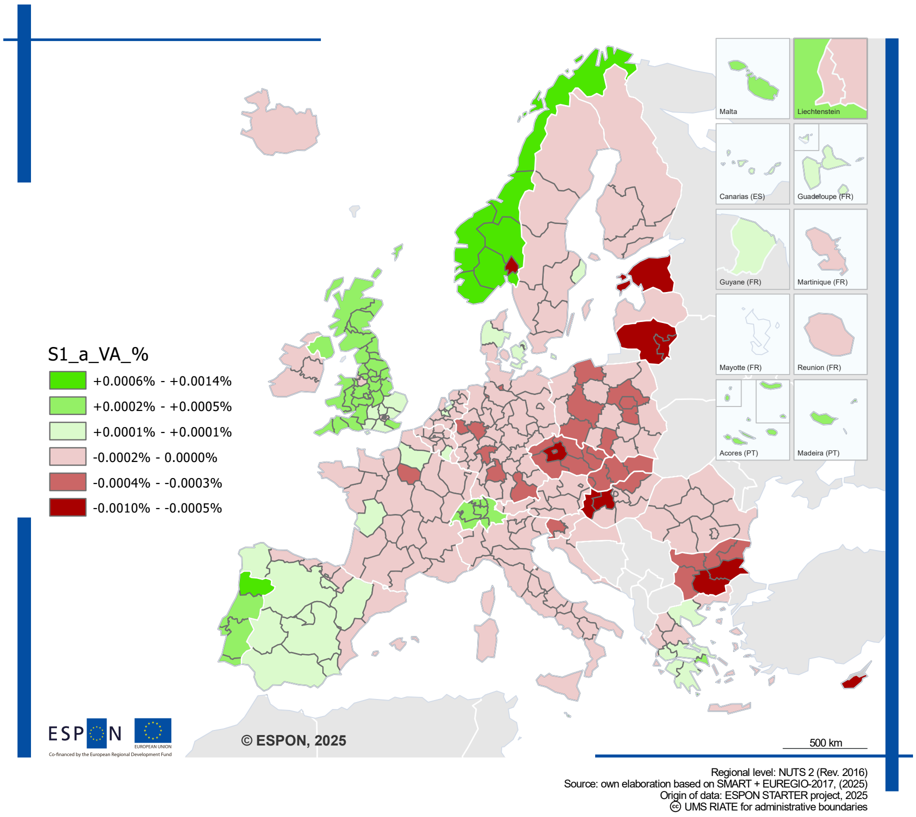
In all cases, the impacts remain within a very low percentage range for both positive and negative impacts. Focusing on the results in **Figure 7**, it is interesting to distinguish between countries in which most regions have positive impacts (the UK, Norway and Portugal) and those in which negative territorial impacts dominate. Then, in countries such as Spain, Greece and France, some regions have positive effects while others have negative ones. To better understand this heterogeneity, it is important to consider that substituting the current main suppliers with new suppliers will slightly alter the current distribution of world growth and trade. Thus, small variations in GDP and employment performance are expected in each European country and region, depending on their sectoral and geographical linkages with the former and new suppliers. The resulting effects will be a combination of factors, such as the presence of manufacturing industries that import 16 strategic raw materials (SRM), which are dependent to varying degrees on participation in global value chains (GVCs) involving these SRMs. It is therefore logical that countries and regions with stronger links to countries reducing exports to the EU (e.g. China, Russia and Turkey) will experience more negative effects (e.g. Eastern and Central European countries), while those with stronger links to potential new suppliers (e.g. Brazil, Indonesia and India) may see an expansion in economic activity.

Figure 7 shows that the effects on GDP (VA) and employment are very similar.

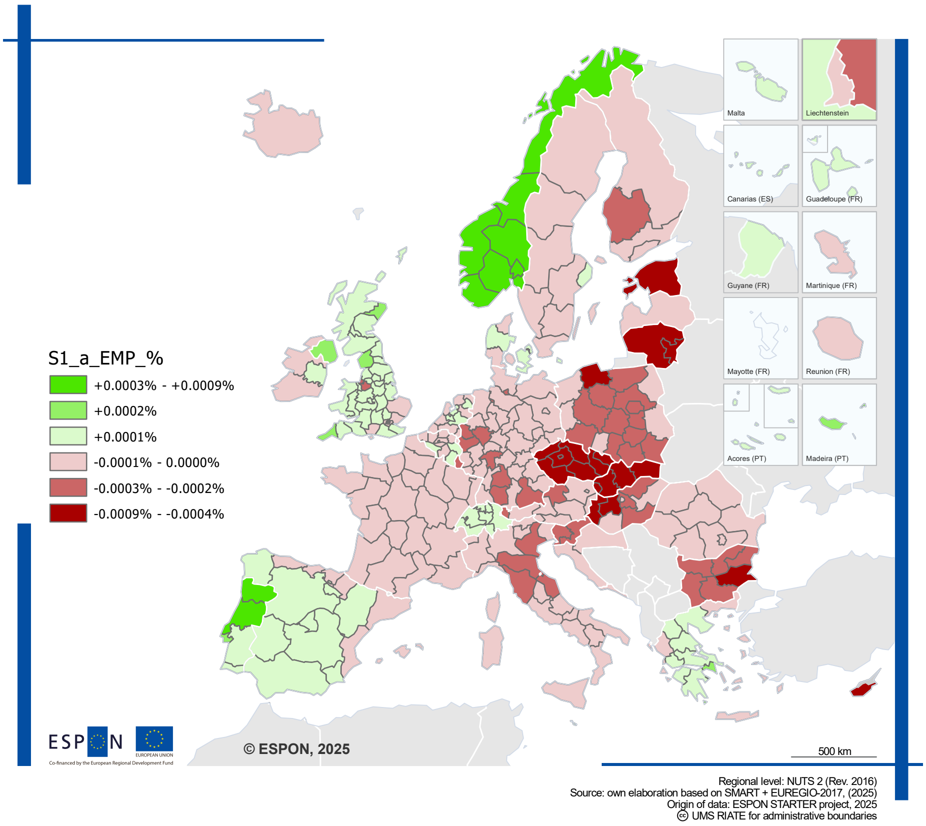
Similarly, when we focus on the results obtained in Scenario B (Alternative), mapped in **Figure 8**, they are very similar to those just discussed in relation to the baseline.

