Measuring Vulnerability of European Imports: Evidence from a New Composite Index

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Abstract

The crises of recent years have unveiled the risk of vulnerability in global value chains and at the same time underscored the need for more resilient global value chains to address potential future disruptions. In this context, the paper introduces a new composite index to measure the vulnerability of imports using 15 different risk-related indicators across five dimensions: (geo-)political, economic, social, environmental and technological. Applying the new index to the European member states indicates that several countries have succeeded in reducing their vulnerability over the course of the last years. For other EU member states, notably in Germany, vulnerability has increased since the beginning of the COVID-19 pandemic. Especially the geopolitical dimension exhibits a sharp increase in most of the EU member states, whereas the economic dimension of the index shows encouraging results, Germany and Slovenia being notable exceptions due to the rising share of China in their imports. Most countries have profit in terms of import vulnerability from diversifying their import sources, especially by reducing the share of Russia in the course of the war in the Ukraine. The other three dimensions, environmental, social and technological, show mixed results. In terms of economic policy implications, the analysis highlights the need for careful evaluation of the impact of import vulnerability on economic development. Measuring import vulnerability, as introduced in this paper, represents the basis for the analysis of policy responses to enhance economic resilience.

Keywords: Global Value Chains; Vulnerability; Import Dependence, Resilience, Sustainability

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1. Introduction

In recent years, open economies have faced significant challenges as they need to cope with multiple – not rarely overlapping – crises that change the geopolitical landscape and endanger economic stability. Whereas in the past internationalization of global value chains (GVC) implied clear economic advantage in terms of efficiency gains, the COVID-19 pandemic and surging geopolitical tensions have highlighted risks to this process. It became evident that increasingly integrated or concentrated GVC might be too vulnerable, putting at risk economic and even national security (Gereffi, 2020). This growing recognition fuelled efforts to implement policy measures to foster economic resilience – both at the microeconomic (firm) level, the mesoeconomic (regional or supra-regional) level and the macroeconomic (national or supra-national, e.g. European) level. The risks associated with over-reliance on foreign suppliers were laid bare and led to a revival of industrial policy, aimed at enabling economies to cope better with vulnerabilities during crises. Furthermore, the complexity and unpredictability that such an intricate network of economic relationships covered by global value chains entails pose new challenges for globally active companies (Smorodiskaya, 2021). Accordingly, it is not sufficient to be selectively informed about own supply chains at the firm level. Instead, measuring and monitoring cluster risks – which emerge from economic decisions of multiple players and result in an overall risk for the economic stability of a country – is of major relevance (Acemoglu, 2012). Importantly, it requires bundled and coordinated efforts at industry, national and even supra-national level to provide proper policy responses and create a resilient business framework (Ciuriak et al., 2020).

There is a growing body of literature that contributes to measuring trade-related vulnerabilities. Many past efforts in this regard were aimed at constructing different measures of critical economic dependencies, especially regarding imports (European Commission, 2020 and 2022; Bonneau and Nakaa, 2020; Flach et al., 2022; Gehringer, 2023; Confindustria, 2023). The different measurement approaches are still in the process of development and are novel to the empirical research of international trade. The contribution of the studies analyzing critical dependencies is significant, as they represent a first attempt to highlight the risks associated with global value chains, especially in the aftermath of the interruptions due to the COVID-19 pandemic and in the context of the geopolitical tensions emerging in recent years. With a few exceptions, the analyses measure vulnerability in terms of concentration of imports and treat all supplying countries in a similar manner, independent of the challenges characterizing the broader economic, social and (geo)political system, the diplomatic relations with their trading partners, their exposure to natural disasters and other environmental risks, as well as their technological positioning.[3] Thus, the results are rather informative than conclusive, as they do not consider these various characteristics of the trading partners.

The aim of the present paper is to fill this gap by developing a novel composite index, Import Vulnerability Index (IVI), for the EU member states. Based on theoretical considerations from the literature on economic resilience as well as a discussion of terminology, the paper identifies five dimensions of potential exposure to risk and vulnerability of imports: (geo-)political, economic, social, environmental and technological.

[3] Rather than focusing on foreign trading partners as a homogenous sample, Gehringer (2023) analyses more specific trade dependences of the EU on China.

Along these dimensions, concrete indicators are used for weighing the import dependency on main supplying countries of each EU member state. The result is a comprehensive index which does not only measure – critical – concentration of imports along the global value chain but also takes into account the individual risk profile of the supplying countries that likely impact vulnerability situation of the importing countries.

The IVI is a novel attempt to develop a quantitative measurement of trade-related vulnerabilities. In this vein, it goes beyond the sole aspect of critical or strategic import dependencies that focus only on a specific element of import vulnerability. It also differs from the existing Trade Vulnerability Index (TVI) by Cotton et al. (2019). The latter was developed with a specific aim to offer an eligibility criterion for the special and differential treatment status of member countries at the World Trade Organization. It measures various internal risk factors – *internal vulnerability* – that determine country's structural and institutional vulnerability. Instead, our index aims at capturing *external vulnerability*, stemming from trade (import) relations with country's main trading partners.

The remainder of the paper is organized as follows: Section 2 sets the conceptual link between trade dependencies and vulnerability of GVC. Section 3 gives an overview of the theoretical literature on economic resilience and vulnerability, both at the macroeconomic level and with regard to global value chains. Section 4 presents the methodology applied for the construction of a composite index of vulnerability for global value chains of the European economies. Section 5 shows the results regarding the development of the index since the beginning of the COVID-19 pandemic for the major EU member states. In Section 6, concluding remarks and policy implications are discussed.

2. Critical trade dependencies and vulnerability

Conceptually, the term critical trade dependence is closely intertwined with the vulnerability of global value chains (GVCs), as high levels of dependence on specific trading partners or products can amplify the exposure of economies to external shocks and disruptions (European Commission, 2021; Mejean & Rousseaux, 2024; Pourshahabi et al., 2024).[4] When a country's production processes or consumption rely heavily on imports from a limited number of sources, disruptions in these trade flows can propagate through GVCs and undermine their capacity to resist.

The European Commission was among the pioneers setting this conceptual link, by mapping trade-related vulnerabilities based on critical (foreign) dependencies across the European value chains (European Commission, 2021). In its flagship document, the European Commission stressed the gains in terms of contained vulnerability that are due to open markets and integrated global value chains. At the same time, however, it highlighted the need for better understanding of strategic trade dependencies as a potential source of vulnerability of European value chain. In a bottom-up trade mapping exercise for more than 5,000 detailed product categories, the study identified 137 products – representing about 6 percent of the extra-EU import value of goods – with high

[4] The issue of import vulnerability is embedded in a broader context of trade vulnerability. This explains why the discussion in Sections 2 and 3 relates more broadly to trade vulnerability, rather than only import vulnerability.

dependency on third countries. The criteria applied for the identification of critical dependency were 1) concentration of EU imports from extra EU sources (measured by the Herfindahl-Hirschman Index, HHI), 2) importance of extra EU imports in overall imports (measured by the ratio of extra EU import value to total EU import value), and 3) substitutability of extra EU imports with EU production (measured by the ratio between extra EU import value and total export value of the EU). In a further step of the analysis, 34 products were considered especially vulnerable with low potential for further diversification and substitution with EU production. An update was published in 2022, emphasizing the progress made in addressing strategic dependencies as well as a second round of in-depth reviews covering new areas (European Commission, 2022).

The approach adopted by the European Commission was followed in analogous analyses in national and regional level reports. A study by Confindustria (2023) highlights the trade-off between trade openness and national autonomy and stresses the need to strengthen supply chains in areas related to the green and digital transition. Expanding the methodology by the European Commission (2021), the study identifies critical dependencies of EU countries based on geographical diversification of imports, substitutability with exports and substitutability within intra-area trade. According to these criteria, 8 percent of European imports from non-EU markets were classified as critical. For the Italian economy, vulnerabilities were identified for 16 percent of the import value – approximately in line with the results for Germany and France. However, Italian critical imports seem to be relatively diversified in terms of product origin, whereas German, French and EU imports as a whole are found to exhibit a clear predominance of China as the main supplier.

Bonneau and Nakaa (2020) investigate critical dependencies along the global value chains from the perspective of the French economy considering the concentration of imports of each product and the centrality of the product in terms of availability of alternative sources. The results indicate 121 products with high concentration and 12 vulnerable products with low diversification potential. Based on these results, the authors conclude that France has a lower number of vulnerable products than its European neighbours and stress the need to acknowledge the advantages of sourcing from abroad in terms of economic efficiency and security of supply (including in times of crisis).

For Germany, Flach et al. (2022) analyze the dependence of the economy on imports of raw materials. Product by product, the authors investigate working conditions, democracy and environmental conditions in the supplying countries to identify critical dependencies on raw materials imports. They conclude that especially raw materials from the group of the rare earths are often imported from countries with low levels of labor and environmental protection or with low democracy standards. At a regional level, Matthes et al. (2023) consider import dependencies of the German federal state of North Rhine-Westphalia and apply the methodology by the European Commission (2021). They find critical dependencies for 9 percent of the imports of North Rhine-Westphalia. However, in the field of electronics and electrotechnics, more than half of the imports can be classified as critical.

Whereas the majority of investigations for the EU (or single EU members) have focused so far on trade – and predominantly import – dependencies from foreign countries in aggregate, there has been only limited attention offer to disentangle more specific trade dependencies from selected trade partners. An exception in this regard offers a study by Gehringer (2023), in which not only e methodological aspects of the measurement of

strategic import dependencies are discussed and developed, but also EU strategic import dependencies on China are thoroughly investigated. Using granular trade data at 6-digit level of the Harmonized System (HS), the study maps these categories of goods for which not only EU imports prevalently come from China, but also China's global market share is substantial (over 30 percent) and EU's trade balance for the good is in deficit. The results are suggestive in disentangling various categories of intermediate and final goods for which strategic import dependence is an issue.

