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Navigating a fragmenting global trading system: insights for central banks

A report of the International Relations Committee Workstream on Trade Fragmentation

No 365

Contents

Abstract

In light of recent global economic and geopolitical shocks threatening trade openness, this report aims to shed light on geoeconomic fragmentation and develops a rich set of new tools to assess its economic effects and implications for central banks. The report shows that, although global trade integration has largely withstood recent disruptions and the rise of inward-looking policies, selective decoupling between few trading partners (United States vis-à-vis China, western economies vis-à-vis Russia) and for specific products (such as advanced technologies) is occurring. Survey data show that, although European firms are reorganising supply chains critical foreign dependencies persist. A firm-level stress test reveals that sudden disruptions in the supply of critical inputs from high-risk countries would lead to significant, albeit very heterogeneous, economic losses across firms, regions and sectors. Addressing foreign dependencies with broad-based protectionism policies, however, is self-defeating. In an extreme counterfactual scenario involving prohibitive and across-the-board trade barriers between geopolitical blocs, global GDP could decline by up to 9% coupled with an increase in global inflation of 4 percentage points in the first year, with the impact persisting for at least five years. It is conceivable that trade fragmentation will unravel over the course of a number of years, with supply disruptions becoming more frequent and severe than in the past. If this process should ultimately lead to a less interconnected global economy, countries might suffer from increased volatility and price pressures, as shocks cannot be easily diversified away through trade. The report concludes that geoeconomic fragmentation significantly increases the complexity and unpredictability of the operating environment for central banks; in addition, it emphasises the need for improved analytical tools and a better understanding of supply chains and trade interdependencies using granular data.

JEL codes: F13, F14, F51, F52, F61, F62, E31, E50

Keywords: trade fragmentation, geoeconomics, global value chains, critical inputs, globalisation

Executive summary

Geopolitical tensions have become a central theme in the economic and public discourses of recent years. The global shocks affecting the world economy have called into question the benefits of trade openness, a central tenet of the post-World War economic order. Governments are increasingly lured by inward-looking policies, aligned with the desire to boost economic resilience and protect national security. If not reined in, these tendencies might unleash a spiral of protectionism, which would have harmful effects on the global economy and welfare.

This report is the joint effort of the European System of Central Banks (ESCB) and provides insights for central banks faced with the task of navigating a fragmenting economy. Geoeconomic trade fragmentation is defined as a policy-driven reversal of global trade integration, which is motivated by domestic economic policy objectives as well as geopolitical and strategic considerations.[1] This report follows up on the 2023 ESCB report reviewing the EU's Open Strategic Autonomy (OSA), which discussed the EU policy agenda related to trade, industrial and state aid measures.[2] This report delves deeper into the trade channel of geoeconomic fragmentation while also providing the ESCB with new monitoring tools and insights to navigate a fragmenting global economy. Albeit the focus is not on monetary policy conduct in the presence of fragmentation, the findings and tools of this report offer useful inputs for the ongoing ECB monetary policy strategy review. The 2021 review stressed the need to anticipate and evaluate the impact of tail events that have a foreign origin.[3] Recent shocks have made this need even more pressing.

This report offers four main findings on trade fragmentation, resulting in four policy implications and as many insights for central banks. This report analyses trade fragmentation based on the underlying assumption that the world economy *exogenously* fragments into three blocs: a western (United States-centric) bloc, an eastern (China-centric) bloc and a neutral bloc of non-aligned countries. This simplifying technical assumption is widely used in the recent literature,[4] but trade fragmentation can also occur within the same bloc (Box 3). Therefore, this division is purely a narrative device and does not reflect any political stance. The main findings, as well as the policy implications and insights for central banks, are discussed below.

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[1] This definition follows Aiyar et al. (2023) and Norring (2024). The link between economic shocks and geopolitical tensions runs both ways: economic shocks can lead to geopolitical tensions and conflicts, while geopolitical disputes often have economic ramifications (Panetta, 2024). This report does not investigate the causal relationship between the two but takes geoeconomic fragmentation as a given.

[2] See IRC (2023), "The EU's Open Strategic Autonomy from a central banking perspective", *Occasional Paper Series*, No 311, December.

[3] See ECB (2021), "The implications of globalization for the ECB monetary policy strategy", *Occasional Paper Series*, No 263, September.

[4] See, among others, Gopinath et al. (2024), Gopinath (2023), Aiyar et al. (2023) and Felbermayr et al. (2023).

Four key findings

First, selective decoupling of trade is already visible, accompanied by lengthening of supply chains (Chapter 2). Global trade integration has largely withstood recent shocks, but bilateral goods trade data point to selective decoupling. Between 2021 and 2023 the eastern bloc's share in western imports decreased by more than 3 percentage points. Lower trade flows between the United States and China, as well as between the EU and Russia, each contributed about one-third to the decline. The timing of decoupling differs in each case. For United States-China it began with the 2018 trade tensions; for EU-Russia it became visible in 2023, following the unjustified Russian war of aggression against Ukraine together with the energy crisis. For the United States, decoupling from China has led to the lengthening of supply chains via increasing indirect trade, though this does not fully offset the reduction in bilateral trade. For the EU dependencies on Chinese imports have recently decreased, mainly in advanced technology products. Corporate surveys reveal that some EU manufacturers are shifting the sourcing of critical inputs from China to within the EU (EU-shoring) to mitigate risks of disruptions.

Second, China is a key supplier of critical inputs for a significant share of manufacturing firms, and supply disruptions would have sizeable albeit heterogeneous effects (Chapter 3). Harmonised corporate surveys across three national central banks[5] and firm-level balance sheet and customs data for five European economies show that 17% to 34% of manufacturing companies rely on China for critical inputs, with 20% to 25% naming China as their main supplier. Surveys indicate that, beyond trade, rising geopolitical tensions primarily impact firms by way of increased uncertainty. While small firms are relatively more dependent on China, a firm-level stress test suggests that supply disruptions affecting large firms could cause significant economic damage, with the resulting loss representing up to 8% of the value added in some sectors across a number of countries. Understanding these risks is crucial in order to assess the potential impact of a weaponisation of critical supplies.

Third, tit-for-tat trade barriers would not eliminate interdependencies but would cause severe output losses and higher inflation (Chapter 4). Using a state-of-the-art multi-country, multi-sector model extended to a dynamic setting, it is estimated that global GDP could drop from nearly 6% – given a scenario of higher trade barriers between the western and eastern blocs on strategic products only ("selective decoupling scenario") – to 9% within a scenario where all products are affected ("severe decoupling scenario"). GDP losses would be heterogeneous across countries, and, over time, trade flows would shift towards neutral countries. If countries within the western bloc raise barriers among themselves, GDP losses would increase substantially (Box 3, Chart A). Trade fragmentation would raise inflation by up to 4 percentage points globally in the first year, with lingering effects. These estimates are conservative, as other possible amplifying channels are not considered here (e.g. impaired knowledge diffusion, adverse confidence effects,

[5] To better understand the exposure of European economies to the sourcing of critical inputs from China, Banca d'Italia, Banco de España and Deutsche Bundesbank leveraged their respective firm surveys during the course of 2023 to ask a set of coordinated questions, and the same questions were also integrated into the European Central Bank's corporate telephone survey.

financial amplification effects, migration/demographic frictions and macroeconomic uncertainty).

Fourth, fragmentation may entail larger and more frequent supply shocks, making sectoral price change more significant for aggregate inflation (Chapter 5). Energy and global supply chain shocks accounted for about half of the core inflation surge in the euro area. In 2021 and 2022 large positive shocks to sectoral prices were associated with higher producer prices both in the euro area and in the United States. As fragmentation gathers pace over the next few years, supply disruptions may increase due to the weaponisation of critical supply chains. This suggests that trade fragmentation may have first-order effects on inflation, as shown by Russia's weaponisation of energy supply to the euro area. While the lowering impact of trade integration on inflation has been limited, as concluded in the 2021 ECB strategy review, trade fragmentation shocks might work differently to trade integration shocks.

Four policy implications

The above findings support the following main policy implications.

First, governments' concerns about economic resilience are valid, but broad-based protectionism reduces welfare and may not fully achieve decoupling. Targeted strategies to reduce foreign dependencies can help mitigate supply disruptions that cause inflation and economic losses. The latter could be sizeable for some firms, industries and regions in the EU (Charts 16 and 17). Broad-based protectionism and uncoordinated industrial policies risk escalating trade barriers, harming global welfare and price stability (Charts 18, 20, and 21) and might not achieve complete decoupling, as restricted products bypass trade barriers via transshipment through neutral countries (Chart 7 and 19). Moreover, in a fragmented world output volatility and inflation would increase due to reduced trade diversification (Chart 27). An alternative to this unfavourable equilibrium is the adoption of targeted de-risking strategies that account for potential drawbacks of excessive regionalisation. These strategies require a coordinated collective effort to ensure their success.[6]

Second, public interventions should be targeted: one size does not fit all. In a geopolitically fragmented world industrial policy is seen as a tool to mitigate risks associated with foreign-sourcing and to support strategic sectors.[7] This report shows that firm-level exposure to fragmentation risks varies depending on the impact channel (Chart 10) and firm characteristics such as size (Chart 12), sector and regional location (Charts 16 and 17). Therefore, policies should be targeted after evaluating their costs and benefits. Even when industrial policies are aimed at

[6] While this report does not make specific proposals for the institutional settings of the world trading system, a more coordinated approach across countries in the formulation and implementation of de-risking strategies would be well warranted. The literature (Staiger, 1995; Staiger and Tabellini, 1989; Toshimitsu, 2014) has shown that a free trade policy is time-inconsistent, and therefore an international organisation such as the GATT/WTO is needed as a commitment device. This argument may also apply to the implementation of de-risking strategies, where the commitment to targeted (and non-escalating) strategies may not be credible without more effective cross-country coordination.

[7] For a broad and recent overview on industrial policies, see Juhász et al. (2023).

remedying market failures (i.e. positive externalities, coordination failures), efficiency concerns and cross-border spillovers ought to be considered. The Draghi Report (2024) echoes these recommendations, calling for actions to reduce foreign dependencies, while carefully assessing trade measures on a case-by-case basis.

Third, enhanced monitoring of production networks is crucial to understanding actual foreign dependencies. The COVID-19 pandemic shock highlighted the need to de-risk supply chains. This report shows that higher trade barriers and de-risking strategies by multinationals may increase indirect trade with high-risk partners, making supply chains more complex (Chart 7). Hence, de-risking policies might not be as effective as intended (Chart 19). Improving visibility and monitoring of production networks (including both direct *and indirect* foreign dependencies) is key to assessing risks accurately. Like-minded partners should coordinate efforts to share data and design monitoring tools that provide insights into indirect trade relations.

Fourth, the increased frequency and magnitude of trade fragmentation shocks require a deeper understanding to undertake effective monetary policy actions. This report shows that sectoral price shocks are more frequent both in a fragmenting and in a fragmented world economy, in turn impacting aggregate prices, especially in the presence of price and wage rigidities (Charts 20, 21 and 27). Central banks must carefully evaluate how fragmentation shocks affect inflation and whether the impact is temporary or whether it is a medium-term trend, the latter being the relevant horizon for monetary policy (Hernández de Cos, 2024). To this end, central banks should use new tools and rely on granular risk assessments and analyses, not only focusing on sectors at high risk of supply disruptions but also fostering international cooperation among central banks to address cross-border challenges.

Four insights to better understand fragmentation

Geoeconomic fragmentation renders the operating environment of central banks significantly less predictable. As a result, geopolitical considerations and spillovers must be integrated into monitoring toolkits being implemented by central banks. To that end, this report offers four key insights, which can be summarised as follows.

First, granular monitoring of fragmentation pressures. As fragmentation is selective (across countries and products), a more granular analysis is warranted. As identified in Chapter 2, the two best practices to foresee fragmentation-driven price pressures are, first, to monitor flows that are at risk of fragmentation (Charts 4 and 5) and, second, to focus on products that are at high risk of weaponisation (e.g. raw materials and other items whose weaponisation potential is higher, such as semiconductors, as illustrated in Box 1) (Chart 6).

Second, conduct regular business surveys to understand firms' exposure to fragmentation risks. Regular business surveys would enable central banks, first, to assess firms' and sectors' exposure to fragmentation risks and related price pressure in a timely fashion and, second, to evaluate how firms implement de-risking actions

to ease medium-term price pressures resulting from fragmentation shocks. The ESCB can enhance cooperation to design harmonised surveys on fragmentation risks across countries, as demonstrated by the joint initiative from Banca d'Italia, Deutsche Bundesbank, Banco de España and the ECB (Chapters 2 and 3).

Third, a deeper understanding of sectoral interdependencies is crucial for central banks to track how price shocks propagate along supply chains. Since many inputs at risk of weaponisation are located upstream in the supply chain, sectoral price shocks may escalate, leading to aggregate price pressures (Chapter 5). However, detailed knowledge of sectoral interdependencies within the euro area and with third countries is limited. Central banks are advised to collaborate with institutions such as the European Commission, IMF, OECD and World Bank to share data and develop detailed inter-country input-output tables to facilitate these analyses.

Fourth, a diverse set of analytical tools and models are necessary to evaluate the impact of fragmentation shocks on activity and prices. This report uses various modelling approaches that were developed in cooperation with national central banks. First, harmonised indicators of trade exposure and stress test analyses on input shortages have been conducted by five central banks. This has involved extracting insights from detailed, confidential firm-level data to inform targeted policies. Second, advanced macro models incorporating inter-country input-output linkages have been used and purposefully augmented to assess the effects of fragmentation on the economy and, in particular, on inflation. The report highlights the potential of broader central bank collaborations for accessing micro-level data and utilising the ESCB's expertise to gain a better understanding of trade fragmentation.

1 A fragmenting global trading system: an introduction

The integration of production processes in complex supply chains operating in different countries has been a distinctive feature of globalisation. The reduction in barriers to trade and to the movement of people, capital, information and knowledge, which gained momentum under the aegis of the World Trade Organisation (WTO), triggered a sharp rise in global economic integration.[8] The increasing participation of advanced and emerging market economies in global value chains (GVCs) was an important driver of economic development and provided a significant boost to per capita income levels (World Bank, 2020). According to World Bank data, the share of trade as a percentage of GDP rose from 25% in 1970 to around 60% before the Great Financial Crisis (GFC) but has since largely stagnated[9].

Trade globalisation is facing significant fragmentation pressures due to growing geopolitical rivalries and a surge in protectionist policies. Scepticism towards globalisation, while dating back to the early 2000s, has been fuelled by the GFC and the shallow recovery that ensued. In many countries this scepticism has contributed to the rise of populist governments and a shift in public attitude towards trade liberalisation.[10] In recent years governments around the world have become increasingly receptive to calls for inward-looking trade policies. These governments are gradually shifting their focus from creating and sharing new wealth towards preserving the distribution of existing economic and political power from their rival countries. The United Kingdom's decision to leave the European Union in 2016 and the United States-China trade tensions in 2018 marked a watershed for the global trading system, as well as the reintroduction of geopolitical considerations into international relations. More recently, the pandemic, the Russian war of aggression on Ukraine and the conflict in the Middle East have stepped up calls not only for greater security in strategic sectors but also for a reduction in excessive dependence on foreign suppliers located in rival countries. The world's largest trading powers have adopted specific initiatives to de-risk supply chains – such as relocation to like-minded countries (e.g. friend-shoring). These policies encompass the EU's Open

[8] The General Agreement on Tariffs and Trade (GATT) was established in 1948 as a set of a multilateral trade agreements. It was transformed into a fully fledged international organisation with the creation of the WTO in 1995. The latter was conceptualised as a forum both for negotiating and operating a global system of trade rules (defined in multilateral trade agreements) and for settling trade disputes among its members.

[9] The GFC marked a slowdown in the speed of economic integration. The IRC (2016) argues that this was due mainly to compositional effects stemming from (1) the growing weight of EMEs in global economic activity, whose economies have a lower trade intensity; (2) a moderation in global value chain expansion, which partly pre-dated the GFC; and (3) diminishing support from trade finance.

[10] Sentiment towards multilateralism, as well as towards the benefits of global economic integration, already started to shift in the early 2000s. The first anti-globalisation demonstrations took place in 1999 (in Seattle). As argued by Rodrik (2021) during the hyper-globalisation phase (i.e. post 1990s) international economic integration seems to have produced domestic *dis*integration in many countries amid rising income inequality and a deepening rift between the winners and losers of exposure to global competition.

Strategic Autonomy (OSA), the US initiative for building resilient supply chains and China's "dual circulation" strategy (IRC, 2023).

The debate over how to bolster Europe's strategic autonomy amid rising geopolitical tensions has been gaining traction within the EU. The Letta Report (2024) emphasised the external dimension of the Single Market, which is no longer seen merely as a way to promote growth and resilience within the Economic and Monetary Union but increasingly also as a tool to tackle new geopolitical challenges and support the EU's role as a global player. The Draghi Report (2024) on the future of European competitiveness advocates, among other things, a reduction in strategic dependencies through a series of proposals: ensuring a stable supply of critical materials by diversifying sourcing countries, pursuing preferential trade agreements with resource-rich countries and forming industrial partnerships. In general, the report argues for the development of a unified EU foreign economic policy to navigate rising geopolitical tensions and calls on the EU to foster trade policy coordination while assessing trade measures on a case-by-case basis.[11]

Understanding how the economy is impacted by the geoeconomic fragmentation process is a matter of importance to central banks. The 2021 ECB Monetary Policy Strategy Review stressed the need for its economic analysis to anticipate and evaluate the impact of tail events of foreign origin.[12] Following Aiyar et al. (2023) and Norring (2024), geoeconomic fragmentation (GEF) is defined as a policy-driven reversal of global economic integration motivated by domestic economic policy objectives, geopolitical motivations and strategic considerations.[13] The focus of this report is on reversals along the trade channel,[14] i.e. trade fragmentation. Like other forms of GEF, trade fragmentation is a gradual and nonlinear process which may unfold over a number of years. During this process, supply chains might go through sudden disruptions and gradual readjustments, with direct implications for the central banks' operating environment and, therefore, for their capacity to ensure price stability. This report is a follow-up to the IRC (2023) report on the EU's OSA,[15] which discussed relevant aspects of the EU's policy agenda regarding trade, industrial and state aid measures while also calling for "the need to incorporate new elements and analytical tools, most notably for the study of inflation dynamics" in ECB and Eurosystem analyses in this new environment. The

[11] It advocates openness for critical technologies where the EU lacks technological capabilities, such as AI and digital infrastructure. In other sectors, protective measures are seen as necessary to ensure a level playing field, particularly in industries subject to foreign state subsidies, such as China's state-backed industries.

[12] See ECB (2021), "The implications of globalization for the ECB monetary policy strategy", *Occasional Paper Series*, No 263.

[13] We also follow Aiyar et al. (2023) by assuming that GEF does not include fragmentation arising from autonomous shifts in preferences or technology; nor does it include fragmentation driven by prudential policies that are undertaken in an internationally coordinated manner – for example, those directed at improving domestic financial stability. In this vein it is worth noting that recent changes in trade patterns may not be entirely attributed to trade fragmentation. Other factors could also be influencing these shifts, such as rising labour costs in China and in other emerging economies, normalisation of the Chinese growth model towards being less export-oriented and more reliant on domestic demand and technological advancements favouring reshoring.

[14] Other channels such as capital flows or the movement of workers, albeit very relevant from an economic standpoint, are not covered.

[15] See IRC (2023), "The EU's Open Strategic Autonomy from a central banking perspective" Occasional Paper Series, No 311.

present report, albeit focusing solely on trade fragmentation, answers to this call precisely by providing novel monitoring tools, insights and best practices for central banks that are faced with the task of navigating a fragmenting global trading system.

This report provides a better understanding of the economic implications of the trade fragmentation process while identifying four lessons for central banks. Although the precise contours of trade fragmentation are still uncertain, a narrative device widely used in the growing literature on this topic – and one adopted in this report – is the notion that the world economy might *exogenously* fragment into three blocs: a western (United States-centric) bloc, an eastern (China-centric) bloc and a neutral (i.e. non-aligned countries) bloc.[16] The report draws on some novel analytical tools to gauge the effects of trade fragmentation on the global economy in a more effective manner and is structured as follows: Chapter 2 takes stock of the status of trade fragmentation by looking at trade flows across country blocs and specific products categories, as well as updated metrics of GVC integration. It shows how evidence from corporate surveys for selected EU countries may provide early insights into firms' de-risking strategies. Chapter 3 uses granular firm-level data that are matched with customs data to develop indicators of exposure to trade fragmentation risks in selected EU countries; the economic implications of supply disruptions in foreign critical inputs are then quantified. Chapter 4 relies on three complementary and state-of-the-art models to assess the potential implications for output and inflation of a wide range of fragmentation scenarios. Chapter 5 delves more deeply into trade fragmentation and supply shocks, particularly the role of industry-specific price shocks as a primary channel through which fragmentation could affect inflation. Chapter 6 concludes and identifies potential areas for future research.

[16] Considered in the abstract, this assumption follows from the fact that a country's incentive to align with one or the other bloc could change over time while also depending on the specific products/sectors under consideration. This is an aspect which is not considered in the analysis.

2 Trade fragmentation: where do we stand?

2.1 A tale of three shocks

A triad of global shocks has hit the international trading system in recent years. First, since 2018 United States-China trade tensions have led to tit-for-tat tariffs covering around two-thirds of total trade between the two economies, the largest bilateral trade flow at the time.[17] Second, since 2020 the supply chain disruptions caused by the pandemic and lockdown measures imposed worldwide have sparked a debate about the need to balance international trade integration with supply chain resilience. Lastly, Russia's unjustified war of aggression against Ukraine, which began in 2022, has triggered an energy crisis and a major geopolitical rift. This unprecedented "perfect storm" that hit global trade has left a profound and visible mark. The level of geopolitical risk has substantially increased and is now about 50% higher than the post-GFC average (Chart 1, panel a); restrictive trade measures are on the rise, with US imports from China no longer the largest trade flow worldwide; and firms are increasingly considering alternative supply chain configuration strategies (reshoring/near-shoring/friend-shoring) in response to the supply chain disruptions of 2021 and 2022, which exposed the vulnerability of a closely integrated world economy.

