Strategic Autonomy and Supply Vulnerability

Mapping and Assessing Critical Dependencies in EU Ecosystems

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Abstract

This paper examines EU strategic import dependencies using product-level trade data for 2017-2021, identifying goods and raw materials relevant for the digital, green, and health ecosystems. Building on European Commission monitoring methods, we combine six import dependency and supply vulnerability indicators and identify potential criticalities within ecosystem relevance product lists. The screen identifies 45 candidate critical products. Digital goods dominate their import value, while lower-value intermediate inputs may create bottlenecks with wider consequences for production. We explain how unreliable access to these goods can constrain capacity utilisation, technology adoption, innovation and productive capabilities. Econometric analysis investigates the correlation of critical imports with aggregate exports across the ecosystems. This work develops an extended data-driven methodology and provides evidence-based insights into the trade-offs between openness and resilience. The paper helps inform the design of innovation and industrial policies aligned with strategic autonomy goals.

1 Introduction

The slowdown in global integration experienced since the Great Recession has been further strengthened by the pandemic and recent geopolitical tensions. A sequence of shocks – from the COVID-19 pandemic to Russia's invasion of Ukraine – has exposed the vulnerability of supply chains, especially in sectors deemed essential for economic security and innovation-led growth.

The robustness and resilience of global value chains (GVCs) to global and local shocks have come under scrutiny, highlighting that bottlenecks along these chains can quickly gain international relevance by disrupting trade and production. For instance, risks of shortages have recently emerged for critical goods, energy sources, and raw materials (e.g. some pharmaceuticals, gas, or semiconductors), due to breakdowns in "choke points" jeopardising the entire supply process and laying bare strategic dependency on concentrated foreign supplies.

Disruptions along supply chains have highlighted economic fragilities that might affect the achievement of key overarching goals set up in G7 discussions based on the guidelines established at the 27th Conference of the Parties to the United Nations Climate Change Conference (COP27). These concerns have become central in global and EU policy debates, where supply security and ecosystem resilience were framed as necessary conditions for achieving sustainability goals (Muench et al., 2022). While disruptions are a short-term issue and are, thus, unlikely to halt an equitable energy transition – a key goal –, they could slow it down and make it harder. In particular, the digital and green transitions are likely to drive up demand for specific products, which if compounded with supply disruptions, can lead to shortages or significant spikes in prices. Identifying and managing the fragilities related to raw materials that are key to the green and digital transition is crucial to safeguard the diffusion of the required technologies at affordable prices. Moreover, within this framework and considering the COVID-19 pandemic shock, it remains relevant to strengthen the global health architecture to prepare for possible future health crises. Against this background, public policy faces the challenge of supporting the robustness and resilience of global supply networks to shocks, while preserving the worldwide benefits of increasing specialisation and division of labour stemming from global integration.

The EU's ambitions for a twin transition – digital and environmental – have further highlighted the need for reliable access to critical inputs and intermediate goods. Strategic dependencies on external suppliers, particularly in concentrated markets, risk undermining industrial competitiveness and the capacity to innovate. These vulnerabilities raise

questions about the extent to which countries and regions can reduce exposure without compromising openness or efficiency. For instance, the Critical Raw Materials Act entered into force on 23 May 2024, establishing a framework to strengthen supply security and diversify sourcing (Council of the European Union, 2024).

Strategic dependencies matter for productivity through several mechanisms. A shortage of a complementary intermediate input can leave labour and capital idle even when that input accounts for a small share of costs. Unreliable access to digital equipment and green capital goods can delay investment and the adoption of technologies embodied in imported machinery. Supply uncertainty can also interrupt experimentation, raise the cost of innovation and discourage firms from investing in skills or organisational changes that complement new technologies. Persistent disruptions may weaken the supplier relationships and accumulated knowledge on which productive capabilities depend.

There are three areas for possible action according to the studies developed so far (Crowe and Rawdanowicz, 2023; Schwellnus et al., 2022b): i) limit excessive dependency on few providers by diversifying import sources; ii) reshape supply chains by encouraging production to return home or to move to closer (friendlier) locations – the so-called reshoring, near-shoring, or friend-shoring; and iii) build stronger inventories for selected key products.

The productivity implications of reducing dependencies are also ambiguous. Diversification, inventories and substitute technologies may preserve production and investment during disruptions, but involve search costs, working capital and potentially higher input prices. Reshoring can sacrifice gains from specialisation, scale and access to foreign technology. The relevant policy objective is therefore reliable access to essential inputs at a proportionate cost; import dependency may signal a potential exposure but alone does not establish a case for intervention.

To support and inform this policy process, this paper extends the existing monitoring framework (e.g. Arjona et al., 2023), based on measures of strategic import dependency, covering the EU economies.[1] Our approach integrates three components: import dependency, measured using product-level trade data; supply vulnerability, assessed via indicators of partner concentration and risk exposure; and potential ecosystem relevance,

[1] We refer to EU as the Member States of the European Union as of 2026.

assigned through published product lists and classifications. The empirical analysis identifies candidate products for more detailed assessment of digital, green and health-related dependencies, rather than establishing that every listed product is indispensable or exposed to a specific geopolitical shock. Finally, the paper discusses some empirically based policy implications looking at the efficiency and security trade-offs of various policy approaches aimed at strengthening the robustness (ability to minimise exposure to risks) and resilience (ability to resume operations after a negative shock) of GVCs and trade flows.

Goods are identified as critical based on their import dependency (European Commission 2021) and supply vulnerability, using granular trade data from the CEPII-BACI database (Gaulier and Zignago, 2010). Specifically, the key critical goods are those associated with sensitive ecosystems identified based on existing publicly available lists of strategic green, digital, and health products, as well as raw materials.

The 2017–2021 screen identifies a limited number of candidate critical products for the EU considered as a single area. Some products rely heavily on a few external suppliers, particularly China, while several metals and minerals combine concentrated export supply with limited intra-EU trade. These results suggest that interventions should target specific products rather than apply across the board. However, the limited number of identified products does not imply that aggregate strategic vulnerability is low, since product counts do not measure the production losses that bottlenecks may cause. The consequences of a disruption depend on actual uses, inventories, supplier switching and the availability of substitutes, which require evidence beyond bilateral trade flows.

The findings confirm that the EU countries largely rely on each other in their economic activity, with some specific but crucial external fragilities. It is also a matter of economic dimension: being the largest markets in the world, EU countries can largely source intermediate inputs from their own domestic market or within the group and obtain low reliance on imports from external sources, while also increasing diversification.

The paper also contributes to the policy debate. By focusing on critical goods in sensitive and strategic ecosystems, policymakers can identify the extent to which their economy's potential and resilience are dependent on just a few trading partners or products. High geographic or product trade concentration can lead to strategic vulnerabilities and expose countries to global economic shocks or geopolitical instability. In turn, policymakers can use this information to promote trade and technological diversification along supply chains as

well as stockpiling (if desirable and possible) to increase the robustness and resilience of their economies while preserving fair and open trade.

By bridging policy analysis and empirical research, this work informs the design of innovation and industrial policies that enhance resilience without resorting to protectionism, preserving openness while mitigating strategic risks. It also connects with analyses on the role of innovation in strengthening strategic autonomy (Edler et al., 2023; Cattani et al., 2023) and the design of policy instruments to support industrial competitiveness (Montresor and Vezzani, 2023; Rodrik, 2004).

This paper uses 2017–2021 trade data. The window includes the pandemic but ends before Russia's invasion of Ukraine in 2022 and the subsequent implementation of the Critical Raw Materials Act. The policy discussion therefore uses these results as an historical baseline and an illustration of a monitoring method, not as a current inventory of EU dependencies or an evaluation of recent policies. Changes in sourcing, technology, trade restrictions and productive capacity after 2021 may alter both the products selected and their rankings. Investigating the evolution of dependencies and the role of policy interventions in addressing them is left for future research.

The rest of the paper is structured as follows. The next section provides working definitions and describes the methodology to identify critical goods and import dependency. The third section presents the main descriptive evidence. The fourth section presents a descriptive econometric exercise on import–export associations. And, finally, the fifth section concludes by discussing policy implications.

2 Defining and measuring strategic dependency

2.1 What we mean by "strategic dependency"

In this paper, the term "strategic dependency" refers to a strong reliance on imports potentially affecting a country's ability to access specific goods or inputs that are key for the functioning of supply chains or satisfying final demand. To analyse these dependencies, it is necessary to identify which goods or inputs warrant further scrutiny at a granular level. Here, "critical" denotes a screening outcome conditional on the indicators and product lists, rather than proof of indispensability or expected economic loss. The identification of such criticality is achieved in three steps following a bottom-up, data driven approach (Figure 1). The first two steps allow to select the products that are both import-dependent and

vulnerable, while the third step further restricts the set of products to those belonging to sensitive or strategic ecosystems, considered pivotal for EU economies:

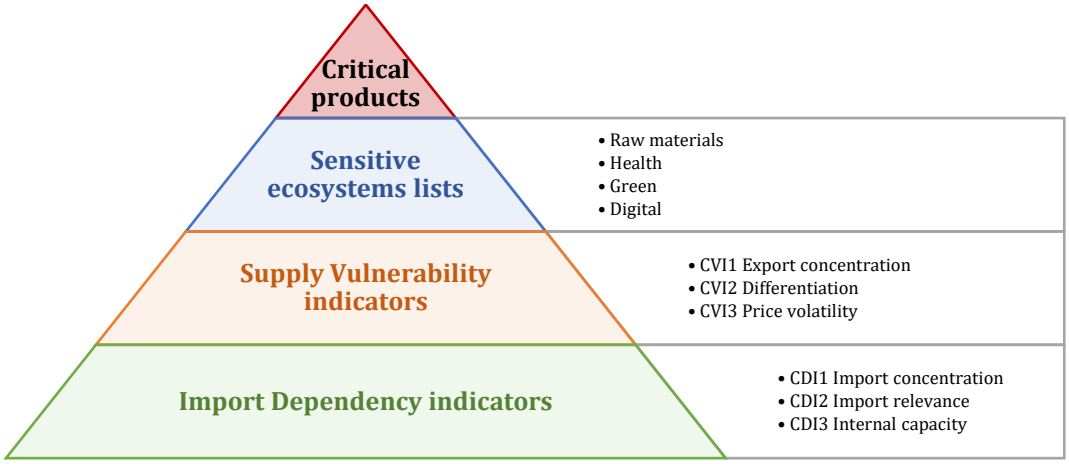
(i) Import *dependency* of HS 6-digit products on extra-area imports is defined in terms of high import concentration from few sources, high relevance of extra-EU imports, and low internal capacity. We identify import-dependent goods following the methodology proposed in European Commission (2021) and Arjona et al. (2023).[2] Adopting this approach, it is possible to compute, for each HS 6-digit product three core dependency indicators: import concentration (CDI1), import relevance (CDI2), and internal capacity (CDI3) (Arjona et al., 2023).