The next section places the concept of vulnerability in a broader context of GVCs. Here, we briefly anticipate this discussion with a specific focus on how countries' trade dependencies are a source of economic vulnerability. To this end, it is useful to look at the theoretical work on production and input-output networks that shows how shocks to a small set of upstream suppliers can be amplified through the network of inter-sectoral linkages: the position and connectivity of a supplier determine its potential systemic impact. Accordingly, concentrated or centrally-placed suppliers are likely to raise aggregate exposure (Acemoglu et al., 2021).

Empirical work during recent major disruptions — notably the US–China tariff episodes and the COVID-19 pandemic — has illustrated both channels of exposure and the real economic costs. Several studies find that sectors and firms with larger shares of imported intermediates from a small number of foreign suppliers experienced larger output contractions and price effects when those suppliers were hit by shocks or when trade policy interrupted flows. These episodes have renewed interest in quantifying which trade links are "critical" and why dependence on a few partners or on particular countries (rather than overall import openness) matters for assessing trade vulnerabilities (Amiti et al., 2020).

The empirical assessment of trade-related vulnerabilities has been under-researched so far. Beyond the aforementioned approaches using exposure and concentration metrics to capture how imports of a good are concentrated across partners, also network and input-output methods deliver useful – although indirect – insights to this analysis. These approaches use the topology of trade and production linkages to assess vulnerability beyond pairwise concentration. Various network metrics (e.g. degree, betweenness, eigenvector centrality) and input-output propagation models identify nodes whose failure would have outsized effects because of their central position or the cascading structure of intermediate use. This literature emphasizes that two countries with identical import shares can have very different systemic importance if one is more central in the global value chain network. Work that formalizes propagation and amplification in production networks provides the theoretical basis for using these network measures as indicators of systemic vulnerability (Acemoglu et al., 2012).

3. Vulnerability, resilience, and sustainability of Global Value Chains

The increasing complexity and interdependence of international trade relations have made questions of vulnerability, resilience, and sustainability central to both academic and policy debates. Together, these three concepts form a conceptual triad that captures how GVCs respond to shocks, adapt to changing environments, and ensure long-term viability. Although the primary focus of this paper is on constructing an index of import vulnerability, understanding the underlying interrelations within the triad is essential for grasping the systemic dynamics of contemporary globalization.

3.1. Vulnerability of Global Value Chains

The recent interruptions of global value chains (GVCs) due to various shock factors – such as the COVID-19 pandemic, the Russian invasion of Ukraine, and rising trade-policy-related tensions – have reinforced the discussion surrounding vulnerabilities and risks associated with participation in internationally integrated production structures. This debate, however, has been ongoing for several decades. Early studies of vulnerability emphasize the exposure of GVCs to disruptions arising from heightened import dependency, concentrated supplier bases, and upstream chokepoints, all of which weaken a system's capacity to absorb shocks (Forbes, 2002). Importantly, the most relevant risks are not short-term interruptions – which can often be overcome within an acceptable adjustment period – but rather persistent or long-lasting disruptions that fundamentally impair the functioning of value chains and pose risks to macroeconomic stability and long-term growth.

A rich body of literature defines economic vulnerability as a combination of exposure and sensitivity to exogenous shocks (Briguglio, 1995; Briguglio & Galea, 2003; Farrugia, 2004). This proneness of an economic system to adverse external events is driven by structural characteristics such as the degree of international economic integration, the concentration of trade relations, and the lack of diversification in production and sourcing patterns (Briguglio et al., 2008). Within this framework, vulnerability arises not only from the magnitude of exposure but also from limited adaptive capacity, i.e. the ability to substitute suppliers, inputs, or technologies in response to disruptions.

While much of the early literature conceptualizes vulnerability as an attribute inherent to each country, the vulnerability of import-dependent value chains is fundamentally relational. The susceptibility of a country's imports depends crucially on conditions prevailing in its supplier economies and on the nature of bilateral and multilateral trade relationships. The latter may refer to a combination of both economic factors – e.g., partners' economic openness and their conditions of trade concentration – and non-economic factors – such as geopolitical tensions, regulatory environments, policy uncertainty, social, environmental or technological factors).[5] This perspective motivates a

[5] These factors stay at the basis of the dimensions that we consider when constructing our index of import vulnerability. However, it is worthwhile to note that the dimensions of vulnerability are explored across various scientific disciplines, especially disaster risk reduction, climate change adaptation, and health research. This

multidimensional approach to GVC vulnerability, as import risks arise from a combination of economic and non-economic factors that jointly shape the reliability of supply.

First, the economic dimension captures the extent to which imports are exposed to concentration risks, limited diversification, and asymmetric dependencies. Import relations with suppliers whose economies are themselves narrowly specialized, highly concentrated, or weakly diversified amplify vulnerability by increasing sensitivity to sector-specific shocks and limiting substitution possibilities (Evenett & Winters, 2020). Economic vulnerability therefore reflects both the structure of import dependence and the resilience of supplier economies.

Second, the geopolitical and political dimension reflects the growing importance of political stability, international relations, and policy predictability for the functioning of GVCs. Imports sourced from countries subject to geopolitical tensions, sanctions risks, or unstable political environments face a higher probability of trade disruptions, export controls, or deliberate weaponization of interdependence (Evenett & Winters, 2020). Recent developments underscore that political risks are no longer exogenous tail events but have become structural features of the global trading system.

Third, the social dimension captures risks related to governance quality, labor standards, and social stability in supplier economies. Weak institutions, fragile labor relations, or widespread social unrest increase the likelihood of production stoppages, strikes, or regulatory interventions, thereby undermining the reliability of supply chains (Lund-Thomsen & Lindgreen, 2014; Ponte & Sturgeon, 2014). Social vulnerability thus affects GVC performance through both direct production risks and reputational or compliance-related constraints.

Fourth, the environmental dimension reflects the exposure of imports to climate-related and ecological risks. Suppliers located in regions prone to natural disasters, climate extremes, or resource depletion face a higher probability of supply disruptions, particularly in sectors reliant on climate-sensitive commodities or energy-intensive production processes (OECD, 2021a; Dellink et al., 2019). As climate change intensifies, environmental vulnerability increasingly constitutes a structural source of GVC risk rather than a transitory shock.

Finally, the technological dimension captures dependencies arising from limited technological diversification, high reliance on foreign technological inputs, and exposure to supply bottlenecks in critical technologies. Concentration in technologically sophisticated inputs or digital infrastructure can generate persistent vulnerabilities, especially when alternative suppliers are scarce or subject to export controls. Technological vulnerability thus reflects the interaction between innovation capacity, technological sovereignty, and supply security.

Therefore, the vulnerability of global value chains is particularly high when the supplying countries of intermediate goods and natural resources are characterized by multiple, overlapping risk factors, the materialization of which can cause permanent or long-term interruptions of trade relations. A multidimensional conceptualization is therefore

leads to several conceptual frameworks (Giupponi, 2015), which, however, are in line with the list of the core dimensions identified in this paper.

essential to capture the complex and interdependent sources of import vulnerability that arise in modern, deeply integrated production networks.

3.2. Navigating the vulnerability-resilience nexus

While the notion of economic vulnerability highlights the susceptibility of production systems to external disturbances, resilience captures their ability to absorb shocks, adapt to changing conditions, and recover from crises without losing essential functionality (Briguglio et al., 2009; Briguglio 2016). It can thus be viewed as the conceptual counterpart to vulnerability: both are intrinsically linked but emphasize opposite characteristics of the same system. Whereas vulnerability expresses the potential for harm, resilience represents the capacity for endurance and renewal. Reducing vulnerability generally enhances resilience, yet the two are not fully symmetrical. A system may be less vulnerable but not necessarily resilient if it lacks the ability to reorganize after a disruption (Briguglio et al., 2009; Martin & Sunley, 2015).

In the context of global value chains (GVCs), resilience refers to the capacity of internationally fragmented production networks to maintain or quickly restore their operational integrity when confronted with disruptions. This property emerges from several interrelated dimensions. At a structural level, resilience depends on the underlying configuration of trade and production linkages. Networks characterized by supplier diversification, geographical dispersion, and modular organization tend to absorb shocks more effectively than those with concentrated dependencies or tightly coupled production stages (Miroudot, 2020). However, structural features alone are insufficient to secure stability. The functional dimension of resilience is equally critical and relates to the operational flexibility of firms and sectors – their ability to substitute inputs, adjust logistics, or reorganize production processes when regular channels are interrupted (Baldwin & Freeman, 2022). Such functional adaptability often determines whether a temporary shock leads to short-lived disruption or prolonged breakdown.

Beyond these immediate mechanisms, resilience also has a dynamic dimension that unfolds over longer time horizons.[6] It encompasses the capacity of economies and firms to learn from crises, to redesign organizational routines, and to transform their production systems in ways that reduce future risk exposure (Pimm, 1984). Dynamic resilience, therefore, links short-term recovery to long-term adaptation. Such a process may require investment in innovation, or more specifically digitalization, as well as institutional reform, so as to capitalize on revolutionary and evolutionary changes that make the recovery effective (Xie et al., 2018). This adaptive quality differentiates truly resilient systems from those that merely return to a pre-crisis state without addressing underlying fragilities. Economies with high level of dynamic economic resilience are able to foster the speed of recovery from a crisis.

Yet, the relationship between vulnerability and resilience is non-linear. Strategies that strengthen resilience in one respect may simultaneously generate new vulnerabilities in another. For example, reshoring production or regionalizing supply chains may reduce

[6] Rose and Krausmann (2013) explicitly distinguish between static and dynamic economic resilience. Contrary to dynamic resilience, static resilience refers to the ability of a particular system to maintain its level of functioning after shocks (Holling, 1973). A high level of static economic resilience is associated with the efficient use of remaining resources in the peak of the crisis.

exposure to foreign shocks, but at the cost of increasing dependence on domestic inputs or diminishing the efficiency gains of international specialization. Similarly, building redundancy into supply networks by maintaining multiple suppliers enhances shock absorption but can raise costs and undermine competitiveness. In a similar vein, resilience should not be conceived as the mere absence of vulnerability, but rather as the capacity of an economy to withstand and recover from shocks despite its inherent structural weaknesses. In this sense, resilience and vulnerability are not strictly opposites but interdependent features: efforts to mitigate one dimension often entail trade-offs in another (Briguglio et al., 2009).

