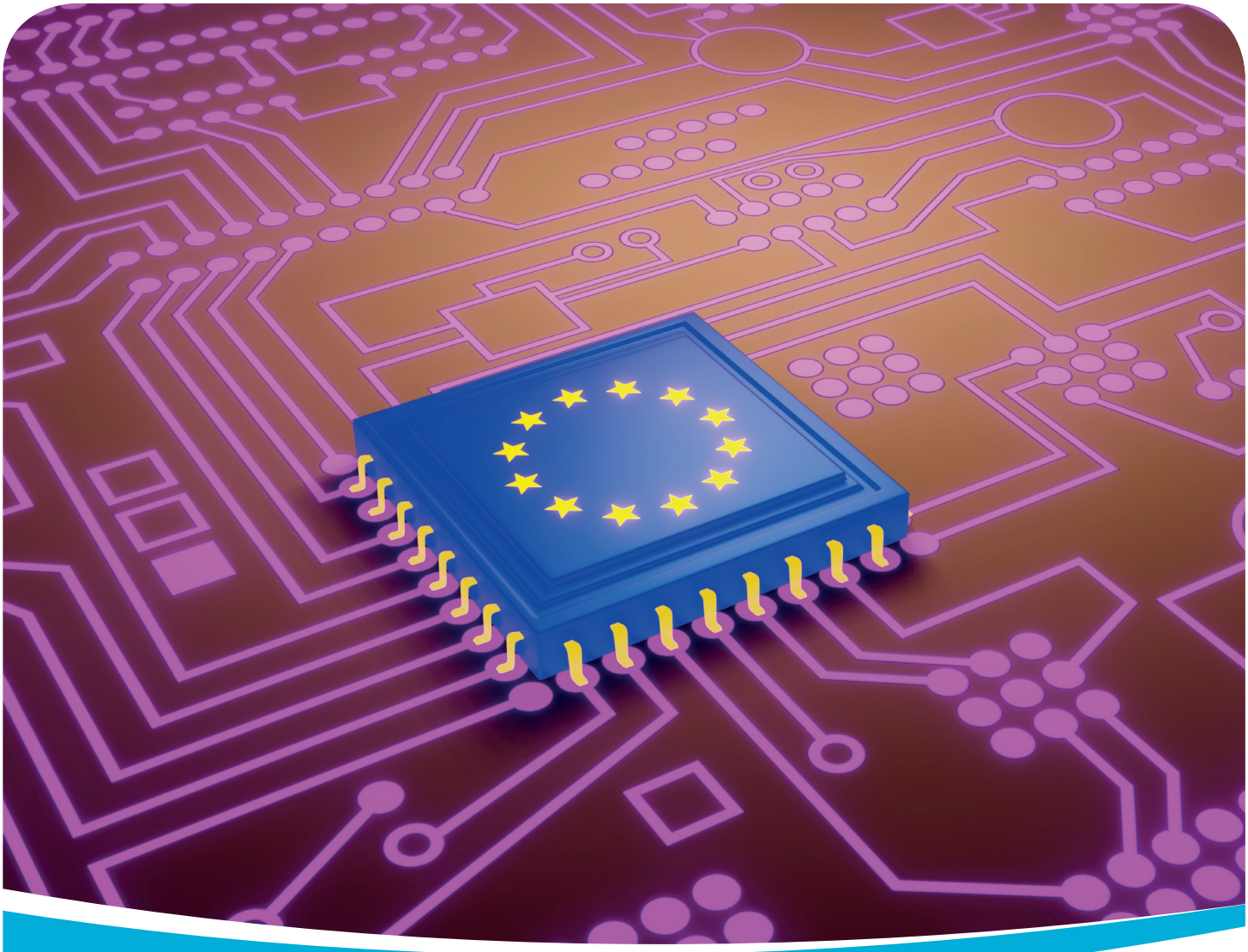

What ways and means for a real strategic autonomy of the EU in the economic field?

STUDY

European Economic
and Social Committee

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Final report

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Table of Contents

Executive summary

The EU has always strenuously promoted economic integration with the rest of the world. In a peaceful world governed by a rules-based system, this strategy made Europe not only one of the most important global trading powers but also one of the most prosperous regions.

The Covid-19 pandemic and the subsequent Russian invasion of Ukraine have fundamentally altered the dynamics of openness and economic integration and foreshadowed a long-term uphill struggle to preserve the EU's prosperity. These disruptive events have underscored the need for the EU to enhance its resilience and ability to safeguard its strategic interests effectively. Already in 2020, alongside the Green Deal, the von der Leyen Commission proposed an EU industrial strategy that would support the EU's 'geopolitical' role through strategic autonomy.

As the EU is gearing up to respond to challenges that could signal a tectonic shift from the multilateral rules-based trading system that has been the hallmark of the post-World War II era, the EU can ill afford to be vague about what strategic autonomy means.

What is strategic autonomy?

The term should not be understood as a reference to autarchy, protectionism, or unilateralism. Neither is it confined to defence and security policy or building resilience or self-reliance. Instead, it should be understood as a means to promote EU interests and values. On its end, the European Commission defines 'open strategic autonomy' as 'the EU's ability to make its own choices and shape the world around it through leadership and engagement, reflecting its strategic interests and values.'

The EU is not alone in its quest to reduce reliance on other countries. All major powers have implemented similar policies advocating different reasons and using different narratives, but with ultimately a similar effect. While in the US, 'America First' became the major slogan under the Trump administration and defined a new yardstick for an inward-looking America, the US had already shown earlier signs of withdrawal from its role of benevolent hegemon. The Inflation Reduction Act (IRA) is the most recent example[1] of a shift towards putting domestic objectives first and then resorting to substantial market intervention to promote them, even at a cost to its global partners.

Similarly, in 2015, China put forward the 'dual circulation strategy', which embedded the idea of China becoming a self-sufficient nation. The strategy was accompanied by the launch of China's industrial policy masterplan 'made in China 2025'. For certain strategic raw materials, China had already – since the 1980s China – crafted plans involving state-sponsored domestic and foreign investments. More recently, China's attitude towards Western economies has become much more assertive and, in some cases, even openly contentious in the direction of a new global leader disconnected from Western powers. Finally, the 'Make in India' initiative, launched in 2014, was a step in a similar direction.

The EU has (thus far) steered clear of openly promoting domestic production. The principles of trade openness and market competition remain at the heart of the EU project and guide its decisions inside and outside. However, a growing number of legislative initiatives (e.g. Single Market Emergency Instrument or the EU Anti-coercion instrument proposed Regulation), investment programmes (e.g. Industrial alliances), and strategic partnerships (e.g. The EU-US Trade and Technology Council) have been designed to better protect and promote the interests of European consumers and firms in the single market or to respond to unfair practices. Furthermore, drawing lessons from the Covid-19

[1] See also The Atlantic Declaration in the framework of UK-US cooperation.

pandemic and recent energy crises, there has been a concerted effort to evaluate the security of supply chains and more broadly EU vulnerabilities.

How vulnerable is the EU economy?

To respond to this question, three dimensions are investigated: Trade (and in particular import) dependencies, exposure to global value chains and access to critical raw materials.

- ***EU import dependencies***

Employing the concept of sensitive ecosystems, as outlined by the European Commission, and focusing on a selection of strategic sectors, our analysis highlights import dependencies within the EU that warrant close scrutiny. Among various product categories, one class stands out for special consideration: the 'Manufacture of computers, electronics, and optical products.' This class defines the 'Digital' ecosystem and plays a significant role in the 'Electronics' and 'Aerospace and Defence' ecosystems. It includes crucial components such as computer chips and semiconductors, and it exhibits a notable degree of import dependency on non-EU countries. Importantly, some of these products have a high concentration of imports in countries characterised by a 'no freedom' status, thereby introducing a relatively higher risk to these dependencies. Moreover, for certain products within this category, substituting with EU production is either impossible or presents significant challenges.

Lastly, the two main EU trade partners – China and the US – supply the EU with a large array of imports with strategic significance. Nonetheless, notable distinctions can be observed between the two. China predominantly exports consumer goods, like domestic appliances and consumer electronics, and the level of EU's dependency on China for these products is very high (for some categories above 60 % of total EU imports). In contrast, the US's main exports to the EU are in activities related to the extraction of fossil fuels and the production of chemicals and pharmaceuticals. Despite these significant exports, the import dependency ratio is relatively low, hovering around 20%.

- ***EU Strategic value chains exposure***

The Covid-19 pandemic and then the war in Ukraine caused major disruptions in modular production systems. This led to questioning the deepening of international specialisation and its net benefits, as well as the need for companies and governments protect themselves against exposure to global value chain disruption.

The EU is strongly integrated in the GVC, its exposure appears to be concentrated in the two main tradeable sectors, manufacturing and services, with quite a lot of heterogeneity across EU Member States in the degree of reliance on GVCs. Exposures in strategic GVCs deserve special attention. Vulnerabilities in access to materials and inputs relevant to chemicals, batteries and hydrogen, semiconductors, cloud and edge technologies and microelectronics belonging to the area of advanced technologies (relevant for several ecosystems) can not only hinder the production of final products within the EU but also impede the capacity to complete production and engage in exports beyond the EU's borders.

Crucially, GVC are likely to become increasingly tangled and intricate in response to Western economies' efforts to decouple and de-risk from countries like China. As a result, indirect dependencies may be concealed within these complex production linkages, making them more challenging to identify.

- ***EU Access to critical raw materials (CRMs)***

The EU’s twin green and digital transition will require rapid and large-scale deployment of green and digital technologies, which are central to the EU’s agenda.

These strategic technologies are highly material intensive and their deployment will imply a considerable increase in the demand for and consumption of raw materials. It is essential that the EU ensure secure and reliable access if it is to establish a competitive position in these markets and sustain the twin transition. Yet, the supply chains of global raw materials are today heavily concentrated in a small number of countries, and **the EU largely relies on imports to meet its raw material requirements – notably from China**.

Given the inherent challenges associated with CRM, the EU must adopt a multifaceted approach to address supply risks and ensure the resilience of its industrial and technological sectors. This approach encompasses various strategies, ranging from material substitution to technological advancements, enhanced material efficiency, and international collaboration. The substitution of critical raw materials with non-critical or less critical alternatives, is feasible in technologies like batteries. By contrast, some technologies, such as magnets and fuel cells, still lack commercially available CRM-free substitutes or face quality trade-offs. In such instances, transitioning to technologies that do not rely on CRMs, like utilising rare earth-free motors in electric vehicles or alternative wind turbine generators that use fewer or no permanent magnets, can be a viable albeit not always efficient solution. Enhancing material efficiency is another avenue to reduce CRM demand without resorting to alternative materials. The need for CRMs has driven optimizations in their usage within products. Technological innovations are expected to decrease the material requirements per unit of energy for batteries and motors in the future. Last but not least, increasing demand and rising prices have prompted shifts in the global CRM production landscape, with new countries willing to exploit their resources. The EU can employ traditional trade policy mechanisms to negotiate CRM trade agreements and take measures to ensure seamless trade. Examples of cooperation in the CRM domain are the strategic partnerships with countries like Canada, Ukraine, Kazakhstan, and Namibia.

Can the euro serve EU strategic autonomy?

The US supremacy in the global order has often been associated with the dominant role of the US dollar in the international monetary system. Consequently, it is a pertinent question to inquire whether the euro, as an international currency, can contribute to the strategic autonomy of the EU. In brief, the euro's potential in this regard is rather limited, and it largely hinges on factors beyond the purview of monetary policy and the ECB. To comprehend this, three distinct dimensions come into play.

First, the **international monetary system** has been dominated by the US dollar for decades. In the first decade of the 2000s, this trend was accompanied by the rise of the euro, but the process stopped during the sovereign debt crisis. Since then, a gradual diversification away from the dollar not in favour of the euro, has started and it is likely to accelerate. Western economic sanctions against Russia may speed up this trend and make the renminbi the main beneficiary of the change.

The second aspect is the role of the euro in **global trade invoicing**. In this domain, there is little doubt about US dollar dominance. The sheer size of the US market, the share of dollarised economies in global trade and path dependence contribute to the continued dominance of the US dollar as the primary currency for international trade. The role of the euro has been growing and it is dominant in transactions where EU countries are one part of the transaction (import or exports). is important to note that when it comes to commodities, the dollar remains the preferred currency for trade invoicing, even for EU countries. Nevertheless, China, since 2009, has been actively pursuing the internationalisation of its currency, the renminbi. Recent events, such as the conflict in Ukraine and the US sanctions against Russia, have created conducive conditions for an increase in business invoicing in Chinese renminbi, signalling a potential shift in the global trade landscape.

The third dimension relates to **control and/or access to payment systems**. Today, in the EU, cross-border card payments are mainly made through two international card payment schemes, owned by US companies. While the US remains a key EU ally, the fundamental role of payment systems in the daily life of people and companies, and the risks associated with a potential lack of access have increasingly attracted attention. EU alternatives to those payment schemes are not efficient at the moment but the landscape is rapidly changing driven by new technical solution. In relation to digital solutions, under certain conditions, the digital euro could reinforce the (euro) retail payments market and hence play a role in the EU enhancing strategic autonomy and resilience.

How to operationalise strategic autonomy?

In this complex set of considerations about a changing geopolitical order and EU priorities as well as complicated web of EU reliance on other nations and what they mean for our production system, the EU critically needs a compass to define strategic lines of policy.

The EU has acknowledged the importance of maintaining, and even fostering, its longstanding partnerships and cooperation with allies and partners, especially the US. Nonetheless, there is little doubt that the uncertain US political landscape is not going unnoticed. The EU increasingly seeks to decrease its reliance on other partners for its security and prosperity. While this is the essence of its search for open strategic autonomy, it is unclear how it can be achieved.

From an economic standpoint, the question boils down to how to identify the degree of openness that allows access to the largest set of international opportunities and satisfies geopolitical considerations.

One way to operationalise this idea is to dissect the problem along two dimensions. The first dimension is t**he degree (and the nature) of reliance on non-EU countries** (existing and emerging). The identification of problematic trade dependencies, goes beyond trade linkages as measured by volumes of imports. It is the combination of high relative import demand dependency, high concentration and low substitutability that are a good recipe for problematic dependency. But the type of product also matters. Not all dependencies should be of concern for the purpose of achieving strategic autonomy – only high dependency on products belonging to sectors which can be qualified as being strategically important. Whether the country from which the EU imports can be considered unreliable or could be tempted to weaponise its dependency is a key consideration for any assessment.

Mapping sectors (possibly products) that are strategically important for the EU is a crucial first consideration for the trade dependency dimension. However, the definition of 'strategic' sectors and products continuously evolves over time, and the risks crucially hinge on technological development and the geopolitical landscape.

The second dimension of the problem is **the state of the global trading system and the geopolitical order.** There is a growing concern that current trade tensions between the US and China could increase further geopolitical rivalry and in turn into a bipolar configuration led by these two economies and their respective allies, the more we move away from a multilateral trade system based on rules and towards a system dominated by power, the higher the risks to which the EU is exposed. In such perspective, the EU should re-engage in the reform of the multilateral system as a way to mitigate its foreign vulnerabilities.

Finally, together with the US, China plays a key role in defining the world's geopolitical space. It must be acknowledged that China holds a central position in global trade and supply chains and any attempt to decouple from China presents challenges for EU policymakers and businesses. In certain sectors, decoupling remains unfeasible due to specific input product supplies and raw material control.

Furthermore, an EU decoupling from China would inevitably contribute to a more divided world, the very outcome that the EU wants to avoid at all costs.

Strategic autonomy, industrial policy and the single market

Traditionally EU policy instruments are associated with the single market and have the fundamental purpose is to protect and enhance the four freedoms and, ultimately, protect and promote the interests of European consumers and firms. The sequence of recent crises and the current contested global economic environment are posing fundamental challenges to the EU on how to achieve its main objectives. Strategic autonomy is certainly one. This has resulted attempt to deviate from or extend the EU policy toolkit and its scope of action.

It is increasingly evident that the traditional tools of the EU single market may not suffice to ensure strategic autonomy in a world where influential players employ state intervention to establish or strengthen their positions on the global stage. It is the understanding of such change that is driving the evolution of the objectives of the EU industrial policy, which has recently surged in significance as a pivotal policy instrument in the EU. Today, the EU industrial policy is no longer solely expected to fortify the EU industrial competitiveness but to achieve strategic autonomy and enhance the EU's long-term resilience through a focus on green industrial transformation. The logic of strategic autonomy implies that making decisions based purely on the economic merits of investments, outsourcing or trade could leave the EU vulnerable to unreliable partners who could use this leverage to achieve political goals at the expense of the EU's interests. In a context of increasing geopolitical rivalry and the steady erosion of the multilateral rules-based trading system, diversifying and securing critical parts of the supply chain therefore become superior objectives.

As a result, the paradigm is shifting towards a scenario in which directing, bolstering, and subsidising investments in specific sectors, economic regions, or countries is the new norm. This evolution presents significant challenges to upholding the principles that underpin the single market, but possibly also EU economic convergence and integration. Opening the possibility for Member States to provide state aid to strategic industrial sectors is likely to create an unlevel playing field, because of the different fiscal capacities of Member States, but also different economic structures and traditions in defining industrial policy at the national level with a view of fostering competitiveness. This raises a question about the existence of a dichotomy between the single market and the objective of strategic autonomy.

Fundamentally, it proves that the EU does not have a true EU industrial policy. As it is today, despite some EU attempts (like STEP, and IPCEIs), the EU industrial policy is confined to set broad common aims, which however are unlikely to be achieved as the sum of national industrial policies, mostly driven by national interests.

Policy considerations

Overall, three broad policy messages emerge for the EU.

First, the EU is made up of trading nations, for which trade has been the main tool of global influence. A reduced openness, whether emerging from external factors or by choice through policies, is going to impact the EU growth model and its role as a global actor. As the EU's relative economic weight declines, driven by the emergence of other economic powers, in a politically more fragmented world, economic relationships will remain crucial to define the key global actors. Hence, **external strategic dependencies should be reduced while simultaneously maintaining a commitment to openness.** This is a crucial starting point in formulating a strategy aimed at strategic autonomy. In practice this requires a combination of actions including i) rethinking production systems towards risk reduction in supply

chains and favouring domestic production of some key goods and services, ii) gaining efficiency in energy consumption, iii) fostering technological innovation, including to reduce dependency on raw materials, and iv) developing new trade partnerships, as part of the strategy to reduce dependencies but also to engage in the reform of the global multilateral system.

Second, in defining a strategy to reduce vulnerabilities or more broadly a de-risking strategy, China deserves a special attention. China is still one of the most important EU trade partners, it is the main supplier of products in sensitive industrial ecosystems and of critical raw materials. Furthermore, China has a very high value chain capacity in manufacturing. Due to the intricate connections of global value chains with China, diversification efforts may not immediately lead to a decreased reliance on Chinese inputs and suppliers in the short to medium term. Even significant shifts in production to alternative destinations may only yield marginal decreases in China's global supply of exports and contribution to manufacturing, or supply chains. These circumstances imply that achieving "de-risking" by reducing trade, investment, and supply chain exposure to China in strategic areas is likely to be a long process. This does not negate the validity of the broader diversification objective. However, it must be recognized that diversification is a complex and long term challenge and expectations much be aligned. In the short term, full de-risking may not only be costly, it is impossible.

Third, while the single market, with its rules and the competition principle, remains the cornerstone of the EU, it is crucial to remember that the single market is not an end in itself; rather, it is a means to safeguard the interests of EU citizens and businesses. There is little doubt that trade tensions and geopolitical challenges are posing a threat to the EU's functioning and the risk of a disconnect between the single market and the pursuit of strategic autonomy is growing. Fundamentally, the root of the disconnect is the absence of a true EU industrial policy. Currently, any EU industrial strategy aimed at achieving strategic autonomy may require measures that, to varying degrees, deviate from the core principles of the single market. These deviations can potentially exacerbate disparities among Member States, both in terms of their industrial capabilities and, ultimately, their economic development. Consequently, to successfully pursue strategic autonomy, a comprehensive reassessment of the EU's industrial strategy is imperative. This reassessment should encompass exploring ways to expand the EU's industrial policy instruments beyond those designed for the single market. Most critically, it necessitates a serious evaluation of the industrial restructuring required to accommodate the priorities of the green and digital transitions.

1. Introduction

Until recently, cooperative, sometimes even global, solutions were considered possible. Since 2020, however, the EU has been confronted with the unravelling of the multilateral, rules-based order which guarantees its security and prosperity. The Covid-19 pandemic and the Russian invasion of Ukraine have amplified and accelerated global forces driven by geopolitical rivalry.

The most important structural feature of the new international system that seems to emerge is not the multilateralism that allowed the EU to prosper, but rather the rivalry between the US and China. In both the US and China, geo-economics and geopolitics are increasingly merging. As a result, the nature of globalisation is changing. Rather than being a tool for reducing conflicts, interdependence is increasingly exposed to the risk of being weaponised. The EU's two most important economic partners are likely to make choices driven by domestic interests and internal political dynamics. The EU may become a hostage of competing powers rather than a player that protects its interests and values.

These disruptive changes have fundamentally altered the dynamics of openness and economic integration and foreshadowed a long-term uphill struggle to preserve the EU's prosperity. They have also underscored the need for the EU to enhance its resilience and ability to safeguard its strategic interests effectively.

All of this has created a demand for more 'European sovereignty'.[2] While developed in the realm of external action to operationalise the EU's response to military aggression and hybrid threats by neighbouring and farther-flung adversaries, the notion of 'strategic autonomy' has been expanded to increase Europe's self-sufficiency and boost its industry in the wake of the Covid-19 pandemic. Since its first-ever Strategic Foresight Report in September 2020, the von der Leyen Commission's transition-led agenda is guided by a compass of strengthening the resilience and sustainability of the EU economy in a world tainted by Sino-American rivalry. Alongside the Green Deal, the von der Leyen Commission proposed an EU industrial strategy that would support the EU's 'geopolitical' role through strategic autonomy.

The mindset behind the Commission's strategy is one of 'open strategic autonomy': the EU wants to be a trade actor in its own right and to shape the world around it in line with its own interests and values, working with others where it can, autonomously where it must. 'Autonomy', therefore, does not amount to 'autarchy'. The strategic choice of openness means that the EU prefers to act multilaterally and with like-minded countries, such as the United States.

In adopting the concept of 'open' strategic autonomy, the Commission argues that strategic autonomy could be achieved without resorting to protectionism, preserving the EU's open economy, and maintaining the economic benefits of interdependence. At the same time, Member States could preserve the benefits of the single market, increase their preparedness for future challenges, and protect the EU against potential retaliation from international trading partners.

As the EU is gearing up to respond to challenges that could signal a tectonic shift from the multilateral rules-based trading system that has been the hallmark of the post-World War II era, it can ill afford to be a spectator and vague about its objectives.

As recent policies put forth by key global powers signal an increasing preponderance of geopolitical rather than economic considerations, the temptation to plunge headlong into a flurry of protectionist policies will be strong. However, they will not ensure either economic security or future prosperity. At this stage, the EU would benefit greatly from clarity on what its drive to achieve strategic autonomy

[2] Speech by Emmanuel Macron, President of the Republic at European Parliament, 17 April 2018.

should translate into in practice. Importantly, EU Member States need to work together to ensure the EU can remain competitive in a more contested world.

It must be recognised, however, that in practice it will be very difficult to strike a balance between openness and autonomy. The latter could easily become a form of disguised economic protectionism that justifies the resort to trade barriers and state subsidies, and in general, to state intervention in the markets. This trade-off is emerging also in the debate at the institutional level, where two camps are developing. On the one hand, those emphasising openness underscore the need for concerted investment to address strategic vulnerabilities but advocate an outwardly oriented EU. On the other hand, those emphasising autonomy point to an EU that should mostly act autonomously and cooperate with others only where possible.

Against this background, the objectives of this study are to:

- bring together the vast evidence base and literature, focusing on the economic dimension of strategic autonomy;
- provide an analysis of EU dependencies and assess related vulnerabilities clarify the notion of 'open strategic autonomy' by providing an operational definition;
- offer an overview of the current policy initiatives with the view to fostering strategic autonomy;
- contribute to the policy debate by providing recommendations based on empirical evidence and policy analysis.

The analysis of EU open strategic autonomy will be limited to the economic field with a focus on industry and its production processes, namely, trade, global value chains and access to raw materials. While aware of the key role played by access to energy sources and skills in the production process and the dramatic changes that each of them is undergoing, for practical reasons these aspects are not covered. Foreign investment aspects form part of the 'peripheral' scope of the study and are considered in so far as they affect production processes. In addition, the role that the euro, as an international currency, could play in shaping EU strategic autonomy is also investigated.

The methodological approach to investigate such issues consists of a combination of desk research, empirical analyses, interviews, and policy analysis.

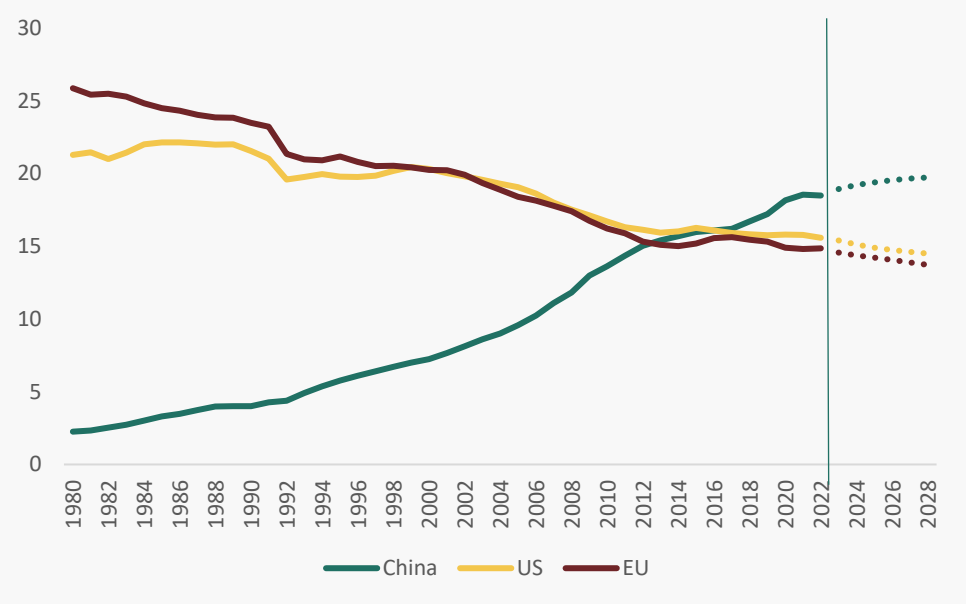
The rest of the report is organised as follows. Sections 2 and 3 set the scene. First, by offering an overview of the state of the EU in the global economic context. Second, by reviewing the concept of strategic autonomy, how it has evolved over time, and the key elements that define it. Among them, economic dependency, and external vulnerability. Building on this, Section 4 offers a full picture of the current state of affairs by measuring EU import dependencies, assessing EU exposure to value chain disruptions and the risks associated with access to critical raw materials. Section 5 focuses on the euro, its current international role and what would be needed for it to play a further role in fostering EU strategic autonomy. Building on the results of the analysis of the previous parts, section 6 attempts to operationalise the concept of strategic autonomy. This is important to shed light on what strategic autonomy means in practice and the policy trade-off that may emerge. Section 7 offers an overview of the various policy initiatives and measures that have been adopted or proposed in recent times to promote EU strategic autonomy, and discusses whether and how the EU industrial policy can contribute to strategic autonomy. The last section concludes with a summary of the policy considerations and options available to policy makers.

2. The EU in the global context

To understand why the concept of EU strategic autonomy is relevant and what it entails, it is important to contextualise recent developments that characterise the EU's role in the global economy. There is no doubt that the Covid-19 pandemic and the war in Ukraine made the geopolitical environment more challenging and are transforming the global economic order. However, the nature and the size of such challenges can only be understood by looking at the key features of the EU as a global economic actor.

While the EU is one of the largest world economies, over the last decades, its share of global GDP has been declining and in 2013 China surpassed it (measured in PPP – see *Figure 1*). The US has followed a similar pattern as the EU. The EU and US relative decline is the direct result of the faster growth of other countries, mostly emerging market economies. They exhibit a large or fast-growing population and are deeply integrated into the global production system (through value chains) and progressively emerging as new economic powers. China is certainly the most prominent among them, but not the only one.

Figure 1. World GDP (PPP) shares, 1980-2028 (projections 2023-28)



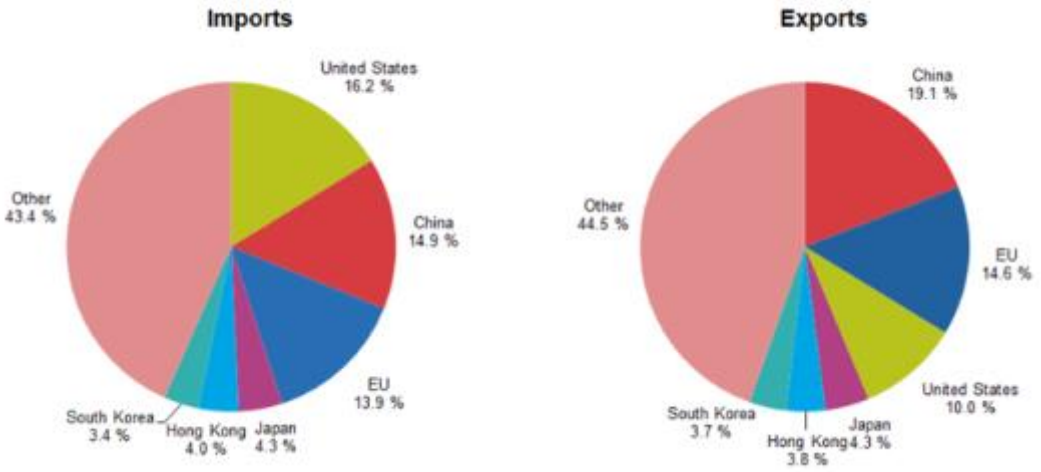
Source: IMF (2022), https://www.imf.org/external/datamapper.

2.1 The EU as an open economy: trade and capital flows

The EU stands out in the global scene as a very open economy. It exhibits very large trade and financial flows, which contribute to a high degree of integration in the global economy. Extra-EU exports amounted to about 16.5 % of EU GDP in 2022[3]. The geographical allocation of EU imports and exports vis-à-vis the rest of the world suggests that the EU's position is quite diversified (see *Figure 2)*, reflecting the high degree of participation in global supply chains. The US and China, the two major EU global partners, are key as both suppliers of imports and destinations of EU exports.