Inward-looking policies, already on the rise before the recent shocks, have markedly accelerated on the back of exacerbating geopolitical tensions. Since the GFC, inward-looking policies have mostly been adopted by governments in advanced economies with the stated aim of protecting workers, companies and national technologies, as well as guaranteeing a level playing field vis-à-vis increasingly aggressive foreign competitors, China above all.[18] While for many years China has been actively pursuing policies aimed at increasing its self-reliance through subsidies and different forms of state aids,[19] the pandemic crisis saw a dramatic surge in these types of policies on the part of western countries that are increasingly motivated by national security and geopolitical concerns amid the need to improve the resilience of supply chains and enhance strategic competitiveness. Moreover, these measures have often targeted key products such as advanced

[17] According to the US customs data, by 2023 US imports from Mexico had supplanted US imports from China as the largest trade flows, standing respectively at 2.2% and 2.0% of world imports, compared with 1.9% and 3.1% in 2018.

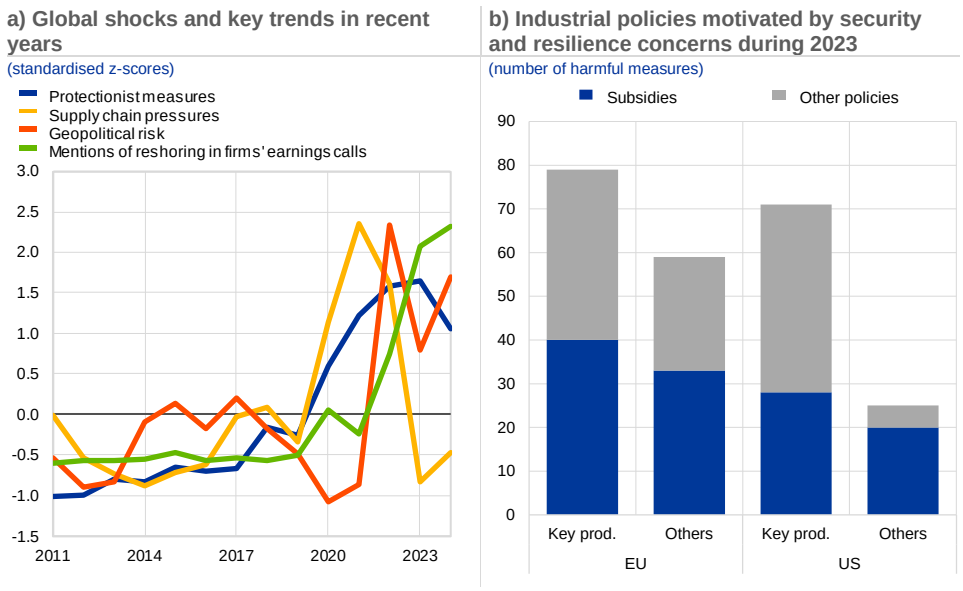
[18] Inward-looking policies encompass all measures which might be harmful to economic and trade integration both directly (i.e. trade measures erecting tariff and non-tariff barriers) and indirectly (i.e. industrial policy measures and those restrictive of labour mobility).

[19] Two key policies in this direction were the "Made in China 2025" industrial policy, launched in 2015, and the 2020 Dual Circulation strategy (García-Herrero, 2021).

technologies and products needed for the green transition (Chart 1, panel b).[20] In this more confrontational geopolitical environment, some countries might strategically exploit interdependencies (so-called "weaponisation of interdependencies") by restricting access to raw materials and critical technological components. Cases in point are Russian gas supplies to European countries, US export controls of semiconductors to China (Box 1) and China's export restrictions on critical metals, as well as technology used to extract and process rare earths.

Chart 1

Global economies amid rising tensions and protectionism



Sources: Caldara and Iacoviello (2022), New York Fed's GSCPI, Global Trade Alert, New Industrial Policy Observatory and NL Analytics.
Notes: Panel a) reports z-scores of different measures, normalised across the 2011-24 period. Panel b) shows inward-looking measures motivated by concerns over national security, resilience of supply chains, geopolitics and strategic competitiveness; "key prod." in the right-hand chart refers to critical mineral products, advanced technology products, semiconductors, low-carbon technologies, dual-use products, hydrogen products, aluminium, iron and steel products and medical products. Solely data for the EU and the United States are reported, as information gathered for other jurisdictions might be influenced by the transparency of political and institutional processes.

Despite this less supportive global environment, and the above-mentioned disruptions, no widespread signs of de-globalisation have materialised to date. The plateauing of global trade integration observed post-GFC and labelled as "slowbalisation" has been due to cyclical and structural factors alike (IRC, 2016; Constantinescu et al., 2020; Antràs, 2020). These included a less trade-intensive composition of growth amid sluggish investment, especially in the aftermath of the European sovereign debt crisis; the fading of one-off factors that fuelled trade expansion in the past two decades (e.g. shift in relative production costs due to narrowing wage gaps between advanced and emerging economies, as well as automation of production processes, shifting global demand towards less import-heavy sectors); and a shift towards policies that were less supportive of free trade

[20] More specifically, the United States increased public subsidies via the Inflation Reduction Act and the CHIPS and Science Act to stimulate domestic industry and lessen dependence on Chinese inputs. Similarly, the EU introduced its own CHIPS Act to enhance competitiveness and resilience in semiconductor technologies, alongside the Critical Raw Material Act to bolster self-reliance and diversification. China escalated its state-backed subsidy programme to promote key productions such as batteries and electric vehicles, aiming to reignite growth.

and economic integration (pre-dating the most recent tensions). A closer look at several state-of-the-art metrics of GVC integration (Borin et al., 2021) suggests that pre-pandemic patterns have remained broadly unchanged, both on an aggregate and on a regional scale. Between 2007 and 2022 global trade openness – measured as the share of imports and exports to world GDP – remained broadly stable, while the level of integration in GVCs – measured as the share of trade and output related to GVCs (i.e. crossing more than one border) – increased slightly, despite the downturn and subsequent rebound recorded during the GFC and pandemic crises (Chart 2). Furthermore, no signs of major drops in the complexity of GVCs have been found in recent years across different inter-country input-output datasets (Mancini et al., 2024b).[21] As of 2022, about half of total trade and almost one-fifth of output have been linked to GVC activities. Interestingly, while the manufacturing sectors are more intensively engaged in GVC activities than services, the latter's integration into GVCs has been on the rise since 2017 and has been left relatively unscathed by the pandemic shock. Across major trading blocs, EU and US participation in GVCs has expanded over the period under consideration. Conversely, China's GVC integration has been broadly stable in trade terms and has even declined in output terms amid a gradual normalisation of its growth model directed towards becoming less export-oriented, less dependent on imported inputs and more reliant on domestic final demand. It should be noted that an overall stable level of international integration does not necessarily imply that a reorganisation of trade flows and supply chains is not happening. For instance, integration within blocs may be intensifying while simultaneously decreasing across blocs. In some cases, trade barriers may have also resulted in longer and more complex value chains. These aspects are explored in the remainder of the chapter.

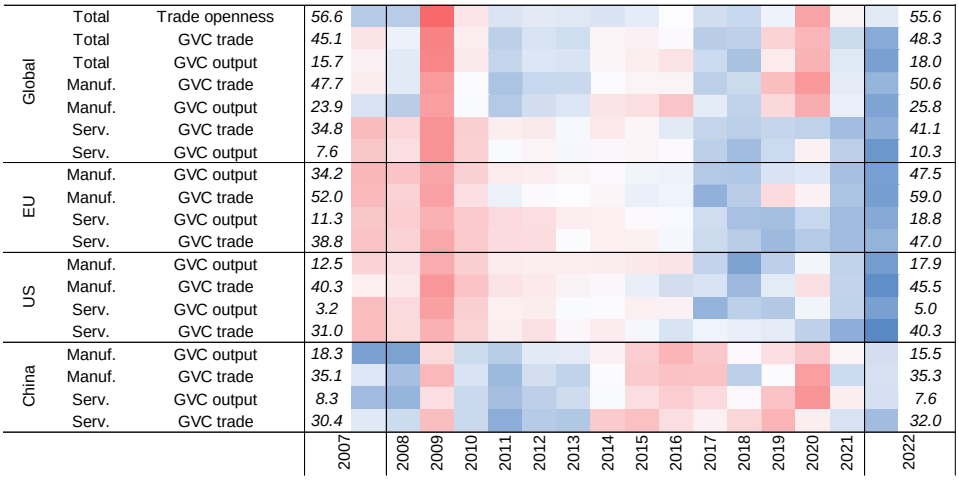
[21] GVC complexity measures the average number of production stages as captured by the extent to which production processes are sliced across industries and countries. See Antràs and Chor (2018) for further details.

Chart 2

At the aggregate level, GVCs have been resilient despite global shocks.

Openness; GVC exports as share of exports; GVC output as share of output; z-scores

(colours are based on z-scores normalised over 2011-22; shares of trade and output)



Source: Authors' own elaborations based on IMF and ADB multiregional input-output at constant prices.
Notes: Measures based on Borin et al. (2021). Data are available in the OECD WITS GVC database. GVC output measures the share of total output related to GVC activities, i.e. crossing more than one border. GVC trade measures the share of total exports related to GVC activities, i.e. crossing more than one border. Openness is measured as exports plus imports over GDP. The services sector focuses on business services; therefore, it excludes hotels and restaurants, transport, public administration, education, health and social services.

Box 1

Foreseeing restrictions in a fragmenting global economy: insights from the digital sphere

Security concerns are prompting heightened scrutiny of international trade flows amid escalating geopolitical tensions. Nowhere is this more evident than in the digital sphere, where concerns over preserving technological superiority and managing risks that derive from digital interconnectedness are fuelling some of the most stringent trade restrictions seen in peacetime. The security-induced fragmentation of both the hardware and the data components of the digital sphere likely foreshadows future developments across the wider economy. Hence, gaining insight into the digital sphere offers a glimpse at possible future developments in the rest of the economy.

On the hardware side, China's rapid technological ascent has raised deep security concerns in the United States, resulting in the creation of a complex set of China-specific export controls on advanced technologies. Certain types of semiconductors and semiconductor manufacturing equipment have long been regulated under multilateral agreements on dual-use items; in 2022, however, the United States vastly expanded its unilateral control regime on these items, together with a set of advanced technologies, when destined for China. The regime was further expanded in 2023 and 2024 and currently targets a much broader set of chips and manufacturing equipment. To mitigate the risk of trade diversion, exports of these items to a wider set of countries beyond China are now controlled. The regime also covers third countries' exports of specific semiconductor manufacturing equipment with even minimal US content, as well as foreign items produced with equipment of US origin, thus affecting flows well beyond United States-China trade relations. Lastly, the regime has also been adopted by allies and partners: Japan and the Netherlands, both producers of advanced chip-making equipment, joined the United States in enforcing export curbs on sophisticated machines and components. China's response to these measures has been to

impose export controls on critical metals – germanium, gallium and their compounds – which are used in semiconductor and electronics production.

Fragmentation in the digital landscape is also happening at the level of dataflows. Digital trade is an important component of the global economy, currently representing about 25% of global trade (OECD, 2023). Digital trade flows – and the enabling dataflows – have been subjected to heightened scrutiny in recent years (Burri and Chander, 2023). Different countries approach the regulation of data transfers from different angles, ranging from privacy to national security (Borgogno and Savini Zangrandi, 2022). More specifically, Europe's approach is centred on the protection of personal data and the need to maintain adequate levels of competition whereas the United States seeks to balance economic freedom with national security, while China prioritises state control and national security (Borgogno and Savini Zangrandi, 2024). As a result, recent evidence points to a surge in digital trade restrictiveness (Patrignani, 2024). Between 2014 and 2022 the OECD's Digital Services Trade Restrictiveness Simulator Index (DSTRI) grew by about 25% on average (OECD, 2023). Similarly, data from the Global Trade Alert (GTA) show that nearly 80% of policy interventions affecting the digital economy have been restrictive in nature since 2021 (Evenett and Fritz, 2021). The security-induced shift with regard to dataflows is particularly evident in the United States. Having traditionally pushed for digital openness, the United States enacted norms in the course of 2024 that pose severe restrictions on data transactions with foreign adversaries, forcing the divestment of Chinese owners from a major social media operator as a result.[22] While it remains difficult to gauge the impact of individual measures, it appears evident that international tensions are leading to a regionalisation of digital markets.

2.2 Selective trade decoupling along geopolitical blocs

In line with the literature, geoeconomic fragmentation is implemented by assuming that the world economy is divided into three distinct geopolitical blocs: western, eastern and neutral. In a global environment fraught with ideological and geopolitical rivalries amid a growing risk of weaponisation of economic interdependencies, countries tend to strengthen economic ties with other countries that share similar political values, economic policies and security interests. While there is significant uncertainty about the precise contours of fragmentation, a common assumption in the fast growing body of literature on the topic is that the world is (exogenously) divided into blocs, with China leading the eastern bloc and the United States leading the western bloc (e.g. Gopinath, 2024; Javorcik et al., 2024; Attinasi et al., 2024c; Goes and Bekkers, 2022).[23] However, this is a highly simplifying assumption, as trade fragmentation can similarly occur within countries of the same bloc. Therefore, this partitioning of the global economy into blocs should be regarded purely as a narrative device and is not intended to reflect any political

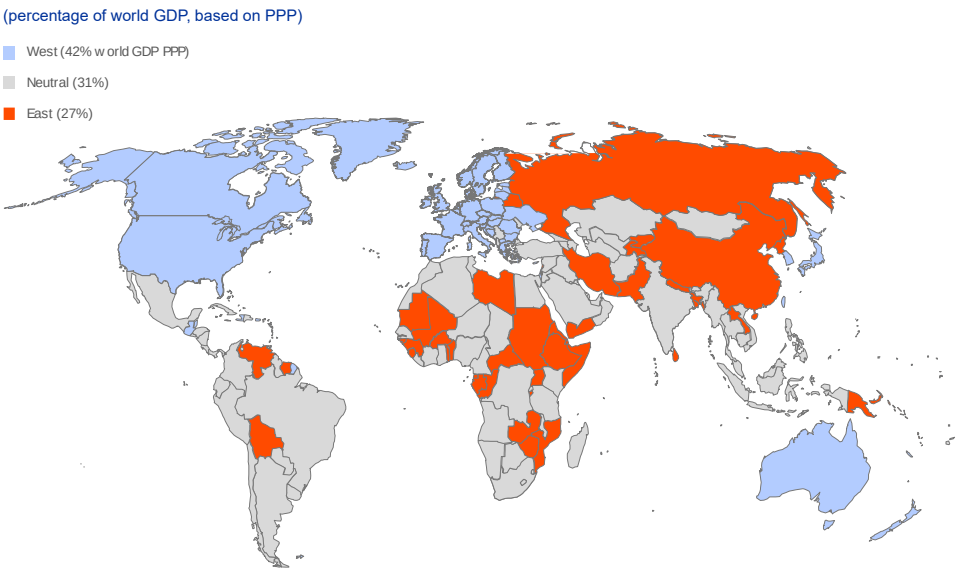
[22] Executive Order 14117 on "Preventing Access to Americans' Bulk Sensitive Data and United States Government-Related Data by Countries of Concern" and the Protecting Americans from Foreign Adversary Controlled Applications Act.

[23] As mentioned above (cf. footnote 11) a country's alignment with one bloc or another may change over time, depending on several factors. While this aspect is not considered in this report, Bolhuis et al. (2023) use a quantitative trade model to simulate the endogenous formation of blocs when countries take trading partners' decisions into account in both simultaneous and sequential games.

stance (Box 3). This report relies on the geopolitical index developed by den Besten et al. (2023) to assign countries to different blocs. The index extends the approach of the above-mentioned studies, which rely solely on the voting patterns at the United Nations General Assembly (UNGA), by including additional measures of political alignment and economic ties between countries. The resulting allocation is depicted in Chart 3 (see Annex 1 for more details).

Chart 3

Geoeconomic fragmentation into western, eastern and neutral blocs

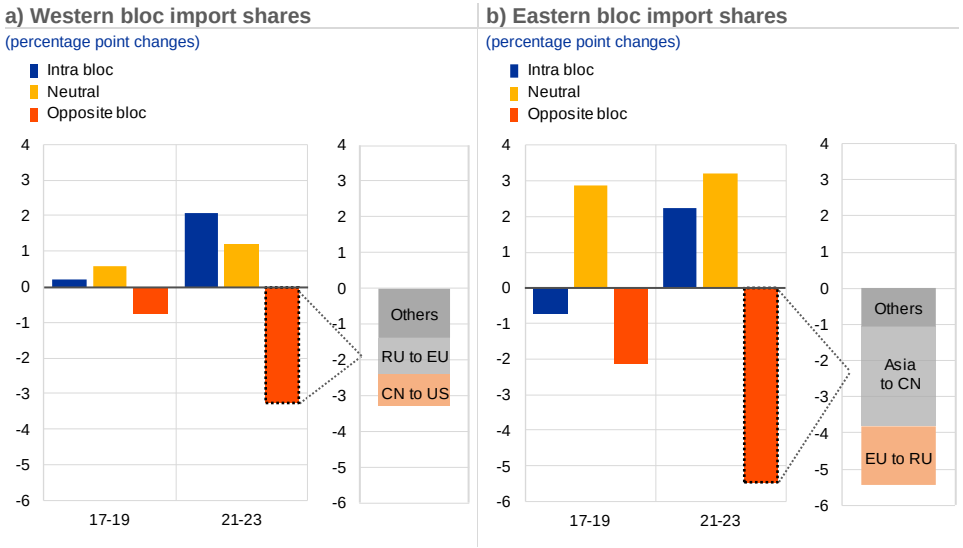


Source: Authors' own elaborations based on den Besten et al. (2023) and Capital Economics.
Notes: The geopolitical index uses the history of sanctions, military imports, UN voting and China's official lending, building on a similar work in den Besten et al. (2023). The geopolitical allocation of Capital Economics is based on a set of political and economic factors (e.g. UN voting, military alliances, territorial disputes, bilateral FDI flows and trade). GDP weights are expressed in PPP, based on October 2023 WEO data.

A process of trade reconfiguration along geopolitical fault lines is ongoing amid stable global trade integration. Trade relationships are shifting to the advantage of closer links with like-minded countries (Conteduca et al., 2024). Over the past few years, each of the two opposite blocs considered in this report appears to have become more self-reliant in terms of import sourcing and, at the same time, appears to have increased the share of imports from economies in the neutral bloc (Chart 4). Already observable before the pandemic, this trend has accelerated markedly more recently.

Chart 4

Ongoing reconfiguration of trade flows along geopolitical lines



Source: Conteduca et al. (2024) with data from Trade Data Monitor (TDM).

Trade reconfiguration along geopolitical fault lines is not widespread but driven by shifting trade ties between specific trading partners. The recent reduction in the western bloc's share of imports from the eastern bloc has been driven both by the sharp drop in US imports from China and by the drop in EU imports from Russia (each contributing about 30% to the overall decline; Chart 4, panel a). China's share in US imports dropped by 4 percentage points between 2017 and 2019 due to United States-China trade tensions; it subsequently declined by an additional 5 percentage points between 2021 and 2023. In parallel, the United States has increased its imports from politically neutral countries, especially Mexico. The EU has greatly reduced the relevance of Russia as an energy commodity supplier following the latter's invasion of Ukraine and attendant sanctions. In contrast, China's share in EU imports declined by only 1 percentage point in 2023, approaching its pre-pandemic level. On the other hand, the overall drop in the eastern bloc's share of imports from the western bloc has been due mainly to a reduction in China's imports from Asian countries that are aligned with the western bloc – namely Korea, Taiwan and Japan (altogether accounting for 60% of the decline, equally distributed among the countries; Chart 4, panel b) – as well as to the reduction in Russian imports from the EU (accounting for one-third of the total).

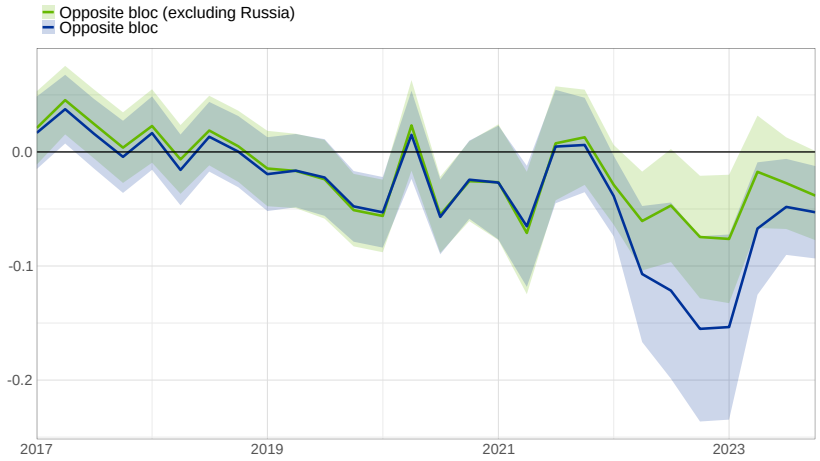
The Russian invasion of Ukraine represents a watershed moment in reshaping global trade along the geopolitical dimension. A granular analysis based on quarterly trade data and on a gravity model (Carluccio et al., 2024) suggests that, all else equal, alignments with specific geopolitical blocs have affected trade flows since the Russian invasion of Ukraine (Chart 5). The analysis shows that bilateral trade between country pairs belonging to the opposite bloc (as defined in this report) has declined compared with trade with neutral countries. In line with the descriptive evidence reported in Chart 4, these results point to a shift in trade flows away from countries belonging to the opposite bloc. Interestingly, this result is driven by trade in specific product categories (i.e. parts and components and capital goods).

