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DEGLOBALISATION? THE REORGANISATION OF GLOBAL VALUE CHAINS IN A CHANGING WORLD

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Deglobalisation? The Reorganisation of GVCs in a Changing World

Alexander Jaax, Sébastien Miroudot and Elisabeth van Lieshout

New evidence is presented on the evolution of global value chains (GVCs) since the Great Financial Crisis. Drawing on novel OECD inter-country input-output tables in previous year's prices, it shows there was no general trend towards deglobalisation in the period up to 2020. The fragmentation of production remained at a historically high level in 2019 and close to the level of 2011, confirming a stabilisation of the depth of global economic integration. Different trends are observed across economies: in the European Union, the import intensity of production grew before the COVID-19 pandemic, while China increasingly relied on domestic inputs. To explain these trends, bilateral trade costs are estimated and their cumulative impact along value chains is then calculated; structural changes and higher uncertainty seem to be the main drivers of increasing cumulative trade costs for some GVCs. To preserve the benefits of GVCs, policy makers should seek to increase the ease of trade and reduce uncertainty.

Keywords: Global Value Chains, deglobalisation, fragmentation of production, trade costs

JEL codes: F14, F15, C67

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Executive Summary

This paper provides new evidence on the evolution of global value chains (GVCs) since the 2008-2009 Great Financial Crisis and examines whether there is a slowdown in the international fragmentation of production or even some kind of deglobalisation. The main data used for this paper cover the period 1995-2020. The findings therefore only partially cover the impact of the COVID-19 pandemic on GVCs and do not capture the effects of increased geopolitical tensions triggered by the Russian Federation's (hereafter "Russia") war of aggression against Ukraine.

One important innovation in this paper is the use of new OECD inter-country input-output tables in previous year's prices for the period 1995-2020. This allows for the analysis to disentangle fluctuations in the price of intermediate inputs from changes in the volume of trade, thereby providing a clear picture of the evolution of the structure of supply chains.

The paper first points out that no general trend of deglobalisation was observed in the period up to 2020 and that the fragmentation of production remained at a historically high level. However, the continuous expansion of GVCs, which was the main trend from the mid-1980s to 2008, stopped with the Great Financial Crisis. Since 2011, the import intensity of production (i.e. the value of trade in intermediate inputs needed to produce one dollar of output) has slightly decreased at the world level. In constant prices, the value observed in 2019 is very close to 2011, confirming a stabilisation of the extent of global economic integration in the second decade of this century.

The analysis also identifies different trends across countries and industries. In the case of The People's Republic of China (hereafter "China"), there was a pronounced shift towards domestic sourcing: its import intensity of production was significantly lower in 2019 than in 2011. The European Union, by contrast, did not show any sign of a slowdown in the internationalisation of its supply chains before COVID-19 (even when analysed as a single economy). Among industries, basic metals, coke and petroleum and electric machinery were the three sectors with the highest decrease in the import intensity of production. But other industries, such as mining (energy products), water transport or postal and courier activities, increasingly relied on foreign sourcing.

Furthermore, there was no general trend towards a regionalisation of value chains and reshoring (in the sense of a higher number of productions stages becoming domestic) after 2011. In addition to China, several Asian economies, such as Malaysia and Indonesia, are a noteworthy exception, as a significant trend towards more domestic production stages already existed there pre-COVID. Moreover, the concentration of supply at the level of aggregate 2-digit industries seems to slightly decrease over time. The data also indicate that countries and industries with a relatively low supply chain fragmentation ratio display a higher concentration of supply, confirming that GVCs are an important source of diversification for the sourcing of inputs.

To explain these different trends, the paper estimates bilateral trade costs and calculates the cumulative impact of these trade costs along value chains. When looking at the evolution of bilateral trade costs since 2011, there was on average a decline until 2015 followed by an increase, bringing their tariff equivalent in 2019 to a level slightly higher than in 2011. Trade costs for final goods and services are higher than for intermediate inputs, suggesting that countries try to facilitate access to foreign sourcing while concentrating trade barriers on competing final products.

The calculation of cumulative trade costs along value chains also points to increases in cumulative trade costs for specific GVCs. Part of this increase comes from the fact that inputs crossing borders multiple times imply that bilateral trade costs are incurred repeatedly. Even in a scenario where these bilateral trade costs remain unchanged, their repetition can lead to higher levels of cumulative trade costs. Similarly, a reduction in the fragmentation of production can mechanically reduce cumulative trade costs in value chains even if bilateral trade costs become higher.

To understand this dynamic of trade costs along value chains and to further investigate the role played by policies, the paper decomposes bilateral trade costs into four categories: ease of trade, trade policy, uncertainty and other determinants of trade costs. A structural decomposition analysis of the change in cumulative trade costs sheds light on the percentage change that can be attributed to each component, as well to changes in the structure of value chains (i.e. changes related to the mix of inputs used by firms to produce their final products). The analysis points out that, after 2011, trade policy measures account for a small share of the observed increase in cumulative trade costs on intermediate inputs. Conversely, changes in the ease of trade (logistics performance and trade facilitation) were associated with small reductions in cumulative trade costs. Structural changes and uncertainty seem to act as the main drivers (on average across countries) of the higher cumulative trade costs observed in some GVCs.

Key messages

- Inter-country input-output data in constant prices reveal a slowdown in the expansion of GVCs since 2011, but the international fragmentation of production remained at a high level in 2019 at the outset of the COVID-19 pandemic.
- Before the pandemic, there was no general pattern of reshoring, regionalisation of value chains or higher concentration of supply at a global scale. But a significant trend towards a higher number of domestic production stages could be observed in China and a limited number of economies in East and South East Asia, such as Malaysia and Indonesia.
- Bilateral trade costs have slightly increased between 2011 and 2019 both for intermediate inputs and final goods and services. Trade costs on final products are higher than for intermediate inputs and services face higher trade costs than manufacturing goods.
- Trade policies slightly increased trade costs along value chains between 2011 and 2019. Structural changes (i.e. changes in the mix of inputs used by firms in their production processes) and a more uncertain environment seem to be the main drivers of increasing cumulative trade costs for some GVCs.
- To ensure that the benefits of open markets and the rules-based international trading system are preserved – particularly after the pandemic and more recent shocks that have affected supply chains – policy makers should focus on reducing uncertainty.

This paper provides new evidence on the main determinants of the reorganisation of GVCs since the Great Financial Crisis. It draws on a set of OECD Inter-Country Input-Output (ICIO) tables converted into previous year's prices in order to disentangle price and volume effects in the evolution of the international fragmentation of production. The main data used for this paper cover the period 1995-2020. The findings therefore focus on the evolution of GVCs in the pre-COVID period and do not capture the impact of the pandemic and effects of increased geopolitical tensions triggered by Russia's war of aggression against Ukraine.

These new data shed light on structural changes in value chains and provide answers to key questions in the current debate on international supply chains, such as: is the international economy experiencing deglobalisation? Are value chains becoming shorter or more regional as a consequence of reshoring or near-shoring? Has the concentration of supply increased along GVCs? What are the main determinants of the reorganisation of GVCs?

This paper is structured as follows. Section 1 provides a series of indicators that characterise the evolution of GVCs between 1995 and 2020. Section 2 presents estimates of bilateral trade costs and discusses their evolution along value chains. Through a decomposition of these trade costs that identifies the role of ease of trade, trade policies and uncertainty, Section 3 sheds light on the main drivers of the reorganisation of GVCs. Section 4 concludes with some policy implications.

1. The slowdown in the fragmentation of production and the debate on a potential deglobalisation

The discussion of a potential 'deglobalisation' comes from the decrease in the elasticity of trade to GDP after the Great Financial Crisis and signs that GVCs may be shortening (Haugh et al., 2016[1]; James, 2018[2]; Livesey, 2018[3]; Antràs, 2020[4]). Since the 1980s, vertical specialisation and the international fragmentation of production have driven the growth of world trade and led to the rise of GVCs (Hummels, Ishii and Yi, 2001[5]; OECD, 2013[6]; Baldwin, 2016[7]; Johnson and Noguera, 2017[8]; Pahl and Timmer, 2019[9]). However, there has been a slowdown in the fragmentation of production after the Great Financial Crisis (Miroudot and Nordström, 2020[10]; Timmer et al., 2021[11]). The import intensity of production, defined as the value of all trade in intermediate inputs along the value chain, as a share of gross output, has slightly decreased between 2011 and 2019 just before the COVID-19 pandemic (Figure 1).

1.1. No deglobalisation, but a slowdown in the expansion of GVCs

The import intensity of production is a good indicator to assess the level of fragmentation of production as it is not a value-added indicator but adds gross imports of intermediate inputs all along the value chain and measures their contribution as a share of gross output (Timmer et al., 2021[11]). As can be observed on Figure 1, the decrease in the fragmentation of production between 2011 and 2019 was more pronounced in current prices than in constant prices. Timmer et al. (2021[11]) already highlighted that the apparent deglobalisation during this period was mostly a price effect because of the decrease in the price of intermediate inputs and particularly some raw materials. The ICIO data confirm this fact, while shedding light on an actual decrease in the fragmentation of production in the most recent period.

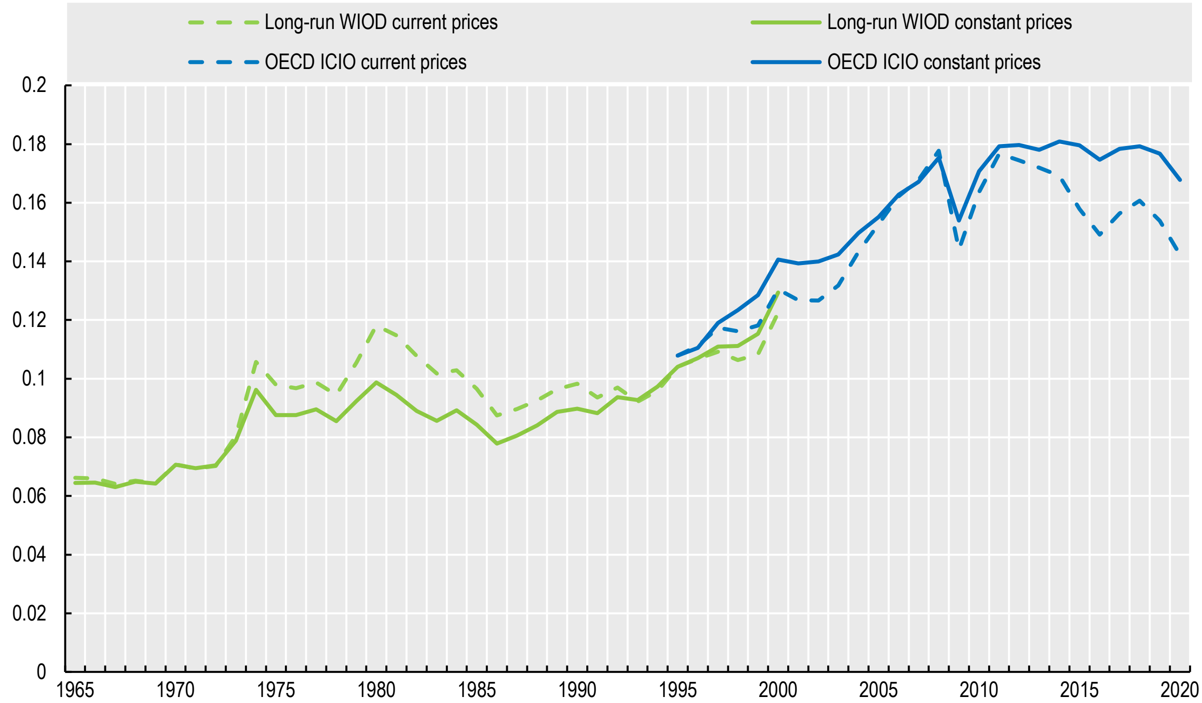
However, it is important to point out that even if the fragmentation of production has slightly decreased, it remained at a high level in 2019, especially when taking a longer time perspective. In 1965, for each dollar of output in the world, the cumulated trade in intermediate inputs was only about 6 cents. Trade in intermediate inputs increased as a share of world output first in the 1970s following the end of the Bretton Woods system and the realignment of major currencies with floating exchange rates.[1] Against the backdrop of advances in information and communications technologies that lowered the costs of coordinating spatially dispersed activities (Bhagwati, 1984[12]), there was then a steep increase in the fragmentation of production starting in the middle of the 1980s when MNEs engaged in vertical specialisation and offshoring strategies.

[1] For a discussion of the evolution of globalisation after the demise of the Bretton Woods system, see, for example, Simmons (1999[67]) and Van Patten (2022[68]).

The rise of GVCs was then facilitated in the 1990s by the collapse of the Soviet Union, the conclusion of the Uruguay Round and the creation of the WTO, a new wave of deep regional trade agreements, and market-oriented reforms in China (and its subsequent accession to WTO in 2001). This period, sometimes described as 'hyper globalisation' (Brakman and van Marrewijk, 2022[13]), saw an increase in the cumulative value of trade in intermediate inputs to 17 cents for each dollar produced, at the outset of the Financial Crisis in 2008.

Whether there is or not a decline in the fragmentation of production after 2011, it is still clear from Figure 1 that the period that follows the Great Financial Crisis of 2008-2009 is different from the two decades before where there was a continuous trend towards greater international fragmentation of production. This expansion stopped in the last decade and this is what needs to be explained.

Figure 1. Import intensity of production at the world level, 1965-2020



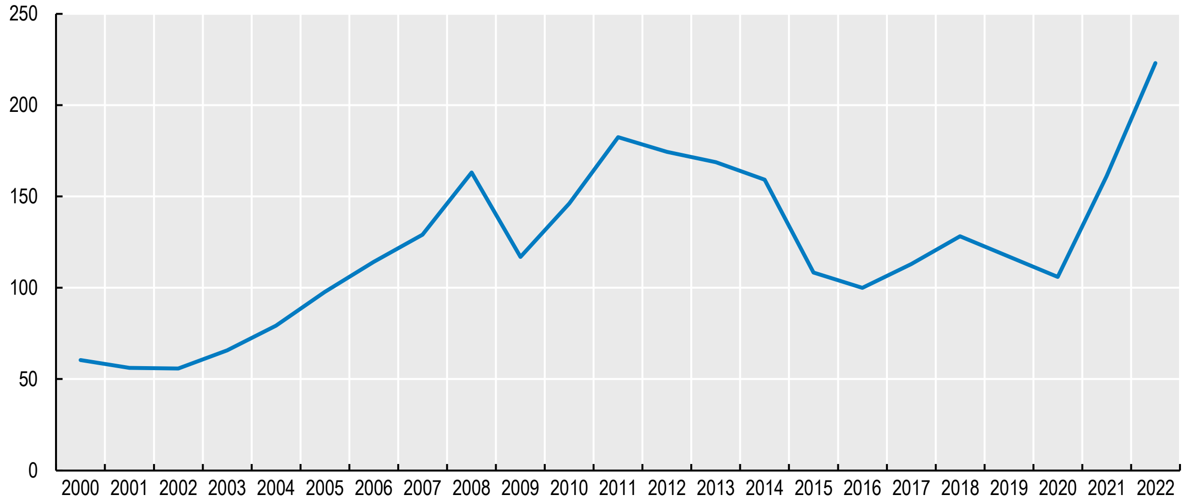
Note: This graph displays the evolution of the import intensity of production, measured as the value of all trade in intermediate inputs along the value chain as a share of gross output. The indicator is chain-linked after being calculated in current and previous year's prices. Reference year is 1995. Aggregation across industries and countries using shares in global final output as weights.
Source: Authors' calculations based on OECD ICIO tables and long-run WIOD tables in current and previous year's prices.

Figure 1 illustrates why it is important, particularly in the recent period, to conduct the analysis in constant prices. We observe a significant divergence between the data in current and constant prices after 2011. This can be explained by changes in relative prices affecting raw materials. The IMF All commodity price index highlights that there was an important decrease in the price of commodities between 2011 and 2016 (Figure 2). When using data in current prices, a drop in commodity prices reduces the value of trade in intermediate inputs even if the volumes traded have not changed. The constant prices correct for these price effects: a decrease in the value of trade in intermediate inputs in constant prices means that volumes traded have reduced.

After 2016, the increase in the import intensity of production was concomitant with higher prices for commodities. While the fragmentation of production reached its peak in 2011, it is noteworthy that the level observed in 2019 remained close to the peak of 2011 (Figure 1). The COVID-19 crisis caused a temporary trade collapse, with lower values for the import intensity of production when lockdowns and disruptions in international transport networks were affecting the international supply of inputs in 2020. Yet what the period after the recovery will look like remains a question mark, especially in light of the war in Ukraine.

