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Article

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Intereconomics

Suggested Citation: Connell Garcia, William; Ho, Victor (2025) : External Vulnerability Index: A Tool to Assess Trade Weaknesses, Intereconomics, ISSN 1613-964X, Sciendo, Warsaw, Vol. 60, Iss. 1, pp. 40-45,
<https://doi.org/10.2478/ie-2025-0008>

This Version is available at:

<https://hdl.handle.net/10419/314841>

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William Connell Garcia and Victor Ho

External Vulnerability Index: A Tool to Assess Trade Weaknesses

International supply chains have become increasingly important to policymakers, academics and business leaders over the last five decades due to their capacity to improve efficiency gains. Indeed, companies have fragmented production across multiple locations worldwide to reduce costs, achieve economies of scale, mitigate risks and gain access to foreign inputs, enabled by greater capital mobility, technological advancements in logistics and telecommunications, and a global shift towards trade liberalisation. The EU's trade openness and its role as a promoter of fair global trade (see Figure 1) highlight the critical importance of well-functioning international markets and supply chains to ensure its sustainable economic growth and resilience. However, recent events such as the COVID-19 pandemic and geopolitical tensions have undermined the previously optimistic outlook on some sensitive global supply chains, leading to concerns about vulnerabilities and dependencies.

The European Commission responded to this evolving landscape originally by publishing a new trade strategy and updating its industrial strategy in 2021. These policy documents aimed at enhancing the transition towards a more resilient and globally competitive EU economy. The adoption of an Open Strategic Autonomy approach by the European Commission has raised awareness of concepts such as “exposure”, “excessive dependencies”, and “strategic autonomy” within sensitive economic sectors. Public policy responses have emphasised the need to consider risks and dependencies in critical areas. The EU has experienced further supply challenges stem-

ming from Russian military aggression in Ukraine, the Israel-Hamas-Hezbollah conflict, and trade weaponisation strategies from countries like China and Russia. As a result, de-risking and economic security have become central to the EU's strategy. Reducing dependencies and enhancing security have been identified as key transformational imperatives to boost EU competitiveness in the Draghi Report (2024). These priorities also feature prominently in the Competitive Compass (2025), which outlines flagship measures to translate this vision into action.

Countries all over the world have started addressing challenges to their economic security¹ and for this reason, it is important to understand recent patterns in international trade. Recent research has pointed to signs of trade fragmentation including Blanga-Gubbay and Rubínová (2023) who argue that since the Russian military aggression against Ukraine in 2022, trade has exhibited a growing fragmentation along geopolitical lines, suggesting the emergence of friendshoring. Along the same lines, Gopinath et al. (2024) emphasise the significant decline in economic linkages among countries belonging to distant geopolitical groups, especially since Russia's invasion of Ukraine. Freund et al. (2023) and Alfaro and Chor (2023) investigate the dynamics of US supply chains as a result of the US-China trade tensions and observe a reallocation of US imports from China to certain low-wage countries, like Mexico and Vietnam. Nevertheless, they highlight that these nations appear to maintain strong economic ties with China, underscoring the enduring indirect exposure of the US to the Chinese market. For the EU, Arjona et al. (2024) highlight that the EU has shown an important reduction in imports from non-agreement partners, such as Russia and China, and an increased reliance on neighbouring and distant agreement partners (see Figure 2).

The global trading environment and recent EU political initiatives highlight the need for enhanced resilience and adaptability. Consequently, it is important to develop data-driven approaches to continue identifying and monitoring EU vulnerabilities compared to its main trading partners. By tracking vulnerabilities, policymakers can develop timely, agile and responsive strategies, and navigate the complexities of a rapidly changing global market.

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Open Access funding provided by ZBW – Leibniz Information Centre for Economics.