Furthermore, the analysis shows that a relevant part of the effects appears to be driven by sanctions imposed by the western bloc on Russia (Chart 5), which de facto entailed a decoupling from Russia and affected many other trade flows (e.g. increase in trade between China and Russia, as well as between sanctioning countries and neutral economies due to trade deflection and re-routing; see Chupilkin et al., 2023; Borin et al., 2023a).

Chart 5

Estimated effect of geopolitical alignment on bilateral trade

(percentage change)



Source: Carluccio et al. (2024).
Notes: Estimates are obtained by regressing the quarter-on-quarter log change in export values between the exporting country and importing country of a certain product (HS4 level) from the first quarter of 2015 to the third quarter of 2023 on a standard set of gravity variables. The reference category includes trade flows that involve the bloc of neutral countries. The estimated coefficients reported in the chart capture the differential growth rate of bilateral exports when the destination country belongs to a different geopolitical bloc with respect to trading with a neutral country.

While trade decoupling between Russia and the western bloc is nearly complete, the reconfiguration of trade vis-à-vis China is still at an early stage. Decoupling between Russia and the western bloc has been extensively analysed in several studies (among others, Bosone et al., 2023; Mancini et al., 2024a; Di Comite and Pasimeni, 2022; Demertzis et al., 2022) and is nearly complete, due also to the strong sectoral specialisation of Russia's exports. The rest of this chapter will focus mostly on China's relationship with the western bloc. In fact, for countries in the western bloc, China is the most significant eastern bloc trading partner; moreover, the reconfiguration of trade vis-à-vis China has likely just begun for the EU and is far from concluded for the United States, as seems to be suggested by business relocation strategies and recent FDI evidence (reported below) – which usually determines future trade patterns.

Shifts in trade flows are particularly evident in key electronics products, driven by the relocation of leading multinational enterprises. The share in imports from China of advanced technology products, especially electronics, has recently declined for both the United States and EU. For the United States this decline began in the wake of trade tensions whereas imports of advanced technology products marked a turning point for the EU starting only in 2023, after peaking in 2021-22 during the post-pandemic recovery and amid associated supply chain disruptions (Chart 6,

panel a). The decline is specific to some flagship products that are common to both the United States and the EU and that are associated with the growing relevance of other sourcing markets (Chart 6, panel b). For example, for both the EU and United States the import share from China in mobile phones and communication apparatus dropped by 4 percentage points between 2022 and 2023 (to 59% for the EU, and to 47% for the United States) whereas India's overall share of the two import categories grew considerably. The share in laptop imports from China dropped by around 14 percentage points for the United States in just one year (from 92% to 78%), having been replaced by imports from Vietnam (+13 percentage points). The trend was similar for the EU, albeit more modest. Lastly, Taiwan's overall share in imports of semiconductors and electronic circuits increased whereas those from China dropped.[24] This product-level evidence resonates with the ongoing reorganisation of some production and distribution chains being conducted by leading multinational enterprises in these segments (HSBC, 2024).

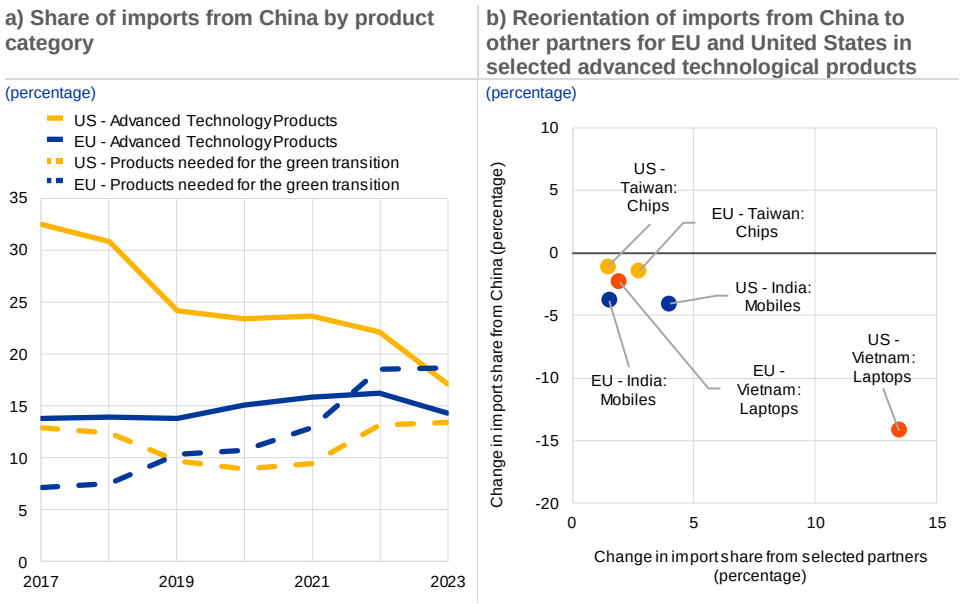
With regard to products that are key to the green transition, a decoupling from China cannot (yet) be observed, which is presumably due to its strong market power. Dependence on China for key products that are essential to the green transition (e.g. lithium batteries, electric vehicles and photovoltaic cells) has grown for both the United States and the EU. The increase is explained by China's dominant market position in the supply chain and rising global demand for these products. China's market share in this product category continued to grow in Germany throughout 2023 and has remained high for the major EU economies. Its share could potentially expand further due to anticipated increases in demand and China's strong control over various stages of production.[25]

[24] These products (laptops, mobile phones and communication apparatus, electronic circuits and semiconductors) are among the top 10 non-energy traded products at the global level and in 2023 accounted for around 10% of all the non-energy international exchanges.

[25] See https://www.iea.org/reports/energy-technology-perspectives-2023/clean-energy-supply-chains-vulnerabilities.

Chart 6

Ongoing reconfiguration of selected trade flows



Source: Authors' own elaborations based on TDM data and Conteduca et al. (2024).

To a certain extent, selective decoupling from China may mask a lengthening of supply chains in the form of higher imports of Chinese products via third countries. The trade reconfiguration patterns described above might mask some degree of lengthening of specific supply chains. For instance, in 2023 Chinese exports of laptop parts and components to Vietnam doubled, increasing by about USD 800 million, while US imports of laptops from Vietnam quadrupled, up roughly USD 6 billion in just one year.[26] A more formal analysis at the product category level suggests that higher US and EU imports from selected third countries (Mexico, Vietnam, India and Taiwan) are, in some cases, associated with a rise in exports from China to the same countries (Conteduca et al., 2024). However, the correlation is only modest for the EU. This evidence may indicate that Chinese products are being partially rerouted with minimal transformation, especially when the destination country is the United States. Nevertheless, detecting deeper supply chain reconfigurations – in which Chinese inputs undergo significant transformations – requires the use of inter-country input-output data, which are typically available with a much longer lag than standard trade data.

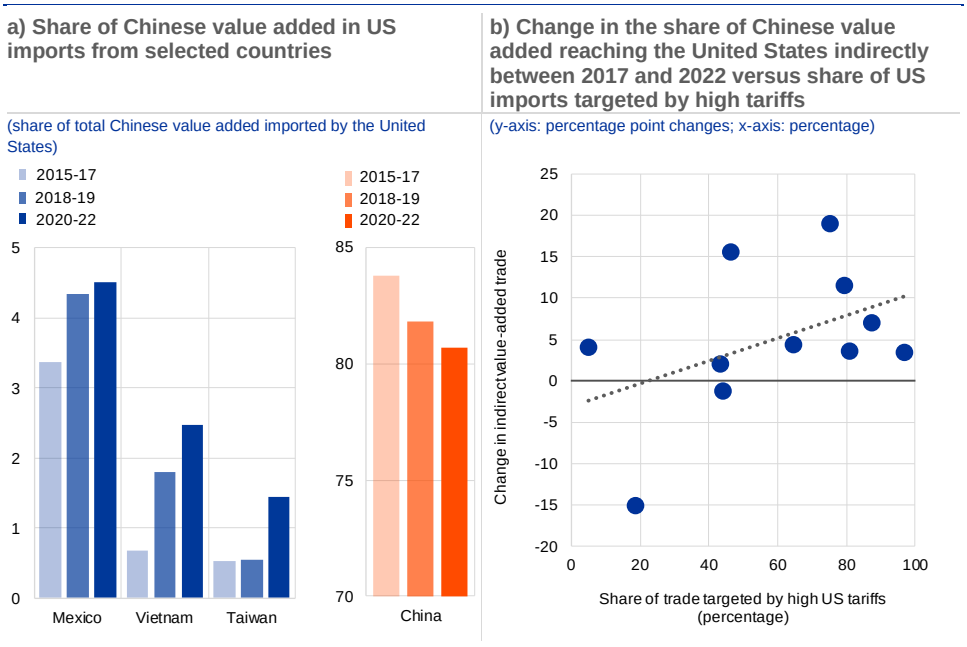
A detailed analysis of direct and indirect trade patterns suggests that US dependencies on China might have declined to a lesser extent than standard trade data suggest. Analyses based on the most recent inter-country input-output tables suggest that the share of Chinese value added directly exported to the United States decreased between 2015 and 2022. At the same time, the share of Chinese value added indirectly exported to the United States via third countries – most notably Mexico, Vietnam and Taiwan – increased (Chart 7, panel a). This evidence

[26] It should be noted that this pattern is not found in mirror statistics. In fact, while there is evidence of an increase in Vietnamese exports of laptops to the United States, Vietnamese imports of laptop parts and components from China actually decreased by about USD 200 million.

hints at a possible restructuring and lengthening of specific supply chains, with production stages localised in third countries that rely more intensively on Chinese inputs than was the case in the past. The increase in indirect trade of Chinese products has been higher in sectors more heavily targeted by US import tariffs (Chart 7, panel b). Overall, the increase in indirect trade flows has not offset the decline in direct trade from China, even in key sectors such as electronics. Thus, US dependencies on China have indeed fallen despite the lengthening of supply chains, albeit possibly to a lesser extent than can be inferred from standard trade data. In contrast, the EU has even seen an increase in direct imports from China compared with indirect ones, possibly due to fewer barriers to Chinese imports compared with those imposed by the United States.

Chart 7

Signs of lengthening of supply chains driven by United States-China tariffs



Source: Conteduca et al. (2024).
Note: Panel a) is based on ADB MRIO data and Borin and Mancini (2023), while panel b) is based on ADB MRIO, TDM data and US tariff data from Peterson Institute for International Economics.

Going forward, emerging signs of fragmentation in foreign direct investments and firms' relocation strategies may be harbingers of further trade fragmentation. While fragmentation of FDIs is not the direct focus of this report, it is worth acknowledging that trade patterns are rather slow-moving, reflecting internationalisation strategies and foreign investment decisions with a time lag. The presence of sunk costs, in addition to the uncertainty that characterises foreign markets, increases the stickiness of past decisions, with internationalisation difficult to reverse as a result (Dixit, 1989; Antràs, 2020). This is why the pandemic shock has not on its own triggered mass foreign plant closures and re-organisation of supply chains (Di Stefano et al., 2022). Firms might perceive the current geopolitical environment as long-lasting, however, inducing changes in foreign investments and revisions to internationalisation strategies, which may foreshadow fragmentation in trade flows.

Recent signs of fragmentation in FDIs suggest that the pace of trade decoupling might accelerate. The majority of advanced economies, including the EU, have recently either adopted or else tightened existing foreign investment screening mechanisms, which empower national authorities to restrict foreign takeovers in strategic sectors.[27] For the EU the outcome of its application show that, even if many transactions are subject to review, the number of blocked transactions is limited, which does not result in lowering the typically significant FDI inflows to the EU (Bencivelli et al., 2023).[28] Planned FDI projects within a bloc of countries have become much more common, while investments across blocs have fallen (UNCTAD, 2024; Gopinath et al., 2024). Greenfield investments to and from China have been decreasing, especially in 2020-23, and this trend similarly seems to be suggestive of fragmentation. Recent studies suggest that FDI fragmentation trends are mainly being driven by the same two shocks that contributed to growing trade fragmentation. United States-China trade tensions prompted companies from both sides to relocate their manufacturing plants to third countries (see Aiyar et al., 2024; Kaaresvirta et al., 2023; HSBC, 2024). Russia's invasion of Ukraine and associated sanctions imposed by the West forced most western companies to cut ties with Russia. This generated an overall increase in geopolitical risk, which made many investors rethink their plans. The rest of the chapter examines evidence from corporate surveys in selected EU countries, investigating the extent to which firms are reconfiguring their supply chains to reduce exposure to high-risk countries. This serves as a key leading indicator of potential trade fragmentation.

2.3 Coping with geoeconomic fragmentation: evidence from corporate surveys

De-risking and reorganisation of supply chains are also gaining traction among European firms. While there is broad evidence that top multinational companies are relocating in response to geopolitical tensions (HSBC, 2024), evidence on European firms' exposure and responses to geopolitical risks is scarce.[29] To partly remedy this gap, in 2023 Banca d'Italia, Banco de España and Deutsche Bundesbank leveraged their respective firm surveys to ask a set of coordinated questions about exposure to China and de-risking strategies, and similar questions were also integrated into the ECB Corporate Telephone Survey (Balteanu et al., 2024a; Attinasi et al., 2023c). The national surveys reveal that around half of the manufacturing companies sourcing Chinese inputs deemed to be critical for their activity have already implemented, or planned to implement by the end of 2024, strategies to reduce supply chain risks (Chart 8, panel a). Rates are higher for

[27] The purpose of investment screening frameworks is to allow authorities to potentially condition or forbid transactions endangering domestic strategic interests related specifically to national security or public order.

[28] While no direct evidence links a reduction in cross-border investments to screening mechanisms, some projects may have been implicitly or explicitly discouraged by the implementation of new screening measures across EU countries. However, measuring this anticipation effect is complex and would require ad hoc analyses.

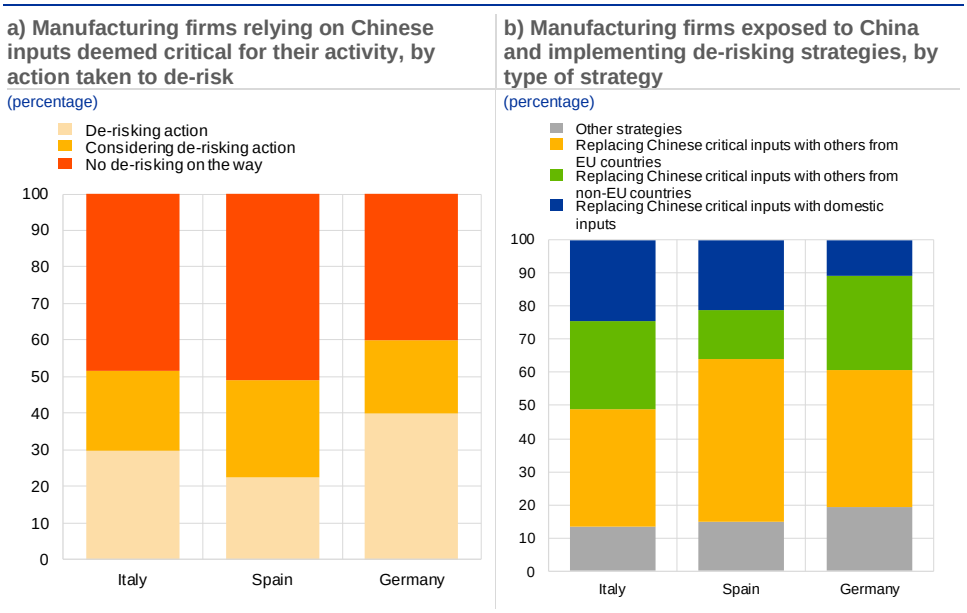
[29] Notable exceptions include the surveys of the EIB (Brasili and Harasztos,2023) and the EBRD (Kitzmüller et al., 2022) for European firms, albeit their focus is on disruptions to supply chains and actions taken by firms to increase resilience rather than on geopolitical risks.

Germany (60%) than they are for Italy (51%) and Spain (49%). Nevertheless, there is still a high share of exposed companies that are neither de-risking nor considering taking action as yet. Among firms that have already taken action, the substitution of Chinese suppliers with EU suppliers ("EU-shoring") is the most frequent de-risking strategy among all three countries, whereas a considerable share of companies in Germany and Italy are also replacing critical inputs sourced from China with inputs from non-EU countries (Chart 8, panel b). The growing relevance of EU-shoring is also confirmed by the ECB survey, as a higher share of firms expect to start sourcing inputs increasingly from inside the EU in the near future compared with what has been done in the last five years (Attinasi et al., 2023c).

Relationships with suppliers perceived as more complex and less substitutable are typically the initial targets for de-risking efforts. On average, firms that source their Chinese inputs through more complex and less easily substitutable transactions have a higher probability of implementing a de-risking strategy (10 percentage points higher in Germany and Spain, and 16 percentage points higher in Italy) compared with firms that source their Chinese inputs through simpler arm's length transactions (Bottone et al., 2024). The risk of economic losses from an increase in geopolitical tensions leading to new trade barriers prompts these firms to proactively decouple from China and seek alternative sources for their most critical inputs.

Chart 8

De-risking among European firms is on the way



Sources: Banca d'Italia, Deutsche Bundesbank and Banco de España.
Notes: Questions – Over the past 12 months, has your enterprise purchased intermediate inputs from China that were critical to your enterprise's production processes or business activities? Has your enterprise undertaken or is your enterprise currently undertaking measures to reduce purchases of Chinese intermediate inputs?

While resilience-enhancing strategies may entail costs in the short run, they can mitigate price pressures from future supply disruptions. Increasing supply chain diversification and resilience is costly (Baldwin and Freeman, 2022) and will likely be passed on to consumers (see also Chapter 5). According to the ECB survey,

about half of the large multinational companies implementing de-risking strategies anticipate upward pressure on their selling prices over the next five years, though this share is lower compared with what has been experienced in the past five years. This might suggest that, in the past, firms have had to revise strategies abruptly and sub-optimally due to unexpected shocks such as the pandemic and Russia's invasion of Ukraine. Pre-emptively implementing de-risking strategies despite initial costs may help alleviate future price pressures stemming from supply chain disruptions. Monitoring these developments is crucial for central banks, underscoring the need for frequent cross-country surveys.

2.4 Implications for central banks

Central banks should closely monitor fragmentation pressures by adopting a more granular approach beyond aggregate trade data. Given the selective nature of the fragmentation process across countries and product categories, standard analyses of global trade prospects, based on aggregate data, must be supplemented with more disaggregated data. The evidence presented in this chapter suggests that the geoeconomic dimension should be factored into standard analyses of trade by monitoring trade flows that are at risk of fragmentation, as well as strategies that are pursued by firms to de-risk. To foresee potential price pressures, the analysis should focus on trade flows of selected products such as raw materials, upstream production and items with higher weaponisation potential (e.g. semiconductors and semiconductor manufacturing equipment).

Albeit beyond the scope of this report, it is important to note that geoeconomic fragmentation may have broader economic implications outside of trade. Geopolitical tensions may have broader implications, including adverse effects on financial stability (ECB, 2024). While this has not materialised to date, geopolitical tensions could increase financial market uncertainty more broadly, especially in the event of their sudden escalation, thereby undermining confidence among investors and heightening risk aversion. The global payment system is also increasingly at risk of fragmentation. After the SWIFT ban against key Russian banks following Russia's invasion of Ukraine in 2022, other countries may explore alternatives to reduce dependence on the existing international financial infrastructure, motivated by fears of sanctions or geopolitical pressures. This could result in the emergence of parallel systems with limited interoperability, leading to higher transaction costs and inefficiencies. Lastly, fragmentation could also have an impact on international currency reserves and invoicing currency for international trade, as some countries might increase the use of alternatives to major traditional currencies (Lagarde, 2023).

3 Exposure to trade fragmentation risks: evidence from granular data

Recent events have highlighted vulnerabilities associated with excessive reliance on key foreign inputs. Shortages in medical supplies and semiconductors witnessed during the pandemic, along with the five-fold increase in natural gas prices following Russia's invasion of Ukraine, served as wake-up calls for policymakers and businesses mainly in advanced economies and spurred concerted efforts to mitigate these vulnerabilities. For central banks, a proper understanding of foreign dependencies is key to assessing potential disruptions to economic activity and price stability that may result from the weaponisation of these dependencies.

This chapter draws from business survey evidence and firm-level data to gauge foreign dependencies in selected EU countries and assess potential disruptions from sudden shortages of key inputs. This chapter leverages detailed firm-level data for selected EU countries to which the respective national central banks have access and is elaborated using a common methodology.[30] This approach comes at the expense of replicability across a larger number of countries due to limited data availability; however, compared with standard analyses of foreign dependencies, which rely on aggregate data (European Commission, 2021; IRC, 2023), it enables additional micro-level patterns that are relevant for the design of adequate policies to be uncovered. First, the degree of firms' dependence on foreign inputs is gauged based on the results of coordinated business surveys conducted by national central banks of three EU countries – Germany, Italy, and Spain (Balteanu et al., 2024a) – and supplemented by information from the ECB CTS (Attinasi et al., 2023c; see also Chapter 2). Second, detailed and refined indicators of foreign dependencies are computed using firm-level data for five EU economies (Belgium, Spain, France, Italy and Slovenia). Third, for the same set of countries, a stress test exercise assesses the short-run economic implications – at the firm, sector and regional levels – of a sudden drop in the supply of key inputs from the eastern bloc (Panon et al., 2024).

[30] The methodology used for the analysis based on firm-level data is a distributed micro-data approach, whereby a common code is shared and used to extract relevant information from each country's data, thus ensuring strict cross-country comparability of results while preserving the confidentiality of the underlying granular data. Firm-level micro-data used in this analysis refer to data that are collected from surveys, censuses or administrative records and that are available to the respective national central banks. Since this type of data often contains sensitive information about businesses (e.g. revenues, exports, location), their use is confidential in order to protect privacy, prevent re-identification risks, maintain trust with respondents and comply with legal obligations.

3.1 Foreign dependencies: business surveys and firm-level evidence

For leading multinational firms operating in the euro area, China is by far the most notable supplier of critical inputs. Nearly 40% of respondents to the ECB CTS survey reported China as the dominant supplier of critical inputs, and all of them considered this an elevated risk.[31] Also, more than 60% of the respondents considered China as a potential risk to their sector's supply chains. Exposure to other partners, as well as their perceived riskiness, is notably lower. Only 8% of respondents reported sourcing critical inputs from the United States, followed by other countries such as Taiwan, India and Brazil.