(ii) Second, we assess possible supply-side risk or *vulnerability* using world export concentration (CVI1), cross-exporter unit-value dispersion (CVI2), and intertemporal unit-value volatility (CVI3). Export concentration describes the breadth of observed supply. The two unit-value indicators add information about price heterogeneity and instability, but do not directly measure technical substitutability, spare capacity or the probability of a supply interruption. Their role is to flag import-dependent products for further investigation.

(iii) Third, to select the products relevant for economies and supply chains, we consider those that are included in the existing lists and classifications (institutional or academic) of HS6-digit products and belonging to *sensitive or strategic ecosystems*. Import-dependent products meeting the vulnerability screen and mapping into one or several of these ecosystems are labelled as candidate critical products. Specifically, the focus is on four categories of goods in sensitive ecosystems: health, green, and digital products and raw materials, which we define in the section 2.2.3 below.

[2] A similar approach, also referring to the one proposed by the European Commission, is also taken in Berthou et al. (2024).

Figure 1 – A bottom-up data-driven approach



Source: authors' own elaboration

2.2 An extended methodology to identify critical products

2.2.1 Import Dependency

Dependency is measured according to three core indicators (CDIs), mentioned above (European Commission, 2021; Arjona et al., 2023). The first indicator looks at the concentration across countries of EU imports from the rest of the world. Import concentration is measured as the 6-digit product level Herfindahl-Hirschman index:

$$CDI_1 = \sum_{i=1}^{N} s_i^2 > 4000$$

where s_i is origin country i share in total extra-area imports of a given product, and N is the number of countries. The threshold chosen for the Herfindahl-Hirschman index corresponds to a very high market concentration; a value of 4,000 indicates that extra-area imports depend mainly on 2.5 foreign suppliers.[3]

The second indicator looks at the relevance of extra-EU imports over the total import of individual products to detect those for which EU countries heavily rely on sources external to this group:

[3] The reciprocal of the Herfindahl-Hirschman index (divided by 10,000) can be interpreted in terms of number of suppliers. An index of 10,000 indicates monopoly, i.e. one supplier. A symmetric duopoly would correspond to an index of 5,000; and so on.

$$CDI_2 = \frac{Extra\ EU\ import\ value}{Total\ EU\ import\ value} > 0.5$$

This indicator thus identifies products whose main source is outside the EU area.[4]

The third dependency indicator considers the existence of internal capacity as a possible source of import substitution. It takes the ratio between extra EU imports and EU total exports of a single product, where exports are a proxy for internal production capacity:

$$CDI_3 = \frac{Extra\ EU\ import\ value}{Total\ EU\ export\ value} > 1$$

According to this indicator, there is a possible dependence when extra-area imports exceed total area exports of the product.

Overall, import-dependent goods are those satisfying *all three indicators* in at least two years within the 2017-2021 period.

2.2.2 Supply Vulnerability

The concept and measurement of import dependency has been explored in the literature, both academic and policy oriented. The measures discussed thus far look at whether imports of a country are concentrated in terms of country of origin or whether the country could produce them domestically. A second key issue is the extent to which countries could, if necessary, find another supplier; after all, it is possible that while a country might be importing the vast majority of a product from another country, a third country might also be a large potential supplier of the same product and that, should import from the original supplier become impractical, it would be possible to turn to the third country as a new alternative supplier. If that is the case while the country's import would still appear to be concentrated, its vulnerability in this product would be tempered.

Export supply vulnerability refers to the opportunities of diversification across alternative external suppliers and supply stability. This dimension aims at capturing the possible sources of vulnerability of the import-dependent goods identified in the previous step. Rather than just refine the list of the identified goods, the main aim here is to assess the opportunities for diversification and possible supply constraints of import-dependent goods. Import-dependent goods with one or multiple sources of vulnerability are candidate critical goods; on the contrary, import-dependent goods with viable diversification opportunities

[4] Intra EU trade (import and export) includes bilateral trade flows in which both trade partners belong to the EU, while extra EU trade includes bilateral trade flows in which one trade partner does not belong to the EU.

and no meaningful supply vulnerabilities are less likely to be problematic. Export supply vulnerability is captured by three core vulnerability indicators (CVIs).

The first indicator considers export concentration across non-EU exporters by means of a 6-digit product level Herfindahl-Hirschman index:

$$CVI_1 = \sum_{i=1}^{N} z_i^2 > 4000$$

where z_i is non-EU exporter i's share in total non-EU exports to the world of a given product, and N is the number of countries. The threshold chosen indicates that non-EU exports originate mainly from 2.5 countries (similarly to the CDI_1 indicator). This indicator has been used also by the European Commission (2021) and Arjona et al. (2023).[5]

The second indicator measures the dispersion of unit values across non-EU exporters. Wider distributions may reflect differences in product mix, quality, production costs or pricing within an HS6 category. They can motivate closer examination of supplier switching costs, while whether suppliers can deliver technically equivalent products at the required scale requires further case-by-case evaluations. The indicator is the interquartile range of the product unit-value distribution, normalised by its median and the number of countries: [6,7]

$$CVI_2 = \frac{uv_{75} - uv_{25}}{(n-1)uv_{50}} > \text{median}(CVI_2)$$

where uv represents the unit value at the corresponding percentile, and n is the number of countries within the interquartile range. As product-level cross-country price distributions are highly skewed and may contain outliers, the interquartile range is particularly appropriate for its robustness. The normalisation allows for cross-product comparisons

[5] It is worth noting that vulnerability can also come from a highly concentrated supply within the EU bloc. However, in line with the European Commission approach, the within-bloc concentration is much less likely to represent a strategic issue.

[6] Observed export price differentiation can be due to several causes like different quality, different production costs, pricing to market and market power, barriers to trade, transport costs, exchange rates (our data are in US dollars) etc. Whatever the cause, price dispersion signals that if a country were to switch suppliers it would likely face a different price and possibly get a different quality or variety of the good. Effective diversification opportunities also depend on these considerations.

[7] Unit values are defined as export value (US dollars) divided by quantity (in kilograms) for each product and exporter to the EU bloc and each year. Unit values are a commonly used proxy of export prices. Possible distortions regard: i) the fact that quantities are measured in kilograms, which is not a relevant unit for all goods; ii) the within HS6 product code compositional effects across different varieties of the good whereby a higher unit value may be due either to higher prices of each variety or to the larger weight of highly priced varieties. Although imperfect, unit values are the most granular proxy of export prices. In the international trade literature unit values have also been used as a proxy for quality (assuming that higher prices signal higher quality; see Khandelwal, 2010).

since the interquartile range is expressed relative to the median, while the number of countries accounts for the density of the distribution. The resulting statistic is a normalised dispersion measure, not an elasticity of substitution or a measure of supplier switching costs. Products in the upper half of its cross-product distribution receive a risk flag. This relative threshold is intended for broad screening; products below it may still face technical, regulatory or capacity barriers to diversification.

The third vulnerability indicator looks at price volatility over time. High unit-value volatility indicates instability in observed trade values per kilogram. It can reflect supply or demand shocks, exchange-rate movements, price trends or changes in the composition of traded varieties and cannot by itself identify supply vulnerability. Differently from the previous indicators, which consider between-country price differences at a given time, the focus is now on the overall price volatility of products over a given lapse of time. Because the distribution of prices over time presents very different characteristics than the cross-country distribution, CVI_2 and CVI_3 are based on different indicators.[8] We compute the 6-digit product level price volatility of non-EU exports as the coefficient of variation of the price level (unit value) during 2017-2021:

$$CVI_3 = \frac{\sigma_{uv}}{\mu_{uv}} > \text{median}(CVI_3)$$

where σ denotes the 5-year standard deviation of the product price level (unit value), and μ is the 5-year mean. [9] Products in the upper half of the cross-product distribution receive a volatility risk flag. With only five annual observations, this statistic is sensitive to trends and

[8] Namely, cross-country price distributions tend to be very wide and asymmetric, with a long right tail and outliers. On the contrary, over time, prices tend to move around a level or a trend. In the former case, outliers are countries that sell at very high or very low prices, but precisely because they are outliers, they do not represent the mass of the cross-country distribution. In the latter case, high volatility can be due to outliers, that is an exceptional price spike or drop, and this is precisely what CVI3 captures. So, for CVI2 the interest is mainly on structural characteristics of the distribution and its percentiles, while for CVI3 large exceptional deviations matter.

[9] Other than the coefficient of variation of the price level, it might be relevant to look at price changes to take into account upward or downward trends. Currently, the indicator, while covering the same period as the others, is time-invariant; considering that we use annual data, a five-year window is the minimum to look at price volatility. Furthermore, while here we focus on annual volatility, it might be even more informative to use high-frequency data to better capture short-run shocks (of course if these shocks are strong enough, they will show in the annual statistics). Moreover, in practice, price volatility is likely to be negatively correlated with market size, which in turn is largely determined by the number of exporters. This implies that goods with few highly concentrated exporters may tend to display high price volatility in the data. Yet, theoretically, even a small monopoly may sell at stable prices, thus looking at price volatility adds information and helps to better characterise vulnerabilities.

exceptional years, including the pandemic; it is not an estimate of the probability of a future supply disruption.

Overall, as the goal is identifying the possible sources of vulnerability among import-dependent goods and excluding products that are unlikely to be vulnerable, products are classified as vulnerable if satisfying *at least one of the three indicators* in at least two years within the period 2017-2021 (CVI3 is calculated once over the full five-year window and is therefore time-invariant). On the contrary, import-dependent goods with no sources of vulnerability are considered not critical: for these goods, while diversification is needed, implementing it does not seem to pose significant challenges.