Figure 7. Baseline: the regional impact of de-risking. Threshold: 65%

a)



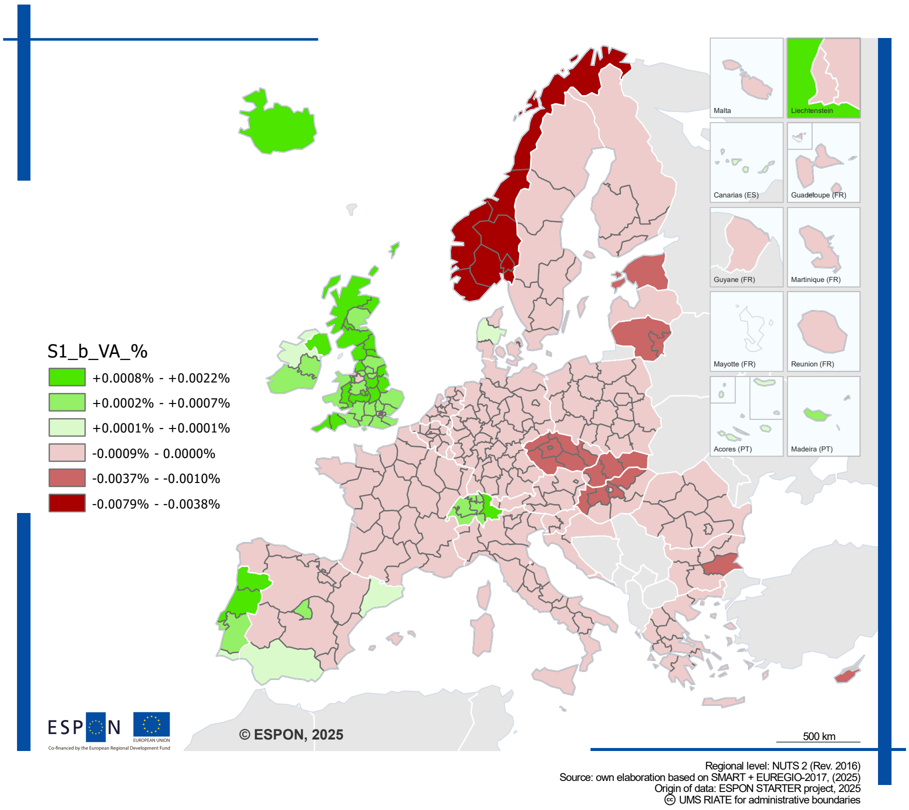
b)



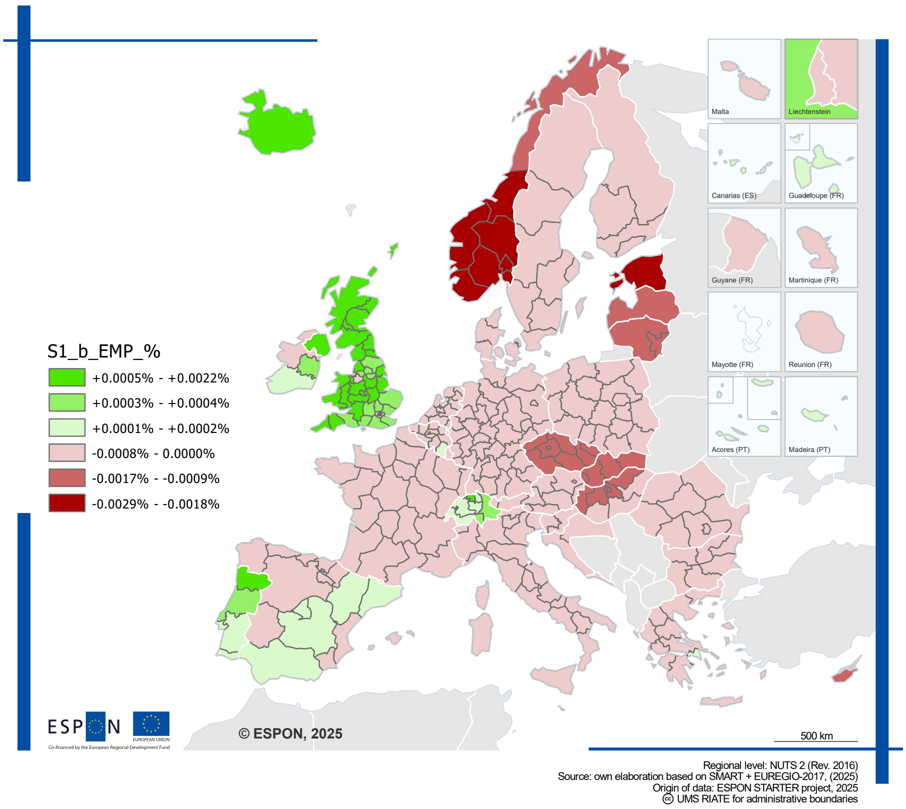
Source: Own elaboration.

Figure 8. Alternative: the regional impact of de-risking. Threshold: 50%

a)



b)



Source: Own elaboration.

4 Policy implications

This section aims to derive different sets of policy implications from the above analysis. Some will be linked to the technical aspects of the analysis and the methodology suggested by the EC, while others will focus more on the effective management of this complex de-risking process.

4.1 Methodological implications

- The EC's efforts to compile a list of SRM are notable and necessary. The efforts of other related institutions (DG Growth, DG Trade, JRC, etc.) to shed light on the complex connections between these key raw materials and the most relevant industries for the economic and social development of our society in the coming years are also outstanding. Having a closed list of products, thresholds and timelines is obviously the first step towards a planned derisking process involving several stakeholders: national governments, regions, cities, firms, households, etc.
- The analysis conducted here revealed the complexity of applying this strategy to real data, identifying the various channels of impact and mapping the potential sectoral and regional effects. Such complexity could interfere with the effectiveness of actions and the ways in which stakeholders should motivate and mobilise their peers in the desired direction without misunderstandings or misinterpretations. Derisking should not be used as an excuse for protectionism; a reasonable degree of efficiency, territorial cohesion and individual equality should be reconciled with the national security aspect.
- In our view, the thresholds and timelines should be flexible. As we have illustrated in this report, simply defining the affected products and including/excluding different stages of transformation (extraction, transformation, final consumption, etc.) will result in a different diagnosis of dependency and a different list of countries from which the EU might want to reduce its risk exposure.
- Moreover, the diagnosis and the list of countries will vary depending on whether an aggregate or product-specific approach is adopted. In this regard, if the analysis and the resulting policies consider the entire SRM aggregate, including all stages (extraction, intermediate and final), the list of countries from which the EU should derisk will differ from that obtained by conducting the analysis on a case-by-case basis. For some specific SRMs, there are excessive providers that appear on the list of potential alternative suppliers for other SRMs. This occurs with Russia and China, as well as with Norway and Turkey.
- It is also important to consider that identifying potential alternative suppliers is not straightforward. In this report, we have taken a cautious approach, attempting to identify alternative suppliers from countries that are already supplying the same item to another European country. This is based on the assumption that the transition process would be faster and the effort required to substitute sources would be less costly. To support this assumption, the current report should be enriched with additional industry input capable of addressing the degree of standardisation and substitutability of each SRM in detail, given the current needs and capacities of each transport and industrial activity.