National business surveys reveal that a large share of the economy is potentially exposed to a sudden stop in the sourcing of critical inputs from China. The three national business surveys reveal that this is especially the case for Germany, where more than one-third of manufacturing companies rely on these inputs (Chart 9, panel a).[32] For Spain and Italy the exposure is relatively high as well, reaching 20% and 17% of the manufacturing firms, respectively.[33] Exposure is also heterogeneous across firms, with the largest ones being exposed to critical inputs from China almost twice as often as the smallest ones. Survey evidence is broadly consistent with the aggregate trade data in the sense that Germany imports a higher share of key inputs from China than the other two countries (Chart 9, panel b). However, these import shares are quite low (between 2% and 5%) compared with the share of firms relying on these inputs, thus suggesting that aggregate trade data may understate the pervasiveness of critical dependencies for the production processes of manufacturing companies.

An escalation of geopolitical tensions with China would have negative effects that extend well beyond the direct trade exposure channel. Around 40% of Italian and Spanish manufacturing companies reported that higher barriers to trade and investment between the West and China could have a negative effect on their activity. This share is much higher for German firms (75%) by virtue of their higher exposure to China (Chart 10). A key channel of disruption to business activity would be the loss of access to Chinese inputs. However, the increase in uncertainty about future economic developments is the most relevant channel for all three economies. As a result, companies with no direct links to China also expect a negative impact on their activity.

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[31] In general, about 55% of the respondents reported that they source critical inputs (fully or heavily) from one or more specific countries. Of these, nearly all indicated that the supply of critical inputs from at least one of these countries is subject to elevated risk.

[32] For the sake of consistency across the three surveys, the share of firms sourcing critical inputs indirectly from China includes only those companies that additionally consider this channel to be the most problematic in the wake of trade fragmentation.

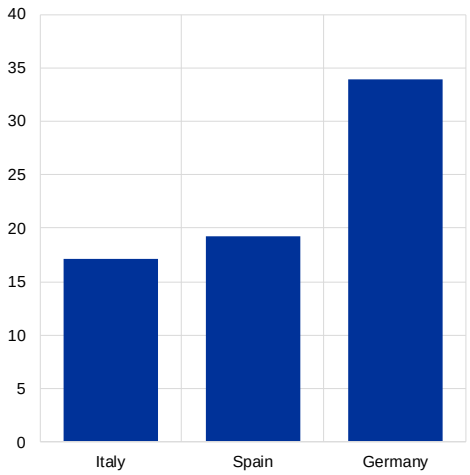
[33] Exposure of the service sector is much lower, albeit non-negligible (15% in Germany, 8% in Italy and Spain alike).

Chart 9

Exposure of manufacturing companies to Chinese critical inputs

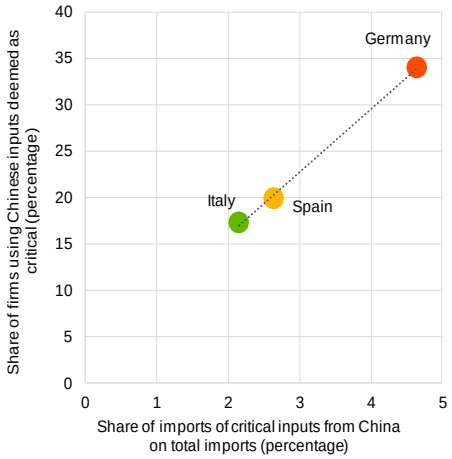
a) Companies sourcing critical inputs from China

(percentage of manufacturing companies)



b) Dependency on China: survey data versus trade data

(y-axis: percentage of manufacturing companies; x-axis: percentage of total imports)



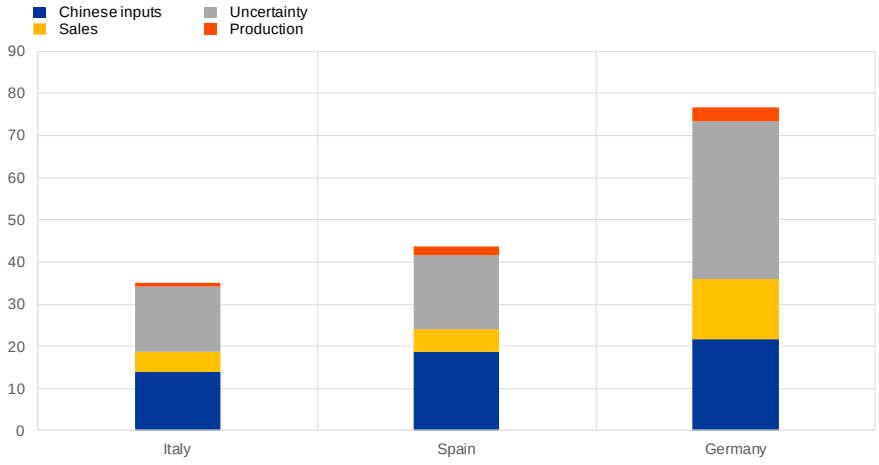
Sources: Banca d'Italia, Deutsche Bundesbank and Banco de España.
Notes: Question – Over the past twelve months, has your enterprise purchased intermediate inputs from China that were critical for your enterprise's production processes or business activities? Right Banca d'Italia, Deutsche Bundesbank, Banco de España and CEPII BACI data. The y-axis reports survey evidence while the x-axis reports the share of imports of critical inputs (advanced technology products, products key for the green transition and raw materials with a highly concentrated supply at the global level, EU foreign-dependent inputs as defined by Arjona et al., 2023).

Chart 10

Impact of an escalation of tensions extends well beyond the trade channel

Companies indicating a potentially negative impact from fragmentation, by channel

(percentage of manufacturing companies)



Sources: Banca d'Italia, Deutsche Bundesbank and Banco de España.
Notes: Question – Imagine a scenario in which economic or geopolitical tensions between China and the West (including the European Union) escalate over the coming months, leading to new trade barriers and restrictions on direct investment. What impact would this have on your enterprise's business activities? The chart reports only the "Mostly negative" answers.

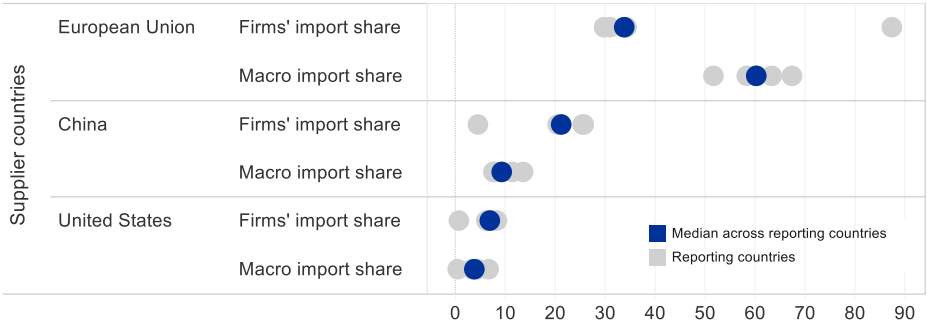
Firm-level data point to more widespread and pervasive foreign dependencies than aggregate data suggest. According to aggregate trade data, about 13% of EU imports of non-energy products are sourced from the eastern bloc, with China alone accounting for about 10% of the total. Sourcing from other EU countries reaches

about 60%. However, granular data tell a different story and reveal that dependency on China is economically more significant, as the country is the main supplier for a substantial share of manufacturing firms, especially for advanced technology products. According to customs data of five EU countries, between one-fifth and one-fourth of importing firms reports China as their main supplier (Chart 11). In most countries, the share of firms reporting the EU as their top source location is only moderately higher (about one-third).

Chart 11

China is the most relevant supplier for a large share of importing firms

(aggregate import shares from a given partner country vs. shares of firms that have the given partner as their main supplier, percentage shares)



Source: Authors' own elaborations based on national customs data and on the Trade Data Monitor (TDM).
Notes: The reporting countries are Belgium, Spain, France, Italy and Slovenia. The reference year is 2022 for all countries except Italy, for which the reference year is 2021. Imports are net of energy flows, monetary gold and other residual items.

Small importers are relatively more exposed to China than large importers, though the latter contribute more significantly to aggregate exposures. Importing firms are classified based on their overall import values.[34] The share of imports from the eastern bloc over total imports is significantly higher for small importers than for top importers (Chart 12, panel a). However, despite their large numbers, small importers represent only a small fraction of the total import value (Chart 12, panel b).[35]

Diversification of imports still appears rather limited for the most exposed firms, especially for small importers. Focusing on those firms and products for which China is the main supplier, it turns out that in approximately 80% of the cases China is the *only* supplier (Chart 13). Low supplier diversification is actually a common trait across trading partners, especially more distant ones. However, the share is much higher for small firms (93% on average), suggesting that the cost of setting up a wide range of trade relationships for small importers is relatively higher, given their stricter budget constraints, and this is especially true for more distant

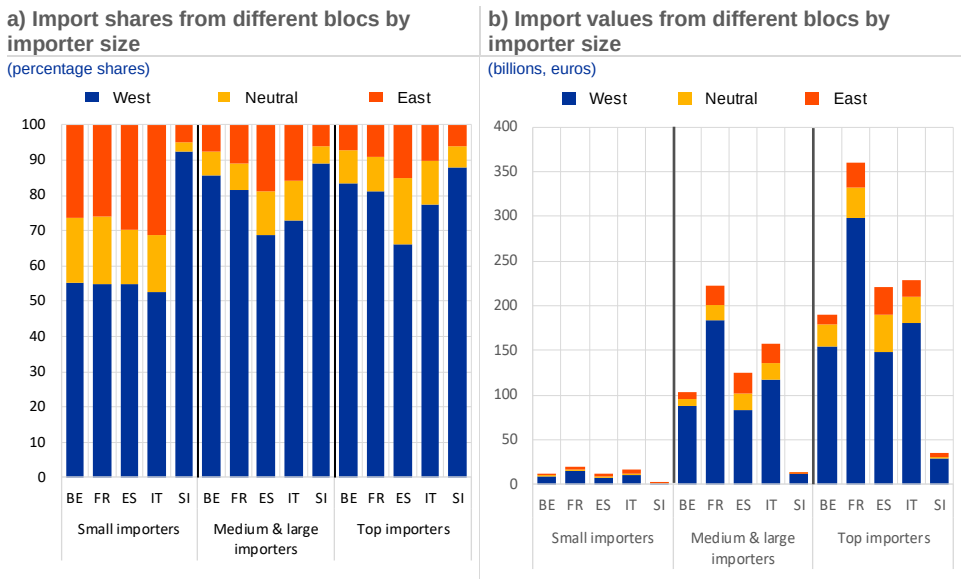
[34] Small importers are those at the bottom 80% of the import distribution, while medium and large importers are those between 80% and 99% and top importers are the top 1% of the import distribution. For Belgium small importers account for 4% of imports, medium and large importers for 34% and top importers for 62%; France: 1%, 32% and 67% of imports; Spain: 3%, 35% and 62% for imports; Italy: 3%, 39% and 58%; and Slovenia: 1%, 22% and 77% of imports.

[35] By contrast, the few top importers alone account for over 60% of aggregate imports.

locations.[36] In only 10% of the firm-product combinations there are – in addition to China – one or more other suppliers from the western or neutral bloc. When this is the case, it is mostly medium, large or top importers that diversify their import sources. For significant shares of firms in the five economies under analysis, products imported uniquely from China include key strategic goods such as machine tools operated by laser, lithium batteries, optical and telephone devices, as well as other selected electronic products.

Chart 12

Sourcing strategies are heterogeneous in firm size



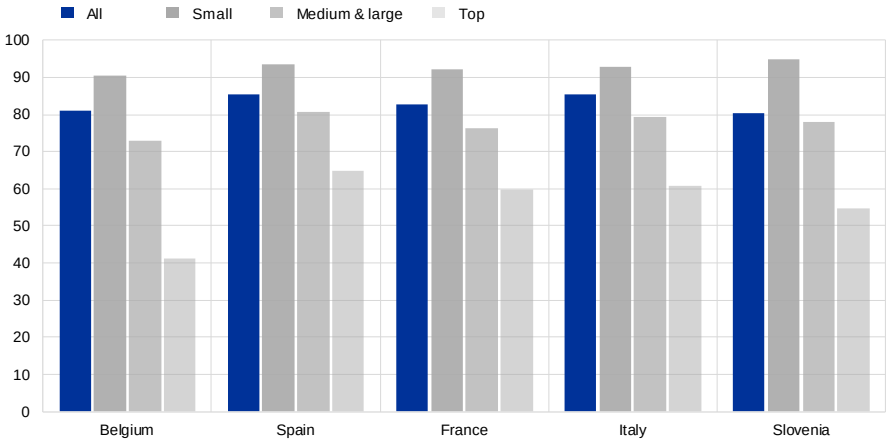
Source: Authors' own elaborations based on national customs data.
Note: Small importers are the bottom 80% of importing firms by import values; medium and large importers are the top 20%, excluding the top 1%; top importers are the top 1%.

[36] When advanced economies such as the United States or Germany are the main source country, only slightly lower shares of firms than those reported for China source uniquely from these countries. However, the share of small firms importing solely from a given trading partner is found to decrease with geographical and "geopolitical" distance (93% on average in the case of China, 89% in the case of the United States, down to 85% in the case of Germany).

Chart 13

When importing from China, small firms display much lower supplier diversification than do larger firms

(percentage of firm products imported uniquely from China by importer size category, as a share of firms importing mainly from China)



Source: Authors' own elaborations based on national customs data.

3.2 A stress test exercise: economic implications of supply disruptions in foreign critical inputs

China is the top foreign provider of critical inputs to the EU. To define foreign critical inputs (FCIs), we use two different criteria: first, a list of inputs susceptible to supply disruptions in a fragmenting global economy due to their intrinsic characteristics is compiled, which includes advanced technology products, as well as products and raw materials crucial for the green transition that are more prone to weaponisation given their increasing demand and their concentration in a rather limited number of suppliers (European Commission, 2021); second, we draw upon the research conducted by the European Commission (Arjona et al., 2023) to identify foreign critical inputs as those with a low level of import diversification, for which foreign sources are particularly relevant for the EU and where the potential for substitutability of supply from within the EU is limited.[37] According to country-level trade data, a third of foreign critical inputs imported in 2022 by the European Union

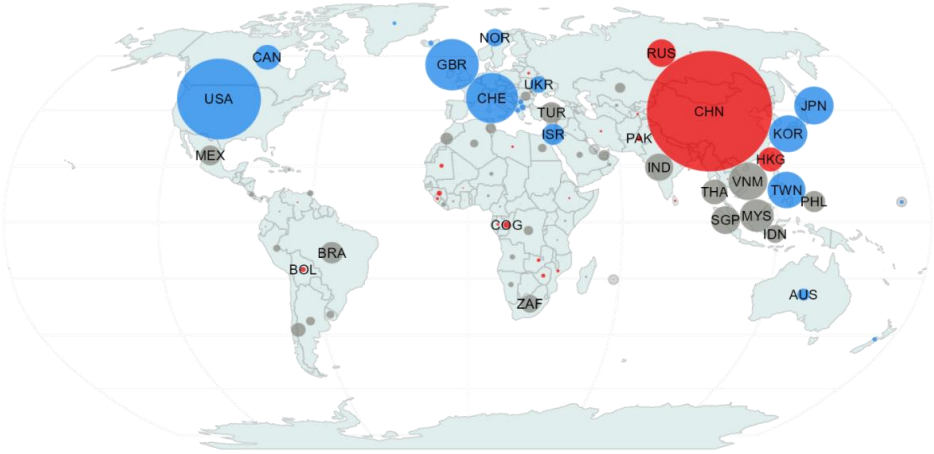
[37] In more detail, critical inputs include (i) inputs classified by the US Census as Advanced Technology Products, which are items used in various fields such as biotechnology, electronics and aerospace; (ii) inputs and raw materials crucial for the green transition, such as lithium, nickel and photovoltaic cells, with a focus on those whose exports from non-EU economies are highly concentrated; and (iii) inputs identified by the European Commission (Arjona et al., 2023) as experiencing significant levels of foreign dependencies.

from extra-EU countries came from China (Chart 14). For the EU, other relevant sources of FCIs from the eastern bloc are Russia and Hong Kong.[38]

Chart 14

A third of foreign critical inputs (FCIs) imported by the European Union from extra-EU countries originates from China

(share of exports of foreign critical inputs in EU imports of FCIs from all extra-EU countries)



Source: Authors' own elaborations based on CEPII BACI 2022 data.
Note: The bubbles represent the share of each extra-EU country's exports of FCIs in EU imports of FCIs from all extra-EU countries. Red bubbles, eastern bloc; blue bubbles, western bloc; grey bubbles, neutral bloc.

Firm-level data indicate that FCI dependence is sizeable for larger and more productive firms, which account for about half of domestic manufacturing value added and employment. Focusing on the five EU countries for which we have access to very detailed and granular information (Belgium, Spain, France, Italy and Slovenia), firm-level import data and balance sheet data are matched with the list of FCIs (see Panon et al., 2024).[39] A few facts stand out. First, in the five economies around 9% of manufacturing firms (about 34,000) are importers of FCIs, while 7% of manufacturing firms are importers of other products but do not buy FCIs from abroad. Second, about half of the economy in each of the five countries considered is directly exposed to potential supply disruptions, as firms importing at least some FCIs from the eastern bloc account for 55% of total manufacturing value added and 52% of employment. Third, these firms are found to be larger and more productive than other firms, even within narrowly defined industries. Specifically, depending on the country, they have 3.5 to 11 times more employment, 5 to 17 times

[38] Recent analyses conducted by the European Commission show that China is a leading global producer for many critical raw materials, both at mining stage (e.g. gallium and germanium) and at processing stage (e.g. magnesium and silicon metal). See Unguru et al. (2023).

[39] This granular analysis is based on 2019 data for data availability and for cross-country comparability. Thus, it does not take into account that de-risking strategies possibly implemented by firms from 2020 onwards may have reduced dependencies. See Berthou et al. (2024) for an analysis that maps dependencies and quantifies their impact at the sectoral level, rather than at the firm level, while covering a larger number of countries.

more turnover, pay 15% to 47% higher wages and have 27% to 44% higher labour productivity than non-importers of such products.[40]

A sudden drop in the supply of FCIs from the eastern bloc would reduce manufacturing value added by between 2% and 3%. A firm-level partial equilibrium model based on a production function approach is used to assess the effect of supply disruptions entailed by a sudden drop in imports of FCIs from the eastern bloc. In the model, firms combine labour, capital and intermediates, which are in turn produced using FCIs and non-FCIs. The scenario consists of a sudden drop in half of the supply of FCIs from the eastern bloc.[41] In line with business survey evidence (Attinasi et al., 2023c; Bottone et al., 2023) and the economic literature (Barrot and Sauvagnat, 2016; Atalay, 2017; Boehm et al., 2019), it is assumed that these inputs cannot be substituted in the short run with other inputs to which firms have access. In the short run supply disruptions would generate a drop in manufacturing value added of 2.0% for Belgium, 2.5% for France, 2.9% for Spain and 3.1% each for Italy and Slovenia (Chart 15). Large firms would account for about 75% of the value added drop in all countries.[42] The results for the top 1% of firms display greater heterogeneity, driving around 15% of the drop for Italy and Spain, 33% for France and Belgium and more than 50% for Slovenia.

The impact would be extremely heterogeneous across sectors and regions. The electrical equipment industry stands out as the most affected sector, with a median value added drop across countries that is more than double the overall decline (about 7%, compared with less than 3% overall). Other industries that are more significantly impacted than the median are chemicals, basic metals, electronics and machinery (Chart 16). These five most affected industries jointly account for almost one-third of manufacturing value added in the countries. Some sectors record a similar drop across countries (e.g. electronics), while country-level results are much more dispersed for other sectors (e.g. chemical industry, machinery), reflecting different cross-country specialisation. At the regional level, the very high variability in the impact of disruptions is driven by two factors (Chart 17). First, regions specialised in sectors heavily reliant on FCIs are more heavily affected; second, there is a high concentration of top producers in some regions, relying on FCIs from the eastern bloc and accounting for a relevant share of the regional value added.

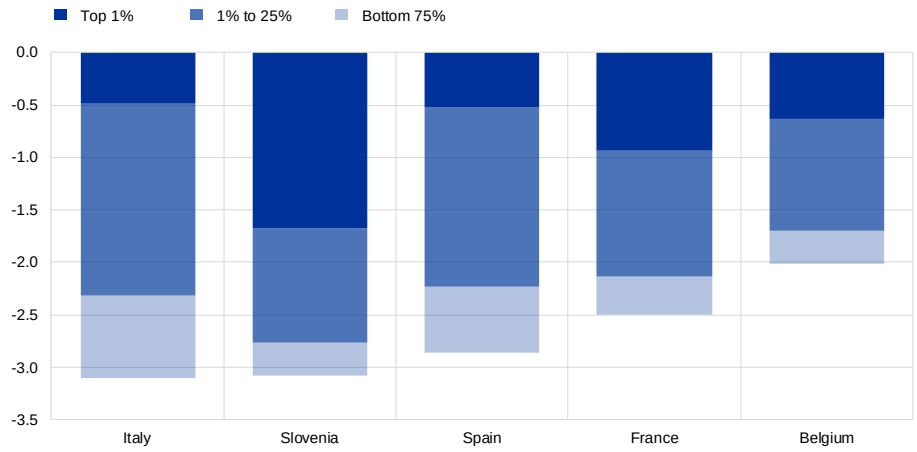
[40] To address the concern that differences in productivity between importers of FCIs and non-importers of these inputs mostly reflect size differences across importers and non-importers, the sample is further restricted to firms importing either FCIs or other products from extra-EU countries. Extra-EU importers are arguably larger than other types of importers since fixed costs associated with sourcing from outside the EU may be larger. The productivity premia in favour of FCI importers remains highly significant: importers of FCIs are 10% to 22% more productive than non-importers of FCIs, which is conditional on sourcing from extra-EU partners.