2.2.3 Sensitive Ecosystems

The final step links the trade screen to three policy domains—health, green and digital products—and a cross-cutting raw-material category. We do this through available public lists so as to focus on products with a relevant role within the selected sensitive ecosystems in the EU economies. List membership is evidence of relevance, not proof that a product is essential to an ecosystem. Published lists and classifications also make the selection rules more explicit. Categories can overlap, and broad HS6 descriptions can combine strategic and other uses. The sources and interpretation of the mappings are as follows:

1. Raw-material products are selected using the product coverage in Rietveld et al. (2022). The label "CRM" is retained as shorthand for this source-based category; it should not be read as certifying that every HS6 code coincides with the EU statutory list of critical or strategic raw materials.
2. The health-related screen uses BEC Revision 5 category 7, excluding products whose end use is consumption only (United Nations, 2016). Category 7 also covers education, culture and sport, so this is a broad screen rather than a dedicated list of essential medical goods.[10]
3. Andreoni et al. (2023) provides a reference classification for digital production technologies. Bontadini and Vona (2023) concerns green goods, rather than digital goods, and provides a reference for the green domain. Applying these sources to trade data requires attention to the source classification and concordance: membership in

[10] The health-related screen uses BEC Revision 5 category 7, "Health, pharmaceuticals, education, cultural, sport", excluding products whose end use is consumption only. The category extends beyond healthcare, so this rule cannot by itself identify essential medical products (United Nations, 2016).

a broad product code does not establish that all its trade serves the corresponding technology or environmental use.

The final list includes 562 product codes.

2.3 Data sources

The main data source is UNCOMTRADE, which is available in a harmonised format from the CEPII-BACI dataset (Gaulier and Zignago, 2010). Gross trade data contain rich information on the products that each country exports and imports from all trading partners and cover around 5000 products and 200 countries. The information is complemented with the classification of HS products into broad economic categories (BEC) to distinguish between intermediate, capital and final goods (United Nations, 2016). For the descriptive econometric exercise we use monthly trade data for EU countries from Comext, compiled by Eurostat.

Product-level trade data offer granular information for dependency monitoring, but the present analysis is retrospective. The 2017–2021 window provides a common HS classification and a multi-year baseline. Updating the exercise beyond 2021 would require harmonising later HS revisions and reassessing the product lists and sourcing structure. Gross trade flows also omit domestic sales, firm-level uses, inventories and indirect dependencies, limiting conclusions about exposure and the production consequences of shortages.[11,12]

3 Critical products and import dependency of EU countries: results

Applying the screen to around 5,000 traded HS6 products yields 45 candidate critical goods (Figure 2). They combine the specified import-dependency conditions, at least one supply-risk flag and membership in the selected ecosystem lists. This is a shortlist for further

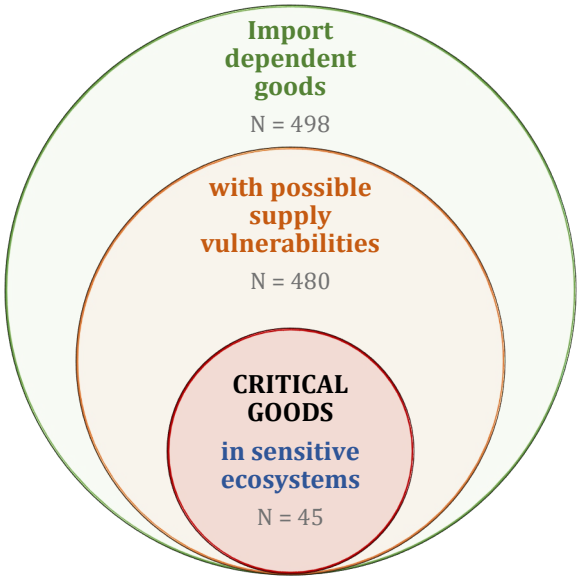
[11] Trade data also come with some limitations. A relevant one regards the fact that only direct bilateral flows of manufactured goods between countries are registered, which might provide a somewhat biased picture of meaningful trade patterns when trade diversion and re-routing through third countries are relevant. Recently, some re-routing and friend-shoring attempts seem to have taken place due to geopolitical tensions. Another important aspect not fully accounted for by trade data regards input-output linkages between countries and sectors, which would help precisely identify bottlenecks along supply chains and their implications.

[12] Inter-country input-output tables (ICIO), such as those compiled by the OECD, can also be used to assess the extent and characteristics of the linkages possibly affecting the functioning of the supply chains even if ICIO data are relatively less timely and disaggregated than trade data. Especially the lack of detailed industry information can limit the accurate identification of critical goods.

investigation; the screen does not demonstrate that every product lacks substitutes, is indispensable to production or would generate cascading disruption.[13]

The contribution is incremental to existing European Commission and OECD approaches. We retain the Commission's trade-based dependency logic and export-concentration measure, supplement them with two unit-value risk indicators, apply a multi-year screen and connect the selected products to explicit ecosystem lists. Arjona et al. (2023) already identifies dependencies in sensitive ecosystems and examines single points of failure in world trade networks. Berthou et al. (2024) combines granular trade and input-output information to map vulnerabilities and simulate shock transmission. Our exercise provides a complementary monitoring application. Different product nomenclatures, periods and selection rules also prevent direct comparisons of headline product counts.[14]

Figure 2 – From 5000+ products to 45 critical goods



[13] See the Appendix, Figure A1 for the detail on all products and Table A1 for the full list.

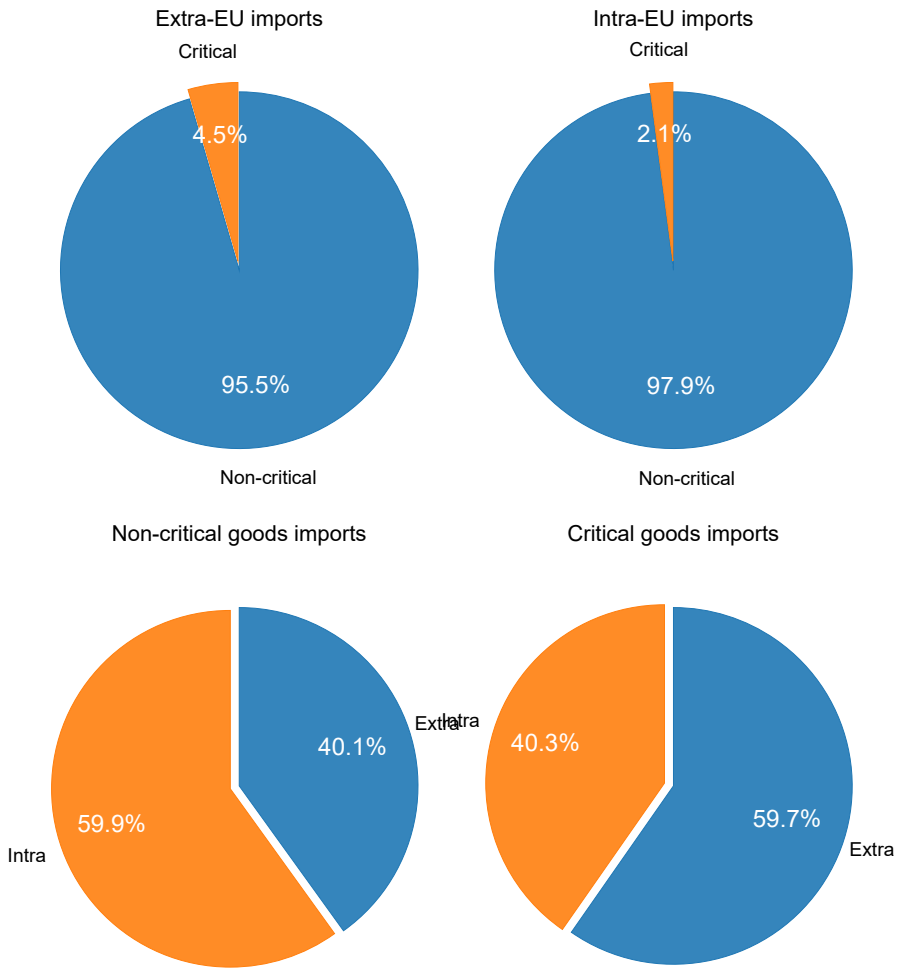
[14] The European Commission (2021), considering only dependency indicators, identifies 390 goods for the EU in 2018 (using the same data and granularity of this paper); they then restrict the list to 137 through a qualitative process of selection of ecosystems; of these, 34 goods are identified as vulnerable. In a subsequent paper by the European Commission (Arjona et al., 2023), using a revised methodology applied to Eurostat-Figaro data for the period 2017-2019, 564 import-dependent products are identified (out of about 9,000 CN8 codes), of which 204 are considered belonging to sensitive ecosystems according to a further qualitative selection.

In what follows, we illustrate some of the goods for which the EU displays high import dependency, might be exposed to vulnerabilities in case of shortage, and map into sensitive/strategic ecosystems:

- Several selected raw-material products, including lithium compounds, magnesium and manganese, can be relevant to manufacturing and technology supply chains.
- Other mineral inputs, including borates and feldspar, appear in the source-based raw-material category; their strategic uses require product-specific assessment.
- Various organic and inorganic chemicals relevant to digital and pharmaceutical industries (alkaloids, antibiotics, borates and vitamins).
- Some advanced machinery and hi-tech equipment (e.g. automatic data processor machines).

As shown in Figure 3, critical products represent 4.5% of extra-EU imports, but only 2.1% of intra-EU trade. Unsurprisingly, for such products, EU countries rely much more on external suppliers than on internal capacity. Similarly, about 60% of non-critical goods imports are sourced internally, while about 60% of critical goods imports come from external sources.