Figure 2. IMF All commodity price index, 2000-2022

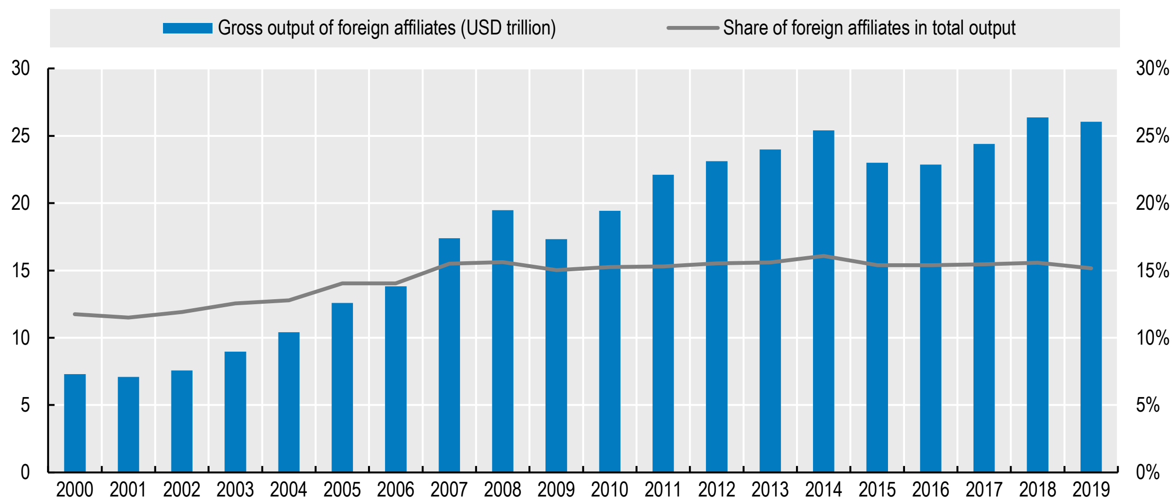
2016 = 100



Source: IMF Primary Commodity Price System.

A slowdown in globalisation can also be observed with respect to the evolution of multinational production. The share of foreign affiliates in world output shows patterns similar to the import intensity of production, with an increase before the Financial Crisis and a relatively flat trend thereafter (Figure 3). This similarity reflects the pivotal role of multinational enterprises in GVCs as orchestrators of flows of components, final goods, capital, and knowledge across borders (Iammarino and McCann, 2013[14]; Cadestin et al., 2018[15]).

Figure 3. Gross output and share of foreign affiliates in world output, 2000-2019



Source: Preliminary estimates from the 2023 OECD analytical AMNE database.

1.2. Some heterogeneity across countries and industries

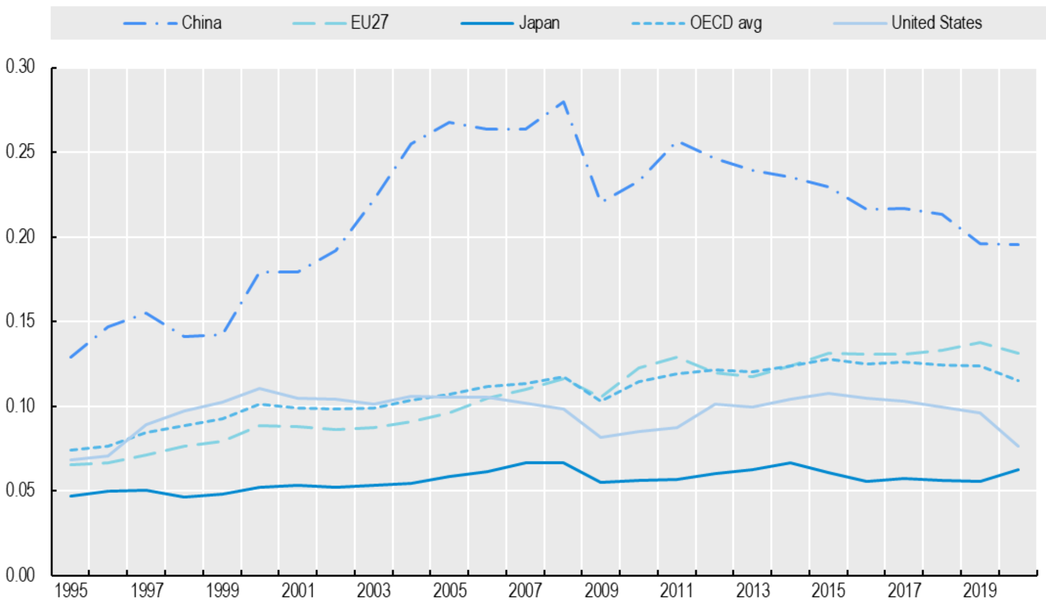
There are differences across countries when looking at the import intensity of production in constant prices (Figure 4). Between 1995 and 2005, we observe a sharp increase in China's reliance on imported inputs. This period was shaped by rapid manufacturing growth and large-scale offshoring of production activities by MNEs to China. This fast industrialisation increased China's reliance on foreign-made inputs (particularly after its accession to WTO in 2001), as the capacity to rely on domestic suppliers remained limited (Baldwin, 2022[16]). Around 2005, there was a slowdown in the expansion of Chinese GVCs and after a peak at the onset of the Great Financial Crisis, the import intensity of production started to decline. Domestic input suppliers became more competitive and China upgraded its position in GVCs, shifting from processing trade and final assembly to the development of branded products incorporating domestic inputs. Notwithstanding this clear trend towards greater domestic sourcing, China's use of imported inputs in 2019 remained relatively high compared to the average across OECD countries.

In OECD countries, the average import intensity of production increased at a slower pace in the 1990s and 2000s and there was still an upward trend after the Great Financial Crisis. The fragmentation of production started to decline only after 2016. However, this relative decline was the result of diverging trends across the main OECD economies. The United States was the economy with a significant decline, while there was no slowdown in the fragmentation of production for the European Union (analysed as a single economy). Imports of intermediate inputs (from extra-EU economies) continued to account for a growing share of production after 2011 (with a decline only observed during COVID-19 in 2020). Japan followed a different pattern, with a decline in the fragmentation of production starting earlier than 2016. However, the import intensity of production in 2019 is close to the one observed in 2011.

A more systematic comparison between 2011 and 2019 for all economies (in constant prices) suggests that the import intensity of production decreased in 31 countries out of 66 in the sample (Figure 5). While EU countries are generally the ones with more foreign sourcing (from extra-EU economies as well as EU economies) in 2019, there are exceptions, such as Austria, Romania, Denmark or Hungary. The countries where there was a noticeable decrease in the import intensity of production are mainly Asian economies such as Chinese Taipei, Indonesia, Malaysia, Thailand, and China.

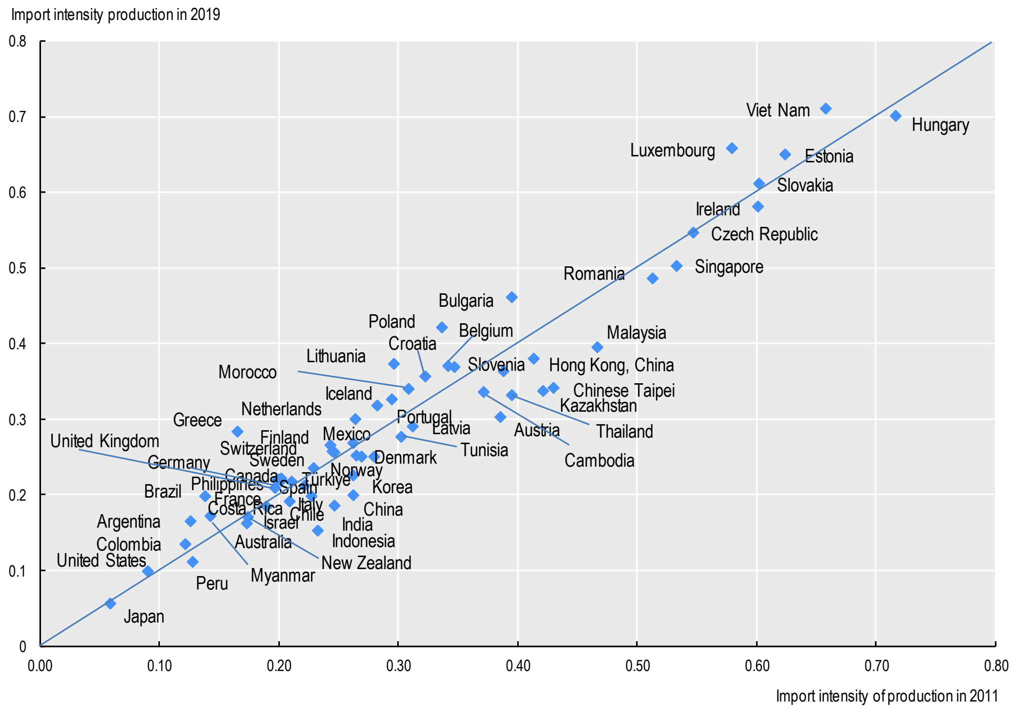
When calculating average values across industries, a lower fragmentation of production is found in about half of the sectors in 2019 (Figure 6). Manufacturing industries where there was a significant decrease in the import intensity of production are basic metals, coke and petroleum and electrical machinery. In the services sector, air transport is also an industry with a relatively important decrease in the fragmentation of production. However, in most services industries, the import intensity of production increased between 2011 and 2019, suggesting that the globalisation of the services sector is still ongoing.

Figure 4. Import intensity of production, main economies, 1995-2020



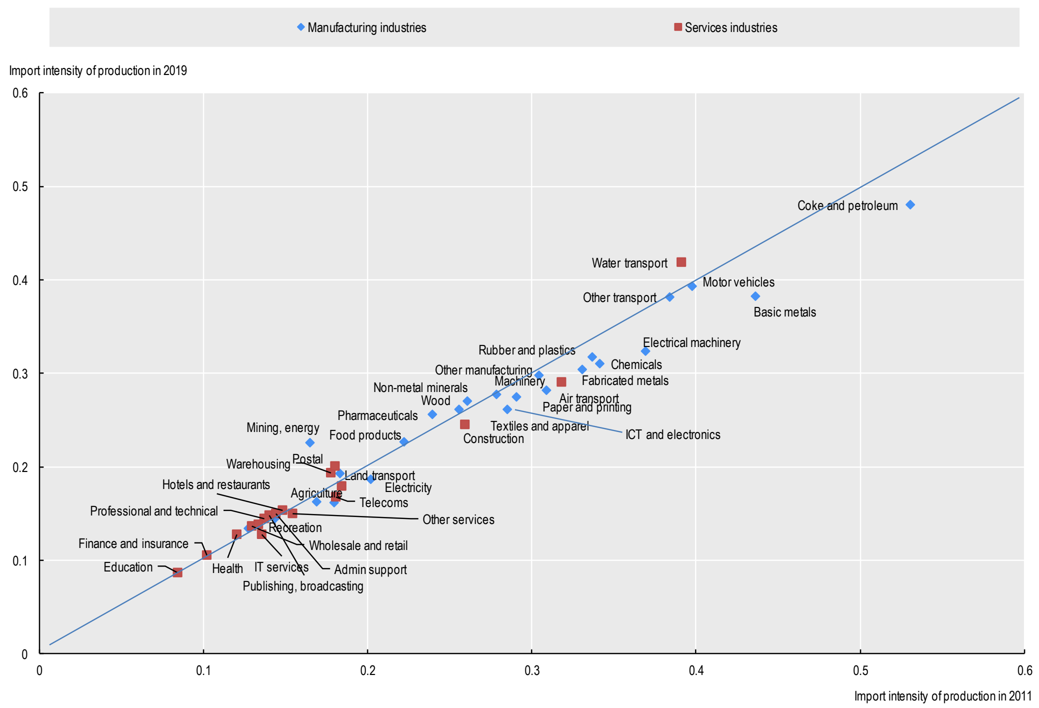
Note: This graph displays the evolution of the import intensity of production, measured as the value of all trade in intermediate inputs along the value chain as a share of gross output. Data are in constant prices, reference year 1995. Values for EU27 were calculated as the EU being a single economy, whereas shares of final production were used to compute a weighted average for OECD countries.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

Figure 5. Import intensity of production, all economies, 2019 versus 2011



Note: Data are in constant prices, reference year 1995. Industries are weighted based on their share in final output with the same weights (2011) for both years.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

Figure 6. Import intensity of production, by industry, 2019 versus 2011



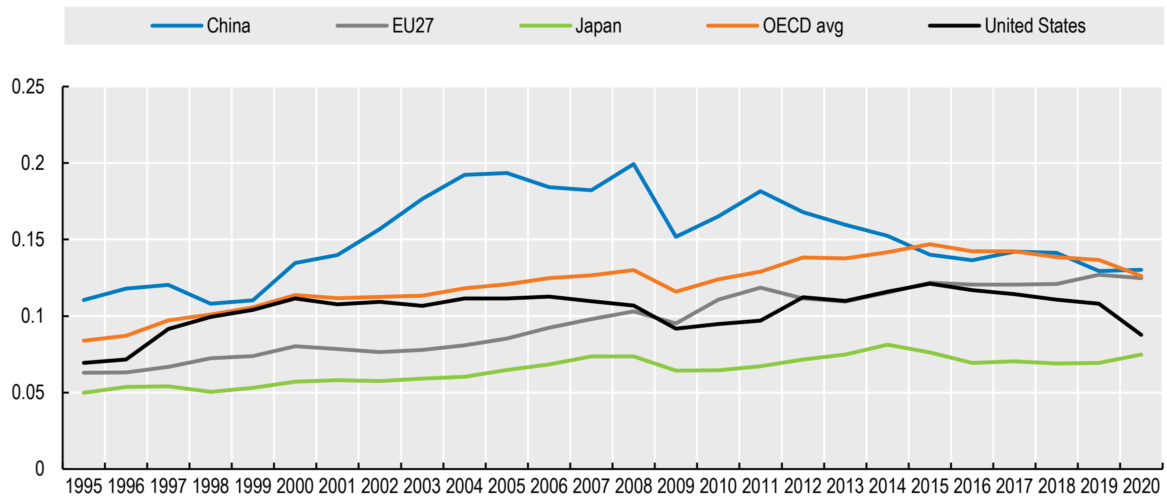
Note: Data are in constant prices, reference year 1995. Countries are weighted based on their share in final output with the same weights (2011) for both years.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

1.3. Supply chains are becoming more domestic or more regional in some countries

The recent debate on international supply chains has suggested that vulnerabilities in international production networks may encourage firms to source more inputs domestically (reshoring) or from neighbouring countries (nearshoring). The OECD ICIO tables available up to 2020 suggest that, at least before the pandemic, there was no global trend towards reshoring or nearshoring. However, signs of such shifts are observed in some countries.

To assess whether there is reshoring in the sense of production in value chains becoming more domestic, Figure 7 shows the ratio of foreign to domestic production stages in the main economies and for OECD countries as an average. Less sensitive to changes in value added than common measures of vertical specialisation, such as the VAX ratio of Johnson and Noguera (2012[17]), this indicator captures the structure of value chains through an index that is proportional to the actual number of production stages (Fally, 2012[18]; Antràs et al., 2012[19]). On average in OECD countries and in the United States, there is a slight trend towards more domestic production stages after 2015. This is also the case in Japan (starting earlier in 2014) but the ratio is increasing again after 2018. In contrast, a pronounced reduction in the number of foreign production stages is observed for China. Compared to the mid-2000s, Chinese value chains were significantly more domestic in 2019. Yet, this pattern is not reshoring in the sense of production previously offshored going back to China: it captures China's upgrading in value chains and the substitution of foreign inputs by domestic inputs. After a rapid increase in the use of foreign inputs relative to domestic inputs following its accession to the WTO in 2001, this shift moves China close to the ratio of foreign to domestic production stages observed on average for the OECD. Contrary to China and the United States, EU economies show no sign of growing reliance on domestic production, with the number of foreign production stages being at its highest level in 2019 just before the pandemic.

Figure 7. Ratio of foreign to domestic production stages, 1995-2020, main economies

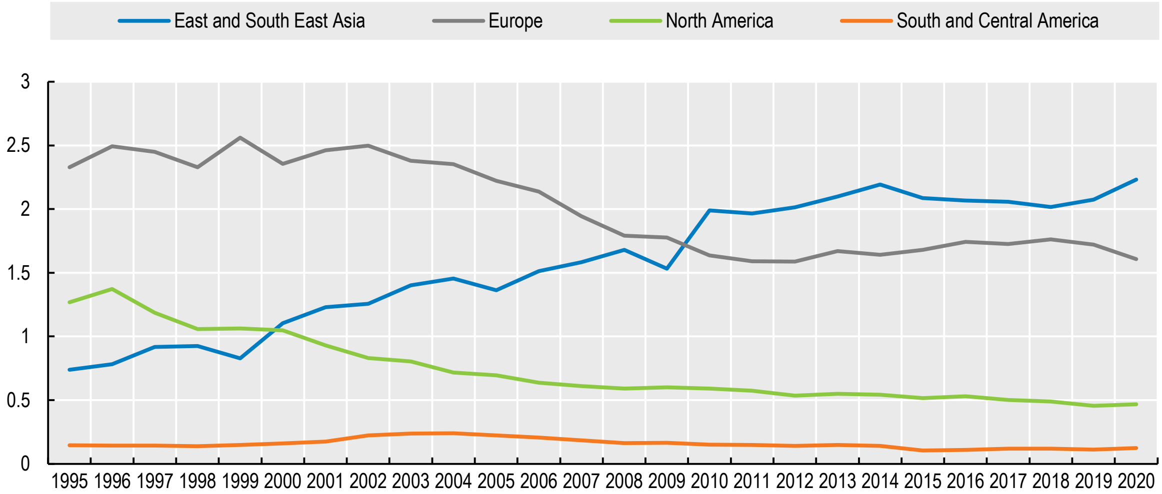


Note: This graph displays the ratio of foreign to domestic production stages. Data are in constant prices, reference year 1995. Values for EU27 were calculated as the EU being a single economy, whereas shares of final production were used to compute a weighted average for OECD countries.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

When looking at the number of production stages, there is no evidence of a regionalisation of supply chains after 2011 in North America and in South and Central America (Figure 8). The two regions where supply chains have become more regional are Europe and East and South East Asia. In the case of Europe, supply chains became more oriented towards extra-EU countries (and particularly Asia) in the 2000s. After the Great Financial Crisis, this trend was reversed but supply chains started again to become more extra-regional after 2018. In East and South East Asia, most of the increase in the ratio of regional to extra-regional production stages took place before 2011 and there was a slowdown in this trend after the Great

Financial Crisis. However, the ratio of regional to extra-regional production stages increased again after 2018. This ratio is higher in East and South East Asia than in Europe (since 2010).[2]

Figure 8. Ratio of regional to extra-regional foreign production stages, 1995-2020, by region



Note: Data are in constant prices, reference year 1995.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

1.4. The concentration of supply has slightly decreased and is lower in value chains that are highly fragmented

Another issue featuring prominently in the debate on vulnerabilities of supply chains is the geographic concentration of supply. Ideally, such concentration should be assessed at a more disaggregated level than allowed by the ICIO tables. Supply may appear diversified at level of broad industries, but patterns of concentration might be more pronounced at the level of firms and products: Each firm relies on different types of inputs sourced from a limited number of countries. However, an analysis at the aggregate level is still useful to provide insights into the evolution of concentration across industries and countries.