[3] The figure comes from Eurostat data, according to which in 2022 extra-EU27 total exports (EXT_LT_INTRATRD) and EU27 GDP (TEC00001, in current prices) amounted to 2.6 and 15.8 million respectively.

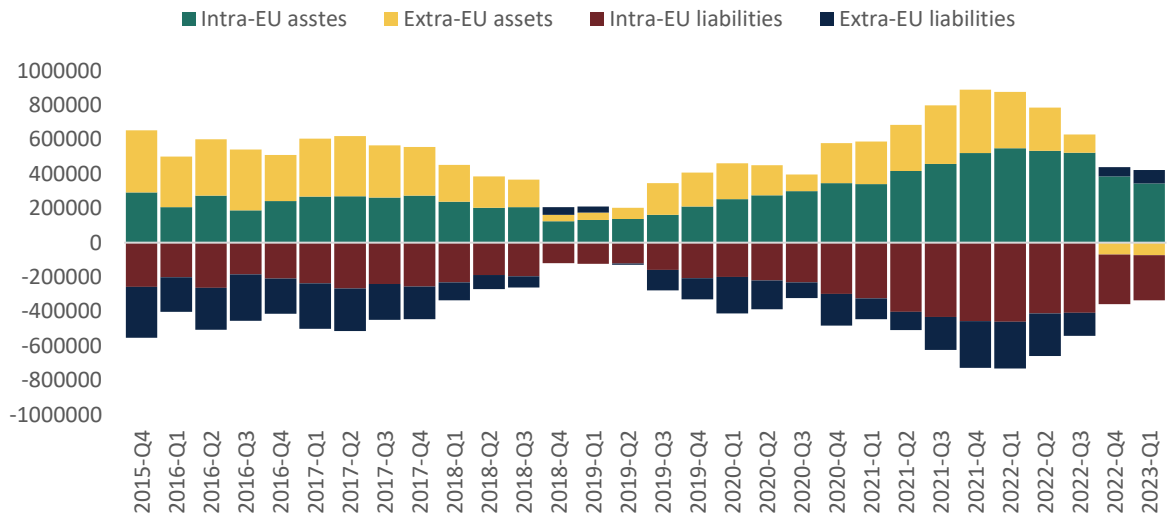
Figure 2. EU imports and exports (2021)



Source: Eurostat, (ext_lt_introeu27_2021) and UNCTAD.

Figure Figure 3 shows the evolution of intra- and extra-EU 27 gross capital flows (in moving average). The EU is one of the main sources and receivers of capital flows at the global level. Although capital flows shrank quite drastically in 2018 and mid-2019[4], they rebounded in the following quarters reaching new highs. After Covid-19 and before the effects of the war in Ukraine became obvious, gross flows (assets and liabilities) had reached the highest levels since 2015. Recent global tension and policy interventions

Figure 3. EU27 Gross flows, intra- vs extra-EU27, million EUR, (2015Q4-2023Q1)



***Source**:* Own calculations based on Eurostat Balance of Payments data.

***Note**:* Moving average over 4-quarters. Liabilities are represented with a negative sign for visualisation purposes. Positive asset flows correspond to EU residents acquiring more assets abroad than they dispose of. Positive values for liabilities indicate disinvestment.

2.2 A challenging geopolitical landscape

[4] According to Alcidi et al. (2020), the foreign disinvestment from the EU, represented by a positive sign of extra-E-27 liabilities, might be explained by the US Tax Cuts and Jobs Act of December 2017, that incentivised the repatriation of profits from abroad.

The rivalry between the US and China (see Introduction) marks a considerable shift in the decades-long trend of globalisation and multilateralism that has been the hallmark of the post-World War II era (Alcidi and Kiss-Gálfalvi, 2023). The return of great power competition leads to tangible economic consequences and creates an unpredictable and uncertain environment. Trade rules, supply chains, access to critical raw materials and energy, as well as finance are some of the main – but by far not the only – areas affected by geopolitical and economic competition[5]. The US-China race for technological supremacy is already impacting the EU through, for instance, restrictions on the sale of advanced chip machinery.

In recent years, the attitudes of the US and China as global economic actors and their relative policy strategies have evolved quite dramatically. On the US side, the shift towards a more inward-looking policy approach has become increasingly clear. While 'America first' became the major slogan under the Trump administration and defined a new yardstick for an inward-looking US, the US had already shown earlier signs of withdrawal from its role of benevolent hegemon. The Inflation Reduction Act (IRA) is the most recent example of a shift toward putting domestic objectives above international commitments. The IRA comprises vast amounts of tax credits for low-carbon investments, amounting to up to USD 360 billion (that in principle could be increased), including USD 60 billion for manufacturing and industry (the type of sectors where trade plays an important role). The tax credits offered through the IRA are a powerful incentive. They provide a direct revenue stream immediately improving the investment case for certain low-carbon technologies, such as carbon capture and storage (CCS) and hydrogen. The IRA has certainly alerted policymakers of both the EU and EU Member States and resulted in a reaction (see Box 1 for an overview of the measures).

On the side of China, in the last couple of years its attitude towards western economies has become much more assertive and some cases even openly contentious. In several areas, as geopolitical tensions grow, China has increasingly moved apart from the West. However, the Chinese plan to reduce its dependencies on other countries was already planned long before global engagement with China was at the highest levels. In 2015, China put forward the 'dual circulation strategy', which embedded the idea of China becoming self-sufficient. The dual circulation strategy is a two-pillar approach aiming at spurring domestic demand ("internal circulation") and, at the same time, supplying export markets ("international circulation"). So, on the one hand, the country seeks to improve its ability to participate in global trade, finance and technology, and on the other hand to strengthen domestic consumption, production and technological capabilities to promote self-reliance. The strategy was accompanied by the launch of China's industrial policy masterplan 'made in China 2025'. Trump and his push for a trade and technology war against China, possibly made the dual circulation strategy more appealing to the Chinese leadership. It materialised in an attempt to insulate the domestic market from the rest of the world by eliminating any bottlenecks in terms of natural resources or technology, and with the purpose of achieving self-reliance served by China's huge domestic market.

From an EU perspective, not only the US and China's respective national strategies matter. The interaction and the tensions between the US and China have implications for the EU and its potential need for increased autonomy. Increasing tensions between the two superpowers and deviations from the rule-based system to which the EU is committed are impacting EU interests.

Besides the geopolitical considerations and the shift in the international order, megatrends such as the digital and green transitions have an important bearing on the EU's outlook. Digitalisation has over the past decades considerably transformed economies and has permeated the everyday life of people around the globe. As this trend is expected to continue, further adaptation and transition to a digital economy for the EU is critical. However, Europe is lagging behind major competitors and other

[5] See Paikin and Katsioulis (2023) and ECB (2023)

advanced economies in its digital performance. Regarding climate change, it is not only likely to lead to more frequent natural calamities and have an uneven impact on EU territories but will also change the global availability of resources and put strains on the sustainability of supply chains. As the following sections point out, both of the above trends have the potential to lead to further dependence on third countries.

Therefore, both economic and geopolitical considerations point to the need for the EU to reduce its reliance on other nations. This is at the heart of EU strategic autonomy.

3. Open strategic autonomy as a concept

The concept of strategic autonomy hails from security and defence policy and its origins can be traced back to the French-British summit in Saint-Malo in 1998. However, the European Council conclusions on the EU common security and defence policy (CSDP) of December 2013 are generally credited for being the first official EU document containing the expression. The 2016 EU Global Strategy used the expression four times, mostly in relation to security and defence. The concept has since become part of the mainstream policy discussion and its scope has expanded to encompass several other areas (Damen, 2022; Council – ART, 2021).

The notion of 'EU strategic autonomy' generally refers to being able to act autonomously, in line with Europe's own interests and values, working with others where it can, alone where it must. The burgeoning literature on the origins, development and definition of the concept has, however, yielded different interpretations and there is no common understanding of what it should entail specifically. 'Strategic sovereignty' is sometimes used interchangeably with strategic autonomy, but the different language tends to reflect underlying sensitivities across Member States. For instance, the cultural connotations of 'sovereignty' differ widely in German and French political discourse (Damen, 2022; Council – ART, 2021; EPRS, 2021a).

A paper issued by the Analysis and Research Team (ART) of the Council (see Box below) has noted that because of these sensitivities, instead of providing a definition of the concept, the debate on strategic autonomy has focused on what it is not. It seems clear that the term should not be understood as a reference to autarky, protectionism, or unilateralism. Neither is it confined to defence and security policy or building resilience or self-reliance. Instead, it should be understood as a means to promote EU interests and values (Council – ART, 2021). The paper also highlights that the EU is not alone in redefining its strategic autonomy: all major powers are doing something similar. The notions of 'America First' and 'Buy American' in the USA, the increasing tendency to self-supportiveness in China, and the 'Make in India' strategy all encompass the idea of less dependence.

Box 1. Conclusions of the Analysis and Research Team of the Council on the definition of strategic autonomy

'Strategic autonomy has been defined (1) narrowly, as the capacity for autonomous military action; (2) broadly, as the reduction of external dependencies in 'strategic' areas; and (3) analytically, as the ability to set one's own ends while having the means to achieve them. Some key lessons can be drawn from the definitional debate on strategic autonomy.

Firstly, if autonomy is conceived of as 'a spectrum ranging from full self-sufficiency to full dependence', it follows that the nature and level of 'optimal' strategic autonomy may vary from one policy area to another; and that an 'optimal' level of strategic autonomy may not coincide necessarily with its 'maximum' level.

Secondly, it is not enough to state that strategic autonomy is not a rejection of multilateral cooperation; instead, it should be stressed that the EU can only contribute to effective multilateralism if it develops its own capacity for strategic autonomy, and conversely that an effective multilateral order is a condition for Europe to fully develop its strategic autonomy: each depends on the other.

Thirdly, a constructive debate on strategic autonomy is only possible if the parties involved share the same understanding of the phrase. And finally, strategic autonomy is not a goal in itself, nor a simple means to an end; rather, it encompasses both dimensions (ends and means) and requires political choices both in terms of strategic priority-setting and in terms of capacity-building.'

The European Parliament Research Service's note on strategic autonomy defines it as 'the capacity of the EU to act autonomously – that is, without being dependent on other countries – in strategically important policy areas. These can range from defence policy to the economy and the capacity to uphold democratic values'.

Importantly, the adjective 'open' has often been added to qualify EU strategic autonomy. The addition is meant to assuage fears arising from associating autonomy with autarky or unilateralism. In the case of the latter, the strategic choice of openness means that the EU prefers to act multilaterally and with like-minded countries, such as the United States.

In the 2021 EU Trade Policy Review, the European Commission defines 'open strategic autonomy' as follows: 'Open strategic autonomy emphasises the EU's ability to make its own choices and shape the world around it through leadership and engagement, reflecting its strategic interests and values.' It further specifies, 'It reflects the EU's fundamental belief that addressing today's challenges requires more rather than less global cooperation. It further signifies that the EU continues to reap the benefits of international opportunities, while assertively defending its interests, protecting the EU's economy from unfair trade practices and ensuring a level playing field. Finally, it implies supporting domestic policies to strengthen the EU's economy and to help position it as a global leader in pursuit of a reformed rules-based system of global trade governance.' The Commission specifies, 'Open strategic autonomy' is a policy choice, but also a mindset for decision-makers. It builds on the importance of openness, recalling the EU's commitment to open and fair trade with well-functioning, diversified and sustainable global value chains. It encompasses:

- resilience and competitiveness to strengthen the EU's economy;
- sustainability and fairness, reflecting the need for responsible and fair EU action;
- assertiveness and rules-based cooperation to showcase the EU's preference for international cooperation and dialogue, but also its readiness to combat unfair practices and use autonomous tools to pursue its interests where needed.'

Consistent with the idea of Open Strategic Autonomy, in October 2023, the Spanish Presidency of the EU published a non-paper aiming to contribute to the design of a comprehensive approach to ensure the EU's Open Strategic Autonomy. It contains concrete lines of actions built around three main areas: i) Bolstering and securing internal production capacities, ii) Enhancing circularity and smart consumption, and iii) Reinvigorating global trade and the multilateral system.

As it will be shown below, the concept of strategic autonomy adopted in this report is centred around economic openness and several actions proposed in Spanish Presidency's paper are in line with the policy options proposed in this report. This is notably the case for i) reducing foreign dependencies, including by fostering domestic production of key goods, services and raw material, ii) enhancing energy efficiency, iii) rebalancing relations with China (without decoupling), and iv) finding alternatives, including by developing new technologies, to raw materials for which the EU cannot sufficiently diversify its demand.

4 How vulnerable is the EU economy?

This section investigates four areas in which global economic linkages in a context of geopolitical tensions may be a source of vulnerability for the EU:

- Import dependence of the EU economy
- EU integration in and exposure to Global Supply Chains (GVCs)
- EU access to critical raw materials
- The international role of the euro.

4.1 EU import dependencies: Ecosystem and sectoral approach

This section assesses the degree of EU import dependence for sensitive industrial ecosystems. The concept of industrial ecosystem was introduced by the European Commission in 2020, in the presentation of the New Industrial Strategy. The strategy is framed around 14 different ecosystems which represent around 90 % of the business value added in the EU.

Industrial ecosystems capture complex interconnections between industries. Rather than looking at a linear value chain, an industrial ecosystem captures a *network of value chains*. From an industrial strategy perspective, this means that even if trade disruptions directly affect only one industry (and one EU country), negative spillovers can propagate through the entire network and affect other industries (and countries) as well. Thus, accounting for EU import dependencies from the industrial ecosystem perspective is key to designing a proper EU industrial strategy.

To analyse import dependency at the level of industrial ecosystems, we rely on the CEPII BACI dataset, which contains bilateral trade flows for about 200 countries at the product level (about 5 000 products). Traded goods are classified according to the Harmonised System (HS) at the 6-digit level[6]; which is the highest level of disaggregation of internationally traded products.

One of the challenges of the analysis is that the concept of ecosystem embeds different sectors and industries, so it entails a high degree of aggregation, with limited details. By contrast, the dataset is characterised by a very high degree of detailed information.

On the one hand, highly disaggregated bilateral trade data allow for the assessment of dependencies at the product level, permitting the identification for each product the countries from which it is imported. On the other hand, the high level of detail leads to complexity, which raises visualisation and communication challenges, but also policy challenges.

To overcome this trade-off, we first compute EU import dependence for each traded product, we then reaggregate products to measure the degree of dependency at the sector (or to be more precise, divisions of products) level focusing on strategic[7] sectors within the ecosystems. To so do, products need to be reclassified. Since industrial ecosystems are defined based on NACE 2 and 4-digit industries,

[6] The version of the dataset used classifies the products according to the HS Revision 1.

[7] For the selection of strategic sectors, we follow the definition used by the IMF (WEO, April 2023), where the selection of industries includes semiconductors, telecommunications, 5G infrastructures, green-transition related equipment, pharmaceutical ingredients, strategic and critical minerals, manufacture and mining. These categories of products are mapped into the NACE (level 2, and 4 digits) ones, which are the basis for the definition of industrial ecosystems. It is important to note that the selection of 'strategic' sectors is not necessarily exhaustive, Ecosystems may include other sectors that could be considered strategic.

the HS 6-digit product data need to be mapped into the NACE classification, which is the base for the aggregation[8].

Of the 14 industrial ecosystems identified by the European Commission, six are labelled as sensitive (*Figure 4*). They include digital, electronics, renewable energy and energy-intensive industries, health and Aerospace and Defence. These are industries and sectors, for which the incapacitation to access certain products or materials could result in debilitating effects on security, economic security and development (including achievement of the green and digital transformation), public health or safety, or any combination of them. Furthermore, some ecosystems are related to critical areas listed in the FDI Screening Regulation (e.g. aerospace and defence ecosystem), the EU's critical raw materials list (e.g. energy-intensive industries ecosystems) and the critical technologies outlined in the action plan on synergies between civil, defence and space industries (e.g. digital and electronics ecosystem).

Figure 4. More sensitive ecosystems

Source: European Commission (2021) p. 13.

The dependency analysis will focus on the 6 sensitive ecosystems listed above as well as on the mobility ecosystem and mining-related activities. The two additions are meant to have more extensive coverage of strategic sectors. Mining activities do not constitute an industrial ecosystem, it is added to the analysis due to its importance for the purpose of strategic autonomy.

4.1.1 Methodology: Dependency indicators and industrial (dis)aggregation

The identification of the degree of EU (import) dependency follows the approach of the European Commission (2022) and is based on three Core Dependency Indicators[9] (CDI), each measuring a different aspect of import dependency:

- CDI1 – import concentration - measures the level of concentration of imports for each product (using: Herfindahl – Hirschman Index, HHI). Following the European Commission (2021), we use

[8] Currently there is no publicly available correspondence table that maps the HS-coded products to the NACE classification system. The correspondence tables between HS and ISIC, and ISIC and NACE, instead, exist and are publicly available (see Eurostat's Metadata Server RAMON). Thus, to map the 6-digit HS traded products to NACE, we first map products to ISIC Rev 4, which serves as an intermediary step to later map to NACE Rev 2. It should be noted that there are some products for which there is no industrial ecosystem mapping and vice versa, for industrial ecosystem referring to services there is no product in the dataset.

[9] For details about the calculations, see Annex II.

a threshold of 0.4 to signal concentration. When CDI1 is higher than 0.4 (less than 2.5 importing countries), it means that the EU has few trade partners from which it imports. The higher the value of the indicator, the lower the number of trade partners from which the EU is importing a certain product. For CDI1 equal one, the EU is importing a specific good only from a single (non-EU) country.

- CDI2 – relative import dependency – measures the importance of extra-EU imports in the total EU demand. Also, in this case, to identify the threshold signalling dependency, we follow the European Commission (2021) and set it at 0.5. A value higher than 0.5 (more than 50 %) for a certain product implies that the product is mostly imported from non-EU countries.
- CDI3 – (inverse) import substitutability – captures whether a product imported from extra-EU countries could be easily substituted with one produced in the EU. The substitutability level is low when the value of the indicator is higher than 1.

Based on the three CDIs, our goal is to identify the degree of dependency of the seven industrial ecosystems identified above plus mining activities to pinpoint the (Divisions and then Classes of) products, within sensitive ecosystems, for which dependency should be a source of concern. Each CDI measures a different aspect that can constitute dependency and thus expose the EU to debilitating effects in case of supply disruptions.

The analytical approach is sequential and reflects the (dis-)aggregation steps from product to ecosystem. First, we look at how the level of dependency at the ecosystem level (the most aggregate level) evolved over time. Next, within each ecosystem, we focus on NACE 2 Divisions of products that match or are associated with strategic sectors. As mentioned above, the list of strategic sectors is borrowed from the IMF 2023 WEO report, which in turn defines the list based on the Atlantic Council selection. For each of the products, we compute the three CDI. In addition, extra-EU countries exporting to the EU are classified according to the freedom status as *Free (F), Partially Free* (PF), or *Not Free* (NT)[10] based on the Freedom House classification in 2021. The purpose of the addition is to highlight that the same degree of import dependency and concentration from a country with freedom status, in principle, should entail different exposure to disruptions and hence less need for autonomy than in the case of a partner country with 'not free' status (autocratic).

4.1.2 Industrial ecosystems

The level of dependency measured by the three CDI is plotted in heatmaps across all 7 ecosystems plus the mining activity and years (i.e. 2000, 2005, 2010, 2015, 2021). Shades of green indicate that the dependency measured by the respective CDI is low. Progressively darker shades of red, instead, indicated an increasing level of dependency captured by the underlying CDI. Figures in cells are rounded values of each CDI at the industrial ecosystem level[11].

For import concentration, as measured by CDI 1 (***Figure 5****,* panel a), all ecosystems exhibit values below the critical threshold (i.e. 0.4) as illustrated by the predominance of green shades over the years. This suggests that the level of import concentration varied only marginally over time, with a slight increase in concentration.

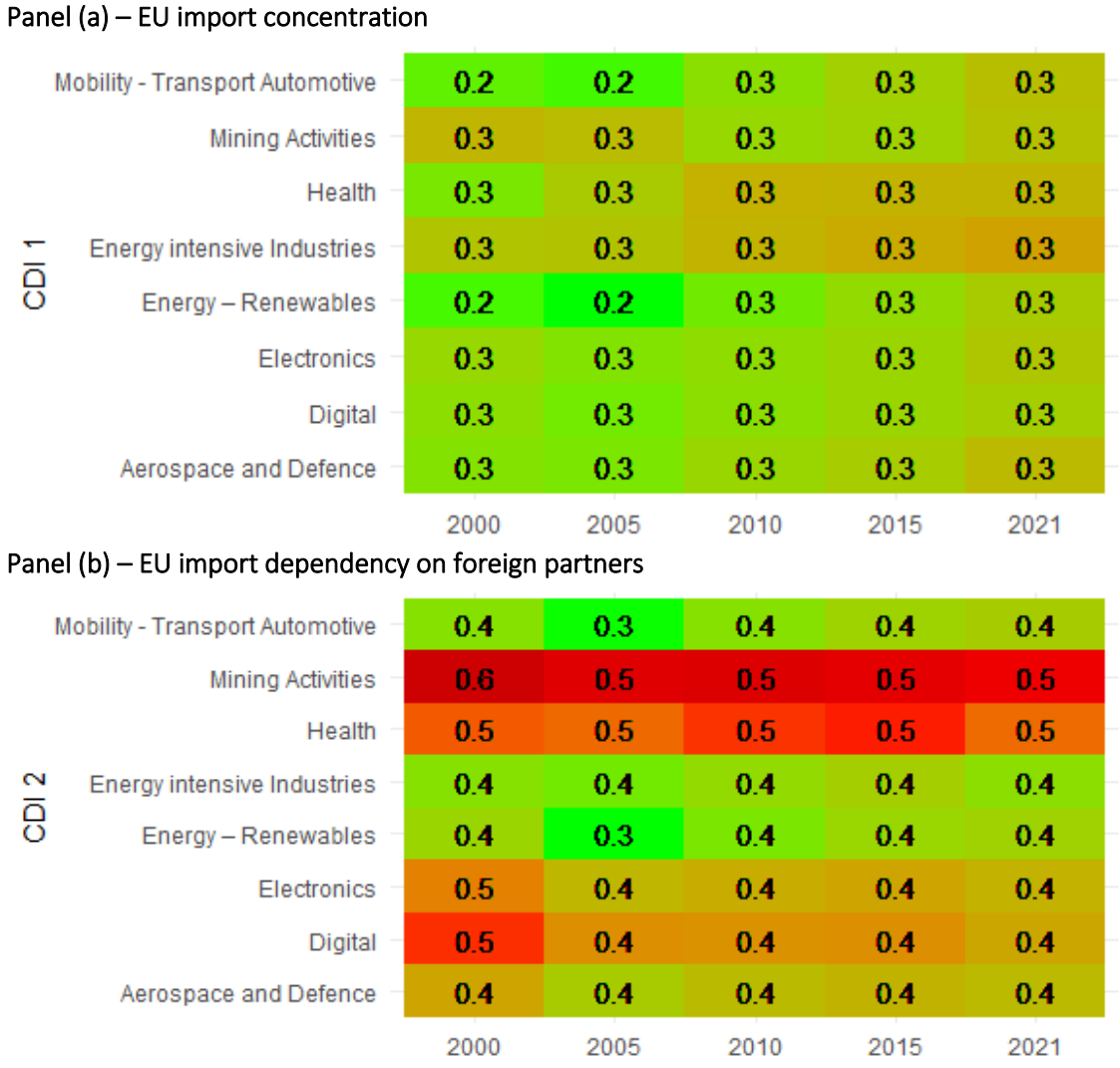
[10] For the full methodology and for more details see: https://freedomhouse.org/reports/freedom-in-the-world/freedom-in-the-world-research-methodology

[11] CDIs at the industrial ecosystem level are calculated by taking the averages of the CDIs of products falling in that ecosystem. It is important to note that because ecosystems are composed of overlapping industries, the same product can fall under more than one industrial ecosystem.

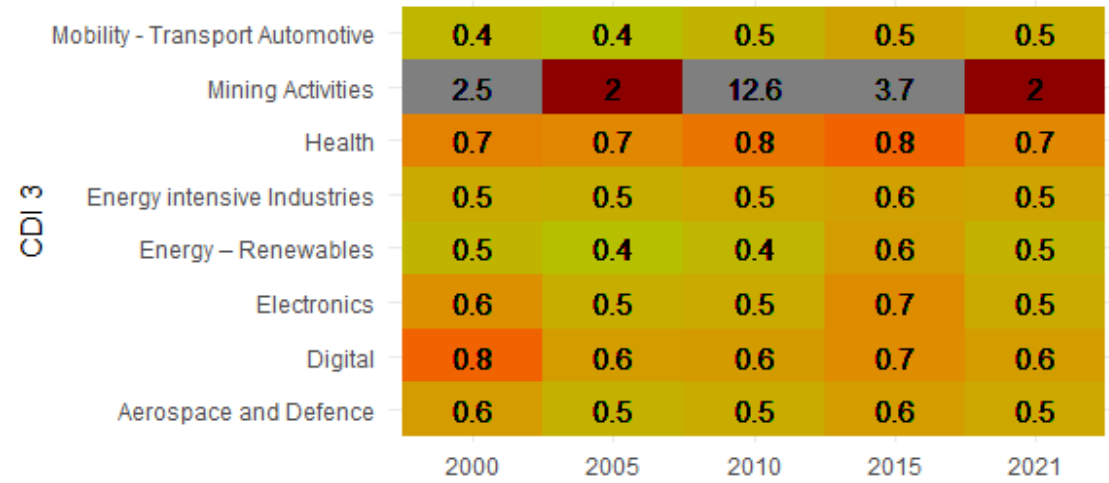
According to the CDI 2 heatmap (***Figure 5,*** panel b), which measures the relative EU demand dependence on extra-EU imports, the high dependency in activities is related to Mining and Health. Both are always above the criticality threshold. Activities related to renewable energy, digital devices, and Aerospace and Defence present a higher critical score as well, but they stay below the threshold and the level of dependency appears to have slightly decreased over time. The heatmap also shows that for the Health industrial ecosystem and Mining activities, the EU market is highly reliant on extra-EU partners, with no sign of decreasing dependence over time. In general, the other ecosystems exhibit scores below the critical threshold (i.e. 0.5), with a mild trend towards increasing dependency.

Figure 5 Panel (c) shows how the EU's capacity to substitute extra-EU trade with intra-EU trade evolved for each ecosystem. Considering that the threshold is 1, only mining-related activities present a score consistently and well above it, suggesting no possibility or very low possibility for substitutability. Additionally, while renewable energy-related industries show quite low values, they have increased over time, suggesting declining substitutability.

Figure 5. EU-level core dependencies indices for strategic industrial ecosystems, selected years



Panel (c) – EU market capacity for substitutability



Source: Own elaboration based on CEPII BACI data.

Note: Cells in grey are associated with exceptionally high values, far above the threshold.

Overall, at the industrial ecosystem level, EU import dependence and concentration do not seem a source of concern and the EU seems to be in a position to offer alternative capacity in most of the ecosystems. Nonetheless, the high degree of aggregation that the ecosystems entail can hide important risks.

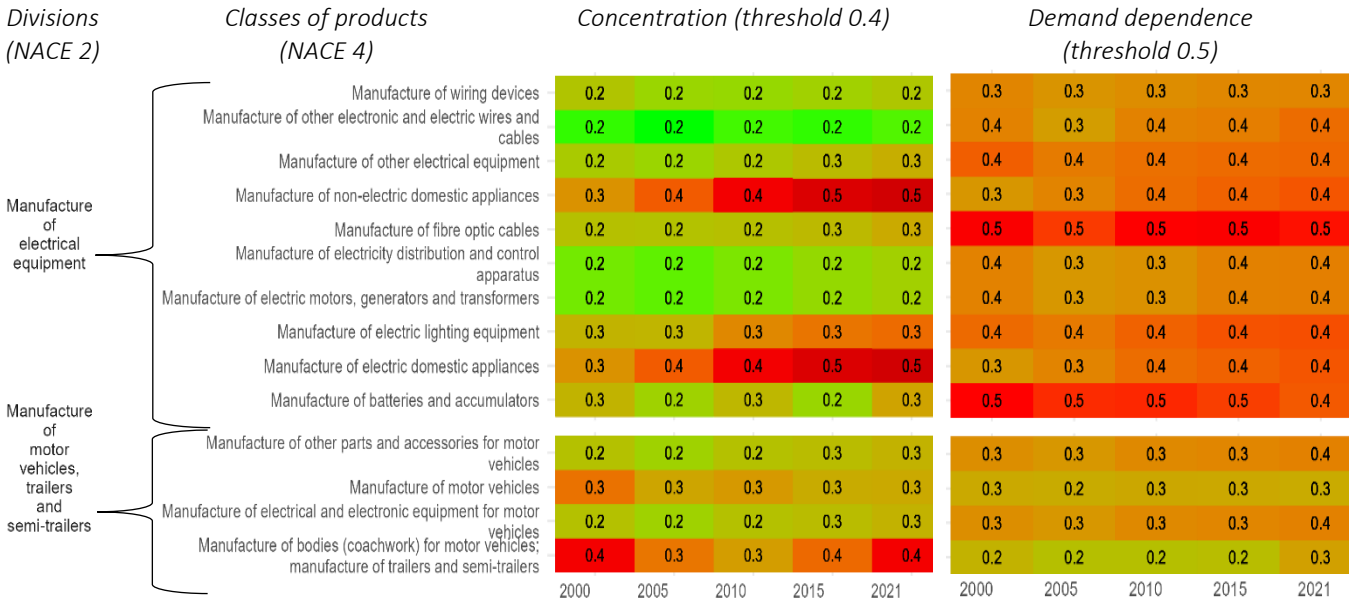
4.1.3 Strategic sectors and strategic products

To ascertain whether this is the case, the rest of this section looks in detail at strategic sectors (at NACE level 2 – divisions – and 4 – classes) within each of the seven ecosystems and mining-related activities.