Figure 3 – EU trade in critical and non-critical products

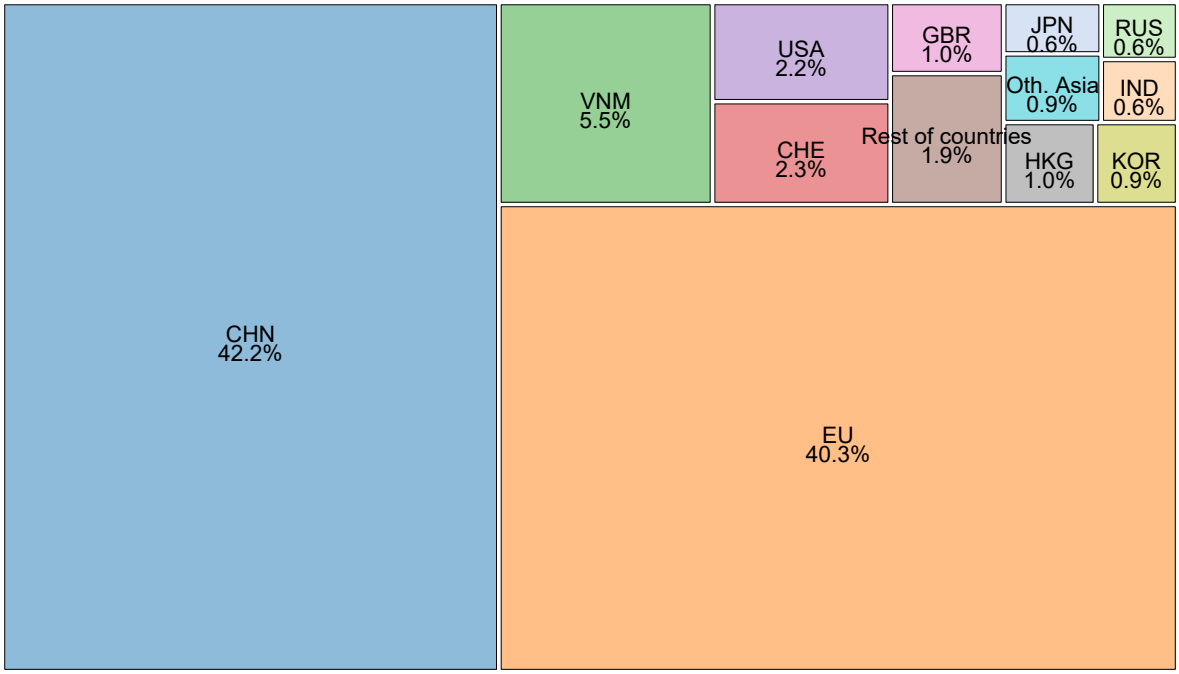


Note: top-left panel, critical goods are 4.5% of all extra-EU imports; top-right panel, critical goods are 2.1% of intra-EU imports; bottom-left panel, extra-EU sources account for 40.1% of non-critical goods imports; bottom-right panel, extra-EU sources account for 59.7% of critical goods imports. Year 2021.
Source: authors' elaborations CEPII-BACI data.

The data suggest that critical goods are disproportionately imported from China, which is the main source of import dependency (Figure 4). More precisely, 42.2% of critical goods imports come from China, 5.5% from Vietnam, 2.3% from Switzerland, 2.2% from USA, 1.0%

from the UK, 1.0% from Hong Kong, 0.9% from South Korea (and 40.3% from the EU area itself).[15]

Figure 4 – Imports of critical products by source country or region



Note: the figure displays the country shares of critical goods imports; e.g. 40.3% of critical goods imports come from the EU area itself (intra-area, this is the same number from the bottom-right panel of Figure 3). Year 2021.
Source: authors' elaborations CEPII-BACI data.

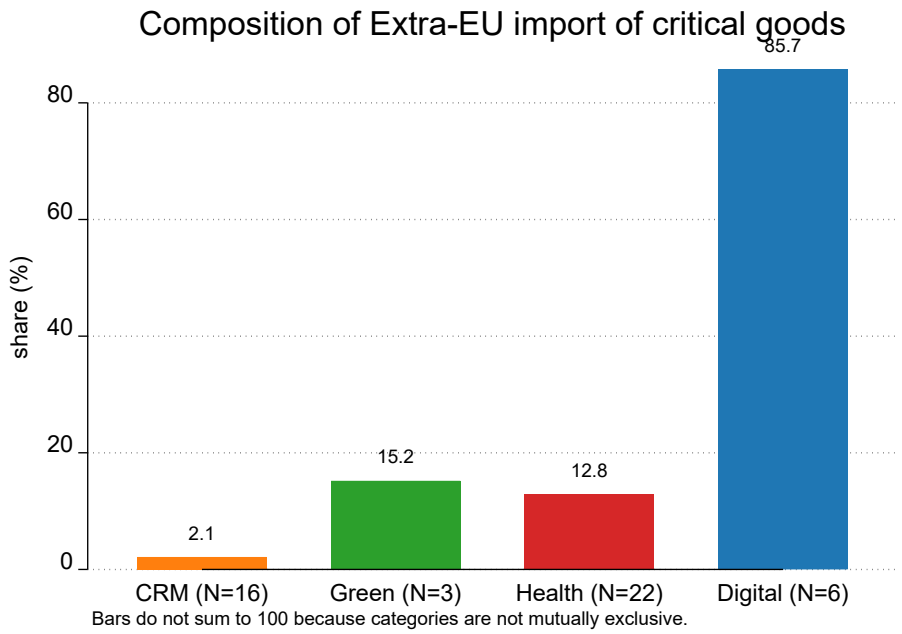
3.1 Critical goods across ecosystems

Import dependencies are not uniformly distributed across ecosystems. Among the 45 candidates identified, 16 belong to the raw-material category, 22 to the broad health-related screen, 6 to the digital category, and 3 to the green category (2 products overlap: 1 belongs to both health and digital, and 1 to green and digital categories). Considering the relevance of raw materials for all the subsequent production stages across several ecosystems, this result motivates closer assessment of bottlenecks and diversification opportunities for this

[15] As noted above, gross trade data do not account for re-export. As a result, imports from Vietnam or Mexico may partly reflect products produced in China or the US and repackaged in Vietnam and Mexico, respectively. Hence, these measures might underestimate dependency vis-à-vis large economies that trade indirectly.

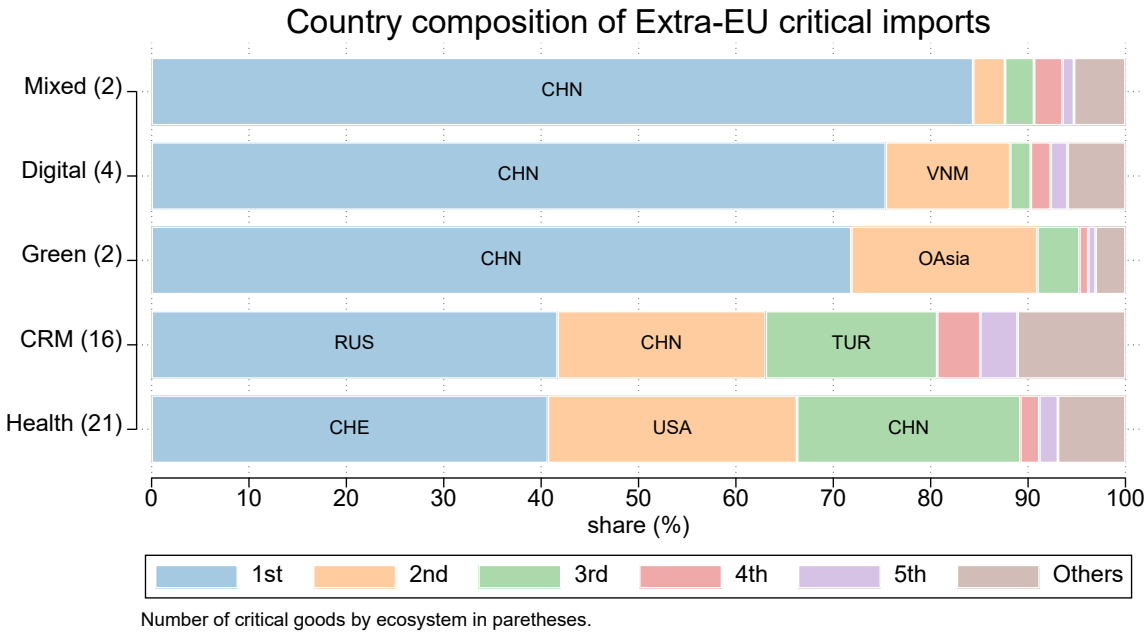
category of goods. As shown in Figure 5, however, the product number does not correspond to the imported value: digital critical products, despite being few, make up 85.7% of all critical imports in 2021, while raw materials represent only 2.1%. Thus, digital goods dominate the import value selected by this screen, especially considering their strategic importance in driving technological leadership, economic growth, enhancing productivity, and shaping the future of global trade. This dependency becomes particularly concerning when supply chains are concentrated in a few countries, potentially exposing economies to significant risks in the event of geopolitical tensions or disruptions. Inspecting Figure 6, this is exactly the case: China is by far the main supplier of digital and green critical products. The country makes up almost 75% of critical digital imports. Furthermore, over 70% of green critical imports and more than 20% of health critical imports are sourced from China. In all ecosystems, concentration is very high as the top five suppliers cover about 90-95% of imports. In relative terms, the relevance of China is largely reduced for the raw materials, whose import sources are more uniformly distributed across suppliers.

Figure 5 – Critical goods imports across ecosystems.



Note: The number of key critical goods (HS6 codes) in each ecosystem is in parentheses. Year 2021.
Source: authors' elaborations CEPII-BACI data.

Figure 6 – Concentration of imports of critical goods across countries by ecosystem



Note: import shares of top 5 extra-EU countries on total critical goods imports. Year 2021.
Source: authors' elaborations CEPII-BACI data.

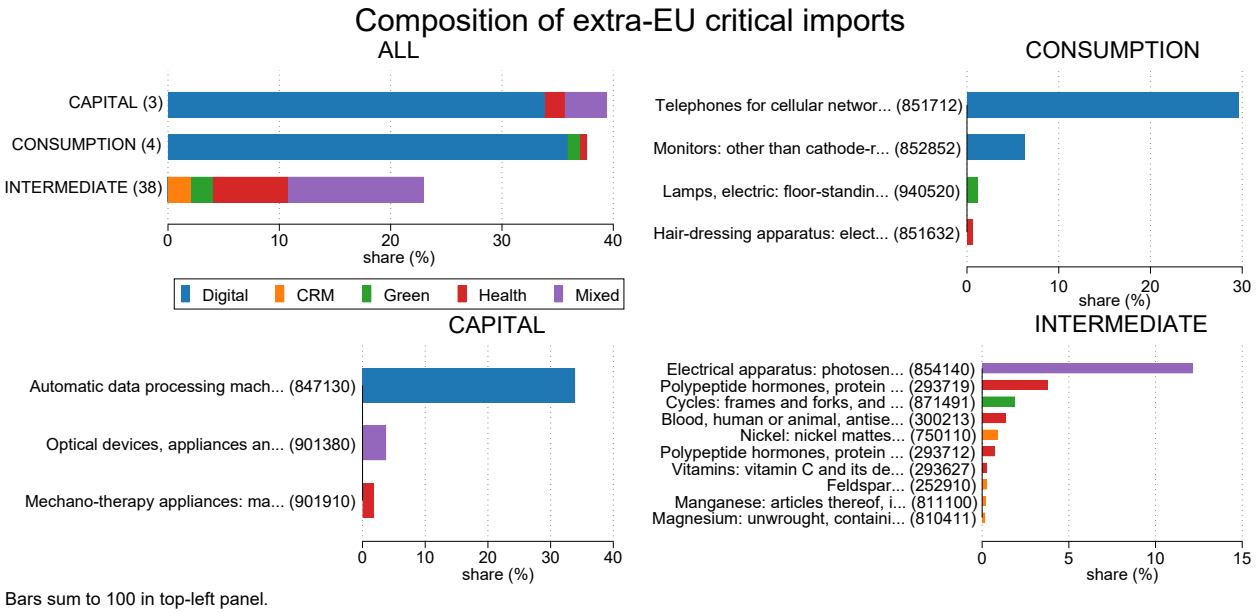
Figure 7 provides further information by splitting the goods by end use according to the BEC classification into consumption, capital and intermediate as well as by single HS6 product. Imports of critical consumption and investment products are concentrated mainly in the digital ecosystem (consumption and capital goods largely correspond to advanced manufacturing products), while intermediates span other ecosystems. The top-left panel shows the composition of critical imports: about 38% are consumption products, less than 40% are capital goods, and the rest are intermediate goods. Intermediates mainly correspond to chemicals and raw materials; they are numerous, 38 out of 45 critical goods, but their import share is comparatively small. The majority of consumption and capital critical goods imported belong to the digital ecosystem, but two specific products stand out for their imported value which together cover almost two-thirds of overall critical imports: mobile phones (telephones for cellular network, 851712; a product with consumption and capital uses), which represent almost 30% of critical imports, and computers (automatic data processing machines, 847130; a product with capital and consumption uses), which make up about 34% of critical imports. Most intermediate goods are raw materials or belong