4.2 Economic policy implications

The EU's recent initiative to address geoeconomic shocks and supply chain disruptions by securing access to critical raw materials is a welcome and necessary step. Free trade and support for a rules-based open economy are embedded in the EU’s DNA. However, in an era of intensified great power competition, it would be irresponsible to rely solely on market forces to guarantee access to the strategic components essential for accelerating the green and digital transitions. These transitions are crucial for the EU, which is currently lagging behind in the Fourth Industrial Revolution and urgently needs to decarbonise in order to enhance its energy security, especially in light of Russia’s invasion of Ukraine.

Nevertheless, in light of the geopolitical shifts that have occurred on the global stage since the publication of ECRMA, which have rendered the United States a far less cooperative partner, the EU could reconsider its strategy for accessing critical raw materials. The results of this report suggest various avenues for proceeding.

- **Redirecting market forces:** The current situation of dependency is the result of market forces and the individual decisions of firms, mainly taken in the context of free-market conditions. With a few exceptions, the distribution of market shares for each SRM stems from the interaction of supply and demand in liberalised markets. Obviously, the presence of imperfect competition in the supply and demand for most of these products has resulted in high levels of dependency on a small number of suppliers. Production concentration is driven by natural resources, but also by historical decisions to specialise economically in order to increase efficiency and welfare. China's strategic dominance in mining and refining many of these products has also played a role. In most European countries, mining activity has been abandoned in favour of imports from countries with lower labour costs and less restrictive welfare, environmental, labour and living conditions regulations. Adding the dimensions of resilience and security (autonomy) to the efficiency-equality dilemma may require policy action. Although market forces are, in principle, capable of internalising the costs of supply disruptions and national insecurity, these processes would be faster and clearer if coordinated and enhanced by national governments and the EC. Additionally, EU member states should consider investing in the mining and processing of specific raw materials, provided they are available and do not have dramatic environmental impacts that EU citizens are unwilling to accept.
- **Defining new mechanisms:** Although this report aligns with the European Commission’s strategy for reducing the risk in the supply of strategic raw materials (SRMs), as set out in the EU Critical Raw Materials Act (ECRMA), it is unclear whether the instruments and measures to be implemented by the Commission and member states will be effective in achieving these objectives. As discussed, market forces may continue to favour concentration, since the main countries supplying SRMs have lower prices, reduced extraction and transformation costs, lower environmental standards and stable, efficient supply channels. Changing trade relations based on free decisions is not easy and requires mechanisms that can incentivise that change at reasonable cost. In this regard, the EC and member states could define and implement a combination of incentives that are compatible with European values and commitments to the WTO. In some cases, sanctions could also be on the table, as has been the case with Russia. To some extent, the lack of resilience and high concentration of supply of a given SRM from a problematic source country could be seen as an externality justifying political intervention. Similarly to how the EU aims to avoid carbon leakage and preserve the level playing field in the EU single market by taxing imports of certain products generated using highly polluting technologies through the CBAM, Europe could use trade quotas or import tariffs to reduce excessive imports of specific SRMs from problematic sources. The recent sanctions imposed by the EU on the Russian oil and gas industry can be seen as an example. Another option could be to define public subsidies or tax incentives for firms that promote this process by substituting suppliers. Furthermore, it is important to note that imports of these SRMs are concentrated among a small number of firms, which are typically associated with energy and industrial clusters. These firms interact closely with national and territorial governments since their activities are highly regulated (e.g. energy, mining, logistics, transportation, defence and telecommunications). In this regard, the 'public procurement' schemes applied at all levels within the European space might offer a salient means of promoting the import diversification envisaged in the EC-RMA.
- **Rethinking supply benchmarks and revising the 65% rule:** As discussed, if the EC's methodology is applied too strictly, it may produce undesirable outcomes. Not all excessive suppliers are the same. The 65% threshold should be considered a benchmark for a rigorous process definition. However, more qualitative dimensions should be included to define an effective strategy. In some cases, concentration is not necessarily dangerous; it should at least be considered an adequate option if potential alternative suppliers are less stable, reliable or aligned with European values. Furthermore, improving trade relations with other countries could facilitate the formation of a strategic alliance that transcends the scope of the ECRMA. This could involve reinforcing interconnections with Canada, Australia, South Africa, Indonesia, the Mercosur countries (especially Brazil), Japan, India and Turkey, for example.
- **An extended globally cooperative European approach to the ECRMA, aimed to maximize the impact and avoid free-riding:** Undoubtedly, both the OSA and the ECRMA are security-related concepts. Therefore, it would be preferable if the European Commission could mobilise all potential partner countries in Europe and beyond, rather than limiting the agreement to the EU27. As we have recently seen in the context of the resurgence of NATO and the adoption of sanctions against Russia, it is crucial to work with countries such as the UK, Switzerland, Iceland and Norway, as well as like-minded advanced countries outside Europe. This analysis shows that Norway and the UK are potential new suppliers of several SRMs, as are Canada and South Korea. Applying the OSA and the ECRMA without these countries could lead to undesirable side effects and restrict the traction capacity of policies. Free-riding should be avoided by establishing

corresponding mechanisms to promote collaboration and joint efforts. The ultimate goal would be to establish a club of like-minded, wealthy liberal democracies that could leverage their market and geopolitical power to negotiate more favourable agreements with countries such as China. Even the US could potentially be part of this club.

