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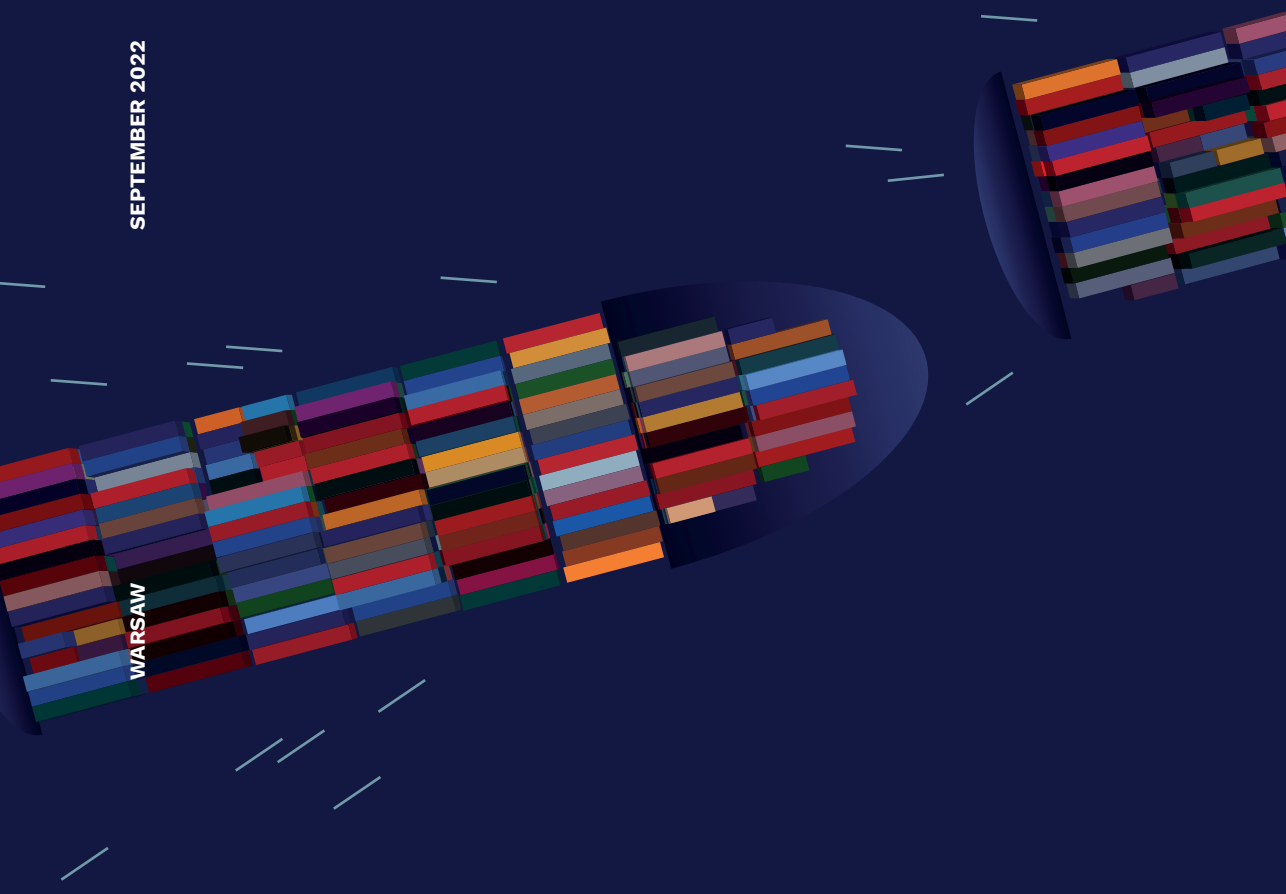

The decade of economic resilience

From offshoring to partial friendshoring

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Authors: Łukasz Ambroziak, Piotr Arak, Łukasz Baszczak, Adam Juszczak, Dominik Kopiński, Paweł Leszczyński, Magdalena Maj, Marek Wąsiński
Cooperation: Joanna Gniadek, Jan Markiewicz, Wojciech Nowakowski, Katarzyna Sierocińska, Jan Strzelecki, Agnieszka Wincewicz, Radosław Zyzik
Substantive editing: Piotr Arak, Andrzej Kubisiak
Editing: Annabelle Chapman
Graphic design: Anna Olczak
Graphic collaboration: Tomasz Gałązka, Sebastian Grzybowski
Text and graphic composition: Sławomir Jarząbek
Polish Economic Institute
Al. Jerozolimskie 87
02-001 Warsaw, Poland

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Key numbers

The EU's economic dependencies

9.4%

of EU supplies of materials for industrial processing came from non-EU countries, including 3.8% from Russia and China

7.4%

of EU imports are products with a high degree of dependence on deliveries from outside the EU-27, including 4.3% among key manufacturing ecosystems

76% of oil and 68% of gas

imports in the EU are from non-OECD countries

For 11 of the 30

critical raw materials, the EU's dependence on imports exceeds 85%

The return of industrial production

USD 142 bn

more greenfield investments in developed countries than in developing countries in 2020 and 2021, for the first time in 20 years

285%

increase in unit labour costs in China over the past two decades

7 EU countries

(the Czech Republic, Portugal, Austria, Britain, Finland, Poland and Sweden) were in the top ten of the Savills Nearshoring Index 2022, which shows the most advantageous production locations, taking into account supply chain resilience

Key findings

The 2020s will be characterised by the inclusion of security considerations in the economic calculations of enterprises and countries. Russia's invasion of Ukraine not only blocked the West's connections with Russia, Belarus (due to sanctions) and Ukraine (due to ongoing military operations), but also marked the end of the current model of globalisation. A move away from priority given to low production and storage costs, in "just-in-time" model, is taking place.

Supply chain resilience and cooperation with trusted partners amid instability and conflicts of interest is transforming the current business model into "just in case". The energy crisis that Europe will experience as a result of its dependence of energy imports from a single source could become a catalyst for these changes. The pandemic had already shaken the production network's stability; lockdowns led to delays in deliveries, product shortages, and maritime transport – which could not keep up with the economic recovery – observed prices increased as much as tenfold.

Russian aggression has added political security, which goes far beyond Eastern Europe, to investment calculations. The escalation of tensions in the Taiwan Strait as a result of US House of Representatives Speaker Nancy Pelosi's visit is the best example of this. It is the symbolic start of a period in which economic resilience will be a priority.

In this context, there are calls for friendshoring – the transfer of production to countries with similar values. Even before the US-China trade war, a tendency to shorten supply chains (nearshoring) or bring them home (reshoring, backshoring) was already visible. This was largely due to rising labour costs and the benefits of automation. Now it will be the result of companies' calculations and, in part, incentives prepared by individual governments. The first factor is illustrated by the Savills Nearshoring Index, a ranking of countries in terms of the attractiveness of locating production there. Seven European countries were in the top ten.

The focus should be on key sectors and on reducing key import dependencies, which will ensure the resilience of supplies to the EU and avoid economic blackmail. According to the PEI's calculations, the key sector in terms

of these dependencies is the energy sector, in which over 50% of the material consumed by the EU is imported. At the same time, the identification of the largest dependencies shows that 8% of EU imports are exposed to a small number of suppliers and the EU's low production potential. More than half of these dependent products relate to four key ecosystems: electronics, health, energy-intensive sectors, and renewable energy. These are the dependencies that the EU's diversification and reshoring activities should primarily focus on. It will be particularly important for the EU to secure supplies of critical raw materials crucial for new technologies, including the green economy.

The pandemic and Russia's invasion of Ukraine led to a shortage of some non-energy raw materials in the EU, pushing up prices significantly and even forcing some factories to suspend operations. Analysis of the shortages during that period should provide a list of sensitive sectors, identified on the basis of import dependency studies, even though the economic slowdown led to a decline in prices and reduced problems with the availability of these raw materials.

An important aspect will be the security of supplies of raw materials and products used in the defence industry. At the same time, increases in military spending will not only limit possible investment in other public sectors, but also limit the economic opportunities to create incentives to secure supply chains.

Partial friendshoring seems necessary, although the economic benefits of this trend may be limited. The opportunity cost of not making supply chains resilient is exposure to economic blackmail and shortages during periods of tension. While calculating unit labour costs and comparing them with productivity shows the attractiveness of EU economies, key factors will be energy prices, access to raw materials and components through supplier networks, and the costs associated with meeting environmental standards. However, friendshoring could drive up product prices, and bringing manufacturing to the EU would not necessarily offer tangible benefits – the EU primarily imports added value generated in sectors with low wages and productivity.

Increasing supply chains' resilience and taking care of "hard security" will require close cooperation within the EU and among allies. The core of these consultations could be NATO and the OECD. EU member states vary in their import dependencies. Close cooperation is needed to reduce this exposure to dependencies in each country, not just from the perspective of the EU as a whole.

Introduction

Russia's invasion of Ukraine is above all a human tragedy, which is taking place in front of the whole world. Ukrainians are dying in a war – started on a whim by another country – in which freedom is at stake. At the same time, it is impossible to avoid discussions on the other consequences of the invasion, from the economic slowdown to changes in thinking about economic processes underway. The Russian invasion shatters the post-Cold War belief in the beneficial effects of cooperation and economic development. Trade and investment cooperation not only failed to democratise Russia, which remains authoritarian, but also did not stop it from attacking a neighbouring country.

This change – preceded by the COVID-19 pandemic – has far-reaching consequences for international relations, as well as for how global value chains (GVC) are constructed. Their resilience was already a major issue following the US-China trade war and the turbulence of the pandemic. This report examines the effects of the Russian invasion in the context of the security of GVC.

The process of shortening supply chains, much talked about during the pandemic, is now not only moving production closer to markets where it will be sold, but also to countries considered like-minded or friendly – which is why the trend is known as "friendshoring". In the first part of the report, we look at what it is, how groups of these countries might be formed, and the potential consequences. In the second part, we calculate the EU's strategic import dependencies that expose it to shortages due to too few suppliers. This applies to both EU material consumption, based on value-added surveys, and individual goods imported by the EU at the six-digit level of HS commodity code aggregation. We supplement them with analysis of dependencies in the energy sector and list the most important shortages of non-energy raw materials and components that the EU has struggled with recently. In the third part, we consider the changes in the state's activities related to the greater focus on "hard security". The report closes with proposed recommendations on to the need to take security and resilience issues into greater account in global supply chains.

What is friendshoring and shortening supply chains?

On 24 February 2022, the day that Russia invaded Ukraine, FDIintelligence calculated that the war puts into question the fate of foreign investments with a total value of USD 500 billion. Between the annexation of Crimea and the start of the war, the first ten largest investors had announced 1,200 greenfield projects in Russia. USD 48.9 billion in investments located in Ukraine are at stake, too.

For five years, global value chains have been experiencing turbulence. The changes began with the trade war between the United States and China in July 2018. This dispute was the first signal that US policy towards global trade, especially with China, had undergone lasting change. In 2020, the pandemic shook supply chains twice. First, limited supply from China caused the early problems with supplying enterprises and consumers with raw materials, as well as parts and products, imported from Asia. Then pandemic-related lockdowns reduced demand for most products, apart from electronics and medical products (Ambroziak et al., 2021a). However, after the first wave of the pandemic – from Q3 2020 – there was a shopping boom, mainly for durable consumer goods, which spilled over into other economic sectors in 2021. Supply, especially in terms of transport, could not take this increase in demand, which led to shortages and, subsequently, inflation.

Russia's invasion of Ukraine not only blocked the West's connections with Russia, Belarus (due to sanctions) and Ukraine (due to ongoing military operations), but also marked the end of the current model of globalization. Before the pandemic, companies – operating according to the "just-in-time" distributed production model – did not stock raw materials, parts and components, because this increased production costs. Supply chains were managed so as to bring in as much as needed for current production. The pandemic highlighted the need to replace this with a "just-in-case" production model, in which companies were prepared for interruptions in deliveries, either by diversifying suppliers or increasing warehouse capacity. In addition, the invasion of Ukraine turned Western investments in fixed assets in Russia and Belarus into sunk capital – that is, losses. In the future, investments in China, among other places, could turn out to be equally risky. Leonard (2022) stresses also other risks of interdependencies e.g. in digital economy from the perspective of not only states and companies but consumers as well. Companies have already started including these kinds of calculations in their decisions (EY, 2022). There will be no return to business as usual.

China was the export beneficiary of the pandemic, primarily in 2020. At the time, its share in world exports increased by as much as 1.5 percentage points. This was related to the above-mentioned mass purchase of medical goods and electronics. However, as the situation stabilised in 2021, China's share fell by 0.7 pp, although still higher than in 2019. Meanwhile, the share of other Asian countries, including Taiwan, Indonesia and Vietnam, has increased over the past year. The downward trend in China's exports is likely to continue in 2022 – not only due to companies' growing concerns, but also due to lockdowns in major economic centres, such as Shanghai.

Chart 1. **Share in global exports of countries with the highest increase in share during the pandemic in 2021 (%)**

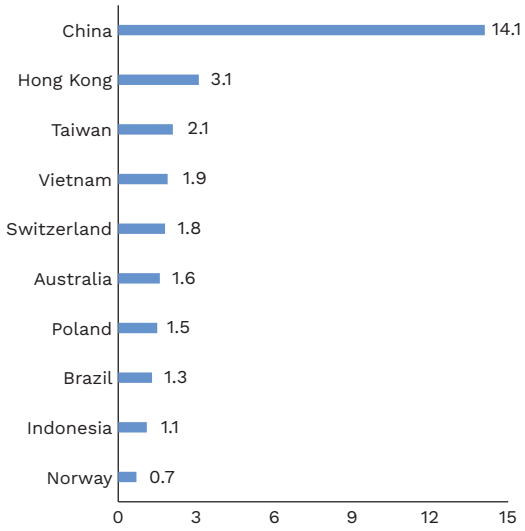
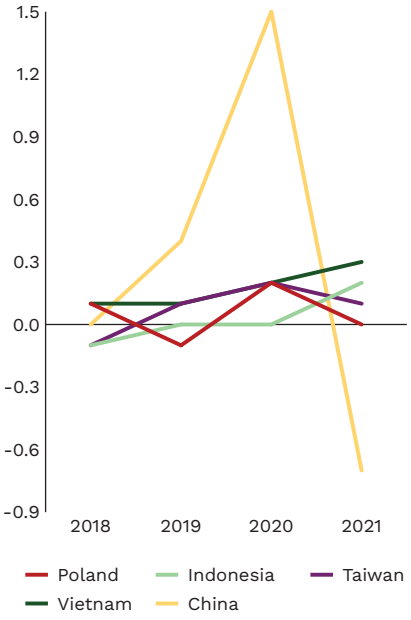


Chart 2. **Change in share of global exports (pp)**



Source: prepared by PEI based on ITC data (2022).