[41] The main limitations of this approach are that prices and factors of production other than FCIs are held constant and that non-directly exposed firms are not affected through indirect importing. Therefore, the framework is appropriate for studying only the short-run effects of input shortages.

[42] This is in line with recent evidence on the pandemic and GFC, suggesting that large firms account for the greater part of both collapses (Bricongne et al., 2024).

Chart 15

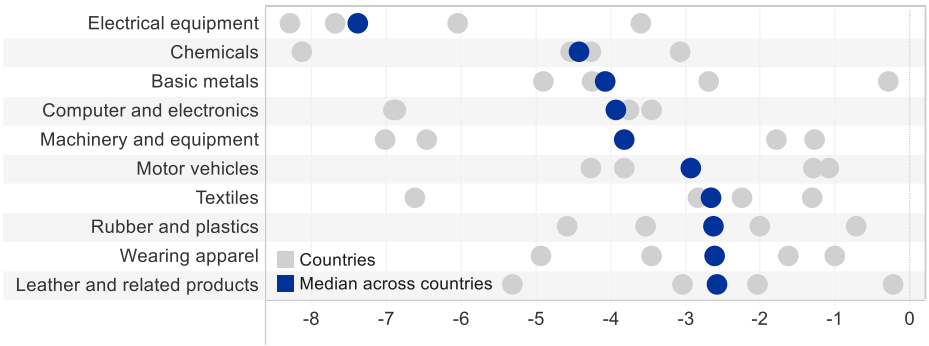
Impact of supply shortages driven by large importers



Source: Based on Panon et al. (2024).
Notes: The chart reports the value-added change (in percentage) coming from a 50% drop in foreign critical inputs (FCI) supply from China-aligned countries. Firm size measured in value added (the percentile calculation includes only exposed firms). Solely manufacturing firms are included.

Chart 16

Impact of supply shortages higher in five key industries



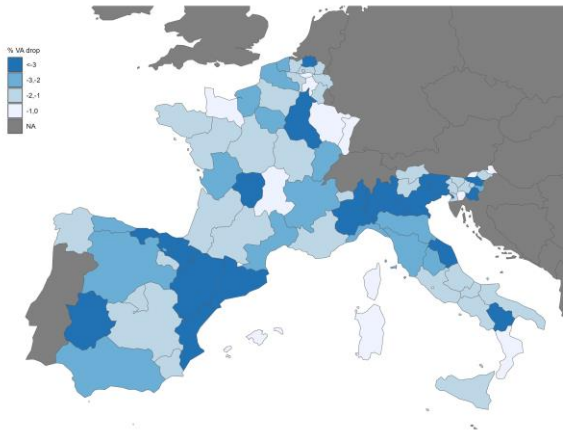
Source: Based on Panon et al. (2024)
Notes: The chart reports the value-added change (in percentage) across the most exposed manufacturing sectors coming from a 50% drop in foreign critical inputs (FCI) supply from China-aligned countries. Box and whiskers plot shows minimum, maximum, median and first and third quartiles of the impact.

Chart 17

Impact of supply shortages highly heterogeneous across regions

Change in manufacturing value added at the regional level

(percentage change)



Source: Based on Panon et al. (2024).
Notes: The chart reports the value-added change (in percentage) across regions coming from a 50% drop in foreign critical inputs (FCI) supply from China-aligned countries. Solely manufacturing sectors are considered.

3.3 Implications for central banks

For central banks to anticipate the impact of fragmentation on growth and price stability, a granular approach to identify strategic dependencies, input concentrations and vulnerabilities is crucial. Timely access to granular firm-level data is essential to analyse and monitor the fragmentation process. More specifically, regular business surveys centred on fragmentation risks and micro-level analyses based on custom data allow central banks to obtain a timely assessment of firms' and sectors' exposure to risks and short-term price pressures driven by fragmentation, which aggregate macro data are unable to uncover. Granular stress tests enable relevant micro-level patterns to be uncovered and are useful to quantify potential effects on price stability and risks to financial stability resulting from shortages in specific inputs due to fragmentation.

4 Trade fragmentation: general equilibrium effects

Trade fragmentation would entail negative economic effects for most countries. Firms' decisions to relocate production or input sourcing in response to fragmentation pressures discussed in Chapters 2 and 3 have broader economic implications not only in terms of investment, spending and employment decisions both domestically and abroad but also, ultimately, in terms of households' welfare, as well as inflation. A range of studies have shown that trade fragmentation entails significant losses for the global economy[43] and have pointed to a magnifying effect of GVCs in the presence of global shocks such as the pandemic, Brexit and the United States-China trade dispute.[44] As trade fragmentation is posed to reconfigure GVCs, a thorough analysis of its economic impact needs to account for the role of supply chains in transmitting and amplifying these shocks.

This chapter considers a wide range of fragmentation scenarios and combines a suite of models to assess the potential implications both for output and for inflation. Multi-country multi-sector (MCMS) models are useful tools for the analysis of trade fragmentation shocks (TFS), as they enable complex sectoral interlinkages to be accounted for.[45] Several studies have used these models to quantify the effects of fragmentation and have found that global output losses from TFS would vary substantially, depending on the assumptions. Estimates range from 0.5%, in the case of selective decoupling, to 12% in the most severe scenarios.[46] However, such aggregate figures partly conceal large cross-country heterogeneities, as small open economies bear the largest losses. In this chapter the MCMS model proposed by Baqaee and Farhi (2024) is used to conduct a counterfactual analysis of different fragmentation scenarios. Unlike previous works, the structure of the model is extended to allow for scenarios that replicate trade restrictions on key and selected products (Conteduca et al., 2025). In addition, to capture the effects of the transition dynamics on inflation, the analysis relies on Quintana (2024), which extends the Baqaee-Farhi model to include firms' investment decisions.[47] The evaluation of the dynamic effects of fragmentation on inflation is complemented by a novel DSGE

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43 Among others, see OECD (2020); Bonadio et al. (2021); Eppinger et al. (2021); Wu et al. (2021); Chepeliev et al. (2022); Quintana (2022); Campos et al. (2023a); Javorcik et al. (2024); Aiyar et al. (2023); and Bolhuis et al. (2023).

44 See Sforza and Steininger (2020), Cappariello et al. (2020) and Balistreri et al. (2018).

45 MCMS models with intersectoral linkages are often used to analyse global value chains. They have been popularised by Caliendo and Parro (2015) and Antràs and Chor (2018), who extended the seminal work of Eaton and Kortum (2002).

46 Among others, recent works based on multi-country multi-sector models are Goes and Bekkers (2022); Attinasi et al. (2023a; 2023b; 2024c); Borin et al. (2023b); Felbermayr et al. (2023) and Eppinger et al. (2023).

47 Despite their appeal, static MCMS models lack a deeper understanding of the dynamic effects of TFS and how they affect variables, including inflation, that are of interest to central banks. As a result, other studies (Hunt et al., 2020; Ahn et al., 2023) have employed dynamic stochastic general equilibrium (DSGE) models for the analysis of TFS, thus illustrating the usefulness of a comprehensive modelling toolkit.

model featuring trade barriers (Lechthaler and Mileva, 2024) (see Box 2 for a more extensive discussion).

4.1 Scenarios of trade fragmentation

Trade fragmentation shocks are modelled as higher barriers to trade between the western and eastern blocs whereas countries in the neutral bloc continue to trade freely. The global economy is assumed to *exogenously* fragment into three blocs, reflecting the geopolitical alignment of countries (Annex 1): a western (United States-centric) bloc, an eastern (China-centric) bloc and a neutral bloc (i.e. countries aligning with neither the western nor eastern bloc). Fragmentation takes the form of higher non-tariff barriers to trade of final and intermediate products between the West and the East. This modelling choice reflects the most recent government policies that increasingly rely on non-tariffs measures – such as regulations, trade bans and customs controls as a means to restrict trade – rather than on tariffs.

Table 1
Scenarios of trade fragmentation

	Sectors affected	Type of shock
Severe decoupling	All sectors	Full trade ban
Mild decoupling	All sectors	Partial trade restrictions
Selective decoupling	Products whose supply is more prone to be weaponised	Full trade ban – only on affected products

*Trade between East and West reverts to the one observed in the mid-1990s (i.e. before sweeping trade liberalisation policies were implemented). **Trade bans are targeted at advanced technologies, raw materials, energy commodities and products whose trade with Russia has been restricted by the EU following the invasion of Ukraine.

Three scenarios of trade fragmentation are considered, which differ along the sectoral dimension and with respect to the size of the fragmentation shock (Table 1). At one extreme, a "severe decoupling" scenario assumes that higher barriers to trade de facto halt trade flows between the two blocs.[48] At the other, a scenario called "mild decoupling" still assumes a decoupling across all sectors, but the level of trade between East and West reverts to the one observed in the mid-1990s (i.e. before sweeping trade liberalisation policies were implemented).[49] The third scenario assumes, more in line with recent evidence (see Chapter 2), a "selective decoupling", where trade restrictions target products whose supply is more prone to be weaponised (i.e. advanced technologies, raw materials, energy commodities and products whose trade with Russia has been restricted by the EU

48 This scenario assumes a trade cost increase large enough to halt trade between the opposite blocs in the affected sectors. This is in line with Campos et al. (2024) and Gopinath et al. (2024) providing evidence that trade between East and West was extremely difficult during the Cold War.

49 The magnitude of the trade shock is calibrated such that the model-implied trade between blocs matches the level of the mid-1990s, based on long-run input-output tables of Timmer et al. (2015). This magnitude is also broadly consistent with the gravity model-based estimate of the increase in international trade associated with the globalisation process since the mid-1990s (see Campos et al., 2023b).

following the invasion of Ukraine; Conteduca et al., 2025).[50] In this case, trade in other products can still be affected, as spillovers propagate through the production networks. Another important product dimension along which decoupling may occur concerns the products involved in the green transition (e.g. electric vehicles and solar panels) as also seen by recent restrictions imposed by the US administration on imports from China. However, the production network structure used to calibrate the Baqaee and Farhi model cannot account for the structural transformations that the green transition will inevitably entail and is therefore not well suited to perform simulations on a "green decoupling" scenario. This aspect, and some preliminary analyses based on projected consumption and production patterns, are discussed in greater depth in Annex 2 (Attinasi et al., 2024b).

Box 2
Modelling the effects of trade fragmentation with a suite of general equilibrium models

The analysis presented in this chapter relies on three complementary and state-of-the-art models calibrated on the OECD input-output tables for 2018.[51]

The first model is the static MCMS model of Baqaee and Farhi (2024). By featuring sectoral interlinkages, it accounts for the propagation effects of trade shocks through global production networks, as well as the substitution effects via international trade. The model simulates the endogenous transmission of shocks both downstream (to consumers) and upstream (to suppliers), simulating the non-linear effects of trade shocks across countries and sectors. Higher trade barriers create an import price shock. As a result, producers and consumers substitute away from more expensive foreign inputs and towards cheaper suppliers (either domestic or foreign unaffected by the trade shock), generating a demand shock for their upstream suppliers. These re-allocate production across countries, affecting trade along the way. It also affects demand for factors of production (capital and labour), leading both to adjustments in production structures and to changes in the disposable income of households. These substitution and re-allocation channels generate general equilibrium effects on demand and supply, which in turn affect trade, production and welfare.

Within the framework of Baqaee and Farhi (2024), different calibrations can be used to account for nominal and real rigidities. The effects of a trade shock are principally governed by two main parameters: the ease of changing suppliers and the degree of nominal wage rigidity. We calibrate two polar setups. The first is a rigid setup characterised by sticky wages and a reduced substitutability across suppliers, reflecting difficulties for producers to adjust their network of suppliers swiftly. Trade elasticities in this setup are calibrated based on the weighted median estimates of sectoral elasticities in Boehm et al. (2023). The second is a flexible setup, which allows for fully flexible wages and a higher substitutability of suppliers through larger trade elasticities based on Fontagné et al. (2022).[52] The estimates reported in the main text relate to the rigid setup, which can be interpreted as the effects of the economy not adjusting swiftly to the trade fragmentation shock. Indeed, empirical findings in the literature show that nominal wages are

50 The list of products hit by restrictions in the selective-decoupling scenario is provided in **Annex 2**.

51 For computational purposes, countries and sectors must be aggregated. Therefore, the static MCMS (section 4.2.1) uses 38 countries and 23 sectors. The dynamic MCMS (section 4.2.2) uses 10 countries and 24 sectors. The DSGE model (section 4.2.2) uses 3 countries and 2 sectors.

52 It is worth noting that, with both types of assumptions, the model estimates general equilibrium effects.

usually sticky (Le Bihan et al., 2012; Taylor, 1980), and supply chains inflexible (Barkema et al., 2019), at least in the short term to medium term. Should appropriate economic policies be implemented to mitigate the effects of trade fragmentation, rigidities would tend to dissipate over time and the economy would gradually adjust towards the flexible setup. To that end, the higher elasticities of the flexible setup may also reflect, to some extent, mitigation strategies adopted by countries, which are not endogenous in the model.

The second model is a dynamic extension of Baqaee and Farhi (2024), enabling the impact of the trade fragmentation shock on inflation dynamics to be explored. While Baqaee and Farhi (2024) can account for rigidities that tend to be more binding in the short term, it cannot provide a transition dynamic towards the new equilibrium. Dynamic effects are modelled using Quintana (2024), who extends the Baqaee-Farhi model to include investment decisions by introducing the assumption that capital is produced by firms with investment goods that can be sourced domestically and internationally, such as intermediate goods. This creates a mechanism in which producers set their level of desired capital based on their anticipations of future economic conditions. In this setting, the endogenous capital accumulation adds a new propagation channel, as in response to a fragmentation shock, with producers in the West and the East adjusting towards a lower desired stock of capital as demand prospects worsen and investment goods become more expensive. This results in more scarring effects from fragmentation.

4.2 General equilibrium effects of trade fragmentation

4.2.1 The impact on activity and global value chains configuration

Losses from trade fragmentation depend on the breadth of affected sectors and can be sizeable. Unsurprisingly, real GDP losses from trade fragmentation are larger in the severe decoupling scenario given the extensive size of the decoupling. In case of selective decoupling, losses are smaller but still significant (Chart 18, panel a). The presence of real and nominal rigidities (Box 2) contributes to larger losses, as they impair a country's ability to adjust and substitute away from more expensive foreign inputs. In the severe-decoupling scenario, real output drops by as much as 8%. GDP losses can be mitigated if the economy is substantially more flexible, with producers and consumers substituting across suppliers, as well as factors of production shifting to sectors in higher demand and wages adjusting.[53] In the extreme case of a fully flexible global economy, GDP losses would indeed be markedly lower.

Trade fragmentation may inflict more scarring effects on the global economy by impairing capital accumulation. As discussed in Box 2, producers in the western and eastern blocs adjust towards a lower desired stock of capital in response to a fragmentation shock, as demand prospects worsen and investment

[53] In more flexible economies, changes in relative prices could also be absorbed by firms' profits – notably for products with a high degree of competition. However, this potential mitigating factor is not accounted for in MCMS models.

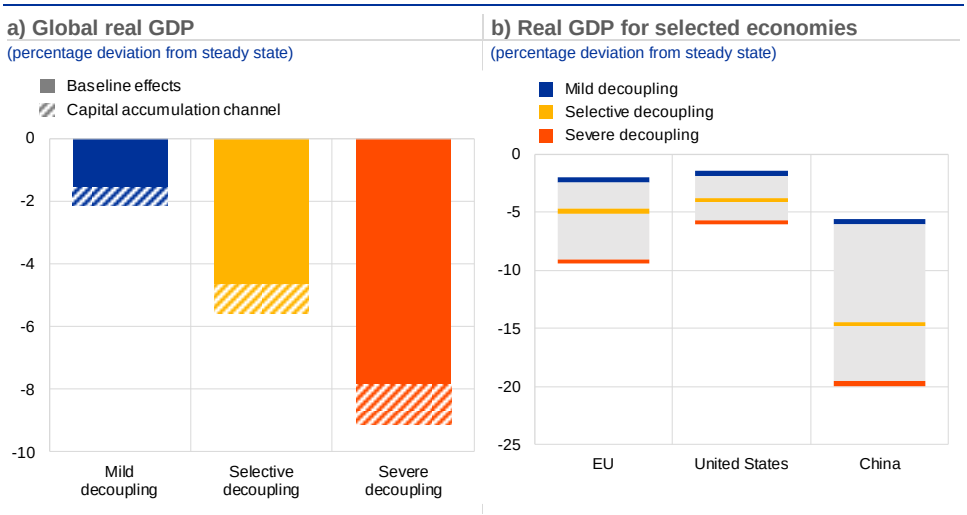
goods become more expensive. This mechanism adds a new transmission channel stemming from fragmentation to the global economy. Compared with the static setting, the capital accumulation channel entails additional losses, as a lower capital stock weighs on global growth (Chart 18, panel a).

Losses at the country level may be sizeable. Real output losses would be heterogeneous across countries, with small open economies that trade more with the opposite bloc (e.g. Taiwan) experiencing larger losses than bigger economies whose internal market mitigates the adverse effects of trade fragmentation. For the United States, losses would range between 2% and 6% depending on the scenario (Chart 18, panel b). For the EU, losses would be larger and range between 2.4% and 9.5%. The larger losses compared with the United States are explained by the EU's relatively higher trade openness and stronger integration into GVCs.[54] Among large economies, China stands as the hardest hit, with losses close to 20% in the severe-decoupling scenario. This reflects the smaller size of the eastern bloc compared with the western bloc, along with China's greater exposure to exports directed toward the western bloc in line with its export-oriented growth model.

Trade fragmentation would entail a reorientation of trade flows to the advantage of the neutral bloc amid substantial losses for the export-oriented eastern bloc. Once the economy adjusts to the new steady state, the East, which is more dependent on exports to the West, loses more than the West in terms of exports (around 50% in the severe-decoupling scenario). Trade will be diverted towards the neutral bloc. Nevertheless, losses in the trade flows between opposite blocs are not fully compensated for by trade diversion within each bloc or towards the neutral bloc, causing sizeable net trade losses at the global level.

Chart 18

Output losses across fragmentation scenarios



Sources: Baqaee and Farhi (2024), Conteduca et al. (2025), OECD TiVA, EORA, Quintana (2024) and authors' calculations.

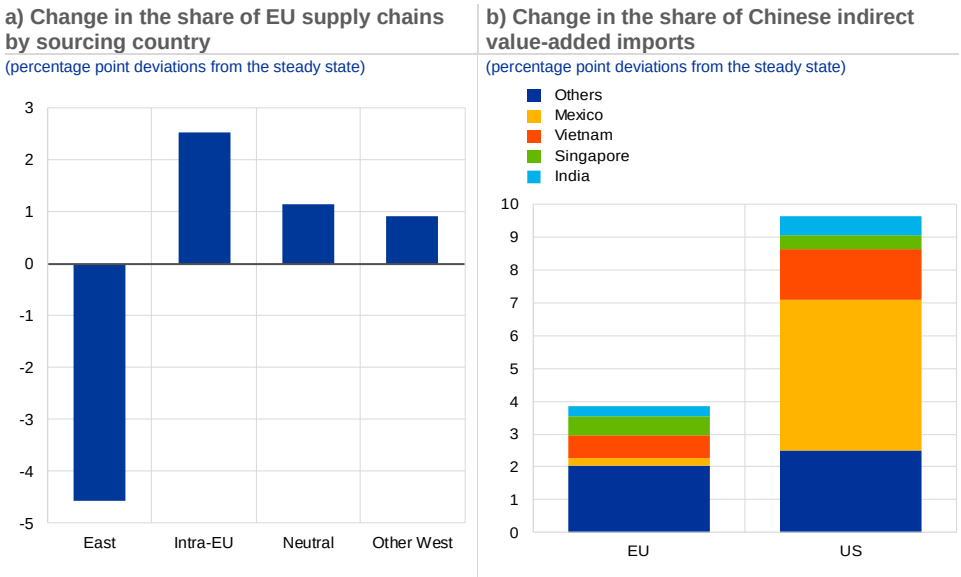
54 Within the EU, the smaller economies that are more connected to the eastern bloc, such as the Baltics and the central eastern European economies, would be more significantly affected by the trade fragmentation shock.

Notes: Non-linear impact simulated through 25 iterations of the log-linearised model. In panel a) the additional impact from capital accumulation is based on Quintana (2024). Effects of the capital accumulation channel for selective decoupling (not feasible in Quintana, 2024) are interpolated from mild decoupling and severe decoupling. In panel b) values include the additional impact from the capital accumulation channel. The EU aggregate also includes results for EFTA countries due to model-based aggregation.

The selective-decoupling scenario would entail a profound reconfiguration of trade patterns, primarily through increased regionalisation and the diversion of restricted products through third countries. While the aggregate level of openness and integration in value chains might not be significantly affected in the selective-decoupling scenario, supply chains would become more regional (Conteduca et al., 2025). In the EU, for instance, supply chains would be reallocated mostly within the region (i.e. EU-shoring) but also towards neutral countries and other western economies (Chart 19, panel a). Second, specific restricted Chinese products, particularly high-tech electronics, would reach the western bloc via third countries, thereby increasing indirect dependencies. What would be observed is an increase in indirect trade from China both for the EU and, to a greater extent, for the United States relative to direct trade severely hit by tariffs, (Chart 19, panel b). This suggests that a full decoupling from China cannot be easily achieved through standard trade bans.[55] In fact, even targeted products find an indirect route to reach the opposite bloc, mainly through Mexico, Vietnam, Singapore and India.[56] These results align with the initial signs of supply chain reconfiguration found in recent trade data reported in Chapter 2.

Chart 19

Reconfiguration of supply chains driven by regionalisation and lengthening



Sources: Conteduca et al. (2025), OECD TiVA, EORA, and authors' calculations.