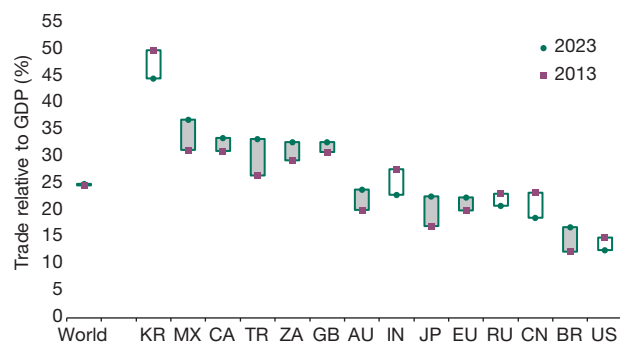
The opinions expressed in this paper are the authors' alone and do not reflect those of the European Commission. The authors are grateful to Román Arjona, Josefina Monteagudo, Cristina Hergehelegiu, Nicolas Listl and Andreas Reuter for the useful comments on previous versions. Any opinion or error is entirely the authors' responsibility.

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¹ See, for instance, the analysis by Global Trade Alert, which monitors public policies that affect global trade.

Figure 1
Trade in goods and services over GDP for major trading entities in 2013 and 2023



Notes: The ratio of the average value of exports and imports of goods and services to GDP is considered. The world excludes intra-EU trade and refers to 2022 instead of 2023. The EU figures exclude intra-EU trade.

Sources: Eurostat, International Monetary Fund (Balance of Payments and International Investment Position Statistics) and the World Bank.

This paper proposes a monitoring tool based on trade data that would allow for the identification and measurement of external trade vulnerabilities. This monitoring tool should also enable comparisons over time and across the EU's major global trading partners, providing a dynamic perspective on evolving trends of foreign vulnerabilities. To this end, the External Vulnerability Index (EXVI) has been developed. The EXVI is a composite indicator that assesses the external vulnerability of traded products within a region, spanning various sectors and supply chains. It quantifies economic vulnerabilities to external shocks by analysing a region's trade dependencies and trade competitive positions. High scores, with a maximum of 1, signal a high risk of foreign vulnerability, while low scores, with a minimum of 0, indicate a lower risk of external vulnerability.²

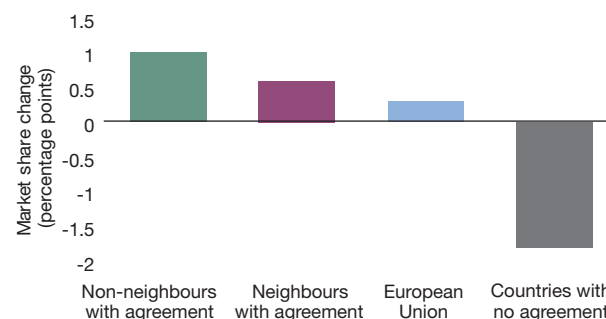
Building the EXVI

Pillar 1: Risks related to foreign dependencies

The first pillar is composed of two indicators, which aim at measuring the concentration of trade flows and the degree to which a country relies on imports relative to its exports. By doing so, it provides insights into an economy's exposure to external risks, such as supply chain disruptions or the emergence of new trade barriers. Economies that rely excessively on foreign inputs, which at the same time are highly concentrated on a limited number of trading partners, are more vulnerable to external shocks.

² Other papers looking at the EU's foreign dependencies include: Arjona et al. (2023), Jaravel and Méjean (2021), Reiter and Stehrer (2021).

Figure 2
Changes in the EU market shares across trading groups for all products from 2021 to 2023



Notes: The classification of countries is based on information on the various trade cooperation agreements of the EU. These include countries with trade agreements that may be in place or provisionally applied, as well as those countries that recently signed Raw Material Partnerships or signatories of the recent 2022 Joint Statement on Cooperation on Global Supply Chains. Besides the UK and EFTA countries, EU neighbours are identified based on information regarding European Neighbourhood Policy and Enlargement.

Source: Arjona et al. (2024).

The first indicator used in this pillar is the Herfindahl-Hirschman Index (HHI). This aims at measuring the level of diversification of imports by analysing the diversity of trade partners for the country's imports. A high HHI indicates a higher dependency on fewer countries, making the economy more vulnerable to external shocks. The first indicator for country i and product k in year t is calculated as follows:

$$HHI_{i,t}^k = \sum_{j=1}^N s_{j,t}^2 \quad (1)$$

where $s_{j,t}^2$ is the share of imports from the trading partner j in the total imports of country i for product k . A HHI closer to 1 indicates a higher concentration of imports, while a HHI close to 0 indicates more diversification of imports.

