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Global value chains: measurement, trends and drivers

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Contents

Abstract

Global value chains (GVCs) have shaped the dynamics of globalisation in recent years. This paper reviews key concepts and tools to measure countries' involvement in GVCs, explores recent trends and investigates the underlying drivers of GVC participation empirically. The analysis in the paper finds that in the last decade, GVCs have undergone an important transformation, with participation falling on the back of rising trade costs and the trade integration of some large emerging market economies slowing, while the role of recent technological developments remains unclear. In addition, supply chains appear to have become increasingly regional over time. The paper also offers an insight into the role of production chain linkages in the transmission of recent global shocks across countries, uncovering important amplification effects on trade and activity. Finally, it discusses future prospects for GVCs and global trade, including in the light of developments associated with the coronavirus pandemic.

Non-technical summary

Global value chains (GVCs) have emerged as a dominant paradigm of production over the past 40 years, reshaping the character and speed of globalisation. One effect is that the pace of growth in world trade has outstripped that of world GDP, rising more than two times faster in the period from 1995 to 2010. Participation in GVCs has enhanced productivity growth, supporting wages and incomes. At the same time, rising vertical linkages have strengthened countries' interconnectedness, magnifying the transmission of shocks. Set against this backdrop, this paper reviews trends and drivers of GVCs, and their implications for the international transmission of shocks. The analysis indicates that after decades of continued growth, participation in GVCs appears to have stalled, contributing to a decline in world trade growth and to lower trade elasticity. At sector level, there has been a continued marked rise in value added trade in services, while sectors that had contributed to the earlier rise of vertical specialisation have experienced a retrenchment. The regional character of GVCs has also strengthened, especially within Asia and Europe. We also find evidence that supply chains played an important role in the international propagation of recent major events, including the COVID-19 pandemic, the United States-China trade dispute and the recent departure of the United Kingdom from the European Union, magnifying the impact on activity and trade. The future of GVCs remains deeply uncertain at this stage. Many of the forces that contributed to their earlier rise have gone into reverse over the past decade, contributing to a slow expansion of GVC participation globally. Trade costs, including transport costs and tariff and non-tariff barriers, have been on the rise since the global financial crisis, making it more costly for firms to offshore production across different jurisdictions. And several emerging economies which had been among the main protagonists of the earlier rise have been gradually turning inward, reducing their reliance on imported inputs. In addition, preliminary evidence indicates that new technologies related to Industry 4.0 may discourage further offshoring to emerging economies, although the long-term impact remains uncertain. Against this background, the COVID-19 pandemic has highlighted the vulnerability of complex supply chains but also their role in cushioning domestic shocks. The debate on reshoring stages of production domestically as a way of increasing the resilience of supply chains is thus still ongoing.

1 Introduction

Over the last 40 years, global value chains (GVCs) have emerged as dominant paradigms of production. Advances in information and transport technologies, coupled with declining trade barriers, since the 1980s have prompted firms to unbundle production into tasks and stages performed in different countries.[1] Hence, the value of traded intermediate goods has doubled globally and currently accounts for more than 50% of world trade. One consequence is that the pace of world trade growth has outstripped that of world GDP growth, expanding twice as fast in the period from 1995 to 2010.[2] Multinational enterprises (MNEs) have emerged as important players within GVCs. They function as networks and undertake different stages of production through their affiliates or via independent suppliers, i.e. on an intra-firm or arm's-length basis.

Increasing vertical integration comes with important macroeconomic implications. Participation in GVCs enables countries to specialise in areas of comparative advantage, enhancing productivity growth and supporting wages and incomes.[3] At the same time, increasing vertical integration can lead to growing interconnectedness across countries, serving to accelerate and magnify the transmission of shocks. GVCs also have important implications in the context of price formation. High linkages in production lead to high synchronicity between consumer and producer prices across countries.[4] Furthermore, because of high interlinkages in production, global economic conditions become relevant in the formation of domestic inflation.[5] In the light of this, it is important for policymakers to monitor the evolution of GVC trade and understand the forces behind it.

Set against this backdrop, this paper reviews recent trends and dynamics that have shaped the pattern of GVC trade in the past decade and assesses the role of GVCs in the transmission of recent global shocks. In Section 2, we take stock of the changing patterns of GVC participation in the last decade. In addition, we introduce a new tracker of regional and global GVC participation which enable us to gauge developments in GVCs participation as they enfold in real time. In Section 3, we discuss the main drivers of GVC participation from a global and country

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[1] See Baldwin (2006).

[2] The increasing trade-to-GDP ratios follow directly from the growing importance of GVCs, as intermediates are transferred across borders several times before the goods/services are sold to the final customer. Because international trade data are expressed in terms of gross output, they include the value of the intermediates imported at each border crossing. By contrast, GDP is a value added concept and captures only the domestic value that countries add in the production of goods and services.

[3] A number of recent studies attempt to quantify the effects of GVC participation on economic growth. Kummritz, Taglioni and Winkler (2017) find that GVC integration generally increases an industry's value added, especially when participating in upstream stages. They additionally highlight the importance of country-specific characteristics and policies when it comes to benefiting from trade integration. Constantinescu, Mattoo and Ruta (2019) find that participation in GVCs is a significant driver of labour productivity. An assessment of the benefits of engaging in GVCs in terms of economic growth and productivity is outside the scope of this paper.

[4] See Auer et al. (2017).

[5] Growing participation of euro area countries in global and regional value chains has prompted the ECB to rethink the use of conventional trade definitions based on gross trade within the analysis and forecasting of the euro area (ECB Working Group on Global Value Chains, 2019).

perspective, shedding light on their relative contribution to the recent slowdown. Section 4 focuses on the role of GVCs in the transmission of macroeconomic shocks. We conclude by assessing the medium-term outlook for GVCs and trade.

The analysis in this paper indicates that GVCs have undergone a significant transformation in recent years. The pace of growth of GVC participation has slowed, in part due to compositional effects triggered by the fact that sectors with a low GVC intensity, such as construction and services, have accounted for an incrementally larger share of world trade over time. Meanwhile, GVCs have maintained a strong regional dimension, especially within Europe and Asia.

Some of the forces that propelled vertical integration before the global financial crisis have reversed over the past decade. Advances in information and communication technologies, declining trade costs, the integration into the world economy of countries in eastern Europe and East Asia and the surge of MNEs as global actors have stalled or even reversed over the past decade, contributing to a slower pace of GVC participation. New technologies related to Industry 4.0 have the power to transform and reshape the global organisation of production going forward. While they could lead to further shortening and regionalisation, the overall direction and size of their impact remain ambiguous at this stage. The coronavirus (COVID-19) pandemic may also exacerbate these trends.

The analysis in this paper also suggests that supply chains are likely to have played an important role in the international propagation of recent major events, including the COVID-19 pandemic, the trade dispute between the United States and China and the departure of the United Kingdom from the European Union. For example, model-based analysis indicates that the organisation of production in supply chains amplified the impact of the 2018-19 surge in tariffs by more than 70% in the case of the United States and by almost three times in the case of China. GVC-related spillovers are also likely to have magnified the impact of the COVID-19 shock, amplifying the decline in global imports and exports by some 25%.

2 Tracking GVCs: measurement and recent trends

This section reviews the key trends and drivers of GVC trade in recent years. Section 2.1 focuses on the measurement of GVC linkages and provides some illustrations. Section 2.2 discusses recent trends and patterns that have characterised GVCs, including the role of MNEs (Box 1), and introduces a new tracker of GVC participation (Box 2).

2.1 Measuring GVC participation

The emergence of GVCs has challenged the conventional use and interpretation of trade statistics and instigated the use of new data and methods. Traditional trade measures record flows of goods and services on a gross basis, meaning that the value of intermediate inputs is counted every time they cross a border for further processing. Therefore, in a world in which intermediate goods cross several borders before reaching the final consumer, gross exports can be subject to significant double-counting. This can lead to a misrepresentation of the contribution of different countries to global trade. To address these issues, researchers and practitioners have increasingly relied on the concept of trade in value added. As part of this, gross exports are broken down according to the country and industry of origin and destination of value added. In other words, value added is traced across borders and apportioned to the countries where it is produced and consumed.[6]

Building on trade in value added data, several metrics have been developed in the literature to track supply chains, including indicators of participation. According to Antràs (2020a),[7] a GVC consists of "a series of stages involved in producing products and services that are sold to consumers, with each stage adding value".[8] Borin and Mancini (2015) offer a more specific definition of GVC trade,

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[6] Measuring trade according to the value added approach has important implications for trade imbalances. For example, in value added terms, the US trade deficit with China is around 20% lower than when it is measured on a gross basis.

[7] A value chain includes all activities involved in delivering a product, including the sourcing of raw materials and parts, manufacturing and assembly, warehousing, inventory tracking, order entry and management, distribution across all channels, customer delivery, and management of the information systems necessary to monitor all required activities. See Antràs (2020a).

[8] The term GVC originated in the management literature. In the economic literature it has been associated with concepts such as: global production sharing, international fragmentation, vertical specialisation, vertical integration, multistage production, subcontracting, offshoring and outsourcing and most recently with trade in tasks. The different terms all relate to the increasing importance of vertical production and trading chains across countries, and we use them interchangeably in this paper. An important distinction emphasised in the literature is between "producer-driven" and "buyer driven" chains. Producer-driven GVCs are found in high-tech sectors such as the semiconductor or the pharmaceuticals industry. Because these industries rely on technology and research and development (R&D), lead firms are placed upstream and control the design of products as well as most of the assembly, which is fragmented across different countries. In buyer-driven chains, retailers and branded marketers control the production, which can be totally outsourced, the focus being on marketing and sales.

characterised by flows that cross at least two national borders. In this paper we adopt their definition, setting GVC-related trade apart from direct trade (both are part of gross trade), which refers instead to trade flows crossing only one border (e.g. goods and services that are directly exported for final use or are used as inputs in production and consumed in the first importing country). Indicators of GVC participation track countries' engagement in GVCs and serve as proxies for the fragmentation of the production process. GVC participation is generally computed as the share of GVC-related trade over gross exports.

Figure 1

Decomposition of country A's exports to country B. Origin and destination of value added
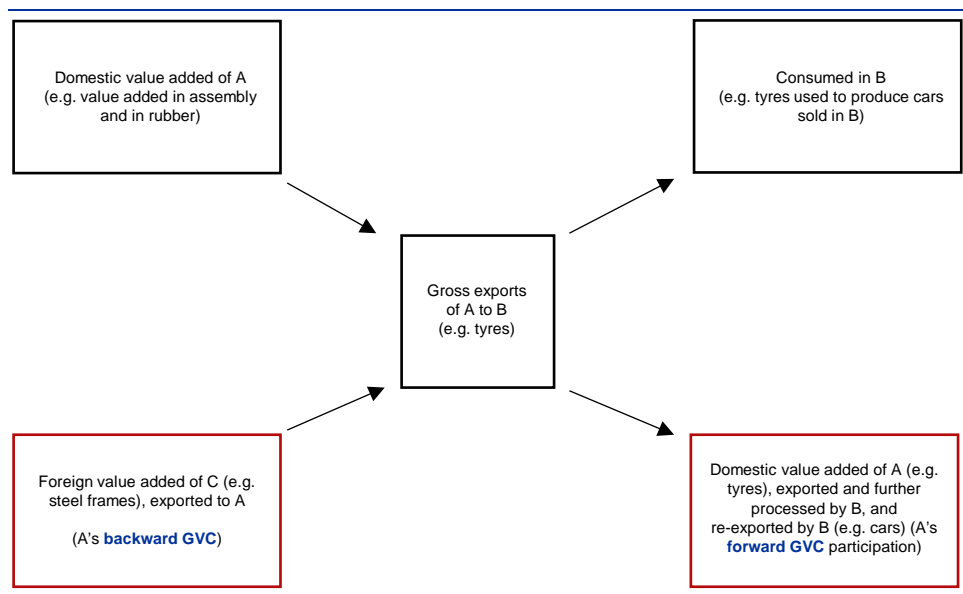
Source: ECB.

At the broadest level of disaggregation, individual countries can participate in GVCs by engaging in backward and/or forward linkages. Upstream or backward participation measures the share of foreign value added embedded in a country's total gross exports. The downstream or forward dimension refers instead to the share of the domestically produced value added embedded in a country's exports that is further re-exported by the destination country. In this respect, re-exported products flow downstream within the value chain. The diagram in Figure 1 provides a simplified illustration of tyre production.[9] In the example, country A is a manufacturer of tyres. In order to produce its exports to B, A can produce and assemble tyres domestically (and hence rely on its own domestic value added), or import parts from abroad (*i.e.* embed value added from third countries in the form of inputs in its production). Backward participation consists of the value added contained in parts (e.g. steel frames) that A imports from a foreign partner C. Forward participation is instead obtained by counting the domestic value added produced directly by A (*e.g.*

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[9] Gross exports can be further decomposed into additional sub-components according to the decomposition proposed by Borin and Mancini (2015). For example, the domestic value added of A that is exported to C could come back to A be further re-processed there and then be exported by A. The diagram in the main text is a simplified version.

in the form of labour to assemble the final product and value added contained in rubber produced in A), embedded into its exports of tyres to B and further utilised by B in the production of exports to a third country D, for example in the form of cars. Measures of GVC participation take into account both backward and forward dimensions, such that in our stylised example, an overall indicator of participation for country A is obtained as the sum of backward (value added in steel frames) and forward value added trade (value added in tyres used to produce cars exported by B to D) (both highlighted with red boxes), expressed as a share of its total gross exports.

An illustration can help to shed light on the concept of trade in value added.
Chart 1 decomposes gross exports of goods to the United States (the sum of all components of the bar except those in light blue), tracking the origin of value added. Taking for example exports originating from the euro area, only around one-third are consumed in the United States (blue bars). In fact, a significant share of euro area exports to the United States consists of intermediate goods that are used in the production of goods in the United States and then consumed in the United States or re-exported to third countries (yellow bars). In turn, euro area exports to the United States include intermediate inputs from third countries, including from countries that are closely embedded in European production chains, such as central and eastern European countries in the automotive sector (grey bars). Euro area exports also include value added from the United States itself (red bars). Finally, euro area exports are sometimes first shipped for processing to third countries, such as Mexico, before being exported to the United States (light blue bars).[10]

Chart 1

Production chain linkages in exports to the United States

(USD billions)

- Exporter's value added in final goods consumed in the United States
- Exporter's value added in intermediate goods for US final production and exports
- Foreign value added in exports (originated in the United States)
- Foreign value added in exports (originated in third countries) and double-counted
- Exporter's value added that goes to the United States through other countries

Sources: World Input-Output Database and authors' calculations.

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[10]   The value added represented by the light blue bars does not accrue to bilateral gross exports to the United States. It is in fact embedded in the gross exports of exporters to other countries, where they are processed and re-exported to the United States.

The type and extent of engagement in GVCs vary across countries. Figure 2 2 shows the backward and forward linkages of advanced and emerging economies in 1990 and in 2018. The darker green and blues areas reflect higher values of participation across the two categories. Small, open economies or countries that are highly involved in the assembly and processing of goods, such as Mexico or countries in emerging Europe, tend to be located downstream in the value chain and have large backward linkages, originating from the fact that a large proportion of their exports consists of foreign value added. Commodity exporters such as Russia and countries in the Middle East and Africa are located upstream and instead exhibit high forward linkages. The latter reflects the fact that exports of commodities from these countries travel along the value chain and serve as inputs in other countries' production. Countries with high forward linkages are not limited to commodity exporters, however. The United States and several large euro area economies also exhibit high shares due to large exports of high value added services (including marketing activities and R&D) that are used as intermediate inputs in other countries.

For many advanced economies, backward and forward linkages have been rising over time (Figure 2). This is an indication of the fact that they engage in GVCs in a multifaceted way, through both vertical and horizontal linkages.[11] Movements along the value chain may also be the outcome of deliberate government policies. In countries such as China, Indonesia, Thailand and Malaysia, for example, forward participation has risen sharply over the past 30 years as a result of policies aimed at shoring up the domestic content of their production and exports. By contrast, economies in emerging Europe have continued to integrate themselves downstream into the supply chains of companies in western Europe, such that the foreign content of their exports has increased more visibly. Countries in Latin America have also seen the foreign content of their exports rise over time. In general (with the exception of Mexico, which is highly integrated in US value chains), participation in GVCs remains low among countries in Latin America when compared with peers.
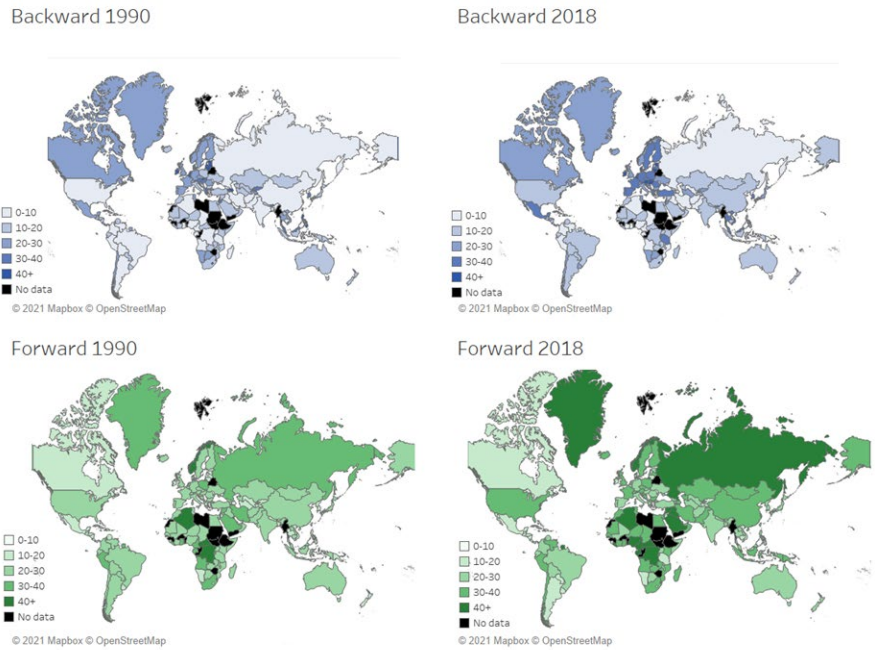
GVCs are complex networks formed of hubs and spokes. Figure 3 shows the network structure of GVCs in 1995 and 2015. The nodes represent countries involved in GVCs, and the size of each node reflects the magnitude of GVC trade (both backward and forward) intermediated by each country (expressed as a share of total world exports). The thickness of each link between nodes represents the share of value added trade between each country pair. The chart highlights the existence of a clear "hub and spoke" structure, with the United States, Germany and China serving as key hubs within each region but also as main connectors across different regions. The chart also reveals important changes across and within regional GVC networks since 1995. Interconnectedness has increased, as more emerging economies in Asia, Latin America and emerging Europe have progressively engaged in regional supply chains. More importantly, China has emerged as a key global player not only by replacing Japan as the main Asian hub

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[11] The coexistence of backward and forward integration strategies of firms along GVCs is documented by Del Prete and Rungi (2020).
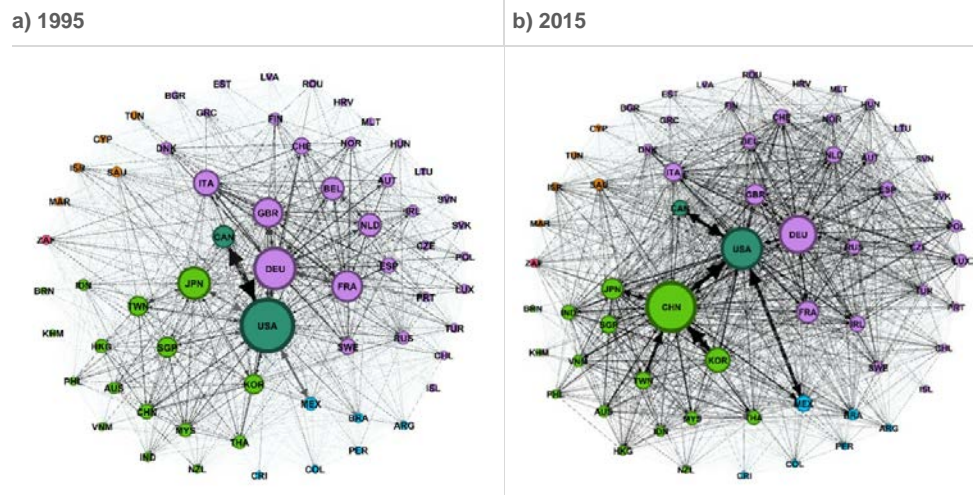
but also by rivalling the United States in terms of share of GVC trade over total exports.