Mobility – transport automotive

Although at the aggregate level, the mobility ecosystem does not seem to display excessive reliance on non-EU countries, for several products in the two strategic divisions of products (i.e. products which can be assimilated to strategic sectors) *manufacture of electrical equipment* and *manufacture of motor vehicles, trailers and semi-trailers,* the level of import dependency is rather high, both in terms of concentration and relative demand dependence, and shows a mild trend towards higher values. Among the two groups of products, *manufacture of electrical equipment* contains two classes of products with high dependency, namely *cables* and *batteries & accumulators*, and two with high concentration, *electric and non-electric domestic appliances.* Interestingly, batteries and accumulators, which are considered of strategic relevance to the digital transition, show rather high dependency (though declining) on non-EU production but the supply is distributed across different countries (low concentration). China and Japan are the top exporters of cells and batteries to the EU, whereas South Korea is the main exporter of parts of electric accumulators.

Figure 6. Heatmap of import dependency, strategic sectors of the Mobility ecosystem, selected years.

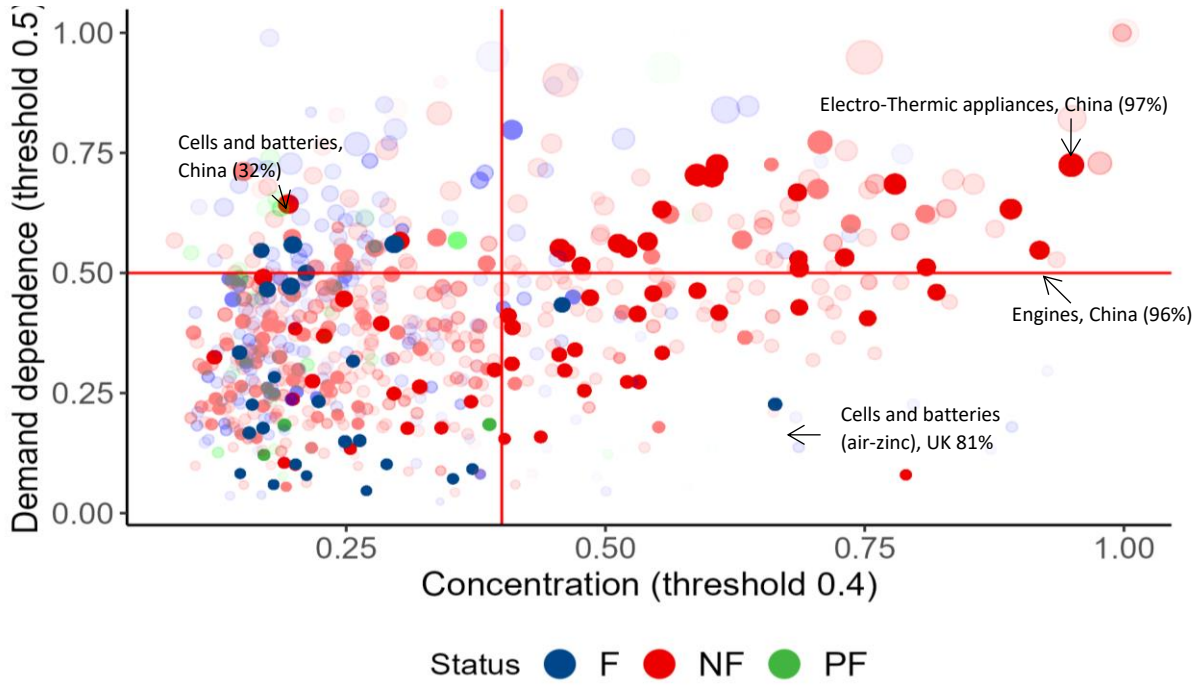


Source: Own elaboration based on CEPII BACI data.
Note: The darker the shade of red, the higher the value of the dependence indicator. Note that the mobility ecosystem partially overlaps with the energy-renewables. The heatmap reports a selection of strategic groups of products.

That said, it is worth pointing out that China is the top exporter of several different materials that are used in the manufacture of electrical equipment and the production of electrical accumulators and cells and batteries, such as lead-acid, nickel-cadmium and nickel-iron-related electrical accumulators, manganese dioxide and lithium. While EU dependency on these materials / products appears low, China seems prominent in the industry. Furthermore, China's exports of electric and non-electric domestic appliances, which are very large, appear to have a low degree of substitutability with EU production (see *Figure* 7, where for all products in the top-right quadrant, China is the top EU supplier).

Overall, in 2021, 82 % of the countries exporting strategic products in the mobility ecosystem to the EU, were classified as not free status by Freedom House.

Figure 7. EU Import dependency by-product and freedom status in the Mobility ecosystem, 2021



***Source**:* Own elaboration based on CEPII BACI data.

***Note**:* The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries.

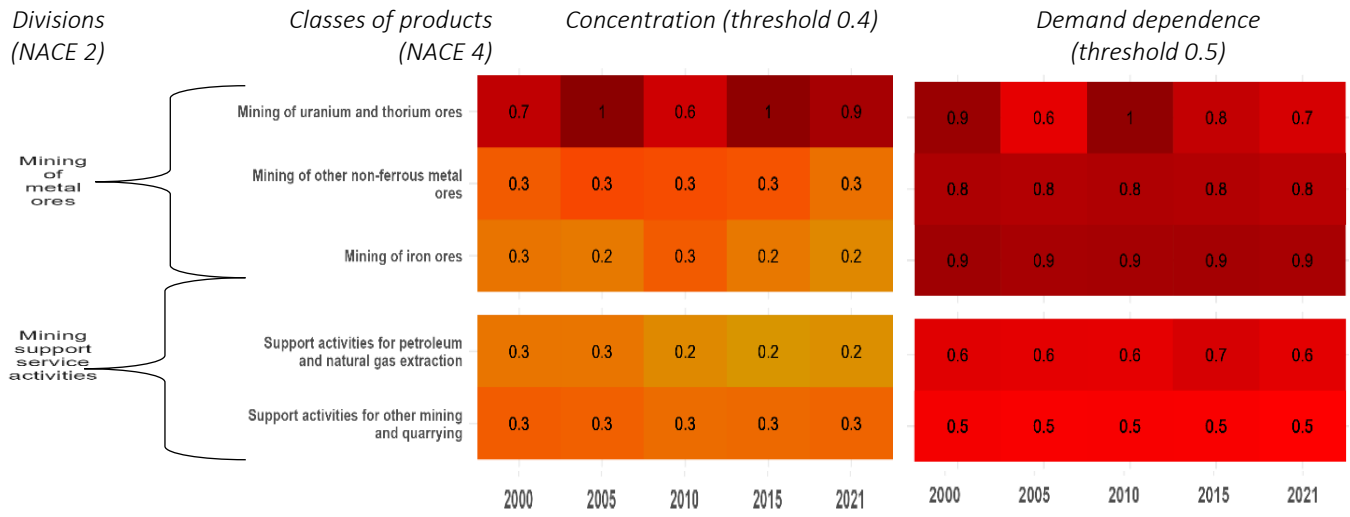
Mining activities

Mining activities do not constitute an industrial ecosystem; however, several traded goods / materials are considered strategic and even critical. Furthermore, as is illustrated in *Figure* 8, they display high import concentration and very high demand dependency.

EU imports of products related to the industry of *mining of uranium and thorium ores* are concentrated in very few countries, in some cases only one. For other classes of products such as *mining of other non-ferrous metal ores* and *support activities for other mining and quarrying* the index of concentration is below the threshold of 0.4, but the darker shades of red indicate it is close to it.

By contrast, the index of EU import dependency is above the threshold of 0.5 across all classes of products and all years and higher than in any other classes of products belonging to other industrial ecosystems. The high values indicate that for these products the EU relies almost exclusively on non-EU countries. In 2021, the dependency is particularly high for products in the *Mining of metal ores.*

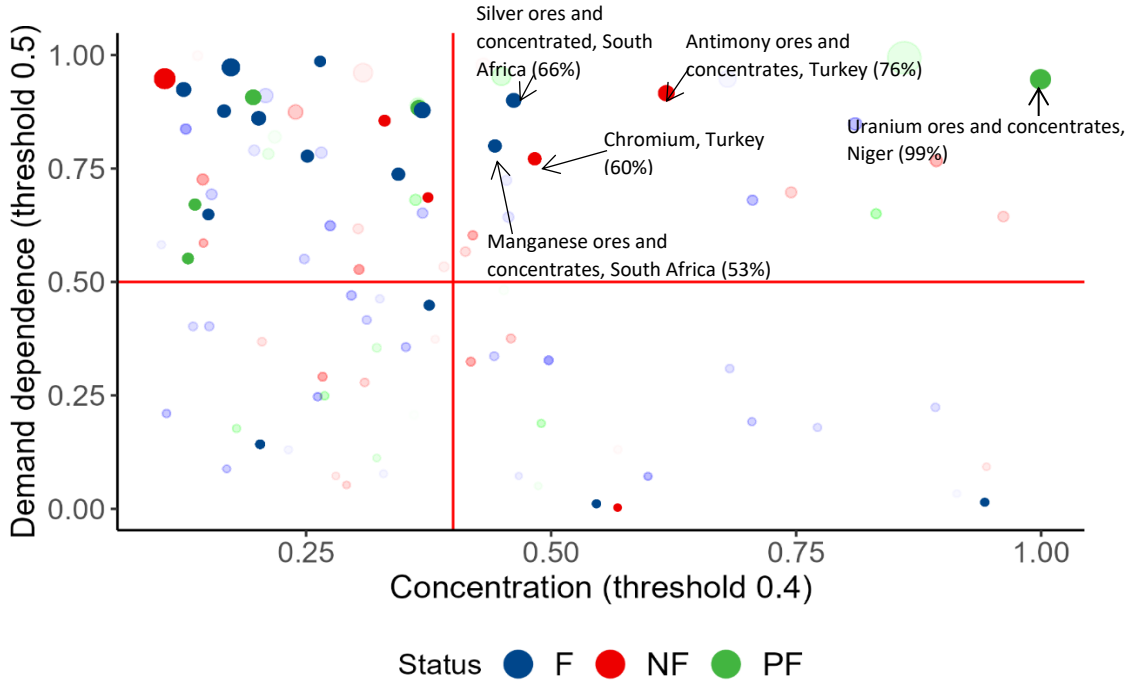
Figure 8. Heatmap of import dependency, strategic sectors of the Mining activities, selected years.



Source: Own elaboration based on CEPII BACI data.
Note: The darker the shade of red, the higher the value of the dependence indicator. The heatmap reports a selection of strategic groups of products.

The high level of concentration and demand dependency, in 2021, is evident also from the scatter plot (see *Figure 9*). Most products are distributed in the high-dependency regions.

Figure 9. Import dependency by product and freedom status in Mining activities, 2021



Source: Own elaboration based on CEPII BACI data.
Note: The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries.

Norway and the United States are the top exporters of natural gas and liquified gas to the EU. Among other countries *vis-à-vis* which the EU exhibits high dependency, there is Niger (uranium ores and concentrates) and South Africa (silver ores and concentrates, and manganese), and Turkey (borates, antimony and chromium).

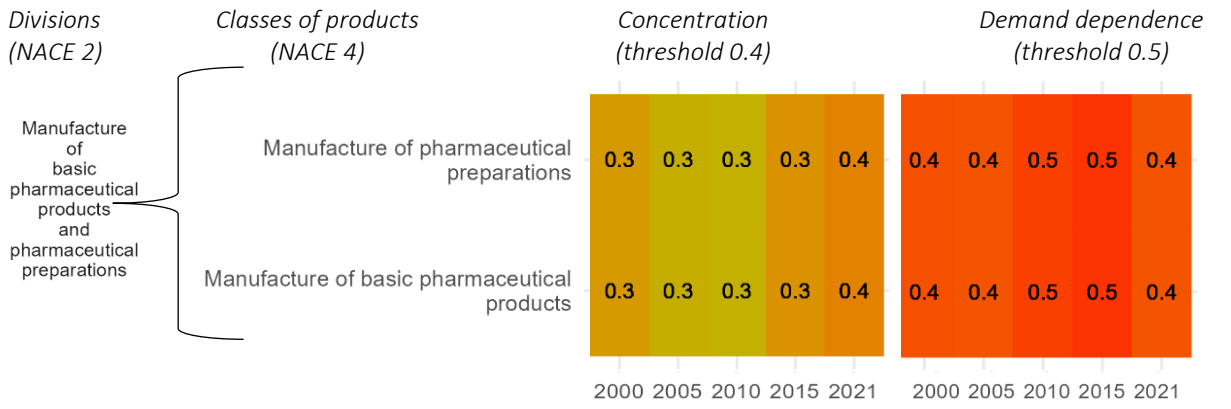
Overall, in 2021, 34 % of the countries exporting strategic products for Mining activities to the EU, were classified as not free status by Freedom House.

Health

At the aggregate level, the strategic classes of products related to pharmaceutical products and preparations do not display a high level of import dependency. The EU demand dependency is above the threshold level for products included in two groups of products considered as strategic, namely the *Manufacture of basic pharmaceutical products and Pharmaceutical preparations,* only in 2010 and 2015.

Nonetheless, as evidenced by the Covid-19 pandemic, the EU can be vulnerable to a safe supply of medical products and pharmaceuticals, which is crucial for the health of Europeans and the EU's open strategic autonomy. In response to existing import dependencies, in 2021, the European Commission established the new Directorate-General of Health Emergency Preparedness and Response Authority (HERA) to identify trade dependencies in pharmaceuticals and contribute to the EU's open strategic autonomy. The Covid-19 crisis highlighted the EU's dependence on imports of pharmaceutical products from single importers.

Figure 10. Heatmap of import dependency, strategic sectors of the Health ecosystem, selected years



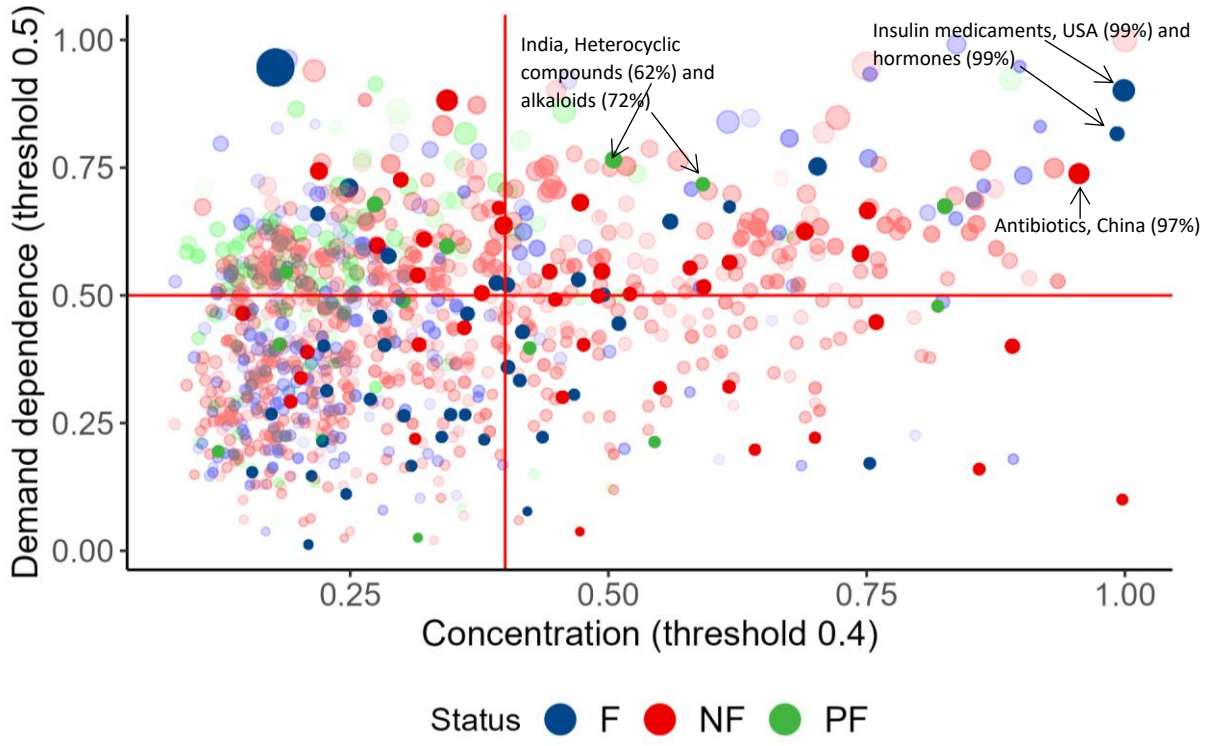
Source: Own elaboration based on CEPII BACI data.
Note*:* The darker the shade of red, the higher the value of the dependence indicator. The heatmap reports a selection of strategic groups of products.

The degree of import concentration of products in this ecosystem is below the threshold level, and similar to other industrial ecosystems, top exporting countries are classified as not free (mainly China). There are, however, a number of products for which the EU's main supplier is India (classified as partially free, in green in the scatter plot), for which the EU demand is in the high dependency region of the scatter plot (see *Figure* 11). India supplies alkaloids, acids, pharmaceutical goods, and heterocyclic compounds. For 7 pharmaceutical products, the EU has above the thresholds

concentration, demand and level of substitutability. The main providers of these products are China (which is the top supplier of 5 of them), the United States and Switzerland.

Other suppliers of products such as alkaloids, acids, antibiotics and other pharmaceutical goods for which the EU demand is dependent are the United Kingdom, Australia, Indonesia and Japan.

Figure 11. Import dependency by product and freedom status in the Health ecosystem, 2021



Source: Own elaboration based on CEPII BACI data.
Note: The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries.

Overall, in 2021, 47 % of the countries exporting strategic products belonging to the health ecosystem to the EU, were classified as not free status by Freedom House.

Energy-intensive industries

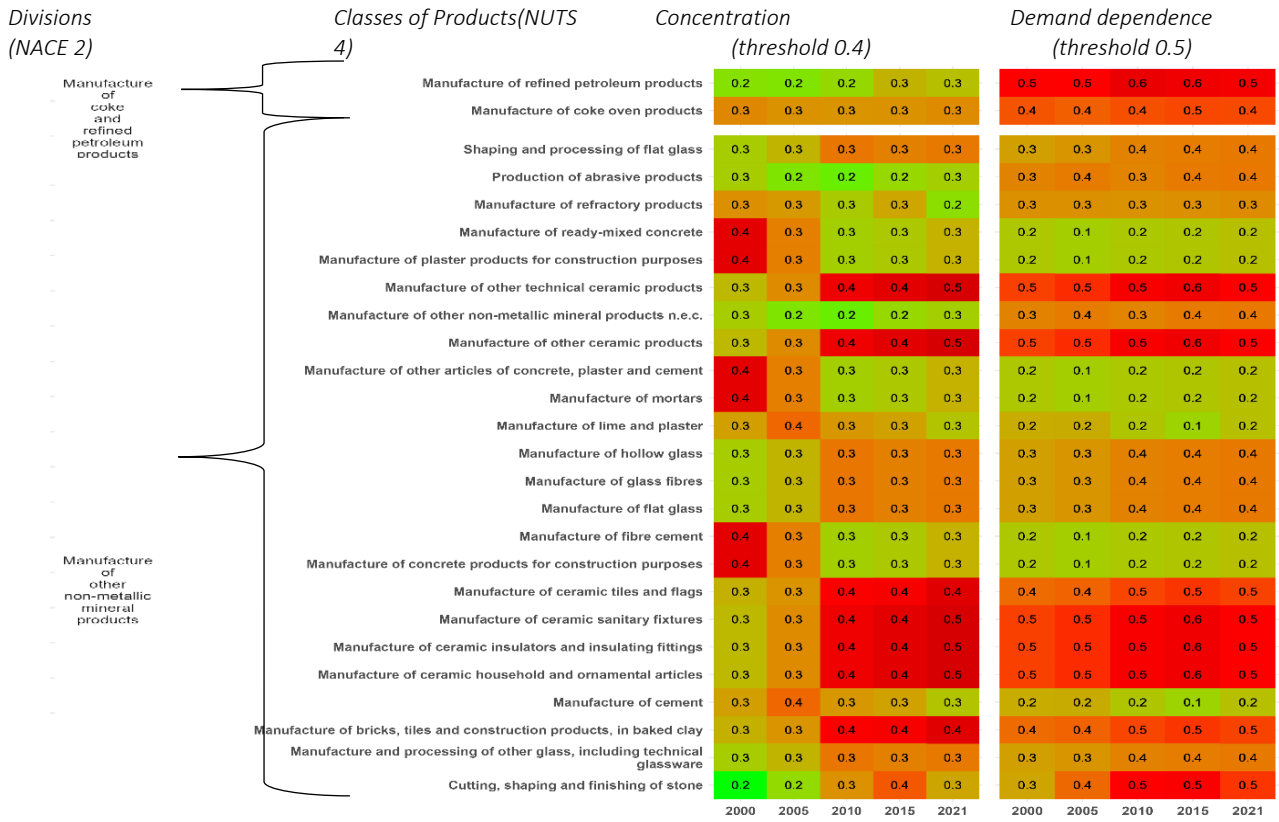
The energy-intensive ecosystem is one of the biggest ones in terms of the number of products. In the ecosystem, *Manufacture of coke and refined petroleum products* and the *Manufacture of other non-metallic mineral products* are considered strategic. Such groups of products are part of many value chains and feed raw, processed and intermediate materials, rather than finished goods, into other productions (and industries)[12]. The production of these goods is not only interconnected with energy providers but also with the waste and recycling industries.

The ecosystem displays a high level of import concentration for classes of products related to the *Manufacture of ceramic products* and *other classes of non-metallic mineral products*. The same classes of products also show an increasing level of demand dependency, reaching the highest level in 2021.

[12] See EC, SWD(2021) 277 final

As for the other classes of products, they display a below-the-threshold and steady level of dependency, indicating that these sectors are diversified in terms of extra-EU suppliers.

Figure 12. Import dependency, strategic sectors in the Energy-intensive industries ecosystem, selected years.



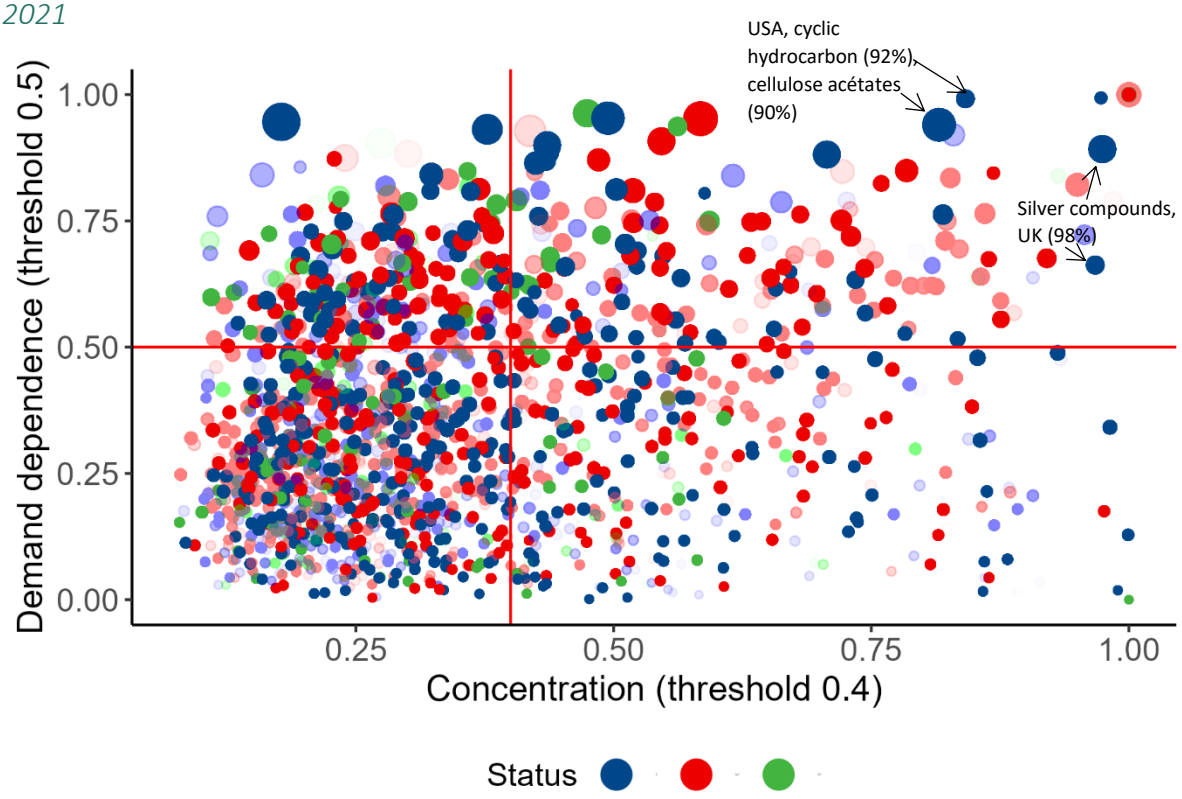
***Source**:* Own elaboration based on CEPII BACI data.
***Note**:* The darker the shade of red, the higher the value of the dependence indicator. The heatmap reports a selection of strategic groups of products.

As shown in *Figure* 13, the distribution of products belonging to this ecosystem is skewed towards the left, indicating below the 0.4 concentration. The top exporting countries are China, Russia and the United States. Russia exports to the EU several raw materials such as iron, nickel, uranium, iron and steel. For eight products for which Russia is the top exporter, the EU is in the position of very high dependency: high concentration, high relative demand dependence and low substitutability. Among these products are nickel; anthracite, synthetic rubber, mineral or chemical fertilisers, semi-finished products of iron, ferrous products, and ferro-tungsten. For a further eight products / materials, the United States is the top exporter to the EU (e.g. ferrous products, beryllium, cyclic hydrocarbons, cellulose acetates, copper, manganates and permanganates etc.). Other top exporters are countries from the MENA and ASEAN regions, South America, and a few African countries (Nigeria and South Africa).

Industries operating within the energy-intensive ecosystem import products that consist of strategically significant materials, particularly linked to the digital and green transition. One such material is silicon, which already plays a vital role in people's lives worldwide. Silicon is indispensable in the manufacturing of power electronics, as well as the production of chips, transistors, integrated circuits, liquid crystal displays, diodes, and other components found in digital products like computers and smartphones. Additionally, silicon is utilised in the creation of solar cells. In terms of silicon trade, China not only

serves as the primary supplier to the EU but also holds the position of the global producer. Alongside silicon, there is an increasing global pursuit of alternative materials. Examples include silicon carbide (Norway being the main supplier to the EU) and Gallium Nitride (Russia and the US being the primary partners to the EU). **These materials could become progressively more significant in the industry as they demonstrate superior qualities compared to existing options**[13]. Overall, in 2021, 54 % of the countries exporting strategic products belonging to the energy-intensive ecosystem to the EU, were classified as not free status by Freedom House.

Figure 13. Import dependence by product and freedom status in the Energy-intensive industries, 2021



***Source**:* Own elaboration based on CEPII BACI data.
***Note**:* The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries.

[13] See e.g. here

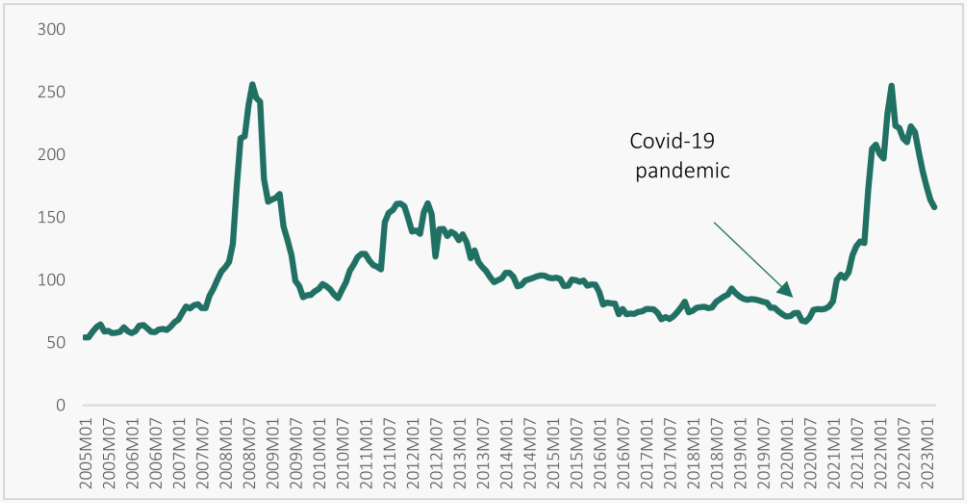
Box 2. Additional dependencies – why are fertilisers important?

Food and agriculture are not included in the list of the sensitive ecosystems. There is an underlying assumption that at the EU level the risk of a food crisis is extremely unlikely. That said several EU countries have increasingly referred to the idea of 'food sovereignty'* and pointed to problems (essentially high prices) driven by dependencies on foreign countries for some specific products (for instance grains). In practice, one of the underlying problems was fertilisers.

Until the start of the war in Ukraine, Russia was the world's largest exporter of fertilisers. This is a key input for agriculture globally, including the EU. International prices of fertilisers have increased markedly and at high speed throughout 2021 until spring 2022. This dynamic is closely linked to prices for natural gas – which is a key input in the production of nitrogen fertilisers. To put it simply, fertilisers are an energy intensive industry. Furthermore due to broader supply chain disruption and transportation costs following the Covid-19 pandemic and the start of the war in Ukraine, the Russian Ministry of Industry and Trade recommended suspension of the export of fertilisers – which has contributed to pushing prices even higher. Worldwide, fertiliser imports appear to be relatively diversified, so the issue is not necessarily supply but rather price.

Higher input prices have fed into higher production costs and have been passed on as higher food prices. Fertilisers account for about 35 % of the marginal cost of production for wheat and maize, hence potentially a high impact on food prices. In poor countries, high fertiliser costs could lead to lower usage, with the risk of depressed yields in the crop season – adding to the shortage of imported grains and putting food security even more at risk.

