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Are supply chain vulnerabilities increasing in the era of geoeconomic fragmentation?

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BOFIT Policy Brief 2024 No. 10

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Are supply chain vulnerabilities increasing
in the era of geoeconomic fragmentation?



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Tuuli McCully and Heli Simola

Are supply chain vulnerabilities increasing in the era of geoeconomic fragmentation?

Abstract

We examine changes in the manufacturing sector value chains of the EU, US, China, and India between 2018 and 2023 by introducing three metrics for supply-chain vulnerability. For our first metric, the physical length of a supply chain based on the distance between the producer of the final product and input source country, we find modest evidence of near-shoring for the US, EU, and India. Second, utilizing political distances between the supply chain participants, our assessment of the geopolitical risks of supply chains reveals slight friend-shoring by the US and EU, mainly a result of Russia's reduced participation in their supply chains. Third, looking at the already extensive supply chain diversification of the studied countries, we find diversification has increased modestly since 2018.

Keywords: global value chains, supply chains, fragmentation, value-added trade, input-output

1. Introduction

The shifting economic relations that reflect the heightened geopolitical tensions of recent years have triggered an international economic policy debate on the increased risk of severe adverse impacts to the global economy through geoeconomic fragmentation (Norrington, 2024). Notably, the current literature has yet to establish substantial evidence of geoeconomic fragmentation from trade or investment data.

To explore fragmentation from a different perspective, we consider international value chains.¹ Constructing manufacturing value chains for selected economies with international input-output tables to discern their evolution over recent years, we measure supply chain vulnerabilities associated with supply chain disruptions related to transport factors (*physical length of the value chain*) and political factors (*political distance between value chain participants*). These vulnerabilities, which have received considerable attention since the Covid-19 pandemic and Russia's invasion of Ukraine, may be amplified by the high concentration of supply chains. Therefore, we also consider the evolving *diversification of international value chains*.

Our analysis focuses on the manufacturing chains of four large economies: the United States, European Union, China, and India. We compare the developments in these value chains between 2018 and 2023, a period that includes three major shocks to global value chains: the US-China trade war, the Covid-19 pandemic, and Russia's invasion of Ukraine. We also differentiate value chains in terms of gross and value-added structure to see if developments differ. While companies make their supply-chain decisions based on gross trade, the effects of those decisions may be diluted by countervailing value-added developments.

Our analysis of changes in international supply chains during 2018–2023 finds some evidence of re-shoring, near-shoring, and friend-shoring, particularly in the case of the US. Overall, however, the evidence is somewhat mixed and changes quite modest. There are minor indications of increased diversification of supply chains, but these changes, too, are relatively small. Comparing supply chain developments in gross and value-added terms suggests that many of these developments are diluted in value-added terms.

The brief is organized in the following way. Section 2 presents the general set-up for our analysis. Section 3 discusses developments in the geographical structure of the value chains of the economies examined. The vulnerability indicators are assessed with section 4 focusing on changes in physical distance, section 5 on changes in political distance, and section 6 on changes in input concentration. Section 7 provides concluding remarks.

2. General set-up

We focus on manufacturing supply chains as they typically have the highest level of integration with international production networks. A supply chain comprises all inputs needed to manufacture the final output of the industry, and the owner of the value chain is the country that produces the final product. In this context, we cannot define the nationality of ownership of companies (for example, both foreign-owned and domestic companies operating in China are treated as “Chinese” manufacturing). In examining the manufacturing value chains of the US, EU, China, and India, we focus on the geographical perspective and slice manufacturing value chains according to the country of origin for a particular input.

¹ The term “international value chain” here comprises the complete production process of a manufacturing industry, including all inputs from all industries and countries. We use the terms “value chain” and “supply chain” interchangeably.