Figure 2
Backward and forward participation (share of gross exports)

Figure 3
GVC networks

a) 1995   **b) 2015**

2.2 Recent trends in GVCs

After more than 20 years of continued growth, the pace of GVC integration has slowed globally. The increase came to a halt with the global financial crisis, and while the recovery was fast, participation in GVCs started to decline again globally in 2011 (Chart 2, yellow line).

Chart 2

Participation in GVCs

(percentage shares of gross global exports)

- Nominal GVC tracker
- GVC participation
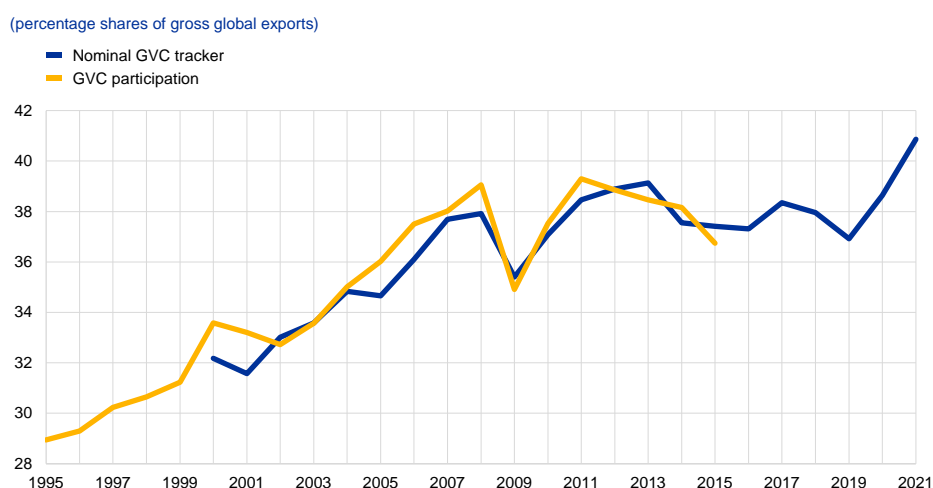
Sources: OECD, Trade Data Monitor and authors' calculations.
Notes: For the period 1995-2015, the yellow line represents GVC participation calculated as the sum of backward and forward participation. The index was extended backward following the methodology proposed by Johnson (2018). The blue line represents a tracker of GVCs built on the basis of selected data on intermediate goods trade. The value for 2021 is calculated as average global GVC participation in the first seven months of 2021. For further information on the methodology behind the tracker, see Box 2.

The deceleration in GVC participation was widespread across countries and sectors. Chart 3 shows indices of GVC participation across countries (left panel) and sectors (right panel) in 2008 and 2015. The left panel indicates that since the global financial crisis, a number of countries have experienced a marked decline in GVC integration. The decline was particularly pronounced in emerging market economies, including China, and to a lesser extent in advanced economies outside the euro area. Conversely, most euro area countries have maintained a steady engagement in global supply chains. The decline was also widespread across sectors (right panel), with the commodities and manufacturing sectors suffering larger drops. By contrast, GVC participation in the services sector was comparatively more resilient.

Chart 3

GVC participation by country (left panel) and sector (right panel)

(percentage shares of gross exports)
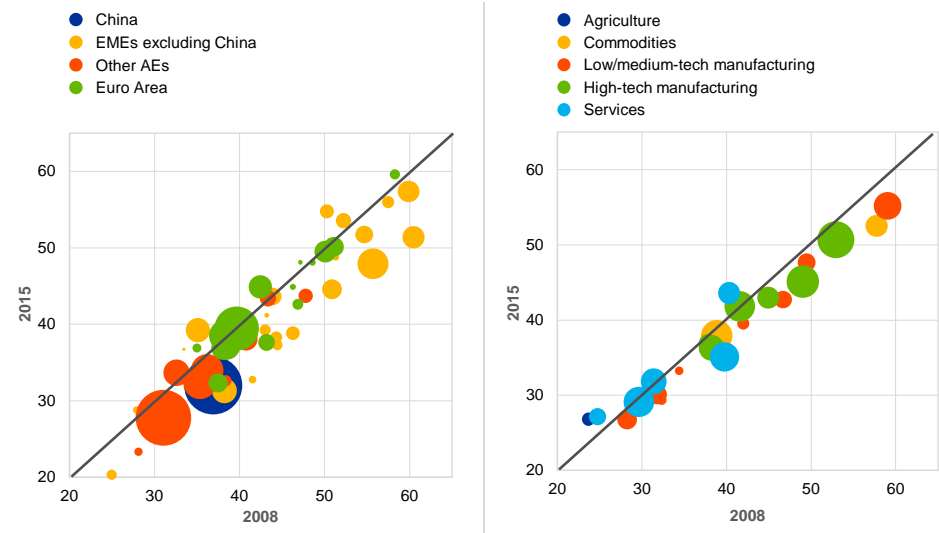
Sources: OECD and authors' calculations.
Note: The size of the bubbles refers to the share of each individual country and sector in gross exports in 2015. EMEs stands for emerging market economies; AEs stands for advanced economies; EA stands for the euro area.

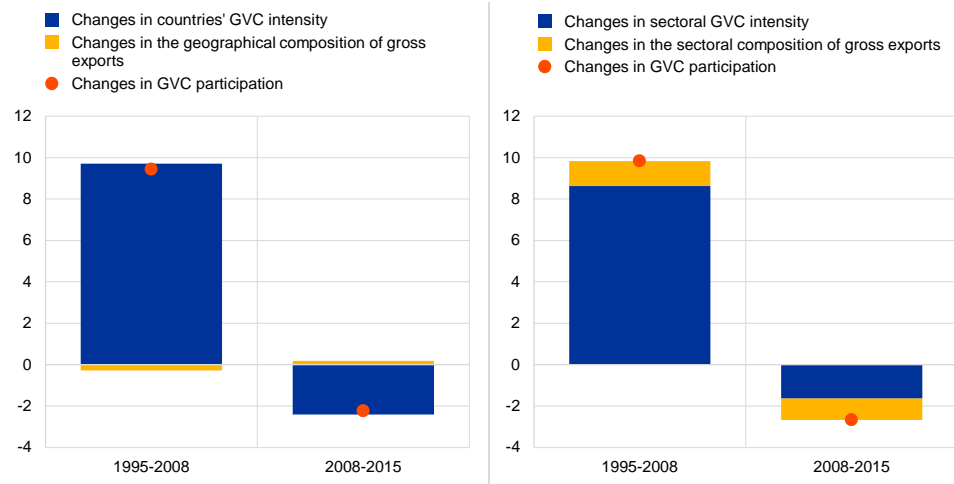**The decline in the pace of integration since the global financial crisis partly reflects changes in the sectoral composition of gross exports.** As discussed in the previous subsection, participation in GVCs is generally expressed as the ratio of GVC-related trade (encompassing both backward and forward linkages) to total gross exports. Therefore, global shifts in participation can be driven by developments in production fragmentation within countries and sectors, but also by changes in the geographical and sectoral composition of gross exports. The latter may reflect the fact that countries and sectors which have a structurally low GVC intensity have increased their share of world trade over time.[12] A simple accounting exercise can help disentangle the relative contribution of these two factors to the global decline in GVC participation. Chart 4 (left panel) shows that from a geographical perspective, both the early rise and the slowdown in global GVC participation since 2008 have been entirely driven by changes in the intensity of GVCs across countries. By contrast, from a sectoral perspective (Chart 4, right panel), half of the decline since 2008 is accounted for by the changing composition of gross exports, which has been skewed towards industries with a structurally low fragmentation of production, such as tourism, transport, financial services and construction.

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[12]   At global level, GVC participation is obtained as the weighted sum of national and sectoral indexes, each expressed as a ratio of GVC trade with the weights determined by a country's and sector's share of gross global exports. Thus, global changes in participation can also reflect shifts in export shares across countries and sectors.

Chart 4

Contributions to changes in global GVC participation

(percentages and percentage points)

- ■ Changes in countries' GVC intensity
- ■ Changes in the geographical composition of gross exports
- ● Changes in GVC participation

- ■ Changes in sectoral GVC intensity
- ■ Changes in the sectoral composition of gross exports
- ● Changes in GVC participation

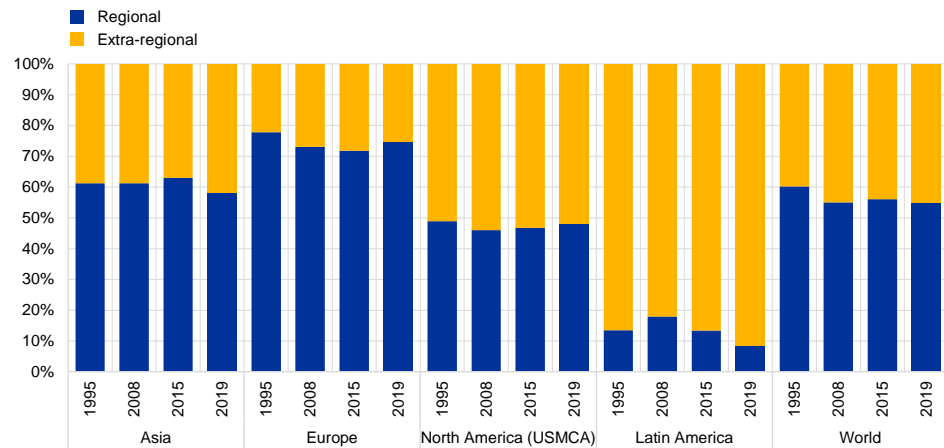Sources: OECD and authors' calculations.
Note: The chart shows the contributions to changes in GVC participation over two periods.

In general, supply chains have retained a strong regional component over time, particularly in Europe and Asia. Chart 5 decomposes the GVC participation of different regions into the contribution of regional and extra-regional trade. For countries in Europe and Asia, and to a lesser extent in North America, GVC participation has risen largely on the back of stronger supply linkages within the region itself, while countries in Latin America have become integrated in GVCs by strengthening linkages with partners from other regions. Since 2011, regional GVC links have somewhat weakened in Asia and Latin America, while in other regions they have remained broadly constant. Overall, supply chains remain clustered at regional level, particularly in Europe and Asia where the majority of supply linkages occur within the region itself. For countries in the USMCA[13] area, almost half of the imported intermediates embodied in gross exports originate within the area. By contrast, extra-regional linkages are more pervasive in Latin America. This phenomenon has involved both multinational and domestically owned companies, which have relocated production to within their region to an equal extent (see Box 1).

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[13] The United States-Mexico-Canada Agreement (USMCA) is a trade agreement between the three countries that was signed on 30 November 2018 and officially entered into force on 1 July 2020. It replaces the North American Free Trade Agreement (NAFTA).

Chart 5

Contributions to GVC participation

(percentages)

■ Regional
■ Extra-regional

Sources: OECD and authors' calculations.
Notes: Figures for 2019 are estimates based on regional trackers of GVC participation. For further information, see Box 2.

Box 1

The role of MNEs in GVCs

Prepared by J. Böning, V. Gunnella and L. Segers

MNEs play a key role in the cross-border organisation of production and GVCs. MNEs have emerged as a model for the organisation of production, allowing firms to benefit from lower trade and coordination costs and dislocate production where it is more efficient.[14] Today, MNEs (domestic and foreign) account for more than one-third of global production. Their activity is particularly predominant in exports (65%) and GVC-related trade (summarised by imports of intermediate inputs, 41%) (Chart A, panel a). When compared with domestically owned companies,[15] foreign multinationals have a substantially large involvement in GVCs, especially in emerging markets and in the euro area (Chart A, panel b). Compared with domestic firms, foreign affiliates of MNEs rely more on backward linkages. This reflects the fact that offshoring activity of MNEs relies on foreign intermediate inputs and that multinational activity is often related to reprocessing activity in the host country. The presence of foreign MNEs is positively associated with foreign value added being sourced from the country where these are headquartered. This emphasises the strong GVC ties of foreign affiliates with parent companies abroad.
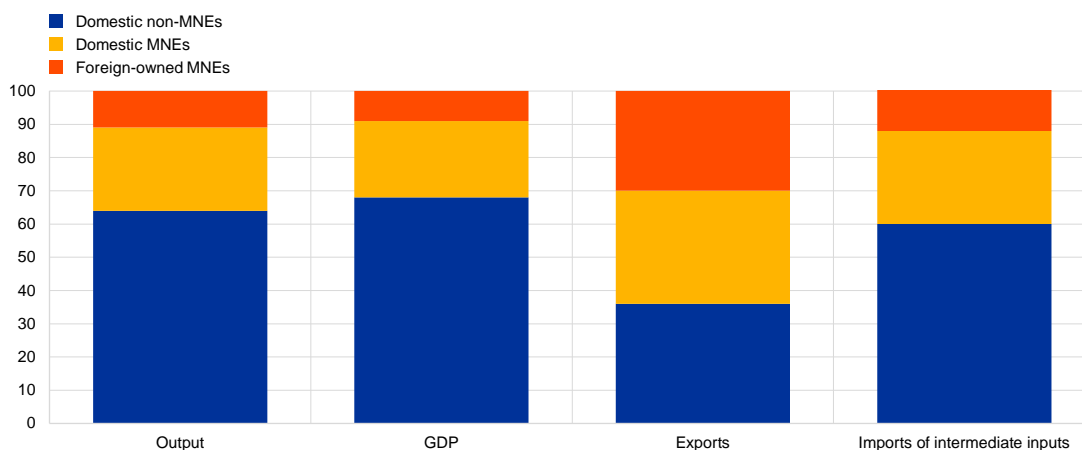
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[14] See Baldwin (2006) and Antràs (2003).

[15] Foreign companies comprise all firms with at least 50% foreign ownership. See the OECD AMNE Analytical Database for further details.
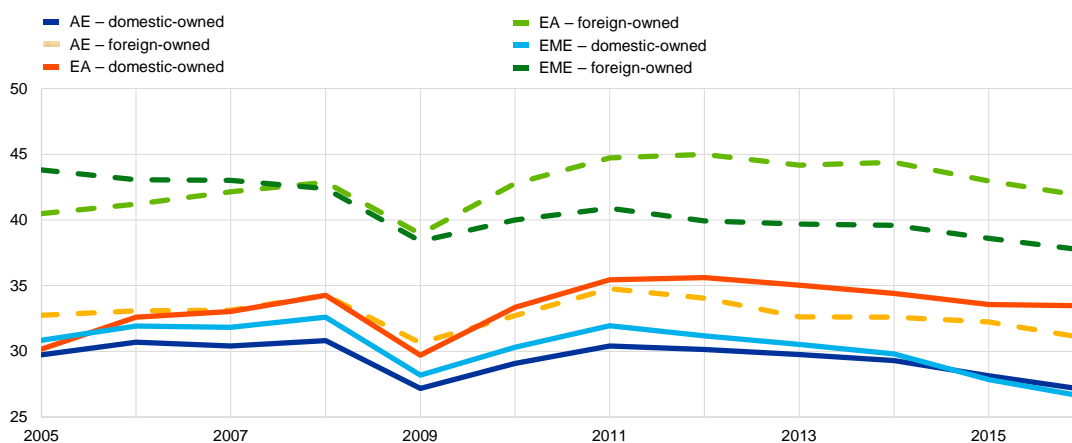
Chart A

MNE activity and GVCs

a) MNE activity

(percentage shares of total)

- Domestic non-MNEs
- Domestic MNEs
- Foreign-owned MNEs

Output | GDP | Exports | Imports of intermediate inputs

b) MNE GVCs

(percentage shares of total exports)

- AE – domestic-owned
- AE – foreign-owned
- EA – domestic-owned
- EA – foreign-owned
- EME – domestic-owned
- EME – foreign-owned

Sources: OECD, Borin and Mancini (2015) and authors' calculations.
Note: Foreign-owned aggregate includes firms with at least 50% foreign ownership. EMEs stands for emerging market economies; AEs stands for advanced economies; EA stands for the euro area.

The search for market access, vertical integration and lower taxes drive MNEs' location choices. The theoretical literature on foreign direct investment (FDI) indicates that multinational corporations operate for market-seeking motives (horizontal integration), efficiency-seeking motives (vertical integration) or a combination of the two (complex integration).[16] More recently, the focus has shifted to the relationship between MNE activity and tax avoidance, with countries with low tax regimes and lenient regulations gaining prominence as host countries.[17] Chart B reports the ten countries (left panel) and sectors (right panel) with the highest share of output attributable to MNEs. In terms of countries, foreign MNEs are prevalent and increasing in emerging countries that have integrated themselves into European production chains (mostly eastern European countries) and in so-called conduit countries (i.e. countries that act as intermediate destinations for offshore centres) or countries with favourable corporate tax regimes. In the latter, including in Luxembourg and Malta,

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[16] The reader can refer to Grossman et al. (2006).