Figure 14. Fertilisers, price Index (2010=100), 2005-2023M3



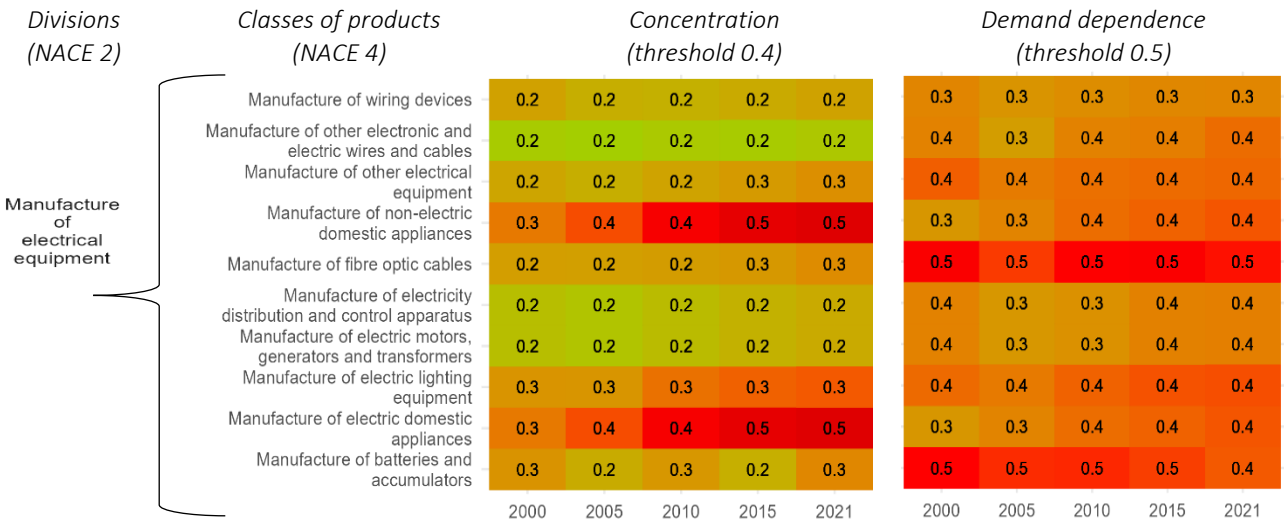
Source: World Bank

*As an example, in Italy and in France the respective Ministries of Agriculture have been renamed to include "sovranità alimentare" and "souverainité alimentaire".

Energy – Renewables

The Renewables industrial ecosystem includes products related to the manufacture and transmission of electricity and electrical equipment (i.e. technologies used for the distribution, storage and transmission of electricity), and those related to the production of renewable energy. The *Manufacture of electrical equipment* ecosystem has a group of products that is considered strategic. It is important to note that the same group of products is strategic also for the Mobility ecosystem (as shown above) as well as the Digital and Aerospace and Defence ecosystems.

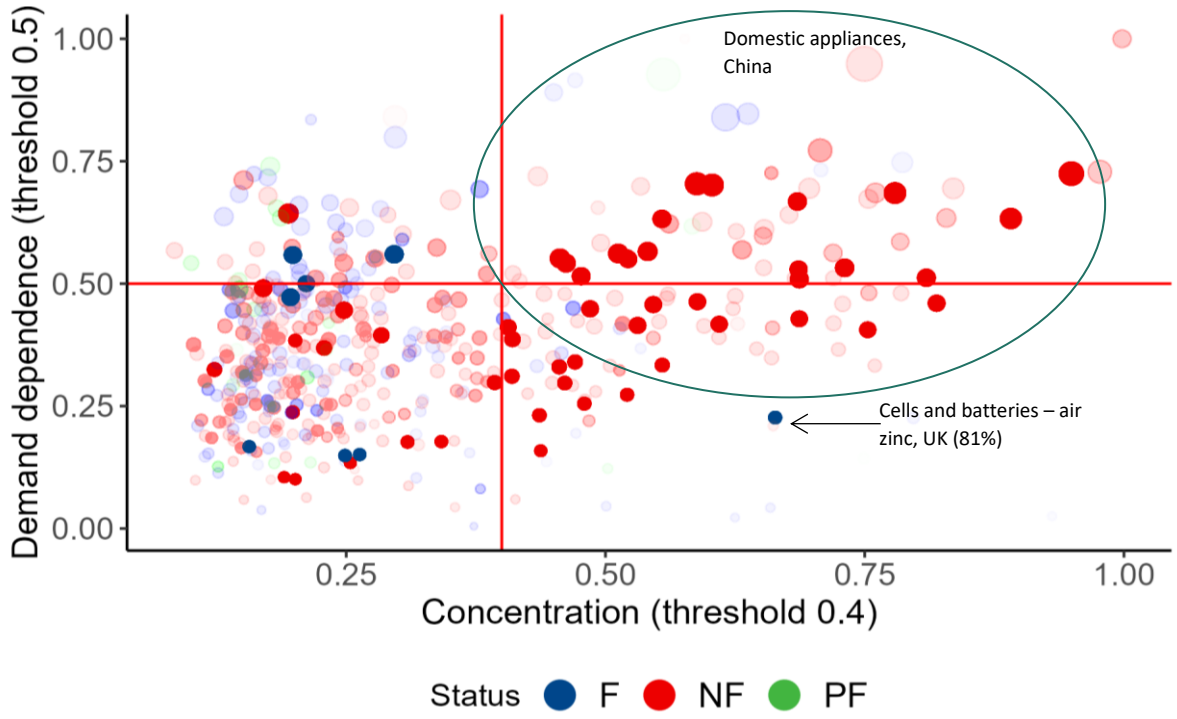
Figure 15. Heatmap of import dependency, strategic sector of the Renewables ecosystem, selected years.



Source: Own elaboration based on CEPII BACI data.
Note: The darker the shade of red, the higher the value of the dependence indicator. The heatmap reports a selection of strategic groups of products.

By looking at the full set of products (not only the ones belonging to strategic sectors) in the ecosystem, it appears that products in strategic sectors are mostly located in the top-right high import concentration and high demand dependency region (see *Figure* 16).

Figure 16. Import dependency by product and freedom status in the Renewables ecosystem, 2021



Source: Own elaboration based on CEPII BACI data.
Note: The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries.

As was indicated for the Mobility ecosystem, it is mostly in the area of domestic electric and non-electric appliances that China is the top exporter to the EU. China is also the main provider of *Cells and batteries*, *Electric accumulators* (and electrical apparatuses in general), *Carbon electrodes* and *Permanent magnets,* for which the level of import dependency is high and the level of substitutability low.

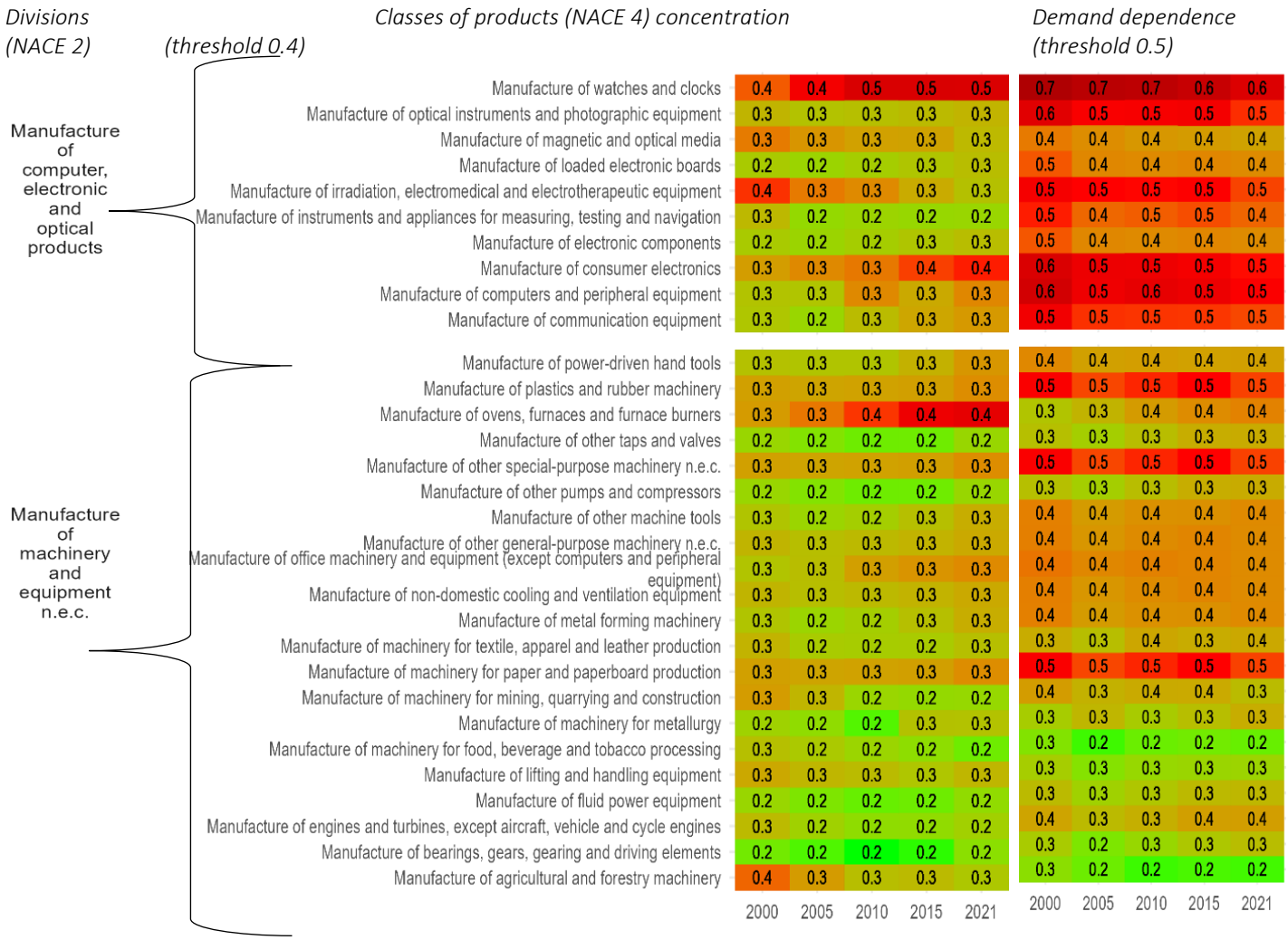
Overall, in 2021, 94 % of the countries exporting strategic products in the energy – renewables ecosystem to the EU, were classified as not free status by Freedom House.

Electronics

Within the Electronics industrial ecosystem, *manufacture of computers, electronics and optical products* as well as *manufacture of machinery and equipment n.e.*c. (not elsewhere classified) are considered strategic sectors. It is important to note that *Manufacture of computers, electronics and optical products* is also considered strategic for the Digital ecosystem and the Aerospace and Defence one.

Import concentration in the Electronics ecosystem is rather low and remained rather stable over the years for most classes of products, with an overall increase in the *Manufacture of ovens, furnaces and furnace burners* and a decrease in the *Manufacture of agricultural and forestry machinery*.

Figure 17. Heatmap of import dependency, strategic sectors of the Electronics ecosystem, 2000-2021.



***Source**:* Own elaboration based on CEPII BACI data.

***Note**:* The darker the shade of red, the higher the value of the dependence indicator The heatmap reports a selection of strategic groups of products.

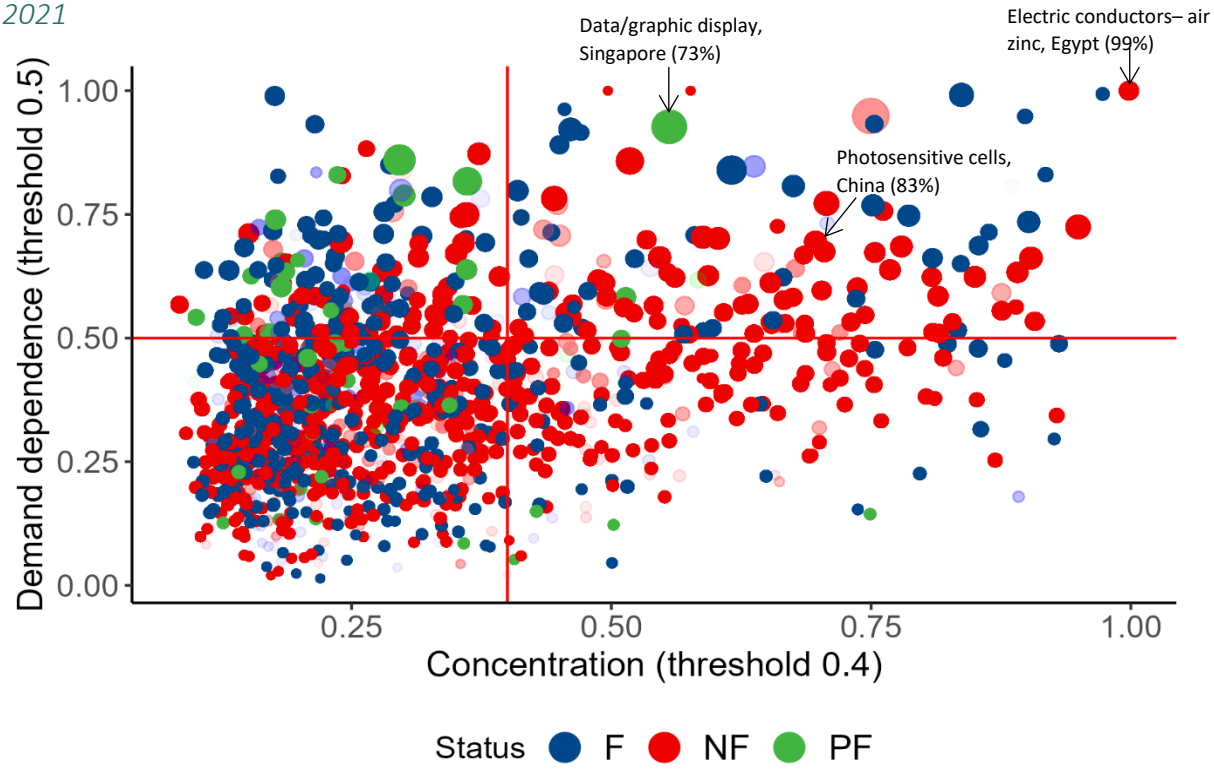
The EU demand is highly dependent on extra-EU suppliers for products related to the *Manufacture of watches and clocks, optical instruments and photographic equipment, consumer electronics and computer and peripheral equipment,* as well as *Manufacture of plastics and rubber machinery, of other special-purpose machinery* and Manufacture *of machinery for paper and paperboard production.*

Most products in this ecosystem are clustered in the region of low dependency – low concentration (see *Figure* 18). However, several products (fall in the group also relevant for other ecosystems) such as *data processing machines, permanent magnets, parts or assembled solar panels etc.,* mainly imported from China, fall under the high dependency region and are difficult to substitute with EU supply.

The top extra-EU exporters are China, the US, the UK and Japan. China is the top exporter of air conditioning machines, thus more related to domestic use, but also of different parts in aluminium. The US is exporting *aeroplanes and aircrafts* (relevant also to the Aerospace and Defence ecosystem), *medical apparatus* and a number *of electrical machines and apparatuses*. Other extra-EU exporters for this ecosystem (insulated electric conductors) Egypt, (engines: outboard motors) Japan, (data/graphic display) Singapore; (calculating machines) Malaysia, and China. However, while most of these countries only export one or a few products, China is the top supplier of a variety of products under the high dependency region.

Overall, in 2021, 63 % of the countries exporting strategic products in the Electronics ecosystem to the EU, were classified as not free status by Freedom House.

Figure 18. Import dependence by product and freedom status in the Electronics ecosystem, 2021

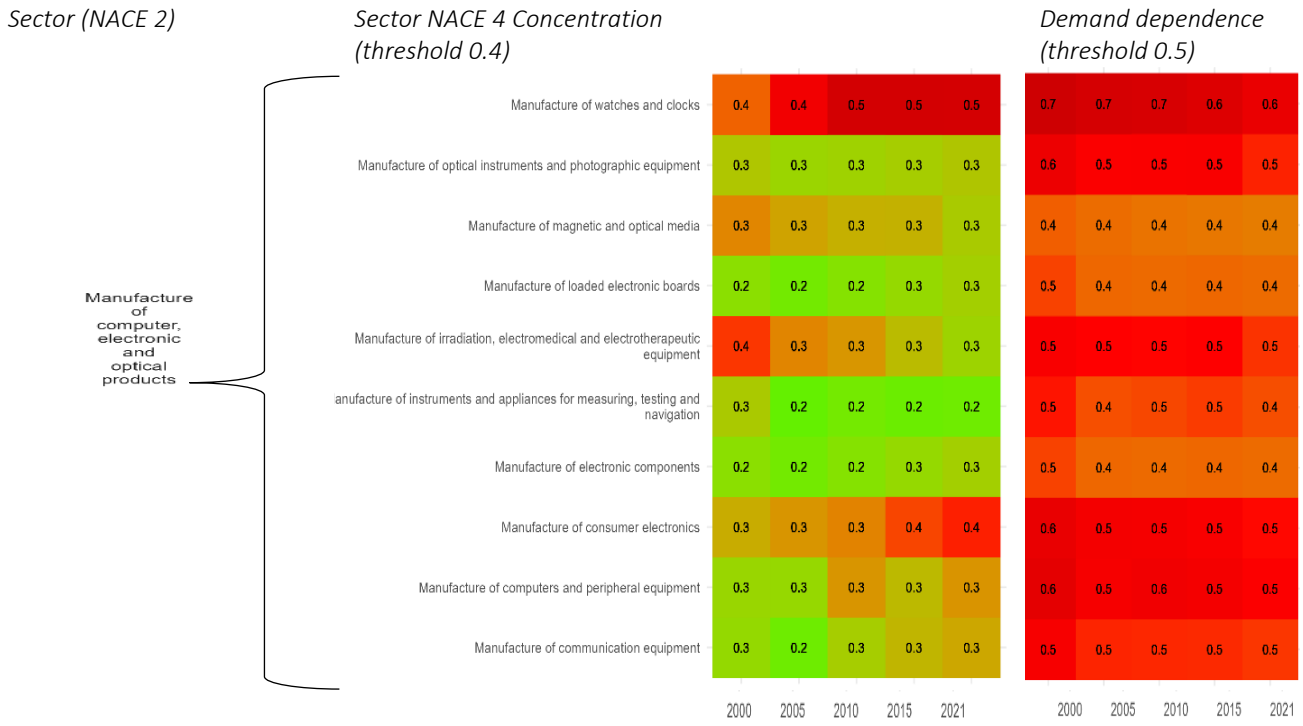


***Source**:* Own elaboration based on CEPII BACI data.
***Note**:* The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries.

Digital

As anticipated above, within the Digital ecosystem, its strategic dimension is captured by *Manufacture of computer electronics and optical products*, which was described above and overlaps with one strategic component of the Electronics ecosystem and one of the Aerospace and Defence ecosystem. As already mentioned above, the sector displays a higher level of demand dependence rather than import concentration (see *Figure 19*).

Figure 19. Heatmap of import dependency in strategic sectors of the Digital ecosystem, selected years.

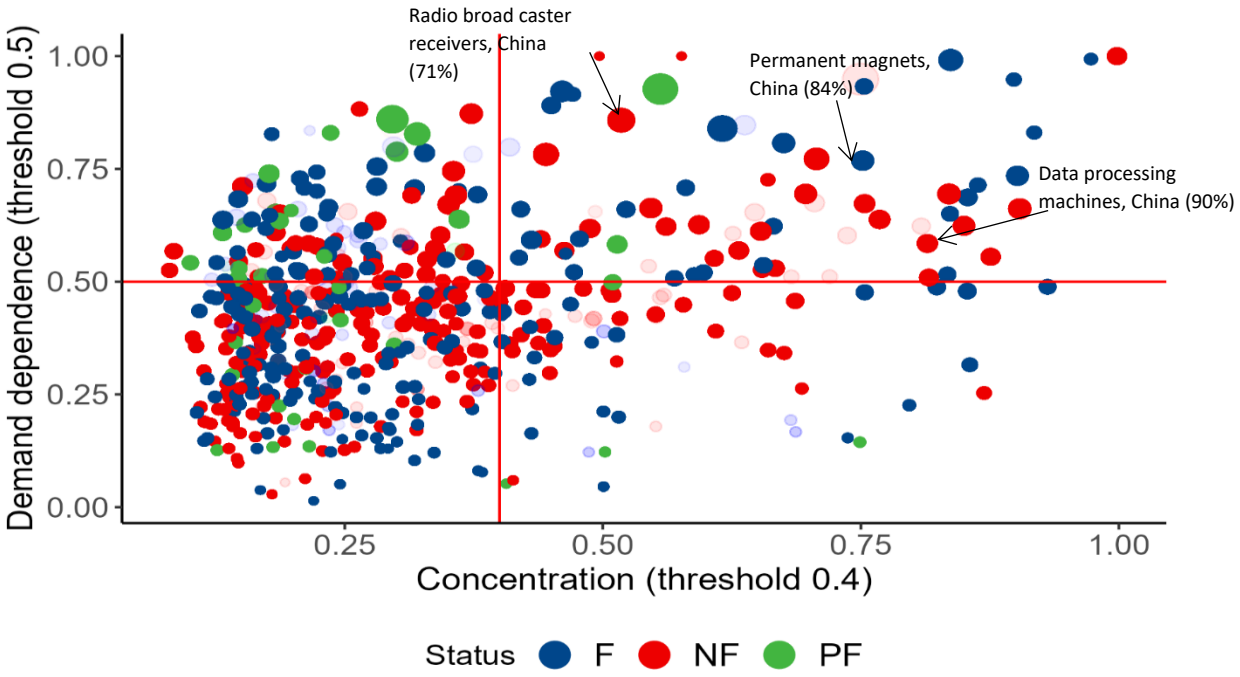


***Source**:* Own elaboration based on CEPII BACI data.
***Note**:* The darker the shade of red, the higher the value of the dependence indicator. The heatmap reports a selection of strategic groups of products.

By looking at the distribution of all products under the ecosystem (not only those belonging to the strategic sector), imported products appear in the two quadrants of low level of concentration (below the threshold) and exhibit different degrees of demand dependency (see Figure 20). Furthermore, although the EU exhibits a good degree of diversification of suppliers, its demand is mainly met by extra-EU partners.

Products in the top-right corner, which identify those for which dependency is particularly high, are also those currently less substitutable with internal production. Among products with these characteristics are *data processing machines, permanent magnets, radio broadcast receivers, sound* and *video apparatus, parts or assembled solar panels* (mainly from China), *calculating machines* (parts or accessories, mainly from Malaysia).

Figure 20. Import dependency by product and freedom status in the Digital ecosystem, 2021



Source: Own elaboration based on CEPII BACI data.
Note: The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries. Some products not relevant to the ecosystem are excluded from the chart.

The Digital ecosystem includes products related to the manufacture of chips and semiconductors, with China and ASEAN countries as top exporters in 2021 in the EU. China for instance is the main exporter of microchips (34 % of EU import share), diodes and transistors. Singapore and Malaysia are top exporters of chips components as well. Although the dependency, as measured by concentration, is below the threshold level, some components are above the threshold demand dependency and level substitutability. As global demand for chips is expected to double between 2022 and 2030, due to the twin transition among other things, these products are highly strategic.

The semiconductor industry is one of the most innovative and complex value chains. Due to rapid advances in the methods of production and materials used in semiconductor products, dependencies and value chains are likely to be shaped by these advances. On the supply side, the semiconductor sector links the digital (electronics and defence) ecosystem to the energy-intensive industries. The latter captures the trade of minerals and raw materials, among which the trade of silicon, key to the production of chips. When it comes to silicon, China is not only one of the top sources but is also the main global supplier (76 %).

Overall, in 2021, 57 % of the countries exporting strategic products in the Digital ecosystem to the EU, were classified as not free status by Freedom House.

Aerospace and Defence

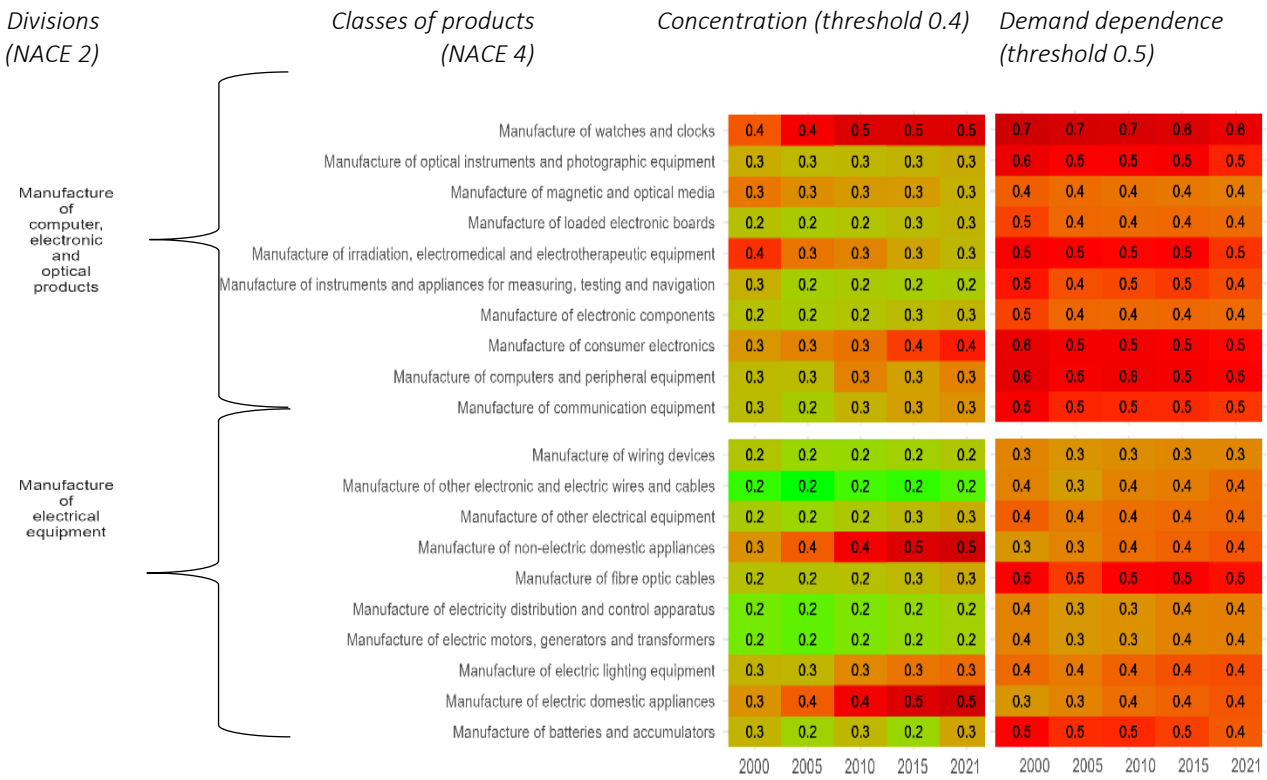
The Aerospace and Defence industrial ecosystem mostly encompasses industries that represent 'dual-use' technologies and its key role is not limited to the aerospace and security industries, as innovative technology developed within the latter can spill over and benefit other industries as well.

As shown in *Figure 21*, within the ecosystem the two strategic sectors *Manufacture of computer, electronics and optical products*, and *Manufacture of electrical equipment* overlap with strategic sectors in the digital and mobility and energy – renewables, respectively.

At the aggregated level, the strategic sectors in the ecosystem are characterised by low import concentration and a higher level of demand dependency. As discussed above, *Manufacture of computer electronic and optical products*, the import concentration increased above the 0.4 threshold level for products in the *Manufacture of watches and clock* and of *consumer electronics,* and in more than half of the classes of products, the level of demand dependency is above the threshold of 0.5.

In other strategic sectors, part of the *Manufacture of electrical equipment,* import concentration grew above the high dependency threshold for categories of goods related to domestic appliances, and the demand dependence stayed rather high for products related to the *Manufacture of optic cables* and *batteries and accumulators.*

Figure 21. Heatmap of import dependency of strategic sectors under the Aerospace and Defence ecosystem, selected years.



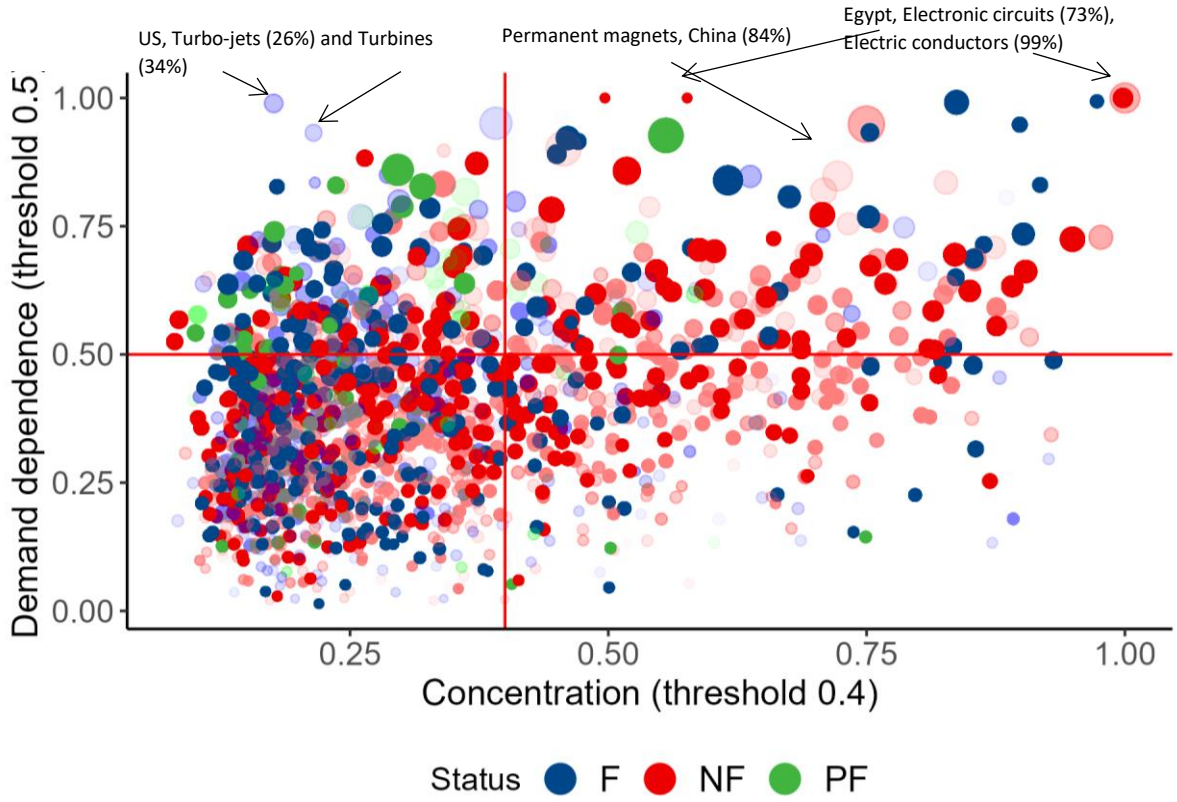
***Source**:* Own elaboration based on CEPII BACI data.
***Note**:* The darker the shade of red, the higher the value of the dependence indicator. The heatmap reports a selection of strategic groups of products.