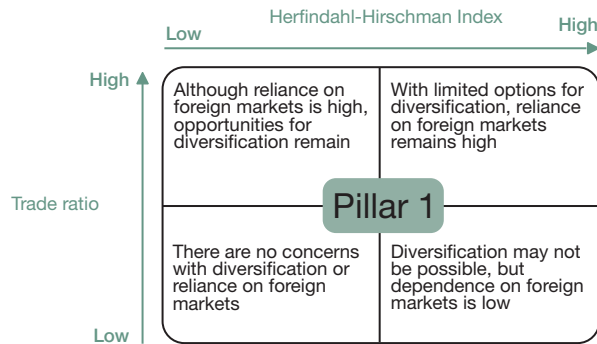
The second indicator used is the trade ratio (TR), which aims at showing the relative size of imports compared to exports for a given country. This ratio can be used to assess trade reliance in the economy. The second indicator for country i and product k in year t is calculated as follows:

$$TR_{i,t}^k = \frac{\text{Total imports}_{i,t}^k}{\text{Total exports}_{i,t}^k} \quad (2)$$

A ratio higher than 1 indicates that a country is running a trade deficit, whereas a ratio lower than 1 indicates that the economy is running a trade surplus.

Figure 3 illustrates the four quadrants into which products can be categorised, offering a simplified view of the coun-

Figure 3
Dependency risk



Source: Authors' own elaboration.

try's classification in terms of dependency risks for specific products. In this case, we are interested in identifying products with limited options for diversification, combined with a high reliance on foreign markets. In Figure 1, this situation is identified by the top-right corner scenario. Other options exist that highlight lower risks of foreign dependencies. For instance, the top-left quadrant identifies products with a high reliance on foreign markets but with a significant potential for diversification. The bottom-left quadrant indicates products with neither excess dependency concerns nor diversification issues. Meanwhile, the bottom-right quadrant highlights products with a low trade ratio, which makes them less risky despite the observed high concentration on a specific origin.

Pillar 2: Risks related to a weak global market position

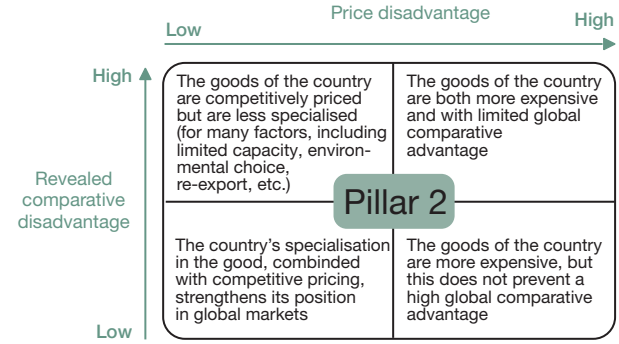
The second pillar evaluates the risks arising from a weak standing in global trade for each product traded. It focuses on two dimensions, namely the revealed comparative disadvantage and the price differences.

The first indicator of this pillar is the revealed comparative disadvantage (RCD), which aims at identifying products in which a country is less competitive relative to other countries. A higher value indicates a comparative disadvantage, implying that a country is less competitive globally in exporting that product. The RCD indicator is calculated by taking 1 minus the revealed comparative advantage (RCA) indicator, which measures what a country is "good at exporting" compared to the rest of the world. This indicator is calculated for each individual country i as follows:

$$1 - RCA_{i,t}^k = 1 - \frac{Exports_{i,t}^k / Exports_{i,t}}{Exports_{w,t}^k / Exports_{w,t}} \quad (3)$$

where k means product, w is world and t is year. In terms of interpretation, a lower value suggests a stronger export spe-

Figure 4
Global position risk



Source: Authors' own elaboration.

cialisation, whereas a higher value implies the product is relatively less important in the export structure of the country.