The value of greenfield investments (new investment projects) points to their collapse in China since 2019, the year after the US started the trade war. Their value halved, as did that of investments in Hong Kong. They fell equally sharply in 2020, but recovered in 2021. As a result, the value of investments in new projects in China in 2021 was 50% lower than in 2019; that in Hong Kong was 12% lower. Meanwhile, the value of greenfield investments in developed countries increased by 5% compared to 2019. This included Japan (increase by 150%), South Korea (by 27%), Taiwan (by 20%) and the EU (by 10%).

Significantly, the pandemic and the political situation reversed almost twenty years of higher greenfield investment in developing countries, in terms of value. In 2021, it was USD 142 billion higher in developed countries. In terms of the total value of foreign direct investment (FDI), which takes into account flows other than those into new fixed assets, China rebounded in 2021 (an increase by 28% compared to 2019), although much more slowly than some developed economies, including the US (an increase of 63%), Japan (79%) and South Korea (75%). The collapse of FDI was felt by the EU, where it fell by two-thirds in 2021, compared to 2019. However, this did not apply to Poland, where it increased by 84%. These fluctuations, especially the data on greenfield investments, point to an existing decline in confidence in locating investments in China. This trend is expected to intensify in the near future as a result of the Russian invasion of Ukraine and growing political tensions in the Taiwan Strait (Simon, 2022).

Chart 3. **Difference in the value of greenfield investments in developed and developing countries (billions of USD)**

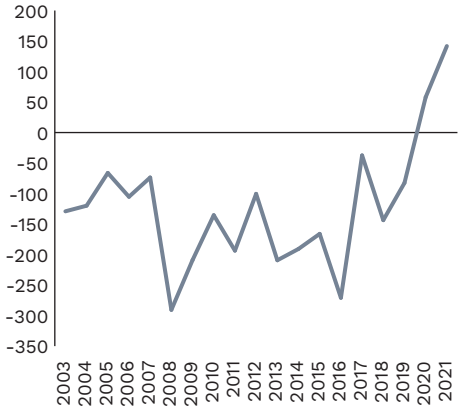
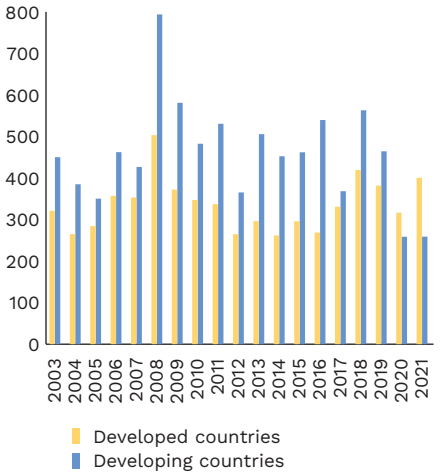


Chart 4. **Value of greenfield investments in developed and developing countries (billions of USD)**



Note: the group of developed countries, as classified by the UNCTAD, includes all of Europe, including Russia, and the US, Canada, Israel, Japan, South Korea, Australia and New Zealand, among others. China was classified as a developing country.

Source: prepared by PEI based on UNCTAD data (2022).

Friendshoring (www1) – organising supply chain based on attitudes towards Western values, primarily democracy – is becoming the new keyword. The exact definition is being created in front of us; each company will contribute to it based on the risk calculation concerning their investments' security. For example, India has not condemned the Russian invasion and is taking

advantage of the possibility of importing energy commodities from it. Previously, there was talk of shortening the supply chain (nearshoring) and relocating production home (reshoring or backshoring), which sought to locate production close to (or in) the markets where the products would be sold, such as the EU. These trends were already observed before the pandemic; they were linked to emerging economies' eroding cost advantage, underestimation of the full costs of offshoring, the need to produce close to markets and innovation, protection of intellectual property, and the need to balance cost savings and risk dispersion (De Backer et al., 2016). From developed countries' perspective, reshoring is an opportunity to attract added value and create jobs.

Russia's invasion of Ukraine is changing the paradigm at multinational corporations, making security and resilience more important than cost-effectiveness. After all, the war and energy dependence on Russia resulted in many economic entities sobering up and the need to reduce risk by diversifying suppliers (for example, through double sourcing) and establish strategic, long-term cooperation with entities and countries that guarantee security of supply. Another direction, especially in the automotive industry, is "Teslafication" (based on Tesla's business model), which involves deepening the supply chain's vertical integration, thereby invoking Henry Ford's traditional production system (www2).

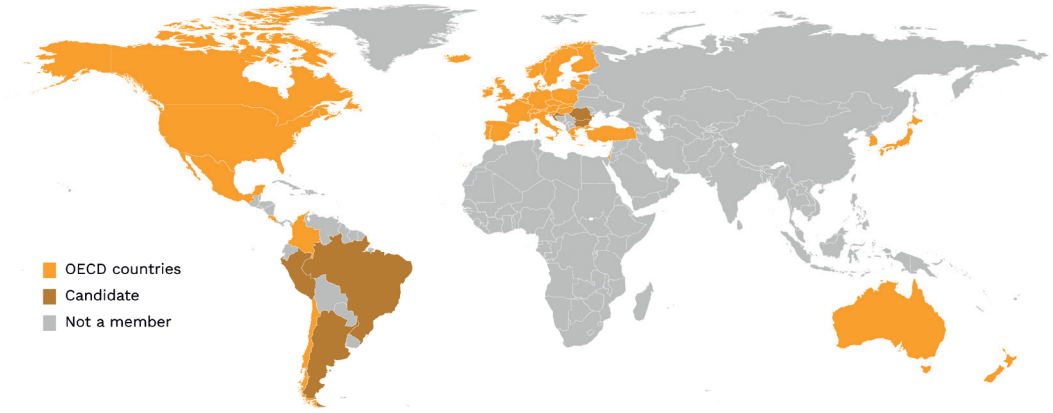
Technological progress and security issues are not separate problems any more. From the perspective of both companies and countries, it is necessary to understand the networks, dependencies, the risk of disturbances as well as aggressive actions aimed at key modern technology centres. From the perspective of some countries, interdependence may, in turn, be a guarantee of security, which will make it difficult for the US or the EU to achieve autonomy, e.g. in microchip manufacturing (Wasser, Rasser, 2022). China itself is trying to reduce dependence form sales and imports markets by implementing the "double circulation" and "Made in China 2025" strategies (Herrero, 2022).

The overriding question of the new order in global supply chains will be the criterion of deeming a given country safe for economic cooperation. Common values – such as democracy or condemning the Russian invasion – reduce the number of partners much more than calculating security risks. The most important question will be the extent to which Asia remains in supply chains. Diversification – that is, partially remaining in Asia, but without being dependent on a single country – will be cheaper than locating all production in developed countries, such as OECD members. In this respect, transatlantic cooperation is needed to develop a unified approach at the country level.

Criteria for friendshoring

The criteria based on which states and companies deem others friendly are highly ambiguous – they should be entities with similar values, representing a non-authoritarian way of governance (www3). NATO members – countries on both sides of the Atlantic cooperating on security – certainly form the core of this group. Another simple indicator of belonging to the group of friendly states could be OECD membership. OECD members and candidates have a high level of economic development, as well as common values, which they manifest during votes at international institutions, among other things. The use of friendshoring within this group seems the most obvious, but it would increase the production costs of many products significantly, as these are higher than in developing countries.

Map 1. OECD membership

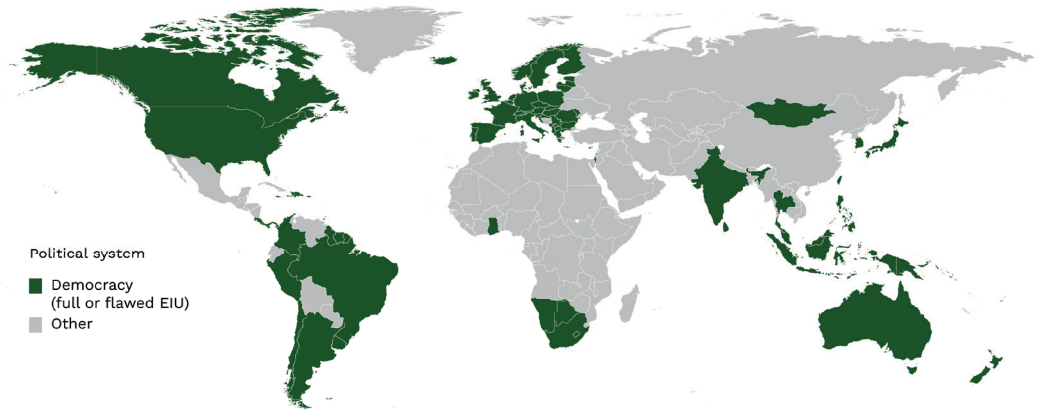


Source: prepared by PEI based on OECD data.

The political system can be an important feature of friendly countries. The Economist Intelligence Unit publishes an indicator describing the state of democracy every year. Based on it, states are assigned to one of four groups:

full democracy, flawed democracy, hybrid system, and authoritarian system. The first two categories make up the group of democratic states.[1]

Map 2. Democracies worldwide



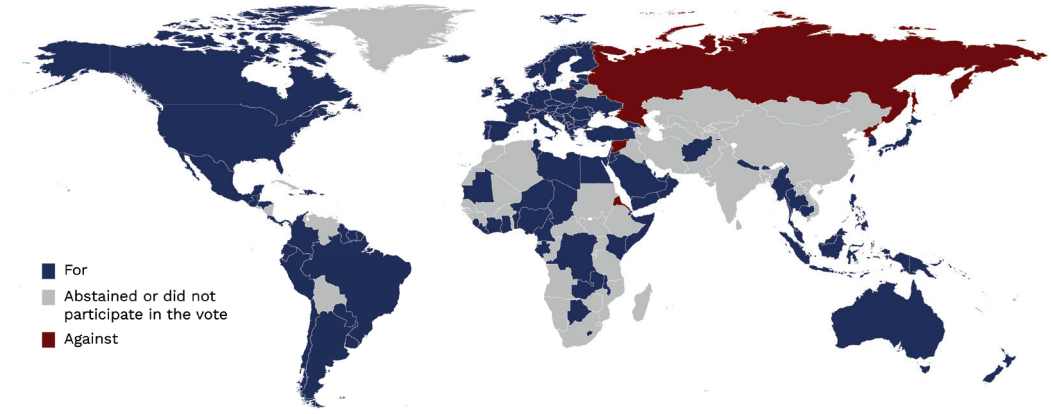
Source: prepared by PEI based on *Democracy Index 2021*, EIU (2022).

The vote in the UN General Assembly on 2 March 2022 on the resolution calling for an unconditional end to Russia's offensive in Ukraine showed significant unanimity among countries worldwide. As many as four-fifths (141 countries out of 181 countries present during the vote) supported the resolution. Only five expressed their opposition (in addition to Russia, these were: Belarus, Eritrea, North Korea and Syria). 35 countries abstained and 12 were absent.

The next vote in the UN General Assembly on 7 April – on the suspension of Russia's Human Rights Council membership – confirmed the previous positions of individual states on the invasion. Although the two votes were not equally significant, it is clear that some of the countries that abstained in March adopted a more decisive stance the second time and opposed the resolution (for example, Algeria, Bolivia, China, Iran, Kazakhstan and Vietnam). The only country that changed its attitude to one negative towards Russia was Mongolia; in the vote on 7 April, it was in favour of suspending Russia's Human Rights Council membership.

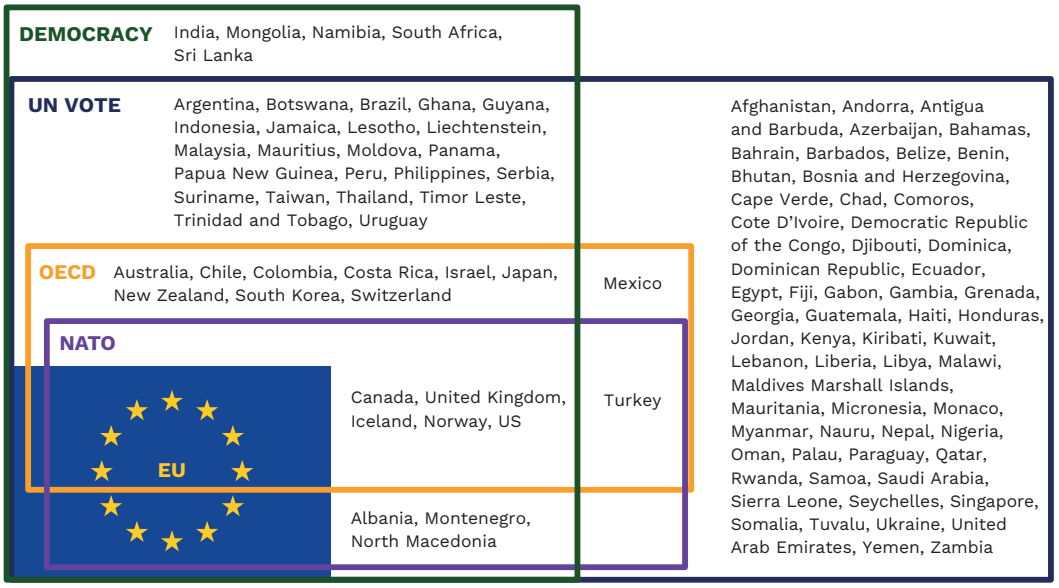
[1] The categorization is based on answers to 60 questions in five different categories, such as: election process and pluralism, civil liberties, government functioning, political participation, and political culture.

Map 3. Results of the vote in the UN on 2 March 2022 on an unconditional end to Russia's offensive in Ukraine



Source: prepared by PEI based on UN (2022).

Infographic 1. Potential groups of friendly countries



Source: prepared by PEI.

The convergence of the results of the UN vote on 2 March with system of government in a given country is noteworthy. All the countries that supported Russia are deeply authoritarian (with a score of below 2.5 on a scale of 0 to 10 in the Democracy Index 2021). The countries that abstained were mostly non-democratic, too. The exceptions were India, Mongolia (first vote only), Namibia, Sri Lanka and South Africa. Apart from these five countries, every other democracy voted for an unconditional end to Russia's offensive in Ukraine. At the same time, the group of democracies is closer to the number of OECD members than to the number of countries that voted against Russia. India, Namibia, and South Africa are prime examples of countries whose inclusion (or lack of inclusion) in the group of friends would have far-reaching repercussions for the relocation of industry, including from China.