Accounting for this nexus between resilience and vulnerability, recent research has shifted toward a more integrated perspective, examining how structural characteristics that create vulnerability also shape the capacity for resilience. In this framework, GVC vulnerability and resilience are conceptualized within a dynamic framework, where system robustness depends not only on minimizing dependencies but also on developing adaptive and reconfiguration capacities (Briguglio et al., 2009; Briguglio, 2016).

3.3. Sustainability as the overarching long-term orientation

While vulnerability and resilience describe how economic systems react to shocks, sustainability captures their capacity to endure and thrive over the long term. In the context of global value chains (GVCs), sustainability encompasses the economic, environmental, and social dimensions that ensure production and trade remain viable, equitable, and ecologically compatible with planetary limits (Berthet & Fusacchia, 2024; Gehringer & Kowalski, 2024). A sustainable GVC is therefore not only efficient and competitive but also able to maintain its productive and social foundations without eroding the resources – natural, human, or institutional – on which it depends.

There are strong intersections between sustainability, resilience and vulnerability.[7] Although the discussion in the relevant literature is still inconclusive (Marchese et al., 2018; Assarkhaniki et al., 2023), sustainability is often viewed as the long-term complement to resilience (Redman, 2014). Whereas resilience focuses on the capacity to absorb and recover from disruptions, sustainability ensures that such adaptive processes do not compromise future stability. This implies that resilience tends to prioritize processes, while sustainability is focused on outcomes that follow from these processes (Redman, 2014; Keenan et al., 2021). This dichotomy is prone to trade-offs. A value chain that is resilient in the short term – since it can resort to processes that ensure its effective adaptation to shocks – but at the same time relies on environmentally harmful practices, precarious labor conditions, or excessive resource depletion remains structurally vulnerable and turns unsustainable in the long run. Likewise, measures to enhance economic efficiency or reduce environmental footprints through lean production or just-in-time logistics may heighten vulnerability to disruptions. At the same time, sustainable practices – such as resource efficiency, circular production models, diversification of supply bases, and social responsibility – thus constitute both a goal and a condition for building resilient and less vulnerable GVCs (OECD, 2021b). The challenge for firms and policymakers is therefore to balance short-term resilience with long-term sustainability,

[7] The perception of overlapping goals and strategies surrounding sustainability and resilience is reflected in practice in combined sustainability and resilience departments at selected government agencies and universities.

recognizing that excessive focus on either dimension may undermine systemic robustness over time.

Ultimately, sustainability provides the normative and strategic framework within which resilience and vulnerability should be understood (Zavala-Alcívar et al., 2020; Setyadi et al., 2025). It shifts the focus from merely coping with shocks to transforming the structure and logic of global value creation toward durability, inclusiveness, and ecological balance. In this sense, sustainability is not only the overarching objective of resilient and secure GVCs, but also the essential foundation upon which their stability depends.

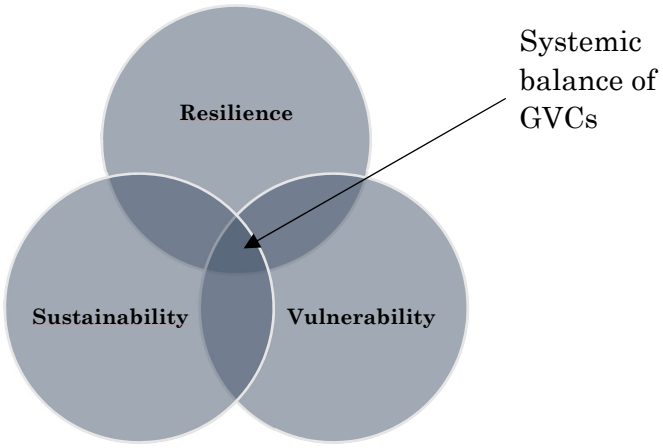
3.4. Connecting the dots: a systemic perspective on vulnerability, resilience and sustainability of GVCs

Despite a considerable body of literature that elaborates on these three concepts, the underlying research streams have developed mostly separately so far. Also, an integrated and systemic approach to assess vulnerability, resilience and sustainability in the context of GVCs is still missing (Negri et al., 2021).

From the preceding conceptual analysis, the concepts of vulnerability, resilience, and sustainability represent interdependent dimensions of the same systemic reality within global value chains (Figure 1). Understanding their interplay requires a holistic perspective that views production networks as complex systems, exposed to fragility but able to adapt and achieve long-term sustainability. Their stability – and thus long-term systemic equilibrium – depends on the continuous balancing of efficiency, flexibility, and long-term viability (Katebi et al., 2025).

In this systemic view, sustainable GVCs are those that effectively minimize vulnerability and enhance resilience through sound governance, strategic diversification, and continuous innovation. Governance mechanisms – both at the firm and institutional levels – set the framework for managing interdependencies, mitigating risks and vulnerabilities that arise from high degrees of international integration (OECD, 2021b; Katebi et al., 2025). Effective coordination, transparency, and compliance with responsible business conduct standards strengthen the reliability of relationships along the chain, enhances resilience and reduce exposure to economic, social, environmental, and geopolitical disruptions that stay at the ground of GVCs vulnerabilities (Asmussen et al., 2023).

Figure 1. Global Value Chains Configuration in the long term



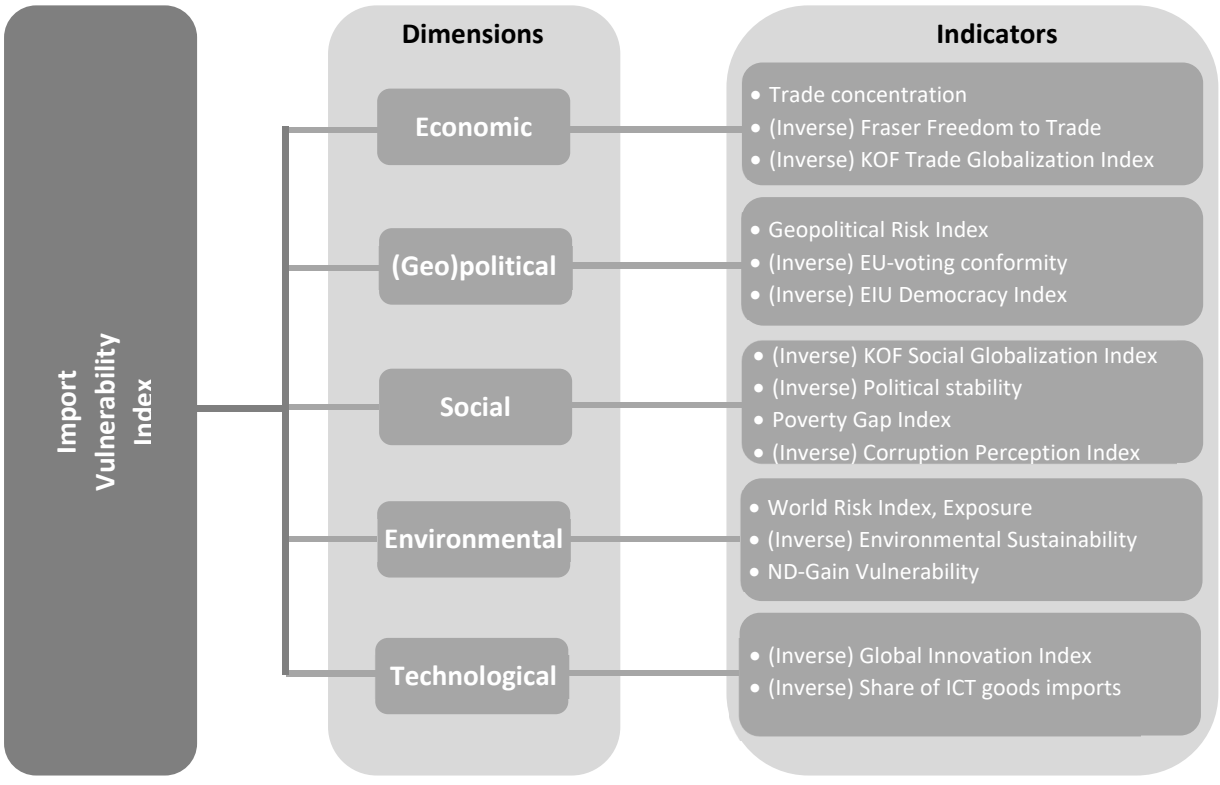
Source: Based on Kolev-Schaefer et al. (2025)

Adopting this systemic perspective has two major implications for the subsequent analysis of the Import Vulnerability Index. First, it underscores that vulnerability, resilience, and sustainability should not be viewed as isolated properties but as co-determined outcomes of underlying structural and institutional configurations. Reducing vulnerabilities – whether through diversification, improved governance, or sustainable practices – simultaneously shapes the adaptive capacity and long-term viability of GVCs. Second, it implies that conceptualization efforts and policy design must account for these interlinkages. The subsequent empirical sections of this paper focus on the vulnerability of import structures, examining how exposure to external shocks varies across partner economies. Yet, given the close conceptual and functional connections between vulnerability, resilience, and sustainability, the outcomes of the vulnerability index have broader interpretive value. They provide insight into how the structure of trade relationships may facilitate or hinder resilience, and how sustainable transformation strategies can be tailored to strengthen the overall robustness of international production systems.