- **Multi-scale approach**: Although the interplay between EU institutions and national governments is the most relevant dimension, derisking should be viewed as a multi-scale process requiring collaboration between regional institutions, cities, firms, and households. In several European countries, important competences directly related to the extraction, transformation and distribution (logistics) of the domestic and imported SRM are run by sub-national governments or city halls. A lack of coordination in the regulation and management of these stages could hinder the effective deployment of the entire process. This is particularly important in areas such as energy, transportation, labour markets, water, the environment and waste management.
- **Cohesion and transitions**: Another relevant conclusion of this analysis is that the territorial and sectoral effects of this derisking process may be uneven, creating initial winners and losers depending on the interplay of various factors, such as the geographical characteristics of each country and region, and the existing sectoral and interregional linkages with countries from which we need to derisk, as well as those that may increase their export shares to the EU. As with other transitions, European and national institutions should pay attention to the territorial consequences of this process and allocate the necessary resources to ensure it is compatible with other goals, such as overall efficiency and desired territorial cohesion.
- **Going beyond trade: expanding production and recycling**: An important limitation of this report is its focus on the trade aspects of the OSA and the ECRMA. At least two significant dimensions, namely the need to expand production and recycling, have been deliberately overlooked. Nevertheless, it is clear that the ECRMA and the expected degree of economic autonomy would be unattainable if Europe did not address these two critical stages of the derisking process. In some cases, Europe's lagging position is imposed by geography and factor endowments. In these cases, little can be done to launch new extraction and refining sites, so the focus should be on stockpiling and recycling. In other cases, however, mining activity has been abandoned due to a lack of competition or social interest. Higher labour costs, a lack of labour supply for tough jobs, and stringent environmental regulations have forced the abandonment of ancient extraction activities in several locations within our territories. The resumption of activity at these sites is an option being revisited by different governments, but this also faces significant opposition from sectors such as agriculture and tourism.
- **Need for a holistic approach, which includes goods, services, labour, capital and technology**: The resurgence of these activities within European territory is also linked to the need for an appropriate labour supply willing to undertake jobs that, in many cases, are associated with dangerous tasks and unhealthy living conditions. As in other sectors, such as agriculture, fishing, construction and defence, appropriate coverage of this scarce job supply is linked to the inflow of migrants from less developed countries — a dimension that is also facing significant social and political opposition in Europe. Furthermore, potential disruptions to the supply of raw materials extend beyond trade agreements; issues may arise from an attempt to weaponise economic interdependence by the true owners (companies or countries) of the assets involved in producing and managing a specific raw material within the global value chain. For example, as shown in Table 3, the EU27 should aim to reduce imports of 'manganese' from the Russian Federation and China by increasing imports from Turkey, South Africa, Egypt and Indonesia. However, it is important to understand that the extraction sites producing and exporting manganese in some of these new suppliers may be partially or wholly owned by actors from third countries that are not friendly towards the EU. The same can be said about the ownership of transportation networks (i.e. ships and ports) involved in deliveries, as well as the technological ties supporting extraction and transportation activities in some of these new suppliers in Africa, Asia, and Latin America. These comments are consistent with the difficulty of determining the extent to which Russia has evaded EU sanctions on the import of oil and gas by re-channeling flows through third parties. This is also associated with current debates raised by the US administration regarding hidden Chinese dominance of certain transport corridors, such as those in Greenland, the Panama Canal, and other relevant transportation hubs worldwide. Thus, the derisking process described in this report should be accompanied by a holistic approach based on diplomacy and economic intelligence. This approach could establish desirable economic, political and financial interconnections with potential new players, equivalent to those already deployed by competing countries such as the US or China. The aim is not to foster a new kind of colonialism, but to foster collaboration and synergy within stable, reciprocal frameworks.

In line with these previous lines of action, it is interesting to consider some ongoing initiatives such as:

- **The Action Plan on Critical Raw Materials** aims to: i) develop resilient value chains for EU industrial ecosystems; ii) reduce dependency on primary critical raw materials by promoting the circular use of resources, sustainable products and innovation; iii) strengthen the EU's domestic sourcing of raw materials;niv) diversify sourcing from third countries and eliminate distortions to international trade while fully respecting the EU's international obligations.
- **The European Raw Materials Alliance (ERMA,** https://erma.eu/) was launched in September 2020 as part of the Critical Raw Materials Action Plan. The aim of such an alliance is to ensure reliable, secure and sustainable access to raw materials by involving all relevant stakeholders, including industrial actors along the value chain, Member States and regions, trade unions, civil society, research and technology organisations, investors and NGOs. Currently, ERMA offers a unique network of over 350 companies, 100 associations, 70 universities and research organisations, as well as several financial institutions, national authorities, ministries and NGOs in Europe and beyond. ERMA also facilitates consultation processes to pre-align with public stakeholders on preliminary investment themes and cases, creating buy-in and identifying critical bottlenecks such as regulations, permits and operating licences. Furthermore, the Raw Materials Investment Platform (RMIP) ensures high investment success rates. Various financing sources (grants, equity, loans and mixed funding) are involved in this process, with different investment volumes and structures.
- Another line of action expressly considered by the EC is related to the **"reduction of the administrative burden"**, streamlining permitting procedures for critical raw materials projects in the EU, while ensuring high levels of social and environmental protection are maintained. To facilitate this, critical raw materials projects, including strategic projects, can engage with a **'single point of contact' in each EU country** that is responsible for coordinating the permitting process. Additionally, selected strategic projects will benefit from support for accessing finance and shorter permitting timeframes (27 months for extraction permits and 15 months for processing and recycling permits). EU countries will also be required to develop national programmes for exploring geological resources.
- In addition, the current EU regulation aimed at promoting the ECRMA will consider the following additional regulatory action mechanisms: 1) **Speeding up** the implementation of projects labelled as **'urgent'**, related to dispute resolution procedures, litigation, appeals and judicial remedies relating to project authorisation and permit-granting procedures; 2) **Monitoring and providing the European Commission with the required information** every two years regarding "strategic projects", including specific information on how they are progressing with the project's implementation, reasons for any delays, and how they intend to remedy this situation and finance the project. 3) **Promoting strategic projects** and providing them with privileged access to a system connecting potential buyers of strategic raw materials. (4) **Providing financial support to 'strategic projects'**, which may be eligible for EU funds if the relevant requirements are met. Relevant funds include the Cohesion Policy, the European Regional Development Fund, the Innovation Fund, InvestEU, the Just Transition Fund and the Recovery and Resilience Mechanism (particularly its RE-PowerEU chapter). Furthermore, the European Commission will adopt measures to attract private investment for strategic projects. This mobilisation of resources will also involve seeking support from the **European Investment Bank Group** or other international financial institutions.
- Moreover, EU countries could introduce measures to enhance the collection of waste rich in critical raw materials and ensure that it is recycled into secondary critical raw materials. EU countries and private operators must investigate the potential for recovering critical raw materials from extractive waste. To encourage the large-scale recycling of permanent magnets, the Act establishes requirements relating to recyclability and recycled content. The Act empowers the Commission to establish rules regarding the environmental footprint of critical raw materials, subject to various safeguards. This will increase the circularity and sustainability of critical raw materials placed on the EU market and allow customers to make informed choices about products containing critical raw materials.
- The European Commission is seeking to include the use of trade agreements to secure and diversify trade in critical raw materials, expand the EU's network of strategic partnerships with a value chain approach and strong sustainability dimension, and deploy projects along the raw materials value chain using the Global Gateway for soft and hard infrastructure. The Commission is also working with EU countries to set up an EU export credit facility to lower the risk of investment abroad, tackle unfair trade practices related to raw materials, and increase enforcement. **This aspect will receive the most attention in Scenarios 2, 3 and 4 of Task 1 of the ESPON-STARTER project.**

5 Conclusions

The ESPON STARTER project examines the regional implications of scenarios linked to Open Strategic Autonomy (OSA), focusing on strategic raw materials as defined in the EU Critical Raw Materials Act (ECRMA). This report presents the analysis conducted under Scenario 1 of Task 1, which examines the territorial impact of replacing supply sources for the sixteen strategic raw materials identified as priorities in the ECRMA. The aim is to reduce external dependence and enhance supply chain resilience, in line with guidance from the European Commission.