A potential way to create a less exclusive criterion would be to create a list of countries considered hostile. These could be countries that voted against the resolution condemning the Russia offensive in the UN General Assembly: Russia, Belarus, Eritrea, North Korea and Syria. From the perspective of global supply chains and alternative sources of energy imports, it would be difficult to exclude non-democratic countries that did not vote to condemn Russia (including China, Vietnam and Kazakhstan). It is particularly important to pay attention to differences in perspectives; for example, deeming China a hostile country would be extremely difficult for countries in Asia, or for Australia and Oceania. China is an important market for sales and supplies, as well as a source of income from the influx of tourists.

Potential consequences of friendshoring

China has become the main destination for the relocation of production (Cui, Lu, 2018), but unit labor costs have increased by 285% over the past two decades, compared to 132% in India, 25% in Thailand and 12% in Cambodia (Savills, 2020). However, China still offers advantages that are not available in smaller Asian countries, in particular its huge (albeit shrinking) workforce, estimated at over 200 million skilled workers (State Council PRCh, 2021).

Friendshoring could push up production costs and prices for consumers. The motive for offshoring – relocating production, for instance to Asia – was simply to reduce manufacturing costs (mainly of labour). Attempting to reverse this process could eliminate the resulting cost advantage of transnational corporations. Advanced economies' competitiveness may be preserved by improving productivity. As firms move production to more mature economies, these countries will typically have higher production efficiencies. In theory, this means that unit labour costs (ULC), the ratio between labour costs and the value of the manufactured product, will not necessarily have to increase at all. In this way, driven only by ULC and based on ILO data, transferring production from China to Poland will reduce unit labour costs by 0.13 (but transferring it from Russia to Poland could increase it by 0.16). Decisions will therefore relate to the basic question: is it worth moving production to low-cost and lower-efficiency locations, such as Vietnam, Thailand or Morocco, or to high-cost and higher-efficiency locations, such as Taiwan, Singapore or Western Europe? And if so, when? Located between them are the Central European countries, where nominal hourly labour costs are almost twice (Poland) and three times (Czech Republic) as high as in China, but with labour productivity that is two and a half times (Poland) and three times (Czech Republic) higher. As a result, unit labour costs in these countries are lower than in China.

In addition to labour costs, differences in energy prices, infrastructure quality, the institutional environment and the openness of the economy are significant when choosing where to locate production. The Savills Nearshoring Index attempts to take these into account. According to its 2020 edition, the most convenient investment directions were Vietnam, Ukraine, Indonesia, Serbia, the Czech Republic, Taiwan, Thailand, Sri Lanka and Russia (Tostevin, Mofid, 2020). China ranked 11th and Poland 20th. However, after taking into account supply chain resilience, the 2022 edition lists seven European countries in the top ten, with China in 30th place (Tostevin, Mofid, 2022). Despite this, excluding China would be a major challenge for many companies.

A well-developed industrial base, calibrated to the needs of producers, with appropriate technological facilities, is important, too. Industry has increasingly advanced technology there, which is gradually breaking through the Western world's dominance (Allison et al., 2021) and huge production capacity (China has almost 30% of the world's industrial production potential) (www4). At the same time, the network of global supply chains and the dispersion of production stages is so large that changing them completely and excluding Chinese partners may be almost impossible; it will certainly be a long-term undertaking (Ting-Fang, Li, 2022).

Chart 5. Labour costs and productivity in selected countries in 2021

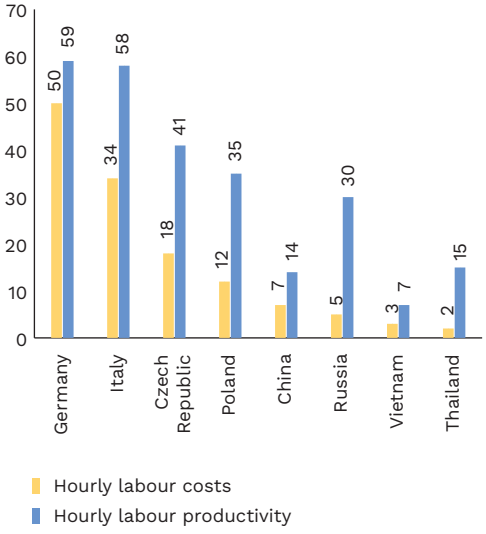
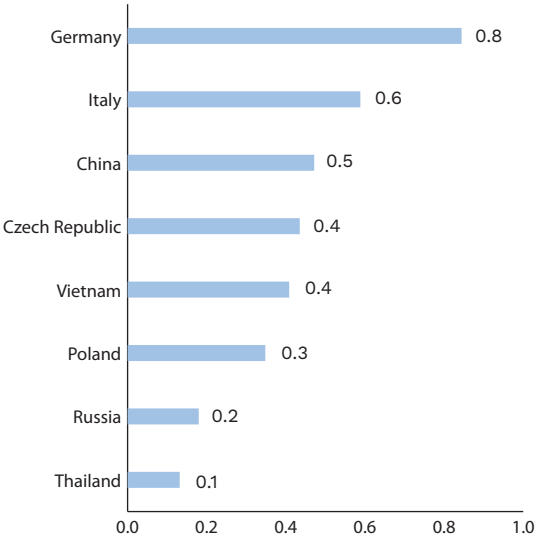


Chart 6. UCL in selected countries in 2021



Note: Russia – 2019, Thailand – 2017, Vietnam – 2020.
Source: prepared by PEI based on ILO data.

The importance of unit labour costs could decrease due to the progressing automation and robotisation of production. While automation could limit the increase in prices caused by the moving production from Asia, it increases the importance of other factors mentioned earlier. The competitiveness of manufacturing will be determined by energy prices, the institutional and regulatory environment, or easy access to suppliers of raw materials and components. The divergence of production costs in developed countries, where the degree of automation is much greater, and in less developed countries, where production processes are more labour intensive, could therefore cease to play a fundamental role in decisions to relocate production. In this

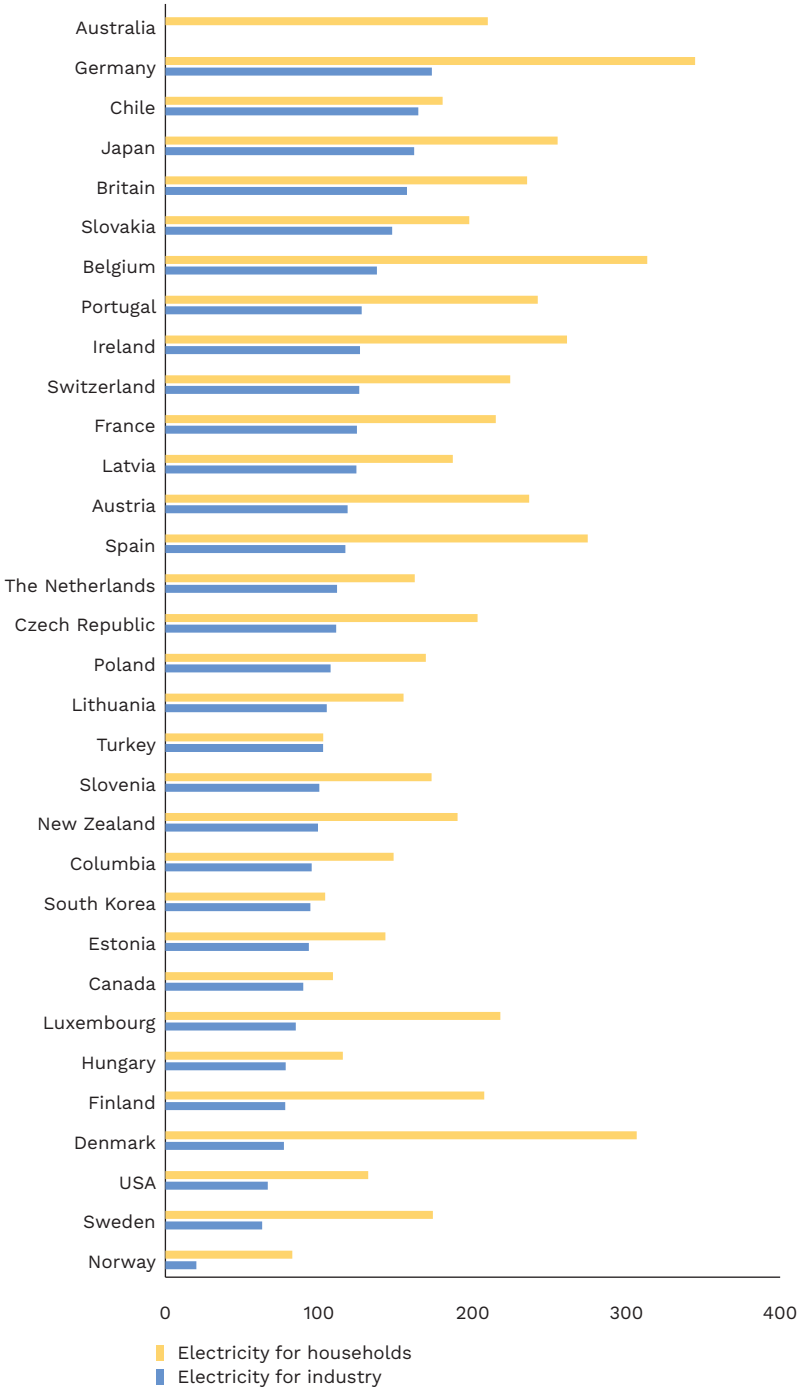
context, Central European countries' competitiveness is growing: automation is accelerating, but labour costs are still relatively low and a highly-qualified workforce readily available. Research indicates that an increase in the number of robots of one per thousand employees increases reshoring intensity in Eastern Europe by 6% (Krenz, Strulik, 2021). Automation also increases companies' resilience to turmoil in the labour market and temporary staff shortages. It will enable a limited number of additional jobs requiring advanced qualifications to be created (De Backer et al., 2016).

Table 1. **Savills Nearshoring Index, 2022**

State	Position in Nearshoring Index	Position in Offshoring index
Czech Republic	1	6
Portugal	2	7
Austria	3	36
Taiwan	4	2
Britain	5	37
Japan	6	38
Canada	7	41
Finland	8	43
Poland	9	12
Sweden	10	50
Germany	18	51
South Korea	19	32
US	22	49
China	30	4

Source: prepared by PEI based on Savills Research.

Chart 7. **Cost of 1 MWh in Q1 2021 (USD)**



Source: prepared by PEI based on IEA data (2021).

Adopting friendshoring will require state intervention in the form of subsidies and policies that encourage companies to shift production. Many production processes will be relocated to more expensive locations, which is sure to result in high costs. For example, the Bank of America estimates that the cost of foreign companies' withdrawal from China, excluding ones serving the local market, could amount to USD 1 trillion over five years (BofA, 2020). Moreover, it will often be a complex and multi-step process, going beyond the transfer of a single production link or factory from one country to another. As a result of the pandemic and the war in Ukraine, companies have undoubtedly realised the importance of security, but for production to be transferred – for example, to an OECD country with higher production costs – corporations will need state assistance. At the same time, the incentive system will distort the efficiency benefits of free trade and may also lead to too many production initiatives, which could increase prices and shortages.

The benefits of friendshoring will largely depend on the product category. In its initial sense, friendshoring only implies decoupling in selected sectors significant when it comes to economic security, such as aviation, drugs or semiconductors; it does not apply to every category of goods. Priority should be given to sectors where the EU and, more broadly, OECD countries have high import dependencies. The question of how far-reaching the relocation of production will be remains open. Some sectors do not require comprehensive reshoring as they are already regionally organised. One example is the automotive Industry, which has been hit hard by the semiconductor shortage and suffered from disruptions in production. At the same time, research indicates that EU imported value added is associated with low-wage and low-productivity jobs (for example, in the textile sector), the import of which would provide lower benefits than high-paid jobs (Bontadini et al., 2022).

According to Bank of America, 303 publicly-traded companies around the world with a combined capitalisation of USD 19 trillion generate at least 5% of their revenues from the Chinese market. The companies with the highest exposure include many German companies from the automotive industry, which is particularly visible in their dependence on local suppliers. Many American companies depend on the Chinese market, too. Sixteen S&P 500 companies generate at least 25% of their revenue from the Chinese market (the average is 5%). Japanese companies' exposure is also significant: 17% of foreign revenue comes from China.

The potential costs of friendshoring include the lost benefits from serving local markets or difficulties reaching them. Offshoring is driven primarily by cost benefits resulting from the difference in production costs between countries. However, this is obviously not the only investment motive. In the case of China, many companies also wanted to ensure access to the gigantic market of the world's second-largest economy or, for example, to avoid trade barriers. Already, the size of the middle class in China is estimated at over 700 million people, slightly less than the combined population of the US and the EU (CSIS, 2021). When planning mass reshoring from this type of location, one should take

into account the lost benefits in the form of revenues from sales to local markets, access to which might be blocked in retaliation.

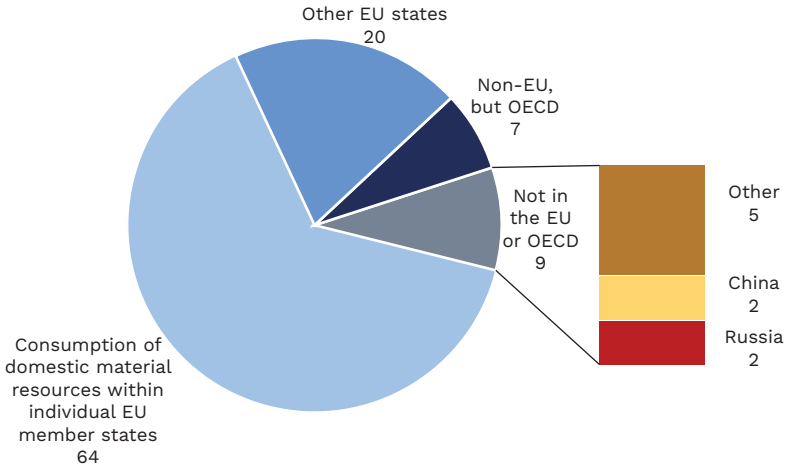
Friendshoring is also associated with two systemic threats in international relations – the even greater assertiveness of hostile powers towards their neighbours and the authoritarian drift of poor states. It can be assumed that one of the many reasons why China has not yet dared to invade Taiwan are the economic consequences – costly sanctions and effectively being cut off from the global economy, financial system, and so on. Implementing the idea of friendshoring on a large scale could become self-fulfilling prophesy. Increasingly separated from the world in economic terms, China would have even fewer reasons to behave peacefully towards Taiwan in the future. Friendshoring could also exclude some underdeveloped countries which, without investment and trade, might drift away from democratic standards. Failure to include them in the group of friends could block development impulses. At worst, these kinds of states will become failed states; at best, they will experience greater poverty and mass migration.