The second indicator is the price competitiveness index (PCI). This indicator measures the price competitiveness of the traded goods of a country relative to its imports. A higher ratio can indicate a price disadvantage, which is important when evaluating the vulnerability to foreign markets, as it affects the capacity of the country to reduce its foreign dependencies. It is important to highlight that a price disadvantage can also originate from a country producing higher quality products, which is not necessarily linked to a vulnerability. To understand the magnitude of the vulnerability, we need to combine it with the RCD indicator. This would enable us to identify products with higher risks of foreign vulnerabilities. The indicator for country i and product k in year t is calculated as follows:

$$PCI_{i,t}^k = \frac{\overline{P}_{i,t}^k (exports)}{\overline{P}_{i,t}^k (imports)} \quad (4)$$

where $\overline{P}_{i,t}^k$ is the average unit price. In terms of interpretation, $PCI_{i,t}^k > 1$ suggests an economy that exports higher prices than it imports, indicating in principle a price disadvantage.

Figure 4 provides the interplay between these two indicators, which are shown in a 2x2 matrix. The most vulnerable quadrant is once again the top right, where the country's goods are both more expensive than those of foreign competitors and are paired with a limited comparative advantage. All the other quadrants represent options characterised by relatively lower levels of vulnerability. The top-left quadrant represents goods that are competitively priced, but the country exhibits lower levels of specialisation. This may result from many factors such as limited production capacity, deliberate national policies prioritising safety or environmental considerations, or the nature of the goods being primarily re-exported. The bottom-left quadrant

shows a favourable situation where the country has a high degree of specialisation, and this is combined with competitive pricing. This combination of factors minimises the country's vulnerability. Finally, the bottom-right quadrant displays a situation in which the goods of the country are more expensive, but this does not prevent the country from achieving a high global comparative advantage. This may not necessarily indicate vulnerability, as it could instead reflect differences in the quality of goods produced.

Obtaining the product, sectoral and national level EXVI

To ensure a standardised analysis, the methodology addresses indicators that fall outside the 0 to 1 range. These indicators are adjusted using winsorisation at a 90% level, a statistical technique that minimises the influence of extreme outliers consequently, minimising the effect caused by anomalous data points. Winsorisation is done on all HS6 product categories combining all three regions (EU, US and China) in a specific year. After winsorisation, a min-max normalisation strategy is applied to rescale the data, standardising it to a common range between 0 and 1 to enable consistent comparisons across variables.

$$Indicator_{normalised} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

where X_{max} , X_{min} will be determined by the regions we would like to include in the analysis. Initially, we will start with the EU, as well as with its main trading partners, the US and China.

In order to aggregate the two indicators in the two pillars, the methodology employs a geometric mean. This method captures the multiplicative interaction between the two indicators, which is useful in this application, as we want to ensure that both indicators are important for the overall risk of vulnerability. In our quadrant, this is shown in the top-right corner. In other words, the geometric mean emphasises balance, suggesting that if either indicator within a pillar is low, the composite score of the pillar will be low.

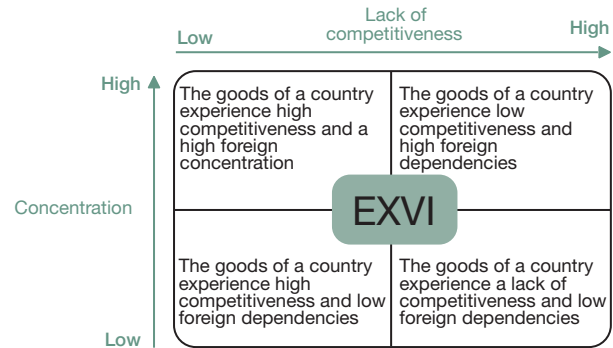
$$Pillar\ 1_{i,t}^k = (TR_{i,t}^{k^{w_1}} * HHI_{i,t}^{k^{w_2}})^{\frac{1}{(w_1 + w_2)}} \quad (5)$$

where $w_1 + w_2$ represent the relative importance of each indicator. This exercise assumes that both indicators are equally important, that is $w_1 = w_2 = 0.5$. The same approach is applied to the indicators in Pillar 2 and to the aggregation of the two pillars, resulting in the product-level EXVI.

$$EXVI_{i,t}^k = (Pillar\ 1_{i,t}^{k^{w_1}} * Pillar\ 2_{i,t}^{k^{w_2}})^{\frac{1}{(w_1 + w_2)}} \quad (6)$$

where again this exercise assumes that $w_1 = w_2 = 0.5$.

Figure 5
External Vulnerability Index



Source: Authors' own elaboration.