Although at the ecosystem or class level, the level of trade dependency is not particularly high, there are still several products for which the EU has countries that are classified by Freedom House as not free as main suppliers. These partners are mainly located in Asia and in the MENA region, and in 2021, 62 % of the imported products are supplied from not free countries (see *Figure* 22).

By looking at all products in the ecosystem (not only those belonging to strategic sectors) the level of import dependency is particularly high for products such as *data processing machines, optical devices,*

permanent magnets and photosensitive electrical apparatus, with China, the US and the UK being the top exporters to the EU. China also exports materials like *iron and steel, aluminium and permanent magnets*. As already observed above, China is the main exporter of *domestic appliances*, which fall in the high dependency region (top-right corner in the scatterplot). The US appears as the main exporter of *aeroplanes and other aircraft* and the UK is the main exporter of different *parts of aircraft and spacecraft and turbojets*, although for such products the EU seem to be in the position of high demand dependence rather than concentration.

Figure 22. Import dependence by product and freedom status in the Aerospace and Defence ecosystem, 2021



***Source**:* Own elaboration based on CEPII BACI data.
***Note**:* The size of the bubbles is inversely proportionate to the degree of import substitutability. Transparent bubbles are products that are not part of strategic industries. Some products not relevant to the ecosystem are excluded from the chart.

EU dependency on China and the US in strategic sectors

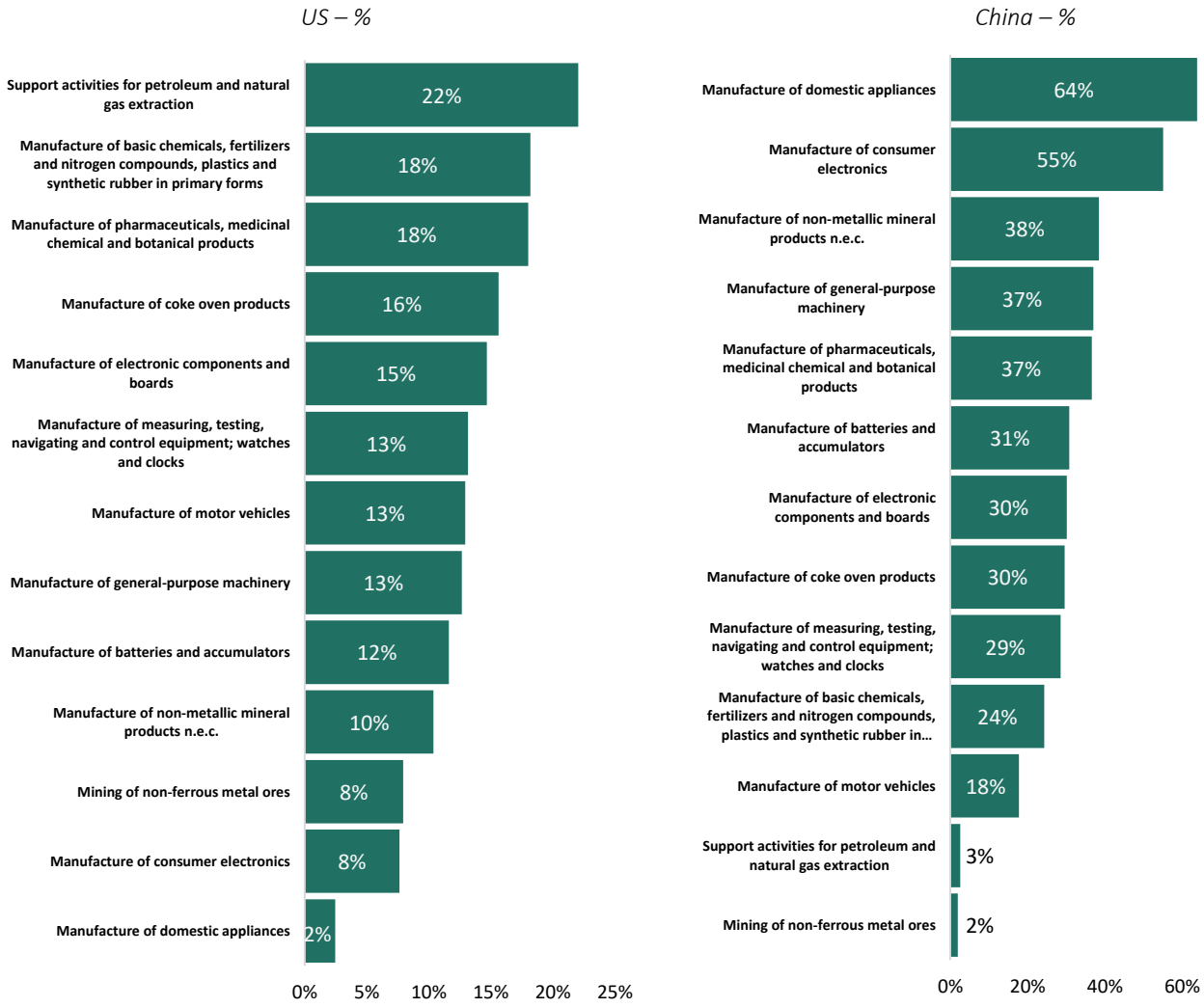
China and the US represent the two main EU trade partners, and they supply the EU with a large set and large volumes of imports. The analysis of ecosystem dependencies has revealed that the US and, above all China, are crucial in supplying products of strategic importance. Yet, important differences exist between the two of them.

Figure 23 ranks the import dependency ratio on China and the US. Two main messages emerge. First, China primarily exports consumer goods, like *domestic appliances* and *consumer electronics*. The US also exports these types of goods to the EU, but the share is almost negligible compared to China's share which is above 60 % for domestic appliances and 50 % for consumer electronics.

Second, the US's main exports to the EU are in *activities related to the extraction of fossil fuels* and *production of chemicals and pharmaceuticals*. However, the import dependency ratio is relatively small,

at around 20 %. Except for fossil fuels extraction, the other products are also imported from China and the import share is even higher.

Figure 23. EU import dependency on the US and China in strategic sectors, 2021.



***Source**:* Own elaboration based on BACI data.

***Note**:* The import dependency share is the ratio between EU imports from the country and total EU imports for the sector.

4.1.4 Is import dependency a problem?

The analysis of import dependencies provides valuable insights into various dependencies and potential future challenges in terms of EU trade integration with global partners. From the macro perspective, the EU exhibits a diverse level of global integration. China, the US, and India, as well as certain countries in Latin America and ASEAN, are consistent partners of the EU, with some specialising in supplying specific products while others have a more diversified portfolio. Upon closer examination of narrower industries or even individual products, however, a notable level of dependency emerges, driven by import concentration, demand reliance, and limited import substitutability. Monitoring of such dependencies at the industry or product level is important. The analysis at the ecosystem level indicates that products imported by firms within a particular industry can be utilised as inputs for industries in different ecosystems. For instance, the manufacturing of computers, electronics, and optical products is part of the digital, the electronic, and the Aerospace and Defence ecosystems. Furthermore,

materials imported by firms in the energy-intensive ecosystem, such as silicon, are indispensable for numerous industries ranging from semiconductors to solar cells, with a profound impact on all strategic industrial ecosystems.

From a forward-looking perspective (as is illustrated in Section 4.3), advances in digitalisation and clean energy will accelerate the competition for minerals and raw materials. Given the nature of the industrial ecosystems, disruptions in supplies have the potential to propagate not only within a single value chain but also across the entire network of industrial ecosystems, which are interconnected networks of supply chains.

Across all strategic industrial ecosystems, China plays a central role as the top EU supplier. China not only supplies goods which are used daily by EU citizens, components that are crucial as inputs for EU industries (e.g. electric circuits, transistors etc.), but is also the top supplier of minerals and materials of strategic relevance (e.g., silicon, permanent magnets etc.) for the digital and green transition. The role of these minerals and materials, some of which are geographically concentrated, is projected to grow faster and could exacerbate trade competition.

Overall, two points emerge, diversification should be pursued to the furthest extent possible. Second, the identification of what is considered strategic is crucial to assess to what extent import dependences are a source of vulnerability.

4.2 Strategic value chains

This section provides an overview of EU strategic value chains and potential vulnerability arising from potential disruptions.

Imports of intermediate goods and retail supply chains have developed into a complicated web of production spanning several countries before goods are bought by consumers. The continuous decrease in transport and communication costs that took place until 2020 led to massive outsourcing of production tasks[14]. Global value chains (GVCs) have become an industry model of production where raw materials and intermediate goods are shipped around the globe multiple times and then assembled in another location. Value chains can be defined as:

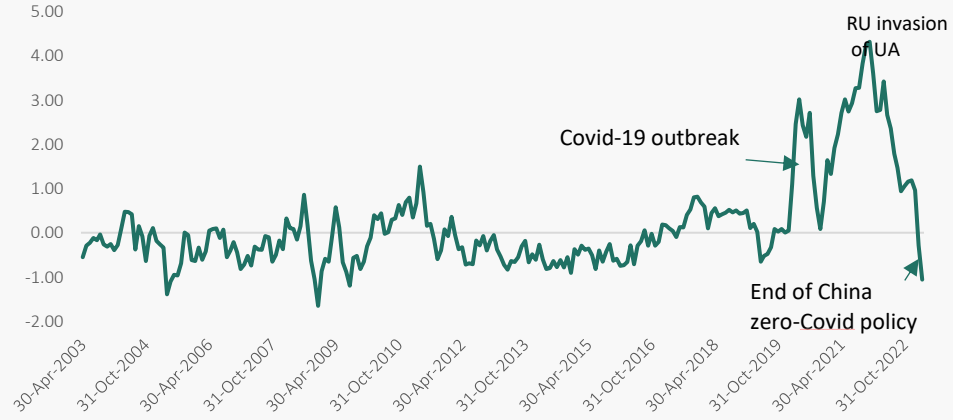
- a set of interdependent economic activities that add value to a product, process or service;
- a group of interlinked economic actors that operate in a strategic network that includes firms of different sizes, sectors, and countries.

The OECD (2020a) reports that value chains are an important source of international trade. Today, about 70 % of international trade involves GVCs, with services, raw materials, parts, components, data and information crossing borders – often numerous times. Complex systems of organisations and activities are located in different countries, typically chosen according to specialisation or competitive advantage criteria.

While the financial crisis and the Fukushima catastrophe had a limited, if any, impact on GVC, increased trade tensions, the Covid-19 pandemic and then the war in Ukraine led to major disruptions of the modular production systems (see Figure *24*). A lesson learnt from the pandemic is that disruptions in international supplies of goods and materials could even undermine the strategic autonomy of State actors.

[14] See the Word Bank

Figure 24. Global supply chain pressure index (2003-2023)



Source: Federal Reserve Bank of New York, Global Supply Chain Pressure Index, https://www.newyorkfed.org/research/gscpi.html.

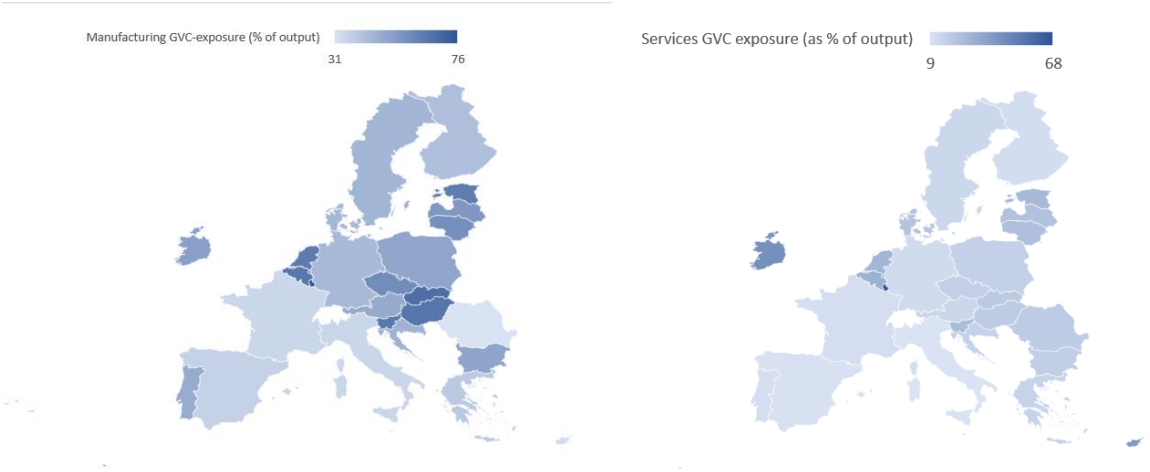
Note: the index integrates several metrics, like global transportation costs and indicators of supply chain-related components from Purchasing Managers' Index (PMI) surveys, with the aim of providing a comprehensive summary of potential supply chain disruptions.

This led to questioning the deepening of international specialisation and its net benefits. An indication of how the discourse and the policy debate about GVC have evolved is given by the change in the wording: global value chain 'integration' has been increasingly replaced by global value chain 'exposure'.

When does integration into a GVC become exposure? To what extent and how should companies and governments protect themselves against exposure to global chain disruptions? The answers depend on the types of risks that supply chains are facing.

The EU exposure to GVCs appears to be concentrated in two main sectors of manufacturing and services, as indicated by the data on the level of production of each sector related to global value chains (World Bank, 2021). Moreover, as is illustrated in Figure 25, in each sector, there is high heterogeneity across EU Member States in the degree of reliance on GVCs.

Figure 25. Geographical distribution of GVC exposure across the EU, manufacturing (LHS) and services (RHS)

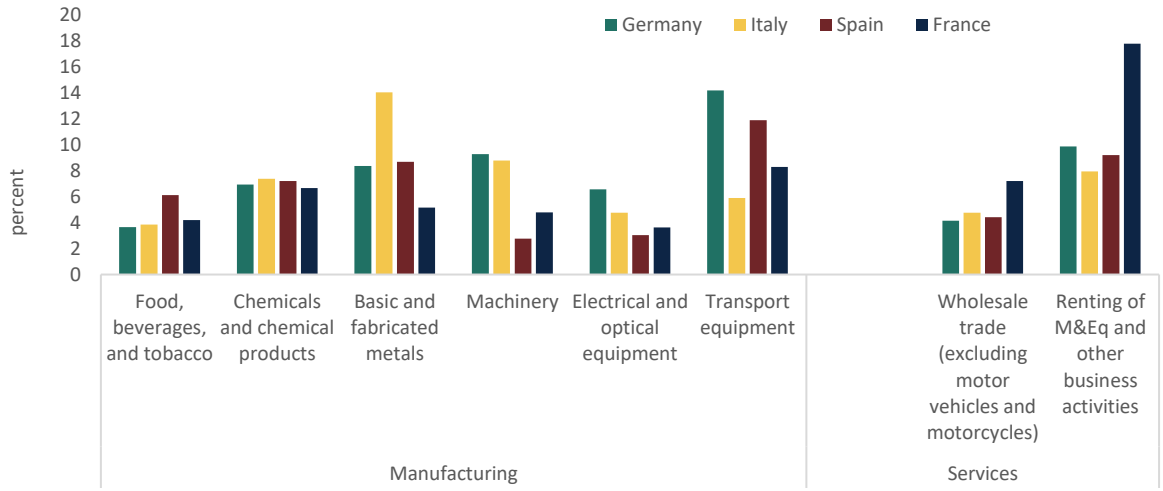


Source: Authors' elaboration based on World Bank, WITS.

Note: 'GVC exposure' based on output or 'GVC-related output' is defined as the output of a country or sector that directly or indirectly crosses more than one border.

A further breakdown by subsectors for the four largest EU countries (*Figure 26*) suggests that relatively high GVC linkages (more than 10 % of output) are observed in transport equipment for Germany and Spain, and in basic and fabricated metals sectors for Italy. As for services, the data reveal a large reliance (around 18 % of output) on GVCs in business activities mainly renting of M&E for France. These cross-country differences are important to take into account in consideration about securing the supply chain in sensible sectors / products and possibilities of reshoring and/or near-shoring them.

Figure 26. GVC exposure (as % of output)-2021



Source: Authors' elaboration based on World Bank, WITS.
Note: 'GVC exposure' based on output or 'GVC-related output' is defined as the output of a country or sector that directly or indirectly crosses more than one border.

Strategic GVCs are value chains that relate to goods and services in sensitive ecosystems. They can affect the EU's core interests, notably regarding health, security and safety, as well as economic development through access to key inputs and technologies necessary for the EU's green and digital transitions. In 2019 the Commission identified six strategic value chains for their potential impact on Europe's industrial competitiveness: i) Connected, clean and autonomous vehicles; ii) Smart health; iii) Low-carbon industry; iv) Hydrogen technologies and systems; v) Industrial Internet of Things and vi) Cyber-security. In practice, the identification of such VC is not only important for the purpose of identifying potential vulnerabilities. It is important to identify where Europe's industries need to build their strengths to boost their competitive advantages and where the EU could and should play a stronger coordinating role to achieve strategic autonomy. Importantly, because of their nature and the inputs that they involve (both raw material and intermediate goods), a redefinition of strategic value chains entails complex adjustments.

4.2.1 Decoupling, de-risking or tangling GVC?

Despite the dramatic polarisation in the US political landscape, the one common element of the previous and the current administration has been the decoupling (or de-risking in the current Biden language) from China. US–China geopolitical tensions (also combined with global factors) have been impacting trade and investment flows into China. US investments in China and China investments in the US have been gradually declining over recent years. By contrast, other emerging economies, particularly ASEAN countries, are experiencing increases in trade and investment flows. Such a reorientation of trade and financial flows is mirrored by changes in the composition of GVC.

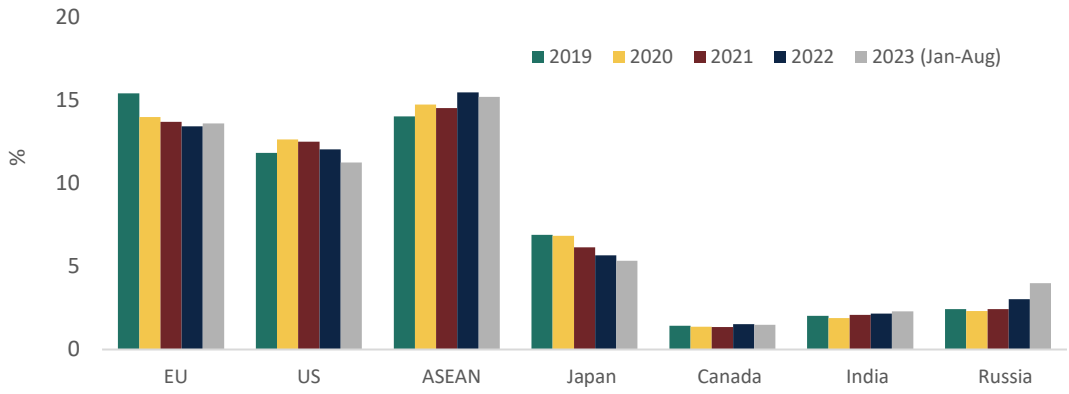
According to a 2021 survey of 338 foreign companies doing business in China, conducted by AmCham Shanghai, Southeast Asia ranked as the top destination for redirected investments from China in favour of diversifying supply chains (followed by Mexico and India), as confirmed by 63 companies. Consequently, several US and western Europe-based companies create a larger share of greenfield FDI projects in Southeast Asian. Furthermore, according to the Reshoring Initiative 2022 Data Report, China is one of the main countries originating reshoring and FDI into the US during 2010-2022, with an increase attributable to supply chain risks and geopolitical tensions observed in 2022. Lastly, according to Investment Monitor, 2023, in 2022, Southeast Asian experienced 61.3 % growth in FDI where Malaysia, Vietnam and the Philippines were the largest recipients, and the US was the leading source market (about 30 %), followed by France, Germany, and the UK together accounting for about 20 % of all FDI projects. This growth was mainly driven by Software and IT services, as well as the Business and Professional services sectors.

This shift is confirmed by a recent study which investigated granular US trade data at the industry level during 2017-2022. Freund et al. (2023) document a redirection of US trade away from China to other countries, mainly Vietnam, Taiwan, and Canada. This seems to be the result of an ongoing change triggered by tariffs introduced under the Trump administration, and further amplified by more recent geopolitical concerns. However, the analysis also suggests that these same economies engaged in stronger trade links (value chains) with China, particularly in strategic sectors. This implies that the dependency of the US on China at least in certain sectors may still prevail. Overall, these GVC dynamics suggest that decoupling in direct trade may only serve to obscure the indirect linkages between the US and China through the industrial supply chains of their trade partners.

In practice, there may be different games at play. China could export to some countries, where it has invested, and which bring very limited value added to products, but that appear as new exporters to western countries. Some of these countries are possibly taking advantage of the trade reorientation to participate more intensively in the value chain production, but still rely on China for inputs (intermediate products) or for raw materials. Concerning the latter, it should be recognised that in certain sectors full decoupling from China is just impossible, as China is not only the major, but sometime the only exporter of some critical raw materials. Whatever it is happening in practice, such new dynamics point to longer or more tangled value chains.

Looking at recent China trade data, between 2019 and 2022 (see *Figure 27*), there is a clear downward shift in the share of trade with the EU, the US and Japan.

Figure 27. China's trade (export and import) share by country/region



Source: Authors' elaborations based on the General Administration of Customs of the People's Republic of China (GACC).

Note: ASEAN (Association of Southeast Asian Nations) include Vietnam, Malaysia, Thailand, Singapore, Indonesia and Philippines.

By contrast, the share of China's trade with ASEAN countries, which was already large, increased further. An increasing trend is also visible for Canada and India and even more in the case of Russia, whose trade share doubled in less than 5 years. The increase stems mostly from exports from China, with around a 78 % surge over the first half of 2023 (compared to a 13 % increase in 2022). Opposite trends occurred with the US, which recorded the largest fall in exports from China.

These developments have also influenced China–EU bilateral relations, which weakened further in the wake of the Russia–Ukraine war. However, the EU's policy stance towards China opts for more 'de-risking' instead of decoupling, implying that a more vigilant approach in reducing strategic dependencies and vulnerabilities of its supply chains should be taken. Despite this, the current environment appears to have brought about challenges for European companies operating in China. The June 2023 Business Confidence Survey published by the European Union Chamber of Commerce in China finds that the higher barriers to market access and rising US–China tensions have complicated the business environment for European companies as the majority (75 %) are pushed to review their supply chains in line with both the EU's de-risking and US decoupling strategy, including shifting existing investments out of China or redirecting their prospective investments from China to other locations.

Due to the intricate connections of global value chains with China, diversification efforts may not immediately lead to a decreased reliance on Chinese inputs and suppliers.[15] Given China's substantial manufacturing influence, even significant shifts in production to alternative destinations may only yield marginal decreases in China's global exports, and its contribution to global manufacturing, or supply chains. Therefore, an extensive relocation of global supply chains can only unfold gradually. This has strong implications on expectation about achieving the objectives of "de-risking".

4.3 Accessing critical raw materials

4.3.1 Raw materials for strategic technologies: what are the key EU supply risks?

Although the notion of strategic autonomy applies to a broad range of sectors and value chains, in the context of critical raw materials it has particular importance for digital and, notably, low-carbon technologies. The EU's twin green and digital transition will require rapid and large-scale deployment of green and digital technologies (Muench et al., 2022). These include technologies employed for clean energy production (i.e. renewables) as well as for the broader decarbonisation of the EU energy system, including in transport (e.g. electric vehicle (EVs) batteries and motors), heating (e.g. heat pumps) and industry (e.g. electrolysers). They also (ICT), such as data transmission networks, data storage and servers (Carrara et al., 2023). Along with these, technologies used in the space and defence sectors will also become increasingly central in the EU's agenda (European Commission, 2022).

These strategic technologies – and the transitions they underpin – are highly material intensive. For instance, an EV requires up to six times the material inputs of a conventional car, and an onshore wind farm up to nine times that of a gas-fired power plant (IEA, 2021). As such, their deployment will imply a considerable increase in EU raw materials consumption. For example, the EU's Joint Research Centre reports how the expansion of EU battery manufacturing alone will lead to a 9- to 12-fold increase in lithium consumption by 2030, and up to almost 21 times by 2050. The EU's demand for platinum – widely used, e.g. in electrolysers and fuel cells, as well as data transmission networks – is expected to increase from less than 1 tonne in 2020 to 2-3 tonnes in 2030 and 10-20 tonnes in 2050; and the EU's consumption of dysprosium, a key ingredient of the permanent magnets used within EV motors and wind turbine generators, is projected to increase from 2- to 6-fold by the end of the decade, and up to seven times by 2050 (Carrara et al., 2023).

[15] See Kratz and Bullenois (2023) for an overview of reasons.

Against this backdrop, ensuring secure and reliable access to raw materials is key for the EU to establish a competitive position in these markets and sustain the twin transition. Yet, the supply chains of global raw materials are today heavily concentrated in a small number of countries, and the EU largely relies on imports to meet its raw material requirements – notably from China. The country holds in fact a dominant position in the supply of several raw materials, including heavy rare earths elements[16] (HREEs) (100 % of global supply), magnesium (91 %) and silicon metal (79 %), among others (European Commission, 2023). **And while there is heavy market concentration for some materials in other world regions (as in the case of cobalt, with 60 % of global production located in the Democratic Republic of the Congo), China often holds a significant stake in mining companies**, which points to an even stronger position than is usually assumed (Leruth et al., 2022).

This quasi-monopolistic market structure is of particular concern in the context of what the European Commission identifies as critical raw materials (CRMs), i.e. materials of high economic importance, high supply risk and general lack of available substitutes[17]. Furthermore, the European Commission has recently identified a subgroup of 16 CRMs, the Strategic Raw materials (SMRs), which in addition to the above features are also fundamental for the manufacturing strategic technologies in the energy, digital, defence and space sectors and whose demand is therefore expected to rapidly increase in the future. As shown in Table 1, for 10 SMRs the EU is entirely (or almost entirely) dependent on imports, in most cases from only one or a few suppliers. For instance, the EU sources 100 % of the rare earth elements (REEs) used for magnets manufacturing and 97 % of its magnesium supply from China, as well as 99 % of its boron supply from Turkey and 79 % of its lithium supply from Chile (European Commission, 2023a).

Table 1. Import reliance, main EU supplier and applications of strategic raw materials (SRMs)

SMRs	IR	Main EU supplier (share)	Li-ion batteries	Wind turbines	Solar PV	Electrolysers	Fuel cells	Traction motors	H2-DRI	Heat pumps	Data transmission networks	Data storage and servers	Smartphones, tablets, laptops	Additive Manufacturing	Robotics	Drones	Space applications
Bismuth	100%	China (65%)									•	•	•				•
Boron	100%	Turkey (99%)		•	•	•	•	•		•	•	•	•		•	•	•
Cobalt	81%	n/a	•			•	•				•		•	•	•	•	•
Copper	48%	Poland (19%)	•	•	•	•	•	•		•	•	•	•	•	•	•	•
Gallium	98%	China (69%)			•						•	•	•		•	•	•
Germanium	42%	China (45%)			•						•	•	•				•
Lithium	100%	Chile (79%)	•								•		•		•	•	•
Magnesium	100%	China (97%)				•						•	•	•	•	•	•
Manganese	96%	South Africa (41%)	•	•		•	•		•	•	•	•	•	•	•	•	•
Natural Graphite	99%	China (40%)	•			•	•		•		•		•		•	•	
Nickel	75%	Russia (29%)	•	•	•	•	•		•	•	•	•	•	•	•	•	•
PGM	96%	n/a				•	•				•	•	•		•	•	•

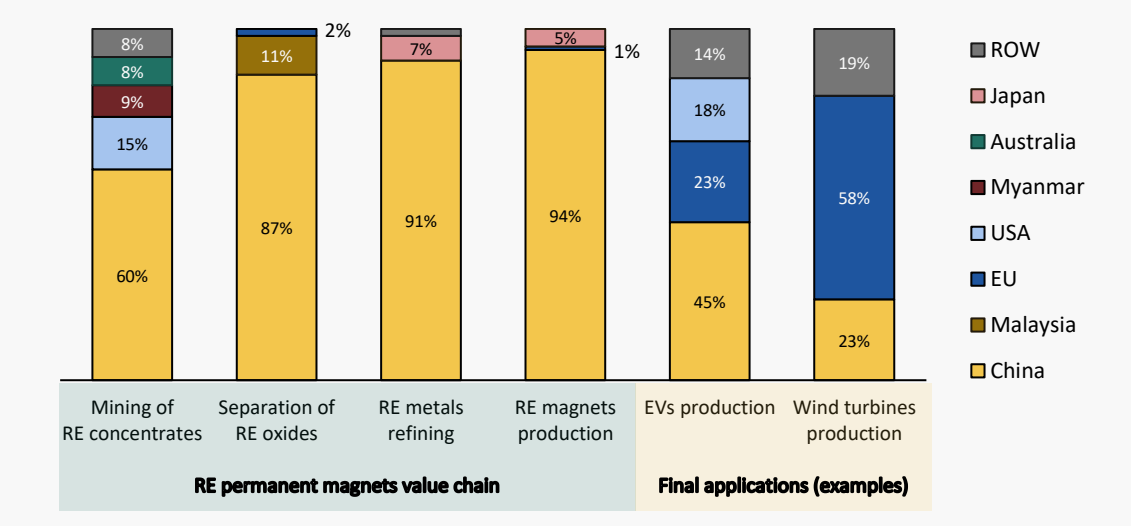
[16] Dysprosium, erbium europium, gadolinium, holmium, lutetium, terbium, thulium, ytterbium, and yttrium.
[17] (European Commission, 2008). Established for the first time in 2008 with the Raw Materials Initiative, the CRMs list has since been updated every three years. The criticality classification depends in fact from demand (economic importance) and supply (Månberger, 2023). The latest list, published in 2023, includes 34 materials (European Commission, 2023).

REEs for magnets	100%	China (n/a)	•		•	•	•		•	•	•	•		•	•	•
Silicon metal	64%	Norway (34%)	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Titanium metal	100%	n/a										•	•	•	•	•
Tungsten	n/a	China (31%)			•							•	•		•	•

Source: European Commission (2023a); Carrara et al. (2023).
Notes: IR (import reliance) = (Import – Export) / (Domestic production + Import – Export); H2-DRI = Hydrogen direct reduced iron and electric arc furnaces; space applications include space launchers and satellites. PGM (Platinum Group Metals) include ruthenium, rhodium, palladium, iridium and platinum; REEs for magnets include the rare earth elements used for the magnets production, i.e. neodymium, praseodymium, terbium, dysprosium, gadolinium, samarium and cerium.