Dependencies on imports and EU sales markets

Due to the potential negative consequences and costs of full friendshoring, it is crucial to investigate the import dependencies that will determine the key areas of intervention. Due to the scale of international ties, we use several research methods. Firstly, based on input-output tables, we show the most important import dependencies in terms of value and sector. Secondly, we also analyse the other side of the dependence, which is significant due to the risk of losing benefits from production in a given distant market – that is, dependence on final demand in non-EU countries. Thirdly, we use the European Commission's method to study import dependencies based on Eurostat data from 2021. Next, we verify the EU's dependence on energy resources, which is often hidden in import statistics. Finally, we look at a few non-energy raw materials, for which shortages occurred at the end of 2021 and the first half of 2022. This provides a comprehensive view of the sectors, raw materials and goods that should be the focus of efforts to increase supply chains' resilience, including by friendshoring.

An examination of the added value flows shows the EU's relatively low dependence on the supply of materials for industrial processing. 83.4% of the materials used in industrial processing in 2018 came from domestic resources or from other EU-27 countries. Of the remaining 16.6%, 9.4% came from non-OECD countries, including 2% from China and 1.8% from Russia. The largest external dependencies, of over 20%, were observed in Greece, Lithuania and Bulgaria (whose use of materials in the EU is not very significant), as well as Ireland and the Netherlands. Ireland has the second-lowest consumption of materials from Russia and China in the EU (1.8%), while that of the Netherlands is above the EU level: 5.4%. For comparison, material consumption in the US was based on domestic resources to a similar extent (81,6%), with just 0.3% coming from Russia and 2.5% from China. The US relied on supplies from non-OECD countries to a slightly lesser extent.

Chart 8. Material consumption in industrial production in the EU in 2018, by origin of value added (%)

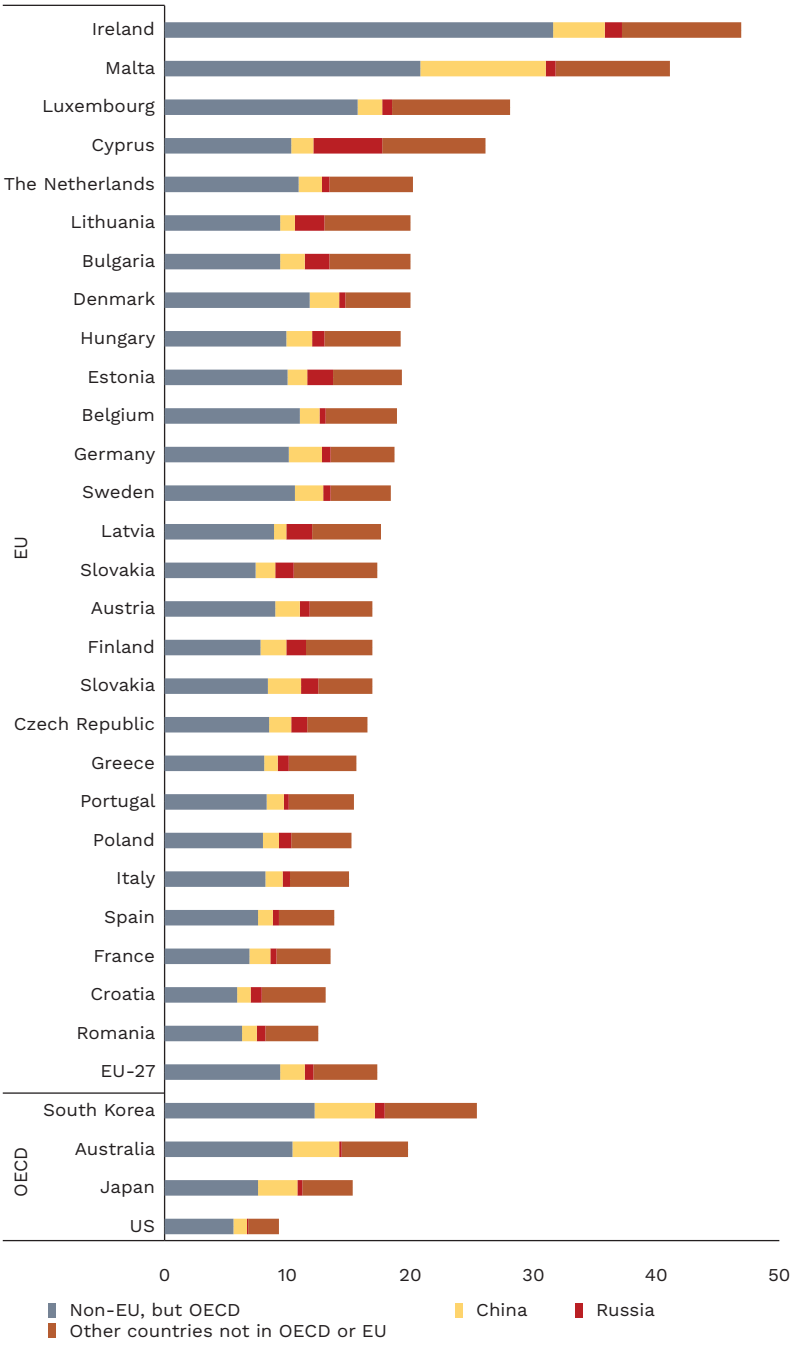


Source: prepared by PEI based on TiVA data.

In terms of sector, the greatest dependencies are visible in the processing of energy resources in the EU (coke and refined petroleum products); 50% of these products are imported from outside the OECD, including 15% from Russia. Russia plays an important role in the supply of materials for the production of metals (4%) and chemicals (2%), while the EU is most dependent on China in the production of computers (8%) and electronic devices (5%). These sectors also dominate when it comes to the EU's dependence on the consumption of materials from outside the OECD.

The EU is twice as dependent as the US on demand in non-OECD countries. In the US in 2018, 9 out of USD 10 of generated added value remained domestically; in the EU, this was only 82.7% of added value generated. In the case of the EU, 8% of it went to non-OECD countries, including 2% to China, and 0.7% to Russia. It is particularly worth emphasising that classifying China as a non-friendly country would be a completely different step from the perspective of these dependencies of the U.S. or the EU than, for example, of Taiwan, Japan, South Korea, New Zealand or Australia for whom China constitutes a much more salient partner.

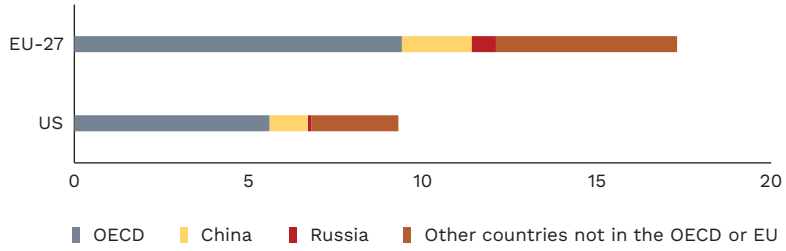
Chart 9. **Added value of selected countries generated by final demand in other countries, distinguishing between OECD members and non-members**



Note: for non-EU countries (the US, Australia, Japan and Korea South), the "Non-EU, but OECD" category includes EU member states.

Source: prepared by PEI based on TiVA data.

Chart 10. EU and US added value generated by the final demand in OECD and non-OECD countries



Note: "OECD" does not take into account final demand generated within the country, in the EU-27 and the US respectively.

Source: prepared by PEI based on TiVA.

Identifying sensitive products in the EU's external imports

Studying import dependencies makes it possible to identify the sectors and products where special attention should be paid to diversifying supply sources. In 2021, the European Commission identified 390 products in EU external imports highly dependent on supplies from outside the EU in 2019 (EC, 2021). These products include 137 critical products; that is, ones in four of the most vulnerable production ecosystems: renewable energy, energy-intensive industries, health, and digital and electronic products.[2] For the purposes of this report being prepared, using the method proposed by the Commission, we drew up a list of these products using data from 2021.

Using the three CDI indicators together, 345 products in EU imports (according to the six-digit HS classification) with a high degree of dependence on supplies from outside the EU were identified. In 2021, they accounted for 7.4% of EU imports from outside the EU (including the UK). Non-OECD countries accounted for 77% of imports of these products; these included China (26%) and Russia (4%). The largest categories were: energy resources, including natural gas (with a classified code), photosensitive semiconductor devices (including photovoltaic panels), and turbojet and turboprop engine parts. To a large extent, the selection of indicators points to dependence among very specific agri-food and textile products (such as fish, spices and materials; for example, cashmere). For this reason, in the next step, the

[2] Sometimes, one more vulnerable ecosystem is identified: security and defence. However, due to lack of knowledge about the exact assignment of production activities to individual ecosystems, we could not isolate this ecosystem.

group of goods identified earlier was limited to the four most sensitive production ecosystems.[3]

The method used by the European Commission to assess dependencies on deliveries from outside the EU

To identify critical products in imports from outside the EU, the European Commission used a bottom-up approach (EC, 2021). From over 5000 products (according to the six-digit HS classification) in the imports of the EU-27 (without Britain), 390 products in all the production ecosystems with a high degree of dependence on deliveries from outside the EU were identified. This was done based on three core dependence indictors (CDIs):

CDI1 > 0.4 – the Herfindahl-Hirschman index, which determines the concentration of imports of a given product (the higher its value, the greater the share of supplies from a small number of countries);

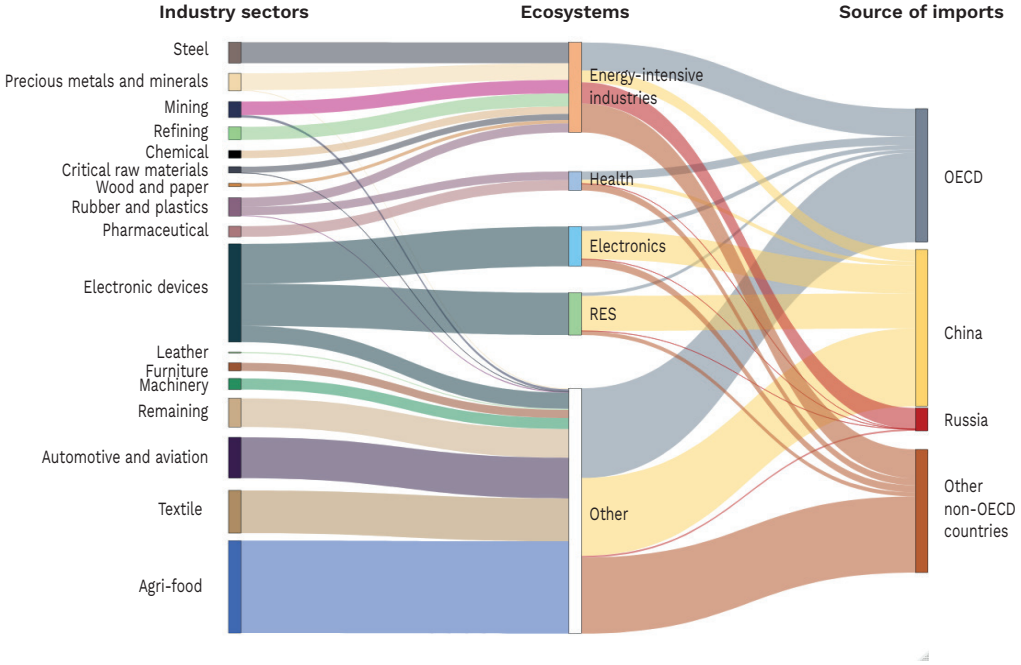
CDI2 > 0.5 – external EU imports as a share of total EU imports (internal and external);

CDI3 > 1 – index of the possibility of replacing imports of a given product from outside the EU with one produced in the EU (calculated as the EU's external imports as a share of the EU's total exports of a given product).

This list includes 106 of the most critical products in EU imports from outside the EU, which accounted for 4.3% of these import in 2021. The largest number of products – as many as 80 – were in the energy-intensive industries ecosystem. A number of chemical products, metal ores and products from them were identified, as well as energy commodities – anthracite and energy raw materials with a secret code (including natural gas). 14 products were linked to the health ecosystem, including active pharmaceutical substances (nitrogen heterocycles, barbituric acid and its salts, vitamin E, insulin, norephedrine, streptomycin, tetracyclines, chloramphenicol), as well as surgical gloves. 11 products were linked to digitisation and electronics (including TV sets and monitors, and radio and television equipment parts). Only one was linked to renewable energy sources: photosensitive semiconductor devices, including photovoltaic cells and finished photovoltaic panels, in which 83% of imports from outside the EU were dependent on China.

[3] We have written more about the problems of identifying ecosystems in Ambroziak et al. (2021, p. 29).

Infographic 2. Relationship between manufacturing sectors, ecosystems and import sources for the most dependent products in EU imports

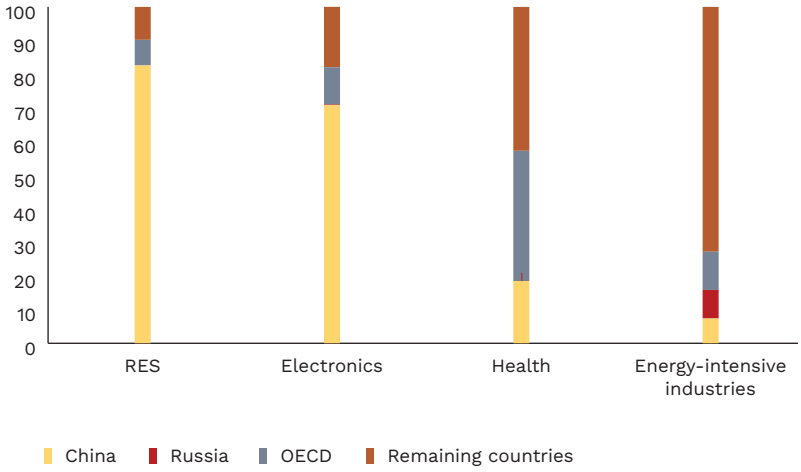


Source: prepared by PEI based on Eurostat data.

As much as 87% of imports of critical products come from non-OECD countries, which accounts for almost 3.7% of EU imports. China is responsible for one-quarter of the supply of critical products, and Russia for 6%. Apart from the health ecosystem, where the value of non-OECD products amounted to 61% of imports, this share oscillates around 90% in the others. The lowest dependence on China – and the highest on Russia (8%) – was recorded in the energy-intensive products ecosystem (7%). 100% of the value of supplies to the EU-27 of nickel stones came from Russia; this was 90% for anthracite and other gaseous liquefied hydrocarbons, 83% for isoprene rubber and 62% for vanadium oxides. Russia was an important supplier of metal raw materials and semi-finished products, including iron ores and products made of iron and steel.