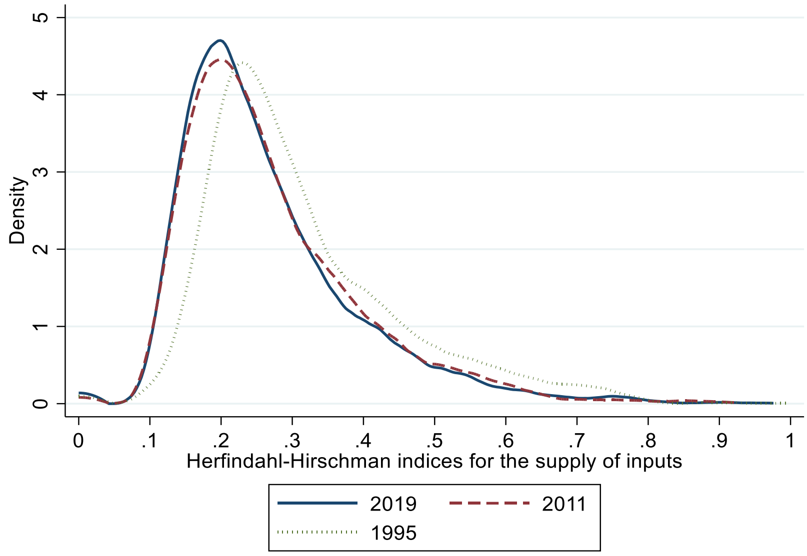
Figure 9 shows the distribution of normalised Herfindahl-Hirschman indices for the supply of inputs in all countries and industries included in the dataset used in this report. This index takes the value of 1 when there is full concentration (i.e. a single country and industry provides all inputs) and a value of zero when the supply is fully diversified (i.e. all countries and industries participate equally in the supply chain, providing the same quantity of inputs). Over the years, the supply of inputs has become more diversified (distribution curves are shifting to the left).

We can also plot these distributions for two groups of industries and countries: those highly integrated in GVCs (based on their import intensity of production) and those that are more focused on domestic supply (Figure 10). As expected, the concentration of supply is much higher (distribution skewed towards higher indices) when production is relying less on international sourcing. Participation in GVCs is a source of diversification of supply across countries and industries.

[2] An analysis in value-added terms (i.e. accounting for the value generated in each regional and extra-regional foreign production stage and not just their number) would show a higher share of regional value added in European GVCs. However, trends are similar over time when comparing data in terms of number of foreign production stages and foreign value added.

Figure 9. Concentration of supply in all countries and industries: 1995, 2011 and 2019

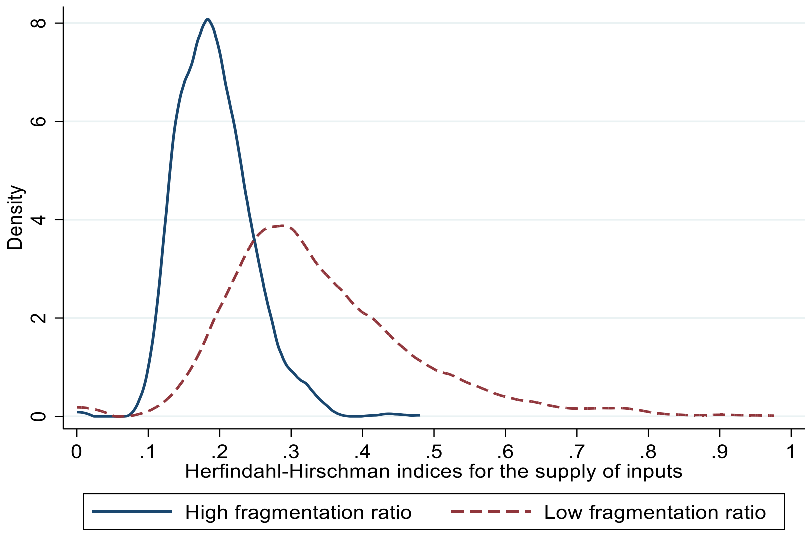
Distribution of normalised Herfindahl-Hirschman indices



Note: A value of 1 indicates full concentration (i.e. a single country and industry supplying all inputs) while zero means that all countries and industries supply the same quantity of inputs (full diversification).
Source: Authors' calculations based on OECD ICIO tables in current and previous year's prices.

Figure 10. Concentration of supply: High fragmentation versus low fragmentation industries, 2019

Distribution of normalised Herfindahl-Hirschman indices



Note: A value of 1 indicates full concentration (i.e. a single country and industry supplying all inputs) while zero means that all countries and industries supply the same quantity of inputs (full diversification). The solid line represents industries in the top half of the distribution of industries with respect to import intensity of production, whereas the dashed line represents industries in the bottom half of the distribution.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

1.5. What are the main determinants of changes in the fragmentation of production?

The literature suggests several explanations for the slowdown observed in the fragmentation of production after 2011. First, several authors observe that new restrictive trade and investment measures have been introduced after the Great Financial Crisis and more recently in the context of trade tensions between some economies (Evenett, 2019[20]; Bellora and Fontagné, 2019[21]). But other structural trends might also affect the reorganisation of GVCs, such as increasing wages in emerging economies and a higher capacity to source inputs domestically, the spread of digital technologies and advanced robotics (Baldwin, 2016[7]; Obashi and Kimura, 2021[22]), the servicification of manufacturing (Cadestin and Miroudot, 2020[23]), the ageing of societies, or the desire of consumers and companies to move to more sustainable and inclusive production methods (Nadvi, 2008[24]; Zhan, 2020[25]).

Moreover, COVID-19 has triggered a new debate on the future of GVCs and risks related to international supply (OECD, 2020[26]; OECD, 2021[27]). Shifts in demand, measures aimed at containing the spread of the virus and the difficulty of anticipating the global trade rebound in the second half of 2020 have created shortages in some key inputs while also increasing shipping rates. As firms will learn from this experience, it might impact the way they will set up their value chains after the pandemic.

Against this backdrop, the following two sections of this paper focus on the evolution of trade costs in GVCs and examine drivers of changes in trade costs.

2. Trade costs along global value chains

This section first presents estimates of bilateral trade costs and discusses trade cost patterns across country groups and changes over time. It then introduces the concept of cumulative trade costs along value chains and looks at whether trade costs have increased within GVCs.

2.1. Bilateral trade costs: Estimation and main trends

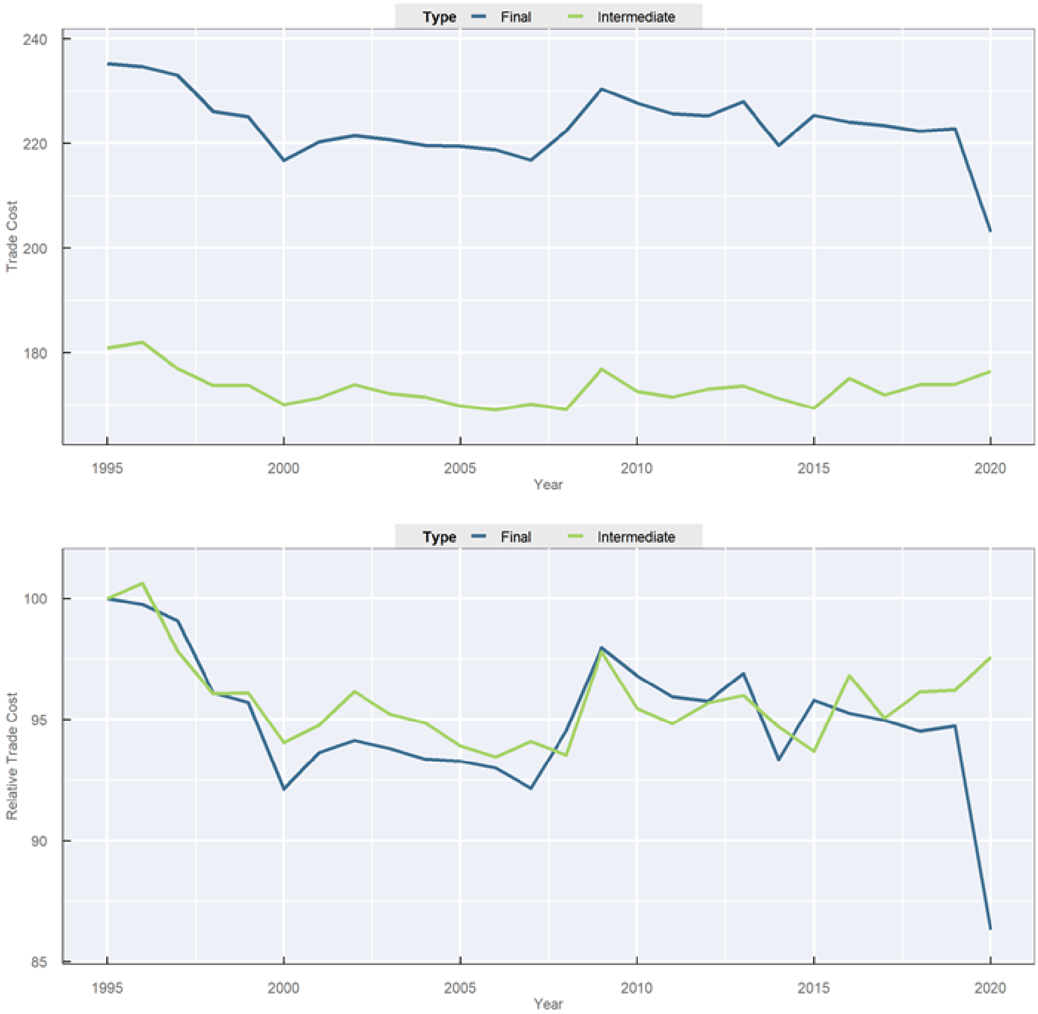
To estimate trade costs, we adopt the approach proposed by Egger et al. (2021[28]), which provides a measure of overall bilateral trade cost that captures all frictions that increase the cost of cross-border trade relative to the cost of economic exchanges within an economy. By applying this theory-driven methodology (described in Annex B) to the information on trade flows and sourcing patterns contained in the OECD ICIO tables, we obtain detailed estimates of bilateral trade costs for every combination of exporting economy, importing economy, supplying industry and year. Moreover, we obtain separate estimates for trade costs referring to trade in intermediate inputs and trade in final products (goods or services).

Figure 11 shows how these bilateral trade costs have evolved over time. The top panel shows that in line with existing findings (Miroudot and Shepherd, 2016[29]), trade costs for final goods are significantly higher than those for intermediate products. The bottom panel demonstrates that costs on final and intermediate products have evolved very similarly over these three decades. In 2008, both types of costs experienced a significant increase before decreasing to levels similar to those observed before the Great Financial Crisis.[3]

[3] Bearing in mind that the methodology for the estimation of trade costs (Annex B) captures all frictions that increase the costs of cross-border trade relative to trade within an economy, the increase in trade costs observed in 2008 reflects the well-known fact that international trade saw a bigger reduction than domestic output during the Great Financial Crisis (Eaton et al., 2016[64]). Contributions investigating the drivers of this pronounced decrease in international trade emphasise a shift in final spending away from tradable sectors (Eaton et al., 2016[64]), greater sensitivity of exports to financial shocks relative to domestic production and sales (Amiti and Weinstein, 2011[65]) and hidden protectionism (Baldwin and Evenett, 2009[66]).

Figure 11. Trends in bilateral trade costs, 1995-2020

Ad valorem tariff equivalent, % (upper panel) and index, 1995=100 (bottom panel)



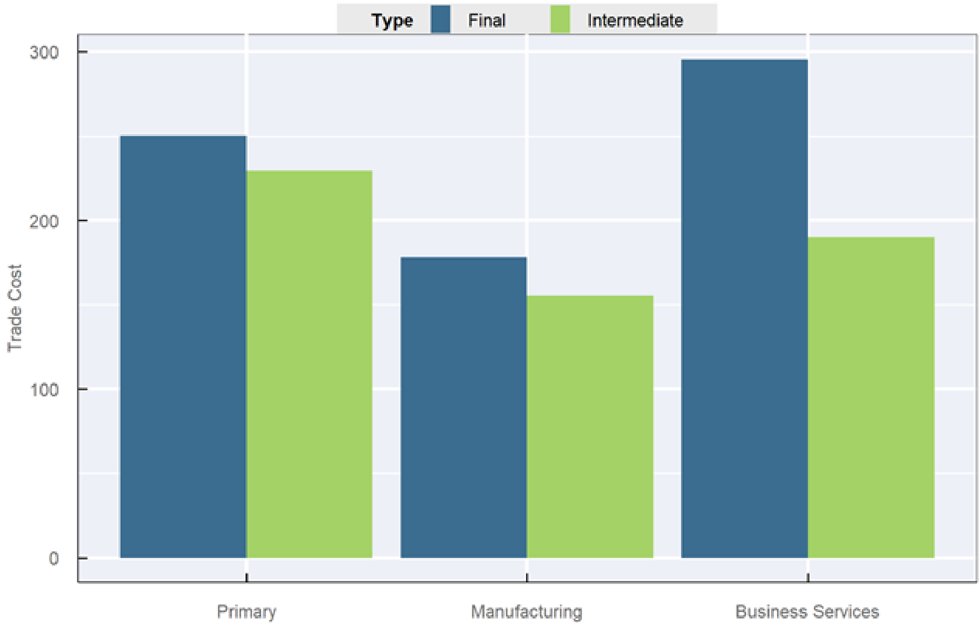
Note: The upper panel shows the absolute value of the trade costs (measured as the ad valorem tariff equivalent), while the bottom panel shows the change in costs relative to the baseline year of 1995. These values are weighted averages across all industries and trade partners, with trade values used as weights.
Source: Authors' calculations.

In the second half of the 2010s bilateral trade costs increased again, albeit only regarding intermediate products. Moreover, the trend line also shows a significant drop in the trade costs of final goods in 2020. These results are tentative, as the data for 2020 still partly rely on projections and national accounts that will be revised by countries. At least three reasons come to mind for this pattern: a) a shift towards consumption of products with lower trade costs during lockdown periods, b) a shift towards nearby suppliers with lower trade costs in response to border closures and shipping delays, and c) a rise in domestic trade costs (through lockdowns) which makes international trade costs seem comparatively lower.

Trade costs differ considerably across different sectors, as shown in Figure 12. For both intermediate and final product transactions, trade costs are lowest in manufacturing. Primary sectors, encompassing agriculture and mining, are subject to relatively high trade costs in both intermediate and final goods. In business services, by contrast, the cost of trade in final products is substantially higher while the cost of trade in intermediate inputs is relatively low. Figure A C.1 in Annex C shows this breakdown for more detailed industry categories.

Figure 12. Bilateral trade costs by sector, 2019

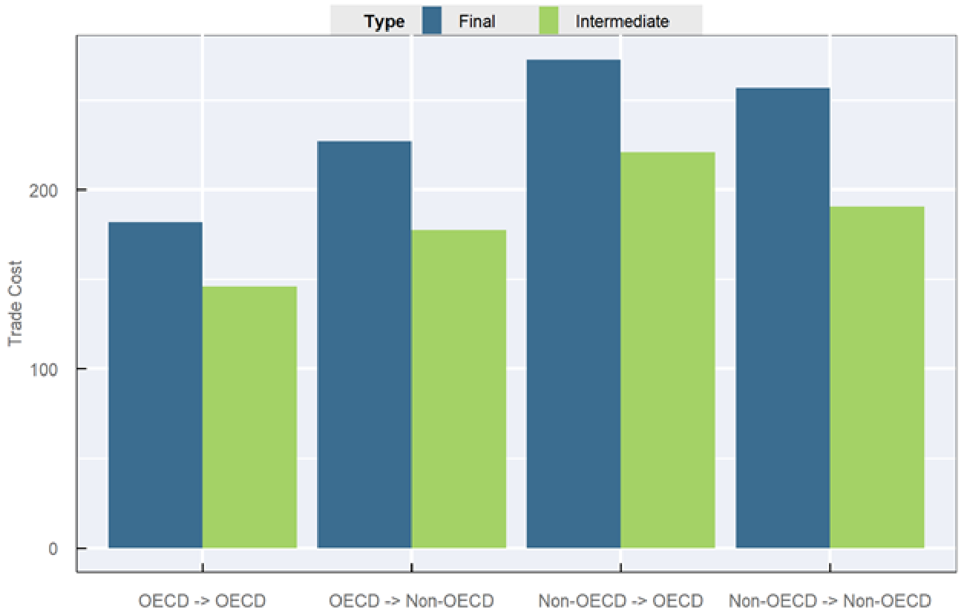
Ad valorem tariff equivalent (%)



Source: Authors' calculations. Trade values were used to aggregate trade costs.