With global raw materials' demand rapidly increasing and geopolitical tensions intensifying, the combination of high market concentration and high import dependency for raw materials exposes the EU to significant supply risks. Yet exposure also exists in other parts of the value chain. **Looking at the entire value chain of strategic technologies, it is worth noting how the EU's inflows of SMRs occur primarily – both in quantity and in monetary terms – in the form of components or finite products embedding these materials, rather than act** (Rietveld et al., 2022). This is because the EU's presence downstream is also often limited, and import dependency is often strong in downstream segments as well. Rare earth permanent magnets, for instance, are almost entirely sourced from China, which controls about 94 % of the global market (see *Figure 28*) (Rizos et al., 2022). Similarly, solar photovoltaic (PV) panels are primarily sourced from China which dominates 89 % of the global supply (Rietveld et al., 2022).

Figure 28. Geographical concentration of the rare earth permanent magnets value chain



Source: Rizos et al. (2022).

Still, as highlighted by Carrara et al. (2023), while the EU is somewhat present in the manufacturing of most strategic technologies, the raw materials step is the only one where the EU is systematically vulnerable for all technologies assessed. In this context, and considering the EU's recent efforts to reshore production of some of these strategic technologies, it therefore becomes increasingly important for the EU to assess all available options to secure access to raw materials supply.

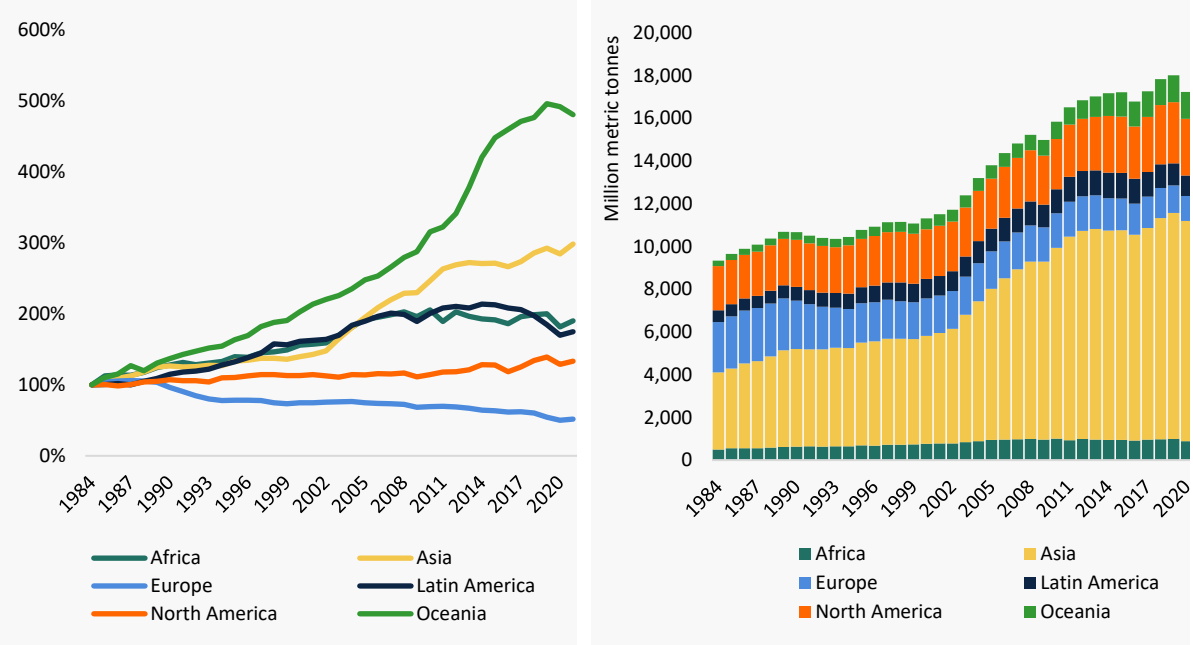
4.3.2 To what extent can the EU exploit its own resources?

Although the EU has dedicated strategies to support domestic supply or resources since the late 2000s, the Covid-19 crisis and the war in Ukraine have provided new impetus to the EU's efforts to investigate the domestic potential to source materials, either in primary or secondary form (Righetti & Rizos, 2023).

EU's domestic mining potential

In terms of primary sources, Europe's mineral production has been steadily decreasing over the last decades *(Figure 29*). At the same time, Asian countries – and notably China – have gradually consolidated their leading position in the primary segment of the supply chain, particularly since the 2000s. Specifically, Chinese mineral production has more than doubled over the last 20 years and currently accounts for over 60 % of the total (Figure *29*). While considerable geological endowments have allowed China to establish its primary role in raw materials supply chains, large internal demand and global economic specialisation have likely been major drivers behind these trends in addition to internal political commitment (Kalantzakos, 2020).

Figure 29. World mineral production, by continent



Source: World Mining Data (2023).
Notes: Bauxite (used for aluminium production) is not included.

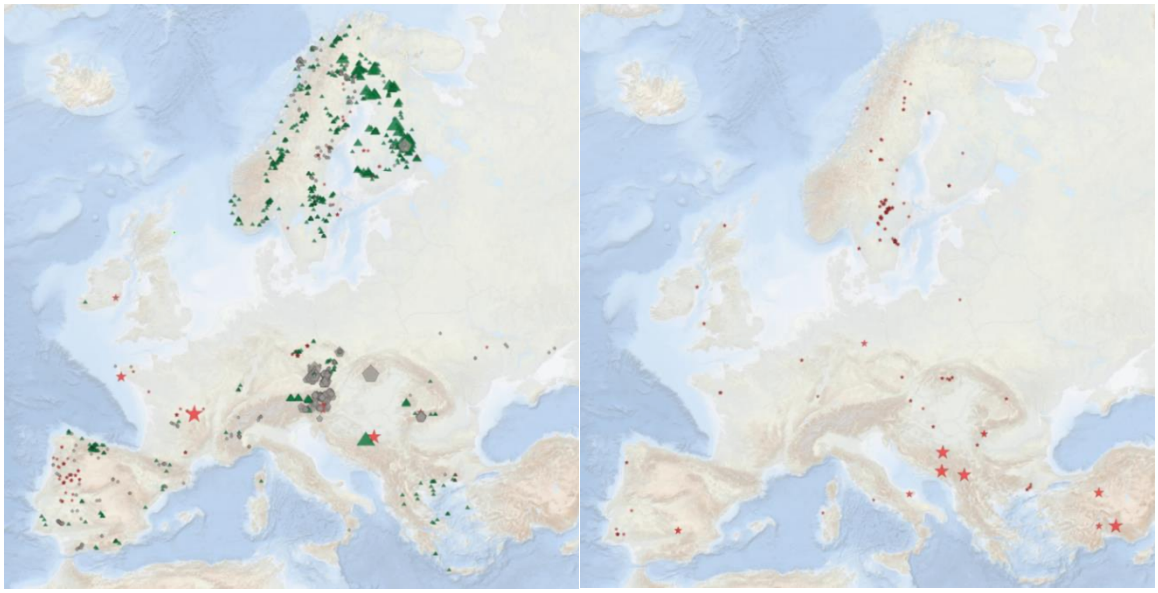
Yet despite its relatively low mining activity, Europe is not lacking indigenous resources. Recent assessments and discoveries have shown that the European mining potential is still largely unexploited. This is particularly the case for 'battery raw materials', i.e. those employed for the manufacturing of li-ion batteries[18]. When it comes to lithium, for instance, Portugal holds some of the largest reserves worldwide, and it is already ranked seventh globally in terms of lithium mine production (USGS, 2023). France could also benefit from substantial lithium endowments, and in late 2022 a major mining project was announced, targeting to produce up to 34 000 tonnes of lithium over 25 years in the Allier region. Overall, European lithium resources are estimated to account for about 6.5 % of the world total and substantial resources have also been identified in Austria, Czechia, Finland Germany, Serbia, and Spain (USGS, 2023). According to estimates by Transport and Environment (2023) based on current and planned mining projects, Europe could potentially secure 31 % of its 2030 lithium demand via domestic

[18] I.e., cobalt, copper, lithium, natural graphite and manganese.

mining, and up to 52 % if all extractive projects currently facing public opposition were to become operational.

European cobalt resources also appear promising. Finland in particular offers interesting prospects for cobalt mining production (see *Figure 30),* though potentially exploitable deposits have also been identified in the Balkans and central and northern Europe (Horn, 2021). Moreover, expanding cobalt mining output could also leverage existing European cobalt refining capacity, second only to China (Finland and Belgium account for 11 % and 5 % of world cobalt processing, respectively (European Commission, 2023a)). Besides battery raw materials, one other interesting group of materials for which Europe shows potential is REEs. Considerable deposits have been identified in Finland, Norway, Sweden, and the Balkans region, with enough resources to potentially serve the entire EU demand (Goodenough et al., 2016). The recent discovery of a deposit in the Kiruna site (Sweden), currently the largest known European REEs deposit, seems to confirm this potential.

Figure 30. Mineral occurrences of battery raw materials (left) and REEs (right)



Source: European Geological Data Infrastructure (2023).
Notes: Battery raw materials include lithium (red stars) cobalt (green triangles) and natural graphite (grey pentagons).

It should be noted, however, that although several sources and recent announcements indicate that the EU has considerable domestic sources for some materials, a comprehensive assessment of unexploited sources has not been carried out at the EU level. While there are technological and geological constraints that make such assessments a complex task, there is currently no coordinated EU system in place to support monitoring and measurements at the national level.

Challenges for exploiting the EU's mining potential

Although mining potential exists, there are several areas where challenges remain or where progress is still to be made to exploit the EU's own primary resources. Based on interviews with experts from the industry and academia and desk research we have identified four prime challenges, namely (i) long permitting processes, (ii) low public acceptance, (iii) lack of skills and (iv) difficulty in attracting investments.

The first key challenge that emerged during the interviews refers to the long permitting procedures for mining projects which can take 10-15 years. This alone would preclude any possible contribution of

additional mining output to covering EU demand until the early 2030s, i.e. during the period when demand for these materials is set to increase the most. Experience from cases in different EU Member States has shown that the permitting process should be regarded as a complex array of steps that need to be taken to comply with varied requirements often coming from different authority levels. As such, planning the period where a mine can provide outputs is challenging which in turn increases the risk of the investment (Söderholm et al., 2015).

A related major hurdle lies in the strong public opposition to mining projects, which often further delays – or blocks – the opening of new mines. One case in point is the controversy over the expansion of the mine in the village of Covas de Barroso, in the Portuguese northern territories (possibly the largest European lithium reserve) which has proved very difficult to implement due to severe public opposition. While public opposition has been strong for some mining projects, in other cases there have been concerns about the extent to which local communities are properly consulted in the process of starting a new mine. One such example refers to the Sami lands in Sweden where there have been controversies over the engagement of the Indigenous populations and the assessments of impacts in the region (Larsen et al., 2022; Lawrence & Larsen, 2017). Such cases contribute to a negative public perception of mining. As noted by one interviewed expert, the limited public knowledge about the origins of materials used in green and digital technologies and the impacts of extracting these materials – which largely take place outside the EU – are among the main factors for the low public acceptance of mining.

Lack of skills is another important challenge reported by the experts. Given the new urgency to accelerate the green transition following the war in Ukraine, the pressure to develop a domestic workforce for new mining projects in the EU increases. However, the mining sector requires highly skilled profiles (e.g. mining engineers), and the EU faces the risk of having a shortage of these profiles. For example, a recent report by the European Labour Authority (2022), identified mining among the sectors for which the northern regions of Finland, Norway, and Sweden face shortages. According to a 2023 paper by McKinsey & Company, attracting young talent for highly skilled professions such as mining engineering is increasingly becoming a challenge for governments across the globe. While traditionally aspects such as the perception that mining jobs can be physically challenging or the unavailability of proper infrastructures (including hospitals and schools) in remote areas have contributed to the unattractiveness of mining jobs, more recently other factors such as competition with digital and technical jobs in other industries are increasingly impacting this negative trend in the sector.

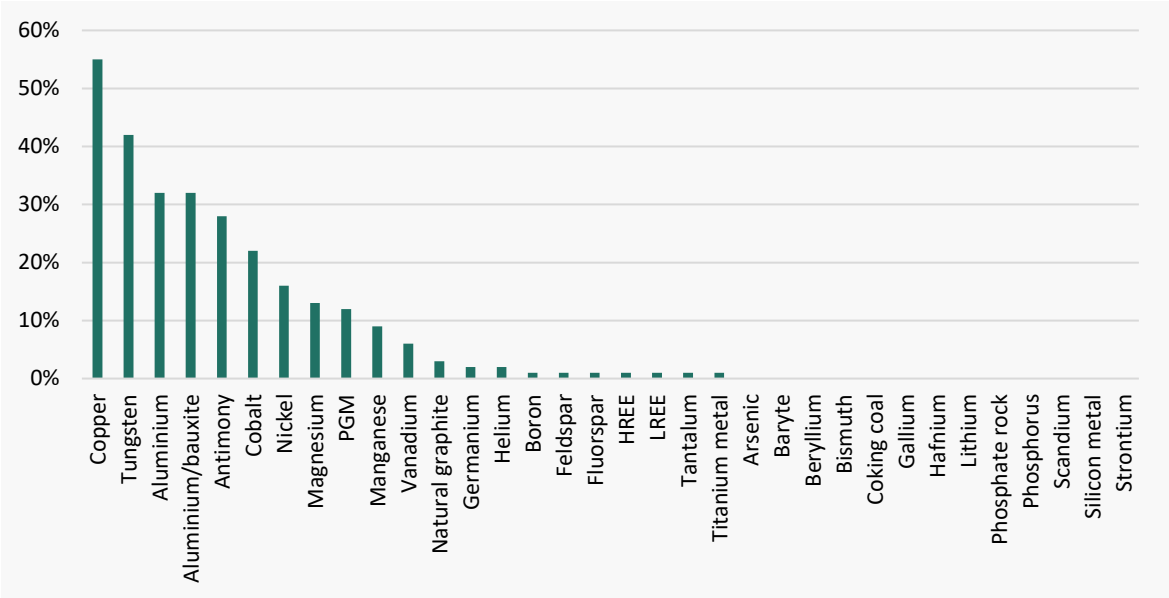
The unattractiveness of mining for investors is also a bottleneck for developing mining operations in the EU. Because of the challenges described above, as well as difficult market conditions caused by high energy costs and uncertain economics due to the high volatility of commodity prices, extractive projects are often considered highly risky and therefore struggle to attract investments. The experts noted that even if the initial investment is secured, some form of financial support is also needed during the so-called 'valley of death', that is after the first investment and before companies start the mining production. Due to the long permitting process, this initial phase before the mine starts operating is also very long and this can be a disincentive for investors. The uncertainties surrounding the legal environment for mining in Europe and how it could evolve in the coming years also makes the mining business case difficult for investors according to the experts.

EU's domestic recycling potential

Along with the increase in domestic mining output, recycling also has potential for contributing to the future EU supply of CRMs and reducing supply risks. Where possible, recycling should be prioritised over primary resource extraction, as it reduces the social and environmental impacts associated with

mining activities. For several widely and long-used base metals such as aluminium, copper or nickel, the recycling industry is already mature, and the EU meets a large share of its needs via recycling. Thanks to favourable physical properties and well-established collection systems, these materials exhibit fairly high end-of-life recycling rates (EoL RR) – e.g. about 40 % for aluminium, 45 % for copper and 57 % for nickel – which have the potential to increase even further in the future (e.g., up to 75 % could be achieved for aluminium (IAI, 2020)). Coupled with somewhat saturated markets, this leads the contribution of recycling towards overall supply – the so-called end-of-life recycling input rate (EoL RIR) – to be relatively high for these materials (see *Figure 31*)[19]. Overall, according to Eurometaux (2019) about half of EU base metal production is covered via recycling.

Figure 31. EoL RIR of CRMs



***Source**:* European Commission (2023a).

As shown in *Figure 31*, however, for most CRMs the input from recycling is either very low or non-existent. While the collection and recycling pathways for CRM-containing products are generally more complex than, e.g. pure aluminium or copper waste streams, their low recycling rates can be attributed to several barriers in place. These include product-specific barriers originating from factors of economic (e.g. high recycling costs, or resource price dynamics), supply chain (e.g. inefficient collection a sorting systems, or lack of coordination among industry players) regulatory (e.g. limitations in the cross-border transport of waste) or of technical nature (e.g. difficulties in product disassembly)[20]. On top of this, the limited available information regarding volumes and types of CRMs already available in-stock as well as in future EoL streams creates uncertainty and further hinders the establishment of markets for recycled materials.

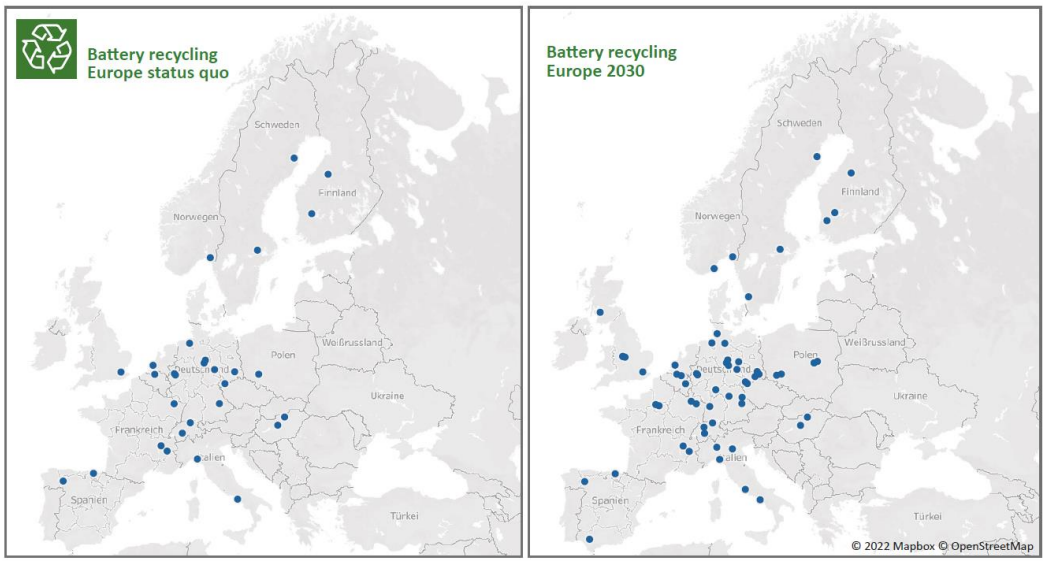
Provided the above bottlenecks were to be addressed, available recycling technologies offer good prospects for rapid commercialisation and scale-up. Good cases in point are the recycling processes of

[19] This condition of saturated market does not apply to nickel, whose consumption is increasing for li-ion batteries manufacturing. This is why the EoL RIR of nickel material is significantly lower than that for materials with comparable EoL RR.

[20] For example, for comprehensive overviews of the barriers hindering the establishment of recycling practices for rare earths magnets and electrical and electronic equipment, please refer to Rizos et al. (2022) and Rizos & Bryhn (2022), respectively.

li-ion batteries and rare earth permanent magnets; based on planned projects, Bünting et al. (2023) expect the EU battery recycling capacity to expand to the point that all EU disposed batteries – and possibly imported volumes as well – could be recycled by the end of the decade. For permanent magnets, recycling capacity will likely take more time to develop at a similar scale, but recycling technologies have reached maturity and recycling plants are now being planned in Belgium and France.

Figure 32. Expected development of EU li-ion batteries recycling plants



***Source**:* Bünting et al., 2023.

Although at different degrees of maturity, recycling processes for CRMs therefore exist and have the potential to rapidly scale in the coming years. However, even if highly efficient recycling chains were to be achieved in a relatively short time, the recycling of low-carbon technologies could not be expected to provide substantial CRM inputs for their manufacturing in the short term. This is due to demand-EoL supply dynamics of these products: while for most of these technologies the market is now rapidly expanding, not many of these applications will have reached the EoL stage in the coming years, due to their relatively long lifetime (typically 10 to 12 years for EVs, but up to 30 for wind turbines and 40 for solar panels).

As such, the mismatch between recyclable and demanded CRMs will be substantial for a few years, and only diminish once markets become saturated and the number of disposed products increases. For most of these products, this will only happen towards the early 2030s or later. For example, in a closed-loop recycling scenario [21] Rizos and Righetti (2022) estimate that a highly efficient system for EV batteries recycling could provide up to 21 % of the lithium, 14 % of the nickel and 18 % of the cobalt required for EV battery manufacturing by 2030, but 10 years later these figures are expected to more than double (52 % for lithium, 49 % for nickel and 58 % for cobalt). Looking instead at the case of wind turbines in the most optimistic scenario the amount of neodymium and dysprosium recycled in 2040 would only represent 13 % and 15 % of the requirements for wind turbines manufacturing, respectively – that is, only a few percentage points more than the 2030 levels.

While closed-loop recycling opportunities (for low-carbon technologies will be limited in the short term, significant untapped potential for CRM recycling might exist for other available waste streams, such as waste electrical and electronic equipment (WEEE) or disposed of (ICE) vehicles. Harvesting materials

[21] Closed-loop recycling refers to the recycling process in which materials from disposed applications are upgraded within the same application category (e.g., from spent to new batteries).

from such EoL applications – so-called 'urban mining' – could represent a significant source of secondary CRMs, as large stocks of these applications are already available in the economy. Still, most of them are not yet properly collected or recycled in the EU. For instance, only 46 % of WEEE is collected in the EU, and in the case of mobile phones, CEPS estimates show that only between 12 % and 15 % of are properly recycled (Rizos et al., 2019). When it comes to EoL vehicles, based on Mehlhart et al. (2017) only about a third of them are currently collected for recycling in the EU.

4.3.3 What policy options?

Substitution and resource efficiency

Shifting CRM consumption patterns could help tackle CRM supply risks by reducing CRM demand. In practice, this can imply a) a substitution at the material level – ideally, from critical to non (or less) critical ones; b) a substitution at the technology or component level – i.e. from CRMs-containing ones to others employing no (or less) CRMs; or c) a reduction in the quantity of CRMs employed within certain technologies and components – i.e. an increase in resource efficiency. Crucially, in all these instances technology performance and cost considerations become key.

At the material level, substitution options already exist or are being explored for several strategic technologies. Batteries are a dynamic technology in this domain. Supply concerns and market dynamics are in fact already driving a shift in battery chemistries, with cobalt-rich lithium-ion batteries being gradually substituted by either (cheaper) nickel-rich ones[22] or by cobalt and nickel-free batteries, such as lithium iron phosphate (LFP) batteries (T&E, 2021). In light of possible lithium shortages or price spikes, lithium-free chemistries such as sodium-based ones are also expected to be increasingly deployed in the medium to long term.[23] While lower performances compared to traditional li-ion batteries are likely to initially limit the scope of application of these alternatives (e.g. to the lowest-performing range of electric vehicles or stationary energy storage systems), rapid battery technology innovations might well lead to CRMs-free chemistries suitable for a larger battery market share (IEA, 2023; Armand et al., 2023).

For some other strategic technologies, CRMs-free substitutes might not yet be commercially available, or only at the expense of technology quality losses. In the case of magnets, rare earths-free compositions – notably the so-called ferrites – have long been employed for several end uses like home appliances, because of their lower costs compared to market alternatives. However, due to significantly lower strength and resistance compared to rare-earth-based magnets, they are less likely to be used, e.g. high performing motors of electric vehicles or wind turbine generators (Kalvig et al., 2022). [24]Magnets of comparable quality, lower CRM content and possibly lower environmental impacts – such as iron nitride magnets (Wang, 2020) – are emerging as possible substitutes, though research in this domain is still ongoing. For fuel cells, iron-nitrogen-carbon catalysts are being explored as substitutes

[22] Nickel supply risk is significantly lower than that of cobalt. Prior to the 2023 CRMs list update, nickel was in fact not considered as a CRM. Therefore, while primarily driven by cost factors such a shift would make sense from a broader security of supply perspective.

[23] According to Bloomberg NEF (BNEF) estimates, the uptake in sodium-ion batteries could help reduce global lithium demand by up to 37% by 2035 (Burton, 2023)

[24] In an effort to reduce environmental and supply risks, Tesla has recently announced the intention to replace rare earths with ferrites in its next-generation of electric vehicles, despite acknowledging their significantly lower performances.

for platinum-based ones[25] though it remains uncertain whether performances are yet comparable (Sgarbi et al., 2022).

Whenever the substitution of CRMs is not technically or economically viable, a change in the type of technology employed could be considered instead. For instance, while today most electric vehicles use (rare earth-based) permanent magnet motors, rare earths-free motors exist and are now being re-evaluated by car manufacturers. Wound rotor and induction motor technologies seem to be the main market alternative in this regard (Carrara et al., 2023), though at the expense of lower efficiency and higher weight (Dorrel et al., 2010). A similar situation applies to wind turbines, where traditional permanent magnet generators could be substituted by either multipolar synchronous generators (i.e. with no permanent magnets) or hybrid drive generators (i.e. employing smaller permanent magnets) (Alves Dias, 2020).

Technology substitution options could also arise further down the value chain. In these cases, however, a greater and more complex set of factors (e.g. including infrastructure availability) need to be considered to assess the efficacy and feasibility of the substitution. Also, and crucially, when assessing substitution options, the broader impact in terms of materials consumption should be considered. Substitution of CRMs often entails that pressure on other (possibly non or less critical) materials will increase. Shifting from permanent magnet-based motors to induction motors, for instance, would reduce rare earth demand at the expense of a substantial increase in copper and aluminium consumption (IEA, 2021). Increasing the share of LFP batteries would allow to drastically reduce nickel and cobalt use but increase consumption of phosphates, which are crucial for fertiliser production (Carrara et al., 2023).

Increasing material efficiency could also help reduce CRM demand while avoiding possible conflicts among alternative materials uses. Like material substitution, reduced CRM intensity in products has already been partly driven by the price and market dynamics of these resources. Within the magnets domain, high prices and a constrained supply of dysprosium – used to increase magnets' resistance to demagnetisation at high temperatures – have led magnet manufacturers to increasingly optimise its use (Pavel et al., 2017). Similarly, research is ongoing to reduce the use of PMGs in electrolysers' manufacturing (Carrara et al., 2023). Lower CRM requirements also occur as an indirect consequence of technology innovation. Improvements in energy densities, for instance, are expected to drive substantial reductions in material requirements per kWh for all battery chemistries in the future as well as lower motors rare earths requirements (Gielen, 2022).

Trade policy and international cooperation

As a result of marked production concentration, CRMs are highly and increasingly traded commodities. According to the OECD (2023), the value of international trade in CRMs increased by 38 % between 2009 and 2020, i.e. faster than of all other raw materials (35 %) and of merchandised products (31 %). Yet interestingly, data show that export restrictions on CRMs have also been steadily rising, marking a fivefold increase over the same decade. These restrictions are often explicitly motivated by economic objectives, such as support to domestic downstream segments in the CRMs value chain (e.g. refining) or simply to generate new tax revenues. But in some cases – notably in China and Russia - motives are typically not or vaguely stated (e.g. 'national security concerns'), and the timing often suggests they are used as a geopolitical lever (so called 'weaponisation' of raw materials supplies) (Seaman, 2023).

[25] Platinum is a CRM belonging to the group of Platinum Group Metals (PGM). Platinum in catalysts could also be partially on entirely substituted with the cheaper palladium, which is yet another CRM among PGMs group.

Whether economically or politically motivated, the projected increase in CRM market pressure, the draw to develop higher-value-added industrial capacity in CRM-rich countries and increasing geopolitical tensions all point to a likely increase in CRM trade restrictions in the future. At the same time, rising demand – and quite possibly prices – of CRMs could improve the economics of primary production, thereby incentivising countries with unexploited capacity to enter an increasingly profitable market. In either scenario, ongoing trends could lead to significant changes in the global geography of CRMs production, hence pushing the EU is to rebalance and strengthen its trade and cooperation network on CRMs.

The primary avenue to do so is via a 'traditional' trade policy. This essentially entails negotiating lower CRMs trade barriers in the context of existing trade agreements or striking new and more favourable agreements. Some observers have observed that the scope for the EU to enlarge and secure its CRM imports network via trade policy might be, de facto, limited (Rietveld et al., 2023). This is partly because the EU trade agreements network is already extensive – 72 countries, the largest in the world – and because a large part (92 %) of CRMs imports value is already free of import duties, with the remaining share having relatively low import tariffs (European Commission, 2023). Still, as the recently concluded trade agreement with Chile shows, along with the prohibition of CRMs export duties (which should nonetheless be kept at the core), other provisions aimed at smoothing CRMs trade can be enforced. For instance, these include actions preventing the creation of export and import monopolies, or deterring trade partners from adopting so-called dual pricing policies[26].

Outside the scope of trade policy, other 'softer' tools can be used to ensure international CRM supplies. Among these are the strategic partnerships on CRMs, such as those the EU struck with Canada, Ukraine, Kazakhstan and Namibia between 2021 and 2022. In practice, such partnerships represent formal (yet non-binding) commitments to explore and expand mutually beneficial forms of cooperation in the CRMs domain. While useful in building a long-term framework for possible future trade relations in CRMs, however, these partnerships tend to be more conducive to other forms of cooperation, e.g. on investment, research and innovation, skills development or standards setting. Furthermore, the non-binding nature of these partnerships make their efficacy uncertain in the short term, particularly against sudden supply disruptions (the strategic partnership in late 2022 with Namibia, for instance, did not prevent the country from banning exports of several unprocessed CRMs in June 2023).

Similar partnerships could also be pursued on a multilateral basis. The Minerals Security Partnership (MSP), for instance, was established in 2022 between a group of 11 countries[27] and the European Commission with the aim of sharing information and catalysing investments into CRMs projects, provided they 'adhere to the highest environmental, social, and governance standards. The European Commission's plan to develop a Critical Raw Materials Club goes in a similar direction, with the yet more explicit intent of bringing together high-consuming and resource-rich countries. While the actual content of the Club is still to be clearly defined, the primary focus of both initiatives seems to be on channelling investments and sharing knowledge rather than fostering trade per se. This is key to ensure sufficient CRMs 'market thickness' in the longer term but can only yield limited results in the short term. Having binding assistance clauses whereby partners are obliged to support each other in case of emergency or supply shortages (Findeisen & Wernert, 2023) would help in that respect.