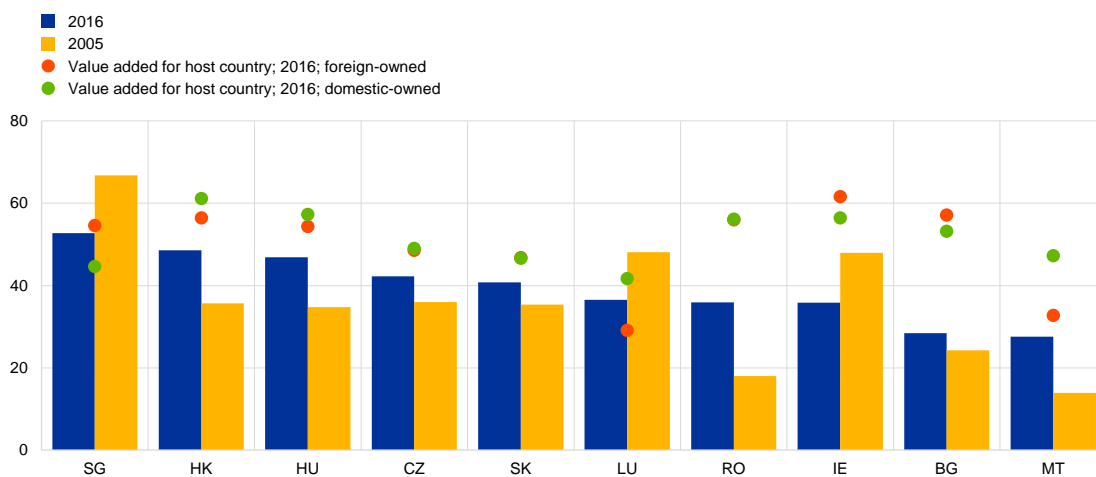[17] See Garcia-Bernardo et al. (2017).

MNEs' production relies largely on foreign value added, whereas in countries where affiliates are engaged in reprocessing, the value added content of the host country is significantly more prominent. Besides the multinational and concentrated character of specific industries such as financial services or wholesale, the right panel of Chart B validates the vertical integration motives of MNEs, since the share of foreign MNE output is higher in manufacturing sectors where production is organised in multiple stages taking place across borders. At the same time, the chart highlights the global character of ownership structures where the share of extra-regional ownership is dominant.

Chart B
Countries and sectors with higher foreign MNE activity

a) Foreign MNE activity by country

(percentage shares of country's total output)

- 2016
- 2005
- Value added for host country; 2016; foreign-owned
- Value added for host country; 2016; domestic-owned

b) Foreign MNE activity by sector

(percentage shares of total global output)

- Intra-regional
- Extra-regional
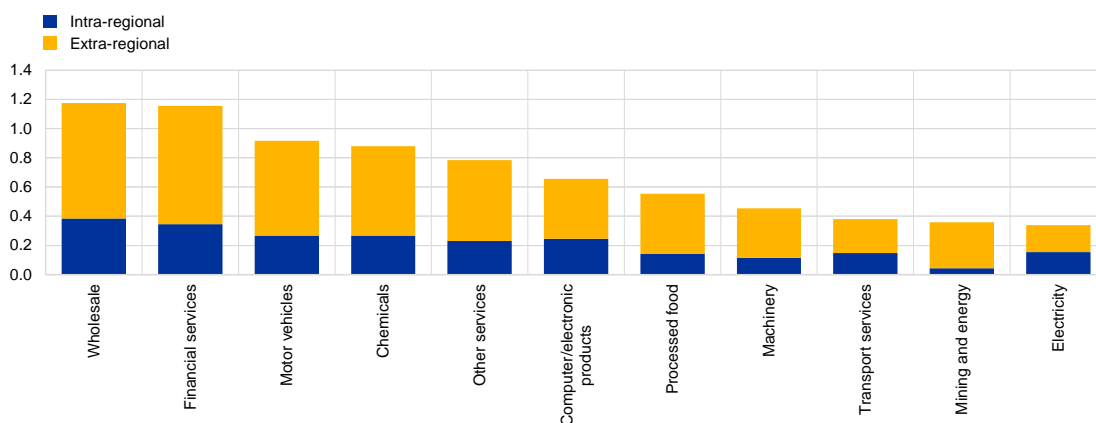
Sources: OECD, Borin and Mancini (2015) and authors' calculations.
Notes: Value added for host country is the domestic value added in production.

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Foreign multinationals operate predominantly through regional production networks.
Besides the canonical categorisations into horizontal, vertical and export platforms, the actual configuration of multinationals' activity is organised into regional production networks where foreign affiliates source their inputs from neighbouring countries and sell their output to large markets nearby.[18] Looking at GVC participation indices of foreign-owned and domestic-owned companies (Chart C) is instructive in this regard. Foreign-owned participation in regional production networks is significantly higher than in production networks outside the region, as is also the case for domestic-owned firms.

Chart C

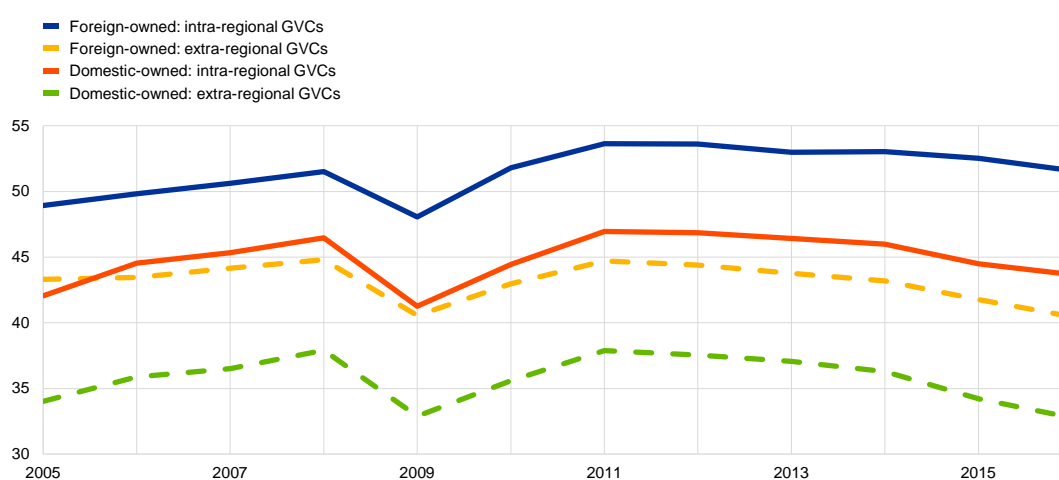Regional and extra-regional GVC participation of foreign-owned and domestic-owned firms

(percentage shares of gross global exports)

Sources: OECD, Borin and Mancini (2015) and authors' calculations.
Note: Foreign-owned aggregate includes firms with at least 50% foreign ownership.

Foreign affiliates have reduced their participation in GVCs, reflecting a decline in the machinery and chemical sectors in Europe and Asia. Chart C shows a declining trend in GVC integration, both for domestic-owned and foreign-owned firms and in extra-regional supply chains in particular. Cluster analysis can help to identify those sectors and countries which witnessed the fastest decline in GVC participation in the period from 2011 to 2016.[19] The analysis identifies two main clusters (Chart D). Within those, the machinery and chemical sectors, which tend to be characterised by highly fragmented production processes, have undergone a pronounced decline in GVC participation, especially in countries in Asia, Europe and North America. This may reflect decreasing fragmentation in the specific industries[20] as well as the rising participation of lower and middle-income countries in the production of intermediate products with higher technological content that were previously imported.
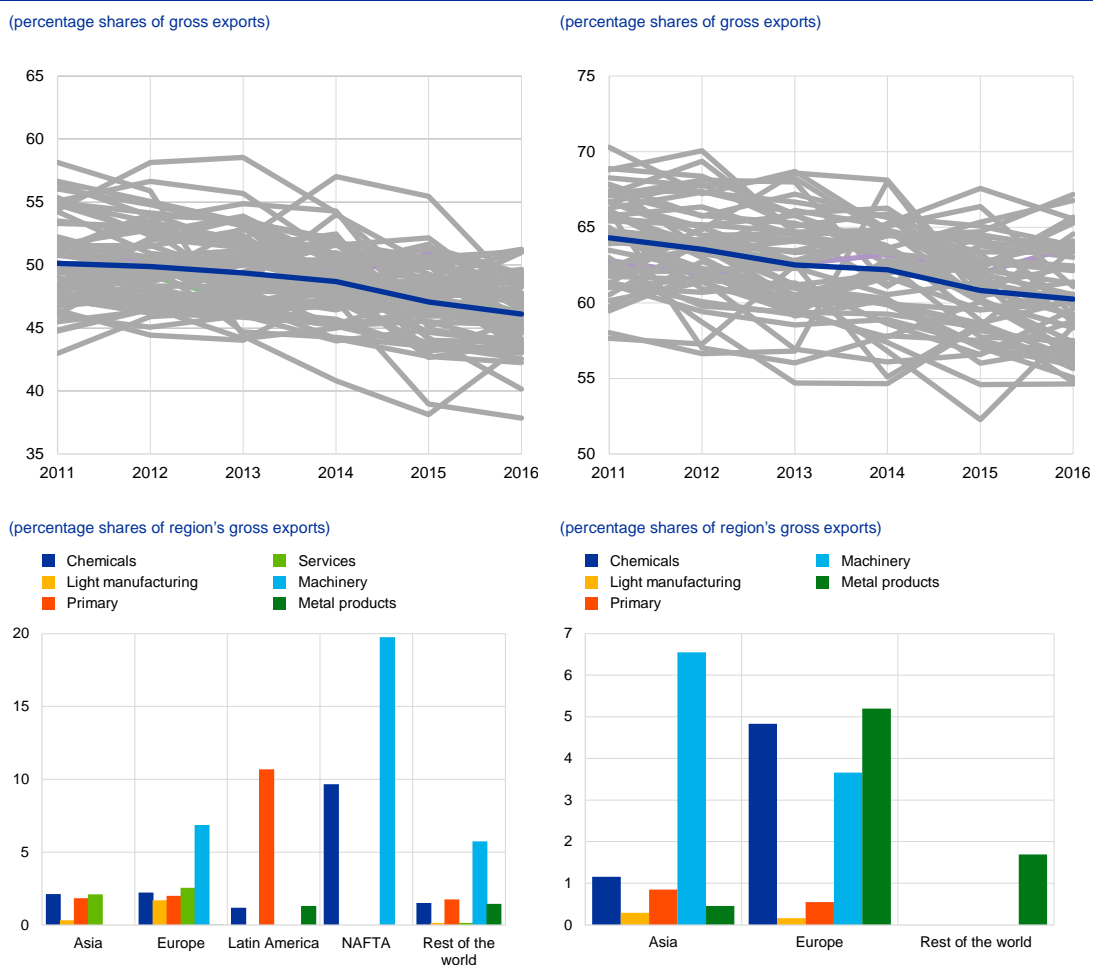
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18   Baldwin and Okubo (2014).

19   The cluster methodology utilises hierarchical clustering with centroid linkage and dynamic time warping as a distance metric. See Aghabozorgi et al. (2015).

20   See Pahl and Timmer (2019).

Chart D

Clusters of foreign-owned country sectors with highest decrease in GVC participation

(percentage shares of gross exports)

(percentage shares of gross exports)

(percentage shares of region's gross exports)

Legend:
- Chemicals
- Light manufacturing
- Primary
- Services
- Machinery
- Metal products

(percentage shares of region's gross exports)

Legend:
- Chemicals
- Light manufacturing
- Primary
- Machinery
- Metal products

Sources: OECD, Borin and Mancini (2015) and authors' calculations.
Notes: Foreign-owned sectors include firms with at least 50% foreign ownership. The top panels display the time series of GVC participation for each cluster. The bottom panels display the share of a region's gross exports for each sector in the respective cluster. Hierarchical clustering with centroid linkage and dynamic time warping as a distance metric has been used. RoW stands for the rest of the world.

At the same time, Asian and European multinationals have boosted supply chain integration within their respective regions. Chart E illustrates the predominant regional character of input sourcing and sales destinations for foreign affiliates in value added terms. Moreover, while intra-regional sales remained broadly stable in the period from 2011 to 2016 in Asia and Europe,[21] the share of intra-regional inputs (including from the domestic economy)[22] increased substantially. Besides the aforementioned role of technology, the geographical localisation of supply chains underlines the role of policy factors such as lower trade integration and a surge in trade distortions at the global level, and risk mitigation motives (see Section 3 and Lund et al., 2020).

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[21] Compared with data for 2005, countries in Latin America and Asia show an increase in intra-regional sales, highlighting the role of increasing demand from emerging countries in the two regions. While for Asia this phenomenon has both a domestic and regional dimension, for Latin America it is mostly domestic.

[22] In Europe, notable exceptions are countries such as Ireland, Malta and Cyprus, which moved towards sourcing inputs from extra-European countries, most likely in relation to US parent companies' activity.

Chart E

Foreign affiliates' value added

(percentage shares of total value added)

- Asia
- Europe
- Latin America
- NAFTA

a) 2011

b) 2016
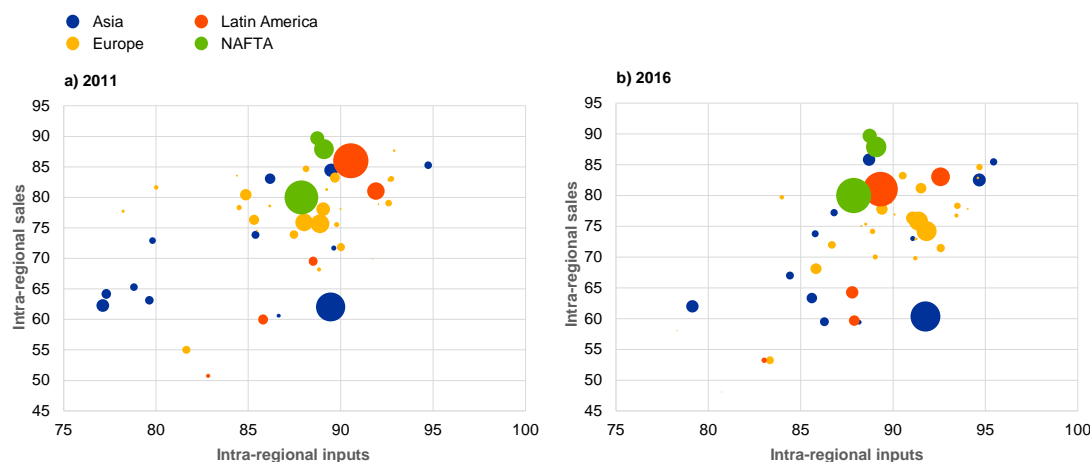
Sources: OECD AMNE Database, Borin and Mancini (2015) and authors' calculations.

From a sectoral perspective, there has been a visible rise of services in value added exports. Services are often referred to as the glue that holds value chains together. They allow different production stages of manufacturing to be linked across countries, including in the form of transport and telecommunications, effectively allowing GVCs to exist. According to traditional trade statistics, services trade accounts for around 20% of world gross trade. When measured according to a value added approach, it represents around 50% of gross value added trade – up from 30% in 1995. The value added of services is often bundled into manufacturing activities and therefore exported as manufacturing goods, which explains the larger share in value added trade.[23] The share of value added in manufacturing production attributable to services has also increased over time. In 2015, services accounted for around 30% of global value added in manufacturing, up from 20% in 2005.[24]

Falling GVC participation has dampened the trade elasticity of income over time. Another dimension of the reduced GVC participation since the global financial crisis has been its role in driving patterns of country and global income elasticity of trade. In order to gauge the quantitative impact of the expansion of GVCs on global trade elasticity, we updated the decomposition proposed in the ECB IRC Task Force

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[23] See Heuser and Mattoo (2017).

[24] In general, the nature of GVC participation by the services and manufacturing sectors is markedly different, with services exhibiting comparatively more forward linkages (as they serve as inputs in manufacturing activity). In addition, instead of following a linear value chain in which products move sequentially from upstream to downstream, adding value at each stage, they follow a "snake" formation in the terminology of Baldwin and Venables (2013).

report of 2016. Specifically, we decompose[25] the trade elasticity into three components: the long-run unit elasticity, the income elasticity related to the intensity of GVC trade and a residual factor relating to the income elasticity of the non-GVC-related import content of final demand. We find that in the period from 1996 to 2000, GVC expansion raised income trade elasticity by more than 0.9 percentage points. In the early 2000s, the contribution declined to 0.1 percentage points (Table 1). During the recession, the average contribution dropped to around zero, where it has remained since. Overall, the analysis suggests that the contraction in global trade elasticity since 1996 can be accounted for by a combination of declining income elasticity related to the intensity of international fragmentation and declining non-GVC-related imports of similar size.

Table 1

Contributions to the global income elasticity of trade

(trade-to-income elasticity and contributions)

	GVCs	Others	Long-term	Trade elasticity
1996-2000	0.94	0.92	1	2.86
2001-2007	0.10	0.13	1	1.23
2008-2015	-0.08	-0.1	1	0.82
2016-2019	0.02	0.02	1	1.04

Source: ECB computations based on Borin and Mancini (2015).
Note: For further details on the methodology behind the computations, see footnote 25.

A new tracker allows us to gauge recent developments in GVC participation.
The scarce availability of harmonised and timely input-output (IO) data poses some challenges in tracking GVC participation. Global IO tables are generally published and updated with long lags, which makes it difficult to gauge changes in the global production structure in real time. To address the lack of up-to-date IO tables, we have developed a timely quarterly tracker of GVC participation. As shown in Chart 2, the tracker (blue line) displays a good correlation with standard measures of GVC participation based on global IO data (yellow line), and it is therefore useful to gauge changes in the global production structure as they enfold. The tracker suggests that between 2015 – the last year for which IO tables are available – and 2019, GVC participation remained broadly stable. Box 2 provides further information on the methodology described above.

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[25]   Expressing total imports Mt as the sum of non-GVC-related ("Ricardian") trade Rt and GVC-related trade Gt, global imports can be written as $Mt = \frac{Mt}{Rt} \frac{Rt}{Yt} Yt$, where Yt denotes the level of global GDP and the ratio $Mt/Rt \equiv GVCMt^*$ is a measure of international fragmentation of production strictly related to GVCs. The second ratio $Rt/Yt \equiv DMFDt$ measures the direct (non-GVC-related) import content of final demand. Taking log differences, dividing through by the log difference of GDP and averaging growth rates over a given sample period {s}, we can decompose the global trade elasticity into three components: the long-run unit elasticity, the income elasticity of international fragmentation intensity ($\eta t, sg_{ggg}\ g$) and a residual factor relating to the income elasticity of the non-GVC-related import content of final demand ($\eta t, sdd\ dd$): $\eta t, sm = 1 + \eta t, sg_{ggg}\ g + \eta t, sdd\ dd$. Note that when GVCs neither expand nor contract, the contribution from the GVC-related component is zero.