The final matrix is displayed in Figure 5. As before, the greatest risk of external vulnerability is observed in the top-right quadrant, where a country's goods face both risk factors, namely low competitiveness and high foreign dependency.

The calculation of the indicator using HS6-level products aggregated into broader baskets offers a practical framework for analysing vulnerabilities in strategic supply chains. This approach is particularly relevant for assessing supply chains targeted by major policy initiatives such as the Chips Act, the Net Zero Industry Act (NZIA), and the Critical Raw Materials Act (CRMA), which will be detailed in the next section. To align with these policies, we have selected a specific set of products within each of these supply chains, based on the assumption that all components are equally essential. Given the low substitutability of these products, a simple average is applied to derive the EXVI. Cross-country comparisons, especially between the EU, the US and China, provide valuable insights for policymakers, highlighting potential areas of strategic vulnerability and informing the design of more resilient supply chain strategies. Furthermore, differences in EXVI scores across countries could serve as an indicator of relative vulnerability to supply chain disruptions in relation to our main trading partners.

Empirical application using three sensitive supply chains

This section focuses on three areas prioritised by EU policymakers since the release of the EU's 2021 trade and industrial strategies.

The first area concerns raw materials, which are central to the functioning of several global supply chains. In April 2024, the

EU adopted the Critical Raw Materials Act,³ defining a list of critical raw materials (CRMs), which are considered important for the wider EU economy, and a list of strategic raw materials (SRMs), which are relevant in support of EU green, digital, defence and space applications and which present risks of dependencies. The focus on raw materials by policymakers is justified by their extensive range of applications and the rising global demand for some of these products such as aluminium, copper, silicon, nickel and manganese and the concentrated supply of many of these materials. Moreover, the Act aims, among other measures, to increase and diversify the EU's CRM supply, including by substituting strategic raw materials. Specially, it sets a benchmark for 2030, stipulating that no more than 65% of the EU's annual consumption of any given strategic raw material should originate from any single third country. In practical terms, the Act aims to reduce the risks associated with these products by strengthening global supply chains. It also seeks to continue to negotiate and implement Industrial Strategic Partnerships, as well as to develop sustainable trade and investment agreements.

A second sensitive area highlighted by EU policymakers refers to the supply chain of semiconductors.⁴ In mid-2023, the EU adopted the Chips Act, which aims at reducing the EU's vulnerabilities and dependencies on foreign actors. This is achieved by enhancing the EU's security of supply, resilience and technological sovereignty. As in the case of raw materials, microchips are pivotal for the manufacturing of current and future critical applications, including items related to work, education, entertainment, healthcare and mobility, among others. We map the supply chain of semiconductors in the EU based on the study conducted by Bonnet and Ciani (2023), who identify products spanning across different segments of the semiconductor value chain. Among these, we also include raw materials, with equal inputs for wafers, silicon wafers, foundry inputs, equipment, as well as final products.

The third sensitive area of products that we examine is the supply chain of technologies that play a central role in addressing climate change. As in previous sensitive areas, the market for these net-zero (NZ) technologies is set to triple by 2030. Recognising their significance, EU policymakers have designated them as critical technologies. On 16 March 2023, the Commission presented the Net-Zero Industry Act (NZIA) with the objective of building additional

3 Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.

4 Regulation (EU) 2023/1781 of the European Parliament and of the Council of 13 September 2023 establishing a framework of measures for strengthening Europe's semiconductor ecosystem and amending Regulation (EU) 2021/694 (Chips Act).

Table 1

Dependencies risk: Pillar 1 of the External Vulnerability Index across strategic supply chains

	Semiconductors	Net-zero technologies	Raw materials	All industrial products
EU	0.13	0.14	0.24	0.17
US	0.12	0.21	0.29	0.39
China	0.18	0.09	0.23	0.10

Note: EXVI scores: 0 = low vulnerability, 1 = high vulnerability.

Source: European Commission, based on the latest BACI database (2022).

Table 2

Global position risk: Pillar 2 of the External Vulnerability Index across strategic supply chains

	Semiconductors	Net-zero technologies	Raw materials	All industrial products
EU	0.39	0.29	0.41	0.35
US	0.35	0.39	0.43	0.39
China	0.21	0.18	0.35	0.23

Note: EXVI scores: 0 = low vulnerability, 1 = high vulnerability.