[26] This refers to a form of subsidy whereby a certain share of domestic raw material production is reserved to the domestic market at a preferential price, below the market price (an issue at the core of the ongoing negotiations with Australia).

[27] The original signatories were Australia, Canada, Finland, France, Germany, Japan, the Republic of Korea, Sweden, the United Kingdom and the United States. India joined in July 2023.

5. Can the euro play a role in strategic autonomy considerations?

In 2021 the Members of the Euro Summit stated the euro can play a role in strategic autonomy considerations. Among the four points put forward in the document, two deserve particular attention. First, 'a sound financial architecture as well as deep, liquid and well-functioning euro-denominated financial markets, and of preserving the EU's ability to ensure its financial stability and resilience'; second, 'a stronger and more innovative digital finance sector and more efficient and resilient payment systems. In this context, exploratory work on the possible introduction of a digital euro should be taken forward'.

The first point implicitly refers to improvements in the EU's internal economic, financial and governance architecture that could contribute to enhancing the international use of the euro as a reserve currency, as an invoicing currency and as a currency used to denominate assets and loans in countries outside the euro area. Crucially such improvements do not depend on monetary policy. Rather, they depend on progress in achieving the capital market union (CMU), completing the Banking Union and potentially other policy initiatives that could enhance the offer of (safe) euro-denominated assets.

The second point refers to the fast and multiple changes that technological changes are driving in the financial sector in two specific areas, the payment systems, and the introduction of central bank digital currencies.

Importantly, from an institutional perspective, the international role of the euro affects the extent to which the EU can maintain or increase influence in global decision-making. For instance, in discussions and negotiations about international debt management and balance of payments as well as participation in international financial institutions[28].

Broadly speaking, the international role of the euro and how it could enhance EU strategic autonomy should be understood in relation to the state of the international monetary system, the dominant role played by the US dollar over decades and emerging new trends driven or accelerated by the war in Ukraine.

5.1 The international role of the euro

In recent years the academic and policy debate[29] about whether the dominant role of the USD as an international currency can be challenged by other currencies, and by the euro, has been growing. Large net economic benefits[30] and asserted geopolitical advantages, including control or access to the financial and payment systems[31], can be gained from being the issuer of a global reserve currency and currency that is used in global invoicing. Geopolitical advantages are difficult to measure and shape as they are typically the result of market forces, but strategic decisions can play a role.

According to the ECB (2023), the international position of the euro remained quite stable in the decade 2010 and during the pandemic up to the start of the war, bucking the trend towards the gradual decline it experienced since the mid-2000s. In 2022, the euro was lagging the USD for most indicators that measure the standing of an international currency (see Figure 33), including global payments despite

[28] See also ECB (2023)

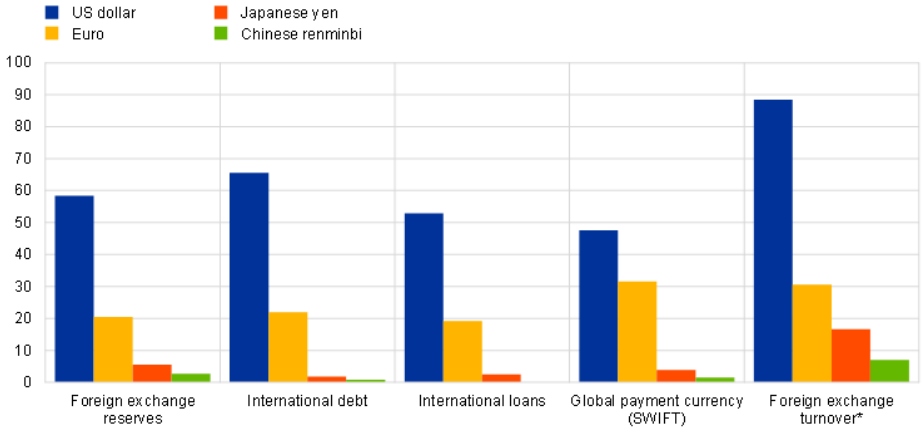
[29] See for instance IMF (2020), but also European Commission 2018, European Commission 2019 https://ec.europa.eu/info/sites/info/files/strengthening-international-role-euro-swd-2019_en.pdf.

[30] A large literature exists on the so-called dollar exorbitant privilege. For an analysis of the potential benefit for the euro, see Eichengreen and Gros (2020).

[31] In 2018, the case of the US sanctions on Iran, opposed by the EU in trying to protect the Iran nuclear deal, revealed the EU dependency on the dollar. This aspect is, however, outside the scope of this study.

the high bar in the chart below, which includes intra-EU trade. Overall, the euro remains the second most important currency in the international monetary system.

Figure 33. Snapshot of the international monetary system (2022Q2), % of total



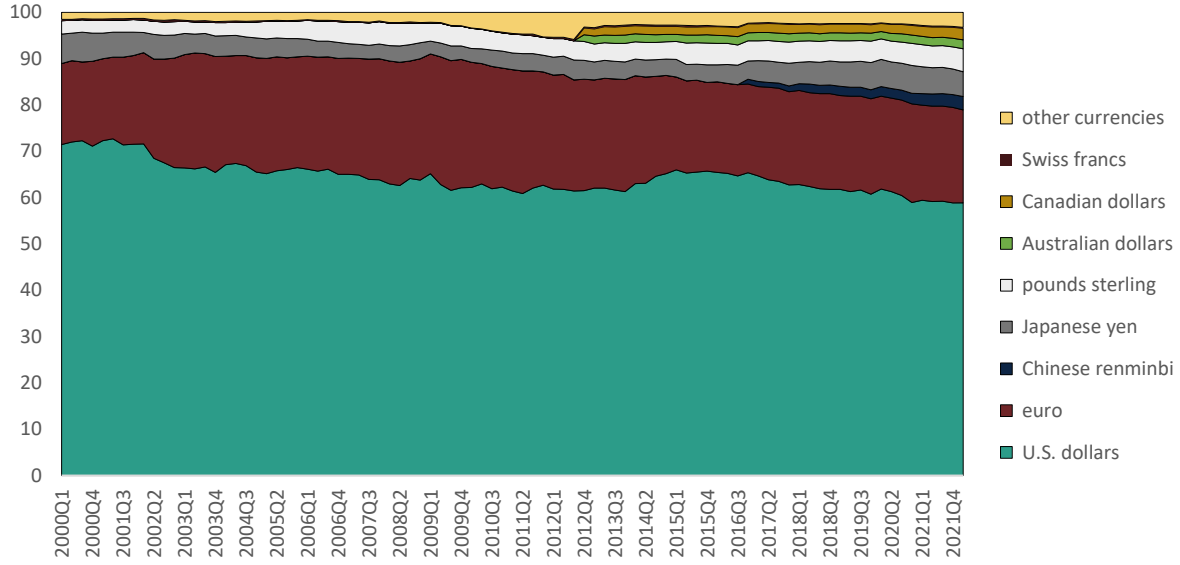
Source: ECB (2023), Chart 2

Note: *Since transactions in foreign exchange markets always involve two currencies, shares add up to 200%

5.1.1 The euro as a reserve currency

Historical data about official reserve holdings show that the dollar's share continued to decline while total holdings increased. However, the dollar is still playing, by far, a dominant role. Figure *34* shows that, in the first decade of the 21st century, the declining share of the dollar was accompanied by an increase, especially in the euro's presence, but this stopped during the euro area sovereign debt crisis and the high substitutability between the euro and dollar ended.

Figure 34. Foreign exchange reserves, currency composition (in per cent), 2000 Q1-2021 Q4



Source: Authors' elaboration based on Currency Composition of Official Foreign Exchange Reserves (COFER), International Financial Statistics (IFS), IMF

Note: Data availability for the Australian and Canadian dollar starts in 2012 Q4 and for the Chinese renminbi 2016 Q4.

Since then, the relative presence of other currencies has slowly increased, suggesting a trend towards diversification. In 2012, the currency of three small, advanced economies like Australia, Canada, and Switzerland found their place as a reserve currency and gradually experienced an increased demand. The Chinese renminbi appears for the first time in 2016. However, they are all very small.

Interestingly, in recent years safe, short-term liquid assets, which typically constitute precautionary reserve assets, are not the only target of central banks, especially those with very large reserve holdings. Asset diversification and instrument composition seem to be as important as the currency denomination of assets. The reason is that holders of large amounts of reserves might invest in longer-term debt instruments and equity instead of sticking only to traditional forex reserve instruments. This implies that not only the capability to issue a safe asset but also the availability of equities, denominated in a certain currency, contribute to the international status of such a currency. Unfortunately, data are limited on the currency composition of reserves and even more so on instruments.

Jones (2018), however, provides some insights based on a survey of central banks' reserve managers. The paper makes two relevant points that support the hypothesis above. Since the global financial crisis, the asset pool overseen by reserve managers has become more concentrated, as a larger share of global reserves belongs to a relatively small number of countries, and the share size is considerably larger than before. The second point is that, similarly to private sector asset managers, reserve managers have increasingly been searching for yield as cash rates have declined to historically low levels in advanced economies. The paper shows a duration extension in US Treasuries and a move into relatively high-yielding, non-traditional sovereign bond markets, as well as a rising interest in asset classes beyond sovereign debt, including equities. These rather recent developments point to the importance of the instruments and not only to the currency denomination of assets purchased as foreign exchange reserves.

These changes point to new trends which are likely to reinforce the current global conditions. First, a large availability of so-called euro-denominated 'safe assets', essentially government bonds with high ratings, can play an important role in boosting the role of the euro. More broadly and reflecting new trends, the large availability of a variety of assets, including equities, denominated in euro can boost its international role. Second; the gradual (and slow) diversification away from the dollar, not necessarily in favour of the euro, may accelerate in the future. As argued below, western economic sanctions against Russia may speed up this trend, and in the end, make the Chinese renminbi the main beneficiary of the change.

5.1.2 The euro as an invoicing currency

To understand how the use of an international currency can affect EU strategic autonomy, its role in global trade invoicing is likely to be very relevant. This is because it can directly affect the exposure of EU businesses to risks. The role of a currency in international invoicing has received growing attention in the economic literature devoted to the international role of currencies, as important deviations from the classical paradigm emerged in the mid-2010s. Gopinath (2015) and Gopinath et al. (2020) postulate the so-called *dominant currency* paradigm, whereby export prices are not set according to the standard *producer currency* principle (the traditional paradigm) but in a so-called vehicle currency. The key observation underlying the formulation of the new paradigm was that most global trade transactions are invoiced in just a few currencies. The largest part uses the US dollar (sometimes in euro) regardless of the countries involved in the transaction. Boz et al. (2022) confirm the new paradigm.

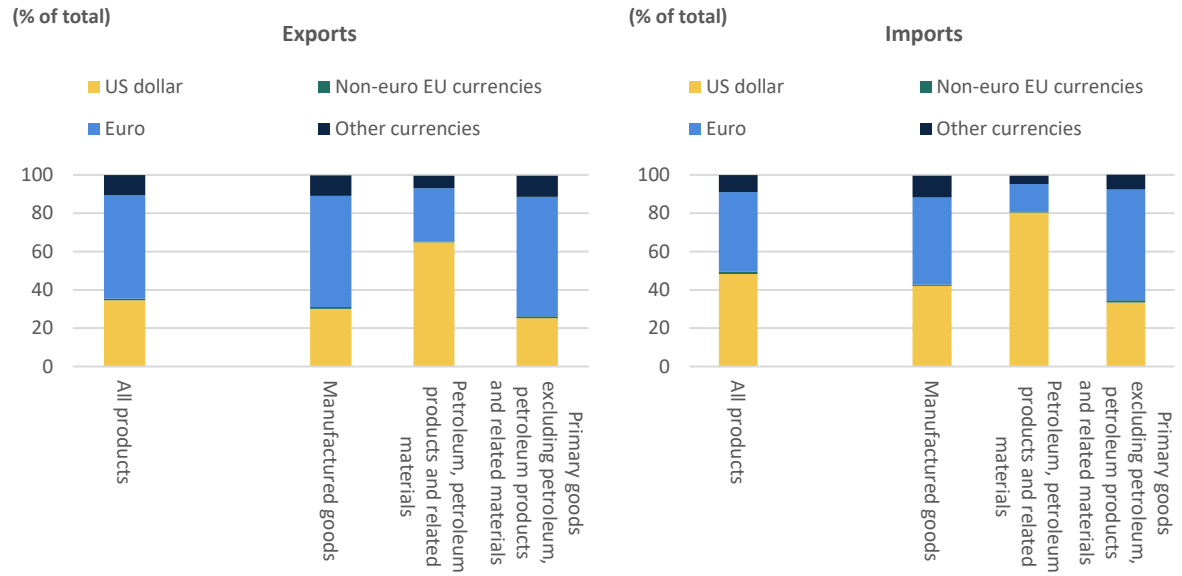
This dominant currency paradigm seems to have been driven by three factors. First, following globalisation, the landscape of global trade has changed, and emerging and developing market economies (EMDEs) have become much bigger players and have substantially increased their holdings of reserves. Their domestic currency is usually not accepted as means of payment outside the country and the US dollar is their main reserve currency. Second, some evidence seems to suggest that the choice of the currency for trade invoicing seems to affect the currency composition of foreign exchange

reserves (and vice versa). Third, the empirical evidence shows that only a few international currencies are used for pricing and financing. The reason is that a big part of the costs of production, above all labour costs, are fixed in the home currency, so the currencies in which the other factors of or input to production are denominated are the same as the pricing.

Against this background, the large size of the US market and the share of dollarized economies in global trade, the relatively low volatility of US exchange rate, and the historical dependence are considered to be the main forces driving the choice of the dollar as a dominant vehicle currency (Mukhin, 2022). While most of these features are captured by empirical studies applying the aggregated data, some analysis using the firm-level data highlights the role of other factors such as bargaining between the exporting and importing firms in choice of invoicing currencies, besides dollar (Friberg and Wilander, 2008, Tille and Goldberg, 2009).

Figure 35 illustrates the dominant role of the US dollar in trades of particularly oil and oil products for most EU economies. Comparatively, for other primary and manufactured goods, the euro has a central position compared to the US dollar. Economic theory suggests 'liquid' currencies, which have the highest volume of trade, have the lowest transaction costs and are therefore more likely to be chosen as a preferred and efficient means for exchanging goods. This is also evident in the invoicing currency profile of the extra-EU trade of sample EU countries. As *Figure 35* indicates, other currencies including the national currency of the non-euro area EU Member States constitute a small part.

Figure 35. Extra-EU trade by invoicing currency (2021)



***Source**:* Eurostat.

Note: Aggregate of Member States for which data are available for 2021 including Germany, Estonia, Ireland, Greece, Spain, Cyprus, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, and Finland. The countries altogether represent around 54 % and 62 % of the total Extra-EU27 exports and imports in 2021, respectively.

China has been seeking to internationalise its currency since 2009 (Eichengreen and Kawai, 2014) and the war in Ukraine may have created favourable conditions for more business invoicing in the Chinese renminbi. Similarly, following the fast-growing trade of African countries with China in recent years, the role of the renminbi as a vehicle currency has been presumably increasing in the region (Boz et al., 2022).

The importance of the dollar or euro in invoicing trade flows of Asian economies can vary depending on the country's economic ties with the US or Europe, the stability of their local currency, and the preferences of the parties involved in the transaction in their industry. In some industries, such as finance, the dollar or euro may be widely accepted as a standard invoicing currency due to their global reach and stability. However, in other industries or regions, local currencies may be preferred due to the ease of transaction and lower transaction costs. That said, Asian countries still rely heavily on the US dollar for invoicing of trade with not only the US but also with other economies in the region. This is mainly due to the lack of a regional common currency like the Euro (Shimizu, 2019*). Figure **36*** and *Figure **37*** below illustrate the dominant role of the dollar, compared to the euro, as a vehicle currency in trade in Asia.

Figure 36. US dollar-invoiced exports and imports and GVC participation, by region

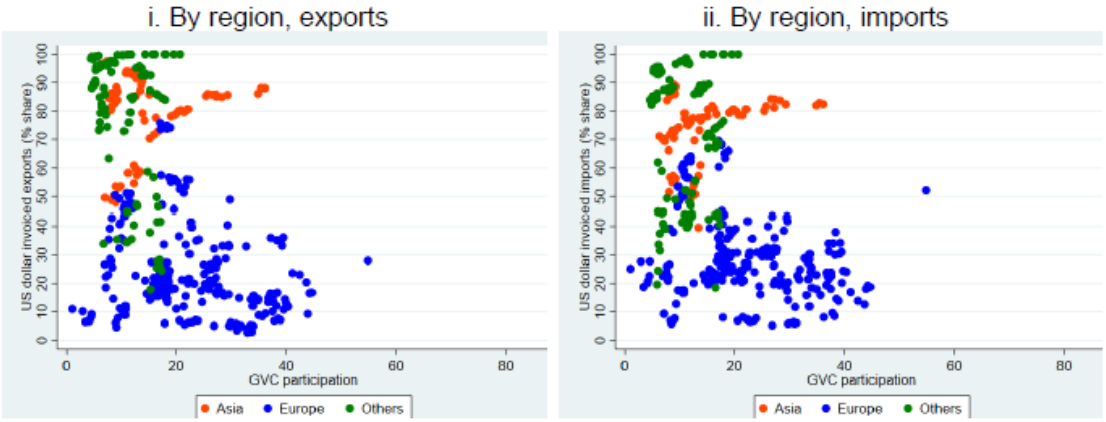
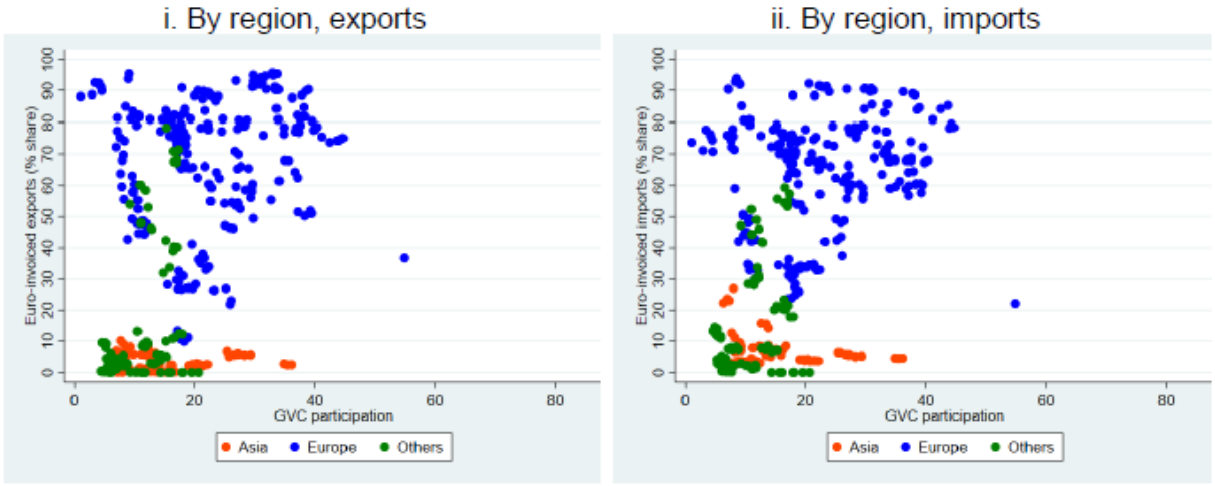


Figure 37. Euro-invoiced exports and imports and GVC participation, by region



Notes: GVC participation refers to GVC-related output as a percentage of output.

Source: Mercado et al. (2023).

While the Chinese yuan has increased in importance as an international currency in recent years, due to promotion policies implemented by the Chinese government and the People's Bank of China such as the establishment of bilateral RMB-denominated swap arrangements with several countries (Sato and Shimizu, 2018), the US dollar remains dominant as the world's primary invoicing currency. An analysis based on large-scale firm-level surveys finds evidence of increasing use of the renminbi by Japanese

subsidiaries operating in China and other Asian countries along their regional and global production network.

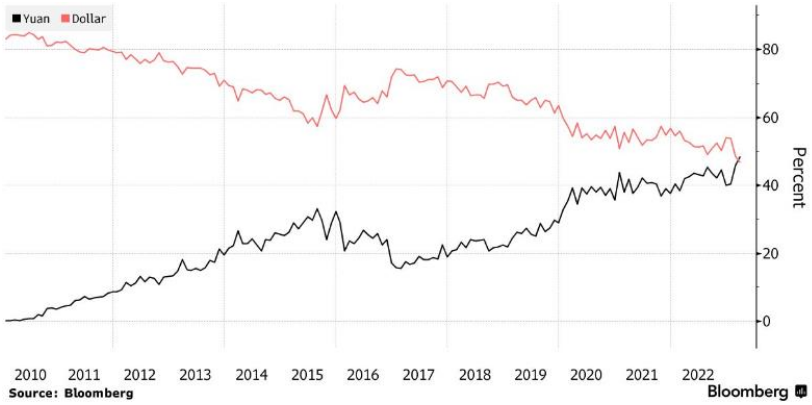
However, it is shown that the US dollar, and to a lesser extent, the yen, are still the main currencies used in trade with other countries (Sato and Shimizu, 2018). This study identifies the size of subsidiaries (measured by the employment of local workers) and precautionary exchange rate risk management by subsidiaries as the main considerations driving Chinese renminbi-invoiced trade. However, they do not find any evidence on the effect of product differentiation on the choice of renminbi for invoicing. These findings are also confirmed by some survey evidence indicating the use of some Asian currencies such as the Chinese renminbi and the Thai baht in trade within the region (Shimizu, 2019).

While these shifts seem to challenge the US dollar as the dominant currency, while fast changes in trade invoicing are unlikely, they are not impossible. The current system is the result of market practices established over decades (since WWII) and which are typically costly to change. A move away from the dollar as the dominant currency may happen if the costs associated with the use of the dollar increase or the benefit of an alternative currency increases.

This typically takes time; however, two sets of costs associated with the use of the US dollar have become more apparent in the course of 2022. The first is the US dollar appreciation. This is a temporary phenomenon, but it has been rather extraordinary (and it amplified existing inflationary pressures in many countries). Choices over invoicing currencies have the potential to impact a country's trade balance because of exchange rate movements. The strong appreciation of the dollar is a concrete example of the additional costs that it entails on USD-denominated imports.

The second cost is only potential, and it is associated with exposure to sanctions (see Box 3 on secondary sanctions). This may be relevant only to countries which are not aligned with the US, but there is no doubt that the financial sanctions against Russia, have worked as a warning for countries which see the US as hostile. For instance, Russia, Iran, Brazil, Argentina, and Bangladesh are making headway in de-dollarisation and in using the yuan for trade. The Chinese yuan is seizing the opportunity and is mounting a challenge to the dollar's dominance. According to Bloomberg, in March 2023, for the first time, usage of the yuan in its cross-border transactions jumped ahead of the USD.

Figure 38. Chinese yuan and USD in Chinese cross-border transactions



Source: Bloomberg.

The renminbi still has many limitations as an international currency. The Chinese government has in place capital controls and the renminbi is not fully convertible (convertibility in other currencies is conditional). In addition, in 2005, China introduced a managed floating exchange rate system. This

means that the currency is no longer pegged to the USD, but the central bank intervenes in the foreign exchange market to influence the value of the currency, which would result from market forces.

From a purely economic point of view, these features make the renminbi a weak alternative to the USD, however, geopolitical considerations are a key driver of the current changes.

It should be recognised that in democratic countries with a market-based economy, the room for manoeuvre of policymakers to influence, and even less impose, the currency of global invoicing is limited. In principle, companies have more leverage than governments.

More broadly, as mentioned above the ECB cannot affect the status of the euro as an international currency. Yet, from an EU perspective, two internal developments matter for expanding the use of the euro as an international currency. The first relates to euro-denominated assets and in particular bonds. To become an international currency, the market of risk-free assets denominated in euro should be liquid and have a large breadth. This requires the availability of very large amounts of euro-denominated assets.

The second development relates to Capital Markets Union, as the international role of a currency is not only based on the availability of public sector assets but also euro-denominated equities.

Box 3. US sanctions against Iran in 2018 and the secondary sanctions

The war in Ukraine and the financial sanctions against Russia, in particular the freezing of its foreign reserves denominated in USD and euro (and held in Western countries), made it clear that extensive reliance on a foreign currency can become a major constraint on the sanctioned economy. An international currency, which is most of the time considered a public good, can be used as a weapon. The issuer of the international currency retains the ultimate control on the currency and can exert a strong power on those using it. Even if the EU was never the object of US sanctions, in 2018 it experienced some side effects liked to its reliance on the US dollar.

In 2018 the Trump administration decided to withdraw from the Iran nuclear deal (the Joint and Comprehensive Plan of Action) and to reinstate previously lifted sanctions under this agreement, whereas the EU remained committed to the continued full and effective implementation of the nuclear deal. However, many EU businesses active in Iran found themselves affected by the US decision.

The main reason was that most trade transactions, and above all oil exports, between EU companies and Iran were denominated in USD. The payment of large transactions denominated in USD most often requires the involvement of a US bank, making the US reinstatement of the US sanctions affecting business.

To protect EU businesses, the EU resorted to the Blocking Statute, which allowed EU operators to recover damages arising from US extraterritorial sanctions from the persons causing them and nullifies the effect in the EU of any foreign court rulings based on them.

In addition, in 2019, the governments of France, Germany and the United Kingdom developed a special purpose vehicle (SPV), known as INSTEX, to enable European businesses to maintain non-dollar trade with Iran without breaking US sanctions.

5.2 Access to and control of payment systems

Non-EU payment-related service providers occupy a dominant position in intermediating European payment transactions. According to the ECB, roughly 70 % of card payment transactions are handled by non-European providers in a market that exhibits high concentration. Such concentration is also combined with a fragmented EU payments market. As the EU Retail Payments Strategy remarks 'With the exception of those large global players, including worldwide payment card networks and large technology providers, there is virtually no digital payment solution that can be used across Europe to make payments in shops and in e-commerce'. In practice, co-badging with an international card scheme is a requirement for the EU-wide acceptance of cards issued under national card schemes[32]. European payment-related service providers are also heavily dependent on service providers from outside the EU. For instance, a small number of large, non-European cloud providers dominate the public cloud market in the EU, a critical technology for the future development of payment systems.[33]

Based on the above, the considerable dependence of EU payment systems on external actors poses a threat to the resilience and functioning of the payments ecosystem and exposes it to risks stemming from potential geopolitical tensions. Moreover, it also raises security concerns linked to data privacy. These concerns form the foundation for several initiatives in the field of payment, including the Retail Payments Strategy for the EU, which explicitly cites the objective of fostering 'Competitive home-grown and pan–European payment solutions […] supporting Europe's economic and financial sovereignty'. The Digital Operational Resilience Act establishes an oversight framework for ICT service providers, even if they reside outside the EU. Creating a more resilient payment ecosystem for the EU will also depend on other initiatives, for instance, the initiative to modernise payment services (i.e. the update of the PSD2).

5.2.1 Would the digital euro make a difference?

The digital euro, although still in its developmental phase, holds some potential to reinforce the EU strategic autonomy. While its precise implications remain somewhat unclear, it is clear that its primary influence on strategic autonomy would be felt through the realm of retail payments.

One compelling prospect is that the digital euro could be issued to facilitate the creation of a comprehensive range of pan-European end-user solutions, by regulated financial intermediaries, designed for easy access by consumers. These end-user solutions could cater to the distribution of both commercial money and central bank-issued currency. In this scenario, the issuance of a digital euro would serve as a mechanism in enhancing the European retail payments market, and hence the EU strategic autonomy. In practice, it would equip the EU to address or avoid potential disruptions in the flow of euro payments arising from geopolitical risks and ensuring the stability and security of retail payment systems.[34]

[32] See ECB (2023), The EU's Open Strategic Autonomy from a central banking perspective: Challenges to the monetary policy landscape from a changing geopolitical environment.

[33] European Commission (2021) Strategic dependencies and capacities: Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery, SWD(2021) 352

[34] See ECB president speech here

6 Towards an operational definition of strategic autonomy

This section attempts to combine the results of the analysis of the previous sections with an assessment of the various policy initiatives and measures that have been adopted or proposed in recent times to promote EU strategic autonomy, with a view to operationalising the concept of strategic autonomy. This is important not only for defining the scope of EU strategic autonomy, shedding light on what strategic autonomy means in practice, and the policy trade-off that may emerge, but also for seeing how companies are looking at this changing environment. This section will map and briefly analyse ongoing EU-level initiatives aimed at moving towards open strategic autonomy. It will also briefly assess the regulatory landscape that shapes not only how policy initiatives are conceived and framed, but also how they are constrained by the institutional set-up, notably through the lens of the EU's Better Regulation agenda.

6.1 The scope of strategic autonomy

Having a clear definition of the scope of the concept is a critical step towards operationalising it. Four questions are relevant for this purpose:

- Where? As illustrated above, the scope of strategic autonomy has expanded from its original focus on security and defence. Yet, pursuing autonomy in every sector and every policy area would not only be a costly and impossible undertaking, it would also not make sense. There is a clear need to identify strategic dependencies[35] and strategic areas for the promotion of EU interests and values. Strategic dependencies are defined as dependencies that are considered of critical importance to the EU and its Member States' strategic interests such as security, safety, health, and the green and digital transformation. In practice, as emphasised in the EESC opinion and as discussed above, a key step is to identify the strategic areas from an EU perspective. The Commission has made clear which areas should be developed as priorities and have a real EU added value, but there is this still a lack of consensus, including across EU institutions. Together with safeguarding European interests, this forms the basis to define an EU industrial policy.
- What degree of autonomy? Strategic autonomy is not a binary concept, but it implies a spectrum of choices ranging from full openness (with no consideration of dependencies, as no risks is associated with trade dependency) to full self-sufficiency. From an economic point of view, none of the choices are necessarily efficient or desirable. Measures in the direction of reduced dependency, such as the creation of strategic stockpiles, the diversification of supply chains, or the reshoring of manufacturing capabilities are likely to involve costs and benefits. Some (such as material and financial costs) are easily measurable, others, such as political and diplomatic costs, but also unrealised costs (reliability of supply in time of stress on GVC) are more difficult to quantify. In practice, the 'optimal' level of strategic autonomy is likely to vary from one area / sector to another.
- What external factors? The concept of EU strategic autonomy, beyond security and defence, has a relatively short history. It developed during Covid-19 when the lockdowns resulted in major disruptions first in the provision of essential goods (e.g. face masks) coming from outside the EU, then more broadly in global supply chains. The concept has become even more relevant since the

[35] The European Commission (2021) p.7 defines dependencies as reliance on a limited number of actors for the supply of goods, services, data, infrastructures, skills and technologies combined with a limited capacity for internal production to substitute imports. Strategic dependencies are defined as dependencies that are considered of critical importance to the EU and its Member States' strategic interests such as security, safety, health, and the green and digital transformation.

start of the war in Ukraine. The war made it clear that the high degree of dependence on Russian gas would result in a major economic shock because of disruptions and eventually a stop in supply. Increased rivalry between China and the US as well as growing geopolitical tensions driven by China's foreign policy activism and its support for Russia are feeding concerns that globalisation is coming to an end. The idea that the global order may break into hostile blocs is gaining support. The way in which the global trading and financial system will evolve plays a major role in defining the desirable degree of strategic autonomy. Importantly, the EU by making choices about its openness contributes to shaping such a system.