Chart 6

Contributions to trade growth by sector (left panel) and contributions to trade growth in intermediate goods by region of economic activity (right panel)

(yearly percentage changes)
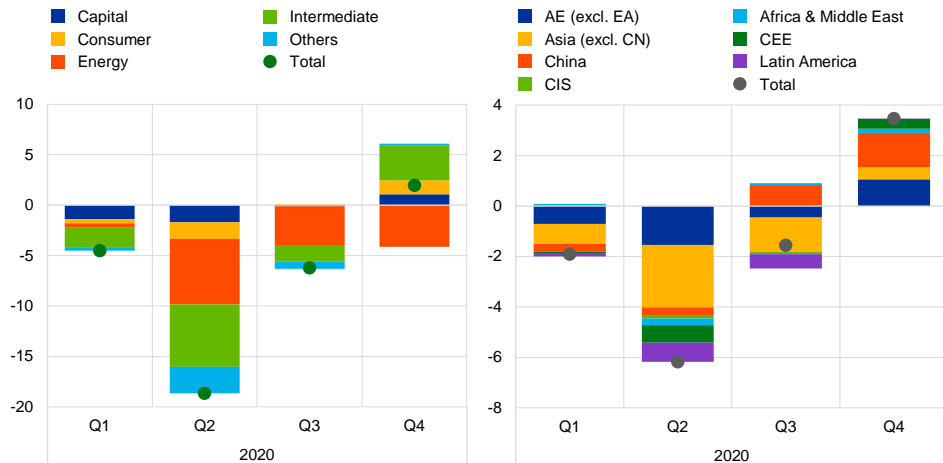
Sources: Trade Data Monitor and authors' calculations.
Note: Data refer to nominal trade in goods.

The COVID-19 pandemic hit supply chains particularly hard, but GVC trade recovered quickly in the second half of 2020. Somewhat surprisingly, our tracker indicates that participation in GVCs may have risen in 2020 (Chart 2), reflecting the fact that during the pandemic, GVC-related trade declined by comparatively less than trade in final goods (see Section 3 on the impact of COVID-19 on GVCs). Chart 6 corroborates this. It indicates that in the first quarter of 2020, trade in intermediate goods declined sharply. This reflects a large contraction in China (right panel). As China started to recover in the second quarter, trade in intermediate goods also bounced back, cushioning the slowdown at global level. By contrast, trade contracted more sharply in other sectors of the global economy, particularly in the energy sector, contributing to the overall fall of world trade to a large extent (Chart 6, left panel). Our tracker indicates that participation in GVCs expanded further in the first half of 2021 as intermediate goods trade grew at a sustained pace,[26] possibly reflecting a rebuilding of inventories driven by the post-pandemic recovery.

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[26] See Exports of intermediate goods gain momentum in Q2 with 47% year-on-year increase, World Trade Organization, 3 November 2021.

Box 2
A new tracker of GVC participation

Global IO tables represent a widely used tool to measure participation in GVCs. These provide a complete overview of market transactions across industries and countries, defining the nature and use of value added (intermediate and final) by the country of origin and destination. The tables are constructed by connecting national IO tables across borders using bilateral trade data.[27] Global IO tables can be used to compute several relevant metrics, including widely reported measures of GVC participation.

Global IO tables are generally published and updated with long lags, which makes it difficult to gauge changes in the global production structure in real time. A number of databases that enable analysis of trade through the lens of GVCs are now available. While comparable in terms of methodology, they differ with respect to the time horizon, countries and sectors covered.[28] The tables produced by the Organisation for Economic Co-operation and Development (OECD) cover the period from 1995 to 2018 and are among the most widely used. Producing and updating the tables is a data-intensive exercise requiring country-level data on value added flows. As a result, the tables are published irregularly and with long lags, which precludes the possibility to produce timely assessments of developments in GVC trade and the cross-border organisation of production. Generally, this does not represent a major stumbling block, as GVCs tend to be stable and develop only slowly over time. This stems from the fact that once investments have been made, they are not quickly reversible and it is cumbersome for firms to rearrange production. However, there are instances whereby specific shocks can alter the international structure of production relatively fast, such as in the case of a trade dispute that involves export bans of certain products or as a result of a shutdown of production in goods and services (as seen in the context of the lockdowns imposed to counteract the COVID-19 pandemic). In both cases, bottlenecks in production can arise quickly, significantly disrupting businesses along the entire chain.

To address the lack of up-to-date IO data, we have developed timely quarterly trackers of GVC participation that rely on trade in intermediate goods. Our trackers are informed by nominal data on intermediate goods trade, which are easily and timely available at monthly frequencies through several sources. These provide information over a longer time span and are available with a lag of only one quarter. Trends in intermediate goods trade are indicative of GVC formation since fragmented production processes require that parts, components and partially manufactured sub-assemblies cross borders before final goods are produced and shipped to final markets (Arndt and Kierzkowski, 2001). As the fragmentation of production across countries has grown, trade in intermediate goods has incrementally become an important driver of world trade. In 2009, world exports of intermediate goods exceeded the combined export values of final and capital goods, with intermediate inputs making up more than half of the total goods imported at global level and close to three-quarters of the imports of large developing economies such as China and Brazil. For the purpose of our tracker, we have selected a specific category of intermediate goods, namely those classified as generic intermediate goods by the United Nations (2019).[29] These appear to be

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27 For an in-depth review of macroeconomic and microeconomic approaches to measuring GVCs, see Johnson (2018).

28 These include the Trade in Value-Added Statistics (covering 66 countries), the World Input Output Database (43 countries), and most recently the Eora Multi-Region Input-Output (MRIO) database (henceforth referred to as Eora (Lenzen et al., 2013) for 189 countries.

29 The tracker is built as simple ratio of generic intermediate imports and exports as a share of total imports and exports. Data are standardised.

better correlated with standard measures of GVC participation based on IO data than input goods in so far as they better proxy the whole set of upstream and downstream activities associated with GVC participation. A simple rolling correlation between imports and exports could also be regarded as a valuable and timely proxy for GVC participation. However, this is more useful to gauge slow-moving trends, as correlations need to be computed over a time window (usually a few years).[30]

Our newly developed tracker accurately traces GVC participation over time. While trade in intermediate goods does not exactly match the cross-border production-sharing activities included in GVC trade on a one-to-one basis,[31] our tracker correlates well with standard measures of GVC participation based on world IO tables. This is shown in Chart 2, which plots together an IO-based index of GVC participation (yellow line) and our newly developed GVC participation tracker (blue line). The measure of GVC participation is constructed by using OECD IO tables and employing the aforementioned definition by Borin and Mancini (2015). The two series co-move over time, with a correlation of 95% over the period between 2000 and 2015, the last year available in the OECD IO tables. We have also developed similar trackers at regional level, including for Europe, North America, Asia and Latin America. Correlations with standard indices of GVC participation from OECD IO tables vary between 90% and 95%.

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[30] See ECB Working Group on Global Value Chains (2019) and Frohm (2020).

[31] For example, in the case of imported intermediate goods that are consumed domestically, crossing therefore only one border.

3 Drivers of GVC participation

This section reviews the main forces driving GVC participation from a global and country-specific perspective, with a view to assessing the contribution of different factors to the recent slowdown. Section 3.1 describes the factors that contributed to the early rise of GVC participation globally. Section 3.2 illustrates how these factors have evolved over the past decade.

3.1 Factors contributing to the early rise of GVC participation

The literature ascribes the fast growth of vertical integration to a combination of policy measures and technological advancements.[32] Rapidly falling transport costs in the early nineteenth century enabled a dislocation of consumption and production across advanced economies, paving the way for the first unbundling. Nevertheless, production remained geographically clustered due to high communication costs, which required technical resources to be physically near other factors of production. Measures of transport costs are scant, but a proxy often deployed in the literature is the CIF-FOB margin. This can crudely be obtained by dividing the price of world imports including the cost of insurance and freight (CIF) by the price of world exports declared free on board (FOB). This margin, which in general exhibits some volatility, has been falling steadily since 1970 (Chart 7, left panel). As the price of shipping has dropped, container fleets have risen rapidly.

Advances in technology further revolutionised global production in the 1990s, leading to a second unbundling (Baldwin, 2016).[33] With the ICT revolution, the cost of organising and managing complex activities over long distances declined rapidly, both within and between companies, allowing MNEs to dislocate production in emerging market economies and take advantage of wage differentials. Analysis by Antràs (2021) indicates that the processing power and memory capacity of computers has doubled approximately every two years since the 1970s. At the same time, the cost of transmitting information over optical networks has decreased by half roughly every nine months. The number of internet users has also increased sharply, from around 0.4% of the world population in 1990 to around 50% in 2017, which amounts to a doubling of internet users roughly every two years (Chart 8, left panel).

The biggest impact of the ICT revolution has been on services trade. While global goods trade has fallen relative to GDP, trade in services is moving in the opposite direction, rising twice as fast as global goods trade since 2003. Services allow different production stages of manufacturing to be linked across countries, including in the form of transport and telecommunications, effectively allowing GVCs to exist. Within services trade, digital trade flows have tripled (Chart 8, right panel).
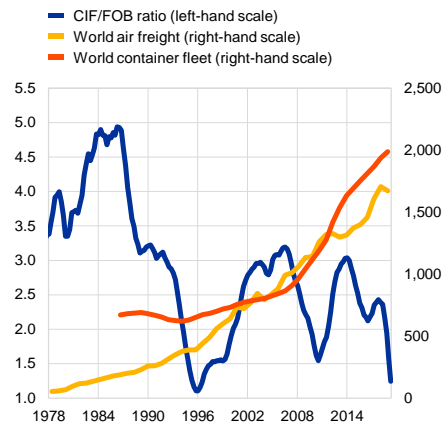
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[32] See Baldwin (2006) and Antràs (2020a).

[33] While the steam revolution was responsible for the first unbundling between production and consumption in the first half of the twentieth century, ICT, in particular communication technology, led to a second unbundling of production activities in the 1980s.

The deployment of ICT has also meant that GVCs have become more knowledge-intensive over time, reflecting rising investment in intangible activities and asset-light forms of production.

Chart 7

World transport costs

(left-hand scale: percentage of imports; right-hand scale: million tonnes)

(indices)

- CIF/FOB ratio (left-hand scale)
- World air freight (right-hand scale)
- World container fleet (right-hand scale)

- Shanghai Shipping Exchange
- FBX China to Europe (left-hand scale)
- FBX China to US West Coast (left-hand scale)

Sources: IMF, Haver and authors' calculations.
Note: We deducted 1 from the CIF/FOB ratio, so that the measure approximates transport costs as a percentage of imports.

Chart 8

Number of internet users and world trade by sector

(percentage share of world population)
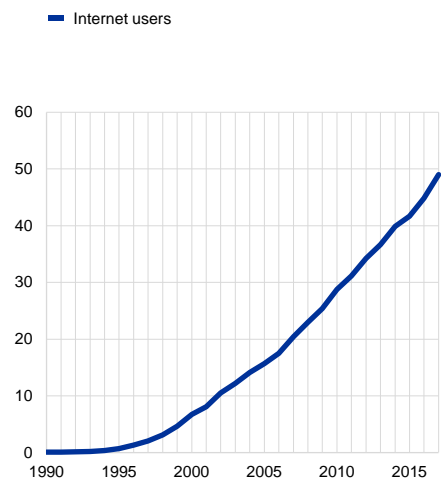
(index: 2003=100; percentages)

- Internet users

- Trade in goods
- Trade in services
- ICT service exports
- Royalties and licence fees (right-hand scale)
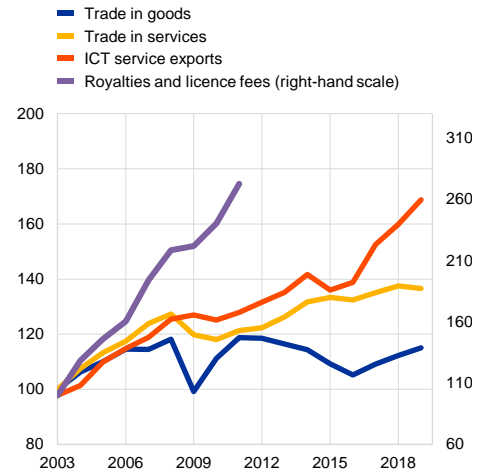
Sources: IMF, Haver, World Bank and authors' calculations.
Note: Trade in goods, trade in services and ICT service exports are expressed as shares of world GDP, whereas royalties and license fees are expressed in US dollars.

Various waves of trade liberalisation in the 1990s led to a sharp and broad-based reduction of tariffs, especially in emerging market economies, thus further enhancing trade integration. Tariff rates and national indices of GVC participation display a negative correlation over time (Chart 9), implying that countries which apply lower tariff rates are more amenable to GVC participation, but also that the steady decline in tariffs across countries since 1980 has fuelled GVC integration on a global scale. As the level of tariffs declined, trade policy uncertainty was also reduced, as highlighted by binding commitments that countries made when entering the General Agreement on Tariffs and Trade (GATT) and World Trade Organization (WTO) or signing regional trade agreements. In other words, not only had tariffs reductions an immediate impact, but there was also the general sense that the institutions being put in place would be effective in precluding the reinstatement of protective trade measures. The empirical literature corroborates this evidence. Conconi et al. (2018) study the implications of the "rules of origin" of the North American Free Trade Agreement (NAFTA) and show that the latter have led to a noticeable increase in intermediate goods from the United States and Canada, while imports from third countries have fallen.

The rise of preferential trade agreements (PTAs) has also favoured participation in GVCs. PTAs have become more comprehensive over time, often encompassing policy areas that go beyond traditional trade policy such as investment, competition and intellectual property rights protection (Fernandes et al., 2021). The literature suggests that countries sign "deep" agreements to promote and facilitate the smooth operation of GVCs. Analysis by Laget et al. (2018) shows that adding a policy area to a trade agreement increases both forward and backward GVC linkages. At the sectoral level, the positive impact of deep trade agreements is found to be greater for higher value added industries, suggesting that deep agreements help countries to integrate themselves in industries with higher levels of value added.

Chart 9

Country average tariff rates and GVC participation

(percentages; percentage shares of gross exports)
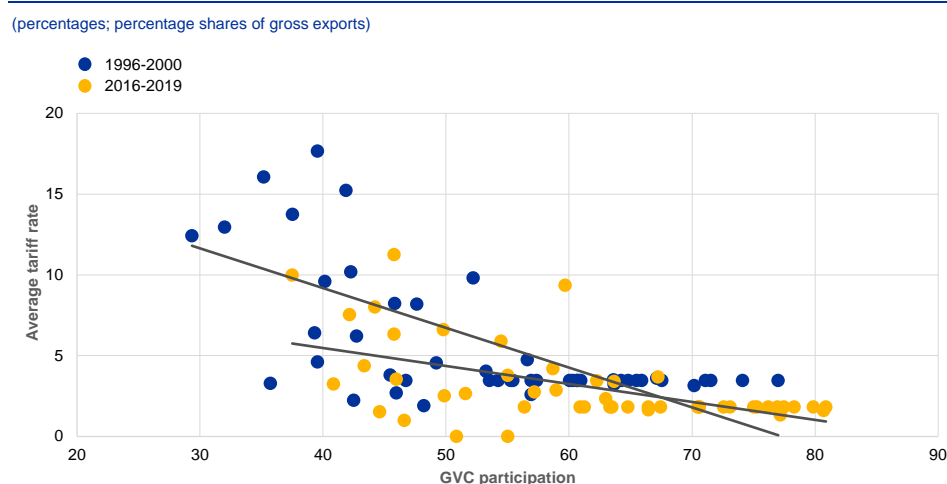
Sources: World Bank, OECD and authors' calculations.

In addition to policy factors and technological advancements, available studies also highlight the role of countries' structural characteristics and institutional factors. Specifically, these affect the extent and the type of countries' engagement in GVCs.[34] For example, countries characterised by a large domestic market tend to rely on few foreign inputs for their production of exports and specialise instead in upstream activities. In addition, as shown in Section 2, countries at an early stage of their economic development tend to specialise in commodity-related value chains, posting high forward linkages, or in manufacturing activities with low value added content. Once they have reached a more advanced stage of development, countries start specialising in more complex activities.

**Beyond specific characteristics and endowments, a broad range of policies and institutions also determine the degree of a country's engagement in GVCs.** By becoming part of a GVC, firms enter into relationship-specific investments which often involve the exchange of highly customised inputs on a repeated basis. Antràs (2021) indicates that firms spend significant time and resources designing the organisational structure of these production networks and are therefore subject to high reputational and transaction costs. In this regard, low quality institutions and a poor business environment tend to be detrimental to the viability of GVCs, as they increase the contractual risks faced by firms and the propensity of firms to invest.

Productivity and cost differentials across countries are also an important determinant of firms' decisions to offshore parts of the production process and whether to do so through FDI, with subsidiaries providing inputs to their parent firms or via arm's-length trade. Therefore, openness to FDI is also strongly associated with the rise of GVCs, particularly backward participation in GVCs (Chart 10). This stems from the fact that FDI has often been aimed at establishing processing facilities in the receiving country, especially in the case of "vertical MNEs" that import intermediates for production and export a large share of final products (see Box 2 on the global role of MNEs). FDI takes place when multinational firms establish operations in foreign countries. Often, the motivation is to produce in the host nation products that were previously exported from the home nation, in order to take advantage of labour cost differentials. To the extent that this occurs, FDI and home nation exports can be treated as substitutes. However, it is often the case that the operations of a multinational firm are vertically linked, such that an increase in activity in the host country generates increased demand for intermediate products (including capital goods) from the country of origin. In addition, marketing and distribution capabilities created by FDI can enable the home nation operations to export final goods and services to customers that would not be reached in the absence of FDI. To the extent that either of these happens, home country FDI and exports can be considered as complements.

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34 See Kowalski et al. (2015).

Chart 10

FDI and GVC backward participation

(logarithms)
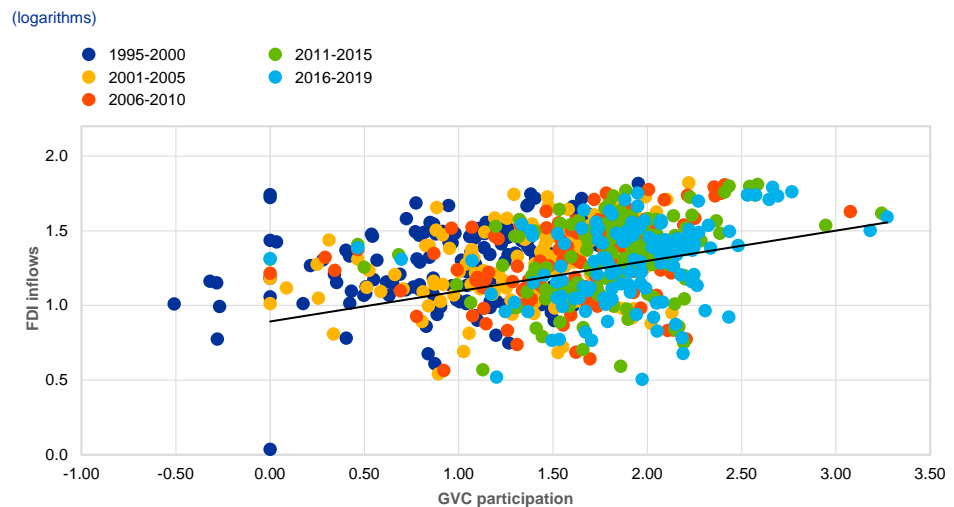
Sources: OECD, Haver and authors' calculations.