4. Constructing the Index for Vulnerability of Global Value Chains

The conceptual background discussed and developed in the previous sections is used in the next step to construct a vulnerability index along the five dimensions affecting economic and non-economic risk exposure discussed above. Figure 2 illustrates the dimensions and indicators chosen to represent them in the construction of the index.

Figure 2. Dimensions and indicators of the composite Import Vulnerability Index (IVI)



Source: own representation

Economic dimension

The economic dimension of import vulnerability captures the structural and trade-policy-related factors that determine how exposed a country's economy is to disruptions in import flows due to economic vulnerabilities of its three major sourcing partners accounting in most of the cases for over XX percent of total imports. High vulnerability in this dimension indicates that a country's import system at source is both highly concentrated and institutionally less open or flexible, reducing its capacity to adapt to changing global conditions. This dimension is assessed through three complementary indicators characterizing the export conditions of the three supplying countries: trade concentration (Herfindahl-Hirschman Index), the inverse Fraser Trade Liberalization Index, and the inverse KOF Trade Globalization Index. Together, these measures combine structural aspects of trade dependence with institutional and policy determinants of economic openness.

Trade concentration is measured in terms of Herfindahl-Hirschman Index for imports and exports (equally weighted). The Herfindahl-Hirschman Index (HHI) captures the degree of concentration of a country's trade relationships by summing the squared shares of its partners in total imports. A high HHI value indicates that trade is highly concentrated among a few partners, implying a greater risk of disruption if one or more of these partners face economic or political instability. Conversely, a low HHI reflects diversified trade relations and thus lower vulnerability. This indicator captures the structural exposure of a country's import network.

The Fraser Institute's Freedom to Trade Internationally (Gwartney et al., 2025) captures the extent to which economic policies – such as tariffs, non-tariff barriers, exchange rate controls, and controls on the movement of people – facilitate or restrict international trade. By using its inverse, the indicator reflects policy-induced vulnerability: countries with more restrictive policy regimes (lower freedom) are considered more vulnerable, as they face greater barriers to adjusting their import sources or responding flexibly to global supply shifts.

The KOF Trade Globalization Index (de facto) captures actual (de facto) integration of a country into the global economy, encompassing trade in goods and services as well as trade partner diversity (Dreher, 2006; Gygli et al., 2019). Its inverse reflects the degree of systemic isolation or limited integration in global trade networks. A higher inverse value implies lower globalization and thus greater exposure to external shocks, as the economy is less embedded in diversified global trade linkages.

(Geo)political dimension

The (geo)political dimension of import vulnerability captures the extent to which a country's dependency on imported products is influenced by political stability, alignment, and geopolitical tensions. It reflects the risk that external political developments in the sourcing partners – such as conflicts, diplomatic rifts, or governance crises – may disrupt import flows, limit access to key markets, or undermine the reliability of trading partners. High vulnerability in this dimension suggests that a country's import dependencies are concentrated in politically unstable or misaligned regions, thereby increasing the likelihood that geopolitical events translate into economic disruptions. This dimension is assessed through three complementary indicators: the Geopolitical Risk Index, the Inverse UN Voting Conformity Index, and the Inverse EIU Democracy Index and is supposed to

capture how geopolitical tensions, international alignment, and regime characteristics contribute to the fragility of trade relations.

The Geopolitical Risk Index measures the intensity of geopolitical tensions, conflicts, and threats that may affect global stability and trade (Caldara & Iacoviello, 2022). A higher GPR value signals heightened geopolitical uncertainty, which can undermine trade reliability through sanctions, transport disruptions, or heightened market volatility. For a country's import vulnerability, exposure to trading partners with elevated geopolitical risk indicates a greater likelihood of supply interruptions stemming from external political instability.

We build an index that measures the UN voting conformity, which measures the degree of alignment between the supplying country's voting behavior in the United Nations General Assembly and that of the European Union. Its inverse is used here to capture political misalignment or divergence in foreign policy positions. Higher values thus reflect greater distance from the EU's geopolitical stance, potentially implying less stable or predictable political relations with key EU trade partners. In the context of import vulnerability, low conformity may translate into increased exposure to political frictions or reduced diplomatic leverage in times of crisis.

The Economist Intelligence Unit's Democracy Index (EIU, 2025) assesses the quality of democratic governance across countries, encompassing electoral processes, civil liberties, and political culture. Its inverse reflects exposure to autocratic or politically unstable regimes. Countries that depend heavily on imports from less democratic trading partners are more vulnerable to disruptions driven by arbitrary policy shifts, weak institutional frameworks, or internal unrest. This indicator therefore captures the institutional dimension of political risk in trade relations.

Social dimension

The social dimension of import vulnerability captures the extent to which societal conditions and institutional quality in the major supplying countries influence a country's resilience to external trade shocks. It reflects how social cohesion, governance quality, and inclusion shape the ability of societies to absorb and adapt to disruptions in global supply chains. A high level of vulnerability in this dimension implies that structural social fragilities – such as inequality, instability, or corruption – undermine a country's capacity to respond effectively to import disturbances and economic stress. This dimension is measured through four complementary indicators characterizing the societal conditions and institutional quality of the supplying countries: the inverse KOF Social Globalization Index, the inverse of political stability and absence of violence indicator (World Bank), the poverty gap (World Bank), and the Corruption Perceptions Index (Transparency International). These indicators combine social integration, institutional robustness, and equity considerations to assess a country's social resilience to trade-related shocks.

The KOF Social Globalization Index measures the degree of cross-border social connectedness through flows of information, people, and cultural exchange. Its inverse captures social isolation or limited global embeddedness, indicating that countries with weaker international social linkages may face greater difficulties in adapting to disruptions in global trade or coordinating responses across borders. A higher inverse value reflects less societal openness and weaker transnational exchange, thereby increasing vulnerability.

The inverse of political stability and absence of violence is an indicator computed by the World Bank and measures perceptions of the likelihood of political instability and violence, including terrorism. Its inverse highlights societal and institutional fragility, capturing the risks associated with social unrest, weak governance, or internal conflict. High values of the inverse index imply that domestic instability can amplify vulnerability by disrupting infrastructure, deterring investment, and eroding institutional capacity to manage import dependencies or supply shocks.

Poverty Gap Index by the World Bank measures the intensity of poverty by estimating how far below the poverty line the average poor household's income lies. A wider poverty gap indicates greater socioeconomic inequality and reflects the distributional and adaptive capacity aspect of social vulnerability – the involvement of trade partners with higher poverty in domestic global value chains make a country less resilient to trade-related disturbances that affect access to essential goods.

The Corruption Perceptions Index (CPI) assesses perceived levels of public sector corruption, with lower CPI values indicating higher corruption. Since corruption weakens institutional efficiency and trust, it hampers coordinated responses to external shocks and distorts policy implementation. In this framework, higher perceived corruption corresponds to higher social vulnerability, as it undermines governance capacity in supplying countries and reduces confidence in the management of import risks.

Environmental dimension

The environmental dimension captures the extent to which the exposure of the supplying countries to natural hazards, environmental degradation, and climate change can disrupt trade and supply chains in the receiving economies. It reflects how ecological risks and environmental resilience influence the stability of import flows and the reliability of trading partners. A higher level of vulnerability in this dimension indicates that a country is more exposed to environmental shocks via its import relations. This dimension is assessed through three complementary indicators: the Exposure component of the World Risk Index, the Inverse Environmental Sustainability Index, and the Climate Vulnerability Index. In a unified framework, these indicators measure the degree of environmental exposure, the sustainability of environmental management, and the sensitivity of economies and societies to climate impacts.

The Exposure component of the World Risk Index measures the extent to which a country's population and infrastructure are exposed to natural hazards such as floods, storms, droughts, or sea-level rise. High exposure values indicate that critical trade and transport systems — ports, logistics hubs, and industrial facilities — are more likely to be affected by environmental events. This indicator thus reflects the physical dimension of environmental risk, capturing how direct hazard exposure can endanger import continuity and supply stability.

Environmental Sustainability measures efficiency and productivity in the process of energy generation, transmission, and distribution. It also assesses efforts towards decarbonization and air quality improvement are accounted for.

The Climate Vulnerability Index measures the susceptibility of countries to the adverse effects of climate change, considering both exposure to climate hazards and adaptive capacity. A higher index value implies greater sensitivity to climate-induced disruptions – such as changing precipitation patterns or heat stress — which can affect agricultural

outputs, infrastructure reliability, and transport networks. This indicator captures the long-term systemic risks that climate change poses to the continuity of international trade flows.

Technological dimension

The technological dimension aims at assessing a partner's exposure to shocks that are driven by its (low) level of technological capacity, innovation performance, and dependence on technological goods sourced from abroad. High vulnerability in this dimension indicates that a supplying country lacks the domestic technological and innovative capabilities required to maintain production or rapidly adjust when access to ICT-intensive inputs is disrupted. This vulnerability spills over to the reporting country through global value chain linkages: when a key supplier itself depends heavily on foreign ICT-intensive goods, any disruption upstream – such as export restrictions, technological sanctions, or supply bottlenecks – can impair the supplier's ability to produce and deliver intermediate goods reliably. As a result, the reporting country faces an increased risk of downstream supply interruptions, delays, or quality losses, even if its own technological capacity is relatively strong. The technological vulnerability of partner countries thus constitutes an indirect but critical source of import vulnerability for the reporting economy.

Two complementary indicators capture technological dimension: the inverse of the Global Innovation Index and the inverse of the share of ICT goods imports. These indicators capture both the internal innovation capacity of a country and its external dependence on technology-intensive imports.

The Global Innovation Index evaluates national innovation ecosystems based on factors such as R&D investment, human capital, infrastructure, and knowledge outputs. Its inverse reflects technological and innovation weakness: countries scoring lower in innovation capacity are less capable of developing domestic alternatives to imported technologies or adapting production systems in response to external supply shocks. High values of the inverse Global Innovation Index indicate an increased risk that technological shocks affecting the supplier will propagate downstream, limiting the reporting country's ability to secure stable and reliable imports.