Although the dependency on non-OECD countries was the lowest in the health ecosystem, with a relatively low dependency on China (19%), the country dominated the supply of certain substances in the pharmaceutical industry: it accounted for as much as 81% of nitrogen heterocyclic compounds and 43% of vitamin E supplies.

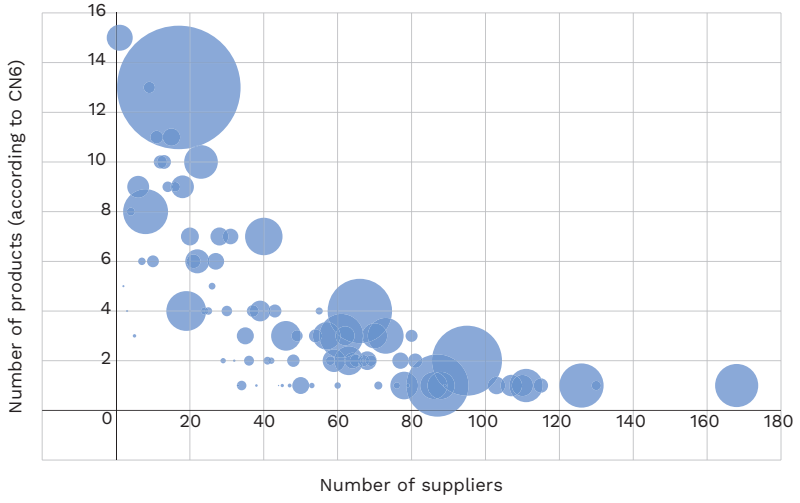
Chart 11. **Share of the value of imports of products with a high import dependency in four critical ecosystems in 2021 (%)**



Source: prepared by PEI based on Eurostat data.

Chart 12. **Number of products (vertical axis) and their total value (circle area) with a certain number of non-EU suppliers (horizontal axis) in EU imports of 345 identified products**

Although there are not many products with few suppliers and the share of these products in EU imports is limited, for some salient products this ratio might be of concern



Note: the circles' area is proportional to the share of products with a given number of suppliers in imports from outside the EU.

Source: prepared by PEI based on Eurostat data.

Poland's dependence on supplies from outside the EU

Using the European Commission's method, 884 products in Polish imports (according to the six-digit HS classification) with a high degree of dependence on supplies from outside the EU were identified. In 2021, they accounted for 29.5% of the value of all imports from outside the EU.[4] Limiting the list to the four most sensitive production ecosystems reduces it to 326 items, which account for 18.4% of external imports. 53 products were in the digital and electronic ecosystem, 31 in the health ecosystem, and only 7 in the renewable energy ecosystem.

Table 2. Statistics on products with a high degree of Poland's dependence on imports from outside the EU in 2021

Name of ecosystem	Number of products	Share in imports from outside the EU	Product examples
RES	7	1.3	Wind generators, parts for cells and primary batteries, nickel-cadmium accumulators, electric accumulators and their parts, photosensitive semiconductor elements.
Energy-intensive industries	240	10.9	Ores and concentrates of copper, iron, chromium, titanium, anthracite, natural gas, silicon, phosphorus, lithium oxide and hydroxide, barium carbonate, various chemicals, superphosphates, various types of wood, many products made of steel and other metals.
Health	26	0.2	Vitamin B1, B6 and C, rutin, pseudoephedrine, streptomycin, tetracyclines and ready-made drugs.
Digitisation and electronics	53	6	Computers and laptops, mobile phones, TV sets, parts for electronic devices.
Remaining ecosystems	553	11.1	-
Overall	884	29.5	-

Source: prepared by PEI based on: EC (2021) and GUS data.

The list of critical products included 103 items (according to the six-digit CN code) for which China was responsible for more than half of the imports of a given product to Poland. The value of deliveries of some products exceeded EUR 0.5 billion. These included telephones, computers and laptops, computer parts, and photosensitive semiconductor elements. In 2021, Russia accounted for over 50% of the value of 22 products delivered to Poland. The most important ones included crude oil, natural gas (classified as a secret transaction), other liquefied hydrocarbons, coal and methanol. It was also the only supplier of products such as lithium oxide, isoprene rubber and halo-isobutene-isoprene rubber.

[4] However, if the indicator proposed by the EC were to be modified and the sum of squares of the share of imports of a given product from individual countries in total Polish imports (not only imports from outside the EU) used to calculate the degree of concentration of imports of a given product, we would get a list of 485 products with a high dependence on supplies from outside the EU.

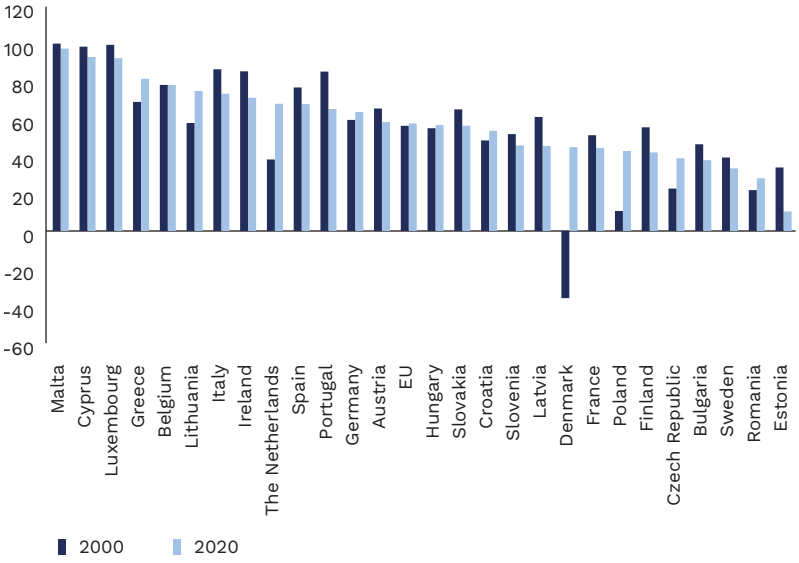
Statistical data also points to EU countries' strong dependency on external imports of products classified in chapter 27 of the Combined Nomenclature – energy resources (including natural gas and crude oil). This item had a value of EUR 39 billion in 2021, which accounted for nearly 2% of imports from outside the EU. However, due to the statistics' confidentiality, it is not possible to obtain detailed data on the product being imported or its origin.

The second edition of the European Commission's report on interdependencies (EC, 2022) assessed the measures taken to become independent from the supply of products from outside the EU identified as sensitive at the time. New areas of interdependence relating to rare earth materials, magnesium and photovoltaic panels were also identified. For the first time, services were also deemed sensitive. In 2020, the European cloud market tripled in value compared to 2017 (it was estimated at EUR 5.9 billion) (www5). However, the share of European cloud service providers decreased from 26% in 2017 to 16% in 2020. Companies outside the EU have a very strong position in the cloud services market. The largest European companies have just 2% of the entire European market. Analytics & Business Intelligence (BI) platforms are another area where there is a risk of EU dependencies. The European big data and business analytics market is estimated to have reached USD 50 billion in 2021, an increase of 7% compared to 2020 (www6), but the most technologically-advanced companies are in North America (41% of all companies) (www7).

Dependencies in the energy sector

In the 20 years since 2000, the average EU-27 country's energy dependence has increased from 56.3% to 57.5%, which means that EU members have become slightly more dependent on energy imports over these two decades.[5] This is largely influenced by the EU's energy dependence on Russia.

Chart 13. EU energy dependency indicator in 2020 and 2000 (%)



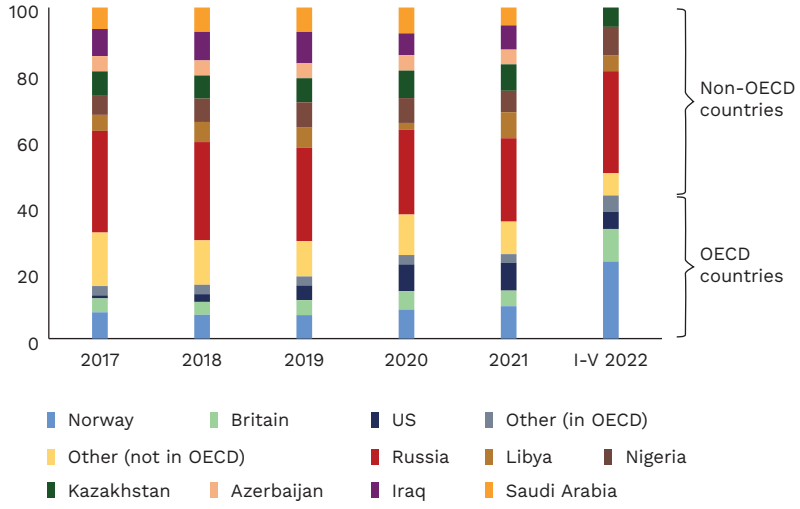
Source: prepared by PEI based on Eurostat data.

[5] The energy dependency index shows how much energy an economy has to import. It is defined as net energy imports divided by the gross available energy and presented as a percentage. A negative dependency rate indicates a net exporter of energy, while a dependency rate above 100% indicates that energy products have been stored.

Energy commodities

The main imported energy products are oil and its products, which account for almost two-thirds of EU energy imports, followed by natural gas and solid fossil fuels, mainly hard coal. Crude oil imports cover almost all of EU demand. Net imports account for 96.2% of gross available energy (as classified by Eurostat). Production in the EU is dominated by Denmark, Croatia and the Netherlands. Crude oil imports to the EU during the past three years were less dependent on supplies from the east. Apart from Russia, which supplies around 25% of crude oil, the EU imports it from Norway, Kazakhstan, the US, Saudi Arabia, Nigeria, Iraq and other countries. **In total, 74% of imported oil came from non-OECD countries in 2021.** In Poland, the share of Russian oil in total consumption and imports has decreased by around 30pp over the last decade and is currently slightly above 60%.

Chart 14. EU oil imports in 2017-2021 (%)



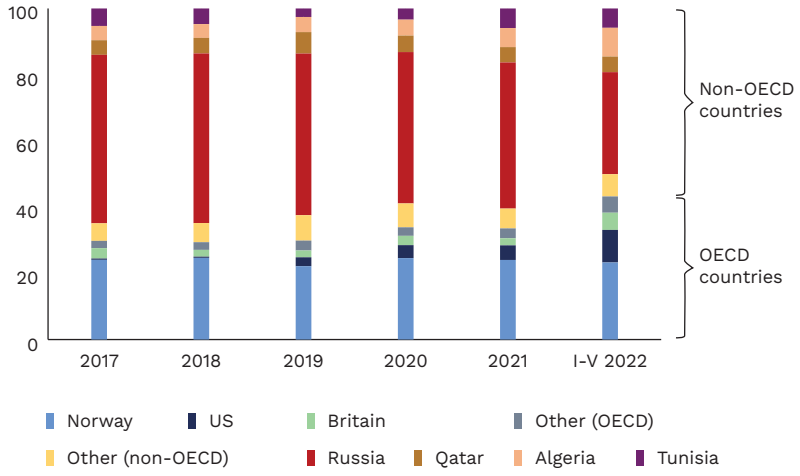
Source: prepared by PEI based on Eurostat data.

Countries in Central and Eastern Europe are more dependent on Russian oil than Western countries. France, Austria and Spain imported less than 10% of this raw material from Russia. In nominal terms, the largest amounts of oil were imported by Germany, the Netherlands and Belgium. Here, the share of Russian gas imports was around 20-30%. In Slovakia, Finland, Bulgaria, Hungary and Poland, it was over 60%.

The EU is 83.5% dependent on gas imports (calculated as the ratio of net imports to domestic consumption). In 2021, after the pandemic, domestic

gas consumption increased by 4.3% year on year and imports from Russia amounted to 155 billion m³, around 45% of all imports and 40% of demand. It was similar two years earlier, when net gas imports from outside the EU amounted to around 360 billion m³, which satisfied 90% of EU consumption (406 billion m³). Apart from Russia, the EU is dominated by gas imports from Norway, Algeria, Tunisia, Britain, Canada and Nigeria. **In total, EU gas imports from non-OECD countries amounted to 66% in 2021.** Between January and May 2022, following Russia's invasion of Ukraine, they dropped to 57%. As in the case of crude oil, countries in Central and Eastern Europe are more dependent on gas supplies from Russia. In nominal terms, the largest importers are Germany, Italy, Hungary and the Netherlands.

Chart 15. Directions of EU gas imports in 2017-2022 (%)

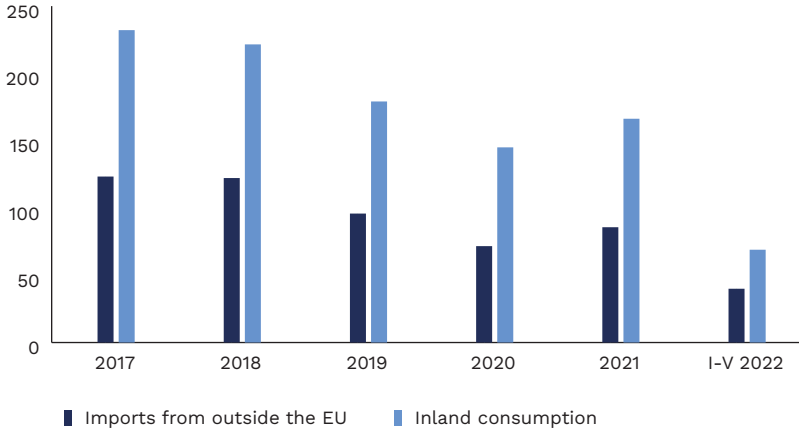


Source: prepared by PEI based on Eurostat data.

Russian hard coal accounts for approx. 45% of raw material imports and around 30% of consumption. In recent years, EU coal imports from Russia has been increasing; they amounted to 56 million tonnes in 2019, and 44 million tonnes in 2020. The other major hard coal exporters to the EU are Australia, the US, Poland, Colombia and Kazakhstan. In nominal terms, most coal from Russia is imported by Germany and Poland. Russian coal was relatively cheap, so imports of it have increased in several countries. The low supply on global markets limits the alternatives to Russian supplies.