- Who should be strategically autonomous, the EU or its Member States? This question, often overlooked, is relevant and politically challenging. From an economic and geopolitical perspective, there is no doubt that the concept of strategic autonomy should apply to the EU. However, differences in economic models and in the industrial basis point to different needs and different degrees of pro-activity towards a search for autonomy.

6.2 A compass to define strategic autonomy?

Against the four questions identified above, we attempt to operationalise the idea of strategic autonomy along two defining dimensions, namely features of the trading system and the geopolitical environment (to capture external, though not fully exogenous, factors) and the degree of dependency (to capture factors that are mostly endogenous).

The identification of the two dimensions is based on two considerations. First, the analysis presented in the previous sections reveals that for certain sectors (or classes of products) the EU is highly reliant on extra-EU imports that in some cases are highly concentrated in a few countries and there is little room for substitutability (at least in the short term) with EU production. In those cases, supply disruptions could lead to shortages and products that are critical or highly sensible to a cascade of economic consequences. Second, the idea that geopolitical fragmentation and deglobalisation is not only becoming more pervasive, but the political discourse is also incorporating new concepts. Friend-shoring is one. It refers to the rerouting of supply chains towards countries considered politically (in the sense of adherence to a certain set of norms and values) and economically close and hence at lower risk of disruption to the flow of business. Already in 2022, the US treasury secretary, J. Yellen, claimed that 'Favoring the friend-shoring of supply chains to a large number of trusted countries, so we can continue to securely extend market access, will lower the risks to our economy as well as to our trusted trade partners. The European Commission's 2022 Foresight Report suggests that '[The geopolitical situation…] will add pressure to move to less vulnerable, more diversified, and more reliable supply chains and, possibly, "friend-shoring"'.

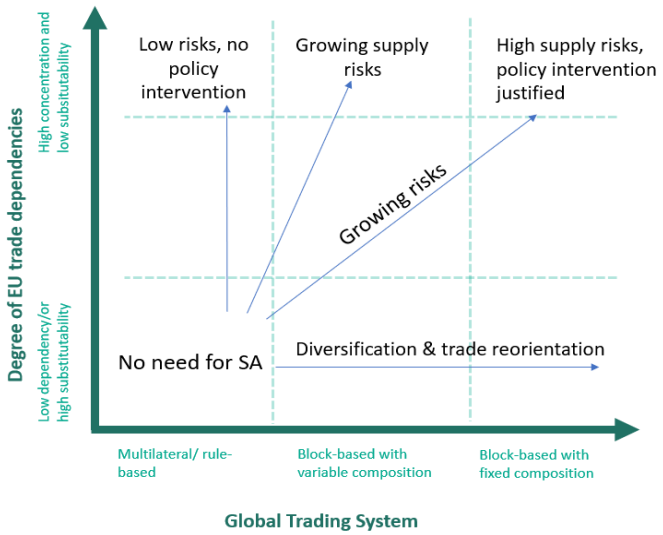
Such changes suggest that the risk of global fragmentation and the emergence of trading blocs is increasingly likely and driven by political and values affinities, rather than pure commercial considerations. One, simplified view, is that the world may split into two competing blocs, with Western democracies on the one hand and authoritarian regimes, close to China and Russia, on the other. While this may be an extreme scenario, a situation with trading blocs having variable composition (possibly shaped by a growing search for diversification of imports but also of export markets) is likely to gradually emerge already in the short term.

The combination of the degree of dependency and the features of the global trade system will crucially determine the desirability of (and the need for) strategic autonomy.

From an economic standpoint, the question boils down to how to identify the degree of openness (something in between full openness and self-sufficiency) that allows access to the largest set of international opportunities and satisfies geopolitical considerations, i.e. that is compatible with an assertive defence of the EU's key interests and its protection against unfair practices (above all the weaponisation of trade).

One way to operationalise this idea is to dissect the problem along two dimensions – The degree (and the nature) of existing (and emerging) trade dependencies and the evolution of the geopolitical space that determines the global trade system (see *Figure 39* below).

Figure 39. Strategic autonomy: a matrix approach



***Source**: Own elaboration.*

The trade dependency dimension (vertical axis in the figure) goes well beyond large volumes of imports[36]. In addition to the extent to which EU countries import a certain good or a product, whether such imports are concentrated in a few or just a single supplier (at country level) should be considered and the extent to which the production could take place in the EU (potential substitutability of imports). In principle, the combination of high relative import demand dependency, high concentration and low substitutability is a good recipe for dependency, but not necessarily for policy intervention (see vertical arrow in *Figure 39*).

But the type of product also matters. Not all dependencies should be of concern for the purpose of achieving strategic autonomy – only high dependency on products belonging to sectors which can be qualified as being strategically important. These are sectors (industries) for which the loss of access to certain products or materials could result in debilitating effects on security, economic security, and development (including the achievement of the green and digital transformation), public health or safety, or any combination of them (see also Section 4.1). Whether the country from which the EU imports can be considered unreliable or could be tempted to weaponise its dependency is a key consideration for any assessment.

Mapping sectors (possibly products) that are strategically important for the EU is a first crucial consideration. However, what constitutes 'strategic' is an even a more critical issue which, as argued above, reflects political and economic priorities. Political priorities, on their end, should be forward-looking. Accurate foresight is notoriously difficult not only because the definition of 'strategic' sectors and products continuously evolves over time, but also because the risks and their perceived magnitudes to an extent hinge on the nature of (future) shocks. The example of the Covid-19 pandemic (e.g. masks, respiratory equipment, vaccines) is a case in point.

[36] While trade dependency mostly refers to imports, exports also matter. As a very open economy, the EU is a central part of many global value chains and hence highly exposed to foreign demand. Therefore, both import and export (trade) dependencies should be considered.

To date, this is still missing in the EU. The notable exception is the JRC's impressive study forecasting the evolution of demand until 2050 in 15 key technologies. In the US, the Atlantic Council identified a clear list of five sectors to monitor for the purpose of friend- or reshoring. A similar list, reflecting EU resource endowment and economic structure, would help to focus efforts but not necessarily lead to the automatic cutting of commercial ties.

The second dimension of the problem (horizontal axis in Figure 39 above) is the state of the global trading system. There is a growing concern that current trade tensions between the US and China could lead to increased geopolitical rivalry and in turn into a bipolar configuration led by these two economies and their respective allies. This could start as blocs with variable composition and substantial trade openness. But if tensions escalate, the blocs could have defined composition and favouring – or even only permitting – intra-bloc trade (see the sliding scale of the horizontal axis). Thus, the more we move away from a multilateral trade system based on rules and towards a system dominated by power, the higher the risks to which the EU is exposed (see the arrows up and to the right of the figure).

Together with the US, China plays a key role in defining the world's geopolitical space. It must be acknowledged that China occupies a crucial position in global trade, supply chains and investment partnerships. Any attempt to decouple or diminish the economic ties with China will lead to major challenges for EU policymakers and companies. Furthermore, an EU decoupling from China would inevitably contribute to a more divided world, the very outcome that the EU wants to avoid at all costs. For these reasons, any adjustment in the trade relations with China carries major economic and political trade-offs.

7 The EU policy landscape

The EU has a broad set of tools that can be deployed to achieve the goals (even broadly) associated with open strategic autonomy.

Traditionally EU policy instruments are associated with the single market. Its toolkit is represented by the common regulatory framework (regulation and competition) among its 27 Member States, whose fundamental purpose is to protect and enhance the four freedoms (movements of goods, capital, services and people) and, ultimately, protect and promote the interests of European consumers and firms. The current contested global economic environment, however, is posing fundamental challenges to the EU on how to achieve its main objectives. This has resulted attempt to deviate from or extend the toolkit and its scope of action.

7.1 Initiatives and governance arrangements towards more open strategic autonomy

Looking back at the sequence of crises of the last two decades, the financial crisis, the Covid-19 pandemic and then the energy crisis following the Russian invasion of Ukraine, each of them pointed to key external dependencies faced by the EU, but above all by groups of EU Member States. It was capital imbalances during the financial crisis, global value chains dependency during Covid-19, and most recently, Russian oil and gas dependency. Each crisis translated into greater EU vulnerability, but the impacts, the urgency to respond and the capacity to respond are different across Member States. The reliance on Russian gas and oil, and even more the substantial reliance on foreign, primarily Chinese, sources for rare earth materials and advanced technological components has further accentuated the necessity for security of supply, which is essential for maintaining economic resilience and independence.

In response to these multiple crises, the list of these instruments has been considerably expanded in recent times. Both in line with the traditional tool, and also resorting to new ones.

Due to its competence in economic policy, legislative initiatives are some of the most important tools to further EU strategic autonomy objectives. Several of these belong to the broadly defined realm of EU trade policy. For instance, the Export Control Regulation adopted in May 2021 aims to control exports, transfer and transit of dual-use items and brokering. The proposed Anti-Coercion Instrument (ACI) Regulation aims to empower the EU to dissuade or counter-economic coercion by third countries through trade measures like extra duties, exclusion from public procurement tenders, export restrictions or limits to foreign direct investment flows. Some of these instruments have an important bearing on EU industrial policy as well. The foreign direct investment (FDI) screening, (Article 1.1) adopted in March 2019, aims to protect national security interests by controlling investment 'on the grounds of security or public order.' The Single Market Emergency Instrument (proposal) is an export control measure which aims to secure the supply of critical goods and services and strengthen governance and resilience during crises. Initiatives focused on industrial policy with strategic autonomy relevance have sprung up amid relatively new-found interest in industrial policy. The US Inflation Reduction Act in 2022 has resulted in a legislative impetus for such initiatives (see Box below).

The EU budget is another important vehicle for advancing OSA policies. The European Commission's assessment identified the following areas of relevance of the budget: defence, research and development (R&D), energy, diplomacy, healthcare, digital and climate investments. The paper considers that areas contributing to OSA in the 2021-27 MFF have been significantly increased. EU budget expenditure can be channelled to target specific activities and/or industries, for instance through the Important Projects of Common European Interest (IPCEIs). IPCEIs are transnational funding projects from several members of the EU aimed at R&D activities and creating cross-border supply

chains. One of the most recent examples of such investment vehicles is the Strategic Technologies for Europe Platform (STEP). The STEP proposal replaces the bigger plan of an 'EU sovereignty fund', an idea proposed by the Commission President and funded by common EU borrowing (similar to the RRF), which never found sufficient support. Instead, STEP builds on existing EU funds, including InvestEU, Horizon, the RRF and the ETS Innovation Fund. Out of EUR 160 billion planned for the Platform, only EUR 10 billion will come from public sources, while the rest is expected to be raised through private investments.

A sidenote concerns the regulatory and budgetary landscape within which EU legislation, investments or other initiatives are conceived. The logic of the EU's Better Regulation agenda largely shapes the regulatory thinking on OSA policies within the European Commission, the initiator of the majority of the below initiatives. While the foresight and resilience components have recently gained increased prominence in the policymaking cycle, regulatory thinking is still largely centred around the cost-benefit analysis approach (Renda, 2022). Translating the findings of risk assessments or foresight exercises into daily policy practice is far from straightforward and is complicated by the fact that investing in resilience 'before the event' is unlikely to be a popular decision with citizens. A CBA-based approach can create issues because governments that speak the 'less is more' language, just as businesses that pursue cost advantages in global supply chains, are unlikely to consider resilience to a full extent. The recent flurry of OSA-related policies marks a clear momentum for the adoption of such initiatives, but the above considerations might still be considered a barrier to further initiatives in the mid-to-long term.

Finally, it is also worth mentioning partnerships such as the EU-US Trade and Technology Council (TTC) or the Global Gateway, which can work as fora for cooperation on strategic autonomy related areas where the interests of participants align.

The above overview shows the breadth of policy options available to the EU to further its OSA agenda. It also clearly conveys the message that rather than being a simple theoretical framework, strategic autonomy is increasingly becoming a policy reality.

Box 4 EU response to the Inflation Reduction Act

As a response to the IRA (as well as to the impact of the energy crisis and Russian war against Ukraine), in February 2023, the Commission published the Green Deal Industrial Plan, a strategy for 'enhancing the competitiveness of Europe's net-zero industry'. It includes a new regulatory frameworks on net-zero technologies (Net Zero Industry Act, NZIA) and critical raw materials (Critical Raw Materials Act, CRMA), a revision of existing state aid rules.

The net-zero industry act (NZIA)

NZIA can be seen as most directly responding to the US IRA, even though the current legislative proposal looks very different from anything pursued by the IRA and builds on EU strengths and (legal) capacity to regulate the internal market. Some parts of the NZIA, as provisions on permitting, access to funding, and regulatory sandboxes, can be seen as trying to address red tape in the economy, and simplifying processes. It also includes a proposal to have minimum domestic production targets for strategic net-zero technologies, though there is not yet agreement on the list of strategic-net-zero technologies. Lastly, the funding is still unclear. The EP supports using at least 25 % of ETS auction revenues to support the objectives of the NZIA. this would not necessarily lead to additional cleantech financing in Europe, as EU Member States by and large already spend most of their ETS revenues on objectives considered in line with EU climate goals.

Critical Raw Materials Act (CRMA)

The CRMA aims at securing the supply of CRMs to support the manufacturing of net-zero (and digital) technologies. Along with a proposal setting conditions and benchmarks for the development of domestic mining and recycling capacity in the EU, the Act comes with an EU CRMs strategy on trade diversification, international cooperation, coordination of finance, skills and R&D and identifies a subgroup of 'strategic raw materials' that are highly important for strategic (green) applications. Crucially, the Act does not mobilise new resources, but provides for a European Critical Raw Materials Board (Member States representatives and Commission) to coordinate existing financing mechanisms.

Revised state aid rules: Temporary Crisis and Transition Framework

Building upon the Temporary Crisis Framework adopted in the wake of Russia's war against Ukraine, the new Temporary Crisis and Transition framework prolongs the possibility for Member States to support the deployment of renewable energy technologies and industrial decarbonisation, while expanding the scope of eligible schemes to those supporting clean tech manufacturing as well as critical raw materials projects. The new framework allows for more flexibility in allocating national budgets and a more generous form of state aid, if a Member State can credibly demonstrate that additional aid is necessary to avoid investments from being diverted away from the EU (so-called matching aid). The latter can be seen as an explicit response to the extensive subsidies offered through the IRA.

7.2 Industrial policy and the single market

After being somewhat overlooked for years, industrial policy has recently surged in significance as a pivotal policy instrument in the EU. This has been the case, and even more prominently, in the US. Initiatives such as the US Chips and Science Act, the EU's Chips Act, the US IRA, and the EU's Net Zero Industry Act are clear examples of such resurgence in the US and the EU, respectively. Two fundamental questions come to the forefront for the EU. Firstly, what is the genuine potential of the EU industrial policy measures to boost EU competitiveness and realistically advance the concept of strategic autonomy? And secondly, can these policies align with the foundational principles of the EU single market?

As illustrated above, it is increasingly evident that the traditional tools of the EU single market may not suffice to ensure strategic autonomy in a world where influential players employ state intervention to establish or strengthen their positions on the global stage. It is the understanding of such change that is what is driving the evolution of the objectives of industrial policy. Today, the EU industrial policy is expected to serve a different purpose than in the past. It is no longer solely about fortifying or

safeguarding the EU industrial competitiveness but rather about "de-risking". It is about reducing EU external reliance on foreign suppliers of critical high-tech products like microchips, electric batteries, or rare earth materials. Simultaneously, these policies aim to enhance the EU's long-term resilience through a focus on green industrial transformation, as exemplified by the European Green Deal (and also IRA in the US)

As a result, the paradigm is shifting towards a scenario in which directing, bolstering, and subsidising investments in specific sectors, economic regions, or countries is the new norm. This evolution will undoubtedly present significant challenges to upholding the principles that underpin the single market, but possibly also EU economic convergence and integration.

Opening the possibility for Member States to provide state aid to strategic industrial sectors is likely to create an unlevel playing field, because of the different fiscal capacities of member states, but also the different traditions in defining industrial policy at the national level with a view of fostering competitiveness.

The EU Chips Act is an example. To achieve the objective of doubling the production of chips on EU soil, given the very high dependence on foreign imports (mostly Taiwan), heavy capital investment is required. Since the beginning of 2023, the Commission approved several billion euro subsidies to support chip production in several Member States, with Germany offering the largest one (about EUR 10 billion to TSMC, a Taiwanese Semiconductor Manufacturing Company).

In practice, with the aim of moving towards strategic autonomy, the main objective of EU competition law, i.e., prohibition of industrial subsidies to prevent concentration in member states with deep fiscal pockets, has been violated.[37]

This raises an essential question about the existence of a dichotomy between the single market and the objective of strategic autonomy. Fundamentally, it also proves the EU does not have a true EU industrial policy. As it is today, despite some EU attempts (like STEP, and IPCEIs) the EU industrial policy attempts to set broad common aims, which are unlikely to be achieved as the sum of national policies, mostly driven by national interests.

[37] In the same vein see Soete and Van Kerckhoven (2023)

8 Conclusions and policy considerations

Covid-19 and the Russian weaponisation of EU energy dependency have raised fundamental questions about the factors that should define the structure of the supply value chain and the supply of energy (and other raw materials). Long supply chains, particularly if scattered across several regions, make it difficult for individual firms to keep their dependencies in check, as downstream actors often have little control over upstream production steps. The logic of strategic autonomy implies that making decisions based purely on the economic merits of investments, outsourcing or trade could leave the EU vulnerable to a few unreliable partners who could use this leverage (the 'weaponisation' of trade) to achieve political goals at the expense of the EU's interests. In a context of increasing geopolitical rivalry and the steady erosion of the multilateral rules-based trading system, diversifying, and securing critical parts of the supply chain therefore become vital objectives.

Consequently, there has been a growing debate in the EU on relocating the manufacturing activities and production sites back from third countries to the EU, reshoring to a geographically close or a 'like-minded' country, near-shoring and friend-shoring. While reshoring can help reduce the vulnerability of critical supply chains and more broadly access to strategic products, it inherently carries an economic cost. In a rules-based trading system, decisions by economic operators to offshore parts of the production process can be assumed to be in line with the logic of comparative advantage building on local factors. Relocation driven by political risks implies less optimal conditions, requiring not only significant investments in infrastructure, technology, and training but also resulting in higher operating costs. Thus implying a trade-off between security of supply versus economic efficiency. While these choices can still offer protection against risks, these costs are likely to lead to higher prices for consumers and lower global competitiveness for re-shored industries. This, in turn, can also have a public cost. For certain businesses re-shoring may be appealing only if the government incentivises the process of handing out subsidies, tax breaks and other similar measures (this is happening in the US with the IRA). This could make some companies dependent on government support. Similar consideration on costs applies in the context of a 'friend-shoring' strategy, whereby the relocation of production takes place towards countries with shared values. The process may be the result of market consideration (pure risk assessment) at the level of companies but it could still lead to higher production costs and higher process for consumers.

Diversification of supplies, encompassing products, services, and investments has already started as part of companies' reassessment of geopolitical risks. In some cases, firms have already chosen to relocate (part of the) production and explore other suppliers. However, in the short term, there are limits to diversification and new dynamics may be at play. In particular, an increasing complexification of value chains may hide indirect linkages and dependencies, while direct trade seems to point to de-risking patterns. This issue applies in particular to China on which the EU has the highest degree of dependence on electronic appliances and critical raw materials. It should be recognised that in certain sectors full decoupling from China is just impossible in the short term. An example is given by some critical raw materials. For some of them, China is not only the major exporter, it is the only one. In these cases, only new technologies use less of those raw materials, combined with 'true' diversification of imports, can reduce EU strategic dependency.

Another important issue concerns the potential asymmetrical impacts, across EU Member States, of an EU industrial policy aiming at strategic autonomy. If a subsidy race were to start, it is likely to favour Member States with deeper fiscal pockets, hence hampering the foundations of the single market. In practice, cross-country differences beyond the availability of financial means, like the sectoral

composition and the political and economic priorities in the country, could also lead to very different national industrial policies and ultimately growing EU divergence.

This points to an important risk. An EU industrial policy, whose aim is to contribute to strategic autonomy, *de facto* challenges the foundations of the single market and risks delivering greater divergences across member states. One of the reasons for such a potential failure is that the EU does not have a true industrial policy, which can enhance EU external competitiveness, through internal competition, and manage to achieve de-risking.

Finally, another related issue needs to be taken into consideration. The EU, like other advanced economies, is facing the fundamental challenge of a restructuring of its industry, especially the most energy-intensive sectors. Such transformation entails coordinated changes within firms and across value chains, which are unlikely to happen without state intervention. Historically, within nation states, the government has played a key role in addressing structural transformations through a variety of industrial policies, ranging from direct subsidies to direct reshaping of industries, to other softer interventions (e.g. alignment of incentives among institutions and organisations, provision of technological and organisational innovation). Not all interventions imply limiting private-sector initiatives, on the contrary, some like the search for both sector-specific and cross-sectoral solutions, innovation efforts or commitment to infrastructural investments can favour them. In the current EU context, a fundamental question is to what extent EU member states are using their domestic industrial policies to drive such restructuring and what is real role of the EU. It is evident that in countries with a strong industrial base, like Germany and France, but not only, national policies are being designed with the purpose of supporting the national industry. Other countries seem rather unprepared to face such challenges. This calls for a further rethinking of what the EU industrial strategy can do to boost EU competitiveness and gain the strategic autonomy needed, without feeding internal divergences.

Overall, three broad policy messages emerge for the EU.

First, openness. The EU is made up of trading nations, for which trade has been the main tool of global influence. A reduced openness, whether emerging from external factors or by choice through policies, is going to impact the EU growth model and its role as a global actor. As the EU's relative economic weight declines, driven by the emergence of other economic powers (like India and some African countries), in a politically more fragmented world, economic relationships will remain crucial to define the key global actors. Hence, external strategic dependencies should be reduced while simultaneously maintaining a commitment to openness. This is a crucial starting point in formulating a strategy aimed at open strategic autonomy. Based on the analysis conducted in this report, this requires the design of a comprehensive approach with actions on multiple fronts. Such an approach should include i) rethinking production systems towards risk reduction in supply chains and favouring domestic production of some strategic goods and services, ii) gaining further efficiency in energy consumption, iii) fostering technological innovation, including to reduce dependency on raw materials, and iv) developing new trade partnerships, as part of a broad EU strategy to reduce dependencies and to engage in the reform of the global multilateral system.

Second, China. China demands special attention when formulating a strategy to reduce vulnerabilities or, more broadly, implementing a de-risking strategy. The intricate connections of global value chains with China mean that diversification efforts may not immediately result in reduced reliance on Chinese inputs and suppliers. Even substantial shifts in production to alternative destinations may only lead to marginal decreases in China's global supply of exports and its contribution to manufacturing or supply chains. Consequently, achieving de-risking is likely to be a prolonged process. This acknowledgment does not diminish the importance of the broader diversification objective. However, it is essential to

recognise that diversification is a complex and long-term challenge, and expectations must be aligned accordingly. In the short term, achieving full de-risking may not only be costly but also deemed impossible.

Third, **EU industrial policy and the single market**. While the single market, with its rules and the competition principle, remains the cornerstone of the EU, it is crucial to remember that the single market is not an end in itself; rather, it is a means to safeguard the interests of EU citizens and businesses. There is little doubt that trade tensions and geopolitical challenges are posing a threat to the EU's functioning and the risk of a disconnect between the single market and the pursuit of strategic autonomy is growing. Fundamentally, the root of the disconnect is the absence of a true EU industrial policy. Currently, any EU industrial policy aimed at achieving strategic autonomy may require measures that, to varying degrees, deviate from the core principles of the single market. This deviation can potentially exacerbate disparities among Member States, both in terms of their industrial capabilities and, ultimately, their economic development. Consequently, **to successfully pursue strategic autonomy, a comprehensive reassessment of the EU's industrial policy is imperative.** This reassessment should involve exploring ways to extend the EU's industrial policy instruments beyond those initially designed for the single market. This encompasses considering the utilisation of EU funds to support a comprehensive EU industrial strategy. While the idea of an EU sovereignty fund, ultimately dismissed, aligns with this direction, alternative options should also be explored. Crucially, reassessing the EU industrial policy demands a meticulous evaluation of the industrial restructuring necessary to accommodate the priorities of the green and digital transitions.

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Annex I: Correspondence between ecosystems and sectors identified in the tender specifications

Sector in the tender specifications	Corresponding industrial ecosystem	Industries included in the ecosystem (NACE Rev. 2)
Aerospace and Defence	Aerospace and Defence	C25 Manufacture of fabricated metal products, except machinery and equipment
		C26 Manufacture of computer, electronic and optical products
		C27 Manufacture of electrical equipment
		C30 Manufacture of other transport equipment
		C33 Repair and installation of machinery and equipment
		H51 Air transport
		H52 Warehousing and support activities for transportation
		J61 Telecommunications
		N80 Security and investigation activities
		Horizontal
Agri-food	Agri-food	A Agriculture, forestry and fishing
		C10 Manufacture of food products
		C11 Manufacture of beverages
		C12 Manufacture of tobacco products
		Horizontal
Digital	Digital	C26 Manufacture of computer, electronic and optical products
		J58 Publishing activities
		J61: Telecommunications
		J62: Computer programming, consultancy and related activities
		J63: Information service activities
		S95: Repair of computers and personal and household goods
		Horizontal
Electronics	Electronics	C26 Manufacture of computer, electronic and optical products
		C28: Manufacture of machinery and equipment n.e.c.
		Horizontal
Energy	Energy intensive Industries	C16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and
		plaiting materials
		C17 Manufacture of paper and paper products
		C19 Manufacture of coke and refined petroleum products
		C20 Manufacture of chemicals and chemical products
		C22 Manufacture of rubber and plastic products

		C23 Manufacture of other non-metallic mineral products
		C24 Manufacture of basic metals
		Horizontal
Energy	Energy – Renewables	C27: Manufacture of electrical equipment
		D35 Electricity, gas, steam and air conditioning supply
		Horizontal
Pharma	Health	C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
		C32 Other manufacturing
		Q86 Human health activities
		Q87 Residential care activities
		Q88 Social work activities without accommodation
		Horizontal
Automotive	Mobility - Transport Automotive	C27 Manufacture of electrical equipment
		C29 Manufacture of motor vehicles, trailers and semi-trailers
		C30 Manufacture of other transport equipment
		G45 Wholesale and retail trade and repair of motor vehicles and motorcycles
		H49 Land transport and transport via pipelines
		H50 Water transport
		H52 Warehousing and support activities for transportation
		Horizontal
Biotech	No corresponding ecosystem	M72.11 Research and experimental development on biotechnology

Note: According to the definition provided by the EC, the category 'Horizontal' refers to activities which contribute to the well-functioning of all ecosystems. The EC distributed the contribution of each of them to each ecosystem using Input-Output tables and excluded financial services. For further information, refer to the EC Staff Working Paper SWP (2021) 353 final.
Source: EC Staff Working Paper SWP (2021) 353 final for the mapping of NACE 2 activities to industrial ecosystems. The authors mapped the latter to the sectors identified in the tender specifications.

Annex II: Core dependency Indices

CDI 1 measures the import concentration for each product p at the EU level. The higher CDI 1 the higher the import concentration, meaning that only a few countries supply the EU of product p.

Formally:

Let $p = 1, \dots, P$ be the number of products HS6 bilaterally traded between EU (aggregate) and extra EU (non-aggregate).
Let $i = 1, \dots, N$ be the number of extra EU countries exporting to the EU.

$$\forall p, and\ \forall i \qquad s_{i,p} = \frac{imp_{i,p}}{\sum_{i=1}^{N} imp_p} \qquad (1)$$

$$CDI_{1,\mathrm{p}} = \sum_{i=1}^{N} (s_i^2) \qquad (2)$$

Following the European Commission approach, if CDI 1 > 0.4, the import for product p is highly concentrated (and potentially at risk of sudden disruption).

CDI 2 measures the total share of extra-EU import of each product of the total EU imports (i.e., extra- and intra- imports). It measures the EU relative dependence on extra-EU imports.

Formally:

Let $p = 1, \dots, P$ be the number of products HS6 bilaterally traded between EU (aggregate) and extra EU (non-aggregate).
Let $i = 1, \dots, N$ be the number of extra EU countries exporting to the EU.
Let $k = 1, \dots, K$ be the number of EU countries exporting to the EU.

$$\forall p, \forall i, \forall k \qquad CDI_{2,\mathrm{p}} = \frac{\sum_{i=1}^{N} imp_{i,p}}{\sum_{i=1}^{N} \sum_{k=1}^{K} imp_{k,i,p}} \qquad (3)$$

Following the European Commission approach, if CDI 2 > 0.5, the EU has demand dependence on extra-EU suppliers of product p.

CDI 3 measures whether the EU would be able to replace products imported form external partners with internal production (i.e., whoever in the EU aggregate). The goal is to assess the EU resilience in case of trade disruptions.

Formally:

Let $p = 1, \dots, P$ be the number of products HS6 bilaterally traded between EU (aggregate) and extra EU (non-aggregate).
Let $i = 1, \dots, N$ be the number of extra EU countries exporting to the EU
Let $k = 1, \dots, K$ be the number of EU countries exporting to the EU

$$\forall p, \forall i, \forall k \qquad CDI_{3,\mathrm{p}} = \frac{\sum_{i=1}^{N} imp_{i,p}}{\sum_{i=1}^{N} \sum_{k=1}^{K} EUexport_{k,i,p}} \qquad (4)$$

Following the European Commission approach, if CDI 3 > 1, the value of extra EU imports is higher than the total value of intra and extra EU exports.

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