to the health ecosystem. Nickel (750110), manganese (811100) and magnesium (810411) are among the main raw materials in terms of import share.

Figure 8 looks at the share of imports sourced from outside the EU area in total intra+extra imports. The shares are all above 50% by construction (as per the CDI_2 indicator), but the figure allows to evaluate the extent of the import dependency. Imports of critical products of all categories are overwhelmingly from outside the EU area, especially intermediates. The top-left panel shows that intermediate goods are highly import-dependent. For many critical intermediates, more than 80% of imports come from third countries (bottom-right panel). Over 90% of optical devices and almost 60% of computers (bottom-left panel), and more than 50% of mobile phones (top-right panel) are imported from extra-EU sources.

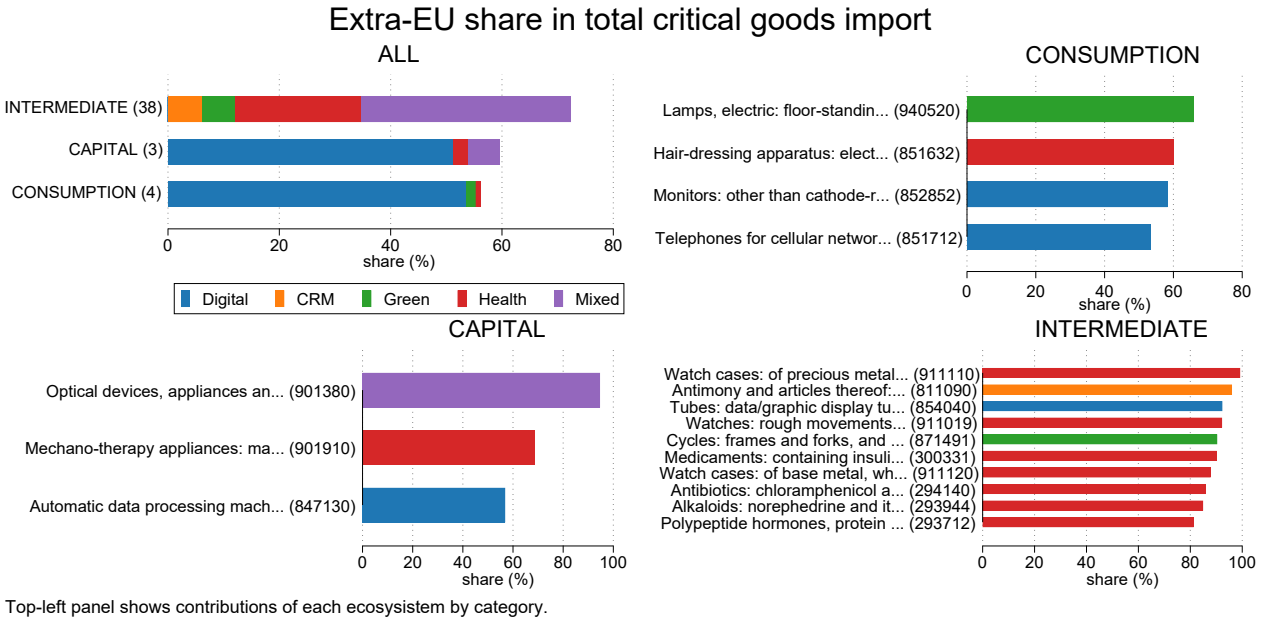
Therefore, the overall picture seems somewhat dichotomic. On the one hand, many dependencies are for health products and raw materials, with relevant possible consequences along supply chains. For these goods, import dependency is particularly strong with cases in which imports from third countries represent more than 80% of total intra+extra imports. However, in terms of imported value the relevance of raw materials is very small, and China is not the only major source of dependency (even if it can be in specific cases). On the other hand, while the dependencies in the digital and green ecosystems concern just few products, they represent the bulk of critical imports and the dependency on China is a major strategic issue.

Figure 7 – Composition of critical imports by Broad Economic Categories and Ecosystem



Note: the figure displays the import shares distribution of critical goods imports by type of good (BEC classification; top-left panel), for critical consumption goods (top-right panel), for critical capital goods (bottom-left panel), and for the top 10 critical intermediate goods. Rankings by import shares on total critical goods imports. In all 4 panels, the denominator is the total extra-EU critical import; bars sum to 100 only in the top-left panel. Year 2021.
Source: authors' elaborations CEPII-BACI data.

Figure 8 – Extra-EU share of total critical import by Broad Economic Categories and Ecosystem



Note: the figure displays the extra EU share of critical import by type of good (BEC classification; top-left panel), for critical consumption goods (top-right panel), for critical capital goods (bottom-left panel), and for the top 10 critical intermediate goods. Rankings by import shares of total critical goods imports. Every bar is extra EU import over total intra+extra import of the category. Year 2021.
Source: authors' elaborations CEPII-BACI data.

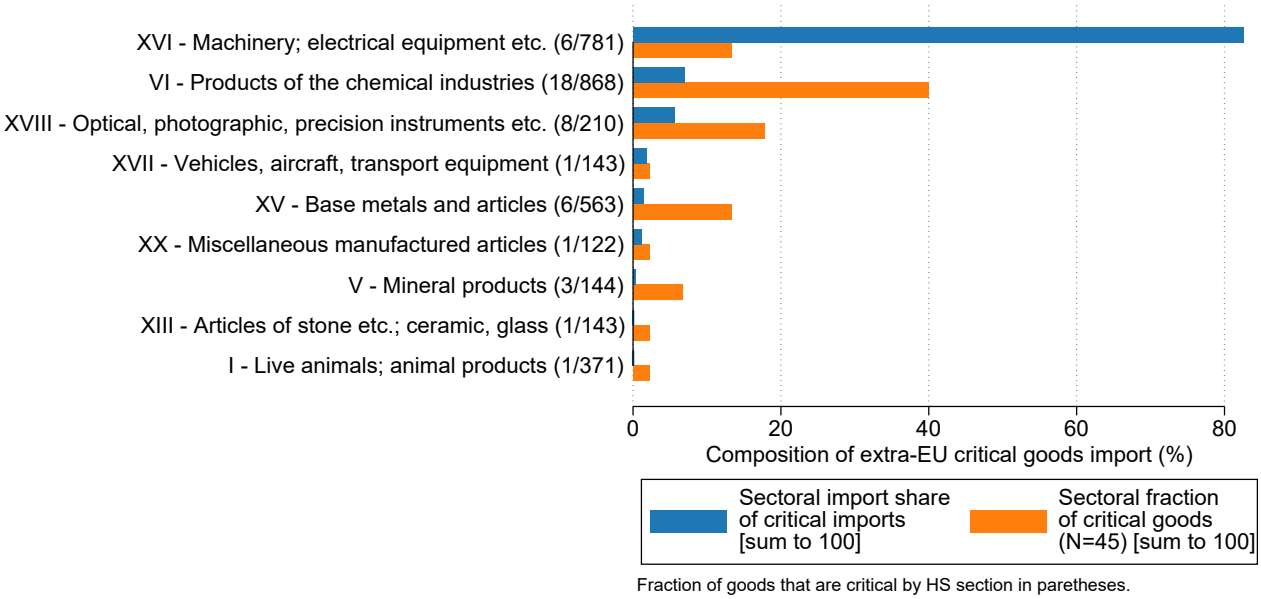
3.2 Critical goods across HS Sections

Grouping goods into sections – reflecting broadly defined economic sectors, arranged according to product characteristics, degree of processing or technological complexity – shows that the highest number of critical goods belongs to the "Products of the chemical industries" category (18 out of all 45 key critical goods; the section includes a total of 868 product codes), followed by "Optical, photographic, precision instruments etc." (8 products) (Figure 9).[16] However, despite being relatively numerous, the import value of these goods is largely surpassed by the 6 critical goods in "Machinery; electrical equipment etc." accounting for about 82% of all critical goods imports. Overall, the EU area strategic dependencies refer

[16] Goods (6-digit codes) can be grouped into broader Harmonised System (HS) sections. The Harmonised System is organised into 21 Sections, which are further subdivided into 96 Chapters (2-digit), then about 1,200+ Headings (4-digit) and 5,000+ Subheadings (6-digit), to which we refer as goods or products.

to two main productive activities: first, for some advanced manufacturing products with a very high import value, and, second, for some chemicals and other raw materials that, despite a negligible import value, are particularly relevant for production processes and supply chains.