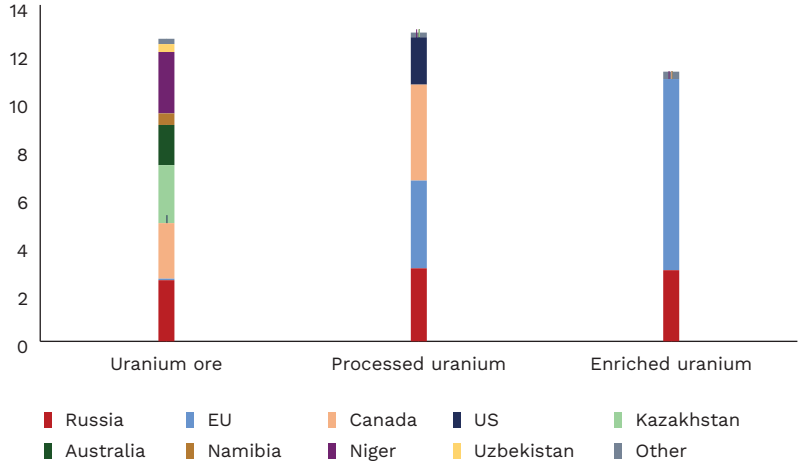
In addition to hard coal, the EU imports anthracite (around 4% of solid fossil fuel imports) and coking coal (32.5% of solid fuel imports) for industry. The largest suppliers of coal to the EU are Australia and the US (around 30 per cent each), followed by Russia and Poland (around 10 per cent each).

Chart 16. **Imports from outside the EU and consumption of hard coal in the EU in 2017-2022 (millions of tonnes)**



Source: prepared by PEI based on Eurostat data.

Chart 17. **EU dependence on supplies and services for the processing and enrichment of uranium at individual production stages in 2020 (thousands of tonnes)**



Source: prepared by PEI based on Euratom Supply Agency data.

EU countries are almost fully dependent on imports of uranium. Deliveries from outside the EU reached around 12,600 tonnes in 2020, which accounted for over 97% of demand (www8). The main suppliers of uranium ore were:

Niger (20.3%), Russia (20.2%), Kazakhstan (19.2%), Canada (18.4%) and Australia (13.3%). In total, nearly 68% of imported uranium came from non-OECD countries. EU countries processed 28% of the imported uranium. The EU also used processing services in Canada (31%), Russia (24%) and the US (15%). 71% of uranium enrichment was carried out in the EU and 26% in Russia. The main importers of Russian enriched uranium (over 94% of the total value of Russian uranium exports to the EU) were Sweden (66.6%), the Netherlands (13.2%), Germany (12.6%) and France (5.2%).

Uranium supplies are more diversified than those of gas. The value of enriched Russian uranium imported by the EU in 2019 was estimated at USD 672 million (0.17% of Russian exports), over 22 times less than the value of imported Russian gas (3.7% of the value of Russian exports) and 91 times less than the value of imported Russian oil (15.2%).[6] The production capacity of European uranium processing and enrichment plants is approximately twice as high as the current total demand for these raw materials on the European market (www8), which makes it much easier to stop using Russian supplies and services in this area.

RES and critical raw materials

Although the EU is the world's second-largest exporter of renewable energy equipment, it is also heavily dependent on imports, particularly for raw materials and components used in their production. China increased its lead over the EU from 25% in 2018 to twice the value of RES exports in 2021, amounting to USD 44 billion. China's share in global exports was around 25% in 2021.[7] One example of the high dependency on supplies from outside the EU is photovoltaics.

Most (63%) of EU solar panel imports in 2019 came from China, followed by Malaysia and South Korea, which accounted for 9% and 6%, respectively. In 2021, of the 10 largest photovoltaic producers, seven were in China and one each in South Korea, Canada and the US (EC, 2022). China is the world's main exporter of photovoltaics and the EU is one of the largest importers. At the same time, with the advancement of technology and the offshoring of panel production, their price has dropped by around 83% over the course of a decade. The potential for diversifying trade with, for example, Malaysia, Vietnam and Korea, is limited in the short term, as these countries' current production potential is much lower. At the same time, the sector depends on value chains currently built around Chinese producers – in terms of raw materials and the capacity to produce silicon wafers, ingots and modules. The EU is looking for an opportunity to increase its independence when

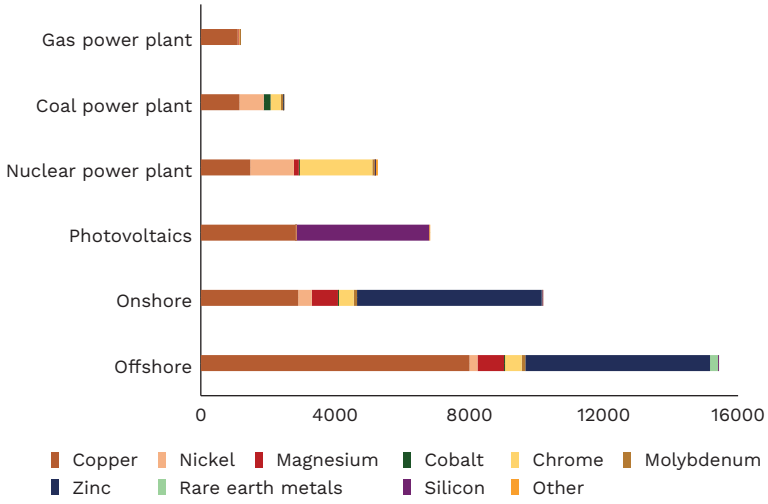
[6] Calculated by PEI based on: OEC (2022).
[7] Calculated by PEI based on WITS-Comtrade data.

it comes to recycling. An estimated 90% of solar panels can be recycled. By 2050, 60-78 million tonnes of photovoltaic waste will be in circulation (IEA-PVPS, 2017).

The EU's dependency in photovoltaic is also a concern in the context of space, security and defence applications. Satellite on-board systems require continuous power throughout the satellite's lifetime, which is usually provided by solar cells. Ultra-high efficiency solar cells for space applications are manufactured by several leading companies around the world (outside the EU). There are also opportunities in the EU, but they would have to be adapted to the needs and requirements of the EU's space programmes, in terms of the level of technological maturity and production conditions.

The energy transition is a process heavily dependent on critical raw materials. To build a 1 MW offshore wind farm, more than 15 tonnes of them are needed – nearly 9 times more than for a gas-fired power plant and over 6 times more than for a coal-fired power plant. In the case of wind farms and photovoltaics, the most consumed materials are copper (8 t/MW for offshore and around 2.9 t/MW for photovoltaics and onshore), zinc (5.5 t/MW for offshore and onshore) and silicon (nearly 4 t/MW for photovoltaics). Nuclear energy is also characterised by higher demand for critical raw materials (over 5 t/MW, including 2.2 tonnes of chromium) than conventional power plants (www9).

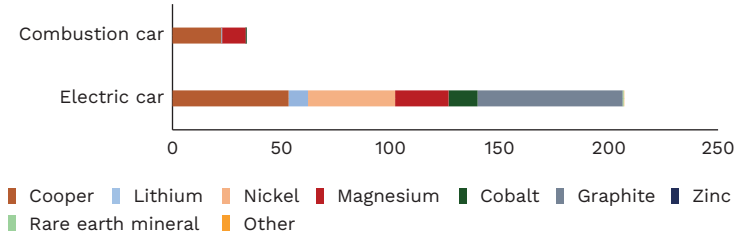
Chart 18. Use of various raw materials to produce 1 MW of installed capacity (kg)



Source: prepared by PEI based on IEA data.

The transition in the transport sector is also dependent on critical raw materials to a significant extent. Producing the average electric car requires over 200 kg of them; over six times more than the average combustion car. The most-consumed items in the production of electric vehicles are graphite (66 kg), copper (53 kg), nickel (40 kg) and magnesium (25 kg) (www9).

Chart 19. Use of various raw materials when producing the average car (kg)



Source: prepared by PEI based on IEA data.

Among the raw materials that are important for the EU economy, in 2020, the European Commission identified 30 which it considered critical. Four of them were not on the list drawn up in 2017: bauxite, lithium, titanium, strontium.[8] Helium was removed from the list due to its declining economic importance.[9]

19 out of 30 raw materials classified as critical by the Commission are used in the renewable energy sector. For 11 of them, the EU's dependence on imports from outside the community is above 85% (for seven of them, it is 100%). The supplies of many raw materials are very concentrated, too: 93% of magnesium and 99% of rare earth metals are imported from China, 68% of cobalt from Congo, 78% of lithium from Chile and 98% of borate from Turkey. China is also an important EU supplier of natural graphite (47%), gallium (27%), germanium (17%) and metallic silicon.

[8] The full list: antimony, barite, beryllium, bismuth, borate, cobalt, coking coal, fluorite, hafnium, heavy rare earth metals, rare earth light metals, indium, magnesium, natural graphite, natural rubber, niobium, phosphorus, scandium, metallic silicon, tantalum, tungsten, vanadium, bauxite, lithium, gallium, germanium, platinum group metals, phosphate rock, titanium, strontium.

[9] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.

Table 3. **Overview of the critical raw materials used in the renewable energy sector**

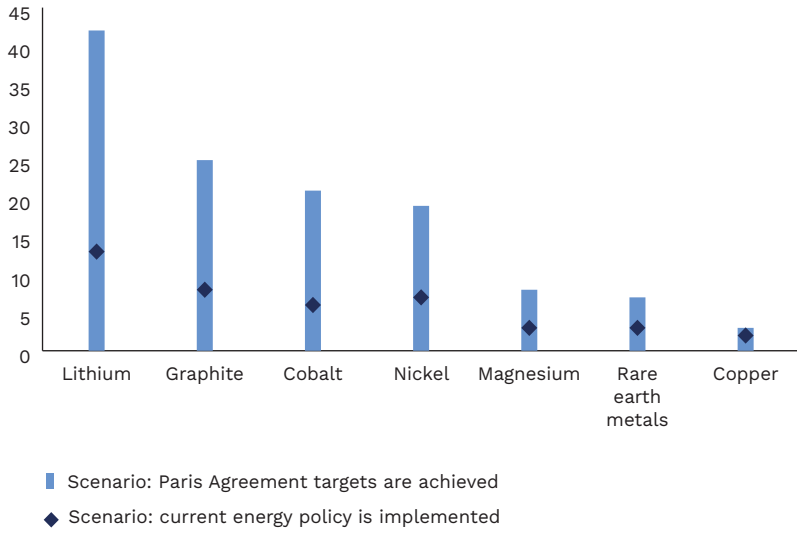
Raw material	Countries that produce it	Main countries supply the EU	EU dependence on imports (%)	Share of raw material obtained from recycling after end-of-life (%)
Cobalt	Democratic Republic of Congo (59%), China (7%), Canada (5%)	Democratic Republic of Congo (68%), Finland (14%), French Guiana (5%)	86	22
Lithium	Chile (44%), China (39%), Argentina (13%)	Chile (78%), US (8%), Russia (4%)	100	0
Magnesium	China (89%), US (4%)	China (93%)	100	13
Graphite	China (69%), India (12%), Brazil (8%)	China (47%), Brazil (12%), Norway (8%), Romania (2%)	98	3
Light rare earth metals	China (86%), Australia (6%), US (2%)	China (99%), UK (1%)	100	3
Heavy rare earth metals	China (86%), Australia (6%), US (2%)	China (98%), UK (1%), others (1%)	100	8
Bauxite	Australia (28%), China (20%), Brazil (13%)	Guinea (64%), Greece (12%), Brazil (10%), France (1%)	87	0
Beryllium	US (88%), China (8%), Madagascar (2%)	x	x	0
Boron	Turkey (42%), US (24%), Chile (11%)	Turkey (98%)	100	1
Coking coal	China (55%), Australia (16%), Russia (7%)	Australia (24%), Poland (23%), US (21%) Czech Republic (8%), Germany (8%)	62	0

Raw material	Countries that produce it	Main countries supply the EU	EU dependence on imports (%)	Share of raw material obtained from recycling after end-of-life (%)
Gallium	China (80%), Germany (8%), Ukraine (5%)	Germany (35%), UK (28%), China (27%), Hungary (2%)	31	0
Germanium	China (80%), Finland (10%), Russia (5%)	Finland (51%), China (17%), UK (11%)	31	2
Hafnium	France (49%), US (44%), Russia (3%)	France (84%), US (5%), UK (4%)	0	0
Indium	China (48%), South Korea (21%), Japan (8%)	France (28%), Belgium (23%), UK (12%) Germany (10%), Italy (5%)	0	0
Scandium	China (66%), Russia (26%), Ukraine (7%)	UK (98%), Russia (1%)	100	0
Metallic silicon	China (66%), US (8%), Norway (6%), France (4%)	Norway (30%), France (20%), China (11%), Germany (6%), Spain (6%)	63	0
Tantalum	Democratic Republic of Congo (33%), Rwanda (28%), Brazil (9%)	Democratic Republic of Congo (36%), Rwanda (30%), Brazil (13%)	99	0
Vanadium	China (55%), South Africa (22%), Russia (19%)	x	x	2
Platinum group metals	South Africa (84%) – iridium, platinum, rhodium, ruthenium, Russia (40%) – palladium	x	100	21

Source: prepared by PEI based on: EC (2020).

The global demand for critical raw materials will increase in the future. According to the International Energy Agency, the demand for lithium used in low-carbon technologies will increase by a factor of 13-42, depending on the scenario (www10), graphite by a factor of 8-25, cobalt by a factor of 6-21, and nickel by a factor of 7-19 (www9). The International Renewable Energy Agency (IRENA) approaches the increase in demand slightly more cautiously, predicting that the global annual demand for lithium will increase from 0.3 Mt per year to 2-4 Mt per year, and that for nickel from 2.77 to 5-8 Mt per year by 2050 (IRENA, 2022).

Chart 20. Expected increase in demand for selected raw materials used in low-emission technologies in 2040, compared to 2020



Note: 2020 = 1. The Paris Agreement target scenario is that all the current net-zero commitments are fully met and extensive efforts are made to achieve short-term emission reductions; advanced economies will reach net zero emissions by 2050, China around 2060, and every other country by 2070 at the latest. Without assuming any negative net emissions, this scenario is consistent with limiting the global temperature rise to 1.65°C (with a probability of 50%). With some negative net emissions after 2070, the temperature increase could be reduced to 1.5°C in 2100.

Source: prepared by PEI based on IEA data.

The European Commission foresees that the demand for critical raw materials will continue to grow. For electric vehicle and energy storage batteries, the EU will need up to 18 times more lithium and 5 times more cobalt in 2030, and almost 60 times more lithium and 15 times more cobalt in 2050, compared to the current (EC, 2020) supplies for the whole EU economy. In the absence of solutions, the increase in demand could lead to supply

problems (EC, 2020). Moreover, the Commission estimates that the demand for the rare earth metals used in permanent magnets – for example, in electric vehicles, digital technologies and wind turbines – could increase tenfold by 2050 (EC, 2020).

Non-energy raw materials

Critical raw materials are of great importance not only in the energy sector, but also in other branches of the modern economy, such as robotics, drones, 3D printing and digital technologies. In addition to those mentioned earlier, the following are also important: antimony, phosphorus, barite, bismuth, tungsten, natural rubber, fluorite, niobium, titanium, phosphate rock and strontium. The EC has pointed to high import dependencies for these raw materials, too.