Recent disruptions, from the outbreak of the SARS-CoV-2 virus and the war in Ukraine to the intensification of US–China rivalry and the election of Donald Trump as US president, have prompted the EU to rethink its approach to globalisation and focus on different aspects of economic security and resilience. These priorities are now reflected in a variety of EU strategies and regulations that emphasise themes such as OSA, de-risking and supply chain diversification.

In this context, the ECRMA has set quantitative targets to secure access to the strategic materials that are vital for Europe's green and digital transitions. The ECRMA has set ambitious targets to secure the supply of sixteen strategic minerals crucial for the EU's industrial, technological, energy and military capabilities, which are essential for achieving strategic autonomy. In order to reduce dependence on countries that dominate the import of critical raw materials, the EU is seeking new trading partners. Diversifying suppliers decreases reliance on current partners and enhances economic security against unexpected economic, geopolitical, or regulatory shocks. This report proceeds in three stages. First, a Product-Level Analysis is conducted to identify significant changes, risks, and opportunities using key metrics from the ECRMA, including Economic Importance (EI), Import Substitutability Indicators (SUBS), Scarcity Measures (SCARCE), and Herfindahl–Hirschman Indices (HHI). Second, a Regional Analysis is performed using the EUREGIO-2017 dataset to simulate the territorial impact of substituting the critical inputs identified.

The country-product analysis concluded with a table identifying the actual excessive suppliers of each of the 16 SRMs, considering two alternative thresholds: the official threshold of 65%, as defined by the EC; and an alternative threshold of 50%, which was used to check the robustness of the results. Next, we defined the percentage of imports from excessive countries that should be substituted by potential suppliers, all of whom export these SRM to the EU. Using the EUREGIO-2017 input-output table, we simulated the impact of this transformation on the current trade pattern to obtain national and sub-national impacts measured in terms of value added, employment and CO_2 emissions.

In general, the effects are extremely low for all countries, including those most affected by the process of detachment from the EU (i.e. China and Russia). As expected, the countries that will reduce their GDP and employment the most are China and Russia, but other relevant countries such as South Africa, Turkey, Canada, the USA and Norway will also reduce their exports to the EU. Conversely, the countries with the most positive impacts are those identified as potential alternative suppliers who are already exporting each of the 16 SRMs to the EU27, such as Indonesia, Brazil, India, Mexico and Australia. It is important to note that these low effects are compatible with other analyses conducted by different authors, who have modelled the impact of sudden supply disruptions for these inputs. In our case, the simulation corresponds to a smooth transition towards de-risking, assuming maximum substitutability between different suppliers of the same HS6 code. This assumes no changes in terms of prices or requirements regarding industrial or transport infrastructure.

In terms of the regional layer of the analysis, our focus is on the 297 NUTS 2 regions that are part of EUREGIO-2017. In all cases, the impact percentages remain very low, for both positive and negative impacts. Some countries, such as the UK, Norway and Portugal, have regions that all obtain positive impacts, while most others have slightly negative impacts. Some countries, such as Spain, Greece and France, have regions with both positive and negative effects. This heterogeneity can be explained by the current sectoral and regional interconnection of these regions with the main current and potential suppliers.

The final section of the report makes several recommendations for policymakers. It emphasises that the European Commission's initiative to define a list of strategic raw materials (SRMs), supported by efforts from DG GROW, DG TRADE and the JRC, represents a critical step towards a coordinated de-risking strategy. However, we highlight the methodological complexities of implementing such a strategy using real-world data and simulations. Key challenges include defining relevant products and stages of transformation, selecting appropriate thresholds and timelines, and interpreting dependencies at aggregate and product-specific levels. These choices have a significant impact on which countries are identified as overly dominant suppliers. Our analysis also shows that, depending on the material, some countries may appear simultaneously as excessive current providers and potential alternative sources. Although we take a cautious, data-driven approach to identifying existing intra-EU trade flows as potential substitution pathways, further sector-specific validation is required. In particular, input from industry stakeholders is essential in order to assess the technical feasibility and economic cost of transitioning supply chains. Ultimately, de-risking should not be equated with protectionism; rather, it must be pursued in a manner that is consistent with economic efficiency, territorial cohesion and fairness.

In terms of specific policy recommendations, this report highlights the challenges involved in aligning Europe's supply of strategic raw materials (SRMs) with the EU's open strategic autonomy (OSA) and critical raw materials act (CRMA). Current dependencies largely stem from decisions made by firms in liberalised markets and historical patterns of specialisation, which are often influenced by cost advantages, regulatory leniency and natural resources in non-EU countries. Addressing these dependencies requires a shift in focus from efficiency alone to incorporate resilience, security, and cohesion. While market forces may eventually internalise the risks of excessive concentration, coordinated policy intervention through incentives, trade instruments, public procurement, and industrial strategy will be essential to accelerating the de-risking process. Crucially, this effort must avoid veering into protectionism, instead fostering a collaborative approach among EU institutions, member states, and key democratic partners such as the UK, Norway, Canada, and Japan. Furthermore, redefining rigid benchmarks such as the 65% rule should enable strategic flexibility based on geopolitical alignment and supply chain realities. A multi-scale governance model involving not just national governments, but also regional authorities, cities and industrial clusters — many of which are deeply embedded in the regulation and logistics of SRM flows — is vital. Given the uneven territorial and sectoral impacts of de-risking, European institutions must ensure that the transition aligns with cohesion objectives and just transition principles.

Finally, while this report has focused on trade dimensions, achieving long-term strategic autonomy also requires the revitalisation of domestic production and recycling capacities, the addressing of labour shortages, and the enhancement of economic intelligence in order to understand the ownership and control of global supply networks. An effective de-risking strategy must be holistic, diplomatic and cooperative — one that aligns economic policy with the broader values of resilience, sustainability and democratic reciprocity.

6 References

Almazán-Gómez, M. Á., Llano, C., Pérez, J., & Mandras, G. (2023): The European regions in the global value chains: New results with new data. Papers in Regional Science, 102(6), 1097–1126. https://doi.org/10.1111/pirs.12760

Almazán-Gómez, M. Á., El Khatabi, F., Llano, C., & Pérez, J. (2024): Modelling regional exposure to new trade wars. Working paper. Submitted to Journal of Policy Modeling.

Arjona, R., Connell, W., Herghelegiu, C. (2023): An enhanced methodology to monitor the EU's strategic dependencies and vulnerabilities, Single Market Economics Papers WP2023/14, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (European Commission), Chief Economist Team.