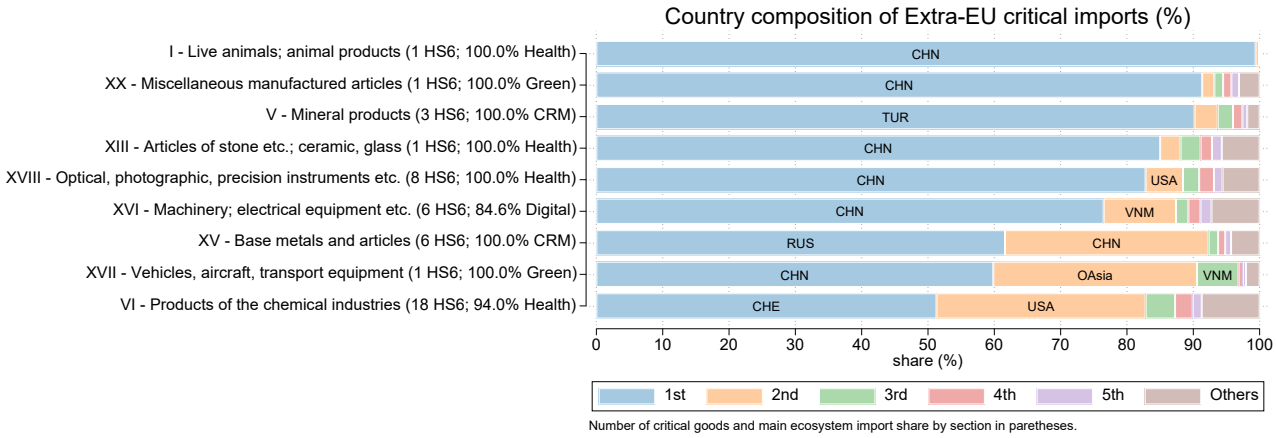
Figure 9 – Number and import value share of critical products, by HS sections.



Note: the figure displays the number and the import shares distribution of critical goods imports across HS section. The number of critical goods and the total number of HS6 codes in each section are shown next to the sector description. Year 2021.
Source: authors' elaborations CEPII-BACI data.

Within sections, there is a very low level of sourcing diversification as critical goods imports are highly concentrated among a few suppliers: the top five countries always account for more than 90% of imports. The evidence that China is a source of dependency is visible across the sectors covered by HS sections. Moreover, in most of them, more than half of critical goods imports come from China, particularly in some advanced manufacturing sectors. China's import share is over 75% in "Machinery; electrical equipment etc." and over 90% in "Miscellaneous manufactured articles" (Figure 10). Turkey is the main source of critical "Mineral products", followed by China. Other than China, the critical "Products of the chemical industries" are also sourced from Switzerland and the USA. Vietnam is a relevant supplier of "Machinery; electrical equipment etc." About 30% of critical products for "Vehicles, aircraft, transport equipment" come from Other Asian countries. Lastly, the import shares of critical "Base metals and articles" are relatively uniformly distributed between Russia and China.

Figure 10 – Concentration of imports of critical goods across countries (5 main exporters)



Note: import shares of top 5 extra-EU countries on total critical goods imports. Year 2021.
Source: authors' elaborations CEPII-BACI data.

3.3 **Sources of vulnerability**

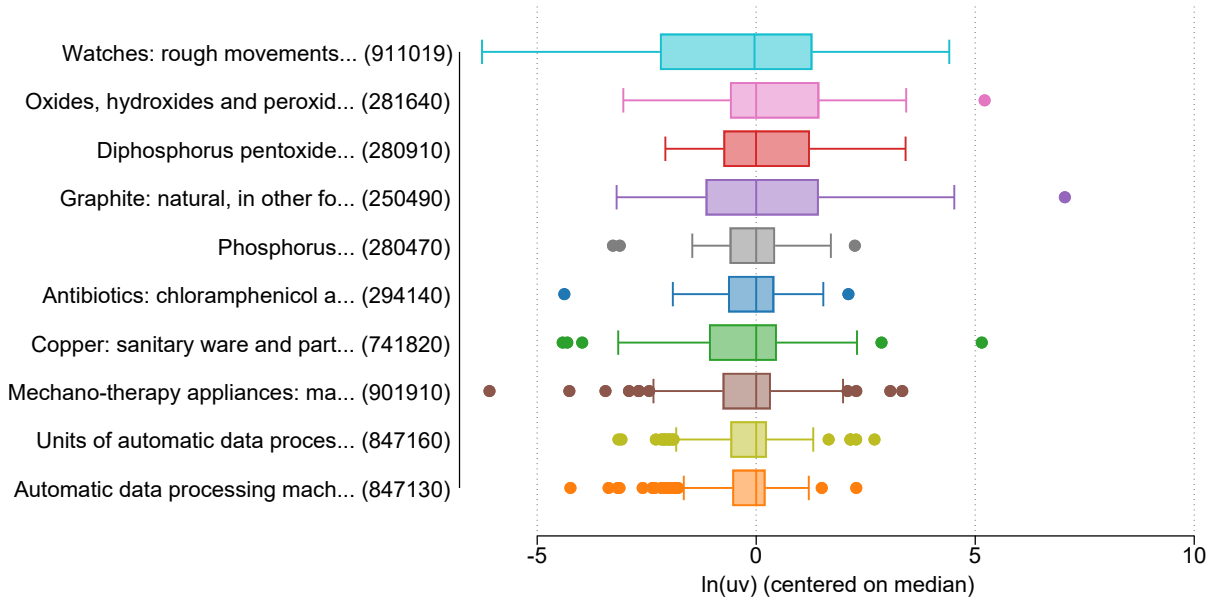
Critical products were selected looking to both import dependency and vulnerability criteria. To complement these findings, we further investigate whether vulnerability originates from a lack of substitutability or from price volatility. For instance, a critical product might be highly specific, so that there are only few alternative suppliers; but it might not be the case for another critical product, for which diversification might be easier, and whose high price volatility implies uncertainty on future import costs. Policies should therefore encourage diversification in the first case while they have to alleviate uncertainty in the second example.

The indicators distinguish concentration of observed export supply from dispersion and volatility of unit values. Concentration motivates investigation of alternative suppliers and capacity; unit-value dispersion calls for evidence on product specifications, quality and switching costs; volatility motivates examination of cost uncertainty and its demand or supply origins.

Figure 11 focuses on the dispersion of prices across possible alternative extra EU suppliers for ten illustrative products selected across the CVI_2 (price dispersion) distribution for year 2021. The CVI_2 is associated with the width of price distributions across exporters. In

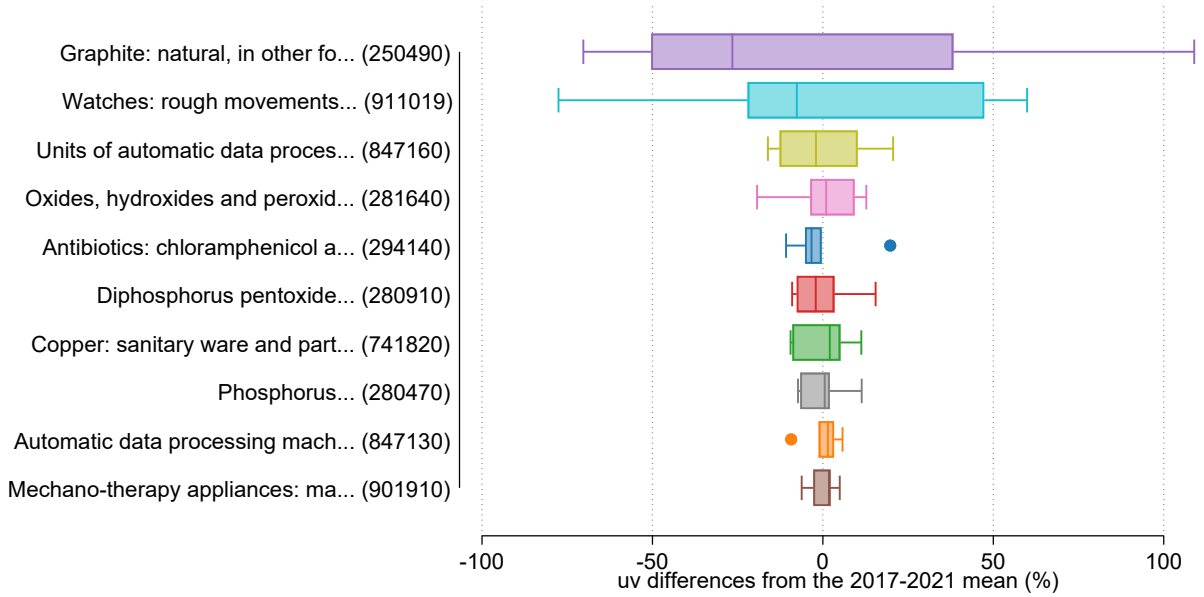
"Computers" (847130) there is a small price dispersion suggesting that it is possible to find alternative suppliers with similar price-quality combinations; this is not the case for the prices of "Watches" (911019) displaying a large dispersion across suppliers. Also "Oxides, hydroxides and peroxides" (281640) are widely dispersed, indicating possible market segmentation, or rather different production costs, that can make the substitution between suppliers relatively more difficult.

Figure 11 – Price dispersion across suppliers for selected critical products, 2021



Note: ten illustrative products across the CVI2 distribution, ordered by the CVI2 indicator (price dispersion). The boxplots represent the export (log) unit value distribution across non-EU exporters. For visual clarity, the distributions are centred on the median; as standard in boxplots, the left (right) side of the boxes identifies the 25th (75th) percentile, the whiskers are the lower (upper) adjacent values, and the dots are outside values. Year 2021.
Source: authors' elaborations CEPII-BACI data.

Figure 12 – Volatility of prices for selected critical products, 2017-2021

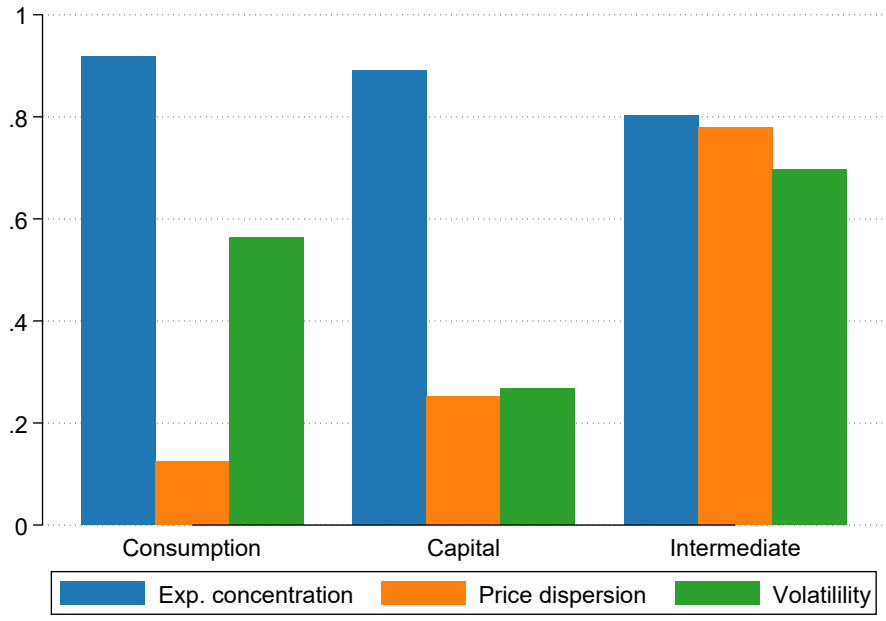


Note: ten selected products from Figure 11, ordered by CVI3 indicator (price volatility). The boxplots represent the distribution of differences from the mean of aggregate unit value of non-EU exports over the period 2017-2021 (i.e. five points in time for each product). As standard in boxplots, the left (right) side of the boxes identifies the 25th (75th) percentile, the whiskers are the lower (upper) adjacent values, and the dots are outside values. Period 2017–2021.
Source: authors' elaborations CEPII-BACI data.