The share of ICT goods imports approximates the extent to which a country imports high-technology products. Its inverse reflects technological dependence and vulnerability: countries with a smaller share of such imports may have limited access to advanced technologies that enhance productivity and resilience. This indicator thus captures the external dimension of technological exposure.

Table 1 summarizes the relevant information on the indicators used in the respective dimensions of the IVI.

Table 1. Indicators used in the construction of the Import Vulnerability Index

	Indicator	Description	Range	Source
Economic dimension	Trade concentration	Herfindahl-Hirshmann Index of export and import concentration	min = 0 (no concentration) max = 1 (extreme concentration)	Own calculations based on Comtrade database
	Freedom to trade internationally	The metric assesses factors beyond tariffs, such as non-tariff barriers, trade regulations, capital controls, and controls on the movement of people.	Min = 0 (least free) Max = 10 (most free)	Fraser Institute's annual report "Economic Freedom of the World"
	KOF Trade Globalization Index (de facto)	The index measures international integration of a country via trade in goods and services as well as trade partner diversity.	Min = 1 (no integration) Max = 100 (full integration)	KOF Swiss Economic Institute
(Geo)political dimension	Geopolitical Risk Index	The index measures the occurrence of impactful geopolitical events/threats by counting the keywords used in the press.	Min = 0 (no geopolitical risk) Max = ∞	Caldara & Iacoviello (2022)
	EU-voting conformity at the UN	The metric measures the degree of alignment between a country's voting behavior in the United Nations General Assembly and that of the European Union	Min = 0 (no conformity) Max sample dependent	Own calculations based on UN voting records
	EIU Democracy Index	The index captures the quality of democratic governance across countries, encompassing electoral processes, functioning of government, civil liberties, and political participation & culture.	Min = 0 (authoritarian regime) Max = 10 (full democracy)	Economist Intelligence Unit
Social dimension	KOF Social Globalization Index	The index measures the degree of cross-border social connectedness through flows of information, people, and cultural exchange.	Min = 1 (no integration) Max = 100 (full integration)	KOF Swiss Economic Institute
	Political stability & absence of violence	The indicator measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Min = -2.5 (highest instability) Max = 2.5 (highest stability)	World Bank
	Poverty Gap Index	The index measures the depth of poverty in a country by capturing the average shortfall of income/consumption for individuals below the poverty line.	Min = 0 (no poverty gap) Max = 1 (maximum poverty gap)	World Bank
	Corruption Perception Index	The index measures the perceived levels of corruption in the public sector, based on experts' and business executives' assessments.	Min = 0 (highly corrupt) Max = 100 (very clean)	Transparency International

Table 1. cont.

Environmental dimension	World Risk Index, Exposure	Exposure is a key component of the World Risk Index that measures how populations are directly affected by natural hazards like earthquakes, floods, storms, droughts, and sea-level rise.	Min = 0 (no exposure) Max = 100 (maximum exposure)	Birkmann et al. (2011)
	Environmental Sustainability	The metric reflects the efficiency and productivity of energy generation, transmission, and distribution, including efforts towards decarbonization and air quality improvement.	Country ranking from 1 (best) to 126 (worst)	World Energy Council's Energy Trilemma Tool
	ND-Gain Vulnerability	A tool to assess the propensity or predisposition of human societies to be negatively impacted by climate hazards.	Min = 0 (low vulnerability) Max = 1 (high vulnerability)	Notre Dame Global Adaptation Initiative
Technological dimension	Global Innovation Index	The index ranks economies by their innovation performance in areas like R&D, institutions, and the private sector.	Scoring system, with no fixed numerical range	World Intellectual Property Organization
	Share of ICT imports	The metric measures the relative intensity of imports of ICT goods over total imports.	Min = 0 (no ICT imports) Max = 100 (all imports are ICT goods)	Own calculations based on UNCTAD Trade & Development data

Constructing the Import Vulnerability Index (IVI)

The Import Vulnerability Index (IVI) is constructed as a composite indicator reflecting multiple economic, geopolitical, social, environmental, and technological factors that shape the exposure of EU member states to external import risks. The index is built in several sequential steps to ensure comparability across countries and dimensions.

All underlying indicators are first normalized using Min–Max scaling to a common range between 0 and 10, where higher values denote greater vulnerability. This transformation ensures that variables originally expressed in different units or scales are made dimensionless and directly comparable. The normalization for each indicator k, each of the three major partner economy j, and time t is carried out according to the formula:

(1) $X_{kjt}^{n} = \frac{X_{kj} - X_j \min}{X_j \max - xj \min} * 10.$

Each normalized variable is then weighted by the respective import share of the supplying country in the sourcing partner country. This step links the intensity of bilateral trade exposure to the underlying vulnerability factors, ensuring that partners with higher import relevance exert proportionally greater influence on the index.

Subsequently, for each reporting country and indicator, the mean across the three major import partners is computed to arrive at a single indicator value for each reporting country-year observation in our sample.

The normalized, weighted, and averaged indicators are then aggregated into five thematic dimensions, as shown in Figure 2. Each dimension is constructed by summing the respective variables within that category and by normalizing the values using Min-Max formula reported above. This process results in dimension-specific vulnerability scores.

Finally, the overall Import Vulnerability Index for each country is derived as the arithmetic mean of the scores from the five dimensions:

(2) $IVI_{it} = \frac{1}{5}\sum_{d=1}^{5} D_{idt}$

where D_{id} denotes the score of country i in each of the five dimensions.

The resulting IVI ranges between 0 and 10, with low/high values meaning low/high import vulnerability.

5. Values and Development of the Index for Vulnerability of Global Value Chains

Figure 3 shows the results of the IVI calculation for the selected years, 2015, 2019 and 2024. The emerging picture is generally mixed. Whereas for various EU countries vulnerability of their imports decreased over time, some countries were unable to reduce it or even observed an increase in import vulnerability. The most significant reduction in vulnerability over the period 2014-2024 took place in Lithuania (by 4.4 index points, IP), Bulgaria (by 2.5 IP), Greece (by 2.2 IP), and Finland (by 1.8 IP). At the same time, the lowest import vulnerability has been persistently recorded in the two Nordic EU members, Denmark (IVI_{2014} = 1.8; IVI_{2024} = 2.0) and Sweden (IVI_{2014} = 1.0; IVI_{2024} = 1.5). Finally, countries with the strongest index increases are Malta (by 1 IP) and Germany (by 0.7 IP).

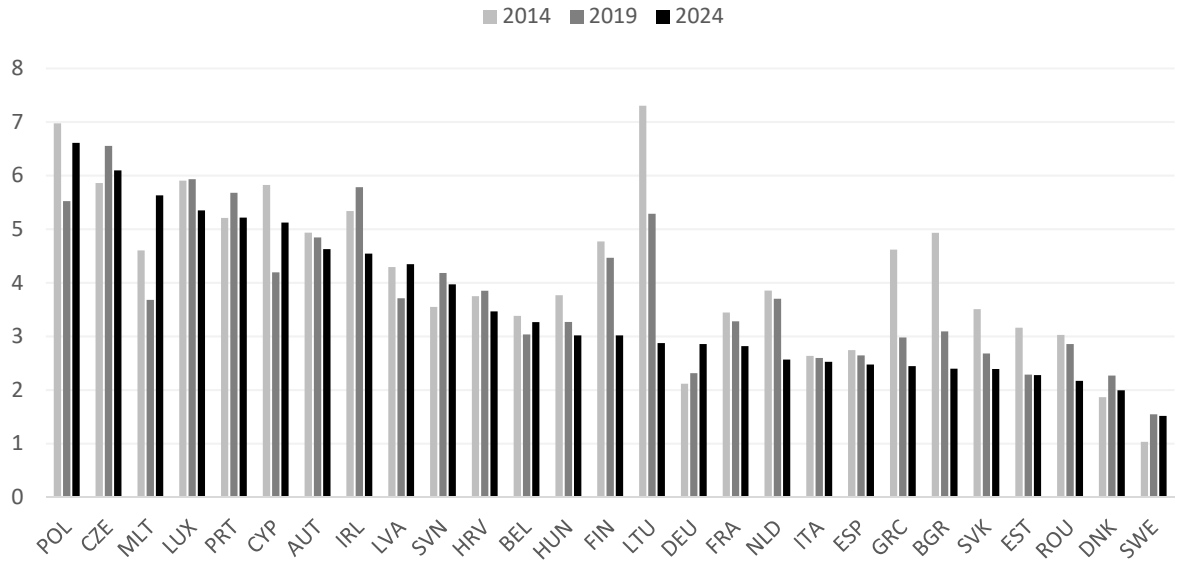


Figure 3. Overall composite Import Vulnerability Index (IVI) for the EU-27

Source: Own calculations

Looking at IVI values in Figure 3, the question about the main driving forces of the different level and development of the vulnerability index arises. The observed reduction in vulnerability is driven primarily by a pronounced decline in the economic vulnerability dimension, whose EU-wide average falls steadily after 2016 and reaches its lowest levels by 2023–2024 (Figure 4). This suggests that diversification of import sources and reduced concentration effects have been the dominant forces behind the improvement in overall import resilience. In contrast, the geopolitical vulnerability dimension follows a markedly different trajectory: after remaining low in the early years of the sample, it rises sharply between 2017 and 2020, reflecting growing exposure to geopolitically sensitive suppliers, before partially receding after 2021 (Figure 5). This pattern indicates that gains from economic diversification were, at least temporarily, offset by heightened geopolitical risk.