Attinasi, M. G., L. Boeckelmann, Meunier, B. (2023): The economic costs of supply chain decoupling. (No. 2839). ECB Working Paper.

Baldwin, R. (2025), 'The Great Trade Hack: How Trump's trade war fails and global trade moves on', CEPR Press, Paris & London. https://cepr.org/publications/books-and-reports/great-trade-hack-how-trumps-trade-war-fails-and-global-trade-moves

Baldwin, R., Freeman, R., & Theodorakopoulos, A. (2023): Hidden exposure: measuring US supply chain reliance (No. w31820). National Bureau of Economic Research.

Bailey, D., de Ruyter, A., Hearne, D. and Ortega-Argilés, R. (2023): Shocks, resilience and regional industry policy: Brexit and the automotive sector in the two Midlands regions. Regional Studies, 57(6), 1141-1155

Baqaee, D., Farhi, E. (2023): Networks, Barriers, and Trade, Econometrica, forthcoming.

Borin, A., Cariola, G., Gentili, E., Linarello, A., Mancini, M., Padellini, T., ... & Sette, E. (2023): Inputs in geopolitical distress: a risk assessment based on micro data (No. 819). Bank of Italy, Economic Research and International Relations Area.

Bradley, M., L. H. Baldwin, P. Deluca, N. Henriquez Sanchez, M. Hvizda, C. D. Smith, N. P. (2023): Whitehead, Supply chain interdependence and geopolitical vulnerability, The case of Taiwan and high-end semiconductors, RAND Corporation Research Report.

Burrell, A., Ferrari, E., Mellado, A. G., Himics, M., Michalek, J., Shrestha, S., & Van Doorslaer, B. (2011): Potential EU-Mercosur free trade agreement: impact assessment. JRC Reference Report. Available online at http://ipts. jrc. ec. europa. eu/publications/pub. cfm.

Cancian, M. (2023): The First Battle of the Next War Wargaming a Chinese Invasion of Taiwan. CSIS Report. https://www.csis.org/analysis/first-battle-next-war-wargaming-chinese-invasion-taiwan

Chepeliev, M., Maliszewska, M., Osorio-Rodarte, I., Pereira, S. E., Filipa, M., & van der Mensbrugghe, D. (2022): Pandemic Climate Mitigation, and Reshoring: Impacts of a Changing Global Economy on Trade, Incomes, and Poverty (No. 9955). The World Bank.

Conte, M., Cotterlaz, P., Mayer, Th. (2022): The CEPII Gravity database. CEPII Working Paper N°2022-05, July 2022.

Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M. P., & de Vries, G. (2013): The construction of world input–output tables in the WIOD project. Economic Systems Research, 25(1), 71–98. https://doi.org/10.1080/09535314.2012.761180

Dietzenbacher, E., van Burken, B., & Kondo, Y. (2019): Hypothetical extractions from a global perspective. Economic Systems Research, 31(4), 505–519. https://doi.org/10.1080/09535314.2018.1564135

Dür, A. (2007). EU trade policy as protection for exporters: The agreements with Mexico and Chile. JCMS: Journal of Common Market Studies, 45(4), 833-855.

Egger, P., Larch, M. (2011): An assessment of the European agreements´ effects on bilateral trade, GDP and welfare, European Economic Review, 55(2), 263-279.E.I.U. Risk Outlook 2024. October 2023. The Economist.

Eppinger, P., G. J. Felbermayr, O. Krebs, And B. Kukharskyy (2021): Decoupling Global Value Chains, CESifo Working Paper, SSRN: https://ssrn.com/abstract=3848341 or http://dx.doi.org/10.2139/ssrn.3848341.

Erixon F., Guinea O., Lamprecht P., Sharma V., Zilli R, (2022): The New Wave of Defensive Trade Policy Measures in the European Union: Design, Structure, and Trade Effects, ECIPE policy brief. available at https://ecipe.org/publications/new-wave-of-defensive-trade-policy-measures-in-eu/

European Commission (2020): Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Blengini, G. A., El Latunussa, C., Eynard, U., Torres De Matos, C. et al., *Study on the EU's list of critical raw materials (2020) – Final report*, Publications Office of the European Union, 2020

European Commission (2023): RMIS – Raw Materials Information System. https://rmis.jrc.ec.europa.eu/eu-critical-raw-materials

European Commission (2021): Strategic dependencies and capacities, Commission Staff Working Document, 352.

European Commission (2021): Trade Policy Review – An Open, Sustainable and Assertive Trade Policy. 18 February. Available at: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_645.

Felbermayr, G., Mahlkow, H., Sandkamp, A. (2023): Cutting through the value chain: The long-run effects of decoupling the East from the West, Empirica, 50, 75–108.

Firgo, M., Gabelberger, F., Reinstaller, A., Wolfmayr, Y. (2024): Assessing Regional Production Potential to Strengthen the Security of Supply in Strategic Products (January 16, 2024). Available at SSRN: https://ssrn.com/abstract=4700122 or http://dx.doi.org/10.2139/ssrn.4700122

Gaalya Micah S. (2015): Uganda's Trade and Revenue Effects with the EAC Countries, DRC and Sudan. Modern Economy, 2015, 6, 338-357

Giammetti, R., L. Papi, D. Teobaldelli, Ticchi, D. (2021): The Network Effect of Deglobalisation on European Regions, SSRN: https://ssrn.com/abstract=3988744 or http://dx.doi.org/10.2139/ssrn.3988744.

Global Policy 2023 Special Issue: EU Trade Policy: Challenges to its Strategic Autonomy. Global Policy, 14: 1-4. https://doi.org/10.1111/1758-5899.13253.

Góes, C., & Bekkers, E. (2022): The impact of geopolitical conflicts on trade, growth, and innovation. arXiv preprint arXiv:2203.12173. World Trade Organization, Staff Working Paper.

Guinea, O., Sharma, V. (2023): European Economic Security and Access to Critical Raw Materials: Trade, Diversification, and the Role of Mercosur. ECIPE policy brief, available at https://ecipe.org/publications/trade-diversification-the-role-of-mercosur/ .

Georgitzikis, K. (2023). Trade codes of non-food, non-fuel raw materials and their products.

Ioannou, D., Pérez, J. J., Balteanu, I., Kataryniuk, I., Geeroms, H., Vansteenkiste, I., ... & Tylko-Tylczynska, K. P. (2023): The EU's Open Strategic Autonomy from a central banking perspective. Challenges to the monetary policy landscape from a changing geopolitical environment (No. 311). European Central Bank.

Javorcik, B. S., Kitzmüller, L., Schweiger, H., & Yildirim, M. A. (2023): Economic Costs of Friend-Shoring (No. 10869). CESifo Working Paper.