55 This result holds in the presence of the type of trade restrictions considered in the report, i.e. higher direct trade barriers between countries. However, other trade restrictions that are more sophisticated may be in place, targeting trade between third countries and setting content requirements for specific goods. While these measures are available in the policymaker's toolkit, it should be noted that they are difficult to design, potentially harming partners, and that the framework considered here is not suitable for addressing them.

56 The role of India is less relevant compared with the other manufacturing hubs, as its specialisation in services trade would limit the scope of its re-exports of Chinese inputs.

Note: The charts compare the baseline configuration of supply chains against the configuration that would emerge in the selective-decoupling scenario under the the flexible setup. Supply chains are measured as imports crossing at least two borders (see Borin et al., 2021); Chinese indirect value added imported by the EU and United States is defined in conformity with Borin and Mancini (2023). The deviations in the left-hand charts sum to zero. The deviations in the right-hand chart would be the same, but with opposite signs, for Chinese direct value-added imports.

The above estimates of the impact of fragmentation should be considered as a lower bound, as several other channels may be at play in addition to trade. The simulations presented in this report focus predominantly on the trade channel, abstracting from other key potential amplification effects. These include impaired knowledge diffusion (Cai et al., 2022), financial amplification (Berthou et al., 2018), frictions to migration and demography (Banerjee and Duflo, 2007) and macroeconomic uncertainty (Caldara et al., 2020). Therefore, our results are likely a lower bound estimate of the losses from trade fragmentation.

Fragmentation losses could increase substantially in the event that trade tensions also escalate among countries that belong to the western bloc. While the fragmentation scenarios considered so far assumed a decoupling only between the western and eastern blocs, it cannot be ruled out that trade frictions arise also among countries within the same bloc, as geopolitical motivations may shift. Losses would increase substantially in this case, as trade between close partners would be affected, as shown in Box 3.

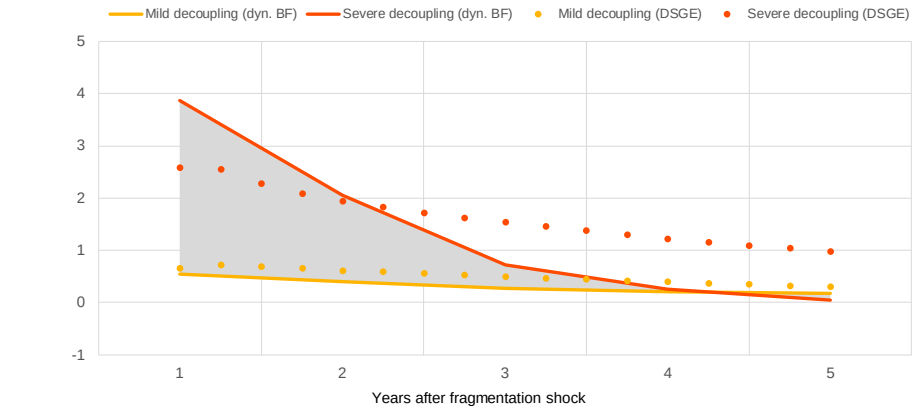
4.2.2 The impact on inflation

Trade fragmentation may lead to higher inflation which would subside only gradually. The trade disruptions associated with fragmentation will lead to higher consumer and producer prices, as access to cheaper foreign suppliers becomes impaired. This import price shock leads to higher inflation, as firms adjust their capital stock and network of suppliers only progressively. Therefore, their cost structure remains suboptimal for some time, implying that the economy experiences inflationary pressures in adjusting to the new regime. Moreover, as workers demand higher wages to recoup the purchasing power losses incurred from higher prices, the higher wages in turn stoke price pressures further. At the global level, fragmentation translates into higher inflation rates. In the severe-decoupling scenario, inflation is up to 4 percentage points higher in the first year after the shock (Chart 20, panel a). As economies adjust only gradually, fragmentation still entails a higher inflation rate five years after the shock. In the mild-decoupling scenario, the impact on inflation rates is lower (around 0.6 percentage point in the first year) yet more persistent. Estimates from the DSGE model developed by Lechthaler and Mileva (2024) also point to higher and persistent inflationary effects of fragmentation. The inflationary impact across countries differs depending on the exposure to trade with the other bloc; the impact in China is higher compared with the euro area and the United States given China's higher reliance on western imports.[57]

[57] Since the model by Quintana (2024) does not feature inflation expectations, the potential effect of trade fragmentation on inflation expectations is not captured in the simulations.

Chart 20

Impact of fragmentation scenarios on global inflation



Sources: Quintana (2024), Lechthaler and Mileva (2024), OECD TiVA, EORA and authors' calculations.
Note: "Dyn. BF" refers to the dynamic extension of the Baqaee-Farhi model by Quintana (2024), and "DSGE" refers to the dynamic stochastic general equilibrium model used by Lechthaler and Mileva (2024).

As a result of the fragmentation shock, second-round effects would increase the persistency of inflation. Focusing on euro area *core* inflation, a key variable in the monetary policy decision process, panel a) of Chart 21 illustrates that the duration of the high-inflation period would depend significantly on how wages adjust in response to inflation. Since the initial disruption of supply chains would increase the relative cost of materials, energy and capital compared with labour, the initial shock could become more persistent due to second-round effects once wages begin to regain lost purchasing power. In the event that the recovery of workers' purchasing power is limited, core inflation would return close to the target level after five years. In contrast, a stronger adjustment of wages in response to inflation, would result in euro area core inflation remaining significantly above the target even after five years.[58] This mechanism may be further exacerbated by the frequency at which firms adjust their prices, which has been shown to be particularly high during periods of high inflation (for the euro area, see Gautier et al., 2024).

The impact on inflation of a severe decoupling would be significantly higher than what the EU experienced as a result of Russia's weaponisation of its gas supply. Before the Russian invasion of Ukraine, Russian supplies accounted for about 45% of Europe's imported natural gas.[59] As a result of the sharp reduction in the gas supply and amid fears of limited substitution possibilities, European gas prices surged by around 300% in the third quarter of 2022 compared with the previous year. The empirical evidence suggests that the contribution of this price increase on core inflation has been substantial (Figure 21, panel b) (Bańbura et al., 2023; Alessandri and Gazzani, 2023). Our results suggest that a more widespread

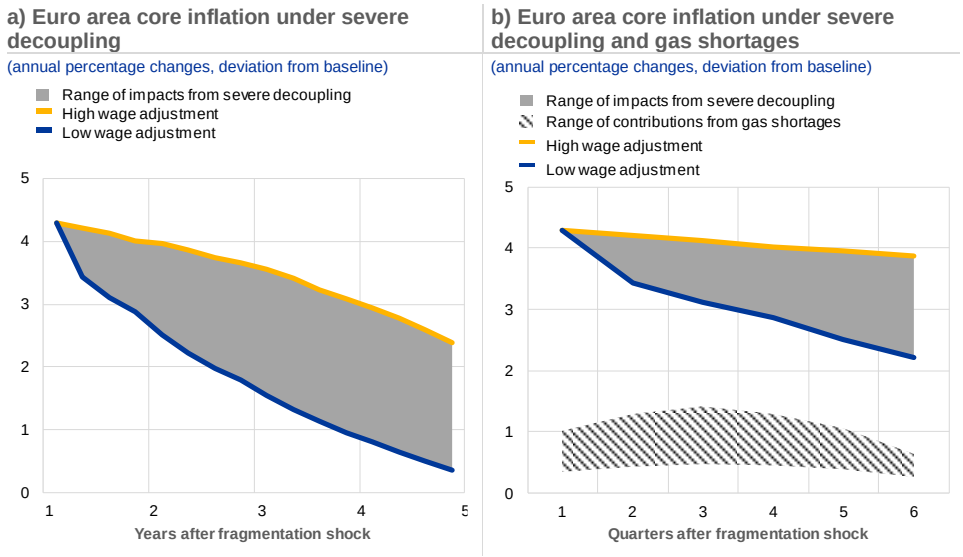
[58] Most models assume partial wage indexation (50% of the previous year's inflation; e.g. Jadresic, 1996; de Schryder et al., 2020), but the literature also points out that wage indexation tends to be higher during high-inflation spells (e.g. Ehrenberg et al., 1983) and could be as high as 90% (Hofmann et al., 2012).

[59] See https://energy.ec.europa.eu/news/focus-eu-energy-security-and-gas-supplies-2024-02-15_en.

weaponisation of supply lines such as the one assumed in the severe-decoupling scenario would entail a much higher impact on inflation.

Chart 21

Inflationary impact of fragmentation scenarios



Sources: Quintana (2024), Bańbura et. al. (2023), Alessandri and Gazzani (2023), OECD TiVA, EORA and authors' calculations.
Note: In panel b), the empirical estimates are based on the period from the third quarter of 2022 to the fourth quarter of 2023.

Anticipation of fragmentation can affect the global economy as firms revise their investment plans downwards ahead of the actual trade shock. If producers anticipate a fragmentation shock, i.e. a worsening of demand prospects, they may start adjusting downward the desired level of capital, thus negatively affecting production.[60] While the anticipation effects smooth the transition path as producers pre-emptively adjust their demand for investment goods, they also imply that inflation and GDP might be affected even before the actual fragmentation shock has occurred. This channel is, therefore, very relevant from the perspective of a central bank navigating a fragmenting trading system.

Box 3

Navigating trade tensions with the East as friend or foe?

Throughout this report the partition of the global economy in three distinct blocs is used as a narrative device to analyse the effects of trade fragmentation. However, the precise contours of trade fragmentation are uncertain, as geopolitical considerations may shift. To account for that possibility, this box looks at the economic effects of a scenario where, in addition to the severe decoupling scenario that is considered in Section 4.2, further fragmentation of trade relationships occurs among countries belonging to the western bloc and vis-à-vis the neutral bloc. More specifically, this box looks at a situation in which the geopolitical alignment of countries in the West breaks apart. In this respect, two additional scenarios are considered.

60 The overall impact on capital accumulation stemming from anticipation is negative, and it results from a negative *volume* effect on capital accumulation and a smaller positive *price* effect that pushes demand up since investment goods from the opposite bloc would become more expensive after fragmentation.

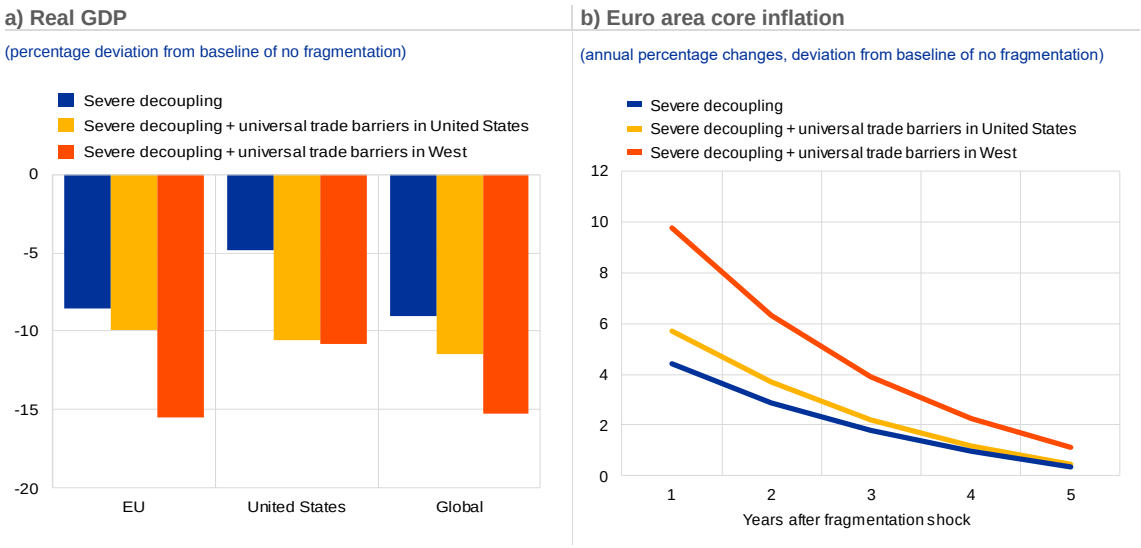
First, it is assumed that the United States imposes partial trade restrictions on trade with countries in the western and neutral blocs, prompting retaliatory measures. While in the severe decoupling scenario US trade with other western and neutral economies endogenously increases owing to trade diversion in response to a halt of trade with the East, in the first scenario examined here trade flows between the United States and the non-eastern economies decline by about one-fourth. The second scenario assumes that all of the countries within the western bloc impose partial trade restrictions among themselves, except for EU member states which do not impose barriers on other EU member states, and vis-à-vis the neutral bloc, leading to a drop in trade flows within the West by about one-fourth. In this scenario countries in the neutral bloc continue to trade freely among themselves and with the eastern bloc, but retaliate against the West which similarly leads to a downturn in neutral countries' trade with the West by about one-fourth.

Panel a) of Chart A illustrates the effects on real GDP for the EU, the United States and the global economy. In a scenario in which, on top of severe decoupling, the United States also imposes trade restrictions against all of its non-eastern trading partners, and these retaliate, real GDP losses for the United States would nearly double, reaching almost 11%, whereas EU losses would only slightly increase to 10% (Chart A, orange bars). The additional losses are significantly larger for the United States, as its trade flows with both western and neutral economies face restrictions. In contrast, the EU experiences no trade restrictions with other western economies and neutral countries, allowing its trade flows with them to continue unaffected. In a scenario in which also countries within the West, including the EU, impose trade restrictions among each other and against the neutral bloc, and the latter retaliates, losses would rise substantially for the EU and at the global level (Chart A, red bars).

Additional inflationary effects would materialise if, in addition to a severe-decoupling scenario, trade barriers are introduced also among countries in the western bloc. For the euro area, core inflation would be around 1.3 percentage points higher in the event that the United States adopts universal trade barriers against the remaining trading partners, and it would be significantly larger and persistent in the case of a more generalised trade decoupling also among western economies (Chart A, panel b). Moreover, the United States would experience higher inflation as a result of a decoupling from its trading partners in the western and neutral blocs. Core inflation would increase by about 3.3 percentages points in the first year if the United States adopts universal tariffs on its imports vis-à-vis the other countries in the western and neutral blocs. These results, while being extreme and quite stylised, provide a warning about the self-defeating nature of trade fragmentation.

Chart A

Additional impact of decoupling within the western bloc



Notes: Non-linear impact simulated through 25 iterations of the log-linearised model. In panel a), the additional impact from capital accumulation is based on Quintana (2024).

4.3 Implications for central banks

Trade fragmentation entails higher inflation which converges back to target only gradually, thus creating a challenging environment for central banks. The stylised counterfactual exercise of this chapter shows that trade fragmentation shocks are akin to supply shocks; as such, they entail large losses in global trade and output, as well as strong and persistent inflationary pressures.[61] The analysis also shows that the economic impact depends on the degree of nominal rigidities in the economy, with larger effects in more rigid set-ups. In addition, mere anticipation of fragmentation can lead to adverse effects on GDP and inflation, thus complicating the operational environment of central banks.

To better understand fragmentation and its effects, central banks' modelling tools should account for the interconnected nature of the economic sectors. The analysis highlights the finding that losses from trade fragmentation can lead to inflationary effects extending beyond the targeted products, as the shocks propagate *via* sectoral interlinkages. In this context, central banks face the challenging task of assessing whether fragmentation shocks are expected to have a transitory effect on inflation or else are likely to affect inflation over the medium term, which is what matters for monetary policy (de Cos, 2024). Albeit outside the scope of this report, it should be noted that the persistency of inflationary pressures might not be independent of the central banks' reaction (Boivin et al., 2009; Hirose et al., 2023).

[61] Using a heterogeneous agent, open economy model Tenreyro et al. (2024) show that the impact of fragmentation on inflation depends not only on the direct effect of higher import prices on supply but, crucially, on how aggregate demand adjusts in response to lower real incomes and productivity stemming from fragmentation.

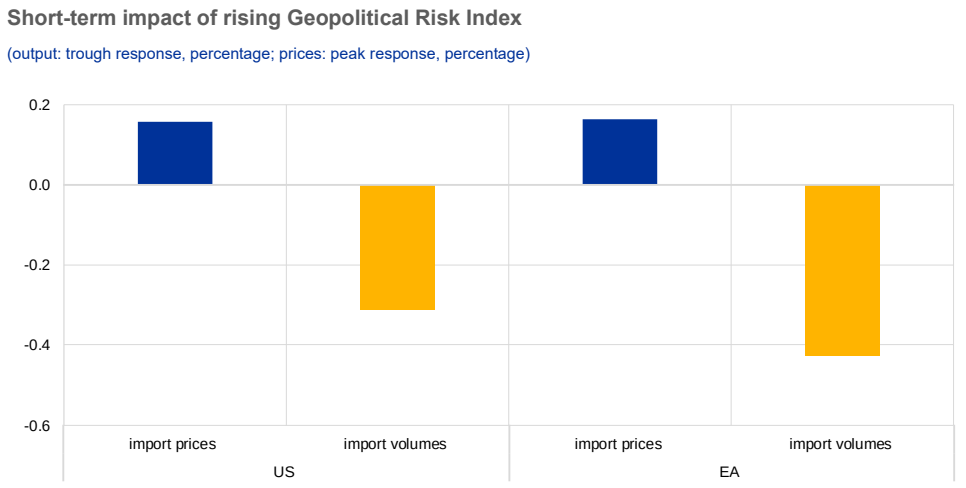
Therefore, central banks should enrich their analytical tools with models capturing a sectoral perspective to reflect the transmission of shocks.

5 Trade fragmentation and relative price shocks: a harbinger of inflation?

The potential effects of trade fragmentation on inflation are of key interest for central banks. The model simulations presented in Chapter 4 showed that trade fragmentation can have a long-lasting effect on global inflation, as it takes time for the global economy to adjust to fragmentation-driven supply shortages. Recent events suggest that, as geopolitical tensions escalate, interdependencies within supply chains can be wielded as strategic tools in the political rivalries between states. In this respect, rising geopolitical tensions can act as a supply shock on trade. Khalil et al. (2024) support this view. Using the Geopolitical Risk Index (GPR) of Caldara and Iacoviello (2022)[62] as a proxy for geopolitical risk, they focus on the United States and the euro area and find that a shock that increases a trading partner's GPR index reduces imports from this country and raises average import prices in both jurisdictions (Chart 22).[63,64]

Chart 22

Rising geopolitical tensions act as a supply shock on trade



Notes: The chart reports effects for the United States and the euro area from increasing a trading partner's GPR index by 50% on imports and import prices from this country. From Khalil et al. (2024).

[62] The authors define geopolitical risk as the threat, realisation and escalation of adverse events associated with wars, terrorism and any tensions among states and political actors that affect the peaceful course of international relations. The GPR is a news-based measure of adverse geopolitical events and associated risks.

[63] A priori, it is unclear how a positive GPR shock affects trade dynamics, as various channels might be at play. In the extreme case of armed conflict, imports volumes would decline and import prices would rise. In less severe cases, an increase in risk premiums on import financing or higher freight and insurance costs could weigh on prices, giving rise to supply type shock patterns. However, demand type shocks patterns are also plausible, as precautionary importers may react to GPR shocks by increasing inventories in the short run and de-risking supply chains in the medium term – moving both import volumes and prices in the same direction.

[64] The findings suggest that, in the short run, GPR matters quantitatively. The effect fades after about one and a half years. The impact of a GPR shock is found to be stronger when geopolitically distant trading partners are affected, suggesting that GPR shocks may support the process of trade fragmentation.

In a fragmenting trading system, sector-specific or product-specific supply shocks risk becoming more frequent. This is likely to result from weaponisation strategies, where a country holding a dominant position in the supply of a specific product (e.g. energy, raw materials, semiconductors) or a high degree of specialisation in certain production stages tries to harm its rivals by restricting their access to those products. A prime example of such weaponisation was when Russia significantly reduced natural gas supplies to Europe following its invasion of Ukraine in 2022. Alessandri and Gazzani (2023) and López et al. (2024) showed that the ensuing gas supply disruptions were a key driver behind the surge in inflation in Europe in 2022, with long-lasting effects on price dynamics.

This chapter delves deeper into the role of sectoral price shocks as a channel through which fragmentation could affect inflation. First, an empirical analysis for the euro area and the United States examines how sharp increases in the prices of specific goods can affect aggregate inflation. Second, a counterfactual model-based simulation is used to understand how the occurrence of these large relative price shocks may change in a fragmented global economy. The latter is motivated by the consideration that, in a fragmented world, trade flows would become more regionalised or concentrated within geopolitically aligned blocs as a result of trade barriers or de-risking strategies adopted by firms (see Chapter 2). On the one hand, the exposure of such shocks may increase owing to the decreased geographical diversification of input sources and final demand (i.e. friend-shoring and near-shoring) (Borin et al., 2021; Bonadio et al., 2021; Caselli et al., 2020; IRC, 2023); on the other hand, reducing trade dependencies may shield countries from global shocks (De Soyres and Franco, 2019), thereby reducing the volatility of shocks to inputs of production. The results we provide support the view that the former argument would win over the latter.