Figure 13. Bilateral trade costs for OECD and non-OECD economies, 2019

Ad valorem tariff equivalent (%)



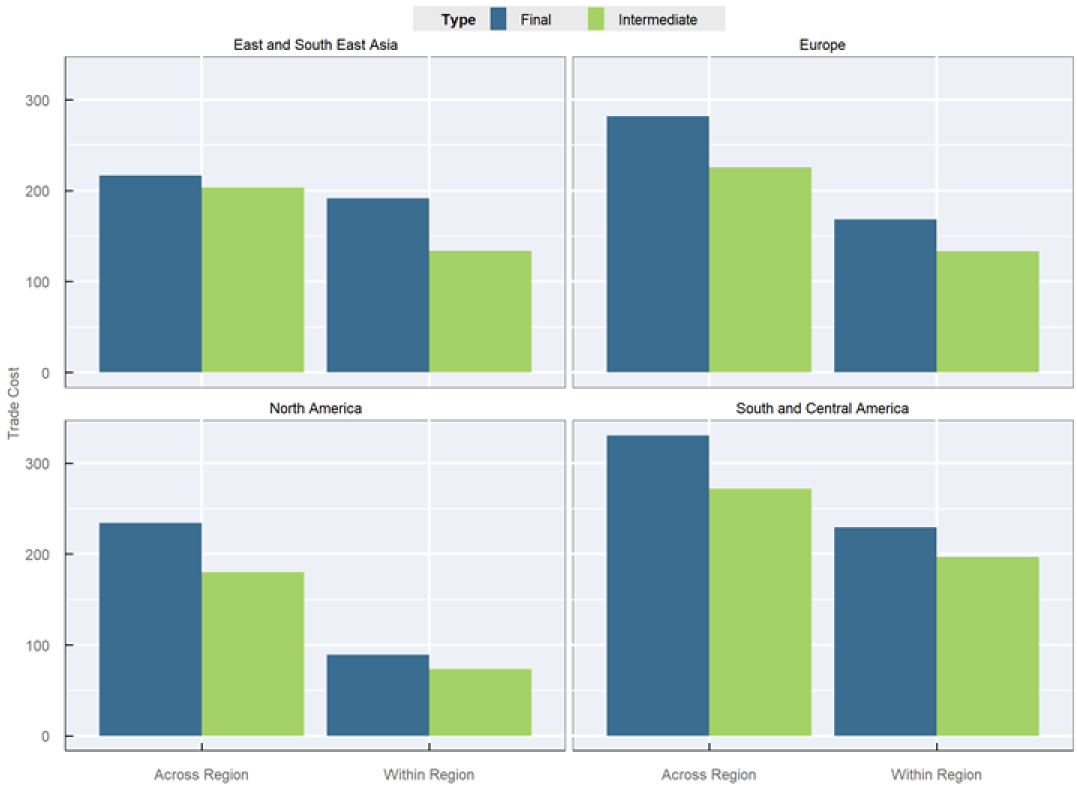
Note: In the x-axis labels, the first term refers to the exporter and the second to the importer (e.g. in OECD → Non-OECD, the trade flows from OECD to on-OECD economies). Trade values were used to aggregate trade costs.
Source: Authors' calculations.

The bilateral trade costs can also be compared based on the countries involved in the transaction. In Figure 13, trade costs are shown depending on whether the exporter and the importer are OECD countries. Trade originating from an OECD country towards either OECD or non-OECD economies has a very similar level of costs. The highest costs are observed for exports by non-OECD countries to OECD countries, particularly for final products. Trade between non-OECD countries is also hampered by relatively high costs.

One prominent aspect of the debate around deglobalisation is the relative role of within- and across-region trade. Figure 14 shows the trade costs for flows within the same region and across different regions, broken up by the region of the importing country. Across all regions the within-region transactions are less costly, but the relative size of the gap differs substantially. In North America, within-region trade is more than 2.5 times cheaper, whereas in East and South East Asia the difference is very small. A similar pattern can be seen when dividing by the region of the exporting country (Figure A C.2, Annex C).

Figure 14. Trade costs within and across region by importer region, 2019

Ad valorem tariff equivalent (%)



Note: An additional 15 countries in the analysis do not fall into these four regions, but are included in the calculations of across-region trade costs. Trade values were used to aggregate trade costs.
Source: Authors' calculations.

2.2. Cumulative trade costs along value chains

To understand the role of trade costs in GVCs, this paper introduces a new indicator which is the cumulative trade costs on intermediate inputs along a given value chain defined by the country and industry of final production.

The calculation is similar to the estimation of cumulative tariffs in value chains (Miroudot, Rouzet and Spinelli, 2013[30]; Johnson, 2018[31]). We can express all bilateral trade costs estimated in the previous section as tariff equivalents and construct a world matrix of bilateral trade costs on intermediate inputs. Using input-output techniques, this matrix can then be applied to the value of trade flows to estimate a cumulative trade cost that can be interpreted as the tariff equivalent of all the upstream trade costs on intermediate inputs weighted by the value added they contribute to final production. The cumulative trade cost is also expressed as a tariff equivalent that can be compared across GVCs. The full methodology is described in Annex B.

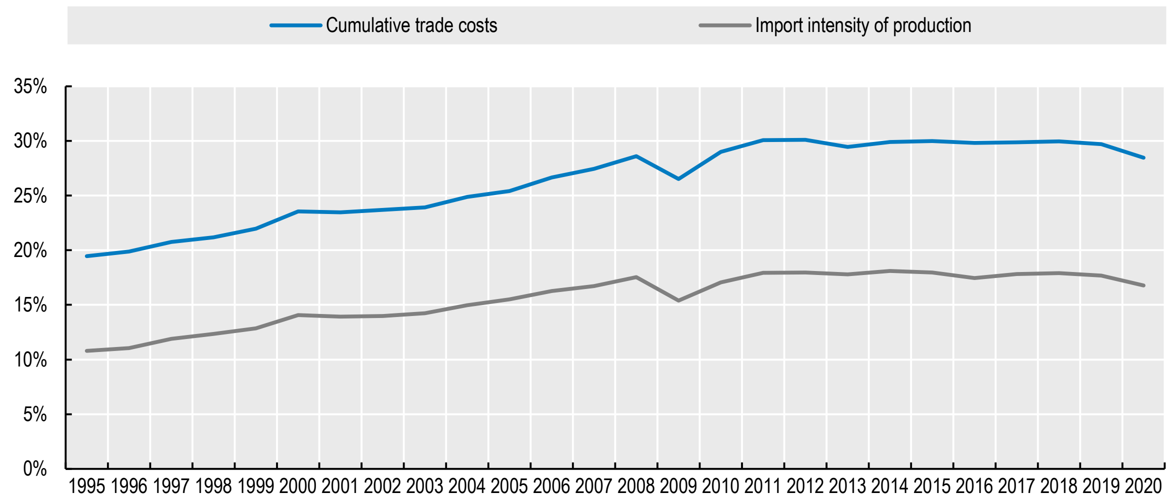
With vertical specialisation, production is fragmented in GVCs and some inputs cross borders several times before being embodied in final products. There are trade costs each time these inputs cross borders and the concept of cumulative trade costs highlights this snowball effect. While we find that bilateral trade costs have generally decreased for intermediate inputs, the structure of value chains and the repetition of trade costs each time inputs cross a border at different stages of processing can lead to an increase in the cumulative costs.

This is what we observe in Figure 15. On average across all GVCs, the cumulative trade costs on intermediate inputs have increased from 19% to 30% between 1995 and 2019. This increase is the consequence of the international fragmentation of production with bilateral trade costs being repeated multiple times in value chains that involve many border crossings. The slowdown in the fragmentation of production after 2011 is reflected in a fairly stable pattern of cumulative trade costs in recent years, which contrasts with the increase observed between 1995 and 2008.

But cumulative trade costs also become higher when bilateral trade in inputs is more costly, such as after the Great Financial Crisis in 2009-2011. While the fragmentation of production went back to its pre-crisis level, the cumulative trade costs became higher in 2011 as compared to 2008.

Figure 15. Trend in average cumulative trade costs along value chains and import intensity of production, 1995-2020

Ad valorem tariff equivalent of all upstream bilateral trade costs on intermediate inputs in the value chain and import intensity of production as a share of gross output



Note: Average across final producers and industries using final output weights.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

The relationship between higher levels of fragmentation of production and higher cumulative trade costs highlighted in Figure 15 suggests that the expansion of GVCs cannot continue indefinitely. At some point, the trade costs (and other transaction costs) become too high, making it no longer profitable to rely on foreign sourcing. This could also explain the slowdown in the fragmentation of production after 2011. Yet, this "peak fragmentation" point must be expected to be heterogeneous across industries, since different industries face different trade costs.

There are also different outcomes across countries (Figure 16). Cumulative trade costs along the value chain have been relatively stable and at a low level for final producers in the United States and in Japan. On average across OECD countries, there is a trend towards increasing cumulative trade costs, which is driven by EU countries. The EU is the economy with the highest level of cumulative trade costs in its supply chains.[4] And since the EU did not experience the same slowdown in the fragmentation of production observed in other countries, cumulative trade costs have also continued to increase. The opposite trend is found in China, where the decrease in the fragmentation of production leads to lower cumulative trade costs. Disentangling the proportional effect of the evolution of the fragmentation of production from actual increases in specific trade costs is the objective of the structural decomposition analysis presented in the next section.

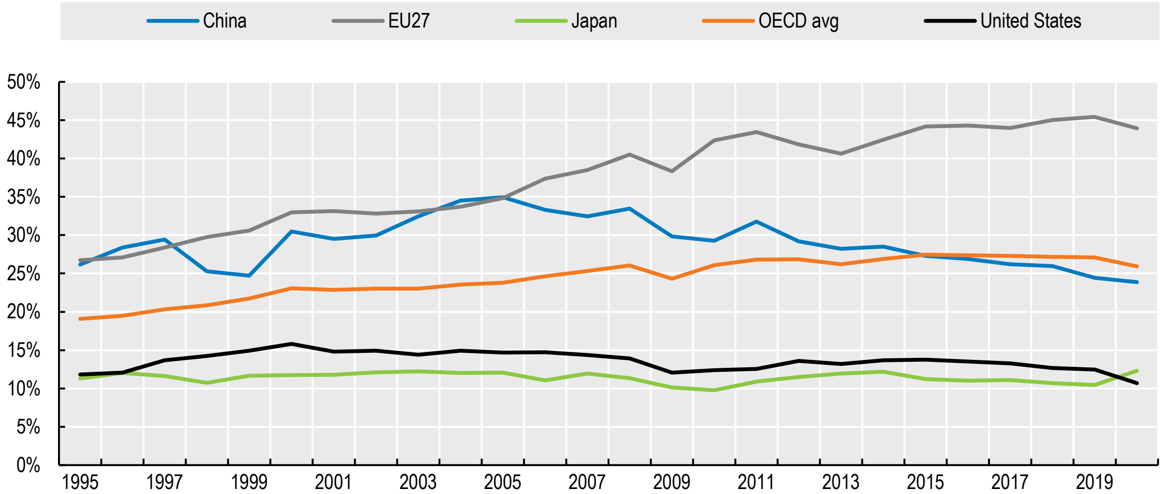
Finally, when it comes to industries, Figure 17 shows the percentage point change between 2019 and 2011 in the *ad valorem* tariff equivalent of the cumulative trade costs on intermediate inputs. Mining, non-metal minerals and transport and storage are the three industries with the highest increase in cumulative trade costs. This increase in cumulative trade costs is not fully the result of a higher fragmentation of production. In these three industries, the cumulative trade costs have increased even more than the fragmentation of production, suggesting higher bilateral trade costs between countries involved in the supply chain.

It is in the manufacturing sector that some industries have seen significantly decreasing cumulative trade costs. In the case of basic metals or electrical equipment, the decrease is proportional to the reduction in the import intensity of production. But for fabricated metals, the cumulative trade costs have decreased more than the fragmentation of production, highlighting an actual decrease in the bilateral trade costs between countries involved in the supply chain.

To disentangle the impact of the fragmentation of production (overall structure of GVCs) from trends related to specific bilateral trade costs, the next section introduces a structural decomposition analysis. In addition, it provides a decomposition of trade costs into different components to analyse further the determinants of the change in cumulative trade costs and link it to specific policies.

Figure 16. Cumulative trade costs by final producer, main economies, 1995-2020

Ad valorem tariff equivalent of all upstream bilateral trade costs on intermediate inputs in the value chain

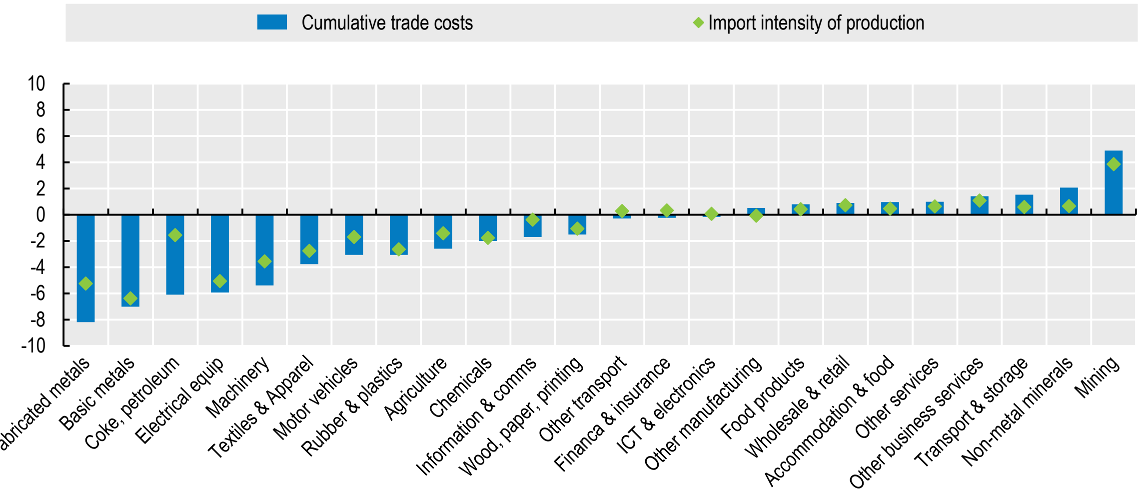


Note: Average across industries weighted by share in final output.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

[4] The trade costs matrix includes estimates for bilateral trade flows between EU member states and results for the EU are therefore not fully comparable with other economies on Figure 16.

Figure 17. Cumulative trade costs on inputs by final production industry and import intensity of production, 2019 versus 2011

Percentage point change in the *ad valorem* tariff equivalent and in import intensity of production



Note: Average across countries using final output weights.
Source: Authors' calculations based on OECD ICIO tables in previous year's prices.

3. Main determinants of the reorganisation of GVCs: A structural decomposition analysis of the evolution of trade costs along value chains

This section analyses determinants of the reorganisation of GVCs. It introduces four groups of variables that help to explain variation in bilateral trade costs.[5] In the subsequent step, the decomposition of bilateral trade costs into four components provides the basis for the structural decomposition of the evolution of cumulative trade costs along value chains.

3.1. Ease of trade, trade policy, uncertainty and other determinants of trade costs

The methodology proposed by Egger et al. (2021[28]) provides a comprehensive measure of trade costs capturing all frictions that make it costlier to trade across borders than within countries.[6] To shed light on the role of key determinants in shaping bilateral trade costs, we run regressions relating trade costs estimates to variables corresponding to four categories of drivers of trade costs.[7]

Titled "Ease of Trade", the first category encompasses a set of variables referring to aspects that are likely to shape the difficulty of exporting goods and services to a diverse set of destinations.[8] The World Bank

[5] Table A B1 in the appendix provides an overview of the data sources for the variables described in this section.

[6] For a description of this methodology, see Annex B.

[7] The contribution of Rubínová and Sebti (2021[54]) is most closely related to the analysis presented in this section. For examples of further studies aimed at decomposing trade costs, see Chen and Novy (2011[59]), Arvis, Duval and Shepherd (2013[60]), Egger and Nigai (2015[49]), Agnosteva, Anderson and Yotov (2019[58]).

[8] While the use of pair fixed effects increases the overall robustness of this analysis, it does not allow for the inclusion of bilateral geographical distance in the regressions (as this time-invariant variable is fully absorbed by the pair fixed effects). A robustness check without pair fixed effects (Table A B.3) also includes geographical distance to take into account the trade costs associated with the difficulty of exporting goods and services to faraway destinations (Head and Mayer, 2014[57]). In addition to transport costs, this variable also captures the cost of gathering information about geographically distant markets,

logistics performance index of the exporter as well as the importer is interacted with bilateral distance to incorporate the relevance of high-quality logistics to trade across large distances. Similarly, the OECD Trade Facilitation Indicators (TFIs) score of the importer is interacted with distance. As distance increases the costs of gathering and exchanging information (Storper and Venables, 2004[32]), trade facilitation efforts, such as the streamlining of customs procedures, appear particularly important when the exporter and the importer are geographically far apart.[9]

The second category is composed of seven variables referring to trade policy. A dummy for trade agreements, an average of applied tariffs, and a count of technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measures are part of this category. In addition, we include a count of measures regarding local content requirements, safeguards, government procurement procedures and subsidies as recorded in the Global Trade Alert database (Evenett, 2019[20]). In light of the growth of digital trade and crucial role of information and communications technology (ICT) in increasing the tradability of services, the second category also encompasses the importer's services trade restrictiveness index (OECD STRI) score (Nordås and Rouzet, 2016[33]), as well as the importer's digital STRI score (Ferencz, 2019[34]) and the importer's digital trade integration score (Ferracane, 2022[35]).