Similarly, for the same illustrative products, Figure 12 shows price volatility over the period 2017-2021 (see indicator CVI_3). The CVI_3 is associated with the width of price deviations from the five-year period average. Some critical goods as "Watches; rough movements" (911019) or "Graphite" (250490) are subject to high price volatility, indicating that they might be more exposed to business cycle shocks or other vulnerabilities. Conversely, "Computers" (847130) or "Mechano-therapy appliances" (901910) display low price volatility.

Figure 13 summarises the normalised ranks of the three indicators by broad economic category. While world export concentration among non-EU exporters is high for all critical goods, vulnerabilities and their sources differ across them, with intermediate goods emerging as the most vulnerable. Indeed, these goods are also characterised by high price dispersion across alternative suppliers thus making diversification harder to implement. They are also subject to high price volatility over time, signalling that foreign supply might be exposed to shocks and uncertainty. These patterns justify closer investigation because small-value inputs may be important production complements.

Figure 13 – Sources of vulnerability of key critical products (2021)



Note: the bars represent the simple cross-product average of normalised CVI rank indicators. Year 2021.
Source: authors' elaborations CEPII-BACI data.

4 The association between critical imports and exports

We complement the descriptive screen with monthly import–export regressions using Eurostat Comext data for 2017–2021. Imports and exports are aggregated by country, ecosystem and month using the selected product codes.

We examine whether imports of critical products correlate with total exports and with exports of critical products within and across ecosystems. The baseline specification relates log exports to critical imports across the four categories and total non-critical imports:

$$\ln(X_{ijt}) = \alpha + \sum_j \beta_j \ln(M_{ijt}^{crit}) + \gamma \ln(\mathrm{M}_{\mathrm{it}}^{non-crit}) + \vartheta_i + \tau_t + \varepsilon_{ijt}$$

where X_{ijt} is export of country i, ecosystem j, at time t or its critical portion, M_{ijt}^{crit} is the imports of critical products for a given country-ecosystem-time. We also include the total imports of non-critical products, to control for countries' overall trade integration and fluctuations. Finally, we include both country and time fixed effects, ϑ_i and τ_t, respectively. Country fixed effects absorb time-invariant country differences, while time fixed effects

absorb shocks common to the countries in a given period. They do not remove time-varying country-specific demand, exchange-rate or production shocks, or reverse causality between imports and exports.

The coefficients are conditional associations, not causal effects of critical imports on export performance. Common demand, imported content of exports, re-exports, nominal price movements and overlapping product assignments can generate co-movement. Moreover, the regressions do not compare the selected products against an independently defined counterfactual set, measure realised shortages or observe productivity, innovation or technology adoption. They therefore cannot validate the screening thresholds or establish that the selected products are more consequential than other inputs.

Table 1 reports positive within-category associations between critical imports and critical exports in all four categories (columns 2, 4, 6 and 8). For total ecosystem exports, the corresponding import coefficient is positive and statistically significant for health-related, green and digital products, but not for raw materials (columns 1, 3, 5 and 7). These outcomes refer to total ecosystem exports and critical exports, respectively; the table does not report a separate regression for non-critical exports.

The within-category coefficients are not uniformly larger in the critical-export specifications. For example, the digital import coefficient is 1.16 for total digital exports and 0.59 for critical digital exports. Differences in point estimates across specifications should not be interpreted as statistically established differences without a formal test.

Critical digital imports are positively and significantly associated with total exports in all four categories. This pattern is consistent with a broad role for digital products in economic activity but may also reflect common nominal demand and trade conditions. The regressions do not identify a technological transmission channel.

Table 1 – Critical imports association with exports across sensitive ecosystems.

	(1) CRM	(2) Critical CRM	(3) Health	(4) Critical health	(5) Green	(6) Critical green	(7) Digital	(8) Critical digital
Critical CRM (ln)	-0.0026	0.1257**	0.0385***	-0.0585	0.0446***	-0.0197	0.0170*	-0.0357
	(0.0260)	(0.0565)	(0.0128)	(0.0417)	(0.0115)	(0.0457)	(0.0089)	(0.0412)
Critical health (ln)	0.1753*	-0.0713	0.2091**	0.3303***	0.1522*	0.0280	0.0962**	-0.0811
	(0.1019)	(0.1036)	(0.0872)	(0.0979)	(0.0790)	(0.0486)	(0.0417)	(0.0658)
Critical green (ln)	0.1300	-0.1061	0.2688**	0.3020*	0.1870*	0.5638***	0.0308	-0.2810**
	(0.1090)	(0.2194)	(0.1280)	(0.1589)	(0.1092)	(0.1756)	(0.0624)	(0.1351)
Critical digital (ln)	1.6835***	0.2624	1.4931***	0.5151	1.3260***	0.0112	1.1582***	0.5914**
	(0.4326)	(0.4592)	(0.3183)	(0.4989)	(0.3061)	(0.3264)	(0.2070)	(0.2626)
Total non-critical (ln)	-1.0008*	0.4331	-0.8771*	-0.2221	-0.6845	0.2777	-0.2754	0.6375*
	(0.5677)	(0.6564)	(0.4595)	(0.5813)	(0.4144)	(0.3108)	(0.2333)	(0.3377)
Constant	-0.1825	-5.1256***	2.1344***	-1.6789***	0.8955**	-1.8966***	1.0832***	-1.5631***
	(0.5107)	(0.6765)	(0.4845)	(0.5893)	(0.4004)	(0.2257)	(0.1480)	(0.5062)
Observations	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
R-squared	0.9822	0.9206	0.9919	0.9240	0.9914	0.9512	0.9945	0.9769
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Dependent variables are logs of exports and explanatory variables are logs of imports. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' elaboration based on Comext data from Eurostat.

Cross-category associations are heterogeneous. Total health-related exports are positively associated with critical imports from all four categories, while total green exports are positively associated with raw-material, health-related, green and digital critical imports. The raw-material coefficient in the latter regression is positive and significant at the 1% level, although small (0.0446). These correlations are compatible with multiple forms of co-movement and do not establish the input requirements of the exporting industries.

For critical digital exports, the coefficients on raw-material and health-related critical imports are not statistically significant, while the coefficient on green critical imports is negative and significant. This heterogeneity cautions against interpreting the table as uniformly positive evidence of technological complementarities across ecosystems.

The econometric evidence thus documents in-sample co-movement that offers support to our methodology and complements the trade screen. It does not demonstrate predictive performance or externally validate criticality. Vertical input linkages and joint exporting associated with demand are possible explanations (Fontagné et al., 2018), alongside common shocks, prices and re-exporting; the specification does not distinguish between them.

Results also stress potential cross-technological interdependences. Critical products of one ecosystem can be linked to exports from other ecosystems. Policies aiming to reduce Europe's dependence should consider technological complementarities within as well as across ecosystems. This appears to be especially the case for the digital ecosystem, whose critical products are related to exports from all other ecosystems. Digital technologies therefore seem to be especially important as enablers of exports from a variety of other technological fields.

5 Conclusions

Preventing disruptions in global trade without negative consequences for economic growth and well-being has recently become a prominent concern in international policy. In the EU economies policymakers have striven to promote the robustness and resilience of GVCs considering imported products that are critical for key industrial ecosystems – such as those supporting the digital and green transitions as well as the health system.[17] There are three areas for possible action according to the studies developed so far (Crowe and Rawdanowicz, 2023; Schwellnus et al., 2022b): (i) limit excessive dependency on few providers by diversifying import sources; (ii) reshape supply chains by encouraging firms to bring production home or to closer (friendlier) locations (the so-called re-shoring or near-, and friend-shoring); and (iii) build stronger inventories for selected key products. Most actions involve decisions taken by

[17] The Critical Raw Materials Act entered into force on 23 May 2024 (Council of the European Union, 2024). It postdates the empirical window and is policy context rather than an intervention evaluated by this paper.

private firms, but there might be the need of supportive public policies when private and public interests are misaligned, or firms suffer from shortsightedness or lack of adequate information about potential disruptions in supply chains. The desirability, design, and implementation of such policies should be evidence-based and carefully evaluated considering the trade-offs between economic efficiency and security as well as possible implications for the fairness and openness of global trade.

This paper contributes to this discussion by providing evidence about the global strategic dependencies of EU countries. Dependencies are examined mainly looking at trade flows. The empirical analysis describes direct trade relationships and possible concentration risks; it does not reconstruct the full production network or quantify downstream losses. Import dependency on critical products (especially raw materials and technologically advanced goods) would make EU economies vulnerable in case of trade disruptions due for example to excessive reliance on specific countries and a lack of viable alternatives, especially in the short run. The focus of the paper is on those products essential for industrial ecosystems supporting the digital and green transitions as well as public health.

The analysis of trade flows suggests that, overall, the number of critical goods is not massive when considering the entire area of EU countries. However, trade disruptions between this group and few other suppliers may trigger major adjustments. Trade data points to the key role of a small set of suppliers, mainly China, as trading partners in strategic areas. Strong dependencies exist for various raw materials and products, ranging from rare earth elements to lithium, and some pharmaceuticals to digital appliances. Critical products include consumption, capital and intermediate goods – with the first two accounting for the largest share of imports – while intermediate inputs merit additional scrutiny because limited availability can interrupt complementary production processes even at low import values. The unit-value indicators alone do not establish how difficult substitution would be.