Source: European Commission, based on the latest BACI database (2022).

domestic manufacturing capacity within the EU.⁵ In particular, NZIA aims to achieve 40% of the production necessary to fulfil the EU's needs for strategic technology products by 2030. The NZ technologies covered in the paper include solar photovoltaics, wind turbines, batteries, heat pumps, electrolyzers and solar thermal technologies. In order to map CN products related to these technologies, we rely on final products and their first-tier components.

In order to calculate the pillars of the EXVI indicator, we will first identify HS6 products in each of the supply chains mentioned above. Using a simple average, which assumes that all the components are equally important, we obtain the two pillars explained above, which are summarised in Table 1 and Table 2. The final EXVI for each supply chain is obtained for the EU, US and China. The aggregated table with the EXVI for each sensitive supply chain and the aggregated industrial sector is shown in Table 3. Based on the latest BACI data, the obtained EXVIs show that the EU is more exposed to external trade vulnerabilities than China, but less so than the United States.

5 Proposal for a Regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act) COM/2023/161 final.

Table 3
External Vulnerability Index across strategic supply chains

	Semiconductors	Net-zero technologies	Raw materials	All industrial products
EU	0.22	0.18	0.28	0.22
US	0.19	0.26	0.32	0.28
China	0.17	0.10	0.24	0.13

Note: EXVI scores: 0 = low vulnerability, 1 = high vulnerability.

Source: European Commission, based on the latest BACI database (2022).

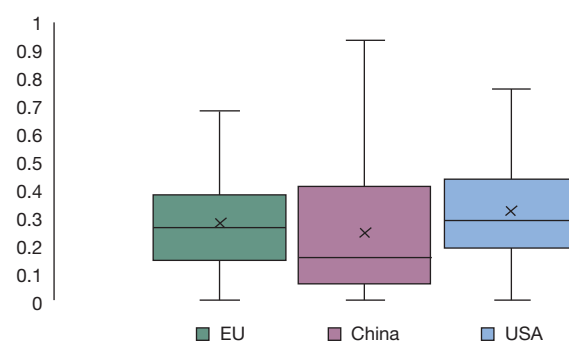
A closer examination of critical areas such as raw materials, semiconductors, and net-zero technologies reveals that the EU is most vulnerable in raw materials. Furthermore, the index shows that the EU is more vulnerable than China in all three supply chains, while it is more vulnerable than the United States only in semiconductors.

As previously highlighted, each EXVI number is composed of different product categories and for this reason, it is also necessary to look at the distribution of the product EXVIs. It is important to highlight that the vulnerability of a given supply chain is determined by its weakest spot. In other words, in the absence of a substitute, a critical component might affect the ability of an entire supply chain to produce. Figure 6 shows the distribution of the list of critical raw materials across the EU, China and the US. Among these regions, we observe that China has a lower aggregate EXVI value than the EU and the US. However, looking at individual products, we observe a low EXVI in some product categories (i.e. aluminium ores, boron, palladium, magnesium), while observing a high EXVI in some other raw materials (e.g. types of nickel, manganese, lithium carbonates, unrefined copper). Looking at the distribution, China has many more products with low EXVI compared to the EU and the US, but the 75th percentile of these products is higher than the EU. This means that although China has low vulnerability across a greater number of products, it also faces higher vulnerability in a larger range of products. In short, the distribution of the EU is more concentrated around the unweighted average than the distribution of China.

Conclusion

The increasing interconnectedness of global trade highlights the need for indicators to assess external vulnerabilities of regions in different products, sectors and supply chains. Accurately identifying and quantifying these vulnerabilities is essential for policymakers to design

Figure 6
Distribution of product External Vulnerability Indices within the raw materials list



Note: EXVI scores: 0 = low vulnerability, 1 = high vulnerability.

Source: European Commission, based on the latest BACI database (2022).

effective strategies that mitigate risks and enhance economic resilience. The EXIV provides a tool in this regard. By integrating key dimensions such as trade dependencies and global market positioning, the EXVI offers a framework to evaluate external risks across products, sectors and countries. As the global trade landscape continues to evolve, tools like the EXVI are useful for informed decision-making and long-term reduction in supply chain risks.

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