Jean, S., Mulder, N., & Ramos, M. P. (2014): A general equilibrium, ex-post evaluation of the EU–Chile Free Trade Agreement. Economic Modelling, 41, 33-45.

Kabir, M., Salim, R. (2011): Analysing Potential Effects of Preferential Liberalisation in Some Asian Emerging Economies. International Economic Journal, 25, 2, 191–213

Khorana, S., Perdikis, N. (2010): EU-India Free Trade Agreement: deal or no deal?. South Asia Economic Journal, 11(2), 181-206.

Lenzen, M., Moran, D., Kanemoto, K., & Geschke, A. (2013): Building EORA: a global multi-region input–output database at high country and sector resolution. Economic Systems Research, 25(1), 20–49. https://doi.org/10.1080/09535314.2013.769938

Leontief, W. (1941): The structure of American economy 1919-1929: An empirical application of equilibrium analysis. Cambridge, Massachusetts. Harvard University Press.

Lim, B., J. Yoo, K. Hong, Cheong, I. (2021): Impacts of Reverse Global Value Chain (GVC) Factors on Global Trade and Energy Market, Energies, 14.

Merciai, S., & Schmidt, J. (2018): Methodology for the Construction of Global Multi-Regional Hybrid Supply and Use Tables for the EXIOBASE v3 Database. Journal of Industrial Ecology, 22(3), 516–531. https://doi.org/10.1111/jiec.12713

Miller, R.E., Blair, P.D., 2009. Input–Output Analysis: Foundations and Extensions, 2nd ed. Cambridge University Press, Cambridge.

Munemo J. (2013): Trade between China and South Africa: Prospects of a Successful SACU-China Free Trade Agreement. African Development Review, Vol. 25, No. 3, 2013, 303–329.

OECD - Organisation for Economic Co-operation and Development (2023a): OECD Recommendations on Regional Development Policy. OECD, Paris

Politico (2025): “EU leaders try to out-bully Trump, floating world trade club without US” June, 27 https://www.politico.eu/article/eu-leaders-donald-trump-us-trade-tariffs-ursula-von-der-leyen/

Remond-Tiendrez, I., Rueda-Cantuche, J. M. (2019): EU inter-country supply, use and input-output tables — Full international and global accounts for research in input-output analysis (FIGARO). In Statistical Working Papers (EUROSTAT). https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2019.pdf

Roy, A., Mathur, S. K. (2016): Brexit and India–EU free trade agreement. Journal of Economic Integration, 740-773.

Scott Lavery (2023): Rebuilding the fortress? Europe in a changing world economy, Review of International Political Economy, DOI: 10.1080/09692290.2023.2211281

Stadler, K., Wood, R., Bulavskaya, T., Södersten, C.-J., Simas, M., Schmidt, S., Usubiaga, A., Acosta-Fernández, J., Kuenen, J., Bruckner, M., Giljum, S., Lutter, S., Merciai, S., Schmidt, J. H., Theurl, M. C., Plutzar, C., Kastner, T., Eisenmenger, N., Erb, K.-H., … Tukker, A. (2018). EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables. Journal of Industrial Ecology, 22(3), 502–515. https://doi.org/10.1111/jiec.12715

Su, C. H. (2018): Regulatory network calibration in the EU-Korea free trade agreement. European Foreign Affairs Review, 23(1).

Thissen, M., Ivanova, O., Mandras, G., Husby, T., 2019. European NUTS 2 regions: construction of interregional trade-linked Supply and Use tables with consistent transport flows (No. JRC115439). Seville.

Thissen, M., Lankhuizen, M., van Oort, F., Los, B., Diodato, D., 2018. EUREGIO: The Construction of a Global IO Database With Regional Detail for Europe for 2000–2010. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3285818

Thissen, M., Oort, F. Van, Diodato, D., 2013. Integration and Convergence in Regional Europe: European Regional Trade Flows from 2000 to 2010.

Tian, W., Yu, M. (2014): Measuring the Impact of Trade Protection on Industrial Production Size. Review of Development Economics, 18(2), 231–253. DOI:10.1111/rode.12081

Timini, J., & Viani, F. (2020): The EU-MERCOSUR free trade agreement: main features and economic impact. Banco de Espana Article, 8, 20.

Timini, J., Viani, F. (2021): A highway across the Atlantic? Trade and welfare effects of the EU-Mercosur agreement, International Economics, 169, 291-308 https://doi.org/10.1016/j.inteco.2022.02.003

Tocci, N. (2021): European strategic autonomy: What it is, why we need it, how to achieve it. IAI. Retrieved on December 2021, from https://www.iai.it/sites/default/files/9788893681780.pdf

Tukker, A., & Dietzenbacher, E. (2013): Global multiregional input–output frameworks: an introduction and outlook. Economic Systems Research, 25(1), 1–19. https://doi.org/10.1080/09535314.2012.761179

Wigger, A. (2023): The new EU industrial policy and deepening structural asymmetries. JCMS: Journal of Common Market Studies, 61(1), 20–37. https://doi.org/10.1111/jcms.13366

Wood, R., Stadler, K., Bulavskaya, T., Lutter, S., Giljum, S., de Koning, A., Kuenen, J., Schütz, H., Acosta-Fernández, J., Usubiaga, A., Simas, M., Ivanova, O., Weinzettel, J., Schmidt, J., Merciai, S., Tukker, A. (2014): Global Sustainability Accounting—Developing EXIOBASE for Multi-Regional Footprint Analysis. Sustainability, 7(1), 138–163. https://doi.org/10.3390/su7010138

7 Annex

The selection of products analysed in this report is based on the JRC document on Trade Codes for the Raw Materials Information System for the 16 strategic products (Georgitzikis, K. 2023). In that document, products were identified using the 8-digit Combined Nomenclature for 2023. For the present work, their equivalence with the 6-digit Harmonized System classification of 2007 has been sought. Some 6-digit categories may therefore encompass different SRM categories (also occurs with the 8-digit classification, as show in the original document) or different stages.