3.2   Drivers of the recent slowdown in GVC participation

Many of the factors that enabled fast GVC integration since the first unbundling have worked in reverse in the last decade, contributing to the decline observed in the data.

Rising global protectionism is likely to have contributed to a slower pace of GVC integration. Following the global financial crisis, the reduction of tariff rates has tapered off (Chart 9). At the same time, the use of regulatory measures and non-tariff barriers, such as export subsidies, restrictions on licensing or FDI and domestic clauses in public procurement, has increased, leading to an overall surge in trade distortions (Chart 11). Protectionist tendencies have intensified further in recent years, culminating in the trade dispute between the United States and China and the departure of the United Kingdom from the European Union.[35] With the onset of the COVID-19 pandemic, protectionist trends were further exacerbated, especially in the first half of 2020. More than 1,900 new restrictive interventions were imposed in 2020 – 600 more than the average of the two previous years – with the latter being already elevated as a result of the intensification of the China-United States trade dispute and the new wave of protectionism. In the first half of 2020, export protectionism has particularly risen in prominence, mainly on the back of country restrictions on shipments of essential medical supplies and personal protective equipment.[36]

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[35]   For an assessment of the impact of the United States-China trade dispute and the United Kingdom's exit from the European Union, see Section 4.

[36]   The WTO has encouraged its members to exercise maximum restraint in the use of export restrictions and other measures that could disrupt supply chains and has also called on members to improve transparency on any new trade-related measures introduced as a result of the COVID-19 pandemic.

The enhanced volatility of transport costs and energy prices represents a further possible driver of the slowdown in GVC integration over the last decade. The decline in transport costs, proxied by the CIF-FOB margin, seems to have come to a halt after the global financial crisis, while volatility has increased (see Chart 7, left panel). Volatile oil prices and a growing imbalance between supply and demand for freight transport services have been singled out as two important determinants. Russell et al. (2014)[37] indicate that these factors may have pushed companies to make transport-driven shifts in their supply chain strategies in recent years, including a shift from offshoring to nearshoring sourcing strategies to reduce the number of miles shipments travel. More recently, one of the side effects of the COVID-19 pandemic has been the sharp increase in shipping rates globally. Measures of shipping rates, including the Shanghai Containerized Freight Index that is based on weekly spot container freight rates (exports) from the port of Shanghai, have more than tripled since early 2020 (Chart 8, right panel).[38]

Declining FDI flows are also linked to the recent moderation in GVC participation. The pace of FDI growth has slowed down markedly after the global financial crisis, falling to an average annual pace of 4% in the period from 2010 to 2019, a decline of 20 percentage points compared with the decade preceding the crisis. The moderation reflects a pronounced fall of inflows into advanced economies amid falling rates of returns. The COVID-19 pandemic had a deep impact on FDI, exacerbating the declining trend. Data from the United Nations Conference on Trade and Development (UNCTAD) indicate that global FDI suffered its sharpest decline on record in 2020 (falling by 42% year-on-year), reaching a level last seen in 2003.

Rising labour costs in emerging market economies represent a further driver of slowing GVC integration. The sustained rise of income in emerging economies in the last two decades has gradually put upward pressure on wages, eroding competitiveness and cost differentials vis-à-vis advanced economies, and thereby reducing the incentive for MNEs to offshore production. With the exception of Mexico, most emerging market economies both in Asia and in emerging Europe have seen a steady rise in unit labour costs in the last two decades, significantly outpacing those in the United States and the euro area. However, the gains from specialisation do not rely solely on factor price differences across countries but can also stem from idiosyncratic cross-country productivity differences for different goods and sectors. A large share of multinational firm activity takes place between countries with similar relative factor endowments and factor prices.

While ICT developments unequivocally boosted GVC participation, the impact of new technologies related to Industry 4.0 remains uncertain. Industry 4.0 refers to the emergence and diffusion of a wide range of new digital industrial technologies broadly related to the Internet of Things, digitalisation, artificial

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37 See Russell et al. (2014).

38 The increase in shipping costs likely reflects a combination of demand and supply factors. In the wake of the pandemic, consumers have diverted expenditure from services (which have borne the brunt of restrictions) to consumer goods. And since consumer goods are more heavily traded, this has resulted in a surge in demand for containers and shipping services. The effect on supply chains has been exacerbated by the effects of the pandemic itself, with severe bottlenecks emerging through 2021, the new post-Brexit regulatory regime that came into force at the start of this year has led to increased trade friction between the United Kingdom and European Union.

intelligence, robotics and automation and 3D printing, among others. On the one hand, technologies related to robotics and automation have the potential to boost productivity and capacity utilisation in high income countries, making labour arbitrage vis-à-vis emerging and developing countries less appealing. This could prompt MNEs to reshore production back to advanced economies. In addition, the use of 3D printing has received new impetus, as it can shorten supply chains and accelerate time to market. On the other hand, technologies associated with growing digitalisation and the adoption of digital platforms are likely to further drive down the cost of cross-border communication and transactions, encouraging further production fragmentation. Evidence on the impact of new technologies on GVCs is scant, and the available studies do not come to conclusive evidence. De Backer et al. (2018) find a negative association between robotics investment and the growth of offshoring in the period from 2010 to 2014. Likewise, Dachs et al. (2017) find a positive relationship between reshoring and an index of Industry 4.0. Model-based simulations by the WTO indicate that the impact of technologies related to Industry 4.0 on the organisation of value chains may be limited.[39]

Chart 11

New trade measures

(numbers)

- Trade restrictions
- Trade restrictions excluding the United States
- Trade liberalisations
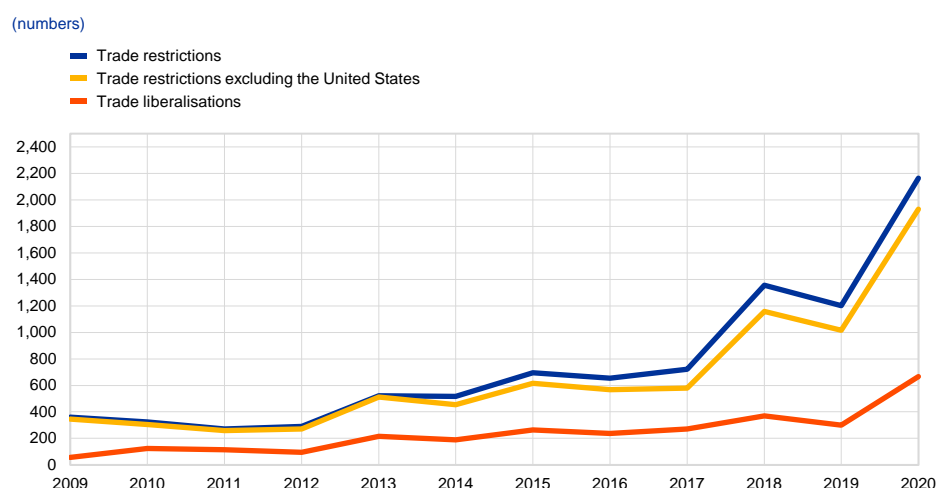
Sources: Global Trade Alert and authors' calculations.
Note: Data exclude late reports for the respective reporting year (the cut-off date is 31 December of each year).

Results from panel estimations confirm the findings from stylised evidence.
We investigate what drives GVC participation from an empirical perspective, relying on a gravity equation for a panel of 57 countries over the period from 1995 to 2015 (further information on the approach used and detailed results are shown in Box 3). Our analysis indicates that being part of a common PTA and the presence of large bilateral FDI inflows lead to higher value-added flows between two countries. Specifically, a 1% increase in FDI inflows is associated with a 0.2 percentage point surge in bilateral value-added trade. Regional integration through trade and investment agreements in South-East Asia, North America and eastern Europe has been linked to the emergence of large international production networks in these regions. Our analysis supports this, showing that the presence of a common PTA

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[39] See WTO (2019).

leads to an increase in value added trade of 0.5 percentage points. Common gravity variables are also important determinants of GVC participation. Countries that are geographically apart tend to engage less in value added trade, as well as those that do not share languages and historical ties. Using a dataset of bilateral import flows that covers 5,000 products and more than 200 countries over the period from 1998 to 2011, Conconi et al. (2020) show that intermediate goods are indeed more sensitive to distance than final goods and that differentiated inputs exhibit the highest distance elasticity.

Economic, policy and institutional factors are also found to be important determinants of GVC integration. Our empirical results suggest that the level of economic development (proxied by GDP per capita) and the degree of industrialisation of the economy (proxied by the share of manufacturing value added in GDP) are positively associated with high backward linkages. Meanwhile, labour costs and backward GVC participation display a negative association, in line with the literature which suggests that low labour costs are an important factor behind offshoring of production. Sound institutions, including effective rules of law and an enabling business environment, also favour the establishment of backward linkages, with an increase of 1% in agents' confidence in their own country's rules of law leading to higher engagement in backward participation of 0.2 percentage points. Finally, the more general policy environment, including spending on education and the tax burden, is also an important determinant. Chart 12 summarises the estimated contributions of policy, economic and institutional drivers to GVC integration of the countries covered in our panel in the period from 1995 to 2015. Half of the increase in GVC integration between 1995 and 2008 can be ascribed to more favourable policies, including falling tariff rates, rising participation in PTAs and higher spending on education and R&D. Enhanced institutions and stronger economic growth account for the other half of the increase. Likewise, the decline between 2008 and 2015 reflects a lower contribution of the policy drivers to a large extent, compounded by falling economic activity and a less favourable institutional set-up. The role of technological progress is difficult to pin down in isolation, as it is often bound to policy and economic variables.

Chart 12

Model-based decomposition of global GVC participation
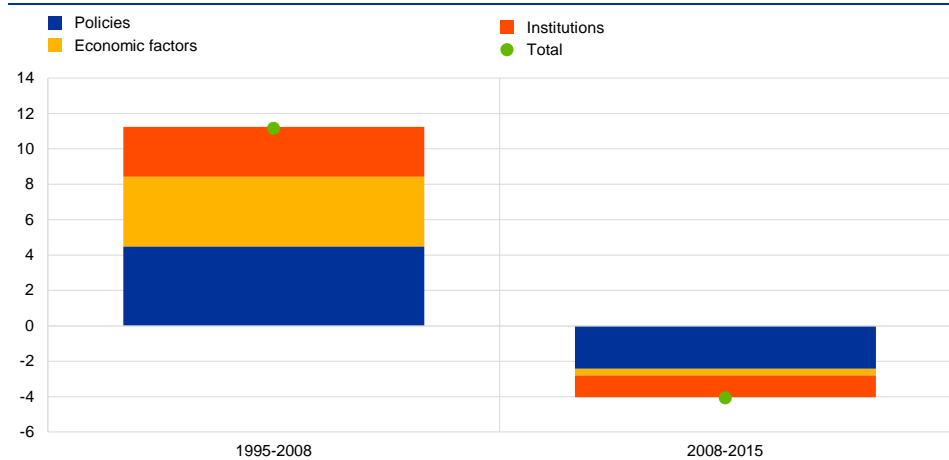
Source: Authors' calculations.
Notes: The decomposition is based on results obtained from panel analysis featuring a gravity equation. For further information, see Box 3.

Box 3
Drivers of GVC participation: a gravity approach

Empirical analysis can help to shed light on the role of different drivers in shaping countries' engagement in GVCs. We rely on a panel analysis featuring a gravity equation to evaluate the drivers of GVC participation for a sample of 57 countries over the period from 1995 to 2015. Gravity equations are widely used as a workhorse for analysing the determinants of bilateral trade flows. The gravity specification has several benefits, including the fact that by controlling for the characteristics of the source and destination countries, it provides a suitable framework to address possible endogeneity arising in the relationship between GVC participation and its determinants. Furthermore, the bilateral perspective embedded in the gravity approach enables a granular understanding of the elements that lead countries to engage in supply chains with each other.

We take the perspective of the importer, in other words a country that receives value added from an upstream supplier in the form of inputs, uses these in production and exports the processed product to a third destination. We investigate the forces that affect its participation within the value chain, proceeding in two steps.[40] For any given country pair i and j, we first estimate the impact of a set of bilateral determinants, including bilateral FDI inflows, the bilateral average tariff rate, the depth of preferential trade agreements and traditional gravity variables such as distance, the presence of a common border and common language, on a standard indicator of forward GVC participation. The latter is defined as the domestic value added of country i embodied in intermediate inputs exported to j, which is processed by j and re-exported to a third country in the form of intermediate or final goods. In a second step, we take the perspective of importer j, trying to quantify the extent to which its economic, policy and institutional characteristics affect its position within the value chain.

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[40] One limitation of the analysis is that bilateral value added flows depend not only on bilateral trade costs but also on costs in third countries through which value added transits from source to destination. Besides difficulties in interpreting gravity results in a standard fashion, empirical complications also arise in trying to capture these indirect effects. As shown by Noguera (2012), their relative importance can be high, although it varies significantly across countries and types of trade costs.

The gravity equation can be written as follows:

$$VA_{ijt} = \beta_1 PTA_{ijt} + \beta_2 tariff_{ijt} + \beta_3 FDI_{ijt} + \beta_4 Z_{ij} + \eta_{it} + \eta_{jt} + \varepsilon_{ijt} \qquad (1)$$

where VA_{ijt} defines the value added embedded in the exports of country *i* to country j, which are then processed by *j* and further re-exported to a third country. The set of *ij* bilateral determinants over time include bilateral tariff rates ($tariff_{ijt}$), bilateral FDI inflows (FDI_{ijt}) and the depth of a PTA (PTA_{ijt})[41] applicable in both countries. Z_{ij} refers to a set of standard gravity variables including the presence of a common border between the two countries, common language and distance. We also add origin and destination time-fixed effects (η_{it} *and* η_{jt}) to control for all origin and destination-specific characteristics. The regression is estimated in log levels using the ordinary least squares (OLS) estimator and includes intra-national trade flows in order to identify the impact of borders on value added trade flows.

Table A

Estimated coefficients from panel regression in equation 1

Value added of i re-exported by j	Bilateral gross exports (GEX)		Bilateral traditional trade (GEX - GVC fw)	
	(1)	(2)	(3)	(4)
FDI outflow (i to j)	0.091***	0.094***	0.088***	0.091***
	(0.010)	(0.012)	(0.010)	(0.012)
Average tariff rate	-0.058***		-0.067***	
	(0.017)		(0.017)	
PTA level		0.225**		0.196**
		(0.106)		(0.103)
Common border (1=yes, 0=no)	0.183***	0.121***	0.177***	0.110***
	(0.090)	(0.083)	(0.089)	(0.083)
Common language (1=yes, 0=no)	0.484***	0.443***	0.476***	0.450***
	(0.081)	(0.116)	(0.077)	(0.114)
Weighted distance (pop-wt, km)	-0.857***	-0.852***	-0.855***	-0.859***
	(0.031)	(0.058)	(0.031)	(0.057)
Observations	11,691	7,163	11,691	7,163
R-squared	0.586	0.359	0.598	0.370

Source: Authors' calculations.
Notes: p<0.01 ***; p<0.05 - **; p<0.10 *; standard errors in brackets. The regression is estimated using annual data for a panel of 57 countries over the period from 1995 to 2015. Exporter time and importer time (annual) fixed effects are included in the panel regression. A robustness check is performed in the column "non-GVC trade (i to j)" by using gross exports from i to j consumed in j, a measure of what is commonly defined "traditional trade".

Table A illustrates the results of the analysis. It suggests that FDI inflows, the depth of PTAs and standard gravity variables are all positively associated with GVC participation. Specifically, an increase of 1% in FDI inflows from *i* to *j* is associated with a 0.1 percentage point increase in the domestic value added of *i* flowing to *j*. The gravity variables are also relevant in this regard (with the expected sign), such that while a common border and language enhance bilateral GVC linkages, distance discourages them. The coefficient of the bilateral tariff rate variable is also statistically significant and comes with the expected sign. Specifically, a 1 percentage point increase in the bilateral tariff rate is associated with a 0.04 percentage point decrease in GVC trade. In order

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[41] The depth of a PTA concerns the coverage of policy areas in the trade agreement. For the purpose of this analysis, only core provisions are taken into account. Core provisions are those that the literature identifies as more meaningful from an economic point of view. See the World Bank's content of deep trade agreements.

to draw a comparison of the effects of these variables vis-à-vis traditional trade, in two further specifications, we replace the dependent variable with gross exports of i to j that are consumed in j (i.e. a proxy for "traditional trade"). Table A shows that despite being significant, FDI and the depth of PTAs are less important for traditional trade than GVC trade. This result highlights the key role that FDI plays in supply chains characterised by vertical MNEs. In addition, for GVC trade, the depth of PTAs in terms of coverage of regulation areas may be a more important feature given the direct involvement of firms in partner countries through their subsidiaries. These results are in line with the literature, which associate the rise of PTAs with increasing participation in GVCs (Laget et al., 2018).

In the presence of importer and exporter fixed effects, a variety of potentially interesting determinants of the origin and destination can no longer be correctly identified in a gravity equation. These include variables that affect trade flows occurring between the two countries without regard to origin, such as country-level economic characteristics, institutional variables and policy variables. Adding country-specific variables to the gravity equation could indeed lead to biased standard errors. A potential solution deployed in the literature is to adopt a two-step estimator.[42] This entails first estimating source and destination country fixed effects η_{it} and η_{jt} in equation 1 and then regressing them on a set of variables specific to country *j*, akin to our second estimated equation (equation 2). Here we take the perspective of importer *j* and assess the extent to which specific economic, policy and institutional characteristics determine its position within the GVC.

$$\eta_{jt} = \alpha X_{j,t} + \varepsilon_{it} \tag{2}$$

Our choice of the variables of interest $X_{j,t}$ is informed by the literature and correlation analysis presented in the previous subsection. Specifically, we include economic characteristics of the importer such as GDP per capita, the level of GDP, the share of manufacturing value added in total GDP and unit labour costs. A second set of variables are of institutional origin and relate to the soundness of the rules of law and the business environment. Finally, we include a set of policy variables, including taxes on corporate earnings, the size of market capitalisation and a measure of expenditure in education and in R&D (which serves as a proxy of technological advancements).

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[42]   See Head and Mayer (2014).