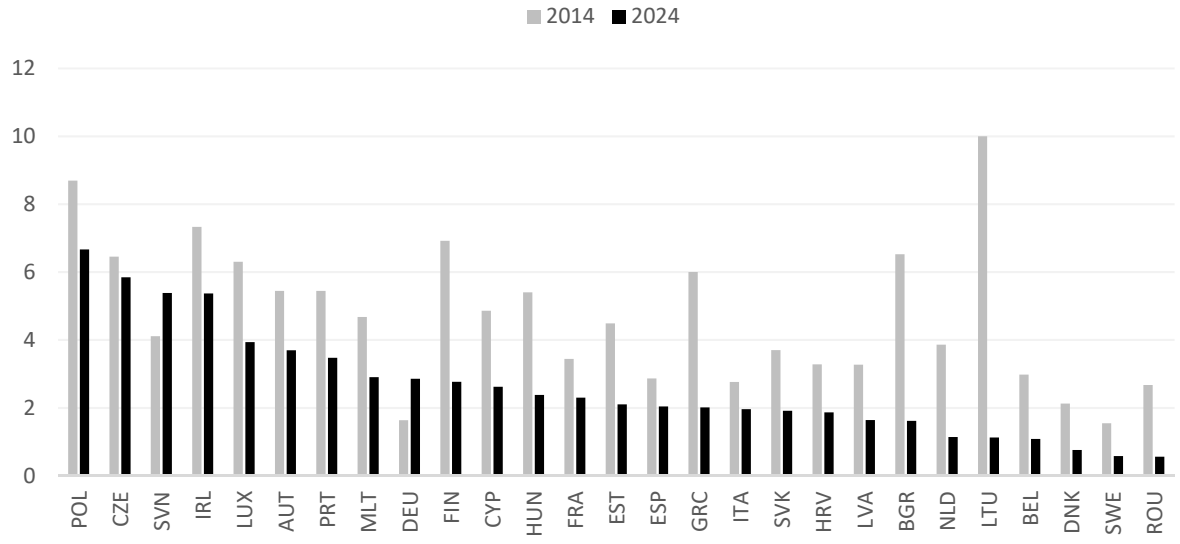


Figure 4. Economic dimension of the Import Vulnerability Index (IVI) for the EU-27

Source: Own elaboration

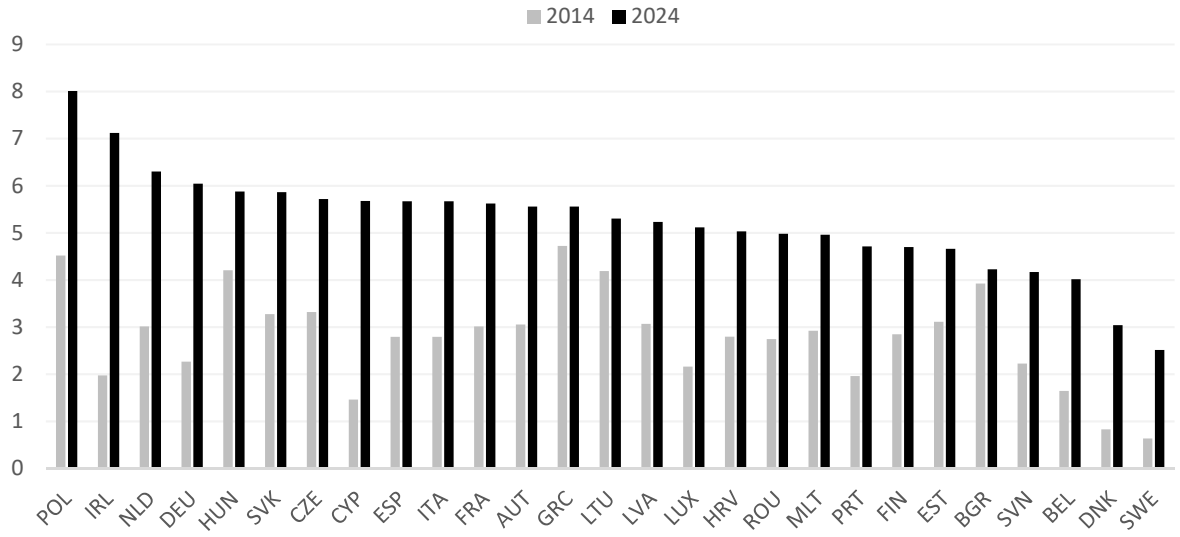


Figure 5. Geopolitical dimension of the Import Vulnerability Index (IVI) for the EU-27

Source: Own elaboration

Useful insights concerning geopolitical dimension can be gained by considering in more detail the main suppliers of countries in our sample. A couple of remarkable and countervailing tendencies deserve particular attention. They are highlighted in Table 2, which shows which countries of the EU-27 had as their first, second or third sourcing partner China, Russia or the US in the three years 2014, 2019 and 2024. These three countries were chosen since geopolitically they represent most contentious partners within the supplier base, although via different channels. Whereas China and Russia underperform in terms of democracy and conformity with the EU voting at the UN, US is most vulnerable in terms of overall geopolitical risk and also has a diverging voting record at the UN. Furthermore, the escalating trade policy conflicts since the beginning of the second Trump Administration indicate rising uncertainty with regard to the future of economic partnerships between the EU member states and the US.

Whereas China has been continuously among the major three suppliers in several EU-27 countries, its importance further increased over time, with 14 countries in 2024 having China among its major three suppliers. Also, the position of the US among the most important suppliers strengthened somewhat over time. Instead, Russia was the most important supplier (especially for energy) for six countries in 2014, and for five still in 2019, but completely disappeared from the list in 2024. Accordingly, China's and US's growing importance as an import partner – also often via comparatively high import shares – contributed to rising geopolitical vulnerability. The opposite is true for Russia. These two effects together likely explain why geopolitical vulnerability dimension of the IVI remained an important contributor to the overall index. At the same time, the China-US-effect prevailed, leading to an increasing tendency in this component over the observation period (Fig. 4). This explanation should be particularly true for Poland given the country's comparatively high dependence on imports from China (11%-15% over the observation period), until 2021 from Russia (5%-7%), and since 2024 from the US (5%).

Table 2. EU-27 countries with major suppliers being China or Russia

Supplier	Supplier's rank	2014	2019	2024
China	1st supplier	DEU, SVK	DEU	BGR, DEU
	2nd supplier	AUT, CZE, FRA, POL	CZE, FRA, HUN, POL	AUT, CYP, CZE, ESP, EST, FRA, GRC, HUN, POL, SVN
	3rd supplier	ESP, ITA, NLD	AUT, ESP, ITA, NLD, SVK, SVN	FIN, SVK
Russia	1st supplier	BGR, EST, FIN, GRC, LTU	BGR, EST, LTU	---
	2nd supplier	HUN	FIN, PLN	---
	3rd supplier	---	---	---
USA	1st supplier			IRL
	2nd supplier	IRL, MLT	IRL	
	3rd supplier		DEU	DEU, NLD, POL

Source: Own elaboration

Poland's intensive reliance on Chinese and Russian imports is also the reason for its high vulnerability in economic, environmental and social dimensions. Although there has been some positive development in this regard over time – with slight improvements in economic and social dimension – Poland persistently reports the highest vulnerability scores in these three dimensions (Figures 4, 6-7). The only exception is the technological dimension, for which the country is positioned in the middle field (Figure 8).

More generally, however, the technological dimension remains persistently elevated throughout the period compared to other dimensions, showing only limited improvement and thereby constituting a structural source of vulnerability that constrains further reductions in the overall index.

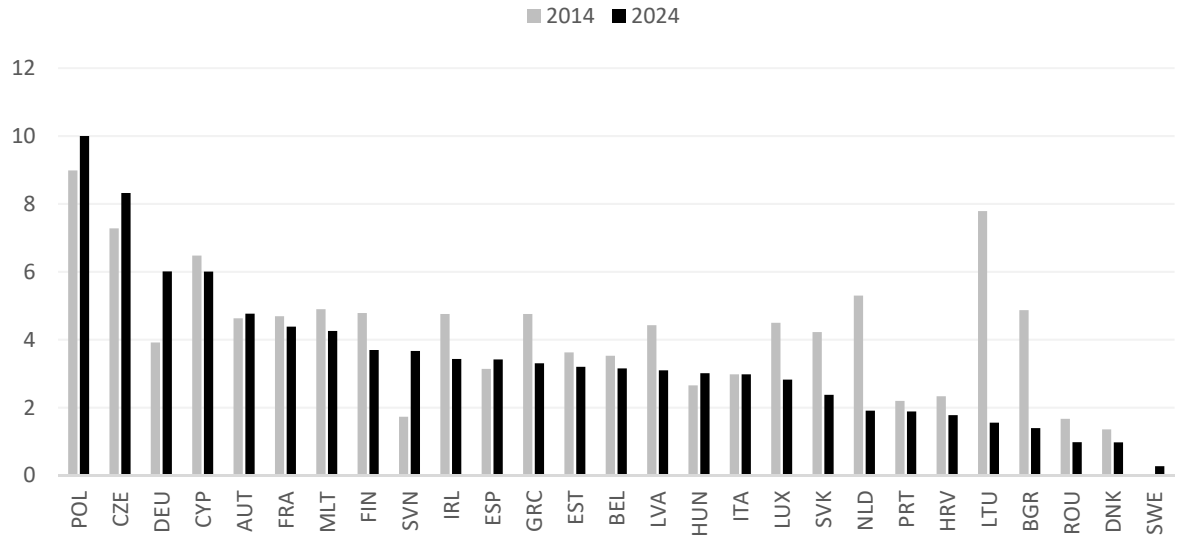
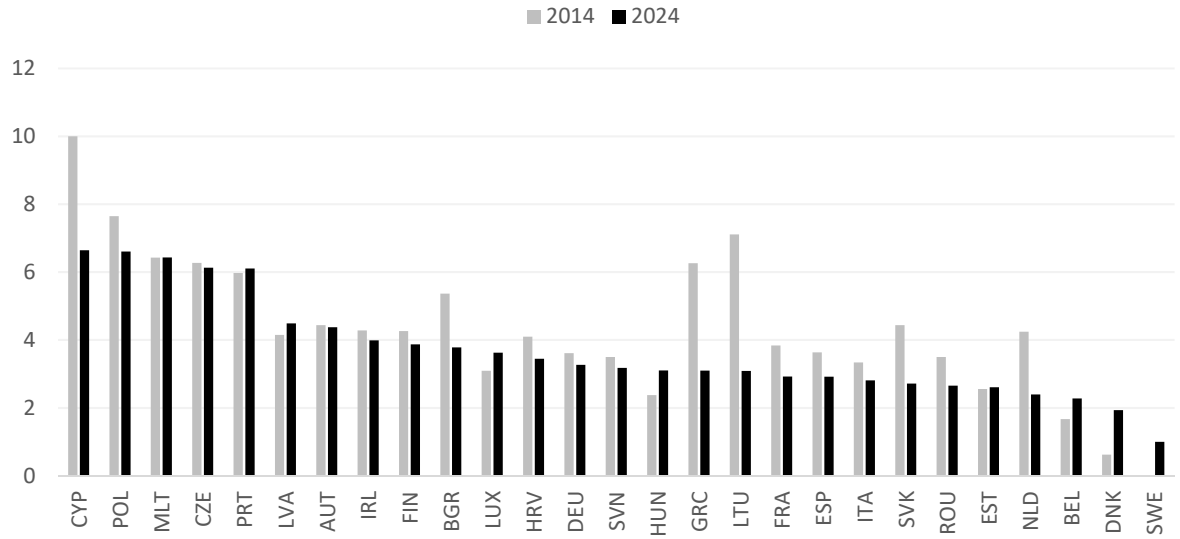