The crisis linked to the COVID-19 pandemic and Russia's invasion of Ukraine have caused significant problems in the supply of other raw materials and components for companies. Disruptions and delays have affected the operation of many industries, in particular the automotive, electrical, electronic, machinery, metal, construction and furniture industries. Disrupted supply chains and shortages of raw materials and components for production have resulted in significant increases in their prices, which has also translated into inflation. The difficulties in obtaining raw materials, such as metals, are a negative sign in the context of growing demand. The OECD forecasts that metal consumption will increase from 8 to 20 billion tonnes in 2060 (an increase of 150%) (OECD, 2018).

In Q2 2022, as many as 51.1% industrial companies in the EU indicated that the lack of components and equipment (for non-financial reasons) is a barrier to their development. The problem was most acute for companies in Germany, Sweden, Denmark and Ireland. Poland was in the lower half of the ranking. **The shortages appeared for several reasons: a sudden increase in demand and intersectoral shifts, difficulties in maritime transport, random events (factory fires), and sanctions and counter-sanctions related to Russia's invasion of Ukraine.** The latter event has significantly affected supplies of steel, palladium, nickel and wood to Europe – in addition to supplies of energy resources. In turn, an earlier phenomenon – the pandemic – significantly limited access to semiconductors (Grzeszak, 2021), which are mainly imported from China, Taiwan, South Korea, Singapore, Japan, Malaysia and Vietnam. EU imports amounted to EUR 34 billion, 72% of them from non-OECD countries. The shortage not only led to an increase in prices, but also halted production at some automotive factories (Święcicki, Ambroziak, 2021). If nothing else happens – other than the pandemic and the war in

Ukraine – a return to normality in the availability of semiconductors can be expected by the end of 2023 (www12). In addition, to reduce the EU and US's dependence on microprocessors from Asia, there have been initiatives that seek to increase domestic production, such as the EU's European Chips Act or the US CHIPS Act (Simon, 2022; Timmers, 2022). Interestingly, among semiconductors and microprocessors, only one product – photosynthetic semiconductors – made it into the group of critically-dependent products. The others did not meet the EC's three criteria, despite the shortages on the market.

Changes in prices provide a good illustration of the growing problem of shortages of non-energy raw materials during the pandemic and its aftermath, as well as the shock of the war in Ukraine. An important example of this kind of raw material is reinforcing steel: its price increased by 50% during the pandemic and by as much as 100% right after Russia invaded Ukraine.

Chart 21. Changes in the price of reinforcing steel (%)

Source: prepared by PEI based on Macrobond data.

The largest economies' sharp and rapid recovery was associated with an increase in the prices of this commodity, at a time when extraction and transport were significantly hampered by lockdowns, high transport and freight costs, and trade restrictions.

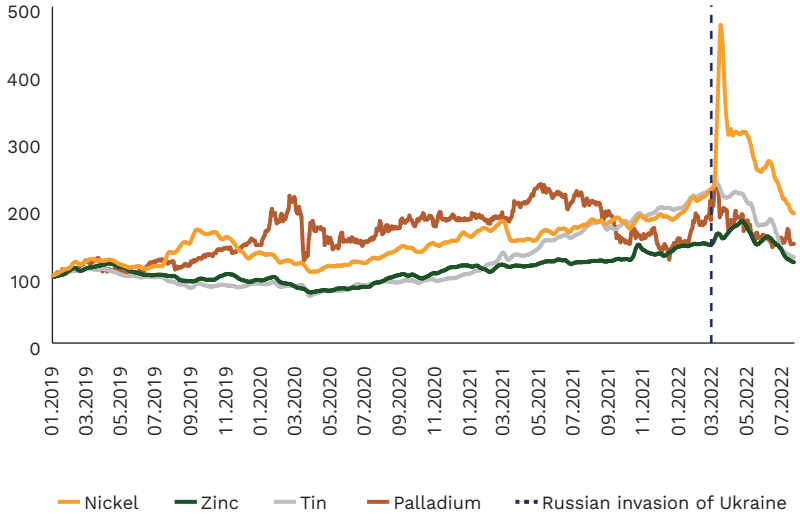
Most of the imports of wood, copper, steel and nickel come from non-OECD countries (60%). Interestingly, only one steel product and one wood product (out of the 38 in the set of related commodity codes) were classified as critically dependent on imports using the product identification method proposed by the European Commission.

Chart 22. Changes in the price of copper (%)

Source: prepared by PEI based on Macrobond data.

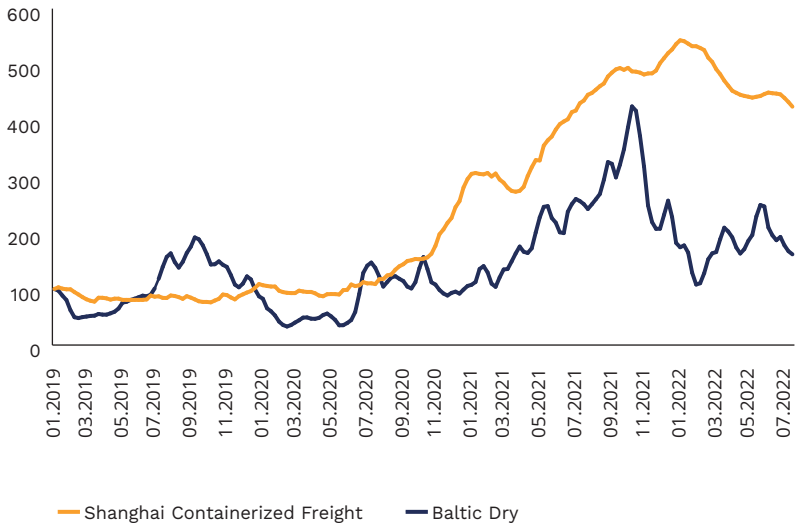
The shortages also affected the prices of more specialist raw materials, such as palladium, nickel, zinc and tin. Palladium is one of the rare earth metals used in the production of electrodes, integrated circuits and automotive catalysts. During some periods, its price was twice as high as at the beginning of 2019. The last time was just after Russia invaded Ukraine; it then dropped to 150% of the pre-pandemic price. The situation is much more dramatic in the case of nickel, which is widely used in the automotive and steel industries to prevent corrosion. In March 2022, it was five times more expensive than three years earlier. Zinc and tin, which are needed to produce many everyday items and in construction, also peaked after Russia invaded Ukraine in spring 2022. The prices of these raw materials remain above pre-pandemic levels, but have been on a downward trend in recent months. This is one of the symptoms of the cooling of the global economy.

Chart 23. **Changes in the price of selected raw materials compared to the start of 2019 (%)**



Source: prepared by PEI based on Macrobond data.

Chart 24. **Sea freight price indices since early 2019 (%)**



Source: prepared by PEI based on Macrobond data.

Movements in ocean freight prices are partly responsible for the emergence of a rising global inflation trend. The chart below shows the changes in the Shanghai Containerized Freight and Baltic Dry indices; that is, the average price for shipping a standard container from the port in Shanghai to various locations, and the average price for chartering dry bulk cargo such as wheat. In 2021, it cost up to four times more to transport bulk goods by sea than two years earlier and, in early 2022, the price of a container was more than five times higher. The delivery time was also significantly longer, making it difficult to maintain the current production model.

The consequences of the economic slowdown for resource shortages and friendshoring

The economic slowdown has limited the issue of product shortages, which can be seen in the decline in the prices of various raw materials and services. This has had a smaller impact on consumer prices, although there was a noticeable slowdown in inflation growth in Europe, and even a decline in it in the US in July 2022, mainly due to the decline in energy commodity prices. Above all, this reduces problems with supplies for industry, which – expecting shortages – had been increasing stocks earlier and thereby compounding market problems. This is particularly evident in the case of falling freight prices and energy commodity prices. The economic slowdown is also reducing the demand for food; as a result, food price indices have returned to the same level as before Russia's invasion of Ukraine, although they stabilised at a high level, still threatening to trigger a food crisis in the world's poorest countries (Ambroziak et al., 2022).

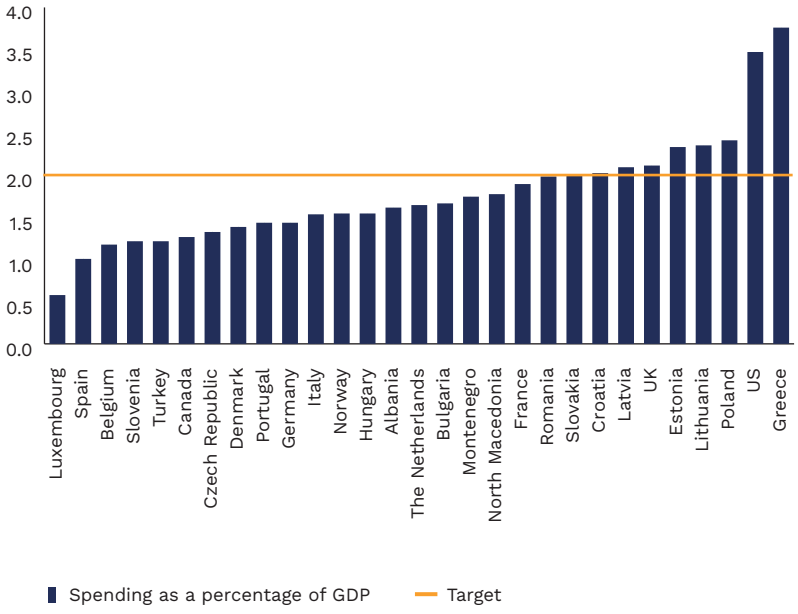
These disinflationary effects of the slowdown are also negative in the context of the prospects of the tendency to secure or shorten supply chains. In times of crises, most companies have to cut costs, which is one of the reasons why suppliers offering the lowest prices are selected (Fabiani et al. 2015; www13). At the same time, companies are less prone to new, capital-intensive production investments or reorganising their network of supply chains, leading to more expensive supplies of raw materials or components. For this reason, the actual valuation of the profitability of relocating production capacity – for example, from China to countries considered friends – will be less favourable during a period of slowdown than during a period in which companies would not face a decline in orders for their products.

Recession also reduces states' budgetary revenues, which could reduce governments' ability to invest in ensuring security. In times of slowdown or recession, increasing military spending, investing in new energy sources or creating a system of incentives to move production to the country could also be much more difficult. For this reason, the trend of friendshoring – while necessary and unavoidable – may not gain momentum before industrial production emerges from the downturn.

Hard security: the increase in military spending and its consequences

One of the consequences of the Russian invasion of Ukraine will be a permanent increase in military spending in EU countries. In 1999-2021, the cumulative increase in defence spending in EU countries amounted to 20%, compared to 66% in the US, 292% in Russia, and 592% in China (European Union External Action Service, 2022). Within NATO, there was a significant increase in the US's share in total military spending and an imbalance between its involvement and that of European allies during that period. In 2022, only 9 out of 30 members met the Alliance's target of spending 2% of GDP on defence (NATO, 2022).

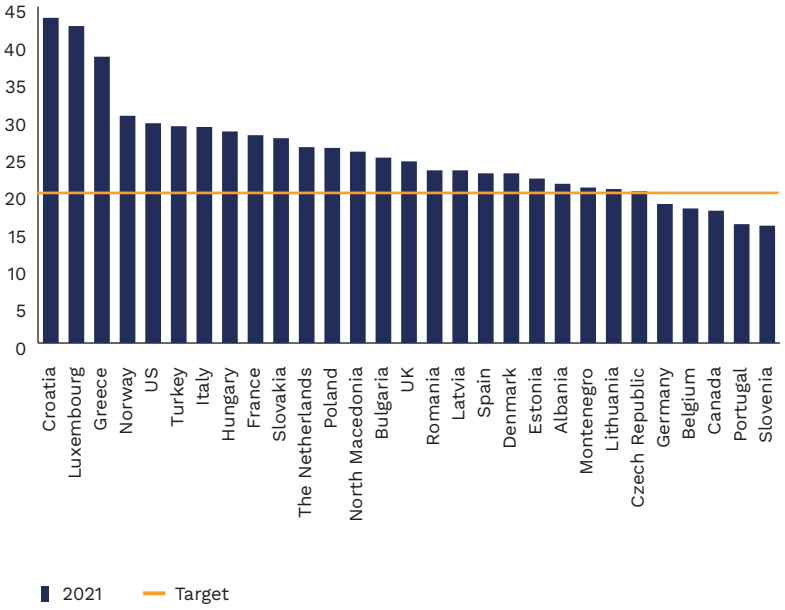
Chart 25. NATO members' spending on defence in 2022 as a percentage of GDP (in 2015 prices)



Note: estimated data.
Source: prepared by PEI based on NATO data.

The main target of 2% of spending on armaments includes the minimum (20%) level of minimum spending that should be allocated to military equipment in relation to general defence spending. According to NATO data, in 2021, Germany, Belgium, Canada, Portugal and Slovenia did not reach the above-mentioned threshold (www14).

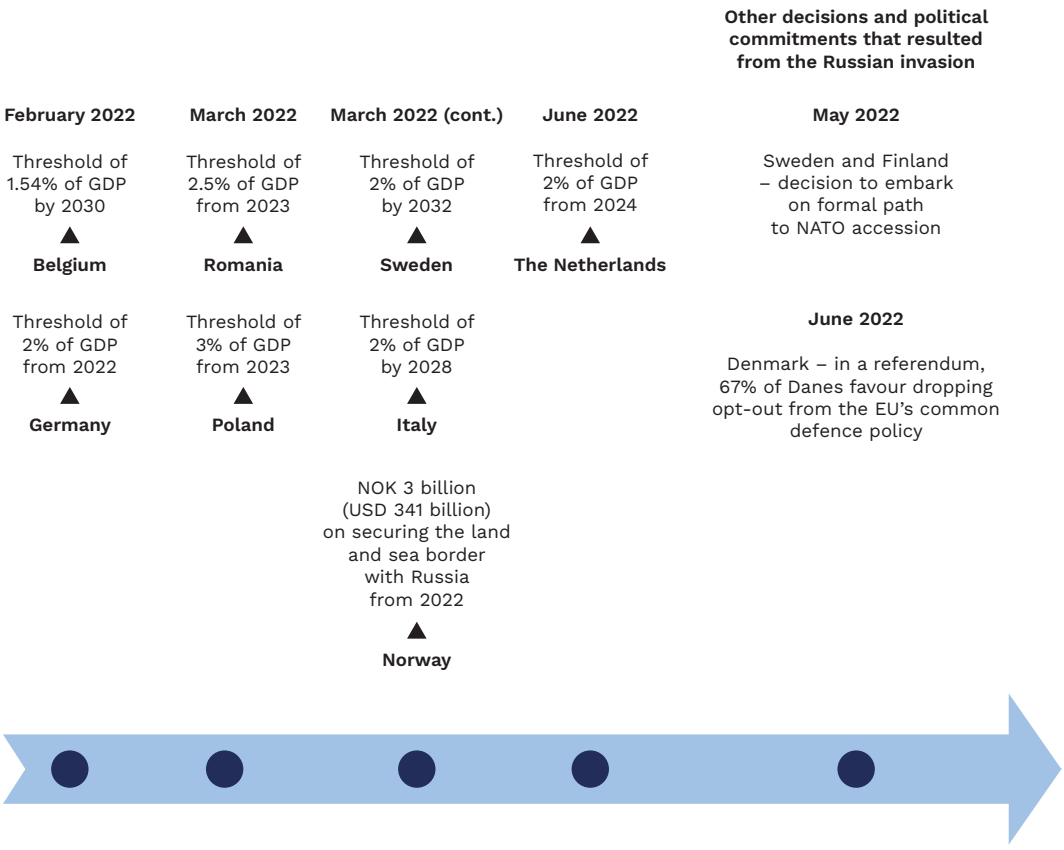
Chart 26. Spending on military equipment in NATO countries in 2021 as a percentage of general military spending (in 2015 prices)



Note: estimated data.
Source: prepared by PEI based on NATO data.