The third category captures drivers of uncertainty. It includes interactions of bilateral distance with a measure of economic policy uncertainty in the exporting economy as well as in the importing economy. This measure relies on references to uncertainty in quarterly reports of the Economist Intelligence Unit (Ahir, Bloom and Furceri, 2022[36]). As corruption is likely to hamper trading companies' capacity to assess the cost of engaging in cross-border transactions (de Jong and Bogmans, 2011[37]), a measure of the control of corruption of the importing economy (interacted with bilateral distance) is also included in this category.

In the fourth category ("Other"), we include the number of unique IP addresses in the exporting economy as well in the importing economy to control for the depth of digitalisation in each of the trading economies.[10] This category also includes a count of the number of voluntary sustainability standards. While such standards are not mandatory requirements defined in laws, in practice compliance is often necessary for producers to participate in global value chains (Fiorini et al., 2019[38]).[11]

Using the estimates of bilateral trade costs at the country-pair-by-industry level presented in section 2.1 as the dependent variable, the panel regressions are run based on the years 2011-2019 and separately for four groups of industries (services, manufacturing, utilities, primary sector). In addition to the variables belonging to the four categories outlined above, the set of right-hand side variables also includes exporter-industry fixed effects, importer-industry fixed effects as well as country-pair-by-industry fixed effects.

The country-pair-by-industry fixed effects absorb all time-invariant bilateral variables, such as geographical distance. Importantly, the inclusion of these fixed effects also implies that all coefficients obtained from these regressions are estimated based on changes over time only. Put differently, no cross-sectional variation across country-pair-by-industry observations is exploited to estimate the coefficients of the variables included in the four categories described above. This approach is motivated by the subsequent use of these regression coefficients as inputs for the structural decomposition of changes in cumulative trade costs in GVCs between 2011 and 2019 (Section 3.2). The structural decomposition focuses on explaining changes over time. The country-pair-by-industry fixed effects in the regressions discussed in

exchanging complex knowledge with business partners in faraway locations, and establishing trustful relationships across large distances (Storper and Venables, 2004[32]; Boschma, 2005[63]).

[9] Note that all regressions incorporate exporter-industry-year as well as importer-industry-year fixed effects. To ensure that variables without variation across sectors, such as the OECD Trade Facilitation Indicators score, do not get fully absorbed by these fixed effects, the use of an interaction with bilateral distance or the use of the bilateral minimum or maximum of the corresponding variable is necessary.

[10] For further details on the use of IP addresses in economic research, see Csonto, Huang and Tovar Mora (2019[61]).

[11] In an alternative set of regressions without country pair fixed effects (Table A B.3), the "Other" category also covers historical and cultural ties between the trading economies (Egger and Lassmann, 2012[62]) – common native language, common religion, and shared colonial history. In the main specification discussed in this section, these time invariant pair-specific variables are absorbed by the pair fixed effects.

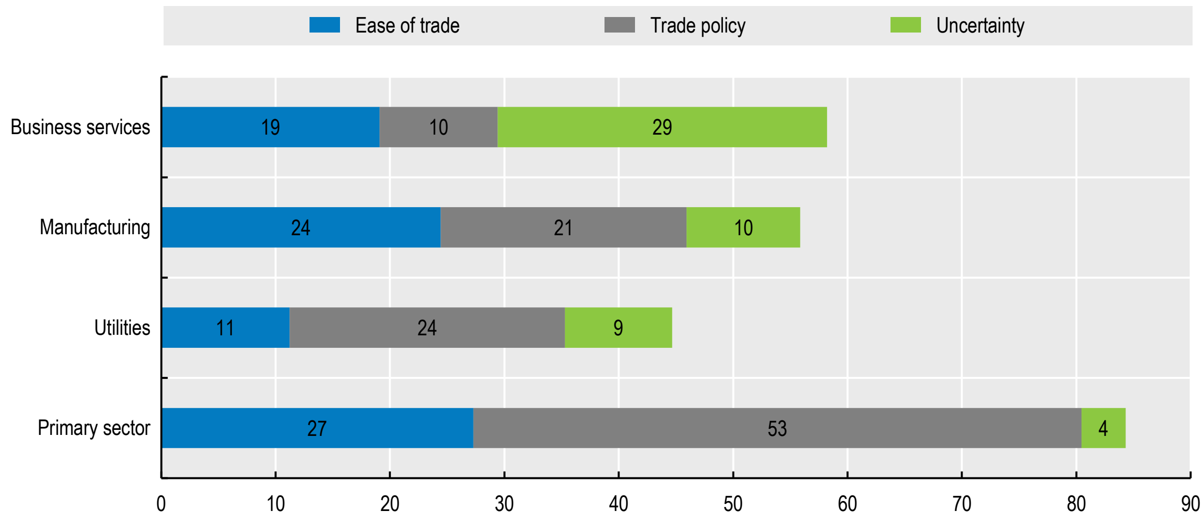
this section therefore ensure that the estimation of the coefficients of determinants of bilateral trade costs is aligned with the following analytical step.

The results of the regressions (Table A B.2) are generally in line with expectations and the related literature. For example, a better logistics performance seems to mitigate the impact of distance on trade costs. While results vary across groups of sectors, they also provide support for the role of trade facilitation in lowering trade costs. Conversely, a higher STRI score (reflecting higher regulatory barriers to services trade) is positively associated with trade costs for services. A positive relationship between the restrictiveness of regulations concerning digital trade (as captured by the digital STRI and the digital trade integration score) is also visible for services. Especially for manufacturing trade, economic policy uncertainty is associated with higher bilateral trade costs. In the “other” category, the findings point to the potential for ICT adoption to lower bilateral trade costs.

Figure 18 illustrates the relative explanatory power of the variables described above with respect to the variation in bilateral trade costs in four aggregate sectors.[12] The percentages indicate how much of the total explained bilateral variation can be attributed to each category of variables. The relative contribution of the different categories varies across manufacturing, business services, utilities, and the primary sector. The category “Ease of trade” accounts for roughly a fifth of the explained bilateral variation with respect to business services and about a quarter in the case of manufacturing. The greater role of this set of determinants with respect to trade costs for manufacturing appears plausible in the light of the corresponding variables’ focus on the transport of tangible products and customs procedures. The explanatory power of trade policy is somewhat smaller for both of these sectors, accounting for approximately 10% (business services) to 20% (manufacturing) of the explained variation in bilateral trade costs. Trade costs for business services seem particularly sensitive to uncertainty, with nearly 30% of variation explained by the variables in this category. The high degree of relationship-specificity and complexity of many services may explain this pattern. In contrast, variables related to uncertainty account for only roughly 10% of the variation of trade cost for manufacturing and only 4% in the case of the primary sector.

Figure 18. Determinants of bilateral trade costs by aggregate sector

Percentage of bilateral variation explained



Note: This graph relies on regressions (exploiting data for 2011-2019) that relate the logarithm of bilateral trade costs for intermediate inputs to variables corresponding to the four categories of determinants described in Section 3.1. All variables were demeaned by partialing out importer-sector-year fixed effects as well as exporter-sector-year fixed effects and country-pair-by-industry fixed effects. The graph shows the contribution of the different groups of determinants to the total variation in trade costs based on the R-squared decomposition proposed by Huettner and Sundner (2012[39]).
Source: Authors’ calculations.

[12] This decomposition relies on the approach proposed by Huettner and Sundner (2012[39]). The percentages cited in this paragraph and displayed in Figure 18 refer to the share of total variation explained by all four categories after having partialed out importer-sector-year fixed effects as well as exporter-sector-year fixed effects and country-pair-by-industry fixed effects.

3.2. Results of the structural decomposition analysis

The purpose of the structural decomposition analysis is twofold. First, as explained in Section 2.2, part of the change in cumulative trade costs does not come from an increase (or decrease) in bilateral trade costs but from the structure of GVCs (the composition and repetition of these trade costs along the value chain). Second, when it comes to the role of bilateral trade costs, we can also rely on the four categories introduced in the previous section to further understand how changes in trade costs along value chains are driven by different determinants.

The structural decomposition analysis can isolate changes in the structure of GVCs, such as:

- A change in the share of intermediate inputs in total output: as firms increase their reliance on outsourcing (rather than producing inputs themselves), they are likely to import more inputs, and greater use of imported intermediates is associated with higher cumulative trade costs. Yet, firms can also source domestically, i.e. an increase in outsourcing does not necessarily lead to greater use of foreign inputs and higher cumulative trade costs.
- A change in the sourcing industry mix. Some industries producing inputs face higher trade costs than others. The composition of sourcing industries has therefore an influence on the cumulative trade costs.
- A change in the sourcing country mix. Countries exporting intermediate inputs are also not facing the same trade costs both with the country importing their intermediate inputs and with respect to third countries from which they source their own inputs. Changes in sourcing countries also impact the resulting cumulative trade costs.

We group these different changes into a single category of ‘structural changes in GVCs’. When presenting results at the country level, this category also includes changes related to the aggregation of results across different final producing industries (the industry composition). Holding bilateral trade costs constant, the structural decomposition analysis indicates the variation in cumulative trade costs that can be explained by these structural changes in GVCs.

We then focus on the contribution of the change in bilateral trade costs to the overall cumulative trade costs. This factor is what allows to disentangle the impact of the structure of GVCs from the impact of the evolution of bilateral trade costs. We further decompose this change in bilateral trade costs to identify the change that can be allocated to the ease of trade (logistics performance and trade facilitation), to the evolution of trade policies (in terms tariffs, NTMs, regional trade agreements, STRIs and digital trade), to uncertainty and to other determinants of trade costs, following the decomposition introduced in the previous section.

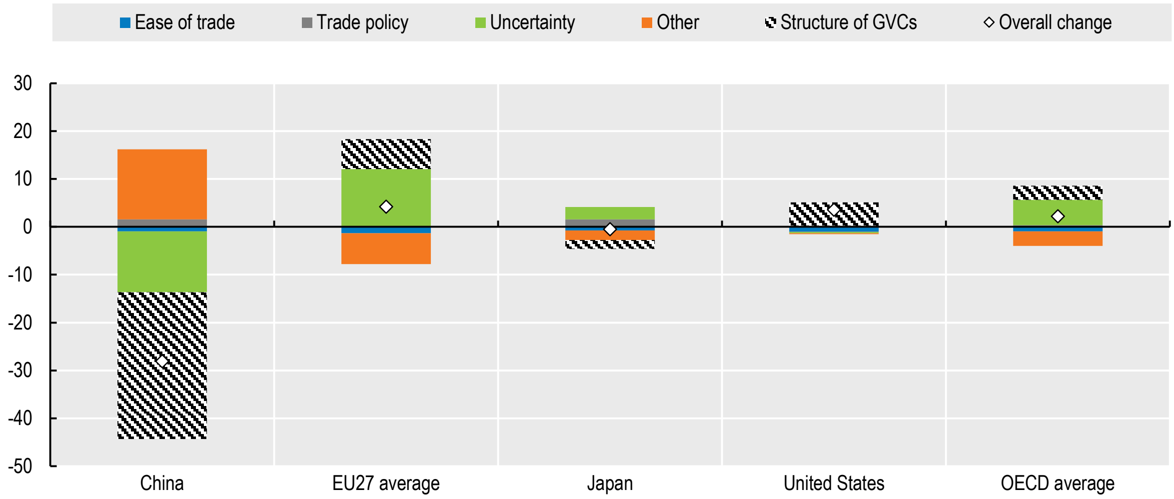
The results of the structural decomposition analysis for all countries are presented in Table A C.1 in Annex C. In the rest of this section, we focus on the main economies and an OECD average to describe overall trends. The change between 2011 and 2019 for the different factors in the structural decomposition analysis is expressed in percentage points and their sum is equal to the overall change of cumulative trade costs (Figure 19).[13]

China is the country that experienced the highest decrease in its cumulative trade costs along value chains between 2011 and 2019 (-28%). To a large extent, the shift of China to domestic sourcing and the lower levels of fragmentation of production in Chinese GVCs explain this decrease. This trend is captured in Figure 19 by the part of the bar corresponding to changes in the structure of GVCs. These changes may reflect the upgrading of Chinese value chains and structural shifts driven by domestic policies in China. Our analysis assesses the impact of policies on international trade costs but does not look at the role of domestic policies in the mix of inputs used by Chinese final producers.

[13] This is not the case when using an average for OECD countries or EU economies.

Figure 19. The role of ease of trade, trade policy, uncertainty and other determinants of trade costs

Percentage point change in the cumulative trade costs between 2011 and 2019, by country of final production



Source: Authors' calculations.

However, Figure 19 also indicates that uncertainty is a factor that, in the case of China, led to a reduction of cumulative trade costs in GVCs. It implies that countries involveld in value chains where China is the country of final production have on average lower levels of economic policy uncertainty and corruption in 2019 as compared to 2011. There is also a small part of the decrease in cumulative trade costs that can be attributed to the ease of trade, i.e. an improvement of logistics performance and trade facilitation indicators along value chains providing inputs to final production in China.

Although small, the contribution of trade policy to cumulative trade costs in Chinese GVCs is positive. The trade policy category captures a variety of trade policy instruments and both liberalising and restrictive measures. The overall stance of trade policy has pushed for higher bilateral trade costs in Chinese GVCs but the methodology cannot allow us to disentangle the impact of different types of policies. It should also be understood that the results do not only reflect the impact of trade policies on direct imports of China but also indirect imports of intermediate inputs between other countries more upstream in the value chain. Trade measures on direct Chinese imports have more weight in the calculation but are not the only source of potential increase in cumulative trade costs.

Lastly, an important increase in cumulative trade costs in Chinese GVCs came from other variables, such as the role of technological change that is controlled for in the 'other' category.[14] But this increase was fully compensated by the large reductions of cumulative trade costs associated with changes in the structure of GVCs and uncertainty.

For the EU and for the United States, as well as on average for OECD countries, cumulative trade costs in GVCs have slightly increased between 2011 and 2019. This increase was generally driven by uncertainty and structural changes in GVCs. While changes in trade policy did, overall, contribute to the increase in cumulative trade costs, it is noteworthy that his contribution was very small. This suggests that discussions on new protectionist measures might have to adopt a broad perspective taking into account that trade policy is only one determinant of the reorganisation of GVCs.

Changes in the ease of trade generally contributed to a decline in cumulative trade costs in line with the improvement in logistics performance and trade facilitation observed in many countries. But as with trade policy, this component of trade costs only explains a small part of the overall trend. It should be stressed

[14] This indicates that countries participating in GVCs in which China is the country of final production saw changes in their "other" characteristics (i.e. in terms of digitalisation and voluntary sustainability standards) between 2011 and 2019 that – on average – contributed to higher cumulative trade costs.

that the variable decomposed is the change in cumulative trade costs, rather than the absolute level. Both trade policy and ease of trade can play a significant role in the level of bilateral trade costs. What Figure 19 suggests it that this role did not significantly change between 2011 and 2019.

Finally, in the case of Japan, there is a slight decrease in cumulative trade costs over the period covered. The structure of GVCs and exogenous factors captured in 'other determinants' are the main drivers of this result. However, it is interesting to note that the trade policy factor is associated with an increase in cumulative trade costs in Japan, as it was the case for China. It suggests that the stance of trade policy within East and South East Asian supply chains may have become more restrictive between 2011 and 2019, a result that can be observed for other economies in the region (see Table A C.1 in Annex C with detailed results by country).

4. Concluding remarks

This paper has highlighted that there was no general trend towards deglobalisation after the Great Financial Crisis of 2008-2009 and that the level of the international fragmentation of production remained high at the onset of the COVID-19 pandemic. However, there was clearly a slowdown in the expansion of GVCs, with several countries showing a downward trend in their use of imported inputs in the recent period.

It is too soon to determine the impact of the pandemic on the evolution of GVCs. The latest year in our data (2020) can only show the impact of some of the disruptions that affected supply chains in the first months of COVID-19. Any structural change in GVCs related to lessons learned and changes introduced to improve the resilience of supply chains will take time to be reflected in input-output data.

The paper provided evidence on some of the drivers of the slowdown in the fragmentation of production. The results suggest that more restrictive trade policies and trade tensions were not the main drivers of the slowdown before COVID-19. Instead, structural factors related to changes in the mix of inputs used by firms and more uncertainty in the global environment contributed to higher trade costs along value chains.

The results included in this paper have several implications for the design of trade policies. First, a decrease in bilateral trade costs on intermediate inputs can be associated with an increase in cumulative trade costs in value chains when production is fragmented (snowball effect) and when sourcing shifts towards industries and countries that still face barriers on trade in intermediate products. A value chain approach is useful to identify the impact of upstream protectionism and how it affects the competitiveness of domestic producers. This approach can also help countries to identify bottlenecks in supply chains not only stemming from risks related to specific countries but also arising from costs.

To ensure that the benefits of GVCs and international trade are preserved, the trend towards increasing trade costs in some value chains should be monitored. Policy makers should seek to increase the ease of trade and to reduce uncertainty. While trade policy (covering regional trade agreements, tariffs, non-tariff measures, measures restricting trade in services and digital trade) was not found to be a major driver of increased trade costs along value chains between 2011 and 2019, it still contributed to higher costs. This result indicates that on average more restrictive trade measures have been introduced along supply chains and that there is room for trade reforms that can reduce costs and facilitate operations of firms, particularly in the context of the post-COVID recovery and aspirations for more resilient supply chains through diversification of supply.