Figure 6. Environmental dimension of the Import Vulnerability Index (IVI) for the EU-27



Source: Own elaboration

Figure 7. Social dimension of the Import Vulnerability Index (IVI) for the EU-27

Source: Own elaboration

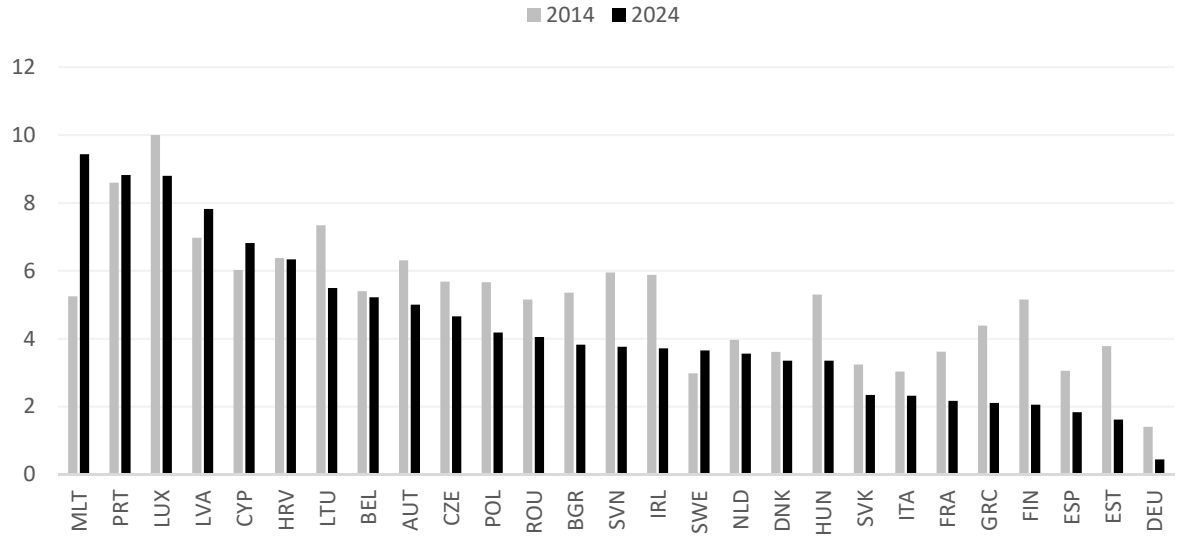


Figure 8. Technological dimension of the Import Vulnerability Index (IVI) for the EU-27

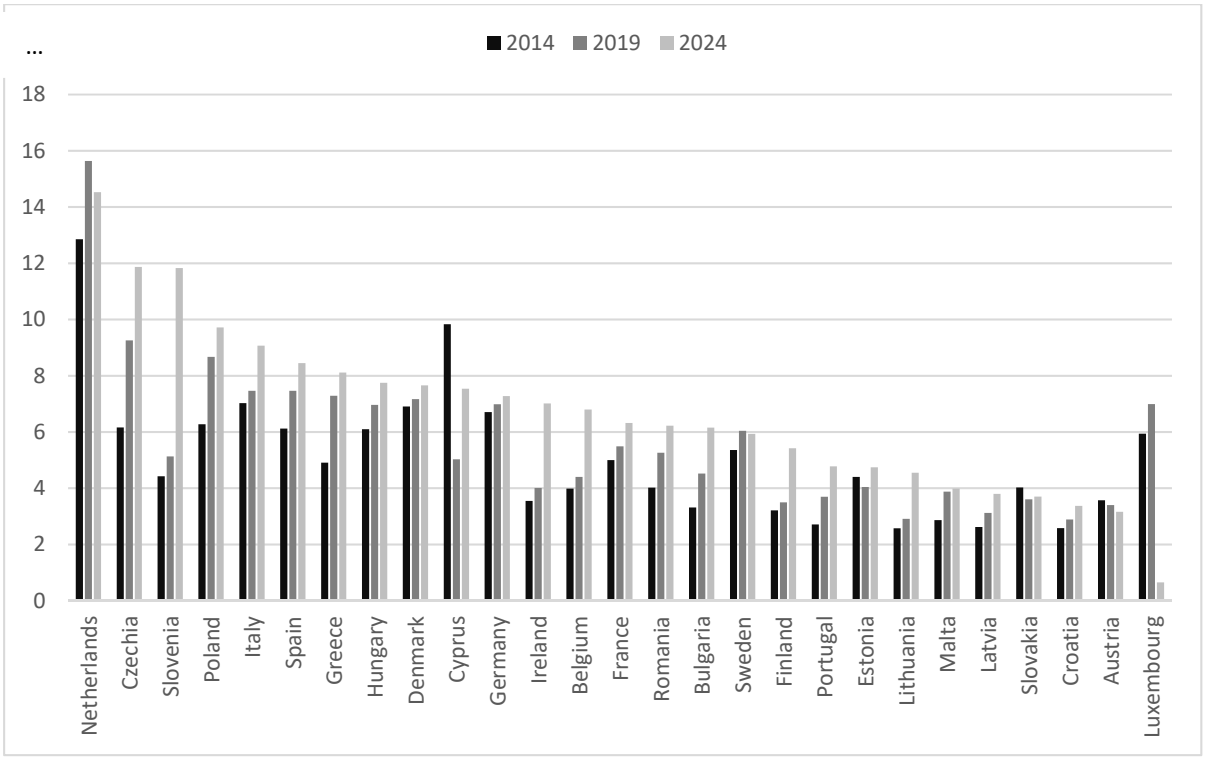
Source: Own elaboration

As already anticipated above, Chinas position as a relevant sourcing partner across the EU-27 is remarkable. In the last decades, China developed into the biggest exporter worldwide, thus delivering not only goods for final demand but also many intermediate products needed in the production of European and other international enterprises. The European Commission (2021) and other authors list numerous products, where the dependence on China is high and stress the need to diversify suppliers to reduce the exposure to global disruptions, especially in the course of trade conflicts and geopolitical tensions. However, contrary to the recommendations, in almost all EU member states the share of China in the overall imports has not decreased but rather risen over time compared to the pre-pandemic period. In some of the countries, the increase was

substantial (Fig. 5) and there was a shift in the structure of imports towards more intermediate products in addition, thus making vulnerability even higher. This is particularly the case in Slovenia, where the share of China in the imports of the country has more than doubles in the last five years to almost 12 percent in 2024 and the share of intermediates in the value of imported goods has increased from 56 to 76 percent. A similar reliance on Chinese supplies is observed in Czechia and to lesser extent in Poland, Italy, Spain, Greece, Hungary. In the biggest EU economy, Germany, the increase in the share of China in total goods imports increased only slightly, and the shift of the deliveries toward intermediates was less pronounced though still noticeable. The overall picture for the EU countries shows rather further concentration of imports from China than diversification. This is in accordance with the observation that the efforts of firms to raise resilience have eased over time and that other goals like efficiency tend to impact strategic decisions surrounding the configuration of global value chains after the short-term transitory period.

Figure 5. Share of China in merchandize imports of EU member states

In percent



Source: own calculations based on data by Eurostat

6. Methodology discussion and sensitivity checks

Several of these underlying indicators used in the construction of the Import Vunerability Index are themselves established composite indices developed in prior literature or by international institutions. This section why their use is methodologically defensible, what potential biases and pitfalls they introduce, and what procedures we apply to limit and quantify those risks.

Using existing composite indices in the construction of the Import Vulnerability Index offers several important advantages. First, it leverages prior validation and domain expertise, since well-constructed indices typically result from rigorous indicator selection, sound theoretical grounding, and various forms of empirical validation such construct, or criterion validity. Incorporating such measures therefore avoids duplicating effort and allows the index to build upon the cumulative methodological knowledge of the research community. Second, the use of established indices improves coverage and comparability, since these measures often provide broad geographic and temporal scope and rely on standardized units of measurement. This enhances the consistency of cross-country and intertemporal analyses, particularly in cases where direct or comparable raw data are unavailable. Third, relying on pre-aggregated indices helps reduce dimensionality and measurement noise by condensing multiple correlated or noisy indicators into a single, more stable metric, thereby improving the overall signal-to-noise ratio of the composite index. Finally, the inclusion of indices that are already familiar to policymakers and stakeholders enhances the policy relevance of the Import Vulnerability Index, making its results more interpretable and directly applicable in practical decision-making contexts.