Some metals and minerals are particularly critical because of the scarce number of exporting countries and the very reduced share in internal trade within the EU area (e.g. lithium, magnesium and nickel). The EU dependency on raw materials is critical considering the role of these materials in production processes and potential constraints on alternative sourcing that require product-specific assessment. This is the case even if raw materials represent a very small share of imports in the area. For technologically advanced goods, compatibility requirements, supplier qualification and production lead times are potential barriers to substitution that the trade indicators do not directly measure. Goods in the digital ecosystem (especially data processing units and phones) suffer from a very high dependency and account for more than 80% of critical goods imports.

Our results provide evidence on the dependencies of the EU as a background for discussing whether and how policies should address them to ensure long-term economic growth, national

security and prosperity. The paper also sets out an analytical framework and a methodology for exploring these issues, possibly on a country-by-country or product-by-product basis.

The productivity relevance of this historical baseline lies in identifying where more detailed assessment may be useful. Digital capital goods can embody technologies that support adoption and complementary organisational investment; low-value intermediate inputs can constrain the use of installed capital and labour; and persistent sourcing uncertainty can discourage innovation and erode productive capabilities. These mechanisms guide the interpretation of the screen but are not estimated here. Its policy use requires updated trade and production information, a tighter assessment of ecosystem relevance and evidence on the costs and feasibility of substitution.

Dependencies arise for many reasons and raise different vulnerabilities, suggesting that they should be addressed using targeted approaches. Mitigating vulnerabilities related to raw materials could require an effort to diversify suppliers in the short run, whenever possible and cost effective, and, in the long run, the development of new technologies that rely less on scarce materials. Reducing dependency in technologically advanced products could instead be achieved by encouraging the development of relevant productive capabilities and fostering innovation within the EU.

Within this framework, the trade-based analysis focuses on three domains of growing policy concerns: human health, digital transformation and a sustainable economy. First, the COVID-19 pandemic has shown the relevance of robust and resilient supply chains for medical products to support national health systems. EU countries have been dependent on extra-regional supply to produce essential personal protective equipment, pharmaceutical ingredients, and medical devices. Second, the digital transformation of EU economies has led to an increasing reliance on technology and data, which also motivates questions about access to equipment supporting AI adoption. The evidence ending in 2021 does not cover the subsequent expansion of generative AI or identify its specific supply dependencies. The digital ecosystem is profoundly shaped by dependencies on countries outside the group, particularly for electronics. The empirical analysis shows that the dependencies are concentrated on a small number of critical digital goods that account for a large share of the imported value. Third and last, the transition to a net zero carbon economy is a priority for EU countries, with ambitious goals for reducing greenhouse gas emissions and promoting the electrification of transport and renewable energy. However, this transition is dependent on access to raw materials such as rare earth elements and lithium, which are predominantly sourced from outside the region and their production is highly concentrated. These materials are essential for technologies like batteries, wind turbines and solar panels.

Mitigating vulnerabilities and dependencies in these three domains is a challenge for policymaking in both the short and long term. In the near term, aside from precautionary

stockpiling, shortages of goods might require temporary support for households and businesses whose incomes or supply chains are under pressure, with significant economic and fiscal implications. Policy issues here are the appropriate targeting of the support measures and the timing of their sunsetting as market tensions ease. Another issue is the potential undesired side effects that stockpiling may have on the availability and sourcing of critical products for countries outside the EU.

In the longer term, enhancing the robustness and resilience of global supply chains can help absorb future global health crises and support the successful implementation of the digital transformation and green transition, e.g. due to the easing of cost pressures on key inputs such as semiconductors or rare earths. However, in open and fair global markets, supply chains are primarily shaped by decisions of private firms over which public authorities have little control, and public intervention may introduce market distortions whose consequences may ultimately fall on consumers (e.g. higher prices or less variety for certain products). Therefore, any public action to enhance the robustness and resilience of global supply chains poses trade, industrial policy and social welfare dilemmas, whose solution requires careful policy design and citizens' awareness of policy consequences.

First, pursuing this objective should remain coherent with the G7 advocacy of free, fair, non-discriminatory, rules-based and sustainable trade. Thus, policies should be designed in a way that strengthens the multilateral trading system: the reduction of strategic vulnerabilities and dependencies should target the strengthening of both individual countries and global economic resilience to shocks. Their implementation must be consistent with the broader goal of preserving the benefits of global trade and GVC networks. This entails preserving openness and maintaining a cooperative attitude within a rule-based trading system.

Second, policies that promote or facilitate the diversification of supply sources for key products should not distort markets and preserve efficient outcomes. Policy evaluation should also consider both the possible impact on global competitive pressures (e.g. effectiveness in preventing the formation of cartels for certain scarce goods) and the time horizon over which the desired effects on the robustness and resilience of supply chains may be obtained.

The policy toolkit to enhance the robustness and resilience of EU global supply chains may include "soft" instruments – such as diplomacy (e.g. exploring alternative sources for key materials or inputs); provision of data and information to firms; or moral suasion and nudging of private companies sourcing choices – as well as more direct measures – such as stimulus to investment in domestic manufacturing capabilities or to R&D aimed at the development of innovative substitutes for strategic products. Bearing in mind that we identified as critical a relatively low number of products, it would be desirable that any policy is adopted on a case-by-case basis (after careful examination of its costs and benefits) and tailored to specific industries and products, given considerable heterogeneity across sectors and firms. The design

of “stress tests” for supply chains that are critical for sensitive and strategic industrial ecosystems could be useful to identify areas in need of special attention. All options must be cost-effective as compared with the economic consequences of possible supply chain and trade disruptions deriving from maintaining the status quo. Finally, the benefits of some of these policies (especially soft ones, such as the collection and provision of information or stress tests) would be greater if they were coordinated internationally.

Summing up, policy measures need to strike the right balance between fostering opportunities and addressing challenges in ways that ensure coherency between short-term and long-term objectives and preserve at the same time the growth potential and the resilience of the global economy. Collaborating with trusted partners to create secure and resilient health, digital and green ecosystems is an essential element of all policies aimed at addressing strategic dependency issues. But vulnerabilities and options for improving GVC resilience are of course specific to each EU country. To identify such challenges and opportunities and policies to address them, the monitoring framework proposed in this paper can also be used to study strategic dependency for individual EU countries.

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Appendix

Table A1 – List of key critical products (HS 6-digit codes)

HS code	Description	BEC5 end use	Ecosystem
050210	Animal products: hair and bristles, of pigs, hogs or boars, and waste thereof	INT	Health
252800	Natural borates and concentrates thereof (whether or not calcined), but not including borates separated from natural brine: natural boric acid containing not more than 85 % of H3BO3 calculated on the dry weight	INT	CRM
252910	Feldspar	INT	CRM
270820	Pitch coke: obtained from coal tar or from other mineral tars	INT	CRM
280470	Phosphorus	INT	CRM
280480	Arsenic	INT	CRM
280910	Diphosphorus pentoxide	INT	CRM
282520	Lithium oxide and hydroxide	INT	CRM
283691	Carbonates: lithium carbonate	INT	CRM
284011	Borates: disodium tetraborate (refined borax), anhydrous	INT	CRM
284019	Borates: disodium tetraborate (refined borax), other than anhydrous	INT	CRM
293627	Vitamins: vitamin C and its derivatives, unmixed	INT	Health
293712	Polypeptide hormones, protein hormones and glycoprotein hormones, their derivatives and structural analogues: insulin and its salts	INT	Health
293719	Polypeptide hormones, protein hormones and glycoprotein hormones, their derivatives and structural analogues: other than somatotropin, (its derivatives and structural analogues) and insulin and its salts	INT	Health
293750	Prostaglandins, thromboxanes and leukotrienes, their derivatives and structural analogues	INT	Health
293943	Alkaloids: cathine (INN) and its salts	INT	Health
293944	Alkaloids: norephedrine and its salts	INT	Health
294140	Antibiotics: chloramphenicol and its derivatives: salts thereof	INT	Health
300213	Blood, human or animal, antisera, other blood fractions and immunological products: immunological products, unmixed, not put up in measured doses or in forms or packings for retail sale	INT/CONS	Health
300331	Medicaments: containing insulin, for therapeutic or prophylactic uses, not packaged for retail sale	INT	Health
330112	Oils, essential: of orange (terpeneless or not), including concretes and absolutes	INT	Health
330113	Oils, essential: of lemon (terpeneless or not), including concretes and absolutes	INT	Health
701890	Glass: articles thereof, statuettes and other ornaments of lamp worked glass, other than imitation jewellery	INT	Health
750110	Nickel: nickel mattes	INT	CRM
810411	Magnesium: unwrought, containing at least 99.8% by weight of magnesium	INT	CRM
810430	Magnesium: raspings, turnings and granules, graded according to size, powders	INT	CRM
810600	Bismuth: articles thereof, including waste and scrap	INT	CRM
811090	Antimony and articles thereof: wrought, other than waste and scrap	INT	CRM
811100	Manganese: articles thereof, including waste and scrap	INT	CRM
847130	Automatic data processing machines: portable, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display	CAP/CONS	Digital
851632	Hair-dressing apparatus: electro-thermic, other than hair dryers	CONS/CAP	Health
851712	Telephones for cellular networks or for other wireless networks	CONS/CAP	Digital
852852	Monitors: other than cathode-ray tube: capable of directly connecting to and designed for use with an automatic data processing machine of heading 84.71	CONS/CAP	Digital
854040	Tubes: data/graphic display tubes, monochrome: data/graphic display tubes, colour, with a phosphor dot screen pitch smaller than 0.4mm	INT	Digital
854140	Electrical apparatus: photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light-emitting diodes (LED)	INT	Digital/Green
871491	Cycles: frames and forks, and parts thereof	INT	Green
901380	Optical devices, appliances and instruments: n.e.c. in heading no. 9013 (including liquid crystal devices)	CAP	Digital/Health
901910	Mechano-therapy appliances: massage apparatus and psychological aptitude-testing apparatus	CAP	Health
910811	Watch movements: complete and assembled, electrically operated, with mechanical display only or with a device to which a mechanical display can be incorporated	INT	Health
910820	Watch movements: complete and assembled, with automatic winding	INT	Health
911019	Watches: rough movements	INT	Health
911110	Watch cases: of precious metal or of metal clad with precious metal	INT	Health
911120	Watch cases: of base metal, whether or not gold-plated or silver-plated	INT	Health
911430	Clock or watch parts: dials	INT	Health
940520	Lamps, electric: floor-standing or for table, desk or bedside	CONS/CAP	Green

Figure A1 – Critical goods selection across all the 5,000 HS6 product codes.