There is also a role for trade policy in the ease of trade and reduction of uncertainty. Trade facilitation and reforms of services sectors such as transport and logistics can also contribute to the ease of trade, while commitments in trade agreements and international co-operation on trade issues can reduce the level of uncertainty. With new risks and crises after the COVID-19 pandemic, reducing uncertainty should even more than before be the focus of policy makers.

The analysis presented in this paper is not without limitations. While ICIO data are ideal for the adoption of a broad perspective aimed at identifying major trends in the evolution of GVCs, they do not allow for a fine-grained analysis of dynamics concerning products or firms. Important nuances of the questions addressed in this paper, e.g. regarding changes in the concentration of supply, could be uncovered by future studies exploiting firm-level data on trade and investment patterns. Similarly, high-frequency data on product-level trade flows may help to improve our understanding of the way increases in uncertainty affect GVCs.

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Annex A. Methodology used for the construction of inter-country input-output tables in previous year's prices

This annex describes the methodology used to estimate the OECD Inter-Country Input-Output (ICIO) tables in previous year's prices (pyp) for the period 1995-2020. The methodology is based on the work done within the World Input-Output Database (WIOD) project and follows the main steps presented in Los et al. (2014[40]) for the construction of World Input-Output Tables (WIOTs) in previous year's prices. As such, this Annex draws on Los et al. (2014[40]). It first presents the data sources that were used to build a full dataset of gross output and value-added deflators for the countries included in the OECD ICIO tables.[15] The Annex then describes the main steps in the construction and balancing of pyp tables.

Construction of US dollar-denominated previous year's price deflators

Deflators were collected from a range of data sources, with the main sources of value added and gross output deflators for target countries being KLEMS projects (35%), UN National Accounts (30%), STAN (25%) and the WIOD socio-economic accounts (10%) (Table A A.1).

Where deflators were not available, the same sector's value-added deflators were used for missing output deflators and missing sectors were substituted with the closest available aggregate. For example, a missing deflator for the chemicals industry may be substituted with the deflator of the chemicals and pharmaceuticals aggregate or the next closest available aggregate. Final demand deflators were taken from the UN National Accounts, with the exception of Chinese Taipei for which deflators were collected from the national statistics office.

Following the methodology of Los et al. (2014[40]), unavailable deflators for taxes, margins etc. related to final demand were approximated using GDP deflators and deflators for NPISH and changes in inventory were implicitly derived from output deflators. Expenditure of non-residents deflators are not available and were instead approximated using the deflators of household final consumption expenditure.

Deflators in national currency were converted using fiscal year adjusted exchange rates and constant price deflators were unchained using ICIO values to arrive at dollar-denominated previous year's price deflators.

Lastly, the deflators for the Rest of the World (RoW) were constructed as weighted averages of the ten largest economies in terms of output per sector using data from the UN National Accounts.

Table A A.1. List of PYP value added and output deflator sources

ISO-3	Economy	Data sources
ARG	Argentina	UN National Accounts
AUS	Australia	STAN, UN National Accounts, WIOD
AUT	Austria	KLEMS, STAN, UN National Accounts
BEL	Belgium	KLEMS, STAN, UN National Accounts
BGR	Bulgaria	KLEMS, UN National Accounts, WIOD
BRA	Brazil	UN National Accounts, WIOD
BRN	Brunei Darussalam	UN National Accounts
CAN	Canada	KLEMS, STAN, UN National Accounts, WIOD
CHE	Switzerland	STAN, UN National Accounts

[15] We used a preliminary version (December 2022) of OECD inter-country input-output tables available for 77 economies and 45 industries over the period 1995-2020. Tables in previous year's prices do not include Bangladesh, Belarus, Côte d'Ivoire, Cameroon, Egypt, Jordan, Nigeria, Pakistan, Senegal and Ukraine. Moreover, OECD inter-country input-output tables have heterogeneous data for China and Mexico to account for differences between exporters or foreign-owned firms and firms that serve the domestic market. We work with a single row or column for China and Mexico in the pyp tables.

ISO-3	Economy	Data sources
CHL	Chile	STAN, UN National Accounts
CHN	China	KLEMS, UN National Accounts, WIOD
COL	Colombia	STAN, UN National Accounts
CRI	Costa Rica	UN National Accounts
CYP	Cyprus	KLEMS, UN National Accounts, WIOD
CZE	Czech Republic	KLEMS, STAN, UN National Accounts
DEU	Germany	KLEMS, STAN, UN National Accounts
DNK	Denmark	KLEMS, STAN, UN National Accounts
ESP	Spain	KLEMS, STAN, UN National Accounts, WIOD
EST	Estonia	KLEMS, STAN, UN National Accounts
FIN	Finland	KLEMS, STAN, UN National Accounts
FRA	France	KLEMS, STAN, UN National Accounts
GBR	United Kingdom	KLEMS, STAN, UN National Accounts, WIOD
GRC	Greece	KLEMS, STAN, UN National Accounts
HKG	Hong Kong (China)	UN National Accounts
HRV	Croatia	KLEMS, UN National Accounts, WIOD
HUN	Hungary	KLEMS, STAN, UN National Accounts
IDN	Indonesia	UN National Accounts, WIOD
IND	India	KLEMS, UN National Accounts, WIOD
IRL	Ireland	KLEMS, STAN, UN National Accounts, WIOD
ISL	Iceland	Eurostat, STAN, UN National Accounts
ISR	Israel	STAN, UN National Accounts
ITA	Italy	KLEMS, STAN, UN National Accounts
JPN	Japan	KLEMS, STAN, UN National Accounts
KAZ	Kazakhstan	UN National Accounts
KHM	Cambodia	UN National Accounts
KOR	Korea	KLEMS, STAN, UN National Accounts, WIOD
LAO	Lao PDR	UN National Accounts
LTU	Lithuania	KLEMS, STAN, UN National Accounts, WIOD
LUX	Luxembourg	KLEMS, STAN, UN National Accounts
LVA	Latvia	KLEMS, STAN, UN National Accounts
MAR	Morocco	UN National Accounts
MEX	Mexico	STAN, UN National Accounts
MLT	Malta	Eurostat, UN National Accounts, WIOD
MMR	Myanmar	UN National Accounts
MYS	Malaysia	UN National Accounts
NLD	Netherlands	KLEMS, STAN, UN National Accounts
NOR	Norway	STAN, UN National Accounts
NZL	New Zealand	STAN, UN National Accounts
PER	Peru	UN National Accounts
PHL	Philippines	UN National Accounts
POL	Poland	KLEMS, STAN, UN National Accounts
PRT	Portugal	KLEMS, STAN, UN National Accounts
ROU	Romania	KLEMS, UN National Accounts
RUS	Russia	KLEMS, UN National Accounts, WIOD
SAU	Saudi Arabia	UN National Accounts
SGP	Singapore	UN National Accounts
SVK	Slovak Republic	KLEMS, STAN, UN National Accounts

ISO-3	Economy	Data sources
SVN	Slovenia	KLEMS, STAN, UN National Accounts
SWE	Sweden	KLEMS, STAN, UN National Accounts
THA	Thailand	UN National Accounts
TUN	Tunisia	UN National Accounts
TUR	Türkiye	STAN, UN National Accounts, WIOD
TWN	Chinese Taipei	KLEMS, National Statistics Office, WIOD
USA	United States	KLEMS, STAN, UN National Accounts
VNM	Viet Nam	UN National Accounts
ZAF	South Africa	UN National Accounts

Note by Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".
Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Main steps in the creation of ICIO tables in previous year's prices

Table A A.2 presents an overview of the ICIO in pyp. Symbols with asterisks indicate values expressed in previous year's prices. Corresponding symbols without asterisks denote values in current prices. Price indices deflators of various sorts are indicated by the symbol *p*. The economy described by this Figure consists of two countries, which both provide a single output. This output can be used as an intermediate input (in either of the two countries) or be used for final demand purposes (also in either of the two countries). Six final demand purposes are discerned: 1) consumption by households (*c*); 2) non-residents expenditure (*nr*); 3) consumption expenditure by non-profit organisations serving the households, NPISH (*n*); 4) government consumption (*g*); 5) gross fixed capital formation (*f*); and 6) changes in inventories (*i*).

The methodology described in Los et al. (2014[40]) is based on Dietzenbacher and Hoen (1998[41]) who proposed an approach to estimate IO tables in pyp based on the RAS algorithm.[16] The approach advocated by Dietzenbacher and Hoen (1998[41]) assumes that data on gross output by industry in pyp (*q**.), value added by industry in pyp (*v**) and total final demand by supplying industry (the sum over all cells in a row in "Final demand in Country 1" and "Final demand in Country 2") are given. This implies that the row totals and column totals for the block of intermediate inputs transactions in pyp are known. Hence, the well-known iterative RAS-procedure can be used to derive each value of intermediate inputs transactions in pyp. The RAS-procedure is completed if the sums over cells in each row are very close to the exogenously given row totals and the same applies to cells in columns. This implies that both rows and columns have been scaled up or down by row- and column-specific factors upon completion of the procedure. Since cells are in both a row and a column, each cell value originally expressed in current prices has been scaled up or down by a cell-specific factor. If RAS is used to deflate cell values in current prices, these cell-specific factors can be considered as cell-specific deflators.

In the case of ICIO tables, the data availability is a bit different from Dietzenbacher and Hoen (1998). Deflating the intermediate inputs block is not sufficient to arrive at fully deflated ICIOs, since estimates of cell-specific values of final demand by supplying industry, use category and country of destination are also part of an ICIO. These values in pyp are not known and should also be estimated. Table A A.2 summarises the data situation. The values (in pyp) in the shaded cells should be estimated using RAS. This requires that the sums over cells in columns and the sums over cells in rows are known.

For the variables included in Table A A.2, exogenous information is indicated in colours: a) information from current price ICIO in orange; b) production and value added deflators by industry in green; and c) national accounts deflators in blue. *p* is price, and volumes are indicated with asterisks *. The values in pyp in the shaded cells are estimated using RAS.

[16] See Bacharch (1970[55]) and Miller and Blair (2022[56]).

The price indices deflators that were described in the previous section are key to obtain a consistent and balanced ICIO in pyp. At this stage, a preliminary overall consistency of the price indices deflators was conducted, assuring that the weighted average of the industry value added price deflators match the GDP deflator and that a given industry gross output price deflator stays in a range between -10% or +10% of the same industry value added price deflator.

For the variables in the rows related to net taxes, the industry-level value added deflators have been assumed to apply ($p1rz= p1v$ and $p2rz = p2v$). To deflate gross output levels, gross output levels in current prices ($q1$ an $q2$) were divided by industry-specific gross output deflators ($p1$ and $p2$). The initial constraints on the columns sums in pyp of the intermediate input block are now given by $z^*11 + z^*21 = q^*1 - rz^*1 - v^*1$ and $z^*12 + z^*22 = q^*2 - rz^*2 - v^*2$. The initial constraints on the entire rows sums in pyp have also been derived: $z^*11 + z^*12 + c^*11 + n^*11 + g^*11 + f^*11 + i^*11 + c^*12 + n^*12 + g^*12 + f^*12 + i^*12 = q^*1$ and $z^*21 + z^*22 + c^*21 + n^*21 + g^*21 + f^*21 + i^*21 + c^*22 + n^*22 + g^*22 + f^*22 + i^*22 = q^*2$.

At this stage, the column constraints for the final demand blocks have still to be determined. Aggregate deflators for household consumption ($p1c$ and $p2c$), for government consumption ($p1g$ and $p2g$) and for gross fixed capital formation ($p1f$ and $p2f$) were estimated based on UN National Accounts. Deflators for taxes, subsidies, international transport margins etc. related to final demand are not available. As an admittedly rough approximation, we assume that $p1rc = p1rn = p1rg = p1rf = p1ri = p1GDP$ and $p2rc = p2rn = p2rg = p2rf = p2ri = p2GDP$, i.e. all deflators are assumed to equal the GDP deflator of the country to where the respective final products are sold. This fixes the initial constraint on the columns of a number of final demand columns: for country 1 we have $c^*11 + c^*21 = c^*1- rc^*1$, $g^*11 + g^*21 = g^*1-rg^*1$, $f^*11 + f^*21 = f^*1- rf^*1$ and analogous expressions apply to the columns for household consumption, government expenditures and gross fixed capital formation in country 2.

The consumption of non-residents is added to household consumption to estimate the values in pyp. After the system is balanced, the split is done by using the shares of non-residents expenditure on the above sum, i.e. household consumption plus consumptions of non-residents in current prices.

Available deflators for consumption expenditures by NPISH ($p1n$ and $p2n$) and changes in inventories ($p1i$ and $p2i$) appeared highly unreliable. As so, we assume that cell-specific deflators in the columns for consumption by NPISH and changes in inventories are equal to the known gross output deflators (e.g. for the cells in the first row, $p11n = p11i = p12n =p12i = p1$). This yields initial values for n^*11, n^*21, n^*12, n^*22 and i^*11, i^*21, i^*12, and i^*22. We use these initial values (indicated by an underlined symbol) to generate Laspeyres aggregates of the elements in the final demand columns related to consumption by NPISH and changes in inventories: $n^*1 = n^*11 + n^*21 + rn^*1$ and $i^*1 = i^*11 + i^*21 + ri^*1$ (and analogous expressions for these final demand categories in country 2). This approach thus basically determines implicit deflators. The initial constraints on the sum of the values in the relevant columns of the final demand block are now given by equations like $n^*11 + n^*21 = n^*1 - rn^*1$.

The Dietzenbacher and Hoen (1998) approach cannot be applied at this stage yet, despite having obtained the initial constraints on row and column sums according to the methods described so far. This is caused by two issues. First, the RAS algorithm cannot deal with negatives, while the columns with changes in inventories frequently contain negative values. In order to address this issue, a possible approach is to use a Generalised RAS (GRAS) algorithm as it was done by Los et al. (2014). However, the option here was to use the traditional RAS approach and to treat the negative values in changes in inventories in the following way: a) the negative values are stored for later use and are transformed in positive values to be used in RAS; b) the row and columns constraints are adjusted to reflect this transformation; c) after the balancing procedure, the negative values are added to the balanced system, obtained from RAS, and the rows and columns totals adjusted accordingly. This procedure provides consistent results with the advantage to be simpler to use and faster than GRAS in terms of computing time.

The methodology described above yields data-driven distinctions between export price indices and price indices for domestically traded products, since generally each cell will have its own deflator ($p11z$ and $p12z$, for example, will be different).

Table A A.2. Stylised ICIO in previous year's prices

	Using Countries / Industries		Final demand in Country 1						Final demand in Country 2						GO
			Households	Non-residents	NPISH	Government	GFCF	Changes in Inventories	Households	Non-residents	NPISH	Government	GFCF	Changes in Inventories	
Supplying Countries / Industries	$z^*_{11} = z_{11}/p_{11z}$	$z^*_{12} = z_{12}/p_{12z}$	$c^*_{11} = c_{11}/p_{11c}$	$nr^*_{11} = nr_{11}/p_{11nr}$	$n^*_{11} = n_{11}/p_{11n}$	$g^*_{11} = g_{11}/p_{11g}$	$f^*_{11} = f_{11}/p_{11f}$	$i^*_{11} = i_{11}/p_{11i}$	$c^*_{12} = c_{12}/p_{12c}$	$nr^*_{12} = nr_{12}/p_{12nr}$	$n^*_{12} = n_{12}/p_{12n}$	$g^*_{12} = g_{12}/p_{12g}$	$f^*_{12} = f_{12}/p_{12f}$	$i^*_{21} = i_{12}/p_{12i}$	$q^*_1 = q_1/p_1$
	$z^*_{21} = z_{21}/p_{21z}$	$z^*_{22} = z_{22}/p_{22z}$	$c^*_{21} = c_{21}/p_{21c}$	$nr^*_{21} = nr_{21}/p_{21nr}$	$n^*_{21} = n_{21}/p_{21n}$	$g^*_{21} = g_{21}/p_{21g}$	$f^*_{21} = f_{21}/p_{21f}$	$i^*_{21} = i_{21}/p_{21i}$	$c^*_{22} = c_{22}/p_{22c}$	$nr^*_{22} = nr_{22}/p_{22nr}$	$n^*_{22} = n_{22}/p_{22n}$	$g^*_{22} = g_{22}/p_{22g}$	$f^*_{22} = f_{22}/p_{22f}$	$i^*_{22} = i_{22}/p_{22i}$	$q^*_2 = q_2/p_2$
Net Taxes	$rz^*_1 = rz_1/p_{1rz}$	$rz^*_2 = rz_2/p_{2rz}$	$rc^*_1 = rc_1/p_{1rc}$	$rnr^*_1 = rnr_1/p_{1rnr}$	$rn^*_1 = rn_1/p_{1rn}$	$rg^*_1 = rg_1/p_{1rg}$	$rf^*_1 = rf_1/p_{1rf}$	$ri^*_1 = ri_1/p_{1ri}$	$rc^*_2 = rc_2/p_{2rc}$	$rnr^*_2 = rnr_2/p_{2rnr}$	$rn^*_2 = rn_2/p_{2rn}$	$rg^*_2 = rg_2/p_{2rg}$	$rf^*_2 = rf_2/p_{2rf}$	$ri^*_2 = ri_2/p_{12ri}$	
Value Added	$v^*_1 = v_1/p_{1v}$	$v^*_2 = v_2/p_{2v}$	0	0	0	0	0	0	0	0	0	0	0	0	
Gross Output	$q^*_1 = q_1/p_1$	$q^*_2 = q_2/p_2$	$c^*_1 = c_1/p_{1c}$	$nr^*_1 = nr_1/p_{1nr}$	$n^*_1 = n_1/p_{1n}$	$g^*_1 = n_1/p_{1g}$	$f^*_1 = f_1/p_{1f}$	$i^*_1 = i_1/p_{1i}$	$c^*_2 = c_2/p_{2c}$	$nr^*_2 = nr_2/p_{2nr}$	$n^{*2} = n_2/p_{2n}$	$g^*_2 = n_2/p_{2g}$	$f^*_2 = f_2/p_{2f}$	$i^*_2 = i_2/p_{2i}$	

Note: Stylised ICIO for two countries, one industry and six final demand categories: 1) consumption by households (c); 2) non-residents expenditure (nr); 3) consumption expenditure by non-profit organizations serving the households, NPISH (n); 4) government consumption (g); 5) gross fixed capital formation (f); and 6) changes in inventories (i).
Exogenous information is indicated in colours: a) information from current price ICIO in orange; b) production and value-added deflators by industry in green; and c) national accounts deflators in blue. p is price, and volumes are indicated with asterisk *. The values in pyp in the shaded cells are estimated using RAS.
Source: Based on Los et al. (2014[40]).