Table B

Estimated coefficients from panel regression in equation 2

Importer (j) fixed effect	(1)	(2)	(3)
Economic variables			
Manufacturing output (% of GDP)	0.538***	0.487***	-0.079*
	(0.038)	(0.048)	(0.043)
GDP per capita	0.039	0.109**	-0.044
	(0.034)	(0.046)	(0.038)
GDP	0.657***	0.588***	0.853***
	(0.011)	(0.016)	(0.011)
Unit labour cost (index, 1990=100)	-0.348***	-0.075	-0.086*
	(0.044)	(0.054)	(0.052)
Institutional variables			
Rule of law (index)	-0.026	0.210***	0.207***
	(0.022)	(0.029)	(0.029)
Days to open a business	-0.011	-0.021***	-0.001
	(0.007)	(0.008)	(0.009)
Policy variables			
Profit tax (% of GDP)	-0.032***	-0.017***	0.064***
	(0.005)	(0.006)	(0.007)
Market capitalisation (% of GDP)	0.040***	0.019**	0.067***
	(0.007)	(0.008)	(0.009)
Education (% of GDP spent on education)	0.313***	0.116**	0.064
	(0.044)	(0.051)	(0.053)
R&D (% of GDP)	-0.107***	-0.039	-0.222***
	(0.022)	(0.026)	(0.027)
Observations	2,069	1,615	1,615
R-squared	0.92	0.83	0.97

Source: Authors' calculations.
Notes: p<0.01 ***; p<0.05 - **; p<0.10 *; standard errors in brackets. The regression is estimated using annual data for a panel of 57 countries over the period 1995-2015. In specification 1 and 2, importer (destination) fixed effects from equation 1 (specification 1 and 2 featuring GVC trade) are regressed on a series of importer economic, policy and institutional variables. In specification 3, importer (destination) fixed effects from equation 1 (specification 3 and 4 featuring traditional trade) are regressed on the importer economic, policy and institutional variables.

Results from this second step indicate that economic characteristics and, to a lesser extent, institutional and policy factors are important determinants of a country's position within the value chain. Table B illustrates this, pointing to a large effect of economic development (proxied by GDP) and the degree of industrialisation of the economy (proxied by the share of manufacturing value added in GDP). At the same time, and in line with the literature, unit labour costs display a negative association with backward participation, suggesting that the higher the cost of labour, the lower the attractiveness of a country as a processor of inputs within a GVC. Sound rules of law, market capitalisation and education level are also significant determinants of a country's position within a GVC, together with policy variables including profit tax. Spending on R&D, a proxy for technological advancements, is negatively associated with backward participation. In specification 3, we regress the fixed effects estimated in the first step regression featuring traditional trade rather than GVC trade on the selected independent variables have in almost all cases a different coefficient sign. This highlights the different nature of GVC trade vis-a-vis traditional trade, and how the two tend to be shaped by different and often contrasting forces.

4   The role of GVCs in the international transmission of shocks

Vertical integration comes with significant macroeconomic implications.
Participation in GVCs has enabled countries to specialise in areas of comparative advantage, enhancing productivity growth and supporting wages and incomes. At the same time, rising vertical linkages have led to growing interconnectedness. This section reviews the role of GVCs in the international transmission of shocks. We start by providing a review of the recent literature. We then present model-based and empirical-based estimates that illustrate the role played by supply chains in the transmission of recent major economic shocks, namely the COVID-19 pandemic, the United States-China trade dispute and the recent departure of the United Kingdom from the European Union.

4.1   Literature review

Production linkages serve as powerful conductors of shocks across countries.
The idea of IO linkages as a key channel for the propagation of shocks is not new, dating back to Leontief (1936) and Hirschman (1958).[43] But it is with the emergence of GVCs as new global paradigms of production that the role of intermediates trade in the international transmission of shocks has gained prominence. Intermediate goods cross a number of borders, acting as conductors of economic disturbances across countries that may not trade directly with each other. Because of GVC linkages, countries' imports and exports are sensitive to disturbances that originate in third countries. For example, the fact that a significant share of imports are used as inputs in the production process and are further re-exported implies that changes in demand in third countries represent an important determinant of a country's imports. This stands in contrast with standard trade models, where imports tend to be expressed only as a function of domestic demand. Similarly, in traditional trade models, a country's exports tend to be expressed as a function of foreign demand. However, the fact that a significant share of exports are used by trading partners in production and further re-exported implies that a country's exports may also be sensitive to demand changes in third countries. GVCs are a relevant channel of

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[43]   More recently though, authors have suggested that supply linkages can also turn isolated idiosyncratic disturbances at certain firms or industries into large macroeconomic fluctuations, akin to signal relays. Analysis by Atalay et al. (2014), for example, indicates that around two-thirds of the variability in aggregate output in the United States reflects sector-specific shocks that spread through IO links. According to Carvalho (2014), this occurs whenever the production structure of an economy is dominated by a small number of hubs supplying inputs to many different firms or sectors. Hubs shorten distances between otherwise disparate parts of the economy that do not directly trade inputs, thus acting as powerful conductors of economic disturbances.

transmission of supply-side shocks[44], as evidenced by the recent negative effects of COVID-related supply bottlenecks.[45]

The role of GVCs in the international transmission of shocks is largely associated with their sticky nature. Several authors in the literature (Antràs, 2020a; Monarch and Schmidt-Eisenlohr, 2020) have documented the sticky nature of GVCs. This reflects the irreversible trait of many investments made by firms in the set-up and organisation of their GVCs. Highly complex goods that require particular production processes or specialised channels may be more difficult to substitute. Thus, the failure of any single supplier could affect the entire production chain, leading to higher production costs for downstream firms when shifting to an alternative supplier, or worse, to a halt in production. Analysis by the IMF finds that highly interconnected countries that produce easily substitutable goods are better positioned to withstand disruptions in GVCs.[46]

The impact of shocks can be magnified through the value chain, as the shock ripples through. The basic idea behind this is known as the "bullwhip effect" and stems from the fact that, amid a change in demand for goods and services, firms also adjust their stock of inventories. In the face of large demand volatility, businesses typically face forecast errors, against which they hedge by building stocks of inventories. Whenever they are hit by a demand shock, downstream suppliers first deplete their inventories, thereby reducing their demand for inputs from upstream suppliers. In general, upstream participants in a supply chain face greater demand volatility than downstream ones. The result is that shocks to final demand are amplified through the value chain. The effect of inventories as an amplification device within a GVC has been studied at several levels of aggregation. Di Mauro et al. (2012) use firm-level transaction data, while Alessandria et al. (2010) use industry data to show that procyclical inventories may have exacerbated the effect of the 2008 recession.

The recent literature documents the rising interdependence of business cycles in the wake of pervasive supply linkages. De Soyres and Gaillard (2020) argue that economic activity across countries becomes more synchronised when the content of their trade is tilted towards intermediates as opposed to final goods. Di Giovanni and Levchenko (2010) deploy a large cross-country, industry-level panel dataset of manufacturing production and trade and show that bilateral international trade increases output co-movement significantly more in cross-border industry pairs that use each other as intermediate inputs. Specifically, they find that vertical production linkages account for some 30% of the total impact of bilateral trade on the business cycle correlation. Frohm and Gunnella (2021) provide evidence that, similar to a closed economy set, it is not IO linkages per se that generate spillovers across

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[44]   Boehm et al. (2019) deploy a rich firm-level dataset from the US Census Bureau and study the effects of the 2011 Japanese tsunami on US firms. They find that US affiliates of Japanese multinationals suffered large drops in output in the months following the tsunami, roughly one-for-one with the fall in their imported inputs. These firms also reduced demand for non-Japanese inputs thereafter, with the impact of the shock spreading through the US economy.

[45]   See Frohm et al. (2021).

[46]   See Korniyenko et al. (2017).

countries, but rather the presence of large hubs in the global economy that tie otherwise unrelated sectors together.

At the same time, participating in GVCs cushions the reaction of trade prices and volumes to exchange rate fluctuations. Intuitively, backward linkages attenuate effects on trade elasticities since, for example, the positive competitiveness effects of a depreciation are counterbalanced by an adverse effect on input costs.[47] Similarly, since some of a country's exports are reimported after processing abroad, any competitiveness effect of a depreciation is attenuated as goods are reimported. Finally, re-exported products can make exports more sensitive to trade partners' effective exchange rates.[48,49] As a consequence of the development of cross-border production chains, exchange rate elasticities have decreased over time (Ahmed et al., 2015).

In the wake of rising participation in GVCs, there is a need to rethink the use of conventional trade definitions based on gross trade within macroeconomic analysis and forecasting. For example, with the increasing fragmentation of production processes, imports are widely used to produce exports, with countries often competing against each other at specific stages of the value added chain. This presents a challenge to traditional measures of real exchange rates, which assume that countries compete to sell products using only domestic inputs. GVCs also imply that countries trade intermediate inputs intensively. Consequently, an appreciation vis-à-vis a trading partner from which a given country imports intermediate goods may be beneficial for the competitiveness of that country as it reduces the cost of intermediate goods imports. To account for this effect, input-output real effective exchange rates (IOREERs) are widely computed in the literature (Georgiadis et al., 2020). In addition, in a world characterised by cross-border production chains, export market shares computed with gross trade flows may not fully reflect a country's contribution to global production. Production processes are increasingly fragmented, and the distinction between production and assembly should be taken into account to correct gross exports for the source of value added.

4.2   GVCs and the international transmission of shocks: recent experiences

The global economy has been hit by several detrimental shocks in recent years. Trade protectionism has increased sharply amid trade tensions between the United States and China and the departure of the United Kingdom from the European Union. More recently, the COVID-19 pandemic crisis has pushed the global economy into a recession of unprecedented severity. These three episodes represent natural experiments which can help to shed light on how different shocks

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[47]   See Amiti et al. (2014) and Georgiadis et al. (2020).

[48]   De Soyres et al. (2021) theoretically and empirically show how each way of participating in GVCs affects exchange rate pass-through and export elasticity.

[49]   To investigate the dampening effect of GVC participation on exchange rate elasticities, a specification with GVC interaction effects is generally used in the literature. This approach could be extended to the analysis of other relevant shocks to global growth, such as those related to monetary or trade policy.

propagate through the global supply chain. While they differ deeply in their origin, the span of countries affected and their economic severity, all are likely to have distressed GVCs. At the same time, value chains have served as vehicles of transmission and amplification of the economic effects on global economic and trade activity. This subsection assesses the quantitative effects of disruptions in GVCs associated with each of these recent events and attempts to quantify the ensuing effects on world trade and activity. The analysis relies mostly on model simulations. Box 3 presents panel-based estimates of the amplification effects of the COVID-19 lockdown in China in early 2020 through the GVC.

4.2.1 The role of GVCs in the propagation of trade cost shocks

In a world characterised by extensive supply linkages, the impact of tariffs and non-tariff measures cumulates along the chain. Higher trade costs arising from import duties and non-tariff-barriers affect economic activity and trade by altering both the quantity and price of traded goods. When levied on intermediate inputs, tariffs and non-tariff costs are incurred every time these are shipped to another country for further processing. This implies that by the time finished goods have reached the final consumer, their price may have risen significantly. Moreover, when imported intermediate goods are subject to higher tariffs or non-tariff barriers, domestic producers in the country imposing them may also suffer. In addition, tariffs and non-tariff barriers are typically levied on a good's gross value of imported goods. Therefore, for those exporters for whom foreign inputs account for a large share of exports, a low nominal tariff can translate into a high value-added tariff. Compared with a situation in which the entire value added of goods is produced domestically, tariffs and non-tariff barriers may have a proportionally larger impact on the profits of exporting firms, thereby increasing the incentive to pass the higher costs on through the value chain. Third countries involved in intermediate stages of production may also face higher production costs. In this subsection we investigate the role of GVC linkages in propagating the effects of two recent episodes of increases in trade costs: the United States-China trade dispute and Brexit.

Tariffs have increased sharply on the back of United States-China trade tensions. The risk of a trade dispute between the United States and China became the focus of attention in 2018 and almost materialised in 2019 as trade tensions between the two countries sharply escalated. The phase one deal signed between the two countries in December 2019 led to a cooling off of tensions. The additional US tariffs that were expected to be imposed on China in December 2019 were cancelled as part of the deal, as well as the ensuing Chinese retaliatory tariffs. Tariffs on USD 250 billion worth of Chinese exports were maintained, however, as a result of which US tariffs returned to their pre-1975 levels (see Chart 13).[50] The confirmed US tariffs affect parts, components and other intermediate products to a large extent. Internal ECB estimates indicate that intermediate goods form around 35% of the goods affected. In this regard, value chains could represent an important vehicle of

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[50] As part of the deal, China also committed to purchase an extra USD 200 billion worth of imports from the United States by the end of 2021. Analysis by the Peterson Institute for International Economics indicates that this target is unlikely to be reached.

transmission of their impact. Existing studies concur that the direct effect of the tariffs implemented in the period 2018-19 is likely to remain relatively contained (Gunnella and Quaglietti, 2019). Still, model-based simulations indicate that in the event of a re-escalation, the effects could turn out to be sizeable, compounded by heightened financial stress and a weakening of confidence.

Chart 13
US tariff rates

(percentages)
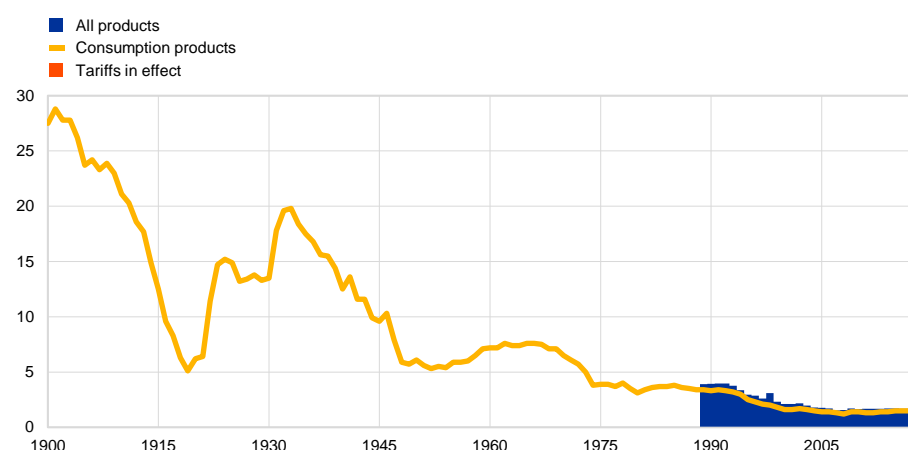
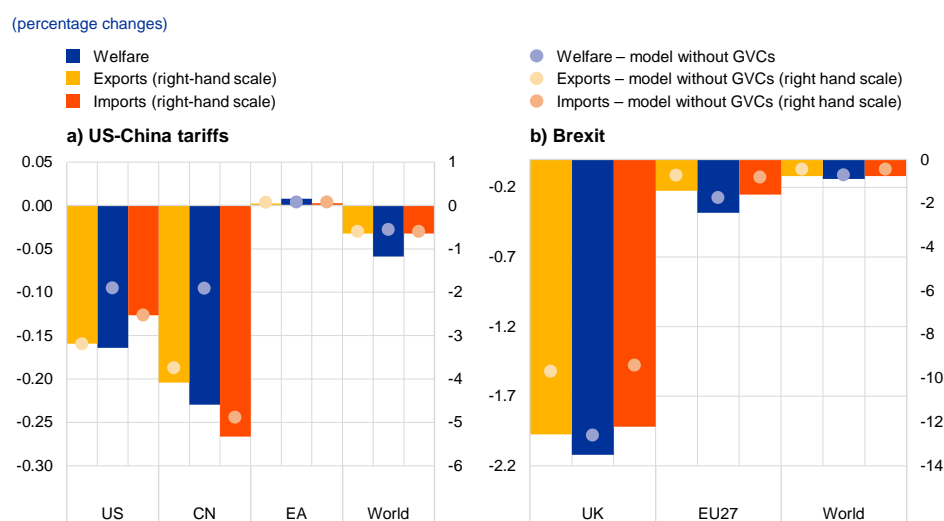Sources: USITC, World Bank, Haver, Citi Research and authors' calculations.

The departure of the United Kingdom from the European Union is likely to result in higher non-tariff barriers between the two blocs. On 24 December 2020, after long negotiations, the European Union and the United Kingdom reached a UK-EU Trade and Cooperation Agreement, which regulates the post-Brexit trade relations between the two (among other things). The deal provides for zero-tariff, zero-quota goods trade between the United Kingdom and the European Union. It also covers matters such as data, energy, transport, movement of people, law and justice, fisheries and UK access to EU programmes. Although there will not be any tariffs levied or restrictive quotas imposed, many goods traded between the United Kingdom and the European Union now face new customs and regulatory checks, including rules of origin and stringent local content requirements.[51] The increased red tape means that businesses face additional costs compared with continued membership of the Single Market and customs union.

Model-based analysis points to the important role of GVCs in amplifying the effect of tariffs implemented by the US and Chinese administrations and the trade effects of Brexit. In order to assess the effects of the tariffs implemented in the context of the United States-China trade dispute and of higher non-tariff barriers resulting from Brexit, we deploy a multi-country, multi-sector general equilibrium trade model of the global economy with trade in both final and intermediate

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[51]   Specific annexes were agreed upon to reduce the non-tariff barriers for medical products, automotive products, chemical products, organic products and wine.

products.[52] The model also allows for the simulation of the welfare effects of a free trade agreement akin to the one signed between the United Kingdom and the European Union.[53] It is important to stress that being a steady state counterfactual exercise, the results refer to long-term effects when all adjustments take place. Chart 14 compares two sets of losses derived from the multi-sector model in the context of the United States-China trade dispute and the departure of the United Kingdom from the European Union: (a) those obtained from the actual structure of IO linkages, and (b) those obtained in a counterfactual scenario where GVC linkages are severed.[54] Results confirm that the organisation of production in supply chains plays an important role in transmitting tariff effects, with the impact of the shocks on welfare amplified by more than 70% in the case of the United States and by almost three times in the case of China. Although the impact on other countries is assessed to remain contained, and some countries would benefit from trade diversion (e.g. the euro area), GVCs still act as an amplifier at global level. The impact of the Brexit shock on welfare is estimated to be -2.1% for the United Kingdom and -0.4% for the European Union.

Chart 14
Amplification effects of trade cost shocks via GVCs

(percentage changes)

- Welfare
- Exports (right-hand scale)
- Imports (right-hand scale)
- Welfare – model without GVCs
- Exports – model without GVCs (right hand scale)
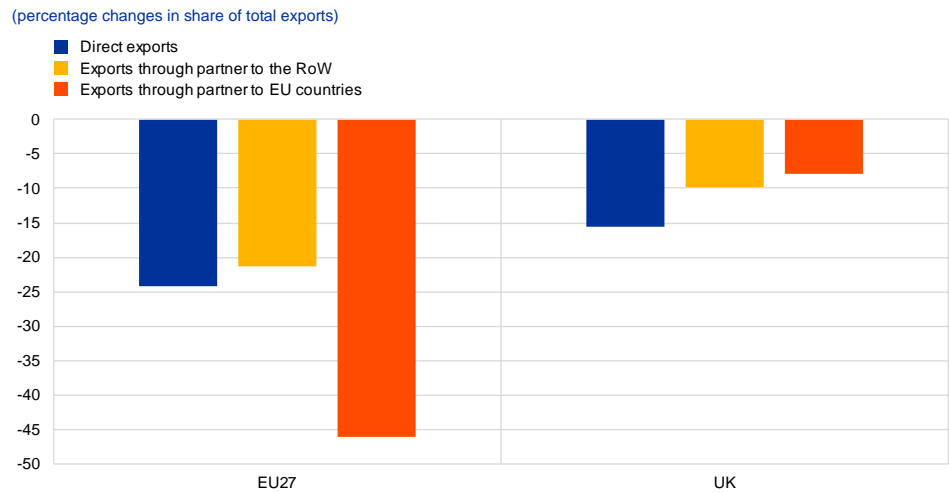- Imports – model without GVCs (right hand scale)

Sources: World Input-Output Database 2016, WTO Integrated Database, ITC Market Access Map, Comtrade, Felbermayr et al. (2017) and authors' calculations.
Notes: For the euro area, the weighted average of Member States is reported. Welfare is measured as real household income. Product-level tariffs have been aggregated to the ISIC Rev. 4 sectoral breakdown. The dots show the effects without GVC-related trade. Panel a: effects from a scenario in which tariffs between the United States and China increase according to the officially published lists. Panel b: effects from a free trade agreement between the United Kingdom and the rest of the European Union. See Cappariello et al. (2020) for further details.