Despite these advantages, the use of existing composite indices in constructing the Import Vulnerability Index also entails several methodological risks that must be carefully managed. A primary concern is the potential for double-counting and conceptual overlap, as externally sourced indices may capture similar dimensions of vulnerability already represented by other indicators, leading to an overemphasis on certain aspects and biased overall scores. Another key risk involves the propagation of measurement error and methodological bias, since any imperfections or subjective weighting embedded in the original indices may be transmitted into the new composite structure. Differences in scale, direction, or temporal coverage also pose challenges, as external indices often use heterogeneous normalization procedures, reference periods, or interpretative conventions (for instance, whether higher values indicate higher or lower vulnerability), which can introduce inconsistencies if not harmonized carefully. Furthermore, methodological heterogeneity across the included indices – stemming from variations in data sources, weighting schemes, or aggregation methods – can compromise the internal coherence and interpretability of the resulting composite index (Gehringer & Kowalski, 2024). Finally, the inclusion of multiple pre-aggregated indices raises the risk of overfitting and reduced robustness, as the index may become sensitive to the idiosyncratic properties of the incorporated measures rather than reflecting a stable and generalizable underlying construct. Recognizing these risks and addressing them through transparency, harmonization, and rigorous sensitivity testing is therefore essential to ensure the validity and credibility of the Import Vulnerability Index.

To limit the aforementioned risks, we performed various sensitivity analyses. One of them consisted in recomputing IVI based on the analysis of the underlying correlations between indicators and the subsequent exclusion of indicators showing high correlation values within the respective dimensions. Table 3 shows the correlation coefficients, where grey areas delimit the dimensions and coefficients in bold imply very high correlations (above 0.8). In particular, within the economic dimension, Fraser Freedom of Trade strongly correlates with the KOF Trade Globalization (corr. coeff. = 0.865), in the social dimension, Corruption Perception Index is correlated with the KOF Social Globalization and with Political stability. Accordingly, we recomputed two alternative versions of the IVI, Version 1, excluding Frazer Freedom of Trade, Version 2 excluding Corruption Perception Index.

Table 3. Correlation coefficients between indicators

	Fraser	T. concentr.	KOF Trade	GPR	EU-voting	EIU	WIR	ES	ND-GAIN	Corrup.	KOF Social	Pol. stability	Poverty	GII	ICT imports
Fraser	1.000														
T. concentr.	0.164	1.000													
KOF Trade	**0.865**	0.111	1.000												
GPR	-0.372	-0.048	-0.422	1.000											
EU-voting	0.789	0.109	0.798	-0.493	1.000										
EIU	0.904	0.144	0.868	-0.312	0.781	1.000									
WIR	-0.819	-0.117	-0.885	0.407	-0.821	-0.887	1.000								
ES	-0.837	-0.171	-0.747	0.283	-0.709	-0.844	0.795	1.000							
ND-GAIN	-0.527	-0.142	-0.564	0.016	-0.517	-0.724	0.709	0.594	1.000						
Corrup.	0.748	0.131	0.789	-0.181	0.607	0.858	-0.671	-0.691	-0.680	1.000					
KOF Social	0.792	0.149	0.793	-0.112	0.652	0.903	-0.789	-0.767	-0.781	**0.870**	1.000				
Pol. stability	0.809	0.109	0.821	-0.420	0.699	0.853	-0.717	-0.682	-0.614	**0.811**	0.778	1.000			
Poverty	-0.301	-0.041	-0.476	0.007	-0.353	-0.346	0.485	0.337	0.542	-0.499	-0.495	-0.339	1.000		
GII	0.386	0.046	0.323	0.123	0.137	0.428	-0.113	-0.345	-0.290	0.731	0.528	0.414	-0.286	1.000	
ICT imports	-0.659	-0.141	-0.639	0.297	-0.670	-0.725	0.864	0.709	0.604	-0.424	-0.665	-0.499	0.271	0.135	1.000

Note: [explain the indicator names]

The resulting indexes display robust results compared with the baseline version. Table 4 shows the values of the baseline IVI, of the two alternative versions – V1 and V2 – as well as the respective differences between the baseline and the alternatives. It emerges that the differences are negligible, with the ranking of countries being broadly stable across the three index versions.

Table 4. Baseline IVI and two alternative versions: V1 without Fraser Freedom of Trade, V2 without Corruption Perception Index

country	Baseline	V1	V2	Δ Baseline - V1	Δ Baseline - V2
SWE	1.5	1.5	1.5	0.0	0.0
DNK	2.0	2.0	2.1	0.0	-0.1
ROU	2.2	2.2	2.1	0.0	0.1
EST	2.3	2.1	2.3	0.2	0.0
SVK	2.4	2.3	2.3	0.1	0.1
BGR	2.4	2.1	2.3	0.3	0.1
GRC	2.4	2.3	2.4	0.2	0.1
ESP	2.5	2.3	2.4	0.1	0.1
ITA	2.5	2.4	2.5	0.1	0.0
NLD	2.6	2.6	2.6	0.0	0.0
FRA	2.8	2.7	2.8	0.1	0.1
DEU	2.9	2.7	2.8	0.2	0.0
LTU	2.9	2.8	2.8	0.1	0.1
FIN	3.0	2.9	3.1	0.1	-0.1
HUN	3.0	2.9	3.0	0.1	0.0
BEL	3.3	3.4	3.2	-0.1	0.0
HRV	3.5	3.5	3.3	0.0	0.2
SVN	4.0	3.6	3.9	0.3	0.1
LVA	4.3	4.3	4.2	0.1	0.1
IRL	4.5	4.6	4.5	-0.1	0.0
AUT	4.6	4.6	4.6	0.1	0.1
CYP	5.1	4.9	4.9	0.2	0.2
PRT	5.2	5.3	5.1	-0.1	0.1
LUX	5.3	5.5	5.3	-0.2	0.1
MLT	5.6	5.9	5.4	-0.3	0.2
CZE	6.1	5.9	6.0	0.2	0.1
POL	6.6	6.3	6.5	0.3	0.1

As an additional robustness check, we assessed the sensitivity of the Import Vulnerability Index to the choice of normalization method. Instead of applying the baseline min–max normalization on a 0–10 scale, we re-estimated the index using z-score standardization to ensure that the results were not driven by the scaling procedure. The resulting index values are highly consistent with the baseline specification, with the baseline ranking of countries remaining unchanged. This confirms that the overall ranking and relative vulnerability patterns remain stable regardless of the normalization method. Detailed results of this robustness exercise are presented in the Appendix 1.

6. Concluding remarks

The crises of the last years have underlined the need to increase resilience of global value chains of the European economies in order to be prepared for potential interruptions in the future. Against this background, the present paper discussed the concept of economic resilience and introduced a new composite index to measure import vulnerability along the five dimensions: (geo-)political, economic, social, environmental, and technological. Applying the new index to the European member states indicates that several countries have succeeded in reducing their vulnerability over the course of the last years. For other EU member states, notably in Germany, vulnerability has increased since the beginning of the COVID-19 pandemic.

Especially the geopolitical dimension exhibits a sharp increase in most of the EU member states, whereas the economic dimension of the index shows encouraging results, Germany and Slovenia being notable exceptions due to the rising share of China in their imports. Most countries have profit in terms of import vulnerability from diversifying their import sources, especially by reducing the share of Russia in the course of the war in the Ukraine. The other three dimensions, environmental, social and technological, show mixed results.

Our analysis also points to a range of future research avenues. First, as the present paper only uses descriptive statistics to analyse the potential relationship between vulnerability of global value chains and economic growth, it is convenient to include a more comprehensive empirical analysis based on panel data and growth econometrics – as suggested in section 5. In addition, the analysis can be extended to consider vulnerability at the sectoral and even product level. And lastly, additional indicators can be included to capture vulnerability in more detail.

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Appendix 1. Robustness Check: Alternative Normalization (z-Score Standardization)

This appendix presents the results of the robustness test in which the Import Vulnerability Index (IVI) was recalculated using z-score standardization of the indicators instead of the baseline min–max normalization on a 0–10 scale. Unlike the min–max approach, which rescales all indicators to a bounded range between 0 and 10, the z-standardization produces both positive and negative values depending on whether an observation lies above or below the sample mean. The purpose of this exercise is to assess whether the choice of normalization method affects the resulting index values and rankings. As shown in Table A.1, the IVI based on z-standardized variables (V3) closely mirrors the baseline results when it comes to the relative position of the countries. All countries maintained their rank based on this alternative normalization method. These findings confirm the robustness and stability of the composite index with respect to alternative normalization procedures.

Table A.1. Comparison of the baseline version of the IVI and one based on z-standardization.

country	Baseline	country	V3 z-standardisation
SWE	1.5	SWE	-1.1
DNK	2.0	DNK	-1.1
ROU	2.2	ROU	-0.3
EST	2.3	EST	0.0
SVK	2.4	SVK	-0.1
BGR	2.4	BGR	0.3
GRC	2.4	GRC	0.3
ESP	2.5	ESP	0.2
ITA	2.5	ITA	0.0
NLD	2.6	NLD	-0.2
FRA	2.8	FRA	0.3
DEU	2.9	DEU	0.8
LTU	2.9	LTU	0.1
FIN	3.0	FIN	-0.1
HUN	3.0	HUN	-0.1
BEL	3.3	BEL	-1.3
HRV	3.5	HRV	-0.1
SVN	4.0	SVN	-0.9
LVA	4.3	LVA	0.1
IRL	4.5	IRL	0.4
AUT	4.6	AUT	-0.4
CYP	5.1	CYP	0.8
PRT	5.2	PRT	-0.5
LUX	5.3	LUX	-0.8
MLT	5.6	MLT	-0.1
CZE	6.1	CZE	0.4
POL	6.6	POL	0.6