5.1 Fragmentation pressures matter for aggregate inflation

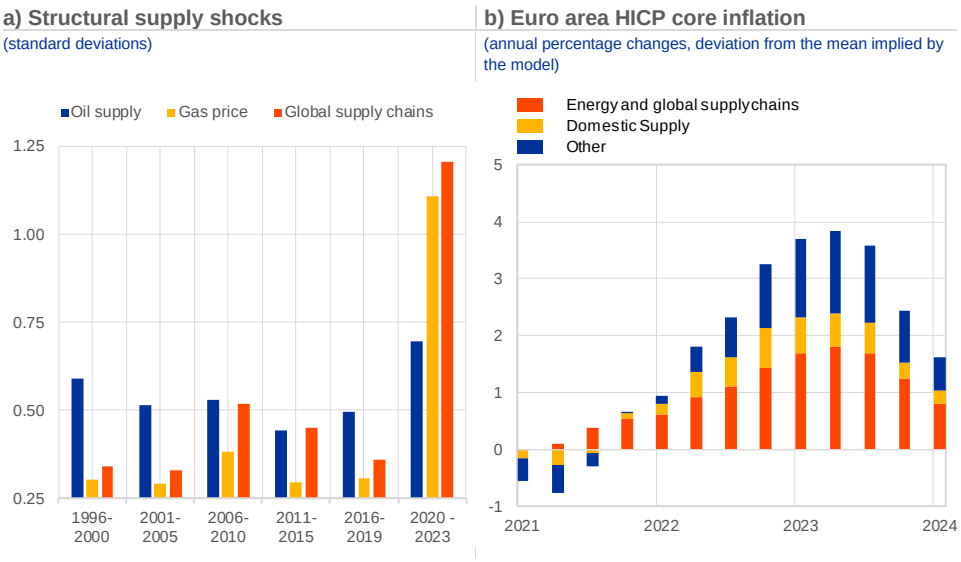
The supply disruptions experienced in recent years have shown how sectoral price shocks may significantly contribute to a surge in inflation. Bańbura et al. (2023) document that in the post-pandemic period and amid increasing geopolitical tensions, disturbances both to gas and oil prices and to global supply chains became larger and more frequent (Chart 23, panel a). The authors also show that these disturbances, which originated outside the euro area, significantly contributed to the surge in its headline and core inflation (Chart 23, panel b). Before the pandemic, the prevailing view was that, when faced with temporary supply shocks, major central banks could use their credibility to “look through” such shocks, as deviations from the inflation target would dissipate as relative prices adjust.[65] However, in a world economy faced with fragmentation pressures (see also Chapter 4), central banks

[65] However, the dynamic version of the model used in Chapter 4, which accounts for capital accumulation, shows that shocks to import prices may generate more lasting inflationary effects.

may need to pay closer attention to supply shocks, even if temporary, as the latter tend to become larger, more frequent and result in aggregate inflationary effects.

Chart 23

Fragmentation-like supply shocks explain bulk of recent surge in euro area core inflation



Source: Bańbura et al. (2023).
Notes: Panel a) shows the point-wise mean of the posterior distribution of the historical decomposition of core inflation. "Energy and supply" capture gas price, global supply chain, oil demand and oil supply shocks. "Domestic supply" captures labour market and other domestic supply shocks. "Other" captures various demand shocks and idiosyncratic components.

The significant role of supply disruptions in explaining the recent inflation surge in the euro area and United States brings into focus the role of industry-specific shocks. Ball and Mankiw (1995) argue that there are non-linearities in price adjustments: since the latter are costly, when faced with large shocks as opposed to small ones, firms tend to adjust prices. Accordingly, large supply shocks can have a disproportional effect on inflation. Building on the earlier intuition of Ball and Mankiw (1995), Rubbo (2024) shows that bottlenecks in the supply of industry-specific inputs after the pandemic were one of the first forces to ignite the global inflation cycle that started at the end of 2020. More generally, Ruge-Murcia and Wolman (2022) find that sectoral shocks were major contributors to the deviations of inflation from target in the United States. Other contributions have demonstrated that, with large inflationary shocks, the frequency of price changes increases, resulting in stronger and faster inflation dynamics (Klenow and Malin, 2010; Nakamura and Steinsson, 2013). Moreover, when prices become more volatile or when larger shocks occur – something that is expected to happen in a fragmenting world – the transmission of shocks to consumer prices tends to be more pronounced (Acharya et al., 2023; Arndt and Enders, 2024).

Box 4

Relative price shocks and aggregate inflation: an empirical approach

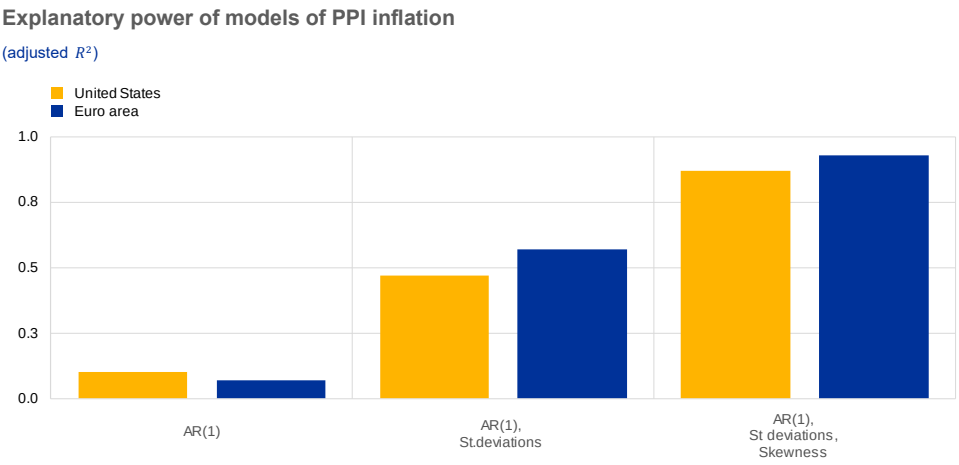
Attinasi et al. (2024a) update the analysis of Ball and Mankiw (1995) for the United States and extend it to the euro area. Ball and Mankiw (1995) argue that, in the presence of large shocks to relative input prices, firms have an incentive to adjust output prices. Large relative price changes associated with industry-specific supply shocks are gauged by means of the skewness of the cross-sectional distribution of (intermediate demand-weighted) input price changes. The skewness measures the asymmetry of a given distribution around its mean and it can be positive (when the right tail of the distribution is longer or fatter than the left tail) or negative (when the left tail of the distribution is longer or fatter than the right tail). Therefore, large positive price changes will be associated with a distribution which is skewed to the right, and negative price changes with a distribution skewed to the left.

The analysis relies on OLS regressions of headline PPI inflation on the second and third moments (variance and skewness) of the cross-sectional distribution of (intermediate demand-weighted) input price changes, as well as lagged inflation to capture persistence. The analysis utilises an annual dataset of year-on-year growth rates of industry-specific input prices, disaggregated at the four-digit sector level for both regions. The data cover the period 1952-2023 for the United States and 2000-23 for the euro area.

The regressions confirm the positive relationship between skewness of input prices and PPI inflation in the United States and euro area. In the regressions for both regions, the skewness is statistically significant and positively related to headline inflation. Moreover, adding skewness to the regressions substantially increases the R-square for both regions' regressions compared with more modest increases when adding standard deviations, suggesting that inflation is related to the occurrence of large relative price changes (Chart B). In turn, the analysis suggests that a bulk of the post-pandemic surge in inflation was associated with large relative input price shocks (Chart 25, left-hand panel), in line with the findings of the recent literature on drivers of inflation in the post-pandemic period (see, for example, Bańbura et al., 2023).

Chart B

Large shocks in relative prices are related to PPI inflation



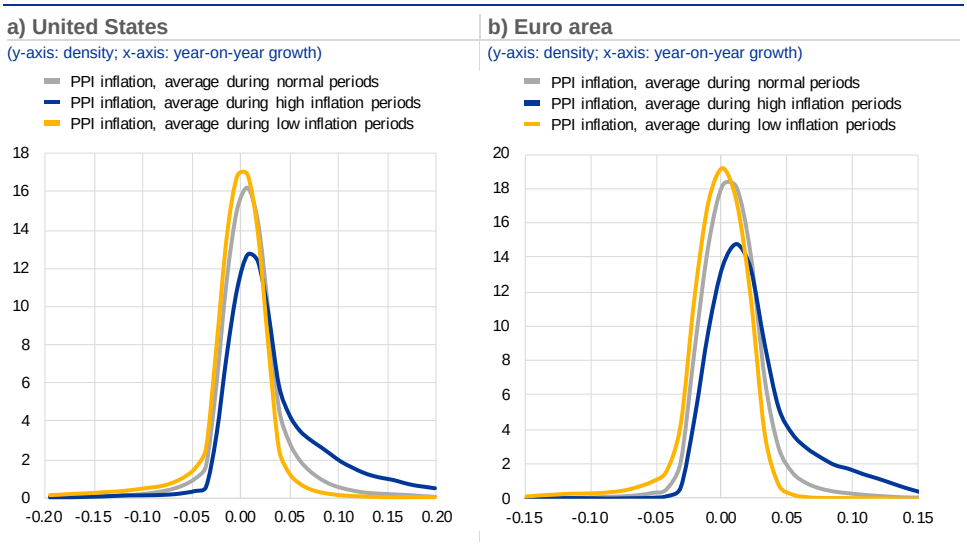
Source: Attinasi et al. (2024a).
Notes: Results from OLS regressions of year-on-year PPI growth on a set of independent variables. For the United States and the euro area dependent variables are PPI growth based on the intermediate demand weights and PPI growth for non-energy industrial goods respectively. Left-hand panel; "AR(1)" refers to an auto-regressive model $\Delta PPI_t = \beta_0 + \beta_1 \Delta PPI_{t-1} + \epsilon_t$. "AR(1), St.deviations" adds to regression line as the standard deviation of the cross-

sectional distribution of year-on-year input price growth $\Delta PPI_t = \beta_0 + \beta_1 \Delta PPI_{t-1} + \beta_2 StDev_t + \epsilon_t$. "AR(1), St.deviations, Skewness" augments the previous model with a variable that captures the skewness of the cross-sectional distribution of year-on-year input price growth, as well as an interaction term with standard deviations (following the regression specification in Ball and Mankiw, 1995) $\Delta PPI_t = \beta_0 + \beta_1 \Delta PPI_{t-1} + \beta_2 StDev_t + \beta_3 Skewness_t + \beta_4 (Skewness_t \cdot StDev_t) + \epsilon_t$.

Large swings in input prices tend to be associated with higher PPI inflation both in the United States and in the euro area. In line with Ball and Mankiw (1995), Attinasi et al. (2024a) gauge the occurrence of large relative price changes linked with industry-specific supply shocks by means of the *skewness*[66] in the cross-sectional distribution of changes in input prices (Box 4). Chart 24 plots the distribution of intermediate input prices during different inflation periods both in the euro area and in the United States. The skewness of input price changes positively correlates with headline PPI inflation in both regions. For instance, years with significant positive skewness saw high PPI inflation (e.g. 1973, 1980 in the United States; 2000 in the euro area), while negative skewness years had low PPI inflation (e.g. 2009). The recent inflationary period in 2021-22 also coincided with large positive skewness in input prices, reflecting substantial relative price shocks in energy and manufacturing. A formal econometric analysis confirms this positive relationship between skewness in input prices and PPI inflation for both regions (Box 4). This analysis suggests that a significant part of the post-pandemic surge in PPI inflation was linked to large relative input price changes (Chart 25, panel a). Moreover, the empirical literature indicates a significant, albeit lagged, pass-through of PPI to CPI inflation, suggesting that large changes in relative input prices affect CPI inflation (Sidaoui et al., 2009; Ahlander et al., 2023), consistent with recent findings on CPI inflation drivers in the post- pandemic period.

Chart 24

Distribution of intermediate input prices indicates large relative price shocks.



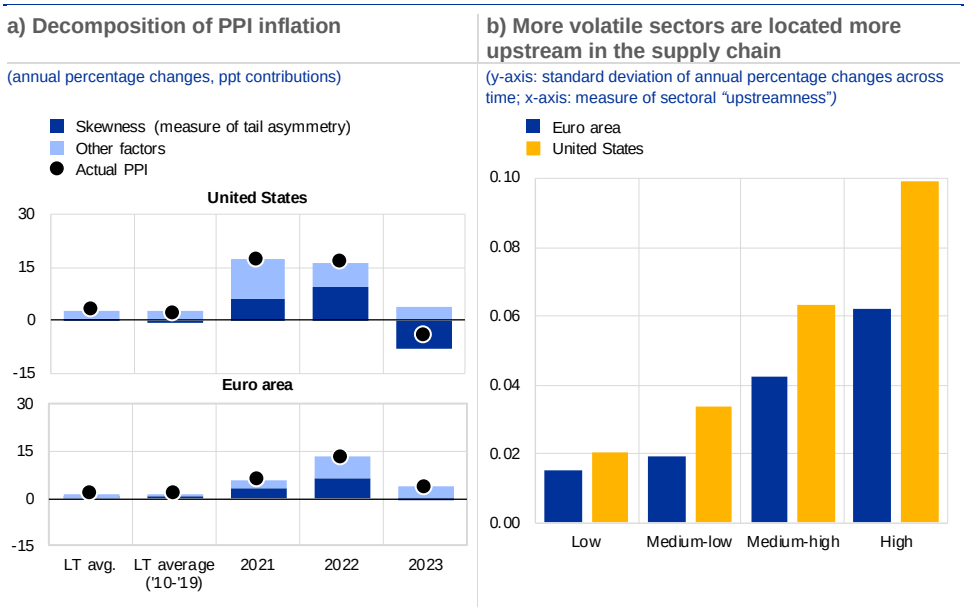
Sources: Bureau of Labour Statistics, Bureau of Economic Analysis, Eurostat and ECB staff calculations.

[66] The skewness measures the asymmetry of a given distribution around its mean and it can be positive (when the right tail of the distribution is longer or fatter than the left tail) or negative (when the left tail of the distribution is longer or fatter than the right tail). For more details, see Box 4.

Notes: Distributions are based on year-on-year growth of four-digit PPI indices for the US (1950-2023) and weighted by intermediate demand weights, while for the euro area (2000-23) they are based on year-on-year growth of four-digit input price indices weighted by intermediate demand weights. Growth rates are shown in decimals. Distributions marked in blue (yellow) represent an average over years with annual headline PPI inflation showing at least one standard deviation above (below) the long-term average calculated over the whole sample. For the United States, periods with high inflation are 1951, 1973, 1974, 1975, 1978, 1979, 1980, 2004, 2008, 2010, 2011, 2021 and 2022, while periods with low inflation are 1952, 1953, 1967, 1985, 1986, 1991, 1998, 2002, 2009, 2015, 2016, 2019 and 2020. For the euro area, periods with high inflation are 2011, 2021 and 2022, while periods with low inflation are 2009, 2013, 2016 and 2020.

Chart 25

Large shocks in relative prices are related to PPI inflation



Sources: Ball and Mankiw (1995), Bureau of Labour Statistics (BLS), Bureau of Economic Analysis (BEA), Eurostat and ECB staff calculations.
Notes: In panel a), the decomposition is based on OLS regressions of headline PPI inflation on the second and third moments (variance and skewness) of the cross-sectional distribution of (intermediate demand-weighted) input price changes, as well as lagged inflation. The long-term average ranges from 1960-2019 for the United States, and 2000-19 for the euro area. Number of yearly observations for the United States is 63, while for the euro area it is 23. In panel b), sectoral "upstreamness" is computed following Antràs et. al (2012) and calibrated on input-output accounts data for the United States in 2017. Sectoral "upstreamness" is considered to be low if the value ranges between 0 and 1, medium-low if between 2 and 3, medium-high if between 3 and 4 and high if larger than 4.

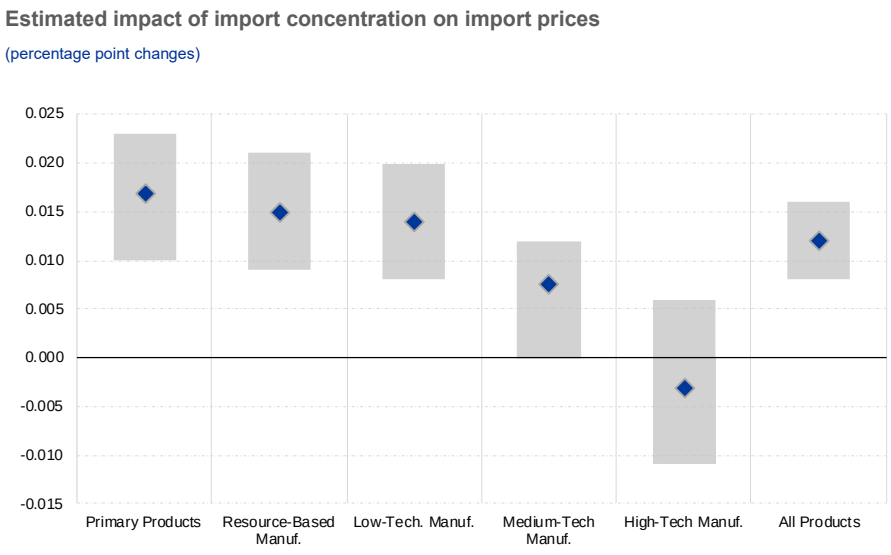
Large changes in input prices are more likely to occur for goods produced in sectors located upstream in the value chains. The theoretical literature proposes several potential underlying causes to explain the positive correlation between price changes' skewness and aggregate PPI, including menu costs for price adjustments or heterogeneous supply curves for industries and primary factors (see Ball and Mankiw, 1995; Rubbo, 2024). Attinasi et al. (2024a) suggest an additional transmission mechanism of large relative price shocks to inflation. In particular, large relative changes in input prices appear more likely to occur for goods produced by sectors located upstream in value chains (Chart 25, panel b), suggesting that the importance of large relative input price changes on inflation is further amplified as input price changes trickle downstream through supply chains. Shocks to prices of upstream goods are more likely to occur during the fragmentation process, as countries may interrupt or restrict exports of key inputs as a form of coercive measure against political rivals. However, it is less clear how exposure to these kinds of shocks might change in a "fragmented world" (i.e. at the end of the fragmentation process) compared with the current deeply integrated trade relations. We deal with this point in the next section.

5.2 A fragmented world is more exposed to sudden and large changes in relative prices

Trade fragmentation and the endogenous response of firms may influence the occurrence of large relative price shocks. On the one hand, companies that respond to geopolitical tensions by reducing the geographical diversification of their imports can be shielded from global shocks (De Soyres and Franco, 2019), thereby reducing the volatility arising from shocks to imported inputs of production. On the other hand, reducing trade dependencies on politically distant countries may result in a higher import concentration or a higher reliance on domestic production, thus reducing diversification. Borin et al. (2021) find that lower GVC integration lowers exposure to external shocks but also increases overall output volatility by enhancing exposure to local shocks. Balteanu et al. (2024b) show that, across EU and OECD countries, high import concentration at the product level tends to be associated with higher import prices, which might be due to reduced competition.[67] However, they find that effects are rather small. On average, reducing the share of the dominant provider from 70% to 40% and sourcing the difference from two additional new exporters is associated with a 0.03 point reduction in the import price relative to the price paid by all other importers of the same product. However, the size of the positive relationship between import concentration and import prices gradually decreases when moving from less sophisticated primary products to more sophisticated high-tech ones. This suggests that the competition channel of import concentration is stronger for more standardised products compared with more complex and customisable goods such as medium-tech and high-tech products (Chart 26).

Chart 26

High import concentration is associated with higher import prices



Source: Balteanu et al. (2024b).

[67] In principle, a lower import concentration could either increase import prices by limiting economies of scale or decrease them through competition effects.

Notes: Marginal effect and 95% confidence interval of a 0.1 point increase in the Herfindahl-Hirschman index (HHI) of import concentration on the import price expressed in deviations with respect to the price paid by all other importers of the same product. Marginal effects are estimated in panel regressions at the importer-product-year level during the period 2000-19 for a sample of 43 EU and other OECD countries, at the HS6 digit level of disaggregation. Other controls include the squared HHI; per capita GDP of the importer in PPP terms; the import market share accounted for by the importer in a product's global market; a proxy for the labour cost of providers, which takes into account the product's share that is sourced from each exporter; a dummy that identifies exclusive trade relations, that is cases in which an importer sources a given product from only one country; and product and year fixed effects. Technological sectors are identified as in Lall (2000). 95% confidence intervals of the linear HHI term are shown. Quadratic terms, which are significant only in the case of primary products, are not shown.

To shed light on the trade-off between reduced exposure to foreign shocks and higher vulnerability to domestic ones, a counterfactual scenario analysis looks at how fragmentation affects the propagation of shocks to activity and prices. The counterfactual scenario relies on a dynamic multi-country multi-sector model (Boeckelmann et al., 2024). The analysis builds on the severe-decoupling scenario of geopolitical fragmentation discussed in Chapter 4. It assumes a permanent increase in iceberg trade costs between countries belonging to the eastern and western bloc, as well as across all sectors, such that trade flows between East and West de facto halt. Essentially, this analysis estimates what would have been an alternative path for output volatility and input price distributions for the period between 2006 and 2023 under a fragmented world scenario subject to the same set of historically observed sectoral disturbances (see Box 5 for details).

Box 5

Does trade fragmentation lead to more relative price shocks? A counterfactual analysis

The counterfactual scenario relies on a dynamic multi-country multi-sector model (Boeckelmann et al., 2024) that accounts for domestic and foreign sectoral linkages in intermediate trade, as well as capital goods as in Quintana (2024). The model is calibrated on the OECD input-output tables for 2018 and quarterly sectoral industrial production data between 2006 and 2023, covering 29 countries and 20 manufacturing, mining and utilities sectors. The analysis builds on the severe-decoupling scenario for a geopolitical fragmentation, as discussed in Chapter 4. It assumes that higher barriers to trade de facto halt trade flows between the eastern and western bloc and across all sectors. The counterfactual scenario computes output volatility and input price distributions from historic disturbances to sectoral productivity (i.e. how efficiently are labour and capital used in production) assuming a permanent alteration in trade patterns due to elevated iceberg trade costs between geopolitical blocs.[68] It then recalculates these metrics given historical cross-country cross-sector trade linkages and production costs. Essentially, this analysis estimates what would have been an alternative path for output volatility and input price distributions for the period between 2006 and 2023 under a fragmented world scenario subject to the same set of historically observed disturbances to total factor productivity.