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52   By mapping bilateral supply chain linkages and value added flows, the model provides a rich framework that captures countries' heterogeneity in terms of the composition of their trade flows as well as in terms of their involvement in GVCs.

53   Sectoral bilateral NTBs have been estimated as an average effect from a theoretically consistent gravity equation. Specifically, NTBs are estimated as the difference between the coefficient of an EU dummy and an FTA dummy coefficient. This is because bilateral trade flows would incur the cost of not being in the EU but benefit from the effects of an FTA. See Cappariello et al. (2020).

54   Specifically, in the counterfactual scenario without GVCs, all bilateral trade flows in intermediate products are set to zero and the corresponding amounts are allocated to final products.

Analysis also points to a significant deterioration in GVC ties between the United Kingdom and the European Union in the long term. The model can also help to shed light on the consequences for direct (i.e. value added in final and intermediate products that are not re-exported) as opposed to GVC-related trade flows (i.e. value added in trade flows that are re-exported) as a share of total countries' exports.[55] First, simulation results show that the decrease in both types of bilateral flows is more pronounced for the rest of the European Union (EU 27), reflecting both a greater decrease in activity and demand in the United Kingdom and higher substitutability of the United Kingdom as a trading partner (see Chart 15). Second, the role of the United Kingdom in EU production networks will change substantially: the share of exports from the EU 27 reprocessed in the United Kingdom for further re-exports to other European countries will decrease by 46%.[56]

Chart 15

Effects of Brexit on bilateral trade between EU 27 and the United Kingdom

(percentage changes in share of total exports)

- Direct exports
- Exports through partner to the RoW
- Exports through partner to EU countries

Sources: World Input-Output Database 2016, WTO Integrated Database, ITC Market Access Map, Comtrade, Felbermayr et al. (2017) and authors' calculations.

4.2.2 The role of GVCs in the propagation of demand and supply shocks during the COVID-19 pandemic

The COVID-19 pandemic unfolded as a combination of supply and demand shocks rippling through the global economy in overlapping waves. COVID-19 hit major GVC hubs sequentially, such that supply chain contagion spread across different networks and in reverse. The first effect of the pandemic was a production shutdown in China, followed by a collapse in domestic demand. As the virus spread, the same shocks hit other Asian countries, leading to supply shortages of inputs from Asia across the globe. As Chinese companies started to reopen, production shutdowns occurred elsewhere in the world, namely across Europe, the United

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[55] In this sense, the reported figures are interpreted as changes in market shares of the trading partner in the specific component.

[56] It is important to note that the figures are in value added terms and exclude double-counting arising from back-and-forth trade between the United Kingdom and the rest of the European Union.

States and the Middle East. As in Asia, the initial supply shock was followed by a demand shock triggered by local quarantine measures and rising unemployment. The supply-side shock which first originated in China subsequently worked its way back via China's dependence on other countries' inputs. Strains have intensified in 2021, reflecting COVID-19 flare-ups in the East Asia and Pacific region, and have led to new closures of factories and ports, but also shocks related to weather disruptions and container scarcity.[57] The existing literature has not yet reached a consensus on the relative contribution of demand and supply shocks to the pandemic crisis.[58] However, recent analysis by Bobasu et al. (2021) indicates that in advanced economies, demand effects dominated in the second quarter of 2020, but with supply effects remaining notable (Chart 16).

Chart 16

Historical decomposition of GDP and consumer price inflation (CPI)

(USD billions)

- Total
- Demand
- Supply
- Others
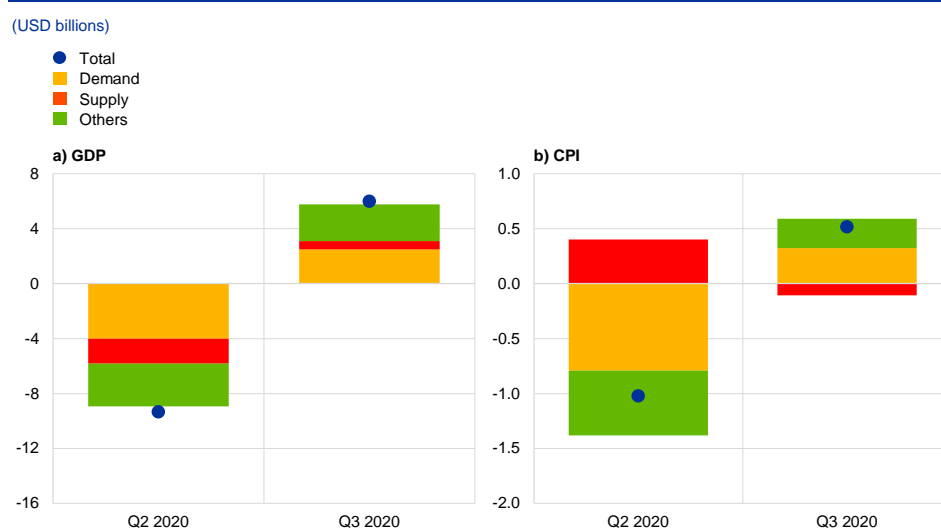
Source: Bobasu et al. (2021).
Notes: Weighted averages of estimated contributions for the United States, the United Kingdom and Japan. Weights are GDP weights in purchasing power parity. "Others" refers to monetary policy and oil shocks. The structural vector autoregressive model comprises oil prices, GDP, inflation and shadow interest rates. A standard set of sign restrictions are used: a demand shock moves prices and output in the same direction, while a supply shock moves them in opposing directions. The oil supply shock increases inflation and decreases GDP, but does not react to domestic interest shocks. A tightening of monetary policy lowers both GDP and prices. The ECB's BEAR toolbox Version 4.2 was used.

Demand and supply shocks generate different dynamics through the supply chain. Due to the supply linkages, demand can be passed upstream through the production chain to input suppliers. Supply disruptions can be instead transmitted down the value chain, with the impact of the shock affecting the production of trade partners positioned downstream in the production network. Acemoglu et al. (2012) argue that in a competitive set-up characterised by a Cobb-Douglas production function, firms in a given industry hit by a shock will produce fewer goods, and the price of their goods will rise. Due to the Cobb-Douglas structure, these effects cancel each other out for upstream firms, leaving them unaffected, while downstream firms

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[57] See Frohm et al. (2021).

[58] Some papers find that aggregate demand shocks dominated in the first quarter of 2020, whereas aggregate supply shocks prevailed in the second quarter of 2020 (see Bekaert et al., 2020). By contrast, other analysis (see Baqaee and Farhi, 2020) used a sectoral model to demonstrate that both stagflationary sectoral supply shocks and deflationary demand shocks are needed to explain the large fall in output and moderate inflation response observed in the United States during the initial lockdown.

feel the increase in prices and consequently lower their overall production. Conversely, if demand in a certain industry increases, firms in that industry increase production, necessitating a corresponding increase in input production by upstream firms. Because of constant returns to scale, however, the increased demand does not affect prices, and so downstream firms are not affected.[59]

Chart 17

Changes in world value added by sector (H1 2020 versus H2 2019)

(percentage changes)
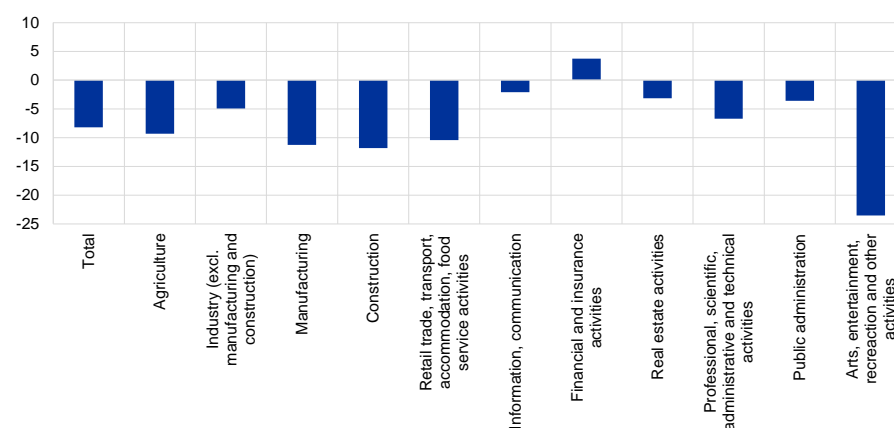
Sources: Haver and authors' calculations.

We produce a first-order approximation of how sectoral demand shocks associated with the outbreak might have propagated through the GVC. In the first half of 2020, output contracted in almost every sector of the global economy, albeit to differing degrees (Chart 17). Utilities, food production and real estate were among the least affected; in general, the greater a sector's reliance on close physical personal contact, the larger was its fall (e.g. tourism and transport, arts, entertainment and hospitality). In order to produce an approximation of how sectoral output losses might have been transmitted through GVCs, we simultaneously trace these through the global production structure using IO data. In a first step, we compute partial elasticities which for each country and sector translate domestic and foreign demand shocks into proportional changes in output, imports and exports of final and intermediate goods to and from all countries and sectors (IO multipliers).[60] We then compute two sets of losses associated with the pandemic: (a) those that originate via trade in final goods, and (b) "indirect" losses generated via the global supply chain, which originate from changes in (domestic and foreign) demand in third countries and translate into lower imports and exports of intermediate goods involving at least two border crossings. This second channel allows us to compute

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[59] Acemoglu et al. (2016) provide quantitative estimates of the propagation effects of supply and demand shocks using US IO tables.

[60] Specifically, we develop expressions for each country's production, exports and imports as weighted averages of sector and country-specific demand changes. The weighting of individual elements of demand changes depends on both intermediate and final goods linkages across sectors and countries. Because each variable – production, exports or imports – has a unique set of weightings, each responds differently to a given vector of demand changes. For further information on the methodology, see Bems et al. (2010).

the amplification effect of the pandemic through the GVCs on a given country's imports and exports.

Our simulations suggest that spillovers through the GVCs are likely to have been sizeable for many countries, amplifying the fall in world trade associated with the COVID-19 pandemic. Chart 18 shows estimates of the potential amplification effect stemming from GVC trade on country imports, exports and activity on the back of the pandemic. Shortfalls generated through supply chain linkages are presented as percentages of the losses estimated to occur via trade in final goods. Our analysis suggests that on the back of sectoral output losses, GVC-related spillovers are likely to have magnified the decline in imports and exports by some 25% for the world economy. The impact is also sizeable at country level, with imports falling severely in most countries.

Chart 18

COVID-19 shock: shortfalls generated through GVC spillovers

(percentage changes)

- Exports
- Imports
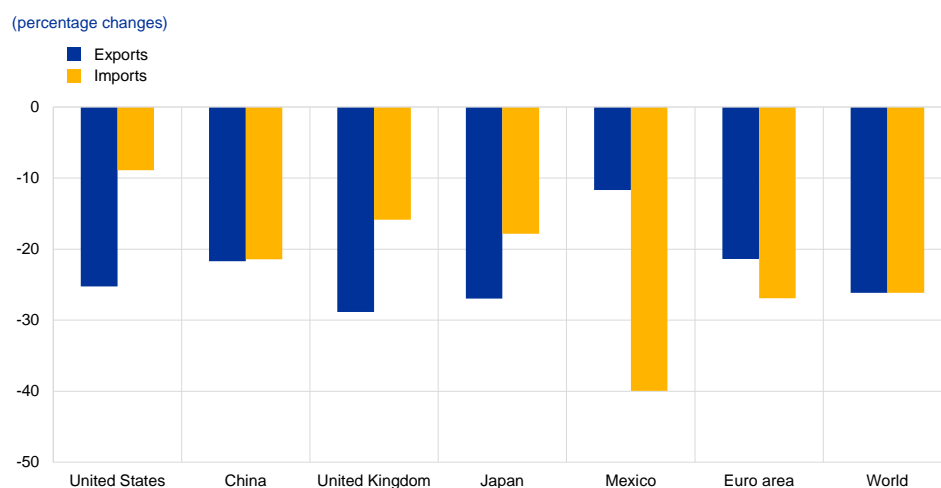
Sources: OECD and authors' calculations.
Notes: The chart shows the additional shortfalls that could be generated for each country through GVC-related spillovers. GVC shortfall is expressed as a percentage of losses estimated to occur through traditional trade (e.g. imports and exports of final goods and intermediates used in production for domestic absorption). GDP losses are derived from losses on imports and exports shown in the chart.

Countries positioned upstream in GVCs are likely to have been particularly affected. Chart 19 shows estimated declines in GVC exports according to the position that each country has within the GVC. Specifically, for each country we relate the additional losses that could be realised through GVC linkages on the back of the pandemic to their relative upstream position in the supply chain. The latter is computed for each country as the average number of intermediate production stages between production and final consumption. Specifically, we assign the value 1 to the share of output sold directly to final consumers, value 2 to the share sold to final consumers after being used by another industry/country, and so on.[61] To obtain a value for each country, we calculate the average across sectors. The chart shows that exports of those countries located upstream in the supply chain may have been affected particularly severely. In our static exercise, this relates to the fact that the

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[61]   For further information on the methodology, see Antràs et al. (2012).

more upstream a country is in a value chain, the larger its share of exports of intermediate goods will be.

Empirical analysis corroborates our simulations, suggesting that upstream suppliers may have been hit harder as a consequence of the decline in demand following the lockdowns in China in early 2020. For the purpose of our analysis, we used a panel model to test which sectors and countries in the Chinese value chain were hit hardest on the back of the lockdown implemented by China in January and February 2020. The analysis indicates that all countries and industries positioned upstream in the Chinese value chain were the heaviest affected, in line with our regression-based estimates. This stems from the fact that as costs accumulated and were amplified through the value chain, partners positioned high up in the Chinese value chain suffered the highest costs (for details on the methodology used for this analysis, see Box 4).

Chart 19
Contributions to export shortfalls and upstream country position in GVCs

(percentage)
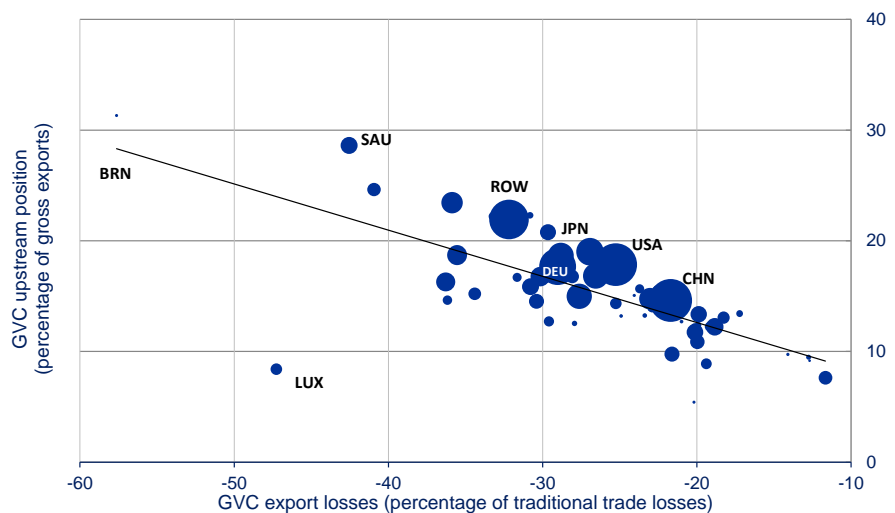
Sources: OECD and authors' calculations.
Notes: The bubble size represents the contribution of the change in GVC exports in a given country to the change in world GVC exports. GVC upstream position is calculated as domestic value added that is further re-exported by trading partners as share of total exports. GVC shortfall is expressed as a percentage of losses estimated to occur through traditional trade (e.g. imports and exports of final goods and intermediates used in production for domestic absorption).

Box 4
The impact of the COVID-19 shock in China on GVCs

In this box, we focus on the COVID-19-related lockdowns and associated demand shock in China and test whether sectors and countries that are upstream to China in the value chain were particularly affected, in line with the findings of our model simulation presented in the main text. We employ a monthly panel model featuring 37 countries and 22 industries between January 2017 and February 2020. For each industry and country, we regress annual percentage changes in total exports of intermediate goods on an interaction variable. In the latter, we combine a dummy variable that takes the value of one in February 2020 (i.e. a proxy for the COVID-19 shock)

with a measure of upstreamness to China computed for each individual country-industry pair.[62] Our measure of upstreamness is obtained by measuring the number of intermediate production stages for each country-industry pair's exports before being consumed in China.[63]

The results suggest that China's upstream suppliers may have been hit harder as a result of the decline in Chinese demand. Table A provides evidence of amplification effects stemming from the demand shock hitting China through the value chain. Specifically, our results suggest that country-industry pairs positioned upstream in the Chinese value chain were hit the hardest, with exports falling on average by 3.8% more compared to more downstream trade partners. While the results should be interpreted with a degree of caution due to the limited period of time available to observe the postulated effect, they overall confirm the presence of amplification (i.e. the bullwhip effect) through GVCs. In addition, results by region suggest that the decline in Chinese demand was borne mostly by China's trading partners in the Asian value chain.

Table A

Estimated coefficients from panel regression

Dependent variable: total country export growth of intermediates	i	ii	iii	iv
	Overall	**By region**		
	Weighted	**Asia**	**NAFTA**	**Europe**
Index of upstreamness to China	0.004	0.021**	0.002	-0.029**
	(0.004)	(0.010)	(0.012)	(0.012)
COVID-19 dummy x index of upstreamness to China	-0.038***	-0.055***	-0.019	0.001
	(0.008)	(0.018)	(0.014)	(0.015)
Lag 1	0.368***	0.404***	0.418***	0.361***
	(0.007)	(0.014)	(0.026)	(0.013)
Lag 2	0.141***	0.110***	0.197***	0.148***
	(0.008)	(0.016)	(0.028)	(0.015)
Lag 3	0.015**	0.066***	0.009	-0.147***
	(0.007)	(0.013)	(0.026)	(0.013)
Intercept	-0.020	-0.073**	-0.008	0.083**
	(0.012)	(0.031)	(0.039)	(0.040)
Observations	16,607	4,154	1,452	4,553
R^2	0.390	0.494	0.594	0.398

Source: ECB calculations.
Notes: p<0.01 ***; p<0.05 - **; p<0.10 *; standard errors in brackets. The regression is estimated using the one-year lagged level of total intermediate exports as an analytical weighting for the observations. Country, industry and time (monthly) fixed effects are included in the panel regression. We also performed robustness tests by moving the COVID-19 dummy to one year before (February 2019) and observing an insignificant coefficient for the interaction term.