We construct supply chains in both gross and value-added terms. In gross terms, the supply chains simply show the immediate origin of inputs. Thus, a Chinese input arriving in the US from Mexico would be considered a “Mexican” input. In value-added terms, the supply chains show the ultimate origin of the inputs. The same input originating in China as above would now be considered “Chinese” regardless of its transit through Mexico or some other third country en route to the US. As noted by Baldwin et al. (2022), both approaches to measuring supply chains are important from the vulnerability viewpoint as supply chains can suffer from shocks that hit the immediate source country or impact the ultimate source country.

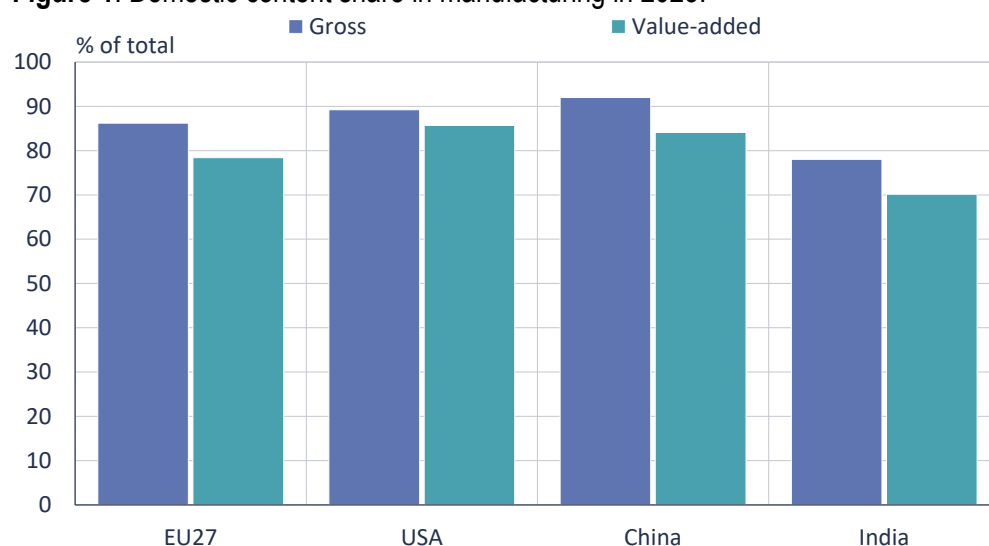
Gross value chains are readily available from international input-output tables. We construct the value-added supply chains applying standard input-output methodology (Simola, 2023; Timmer et al., 2015). We use the international input-output tables provided by the Asian Development Bank (ADB). The data cover sixty-two economies, an aggregated rest-of-the-world (RoW) bloc and thirty-five sectors. The data are expressed in current US dollars and cover the years 2007–2023.

Our analysis focuses on the US, EU, China, and India in recent years. We calculate our vulnerability indicators for gross and value-added supply chains and examine their evolution during 2018–2023 across economies and manufacturing industries. The measure for vulnerability to transport disruptions is constructed as the weighted average of the physical distances associated with imported inputs of the chains. Similarly, the measure for geopolitical risk is a weighted average of the political distances associated with imported inputs of the chains. We measure vulnerabilities related to supply chain concentration with the Herfindahl-Hirschman Index calculated for the imported inputs in the chains. UNCTAD (2024), for example, uses similar measures.

3. Developments of supply chains in major economies

Looking at the general features in the supply chains of the US, EU, China, and India, we see that the share of domestic content is high (70–90 %) in the manufacturing industries of all these economies. India sits at the lower end of the range, while the US and China sit at the high end (Figure 1).²

Figure 1. Domestic content share in manufacturing in 2023.