The latest stage of the Russian invasion of Ukraine, launched on 24 February 2022, mobilised many Western countries, including those that are not NATO members, to revise their defence policies almost immediately. The most tangible example of this is the increase in planned military spending (see Infographic 3). Moreover, the material (non-financial) dimension of European armaments includes the scale of employment in the arms industry sectors, the number of employees in the part of the public sector related to the military administration, an increase in the demand for raw materials needed to produce armaments, and so on.

Infographic 3. Changes in selected countries' approach to defence policy as a result of Russia's invasion of Ukraine in February 2022



Source: prepared by PEI.

Increased production of all types of military equipment pushes up demand for a whole range of natural resources, materials, alloys and parts. The simultaneous rearming of many European countries means a greater demand for these goods, which could mean an increase in their prices, supply difficulties or that new investments become more profitable. The global nature of the production chain in this industry is key here. According to a study by Pavel and Tzimas (2016), the EU arms industry uses 39 different natural resources (mostly metals) to produce the most important materials of various types; half of them are entirely imported from outside the EU. One-third of the imports of natural resources essential for the EU's defence industry come from China. In addition, during the period studied (up to 2015), the number of processed materials of strategic importance for the European arms industry that are manufactured in the EU decreased. Imports of more technologically-advanced semi-finished products, such as microprocessors

or semiconductors, which in 2021 amounted to over USD 34 billion, are also significant. These goods are of key importance; in response to the increased security threat in Europe, the EU has launched a programme for the development of domestic production (www15). In terms of military technologies, the EU's dependence on imports is lower than in the case of raw materials or simple materials, and its main partners are allied countries, such as the US (Belin et al., 2017).

The financial resources allocated to investments in armaments will not fully ensure the effect of the Keynesian multiplier of public investment in Europe. A large part of EU countries' armaments are produced in the US. In Poland – like in many other European countries – it is not currently possible to rearm quickly and comprehensively by mainly relying on domestic industry. Depending on rearmament plans' time horizon, it may be more stable and potentially more profitable to build armaments plants in the country or at the EU level, offering an alternative to imports from overseas in selected areas.

The ranking of the hundred largest companies in the arms industry (including subsidiaries) prepared by SIPRI (for the year 2020) includes 28 companies from Europe (excluding Russia), mainly from Britain, France and Germany (www5) and 45 companies from the US. The European arms manufacturing market is not only concentrated in a few countries, but also at several companies. Most of the funds from the European Defence Industrial Development Programme may ultimately go to the top five players: Airbus, Leonardo, Thales, Dassault Aviation and Indra Sistemas (Curic, Pena, Rico, 2022).

Higher spending on armaments, increasing the size of the army or developing equipment must entail the expansion of the domestic armaments industry. According to analysis by Bruegel, the defence industry in Europe employed around 500,000 people in 2014; indirectly, this industry generates an additional 1.2 million jobs (Roth, 2017). The total number of army personnel in the EU and Britain is slightly over 2 million people (www16). Significantly, there has been a downward trend in army size in almost every EU country since the end of the Cold War.

Increasing the size of the army – which some countries may decide to do – generates a specific opportunity cost: potential employees are taken from the labour market for several, or even over a dozen, years. At the same time, the number of people employed in the arms industry and public administration in sectors related to the military, who are needed for efficient management at the political level, increases. This means that there is a specific negative multiplier effect of the army's development in terms of numbers, which may result in labour shortages in civilian industries.

Increasing outlays in too short a period of time generates the risk of ineffectiveness. Increasing armaments spending will fulfil its purpose, both politically and economically, if countries work together. Established in 2004, the European Defence Agency (EDA) is designed to support new initiatives and promote cooperation between member states for

the development of EU countries' joint defence capabilities. It also helps member states that choose to do so to develop joint defence capabilities. Thus, it is in line with the objectives of the EU's Common Security and Defence Policy (CSDP). One of the EDA's objectives is for joint investments by member states in their defence capabilities to represent at least 35% of all their investments. However, according to the Agency's data, in 2020, only 11% of investment projects were implemented as part of cooperation between countries. One of the reasons for their low willingness to cooperate in this area is the way in which countries perceive security and the defence industry. Practically everywhere, it is of a strategic nature and considered a fundamental domain of the state's activity. This is partly why it is common practice in the EU to protect domestic companies operating in the defence sector, often bypassing EU competition rules, which is synonymous with supporting enterprises that would not be able to survive under market conditions (Liberti, 2011).

In line with the results of empirical analyses, at best, defence spending can stimulate economic growth in the short term and concern only selected sectors (for example, increasing employment in the army and industry).

Guns versus Butter

The juxtaposition of butter and weapons, familiar from economic textbooks, is a way of illustrating the dilemma of countries considering allocating more money to military projects. Spending too much on the army can result in the under-financing of investments – for example, on infrastructure or education – which will translate into a less competitive economy.

However, the research on the relationship between GDP growth and military spending has failed to find clear patterns. A meta-analysis of 42 studies on the relationship between arms spending and economic growth showed that, in poorer countries, greater spending on arms slows down economic development. However, in richer countries, higher spending on military projects turns out to be beneficial for GDP growth. In the case of these countries, more weapons can mean more butter ("The Economist", 2022).

More in-depth research often highlights the undesirable effects and opportunity costs of increased spending on arms. The most frequently-mentioned ones are:

- **lower economic growth in the long term** – comparative analysis of nearly five decades of military spending in 83 countries with different levels of development (www17) shows that increasing military spending has a particularly strong negative impact on wealthy countries' economic growth (D'Agostino et al., 2017). Aggregated data for all the countries analysed shows that a 1% increase in defence spending within a 20-year period

leads to 9% decline in economic growth. Other studies that took into account the interests of the armaments sector and negative externalities for non-military sectors also suggest that defence spending has negative impact on economic growth (Dunne, Tian, 2016);

- **lack of funds for other public spending (including on healthcare)** – Fan, Liu and Coyte (2018) developed a statistical method – structural equation modelling – that allowed them to eliminate possible parallel cause and effect relationships. With its help, they analysed data from 197 countries for 2000-2013 in terms of the impact of military spending on healthcare spending. They concluded that an increase in defence spending has a negative impact on the level of health spending, which is a significant risk factor for public health and individuals' wellbeing. Their calculations show that, over time, a 1% increase in military spending leads to a 0.62% decrease in spending on healthcare. At the same time, they noted that the increase in spending is more connected to the increase in GDP in a given country than the increase in spending on healthcare;
- **an increase in debt** – according to some economists, in conditions of continued growth in debt, an increase in defence spending and other budgetary spending may have secondary consequences for economic growth, mainly due to rising interest rates that compensate investors for the increased risk (Nickel, Tudyka, 2014). Higher debt-servicing costs would reduce the amount of funds available for state spending. High interest rates would further increase the cost of capital in the private sector, making it difficult for entrepreneurs to make investments increasing profits and productivity (Égert, 2015);
- **a decline in productivity** – national budgets' limited possibilities – including the small scope for shifts in the area of health protection or social security – in the face of growing defence needs create a risk of cuts in the area of education or infrastructure, among other things. A deterioration in education quality is associated with a decline in the competences, knowledge and skills needed on the labour market, which is a direct cause of lower labour productivity in the long run;
- **a deterioration in infrastructure** – the authors of the Rand Corporation report (Rooney, Johnson, Priebe, 2021) point out that an increase in defence spending reduces the positive effects of infrastructure investments (through the opportunity cost). For OECD countries, the infrastructure investment multiplier was estimated to be at least 1.5, which exceeds the estimated multiplier for military spending. However, the positive effects of infrastructure spending are felt over the long term, while increased arms spending has more direct effects (for example, in employment) and may hamper growth in the long term due to constraints on public investment.

The experiences of the USA and Europe in the 20th century show that huge research projects increase the defence potential of states, the competitiveness of their economies, and strengthen international cooperation. Big Science projects therefore entail three types of benefits: military, diplomatic and economic (Hallonsten, Cramer, 2020).

The experience of previous conflicts and wars shows that a shift in public policy priorities can lead to certain positive results, namely, an increase in spending on research that aims to develop technologies that ensure military advantage while increasing the economy's competitiveness. In 2017, almost one-third of patents were the result of public funding; the Department of Defense was the largest financing institution (6.2%) (Fleming et al., 2019). In 2020, only 1.2% of all defence funds were used to finance R&D. Of this amount, most of the money was invested by two countries: Germany and France.

Summary

An examination of dependencies from several perspectives reveals a key issue linked to energy security and the significant share of energy imports in the EU consumption. The winter of 2022-2023 will reveal the scale of the economic problems that could result from the insufficient diversification of raw materials supplies. The International Monetary Fund estimates the EU's economic losses as a result of its dependence on gas imports from Russia and the risk of interruptions of supplies at 0.4-1.4% of GDP over the next 12 months (starting from July 2022) (IMF, 2022). The war that broke out in Europe required a reaction and EU sanctions on Russia, including an embargo on certain imported raw materials (not only energy commodities). Dependence on a country (or company) whose actions violate the basic rules of international relations exposes one to negative consequences as a result of that country's decision (e.g. the suspension of supplies of medical devices from China during the pandemic), as well as to a pro-active response by the EU (the embargo on oil imports). Dependencies on countries whose actions could force the EU to respond with radical measures are particularly significant.

This kind of situation might include a Chinese attack on Taiwan; the value of EU imports from the China accounts for 25% of the EU's supply of the products with the highest dependencies within the four critical ecosystems. The key dependencies on China relate to photovoltaics, pharmaceuticals and electronics. In addition, China plays an important role in the supply of critical raw materials that the European Commission's methodology does not always identify as critical. To harness the potential of renewable energy sources to build the EU's energy independence, 11 raw materials will be of greatest importance in building an independent supply system for value chains.

In addition, the shortages during the pandemic point to sectors sensitive to disruptions in the supply chain. These include the construction sector, which has been affected by the shortages of steel, wood, electronics and machinery, the automotive sector, which has been affected due to difficulties obtaining metals and microprocessors, and agriculture, which has been affected by the sanctions imposed on fertilisers imported from Russia and Belarus. Particular attention should be paid to supply chains in the health (medical and pharmaceutical), armaments and space sectors, in which Europeans' security may depend on suppliers' reliability.

Recommendations

Above all, due to EU countries' significant dependence on imports, cooperation between them should be increased. Individual member states face different problems of dependence on external suppliers, as well as problems with the prices of raw materials they are offered. Enhanced cooperation at EU level should therefore not only reduce the EU's sensitivity to non-EU suppliers, but also that of each member state. In the case of Polish imports, the list of sensitive products differs from the German, Portuguese or EU-wide list.

States and individual companies should take care of the security of supply, which primarily involves ensuring that the network of suppliers is diversified. Friendshoring may be more difficult to implement in the current macroeconomic conditions. They should prioritise a reduction in dependencies in critical sectors such as health, electronics, energy and energy-intensive industries. A comprehensive look at dependencies, not only from the perspective of meeting criteria or the EU as a whole, is also needed. The supply chain for critical raw materials or ones needed for industry has to become more secure. On the one hand, diversifying suppliers will be key; on the other, a system of incentives to shorten production chains or vertically integrate production processes scattered around the world is needed. Helping firms set criteria for diversification and safe places to invest will be important, so that businesses are not caught off guard by sudden political shifts or other events in the future.

The analysis of the possible criteria for classifying countries as "friendly" illustrates the difficulties in unequivocally defining individual countries' affiliation. The countries that the EU may have to fully decouple from are the ones that backed the Putin regime in the vote on the war in Ukraine: **Russia, Belarus, Eritrea, North Korea and Syria.** Countries that are not on this list – or the list of states that have condemned Russia's invasion of Ukraine, or the list of democratic states – could be included in the list of countries towards which the EU should not be critically dependent on supplies and which require diversification and caution when doing business.

It is also necessary to prepare a policy of support for developing countries that have, say, a different political system. A strategy for building relations

with these kinds of countries is needed, so that freedom in countries that are not fully democratic does not decline. Difficult access to developed countries' sales market could destroy any democratic tendencies. At the same time, radical changes in the supplier network may be very difficult due to the scale of connections and the specialisation of production processes. Complete decoupling from China could also create new threats in the EU's relations with Beijing.

From an economic perspective, friendshoring is not profitable for Europe or the world. To some extent, however, it is needed to guarantee the safety of production processes. The opportunity costs of economic blackmail in conditions of overdependence expose the EU to even higher socio-economic costs. At the same time, these dependencies reduce the EU's ability to help other countries, such as Ukraine. Radical changes to supply chains will be costly; they may lead to a loss of potential efficiency benefits, such as economies of scale in production, increase product prices, hinder developing countries' growth (more frequently, less democratic ones, for instance), and bring production with lower added value to developed countries. Russia's invasion of Ukraine will have far-reaching and long-term negative effects that will take years to reverse while building new confidence in the international arena. For this reason, friendshoring should not aim for total decoupling from non-allied states, but rather strive to guarantee the resilience of the supply chain, especially in critical sectors, should the international political situation deteriorate.

The period of economic development of the past few decades shows clearly free trade and limiting protectionism is the most beneficial, in terms of social progress and lifting people out of poverty. Open markets and a transparent regulatory framework are in the interest of Poland and the EU, as the world's leading trading region. The hope is that, in the future, developed countries will strive to build an open and fair world trade system based on bilateral and multilateral agreements.

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