Table 4. Products HS6 included in the analysis

HS6 (2007)	STAGE Extraction /Mining	STAGE Intermediate /Final	Sector (64)	Strategic products included in HS6 product
250410	1		B	Graphite
250490	1		B	Graphite
250610	1		B	Silicon
250620	1		B	Silicon
251810	1		B	Magnesium
252890	1		B	Boron
253090	1		B	Lithium; Manganese; Rare Earth Elements
260200	1		B	Manganese
260300	1		B	Copper
260400	1		B	Nickel
260500	1		B	Cobalt
260600	1		B	Gallium
260700	1	1	B	Bismuth; Copper
260800	1	1	B	Copper; Germanium
260900	1		B	Bismuth
261100	1		B	Tungsten
261400	1		B	Titanium
261610		1	B	Copper
261690	1	1	B	Copper; Platinum
261790	1		B	Bismuth; Germanium
261900		1	E37_39	Manganese
262019		1	E37_39	Copper
262029	1	1	E37_39	Bismuth; Copper
262030		1	E37_39	Copper
262099	1		E37_39	Bismuth; Nickel; Tungsten
280450		1	C20	Boron
280461		1	C20	Silicon
280469		1	C20	Silicon
280519		1	C20	Lithium
280530		1	C20	Rare Earth Elements
281000		1	C20	Boron
281210		1	C20	Silicon
281290		1	C20	Boron

281390		1	C20	Silicon
282010		1	C20	Manganese
282090		1	C20	Manganese
282200		1	C20	Cobalt
282520		1	C20	Lithium
282540	1	1	C20	Cobalt; Nickel
282550		1	C20	Copper
282560		1	C20	Germanium
282590		1	C20	Bismuth; Gallium; Tungsten
282619		1	C20	Lithium; Tungsten
282690		1	C20	Boron; Copper; Germanium; Lithium
282735		1	C20	Nickel
282739		1	C20	Cobalt; Copper; Gallium; Germanium; Lithium; Manganese; Tungsten
282741		1	C20	Copper
282749		1	C20	Bismuth
282759		1	C20	Lithium
282990		1	C20	Lithium
283090	1	1	C20	Cobalt; Copper; Nickel
283324		1	C20	Nickel
283325		1	C20	Copper
283329		1	C20	Cobalt; Manganese
283330		1	C20	Manganese
283429		1	C20	Bismuth; Cobalt; Copper; Nickel
283691		1	C20	Lithium
283699		1	C20	Bismuth; Cobalt
283719		1	C20	Copper; Nickel
284011		1	C20	Boron
284019		1	C20	Boron
284020		1	C20	Boron
284030		1	C20	Boron
284161		1	C20	Manganese
284169		1	C20	Manganese
284180		1	C20	Tungsten
284190		1	C20	Bismuth; Cobalt; Germanium; Lithium
284290		1	C20	Bismuth; Copper; Gallium; Germanium; Lithium
284310		1	C20	Platinum
284390		1	C20	Platinum
284610		1	C20	Rare Earth Elements
284690		1	C20	Rare Earth Elements
284800		1	C20	Cobalt; Copper; Gallium; Germanium; Manganese; Nickel; Silicon
284920		1	C20	Silicon
284990		1	C20	Boron; Manganese; Tungsten
285000		1	C20	Boron; Gallium; Germanium; Manganese; Silicon; Tungsten
291529		1	C20	Cobalt

291711		1	C20	Cobalt
293100		1	C20	Boron; Gallium; Magnesium; Manganese; Silicon
310490	1		C20	Magnesium
360690		1	C31_32	Rare Earth Elements
380120		1	C23	Graphite
380190		1	C23	Graphite
381590		1	C20	Germanium; Rare Earth Elements; Tungsten
381800		1	C20	Germanium
382430		1	C20	Graphite; Tungsten
382490	1	1	C20	Lithium; Nickel; Platinum; Rare Earth Elements; Tungsten
400520		1	C22	Graphite
400591		1	C22	Graphite
400599		1	C22	Graphite
681389		1	C23	Graphite
711011		1	C24	Platinum
711019		1	C24	Platinum
711230		1	E37-39	Platinum
711292		1	E37-39	Platinum
720150		1	C24	Manganese; Nickel
720211		1	C24	Manganese
720219		1	C24	Manganese
720230		1	C24	Manganese
720260		1	C24	Nickel
720280		1	C24	Tungsten
720291		1	C24	Titanium
720299		1	C24	Boron; Rare Earth Elements
720421		1	E37-39	Nickel
721810		1	C24	Nickel
721891		1	C24	Nickel
721899		1	C24	Nickel
740100		1	C24	Copper
740200		1	C24	Copper
740311		1	C24	Copper
740312		1	C24	Copper
740313		1	C24	Copper
740319		1	C24	Copper
740321		1	C24	Copper
740322		1	C24	Copper
740329		1	C24	Copper; Nickel
740400		1	E37-39	Copper
740500		1	C24	Copper
740610		1	C24	Copper
740620		1	C24	Copper
740710		1	C24	Copper
740721		1	C24	Copper

740729		1	C24	Copper
740811		1	C24	Copper
740819		1	C24	Copper
740821		1	C24	Copper
740822		1	C24	Copper; Nickel
740829		1	C24	Copper
740911		1	C24	Copper
740919		1	C24	Copper
740921		1	C24	Copper
740929		1	C24	Copper
740931		1	C24	Copper
740939		1	C24	Copper
740940		1	C24	Copper; Nickel
740990		1	C24	Copper
741011		1	C24	Copper
741012		1	C24	Copper
741021		1	C24	Copper
741022		1	C24	Copper
741110		1	C24	Copper
741121		1	C24	Copper
741122		1	C24	Copper; Nickel
741129		1	C24	Copper
741210		1	C24	Copper
741220		1	C24	Copper
750110	1	1	C24	Cobalt; Nickel
750120	1		C24	Nickel
750210		1	C24	Nickel
750220		1	C24	Nickel
750300		1	E37-39	Nickel
750400		1	C24	Nickel
750511		1	C24	Nickel
750512		1	C24	Nickel
750521		1	C24	Nickel
750522		1	C24	Nickel
750610		1	C24	Nickel
750620		1	C24	Nickel
750711		1	C24	Nickel
750712		1	C24	Nickel
750720		1	C24	Nickel
780199		1	C24	Bismuth
810110		1	C24	Tungsten
810194		1	C24	Tungsten
810196		1	C24	Tungsten
810197		1	E37-39	Tungsten
810199		1	C24	Tungsten

810411		1	C24	Magnesium
810419		1	C24	Magnesium
810420		1	E37-39	Magnesium
810430		1	C24	Magnesium
810490		1	C24	Magnesium
810520		1	C24	Cobalt
810530		1	E37-39	Cobalt
810590		1	C24	Cobalt; Nickel; Tungsten
810600		1	C24	Bismuth
810820		1	C24	Titanium
810830		1	E37-39	Titanium
810890		1	C24	Titanium
811100		1	C24	Manganese
811221		1	C24	Nickel
811292		1	C24	Gallium; Germanium
811299		1	C24	Gallium; Germanium
854810		1	E37-39	Cobalt; Lithium; Manganese; Graphite; Nickel

ESPON

Co-funded by the European Union
Interreg

espon.eu

ESPON 2030

ESPON EGTC
11 Avenue John F. Kennedy
L-1855 Luxembourg
Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: info@espon.eu
www.espon.eu

The ESPON EGTC is the Single Beneficiary of the ESPON 2030 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway, and Switzerland.