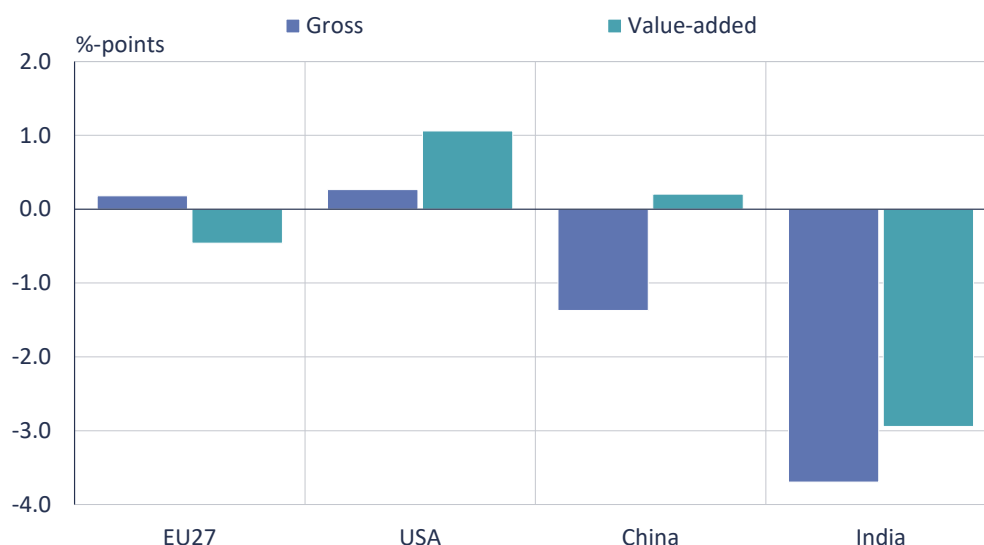
Source: Authors' calculations based on ADB data.

² For the EU, domestic content refers to inputs originating within the EU27. China's share of domestic value-added could be somewhat biased upwards. The data is based on the traditional assumption that the input shares are identical in production for domestic consumption and exports. In the case of China, in particular, this is not always the case.

The data suggest that the share of domestic value-added declined in China and India in gross terms between 2018 and 2023 (Figure 2). In value-added terms, however, the domestic share in China increased slightly, suggesting that more Chinese value-added was embodied in Chinese imports. For India, the domestic share also declined in value-added terms, but less than in gross terms.

For the EU and the US, the domestic share slightly increased in gross terms, possibly indicating re-shoring. For the US, the increase was even larger in value-added terms, suggesting that more US value-added was embodied in US imports. For the EU, the changes were quite small. In value-added terms, the domestic share slightly declined.

Figure 2. Change in the share of domestic content in manufacturing between 2018 and 2023.



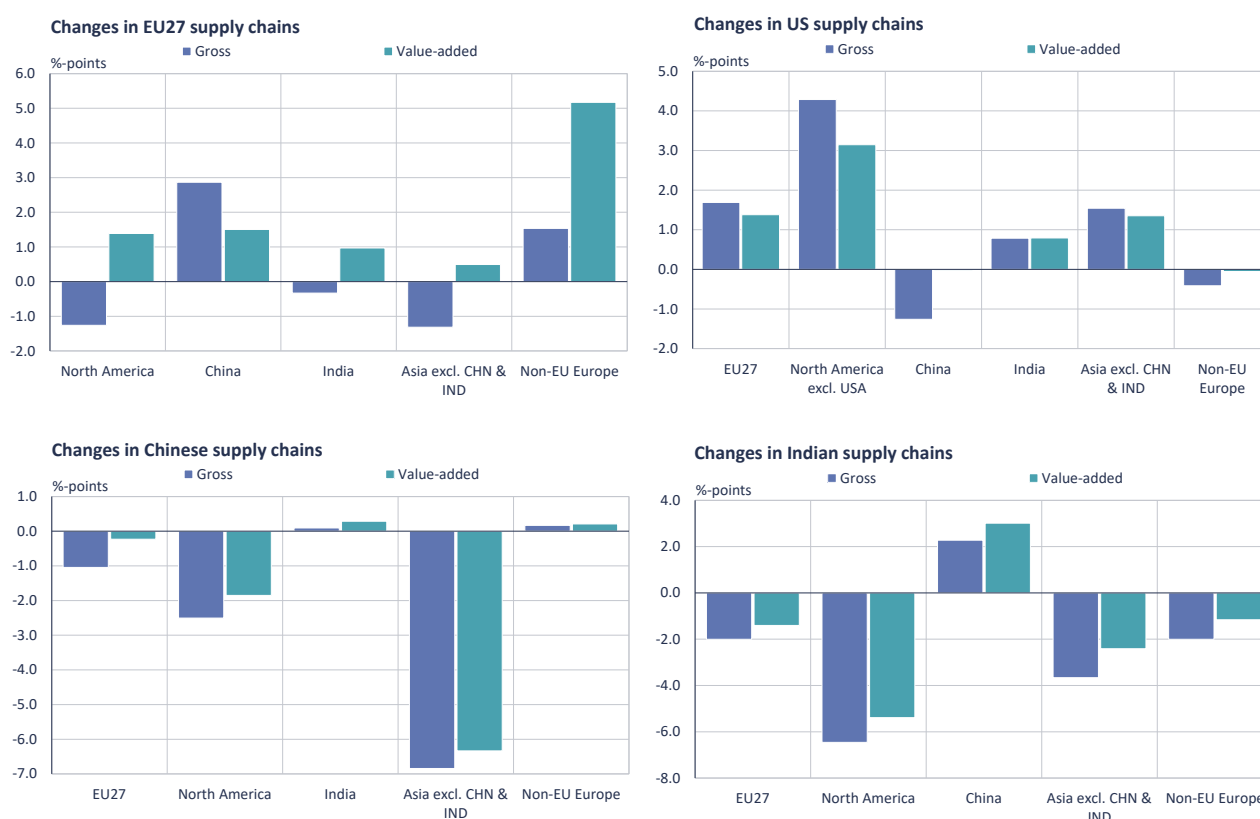
Source: Authors' calculations based on ADB data.