In addition to reorienting supply chains and trade relations, a more fragmented world could also affect sector supply shocks. To account for the fact that the nature of underlying supply shocks may change in a fragmented world, the analysis considers a supplementary counterfactual scenario. The scenario recomputes implied output volatility and cross-sectional distributions of input prices for a

[68] The model allows to estimate sector level disturbances to total factor productivity for all sectors across countries in the sample and for the period between 2006 and 2023.

trade fragmentation scenario subject to a set of alternative (instead of historic) factor productivity shocks, where the alternative shocks account for permanently more volatile geopolitical risk.[69]

The counterfactual analysis suggests that output volatility might be higher in a fragmented world economy whereas supply shocks could be larger and more frequent. A regionalisation of supply chains might imply a reduced geographical diversification of suppliers for companies. As a result, shocks to companies' inputs of production would average out less, given a higher exposure to fewer trading partners and less variation in regional origins of inputs. In turn, large shocks to companies' input of production might become more frequent. Given these considerations, the counterfactual analysis suggests that in the hypothetical severe-decoupling scenario, the volatility of global output could increase by about 1.5 standard deviations (an increase in volatility of about 8%, see Chart 27, panel a, dark blue bars).[70] Output volatility would increase in all geopolitical blocs but more so in the eastern bloc compared with the western bloc, reflecting the former's smaller size (in terms of production volumes and number of countries).[71] The neutral bloc would experience only a marginal increase in output volatility, as its imports are not directly affected by trade barriers. Lastly, to account for the fact that the nature of the underlying supply shocks might change in a fragmented world, the analysis considers another counterfactual scenario in which the fragmented world economy is subjected to a set of alternative (instead of historic) factor productivity shocks that account for a permanently more volatile geopolitical environment. In this additional scenario (Chart 27, panel a, light blue bars), global output volatility could further increase by 4 percentage points. The effect for output volatility in the eastern bloc would be higher than in the western bloc, reflecting a higher elasticity of sectoral factor productivity to geopolitical risk in the eastern bloc.

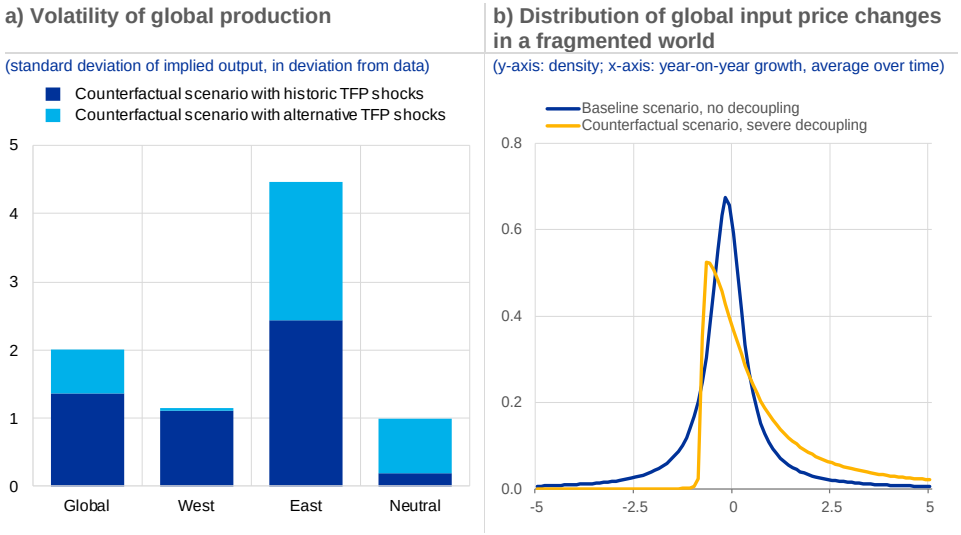
[69] The set of alternative TFP shocks is derived in two steps. First, historic model-implied country-sector TFP shocks are regressed on the global geopolitical risk index developed by Caldara and Iacoviello (2022); second, the analysis constructs the set of alternative TFP shocks using the regression parameters from the first step and a counterfactual geopolitical risk index, whose overall volatility is re-scaled to match the index's volatility during the period between the Russian invasion of Ukraine in 2022 and the end of 2023.

[70] A more severe fragmentation scenario such as the severe-decoupling scenario discussed in Chapter 4 could lead to a more pronounced increase in output volatility.

[71] The effect on output volatility varies by sector also. For example, the increase of output volatility in the eastern bloc is more pronounced for manufacturers of computer, electronic and optical products and for manufacturers of other transportation equipment. In turn, output volatility in the western bloc increases most for the utilities sector (electricity, gas, steam and air conditioning supply) and for chemicals manufacturers.

Chart 27

Fragmentation could lead to stronger and more frequent relative price shocks



Sources: UNIDO, OECD, Haver and ECB staff calculations.
Notes: TFP stands for total factor productivity. Estimates are based on a counterfactual analysis from a dynamic multi-country multisector model (Boeckelmann et al. 2024) and assume a fragmentation of the world economy along the lines of the severe-decoupling scenario discussed in Chapter 4.

Companies in a fragmented world would face more frequent and larger input price shocks. The counterfactual scenario shows that the global distribution of input price growth becomes more positively skewed in a fragmented global economy (i.e. the right tail of the distribution becomes fatter or longer than the left tail). One interpretation of this result is that all geopolitical blocs experience positive shocks to input prices on average in the counterfactual scenario which are more frequent and larger (yellow line in Chart 27, panel b). The empirical analysis in section 5.1 suggested that a more right-skewed distribution of input price growth is consistent with a regime featuring higher PPI inflation. Therefore, the fact that positive large relative price shocks more than compensate for negative shocks would suggest upside risks for global inflation in a fragmented world economy.

5.3 Implications for central banks

Trade fragmentation could entail additional inflationary pressures amid more frequent and larger supply shocks, affecting the operational environment of central banks. Along the fragmentation process, the potential weaponisation of critical supply chains and stronger commodity price movements may cause more frequent and larger supply shocks, with potential implications for inflation. The counterfactual scenario analysis of Section 5.2 shows that, even in the new equilibrium of a geopolitically fragmented world economy, output is more volatile and inflation is higher owing to lower diversification of suppliers. Trade fragmentation can therefore have first-order effects on inflation, affecting the operational environment of central banks. Moreover, geopolitical fragmentation could have implications for the synchronisation of monetary policy, as geopolitically aligned countries are increasingly exposed to a similar set of shocks. Given these considerations, central

banks should for their part incorporate more formally global and geopolitical sources of domestic inflation in their analytical tools.

Central banks' analyses should take into account the sectoral dimension of price pressures along the supply chain. The interconnected nature of production processes and the fact that most inputs at risk of weaponisation are located upstream in the supply chain imply that sudden and large sectoral price shocks can be amplified into aggregate price pressures. A thorough understanding of sectoral dependencies, coupled with the use of dynamic network models, is useful for understanding the propagation of sectoral price shocks along the value chain, and helpful in distinguishing temporary from persistent price pressures. To this end, it is desirable for central banks to join forces with other institutions for purposes of sharing data that are at their disposal and building updated and more detailed inter-country input-output tables to facilitate these analyses.

6 Conclusions and way forward

The aim of this report is to foster the ESCB's understanding of the trade fragmentation process, a key issue at the forefront of the global policy debate. It represents the joint contribution of the ESCB (i.e. the ECB and nine other national central banks) and makes significant headway towards deepening our understanding of the trade fragmentation process, including its implications for supply chains configurations and, more broadly, for inflation and growth.

It is important for the ESCB to enhance its toolkit to monitor and analyse the trade fragmentation process. This report draws on a rich set of studies jointly developed by experts of the IRC Trade Expert Network and referenced in Annex 3. Specifically, it includes tools to track trade developments factoring in the geopolitical dimension; harmonised corporate surveys for the timely monitoring of firms' vulnerabilities, de-risking strategies and price pressures; indicators of foreign dependencies based on granular custom data; stress tests to assess the impact of shortages in key inputs at the firm, sector and regional level; state-of-the-art macro models featuring supply chain interlinkages to evaluate the impact of fragmentation on activity and inflation; and the propagation of shocks, including sectoral price shocks. These tools (i.e. codes and methodologies) are available for sharing within the ESCB.

Going forward, cooperation among ESCB members remains key to facilitate data collection and sharing, as well as to sharpen our insights into the fragmentation process. This report highlights the need for timely and granular data. In particular, firm-level data for individual EU countries, as well as more detailed multi-country input-output data, at least for the euro area, are key for a deeper understanding of the impact of foreign-origin shocks, which could well serve as an input for designing policies. A collective effort should aim to increase cooperation among central banks and other institutions to collect and share these data. At the same time, the research agenda on the fragmentation process remains extensive. Looking ahead, more analysis will be necessary regarding other aspects of geoeconomic fragmentation (e.g. financial fragmentation), as well as the interplay between trade fragmentation and other policies (e.g. climate change).

The findings and the legacy of this report provide useful inputs for the ongoing ECB strategy review. The global nature of the shocks that have hit the euro area economy in recent years highlights the importance, already foreseen in the 2021 ECB strategy review, of better understanding the impact of shocks of foreign origin. In this respect, the insights of this report, when compared with those from the 2021 strategy review, suggest that trade *fragmentation* shocks may affect the global economy differently to trade *integration* shocks.

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Annex 1: Allocation of countries to geopolitical blocs

Countries are mechanically allocated to each geopolitical bloc (western, eastern and neutral) according to an index of economic and political alignment. The index extends the approach taken in most of the literature (e.g. Goes and Bekkers 2022; Attinasi et al., 2023a; Javorcik et al., 2024; Gopinath et al., 2024), which relies solely on the voting patterns at the United Nations General Assembly (UNGA) by including additional measures of political alignment and economic ties between countries. For 63 countries covering 87% of global GDP, the allocation relies on an index developed in the spirit of den Besten et al. (2023). Since this index is not available for all countries, the allocation of the remaining 166 smallest countries covering 13% of global GDP relies on Capital Economics (2023), which considers a broader set of political and economic variables.[72] EU countries are allocated collectively, reflecting the competency of the EU to design trade policy for the whole group.

The geopolitical index is a modified version of the one presented in den Besten et al. (2023) and uses the history of sanctions, military imports, UN voting and China's official lending. The first proxy of geopolitical alignment considered is the number of times a country has been sanctioned by China compared with the United States, using data from the Global Sanctions Database (Felbermayr et al., 2020; Kirikakha et al., 2021; Syropoulos et al., 2024). The second proxy is the share of military imports from China versus the share from the United States, obtained from the SIPRI Arms Transfers Database on bilateral military imports. The third proxy is a country's voting history at the United Nations General Assembly, including the votes in 2022. The fourth proxy is a country's external debt to China over its GDP, as estimated by Horn et al. (2021). All the proxies are averaged from 2011 until the most recent year and aggregated through a simple average. The final index ranks countries from 0 (alignment with the United States) to 1 (alignment with China). Countries with an index below 0.25 are assigned to the western bloc, and those with an index above 0.75 are allocated to the eastern bloc; with the remaining countries classified as neutral.

For countries not covered by the den Besten et al. (2023) index, the allocation is supplemented by Capital Economics (2023). The classification in Capital Economics (2023) relies on a broader set of indicators, as it considers additional geopolitical and economic variables such as public opinion about China and the US, security alliances, territorial disputes, FDI from China and the United States and exports to China and the US, as well as participation to the Belt and Road Initiative. While mostly data-driven, the allocation also relies on the country expertise of staff at Capital Economics. Countries are allocated to five blocs: United States and close

[72] Capital Economics (2023) represents a close match to the index of den Besten et al. (2023): for countries covered in both classifications, the implied allocations are highly correlated, with 60 countries out of 63 allocated to the same bloc.

allies, leaning toward the United States, unaligned, leaning toward China, and China and close allies. We mechanically allocate countries that are either leaning or unaligned to the neutral bloc whereas the United States (China) and close allies join the western (eastern) bloc.

Annex 2: Split IO tables and the selective decoupling scenario

While input-output (IO) tables are a fundamental source of information for assessing the macroeconomic impact of trade fragmentation, they are generally available at a level of aggregation that is too coarse to analyse the impact of targeted restrictions. IO tables are at the core of the MCMS models used to assess the impact of fragmentation – such as Baqaee and Farhi (2024) and Quintana (2024), which focus on propagation effects of economic shocks through global production networks, as well as the substitution effects *via* international trade. IO tables are fairly granular; for example, the OECD IO tables include 45 broad sectors (e.g. “motor vehicles”, “basic metals”, “construction”). However, trade policies are usually aimed at targeted sets of products (e.g. the US Inflation Reduction Act on products for the green transition; western sanctions on Russia that are centred on dual-use products). Given the granularity of the available IO tables, it would be impossible to isolate the effects of such targeted products. This limitation has triggered analytical work to construct ad hoc IO tables, called split IO tables, which expand the sectoral granularity.

Split IO tables, which use trade data to decompose each sector into restricted and unrestricted components, enable the study of targeted trade policies. Following the methodology outlined in Borin et al. (2023b), each row and column of the original IO table is decomposed into *restricted* and *unrestricted* components. Such an expansion of the initial IO table requires two steps. The first is to bridge the gap between the HS nomenclature – which identifies the products subject to restrictive trade measures (representing the restricted component) – and the sector classification used in the starting IO table. This step is done by resorting to the OECD’s conversion key from the Bilateral Trade in Goods by Industry and End-Use Category (BTDIxE; OECD, 2021). The second involves splitting each row and column of the IO table into *restricted* and *unrestricted* parts, where the *restricted* part aggregates all restricted products that belong to the sector corresponding to the row or column of the IO table. This is achieved by computing the share of restricted products in trade flows between all countries and sectors. Shares are based on the *Base pour l’Analyse du Commerce International* (BACI) by the CEPII (Gaulier and Zignago, 2010), which provides the bilateral trade flows for 200 countries at the product levels.

Selective-decoupling scenario

The selective-decoupling scenario, which assumes a weaponisation of mutual dependencies, accounts for granular shocks affecting mostly high-tech products and critical raw minerals. To this extent, Conteduca et al. (2025) define as *restricted*, i.e. targeted by trade restrictions, the following products:

- products included by the US Census in the Advanced Technology Product classification, assigning items (defined at the 10-digit commodity level) to production processes of applications in the following fields: biotechnology, life science, opto-electronics, information & communications, electronics, flexible manufacturing, advanced materials, aerospace, weapons and nuclear technologies;[73]
- products whose trade with Russia has been restricted following the invasion of Ukraine (see Borin et al., 2023b);
- products involved in the ongoing green transition, as well as energy commodities, oil and gas.

Green-decoupling scenario

Goods targeted under a green-decoupling scenario are mostly based on the products targeted by the US Inflation Redaction Act (IRA) and cover the full supply chain. While the current information contained in the available IO tables likely understates the future use of energy technology, we attempt to study the impact of restrictions affecting the green products supply chains within the green-decoupling scenario. As a recent example of trade barriers targeting products for the green transition, the US IRA provides the basis for restricted products. It covers notably electric vehicles, batteries, rare Earth minerals (both raw and processed) and renewable-energy equipment, as well as chemicals used in the production of these goods (e.g. lithium oxides and hydroxides, sulphates of nickel). This list is supplemented by other green products identified by the European Commission as critical but not already listed in the US IRA (e.g. nickel powders) and by heat pumps. This provides a list of 129 of HS subheadings. They cover the full supply chain of green products, going from very upstream materials (e.g. rare Earth minerals) to very downstream goods (e.g. electric vehicles, solar panels). As a caveat, the figures and assessments produced within this framework have to be taken as a lower bound for the negative effect of trade fragmentation of this supply chain. Moreover, the analysis does not incorporate the economic costs associated with slowing down the transition to green technologies.

Projections on the future intensity of green technology usage are used to assess the future impact of trade fragmentation affecting green products. Available IO tables account for the current state of global value chains. To circumvent this limitation and account for the future state of supply chains, the initial methodology of Borin et al. (2023b) is extended to simulate changes in demand. Based on assumptions from the International Energy Agency (IEA), Attinasi et al.

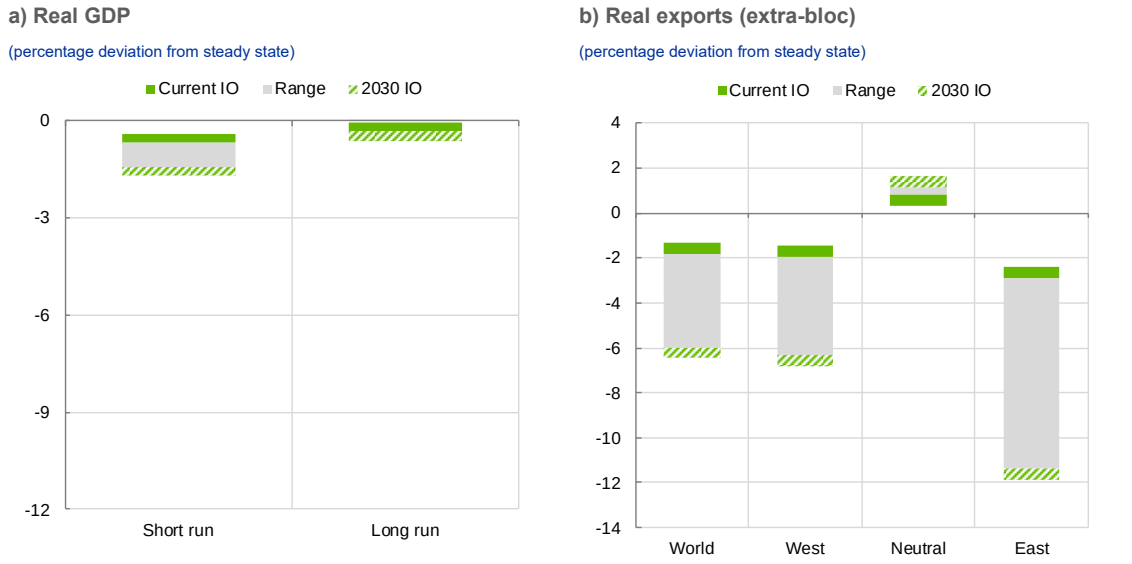
[73] The 10-digit classification, known as Schedule B number, is the nomenclature used by the United States to classify products for exports. The first six digits of this nomenclature corresponds to the respective HS subheading.

(2024b) simulate the state of global supply chains for green products by 2030.[74] This is combined with a refinement of the split IO methodology to better account for specific sectoral linkages: the resulting IO table represents a hypothetical global economy after the green transition.[75]

While the impact is limited on current IO, they can be substantial when accounting for how the green transition will affect the global economy. Under the current IO, GDP losses are very limited in the long run but still reach 0.4% in the short run, as the targeted products are difficult to substitute (Chart A1, panel a). This relates to the microscopic size of the affected sectors in the global economy currently: for example, in 2018 (the year the OECD IO table relates to) electric vehicles accounted for 2.3% of car sales; this share is expected to jump to 41% by 2030 (IEA, 2023). The impact is therefore magnified when accounting for structural changes in the economy by 2030, with around 1.7% in the short run. Global trade losses, 1.3% under the current IO tables, are also inflated to 6.0% under the hypothetical IO table by 2030 (Chart A1, panel b). In line with the findings in other scenarios, the export-oriented eastern bloc is more affected by the imposition of trade barriers.

Chart A1

Output and trade losses across "green war" scenarios



Sources: Baqaee and Farhi (2024), Attinasi et al. (2024b), OECD TiVA, EORA and authors' calculations.

[74] This uses the Leontief inverse matrix which is obtained from an inversion of the IO table and links final demand with output. Using this matrix, one can estimate how changes in final demand affect the output in each sector. Changes in final demand are calibrated based on external assumptions from the International Energy Agency on market size of green sectors by 2030.

[75] More precisely, the initial Borin et al. (2023b) methodology assumes that restricted products are sold in the same proportion to all sectors in the recipient country. This assumption might, however, be too naïve for the highly specific green products. For example, one can assume that a larger share of "batteries for electric vehicles" are sold to the car industry than to other sectors. In practice, these additional assumptions on using sectors are based on Fally and Sayre (2018) and industry reports.

Notes: Non-linear impact simulated through 25 iterations of the log-linearised model. The current IO scenario accounts for the state of global supply chains as of the present day. The 2030 IO scenario simulates the state of global supply chains for green products by 2030 based on assumptions about the demand for green products made by the International Energy Agency. The scenario used in the main part of the report is the *current IO*.

Annex 3: Trade Experts Network sources underlying the report

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Co-leads of the Trade Fragmentation Workstream

Attinasi Maria Grazia
European Central Bank
email:
Maria_Grazia.Attinasi@ecb.europa.eu

Mancini Michele
Banca d'Italia
email:
michele.mancini@bancaditalia.it

Analytical coordinators

Bottone Marco
Banca d'Italia
Conteduca Francesco Paolo
Banca d'Italia

Giordano Claire
Banca d'Italia
Panon Ludovic
Banca d'Italia

Boeckelmann Lukas
European Central Bank
Meunier Baptiste
European Central Bank

All work stream members

Khalil Makram
Deutsche Bundesbank
Kutten Ambre
Deutsche Bundesbank
Strobel Felix
Deutsche Bundesbank
Balteanu Irina
Banco de España
Campos Rodolfo
Banco de España
Quintana Javier
Banco de España
Timini Jacopo
Banco de España
Viani Francesca
Banco de España
Carluccio Juan
Banque de France
Gaulier Guillaume
Banque de France
Schmidt Katja
Banque de France

Smagghue Gabriel
Banque de France
Stumpner Sebastian
Banque de France
Borgogno Oscar
Banca d'Italia
Borin Alessandro
Banca d'Italia
Giglioli Simona
Banca d'Italia
Savini Zangrandi Michele
Banca d'Italia
Almeida Ana M.
Banco de Portugal
Kaaresvirta Juuso
Suomen Pankki
Nuutilainen Riikka
Suomen Pankki
Caka Peonare
Banka Slovenije
Matavulj Noemi
Banka Slovenije

Bańbura Marta
European Central Bank
Bobeica Elena
European Central Bank
De Castro Martins Bernardo
European Central Bank
Di Casola Paola
European Central Bank
Gerinovics Rinalds
European Central Bank
Ioannou Demosthenes
European Central Bank
Lebastard Laura
European Central Bank
Martínez Hernández Catalina
European Central Bank
Morris Richard
European Central Bank
Serafini Roberta
European Central Bank
Essers Dennis
Nationale Bank van België/
Banque Nationale de Belgique
Lechthaler Wolfgang
Oesterreichische Nationalbank

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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