Annex B. Methodology used to calculate and decompose cumulative imports and cumulative trade costs along the value chain

Input-output techniques allow to track all intermediate and final transactions and thus all trade flows along GVCs. From the OECD ICIO tables, we extract for each year a vector of gross output y of dimension GN with G the number of countries (67)[17] and N the number of industries (45), a vector of value added va (also of dimension GN), a matrix of intermediate consumption Z of dimension GN x GN and a matrix of final consumption F of dimension GN x G.

Cumulative imports of intermediate inputs along the value chain

To look at imports of intermediate inputs along a given value chain, we can refer to the Leontief price model and its interpretation of each column in the input-output table.[18] When summing down a column, gross output is equal to the sum of intermediate inputs plus value added. In matrix notation and transposing to read the sum in rows with column vectors for gross output and value added, we have:

$$y = Z'i + va$$

where i is a summation identity vector (column vector of dimension GN with ones).

We then create a matrix A of intermediate inputs requirements indicating for each dollar of gross output the value of inputs needed from each supplying country and industry. This GN x GN matrix is:

$$A = Z\hat{y}^{-1}$$

where $\hat{y}$ is the diagonal matrix of vector y (gross output).

Combining the two above equations and defining $v = \hat{y}^{-1}$ as the column vector of value added to output ratios, we obtain:

$$i = A'i + v$$

This equation can be understood as a decomposition of gross output where gross output has been normalised to one (the identity vector i) and is the sum of value added in the sector of final production (v) and the value added embodied in the inputs used by this sector (decomposing value added backward in the value chain):

$$\begin{aligned} i &= A'i + v \\ &= v + A'v + A'^2v + A'^3v + \cdots \\ &= (I - A')^{-1}v \end{aligned}$$

where $(I - A')^{-1}$ is the transpose of the Leontief inverse. This equation indicates the gross value created at each stage of production. i is the gross value created at the final production stage (normalised to one), while $A'i = 0 + A'v + A'^2v + A'^3v + \cdots$ is the gross value created by the first-tier suppliers of inputs, $A'^2i = 0 + 0 + A'^2v + A'^3v +$ is the gross value created by second-tier suppliers of inputs, and so on.

If we sum gross output across stages of production, we get a cumulated gross output:

$$\begin{aligned} y^{cum} &= i + A'i + A'^2\mathrm{i} + A'^3\mathrm{i} + \cdots \\ &= (I - A')^{-1}i \end{aligned}$$

[17] The pyp tables are available for 67 countries (including 'rest of the world').

[18] See Miller and Blair (2009[53]), Chapter 2, Section 2.6.3.

Cumulative imports of intermediate inputs along the value chain can be obtained by following the same logic, starting from gross output normalised to one. The value of imported inputs from first-tier suppliers (expressed as a share of gross output) is given by the part of matrix A corresponding to imports of intermediate inputs (i.e. the off-block diagonal elements):

$$x^{tier1} = (E \circ A')i$$

with E a trade selection matrix in the GN x GN dimension with zeroes on a N x N block diagonal and ones elsewhere in order to remove domestic transactions and keep only imported inputs.[19] Multiplying x^{tier1} by A' provides imports from second-tier suppliers (with all values now imported in the A' matrix), so that $x^{tier2} = A'(E \circ A')i$. The cumulative imports of intermediates expressed as a share of gross output in country r and industry k are:

$$\begin{aligned} x_{rk}^{cum} &= (E \circ A')i + A'(E \circ A')i + A'^2(E \circ A')i + A'^3(E \circ A')i + \cdots \\ &= (I - A')^{-1}(E \circ A')i \end{aligned}$$

Timmer et al. (2021[11]) interpret x_{rk}^{cum} as a supply chain fragmentation (SCF) index that indicates for each dollar of output in a given value chain the sum of all the value of imported intermediate inputs. This index measures the level of fragmentation of production in each country (of final production) and industry.

Unlike other measures of vertical specialisation such as the VS index introduced by Hummels et al. (2001[5]) or the VAX ratio of Johnson and Noguera (2012[17]), it captures fragmentation in upstream industries and continues to increase when the foreign value embodied in production remains the same but reflects the contribution of more countries in the value chain. Since it double counts the value of intermediate inputs, it can take values higher than gross output (i.e. values above one).

Cumulative trade costs along the value chain

The concept of cumulative tariffs was introduced in Miroudot et al. (2013[30]). Muradov (2017[42]) and Johnson (2018[31]) discuss its theoretical foundation while Mao and Görg (2020[43]) and Duan et al. (2020[44]) provide some empirical applications and extensions.

The formulas developed for tariffs also work for any type of trade costs that can be expressed *ad valorem*. From a theoretical perspective, we can start again from the Leontief price model and the decomposition of gross output introduced in the previous section. Following Johnson (2018[31]), we can account for the fact that there is a difference between the value of inputs in basic prices and purchaser's prices by introducing a matrix M that includes trade and transport margins, tariffs and other taxes less subsidies on products. Matrix M is defined as $M = A^{purchaser} - A^{basic}$ (we use the A matrix so that M is directly expressed as a share of gross output and can be regarded as a matrix of margins coefficients). We can then rewrite the equation decomposing gross output as:

$$\begin{aligned} i &= A'i + M'i + \tilde{v} \\ &= (I - A')^{-1}M'i + (I - A')^{-1}\tilde{v} \end{aligned}$$

where $\tilde{v}$ is a vector of value added to output ratios that does not include anymore the taxes less subsidies on products, trade and transport margins. The term $(I - A')^{-1}M'i$ aggregates all the margin coefficients along the value chain and already provides the formula for the calculation of cumulative trade costs on intermediate inputs (for a given country and industry of final production in the dimension GN).

If we define TC_{olrk}^{int} as the GN x GN matrix of bilateral trade costs on intermediate inputs exported from country *o* and industry *l* to country *r* (of production) and industry *k* (with different bilateral costs for each supplying industry but the same costs for using industries) and assume that margins only include these trade costs, we have: $M' = A' \circ TC_{olrk}^{int}{}'$. And the cumulative trade costs on intermediate inputs used by country *r* and industry *k* is:

$$ctc_{rk}^{int} = (I - A')^{-1}(A' \circ TC_{olrk}^{int}{}')i$$

[19] The circle in the equation refers to an element-wise multiplication (Hadamard product).

This equation is actually very similar to the equation summing imports of intermediate inputs (expressed as a share of gross output) across production stages. We can also keep a bilateral dimension in the cumulative trade costs by not multiplying by the identity vector i. The GN x GN matrix obtained $CTC_{rkol}^{int} = (I - A')^{-1}(A' \circ {TC_{olrk}^{int}}')$ indicates the cumulative trade costs between country *r* of production of *k* and country *o* of origin of input *l* at the beginning of the value chain.

The final stage of production and related costs can also be added to the analysis by creating a matrix of trade costs for final products. The cumulative trade costs along the value chain for final products exported from *r* (country of final production) to *c* (country of final consumption) and belonging to industry *k* are then:

$$CTC_{rkc} = TC_{rkc}^{fin} + (I - A')^{-1}(A' \circ {TC_{olrk}^{int}}')iu'$$

where u is a unit vector of dimension G x 1.

Estimation of bilateral trade costs

The literature offers several methods to estimate theory-consistent partial equilibrium bilateral trade costs. The starting point is generally the structural gravity model (Anderson and van Wincoop, 2003[45]; Anderson and Yotov, 2010[46]). Some of these methods are based on a calculation (Head and Ries, 2001[47]; Novy, 2012[48]) while others combine some estimation and calibration (Egger and Nigai, 2015[49]; Anderson, Larch and Yotov, 2018[50]). We rely on the later and more specifically the methodology developed by Egger et al. (2021[28]) that was used by the WTO to create its Trade Cost Index.

As the authors rely on data from the World Input-Output Database (WIOD) and take advantage of the four dimensions in the Z matrix of intermediate consumption (country of origin, industry of origin, country of production, industry of production), it is well adapted to the OECD ICIO tables. Moreover, the methodology provides estimates for directional bilateral trade costs, which is an advantage to link results to policy changes.

For each industry *s* and year *t* in the ICIO,[20] the following gravity model is estimated with a set of constraints:

$$\ln \frac{X_{ij,t}^{sr}}{X_{ii,t}^{sr}} = e_{i,t}^{s} + d_{ij,t}^{s} - e_{j,t}^{s} + \epsilon_{ij,t}^{sr} \text{ such that } e_{i,t}^{s} = e_{j,t}^{s}\ \forall i = j \text{ and } s \neq r$$

where $X_{ij,t}^{sr}$ are the trade flows of intermediate inputs (from the Z matrix) from country *i* to country *j* and from industry *s* to industry *r*, $X_{ii,t}^{sr}$ are the domestic flows in country *j* from industry *s* to industry *r*, $e_{i,t}^{s}$ are exporter fixed effects, $e_{j,t}^{s}$ are importer fixed effects, $d_{ij,t}^{s}$ are country pair fixed effects and $\epsilon_{ij,t}^{sr}$ is an is an idiosyncratic stochastic term. OLS regressions with no constant and robust standard errors are used.

In the regression, the coefficients of the country pair fixed effects are used to recover bilateral trade costs. Egger et al. (2021[28]) show that the log of partial equilibrium trade costs can be obtained as $T_{ij,t}^{s} = -\frac{1}{\theta^{s}} d_{ij,t}^{s}$ with θ^{s} an industry-specific elasticity that can be estimated from the data.[21] Since the gravity equation divides trade flows of intermediate inputs by domestic flows in the dependent variable, this variable tells us how many times costs are higher for exporters of inputs as compared to domestic producers. We can then derive a tariff equivalent (by taking the exponential and removing one).

The above methodology provides trade costs for intermediate inputs. However, trade costs for final products can be estimated by including in the model final consumption as an additional sector *s*.

[20] Due to data availability for the variables used in the decomposition of trade costs, we estimate bilateral trade costs for 27 industries and 61 countries. The list of countries can be seen in Table A.C.1 in Annex C presenting the detailed results of the structural decomposition analysis. The 27 industries are an aggregation of the initial 45 industries in the ICIO tables and still cover the full economy.

[21] The parameter θ reflects the shape of the underlying Pareto distribution of firm productivity in sector *s*. Higher values of θ are associated with a smaller dispersion of productivity in the sector and therefore a higher elasticity of trade to changes in trade costs. Egger et al. (2021[28]) also provide a methodology to estimate θ. Values for θ in this report rely on WTO estimates (Rubínová and Sebti, 2021[54]).

Regressions of bilateral trade cost estimates on determinants

Once bilateral trade costs have been estimated, we run additional regressions to identify the main determinants of their change over time. Table A B.1 provides the list of variables that are used to cover the four dimensions used in the structural decomposition analysis of cumulative trade costs: ease of trade, trade policy, uncertainty and other determinants. Regression results are presented in Table A B.2.

Table A B.1. Right-hand side variables included in regressions

Variable	Measurement	Data source	Notes
Logistics	Logistics Performance Index of exporter and importer	World Bank	* (a)
Trade Facilitation	Trade Facilitation Indicators, maximum of importer and exporter	OECD	(b)
Digital STRI	Digital services trade restrictiveness index, minimum of importer and exporter	OECD	(a) (c)
Digital Trade Integration score	Number of restrictive measures on data flows in place, minimum of importer and exporter	European University Institute	(c)
Trade agreement	Binary, presence of a trade agreement between the economies	CEPII	
Tariffs	Average applied tariff of importing economy	Comtrade/TRAINS	(d)
Services trade restrictiveness	Average STRI score of importing economy	OECD	(a) (c) (d)
SPS/TBT	Log count of TBT and SPS measures in place by importer for exporter	Ghodsi et al. (2017[51])	(d)
Trade interventions	Log number of trade interventions implemented by importer for exporter	Global Trade Alert	
Uncertainty	Uncertainty index for importer and exporter	World Uncertainty Index	* (b)
Corruption	Control of corruption score, minimum of importer and exporter	World Bank	
Sustainability standards	Log number of sustainability product standards in place between importer and exporter	International Trade Center	
ICT adoption	Log number of unique IP addresses (v4) in exporting economy interacted with bilateral distance Log number of unique IP addresses (v4) in importing economy interacted with bilateral distance	Asia-Pacific Network Information Centre	*

Note: * indicates that the variable was interacted with the geographical distance between the two economies in order to obtain a dyad-specific version of the measure. The decomposition method (Section 3.2) required right-hand variable data for all countries and years, which was not always available in the data sources. Letters indicate the approach(es) used to extend the coverage as needed.
(a) indicates the use of the first available year for all previous years, use of the last available year for all subsequent years, or linear interpolation for data available less frequently than annually.
(b) means that one or two similar countries were used to substitute for the values of a missing country.
(c) designates that a regression-based imputation was applied.
(d) applies when data is only available for some sectors and means the average value for the country was applied to all other sectors.

Table A B.2. Results of regressions exploring determinants of bilateral trade costs

	(1)	(2)	(3)	(4)
	Manufacturing	Business services	Primary sector	Utilities
Logistics performance index (exporter) X Log distance	-0.0007	0.0026*	0.0028	-0.0020
	(0.0015)	(0.0015)	(0.0045)	(0.0128)
Logistics performance index (importer) X Log distance	-0.0030*	-0.0027	-0.0077**	0.0197*
	(0.0017)	(0.0031)	(0.0037)	(0.0100)
Trade facilitation score (importer) X Log distance	-0.0037*	-0.0017	0.0098	0.0116
	(0.0020)	(0.0055)	(0.0069)	(0.0132)
Trade agreement	-0.0094	-0.0247**	0.0495**	0.0060
	(0.0082)	(0.0125)	(0.0222)	(0.0309)
Average applied tariff	0.0000	-0.0001	0.0001	-0.0017
	(0.0001)	(0.0007)	(0.0002)	(0.0029)
Log number of SPS and TBT measures	-0.0011	0.0075	-0.0088**	0.0547
	(0.0010)	(0.0102)	(0.0039)	(0.0450)
Log count of measures imposed by importer	0.0036	-0.0009	-0.0187**	-0.0588
(Global Trade Alert)	(0.0026)	(0.0047)	(0.0077)	(0.0435)
STRI (importer)	-0.4277*	0.1250	-0.4949	0.5038
	(0.2338)	(0.2464)	(0.6865)	(1.4326)
Maximum of digital STRI	0.0042	0.0041	0.1521	0.2267
	(0.0618)	(0.0529)	(0.1142)	(0.1863)
Maximum of digital trade integration score	-0.0006	0.0002	0.0022*	-0.0043
	(0.0004)	(0.0009)	(0.0013)	(0.0081)
Control of corruption of importer X Log distance	0.0041*	0.0076	-0.0011	-0.0008
	(0.0021)	(0.0084)	(0.0028)	(0.0110)
Economic policy uncertainty index (exporter) X Log distance	0.0005	-0.0010	-0.0046	-0.0029
	(0.0009)	(0.0015)	(0.0039)	(0.0089)
Economic policy uncertainty index (importer) X Log distance	0.0017*	-0.0001	0.0014	-0.0129
	(0.0010)	(0.0020)	(0.0024)	(0.0118)
Log count of voluntary sustainability standards	-0.1451	-0.3132***	0.2827	-2.0713
	(0.0939)	(0.1200)	(0.2570)	(1.6611)
Log number of IP addresses (exporter) X Log distance	-0.0026*	-0.0017	-0.0021	0.0137
	(0.0016)	(0.0031)	(0.0039)	(0.0225)
Log number of IP addresses (importer) X Log distance	-0.0021	0.0048	0.0012	-0.0026
	(0.0022)	(0.0052)	(0.0032)	(0.0072)
Observations	475,776	191,160	62,658	30,843
R-squared	0.8794	0.9647	0.8114	0.8332

Note: Robust standard errors (clustered by exporter-industry as well as importer-industry) in parentheses. All regressions rely on data for the years 2011-2019 and include importer-industry fixed effects, exporter-industry fixed effects, as well as country pair-industry fixed effects. A constant is included but not reported.
Source: Authors' calculations.