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[62] See also Ferrari (2019).

[63] Distance from China is measured as the average number of times a good is used as an input by other industries (either in the same country or not) before being absorbed in China.

5   Discussion: the future of GVCs

GVCs are undergoing a rapid transformation. Participation in GVCs enables countries to specialise in areas of comparative advantage, enhancing productivity growth and supporting wages and incomes.[64] However, after three decades of continued growth, GVC participation is on the decline. To some extent, this reflects to compositional effects triggered by the fact that sectors with a low GVC intensity have accounted for an incrementally large share of world trade since the global financial crisis. Nevertheless, GVCs remain highly complex and maintain a strong regional dimension, especially within Europe and Asia.

There are a number of drivers behind the slowdown in GVC participation. Forces that contributed to the early rise have stalled or reversed over the past decade, contributing to a slower pace of GVC participation globally. Trade costs, including transport costs and tariff and non-tariff barriers, have been on the rise since the global financial crisis, making it more costly for firms to offshore production across different jurisdictions. Several emerging market economies in Asia have been gradually turning inward, reducing their reliance on imported inputs. Most of these factors represent structural shifts and may continue to unfold in the coming years, reshaping the future path of GVCs and of world trade in general. The diffusion of new technologies related to Industry 4.0 is also likely to affect GVCs. However, evidence on their impact remains scant, and the studies that are available have not reached conclusive findings.

GVCs are complex and extensive networks, and a breakdown in one part of the chain may quickly have detrimental global effects. As documented in this paper, supply chains are highly vulnerable to global risks. GVCs have also played an important role in the transmission of recent major events such as the COVID-19 pandemic, in which GVC-related spillovers are likely to have magnified the decline in global trade by some 25%. GVCs were hit hard in the first few months of 2020, including on the back of lockdowns in China, but intermediate goods trade recovered relatively quickly in the second half of the year, with GVCs showing some degree of resilience.

Risk mitigation concerns related to the COVID-19 pandemic have sparked debates about the reshoring of production. The COVID-19 pandemic has led to supply chain disruptions at several points, including those related to plants and shipping halts during the heights of the pandemic, supply bottlenecks in the logistics sectors during the recovery phase and the shortage of specific components (medical-related initially, intermediate inputs in the recovery phase) in the course of 2021. On the one hand, complex and geographically sparse supply chains have

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[64]   A number of recent studies attempt to quantify the effects of GVC participation on economic growth. Kummritz et al. (2017) find that GVC integration generally increases an industry's value added, especially when participating in upstream stages. They additionally highlight the importance of country-specific characteristics and policy for benefitting from trade integration. Constantinescu et al. (2019) find that participation in GVCs is a significant driver of labour productivity. An assessment of the benefits of engaging in global value chains in terms of economic growth and productivity is outside the scope of this paper.

been key in buffering domestic shocks (Espitia et al., 2021). At the same time, GVCs have served as conductors of foreign shocks and amplified their effects, including in recent catastrophic events (see Section 4.2.2). The complexity of companies' input sourcing structures has recently been viewed as a vulnerability, to the extent that some companies are revising their inventory models and governments are discussing initiatives to reshore stages of production domestically.[65] A debate has emerged over how to improve GVCs' resilience while still capturing efficiency gains stemming from specialisation and comparative advantages. Some claim that more localised production would provide greater security of supply and lower uncertainty for consumers and businesses, thus calling for the reshoring of GVCs. Others advocate the opposite, arguing that reshoring also means greater reliance on own production, which limits the scope for cushioning shocks, particularly those that may originate domestically. The World Bank and OECD (2021) indicate that GVCs play an important role in cushioning economic shocks, hence warning against policies aimed at reshoring. At the same time, supply chains characterised by low diversity of suppliers or buyers can increase the probability of disruption and magnify the propagation of shocks.

The pandemic has the potential to catalyse supply chain changes that were already underway, thereby enhancing resilience, including through the more extensive adaptation of digitalisation and more sustainable production networks and practices. Results from a survey carried out by the World Bank[66] on 78 affiliates of MNEs operating in 36 developing countries indicate that in order to increase supply chain resilience, about 60% of the surveyed MNEs have turned to digital technologies in search of optimising capacity and improving logistics. Around a third reported mapping the tiers of their supply chains to improve visibility of potential vulnerabilities. Some are diversifying suppliers (37%) and production sites (18%), and only a small number of firms are shifting production closer to consumers by nearshoring or reshoring (14%). A potential further effect associated with the pandemic is a change in the distribution of (perceived) uncertainty among economic agents. COVID-19 not only highlights that pandemics are likely to be particularly disruptive in a globalised world but has also drawn new attention to other types of shocks associated with, for example, climate change. The need to cushion risks and enhance resilience could prompt firms to reduce reliance on just-in-time supply chains. Recent research from Capgemini[67] suggests that the proportion of firms focusing on just-in-time sourcing and manufacturing is expected to decline in the next three years.

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[65] See World Bank and OECD (2021) and Lund et al. (2020).

[66] See Saurav et al. (2020).

[67] See Capgemini (2020), Fast Forward: Rethinking supply chain resilience for a post-COVID-19 world.

References

Acemoglu, D., Akcigit, U. and Kerr, W. (2016), "Networks and the Macroeconomy: An Empirical Exploration", *NBER Macroeconomics Annual 2015*, Vol. 30, National Bureau of Economic Research, pp. 273-335.

Acemoglu, D., Carvalho, V.M., Ozdaglar, A. and Tahbaz-Salehi, A. (2012), "The network origins of aggregate fluctuations", *Econometrica*, Vol. 80, No 5, pp. 1977-2016.

Aghabozorgi, S., Shirkhorshidi, A.S. and Wah, T.Y. (2015), "Time-series clustering – A decade review", *Information Systems*, Vol. 53, pp. 16-38.

Ahmed, S., Appendino, M. and Ruta, M. (2015), "Depreciations without Exports? Global Value Chains and the Exchange Rate Elasticity of Exports", *Policy Research Working Paper Series, No* 7390, World Bank, August.

Alessandria, G., Kaboski, J.P. and Midrigan, V. (2011), "US Trade and Inventory Dynamics", *American Economic Review,* Vol. 101, No 3, pp. 303-307.

Amiti, M., Itskhoki, O. and Konings, J. (2014), "Importers, Exporters, and Exchange Rate Disconnect", *American Economic Review*, Vol. 104, No 7, pp. 1942-1978.

Antràs, P. (2003), "Firms, Contracts, and Trade Structure", *Quarterly Journal of Economics*, Vol. 118, No 4, pp. 1375-1418.

Antràs, P. (2020a), "Conceptual Aspects of Global Value Chains", *Policy Research Working Paper Series*, No 9114, World Bank, January.

Antràs, P. (2020b), "De-Globalisation? Global Value Chains in the Post-COVID-19 Age", NBER Working Paper Series, No 28115, *National Bureau of Economic Research, November*.

Antràs, P. (2021), "Conceptual Aspects of Global Value Chains", The *World Bank Economic Review,* Vol. 34, Issue 3, World Bank, pp. 551-574.

Antràs, P., Chor, D., Fally, T. and Hillberry, R. (2012), "Measuring the Upstreamness of Production and Trade Flows", *American Economic Review*, Vol. 102, No 3, pp. 412-416.

Arndt, S. and Kierzkowski, H. (eds.) (2001), *Fragmentation: New Production Patterns in the World Economy*, Oxford University Press, Oxford.

Arriola, C., Guilloux-Nefussi, S., Koh, S.H., Kowalski, P., Rusticelli, E. and van Tongeren, F. (2020), "Efficiency and risks in global value chains in the context of COVID-19", OECD Economics Department Working Paper Series, No 1637, Organisation for Economic Co-operation and Development, December.

Atalay, E., Hortaçsu, A. and Syverson, C. (2014), "Vertical Integration and Input Flows", *American Economic Review*, Vol. 104, No 4, pp. 1120-48.

Auer, R., Borio, C. and Filardo, A. (2017), "The globalisation of inflation: the growing importance of global value chains", *BIS Working Paper Series,* No 602, Bank for International Settlements, January.

Baldwin, R. (2006), *Globalisation: the great unbundling(s)*, *prepared for the Finnish Prime Minister's Office, Economic Council of Finland (in the context of the EU Presidency 2006)*.

Baldwin, R. (2016), *The Great Convergence: Information Technology and the New Globalization*, Harvard University Press, Harvard.

Baldwin, R. and Okubo, T. (2014), "Networked FDI: Sales and sourcing patterns of Japanese foreign affiliates", *The World Economy*, Vol. 37, Issue 8, pp.1051-1080.

Baldwin, R. and Venables, A.J. (2013), "Spiders and snakes: Offshoring and agglomeration in the global economy", *Journal of International Economics,* Vol. 90, Issue 2, pp. 245-254.

Baqaee, D. and Farhi, E. (2020), "Supply and Demand in Disaggregated Keynesian Economies with an Application to the Covid-19 crisis", NBER Working Paper Series, No 27152, *National Bureau of Economic Research*, February.

Bekaert, G., Engstrom, E. and Ermolov, A. (2020), "Aggregate Demand and Aggregate Supply Effects of COVID-19: A Real-time Analysis", *Finance and Economics Discussion Series,* No 2020-049, Board of Governors of the Federal Reserve System, May.

Bems, R., Johnson, R.C. and Yi, K.M. (2010), "Demand Spillovers and the Collapse of Trade in the Global Recession", *IMF Economic Review*, Vol. 58, Issue 2, International Monetary Fund, pp. 295-326.

Bobasu, A., Crucil, L., Dieppe, A. and Tirpák, M. (2021), "Pandemic-induced constraints and inflation in advanced economies", *Economic Bulletin*, Issue 1, ECB, Frankfurt am Main.

Boehm, C, Flaaen, A. and Pandalai-Nayar, N. (2019), "Input Linkages and the Transmission of Shocks: Firm-Level Evidence from the 2011 Tōhoku Earthquake", The *Review of Economics and Statistics*, Vol. 101, Issue 1, pp. 60-75.

Borin, A. and Mancini, M. (2015), "Follow the value added: bilateral gross export accounting", *Working Paper Series, No* 1026, Banca d'Italia, July.

Cappariello, R., Gunnella, V., Franco-Bedoya, S. and Ottaviano, G. (2020), "Rising protectionism and global value chains: quantifying the general equilibrium effects", *Working Paper Series*, No 2360, ECB, Frankfurt am Main, January.

Carvalho, V.M. (2014), "From Micro to Macro via Production Networks", Journal of Economic Perspectives, Vol. 28, No 4, pp. 23-48.

Conconi, P., García-Santana, M., Puccio, L. and Venturini, R. (2018), "From Final Goods to Inputs: The Protectionist Effect of Rules of Origin", *American Economic Review*, Vol. 108, No 8, pp. 2335-2365.

Conconi, P., Magerman, G. and Plaku, A. (2020), "The Gravity of Intermediate Goods", *Review of Industrial Organization*, Vol. 57, Issue 2, pp. 223-243.

Constantinescu, C., Mattoo, A. and Ruta, M. (2019), "Does vertical specialisation increase productivity?", *The World Economy*, Vol. 42, No 8, pp. 2385-2402.

Dachs, B., Kinkel, S. and Jäger, A. (2017), *Bringing it all back home? Backshoring of manufacturing activities and the diffusion of Industry 4.0*, paper presented at the 2017 DRUID conference, New York.

De Backer, K., DeStefano, T., Menon, C. and Suh, J.R. (2018), "*Industrial robotics and the global organisation of production*", *OECD Science, Technology and Industry Working Paper Series,* No 3, Organisation for Economic Co-operation and Development, February.

Del Prete, D. and Rungi, A. (2020), "Backward and Forward Integration Along Global Value Chains", *Review of Industrial Organization*, Vol. 57, Issue 2, No 5, pp. 263-283.

De Soyres, F., Frohm, E., Gunnella, V. and Pavlova, E. (2021), "Bought, sold and bought again: The impact of complex value chains on export elasticities", *European Economic Review*, Vol. 140, November.

De Soyres, F. and Gaillard, A. (2020), "Global Trade and GDP Co-Movement", *International Finance Discussion Papers,* No 1282, Board of Governors of the Federal Reserve System, May.

Di Giovanni, J. and Levchenko, A.A. (2010), "Putting the Parts Together: Trade, Vertical Linkages, and Business Cycle Comovement", *American Economic Journal: Macroeconomics*, Vol. 2, No 2, pp. 95-124.

Di Mauro, F., Ottaviano, G., Vicard, V., Altomonte, C. and Rungi, A. (2012), "Global value chains during the great trade collapse: a bullwhip effect?", *Working Paper Series*, No 1412, ECB, Frankfurt am Main, January.

ECB IRC Trade Task Force (2016), "Understanding the weakness in global trade: What is the new normal?", *Occasional Paper Series,* No 178, ECB, Frankfurt am Main, September.

ECB Working Group on Global Value Chains (2019), "The impact of global value chains on the euro area economy", *Occasional Paper Series*, No 221, ECB, Frankfurt am Main, April.

Espitia, A., Mattoo, A., Rocha, N., Ruta, M. and Winkler, D. (2021), "Pandemic trade: COVID-19, remote work and global value chains", The World Economy, (forthcoming).

Felbermayr, G., Groeschl, J. and Heiland, I. (2017), *The European Union in turmoil: a general equilibrium analysis of trade and welfare*, mimeo.

Fernandez, A.M., Rocha, N. and Ruta, B. (2021), *The Economics of Deep Trade Agreements*, CEPR Press and World Bank Group, June.

Ferrari, A. (2019), *Global Value Chains and the Business Cycle*, available at SSRN 3249434, February.

Frohm, E. (2020), "Restrained foreign trade after 2009: discussion of possible consequences for Sweden", *Sveriges Riksbank Staff Memo*, Sveriges Riksbank, May.

Frohm, E. and Gunnella, V. (2021), "Spillovers in global production networks", *Review of International Economics, Vol. 29, Issue 3, pp. 663-680*.

Frohm, E., Gunnella, V., Mancini, M. and Schuler, T. (2021), "The impact of supply bottlenecks on trade", *Economic Bulletin*, Issue 6, ECB, Frankfurt am Main.

Garcia-Bernardo, J., Fichtner, J., Takes, F.W. and Heemskerk, E.M. (2017), "Uncovering Offshore Financial Centers: Conduits and Sinks in the Global Corporate Ownership Network", *Nature Scientific Reports*, Vol. 7, Issue 1, pp. 1-10.

Georgiadis, G., Gräb, J. and Khalil, M. (2020), "Global value chain participation and exchange rate pass-through", *Bundesbank Discussion Paper Series,* No 67, Deutsche Bundesbank.

Grossman, G., Helpman, E. and Szeidl, A. (2006), "Optimal integration strategies for the multinational firm", *Journal of International Economics,* Vol. 70, Issue 1, pp. 216-238.

Gunnella, V. and Quaglietti, L. (2019), "The economic implications of rising protectionism: a euro area and global perspective", *Economic Bulletin*, Issue 3, ECB, Frankfurt am Main.

Head, K. and Mayer, T. (2014), "Gravity Equations, Workhorse, Toolkit and Cookbook", in Gopinath, G., Helpman, E. and Rogoff, K. (eds.), *Handbook of International Economics*, Edition 1, Vol. 4, Elsevier, pp. 131-195.

Heuser, C. and Mattoo, A. (2017), "Services Trade and Global Value Chains", *Policy Research Working Paper Series,* No 8126, World Bank, June.

Hirschman, A.O. (1958), *The Strategy of Economic Development*, Yale University Press, Yale.

Johnson, R.C. (2018), "Measuring Global Value Chains", *Annual Review of Economics*, Vol. 10, pp. 207-236.

Korniyenko, Y., Pinat, M. and Dew, B. (2017), "Assessing the Fragility of Global Trade: The Impact of Localized Supply Shocks Using Network Analysis", *IMF Working Paper Series, No 17/30*, International Monetary Fund, February.

Kowalski, P., Gonzalez, J.L., Ragoussis, A. and Ugarte, C. (2015), "Participation of Developing Countries in Global Value Chains: Implications for Trade and Trade-Related Policies", *OECD Trade Policy Paper Series*, No 179, Organisation for Economic Co-operation and Development, April.

Kummritz, V., Taglioni, D. and Winkler, D. (2017), "*Economic Upgrading through Global Value Chain Participation: Which Policies Increase the Value Added Gains?*", Policy Research Working Paper Series, No 8007, World Bank, March.

Laget, E., Osnago, A., Rocha, N. and Ruta, M. (2018), "Deep Trade Agreements and Global Value Chains", Policy Research Working Paper Series, No 8491, World Bank, June.

Lenzen, M., Moran, D., Kanemoto, K. and Geschke, A. (2013), "Building Eora: a global multi-region input-output database at high country and sector resolution", *Economic Systems Research*, Vol. 25, Issue 1, pp. 20-49.

Leontief, W.W. (1936), "Quantitative input and output relations in the economic system of the United States", *The Review of Economic Statistics, Vol. 18, No 3,* pp. 105-125.

Lund, S., Manyika, J., Woetzel, J., Barriball, E., Krishnan, M., Alicke, K., Birshan, M., George, K., Smit, S., Swan, D. and Hutzler, K. (2020), *Risk, resilience, and rebalancing in global value chains*, McKinsey Global Institute.

Monarch, R. and Schmidt-Eisenlohr, T. (2020), *Longevity and the Value of Trade Relationships*, mimeo, Federal Reserve Board.

Noguera, G. (2012), "Trade Costs and Gravity for Gross Trade and Value Added Trade", *Job Market Paper*, UC Berkeley and Columbia University, December.

Pahl, S. and Timmer, M.P. (2019), "Patterns of vertical specialisation in trade: long-run evidence for 91 countries", *Review of World Economics*, Vol. 155, pp. 459-486.

Russell, D., Coyle, J.J., Ruamsook, K. and Thomchick, E.A. (2014), "The real impact of high transportation costs", *Supply Chain Quarterly, Council of Supply Chain Management Professionals, March*.

Saurav, A., Kusek, P. and Kuo, R. (2020), *The Impact of COVID-19 on Foreign Investors: Early Evidence from a Global Pulse Survey*, World Bank, April.

United Nations Department of Economic and Social Affairs, Statistics Division (2019), "Classification by Broad Economic Categories Rev.5", *Statistical Paper Series,* No 53, United Nations.

World Bank and Organisation for Economic Co-operation and Development (2021), *"Global value chains: Efficiency and risks in the context of COVID-19", OECD Policy Responses to Coronavirus (COVID-19), February*.

World Trade Organization (2019), "Technological Innovation, Supply Chain Trade, and Workers in a Globalized World", *Global Value Chain Development Report 2019, April.*

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