Table A B.3. Alternative results of regressions without country-pair fixed effects

	(1)	(2)	(3)	(4)
VARIABLES	Manufacturing	Business services	Primary sector	Utilities
Logistics performance index (exporter) X Log distance	-0.0145***	-0.0098***	-0.0130**	0.0008
	(0.0016)	(0.0021)	(0.0056)	(0.0267)
Logistics performance index (importer) X Log distance	-0.0128***	-0.0145***	-0.0187***	0.0078
	(0.0021)	(0.0051)	(0.0041)	(0.0152)
Trade facilitation score (importer) X Log distance	0.0013	-0.0003	0.0206***	0.0106
	(0.0019)	(0.0048)	(0.0077)	(0.0181)
Log distance	0.7975***	0.6303***	0.7124***	0.7909**
	(0.0332)	(0.0585)	(0.0898)	(0.3749)
Trade agreement	-0.0478***	-0.0284***	-0.0431**	0.1343
	(0.0052)	(0.0063)	(0.0191)	(0.0938)
Average applied tariff	0.0004**	0.0010	0.0000	-0.0065
	(0.0002)	(0.0009)	(0.0004)	(0.0066)
Log number of SPS and TBT measures	0.0006	0.0309***	-0.0047	0.0146
	(0.0011)	(0.0102)	(0.0038)	(0.0631)
Log count of measures imposed by importer	-0.0285***	-0.0177***	-0.0349***	-0.0213
(Global Trade Alert)	(0.0033)	(0.0048)	(0.0109)	(0.0421)
STRI (importer)	0.5267***	0.3721***	0.5892***	0.1148
	(0.0576)	(0.0784)	(0.1732)	(0.9836)
Maximum of digital STRI	-0.0272	-0.0246	-0.0030	0.8743
	(0.0448)	(0.0487)	(0.1083)	(0.5474)
Maximum of digital trade integration score	0.0014***	0.0017**	0.0042***	-0.0089
	(0.0005)	(0.0007)	(0.0015)	(0.0071)
Control of corruption of importer X Log distance	-0.0085***	-0.0062	-0.0066*	-0.0091
	(0.0019)	(0.0056)	(0.0040)	(0.0120)
Economic policy uncertainty index (exporter) X Log distance	0.0031***	0.0011	-0.0008	-0.0015
	(0.0010)	(0.0016)	(0.0038)	(0.0087)
Economic policy uncertainty index (importer) X Log distance	0.0041***	0.0014	0.0048*	-0.0112
	(0.0010)	(0.0021)	(0.0027)	(0.0128)
Shared border	-0.0849***	-0.0956***	-0.1021***	0.0616
	(0.0080)	(0.0103)	(0.0185)	(0.2741)
Landlocked	0.0283	0.0404*	0.0471	0.2607
	(0.0180)	(0.0216)	(0.0521)	(0.1607)
Common native language	-0.1459***	-0.1300***	-0.0198	-0.0707
	(0.0160)	(0.0190)	(0.0518)	(0.1355)
Common religion	-0.0453***	-0.0365***	-0.0836**	-0.1256
	(0.0091)	(0.0108)	(0.0384)	(0.0786)
Common legal origin	-0.0477***	-0.0444***	-0.0512***	-0.0188
	(0.0036)	(0.0047)	(0.0141)	(0.0604)
Shared colonial history	-0.0840***	-0.1017***	-0.1002***	-0.3598**
	(0.0078)	(0.0099)	(0.0217)	(0.1511)
Log count of voluntary sustainability standards	0.2013***	0.1143*	0.3416**	-0.7268
	(0.0475)	(0.0656)	(0.1416)	(0.9980)
Log number of IP addresses (exporter) X Log distance	-0.0145***	-0.0115***	-0.0122**	-0.0213*
	(0.0014)	(0.0022)	(0.0048)	(0.0123)
Log number of IP addresses (importer) X Log distance	-0.0135***	-0.0093***	-0.0118***	-0.0185*
	(0.0016)	(0.0030)	(0.0039)	(0.0106)

	(1)	(2)	(3)	(4)
VARIABLES	Manufacturing	Business services	Primary sector	Utilities
Observations	0.73	0.89	0.63	0.43
R-squared	475,776	191,160	62,658	30,843

Note regarding Table A B.3: Robust standard errors (clustered by exporter-sector as well as importer-sector) in parentheses. All regressions rely on data for the years 2011-2019 and include importer-industry fixed effects and exporter-industry fixed effects. A constant is included but not reported.
Source: Authors' calculations.

Structural decomposition analysis

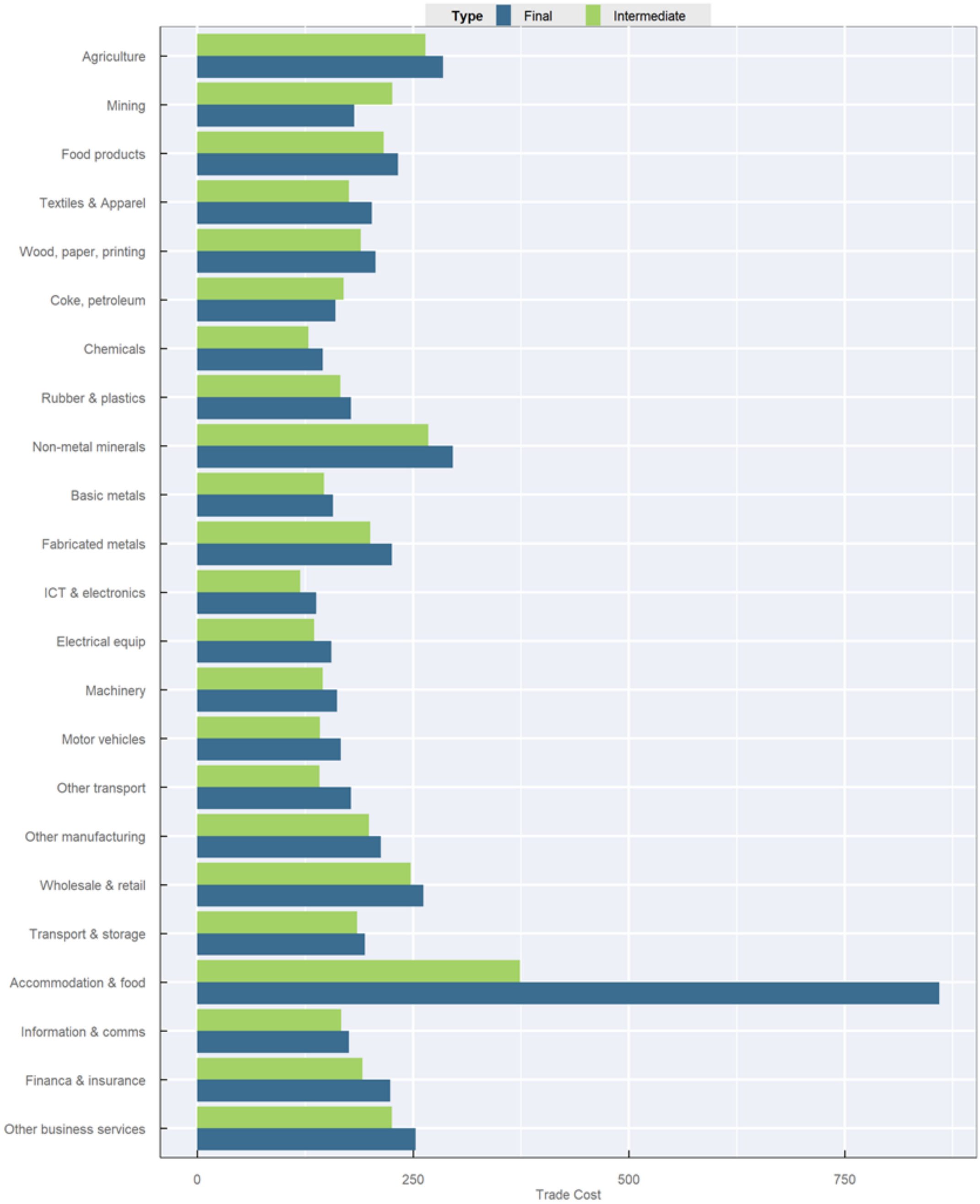
Structural decomposition analysis (SDA) techniques allow to decompose the growth of a variable into changes in its determinants. We decompose the change in cumulative trade costs between 2011 and 2019 using ICO tables in constant prices created by chain-linking the pyp and current price tables. For this part of the analysis, tables are aggregated to 27 sectors and 61 countries (as done in the decomposition of trade costs).

The impact of structural changes in GVCs is captured by changes in the A matrix, while changes related to bilateral trade costs are identified with the trade cost matrix (on intermediate inputs) that includes the estimates of bilateral trade costs obtained with the gravity regressions. The trade cost matrix is decomposed into the four dimensions described in the previous section: ease of trade, trade policy, uncertainty and other determinants of trade costs.

Following Dietzenbacher and Los (1998[52]), we use the average of the two so-called polar decompositions to calculate the part of the change in cumulative trade costs that can be explained by the different factors. When doing the decomposition at the country level, an additional factor is introduced that captures changes in the composition of industries (their share in gross output).

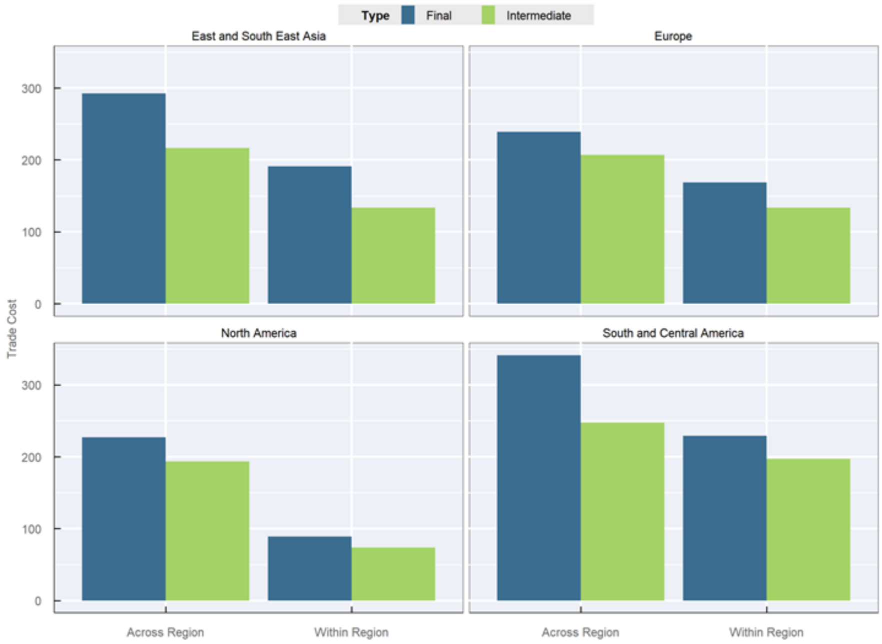
Annex C. Additional results on bilateral trade costs and cumulative trade costs along value chains

Figure A C.1. Bilateral trade costs, by industry, 2019



Note: Shown here are the industries that make up the three broader sector groups displayed in Figure 12 (that is, primary, manufacturing, and business services).
Source: Authors' calculations based on OECD inter-country input-output tables.

Figure A C.2. Trade costs within and across region, by exporter region



Note: An additional fifteen countries in the analysis do not fall into these four regions, but are included in the calculations of across-region trade costs.
Source: Authors' calculations based on OECD inter-country input-output tables.

Table A C.1. Structural decomposition analysis, detailed results

Percentage point change in cumulative trade costs along the value chains of each final producer between 2011 and 2019

Country	Cumulative trade costs in 2011	Cumulative trade costs in 2018	Overall change (%)	Change in trade costs: Ease of trade	Change in trade costs: Trade policy	Change in trade costs: Uncertainty	Change in other determi-nants of trade costs	Change in structure of GVCs
Argentina	0.29	0.39	30.42	0.41	0.33	2.94	1.21	25.53
Australia	0.36	0.32	-9.13	-0.51	-0.05	1.38	-3.82	-6.14
Austria	0.70	0.43	-48.26	-0.88	0.72	2.89	-11.76	-39.23
Belgium	0.56	0.55	-0.48	-0.54	-0.05	8.41	-9.34	1.06
Brazil	0.28	0.42	40.85	0.42	0.16	-0.91	3.47	37.72
Bulgaria	0.77	0.90	15.55	-0.31	0.09	1.81	-7.47	21.44
Canada	0.30	0.32	6.23	0.09	0.72	0.88	-7.84	12.38
Chile	0.45	0.44	-2.42	-1.13	0.72	-1.91	8.90	-9.00
China	0.29	0.22	-28.12	-0.96	1.56	-12.70	14.64	-30.66
Chinese Taipei	0.72	0.69	-4.62	0.18	1.31	0.04	6.15	-12.29
Colombia	0.30	0.35	14.47	-0.64	-0.10	0.46	4.80	9.95
Costa Rica	0.38	0.34	-11.57	-0.30	0.06	0.38	-8.32	-3.39
Croatia	0.80	0.67	-16.64	-0.91	0.15	1.00	-12.43	-4.44
Czech Republic	0.85	0.82	-3.24	-1.87	0.37	2.44	-1.41	-2.76
Denmark	0.48	0.51	4.48	-0.78	0.20	2.75	-2.07	4.38
Estonia	1.26	1.25	-0.48	-1.93	-0.09	-2.69	-3.13	7.35
Finland	0.49	0.52	6.84	-0.48	0.53	4.55	-6.72	8.96
France	0.25	0.30	15.45	-1.74	-3.00	-10.92	13.37	17.73

Country	Cumulative trade costs in 2011	Cumulative trade costs in 2018	Overall change (%)	Change in trade costs: Ease of trade	Change in trade costs: Trade policy	Change in trade costs: Uncertainty	Change in other determi-nants of trade costs	Change in structure of GVCs
Germany	0.29	0.30	5.34	-1.41	0.02	7.28	-7.11	6.56
Greece	0.37	0.61	50.64	-1.58	0.15	1.79	-7.69	57.98
Hong Kong, China	0.64	0.54	-16.66	1.64	6.47	27.84	-38.30	-14.31
Hungary	1.10	1.05	-4.64	-2.73	-0.18	1.48	2.10	-5.32
Iceland	0.75	0.86	14.20	0.02	-0.04	3.41	-15.51	26.32
India	0.40	0.34	-15.94	-0.50	1.10	2.04	3.53	-22.10
Indonesia	0.33	0.24	-31.46	-1.33	1.74	34.78	-29.12	-37.52
Ireland	1.08	0.78	-33.07	0.51	10.19	102.75	-108.45	-38.07
Israel	0.43	0.36	-16.47	-0.66	0.39	3.00	-0.42	-18.78
Italy	0.35	0.32	-9.68	-1.81	0.15	12.34	-13.00	-7.35
Japan	0.10	0.10	-0.47	-0.72	1.57	2.59	-2.03	-1.87
Kazakhstan	0.96	1.00	4.49	-0.43	-0.25	3.98	11.10	-9.90
Latvia	0.58	0.56	-3.82	0.75	1.01	4.80	-6.84	-3.54
Lithuania	0.63	0.75	16.41	-0.18	-0.02	3.05	-16.89	30.46
Luxembourg	0.91	0.89	-1.69	0.29	0.47	11.68	-27.44	13.31
Malaysia	0.70	0.62	-11.32	0.08	0.16	3.00	4.14	-18.70
Mexico	0.37	0.37	0.80	-1.27	-0.37	-2.16	-5.10	9.70
Morocco	0.68	0.64	-5.12	-1.46	-2.03	-1.77	-7.03	7.17
Netherlands	0.44	0.50	12.61	-0.52	0.30	4.72	-6.00	14.11
New Zealand	0.46	0.45	-2.42	-2.03	0.01	1.97	0.92	-3.30
Norway	0.48	0.48	1.25	-0.64	0.15	2.09	-1.92	1.57
Peru	0.27	0.26	-6.13	0.15	-0.43	-1.51	-0.21	-4.13
Philippines	0.39	0.41	6.08	0.39	0.58	1.42	-2.00	5.68
Poland	0.53	0.68	24.65	-1.90	-0.23	2.99	-7.00	30.79
Portugal	0.51	0.57	10.22	-1.64	-0.12	1.62	-7.80	18.17
Rest of the World	0.10	0.09	-10.06	-0.65	0.68	7.48	-6.24	-11.33
Romania	0.91	0.91	-0.21	-2.45	-3.71	-20.09	23.11	2.92
Russia	0.36	0.38	3.92	-2.03	-0.53	4.75	3.71	-1.98
Saudi Arabia	0.51	0.61	18.26	0.18	0.51	4.76	5.34	7.47
Singapore	0.73	0.72	-1.67	0.12	0.23	3.09	-0.28	-4.82
Slovakia	1.04	1.30	22.14	-0.61	0.39	0.89	1.22	20.24
Slovenia	0.73	0.82	11.60	-1.18	0.34	1.38	-3.56	14.63
South Africa	0.46	0.52	12.60	0.59	-0.55	1.83	7.51	3.23
Korea	0.39	0.37	-4.87	-0.35	1.74	-0.29	11.15	-17.13
Spain	0.37	0.40	7.73	-1.76	0.09	0.47	-2.56	11.49
Sweden	0.43	0.41	-6.02	-0.82	0.48	8.59	-5.70	-8.57
Switzerland	0.37	0.36	-1.68	-0.50	0.29	4.79	-7.34	1.07
Thailand	0.55	0.51	-7.84	-0.88	2.39	1.06	6.38	-16.79
Tunisia	0.60	0.54	-10.09	1.84	-1.35	-0.58	2.26	-12.26
Türkiye	0.46	0.40	-14.11	-0.34	-1.20	-0.91	-1.74	-9.91
United Kingdom	0.31	0.33	5.85	-0.77	-0.06	14.90	-12.37	4.14
United States	0.11	0.12	3.55	-1.00	-0.08	-0.26	-0.20	5.10
Viet Nam	0.91	1.18	25.19	-2.45	-1.02	-0.98	17.41	12.23

Source: Authors' calculations.

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Comments are welcome and can be sent to tad.contact@oecd.org.