Focusing only on the foreign content in the manufacturing supply chains shows that there are differing developments in the EU, the US, China, and India. For EU supply chains (Figure 3), the Chinese share expanded by around three percentage points for gross inputs, with the country providing 12 % of foreign inputs by 2023. In value-added terms, China's share increased by close to two percentage points to 13 % by 2023. The North American (US, Canada, Mexico) share decreased by one percentage point for gross inputs and increased by one percentage point for value-added inputs to 18 % and 21 %, respectively. The Indian share remained relatively unchanged in gross terms, and rose by one percentage point in value-added terms to 3 % in both cases. Most notably, Europe's non-EU countries (Norway, Switzerland, Türkiye, and the UK) increased their importance in the EU's supply chains by close to two percentage points to 26 % by 2023 for gross inputs and by five percentage points to 21 % for value-added inputs. These broad increases were counterbalanced by significant decreases in inputs from the RoW bloc. These results suggest near-shoring dynamics in Europe, even though there is no evidence of a reduction in China's participation in EU supply chains.

In contrast to the EU trend, China's participation decreased in gross terms for US supply chains. China's share of gross foreign inputs decreased by one percentage point to 7 % by 2023, while in value-added terms China's share remained unchanged at 11 %. As such, Chinese value-added continues to enter the US embedded in imports from other countries rather than directly, likely a consequence of the US-China trade war. The EU increased its participation by two percentage points in gross chains and one percentage point in value-added chains to 19 % and 21 %, respectively. The North American partners of the US increased their shares by four percentage points to 37 % for gross inputs and by three percentage points to 27 % for value-added inputs. This finding also points to near-

shoring dynamics in the US. India's share in the US supply chains increased by less than one percentage point to 3 % for both gross and value-added inputs.

Figure 3. Percentage-point changes in foreign content shares in manufacturing supply chains in 2018–2023.



Source: Authors' calculations based on ADB data.

The composition of Chinese supply chains experienced substantial changes, most notably the significant decrease in South Korea's participation in Chinese chains that resulted in a drop in the Asian input share (excl. China and India) of almost seven percentage points in gross terms to 28 % and six percentage points to 26 % in value-added terms by 2023.³ At the same time, North America reduced its participation in the Chinese value chains, likely reflecting technology export restrictions in the US. The input shares of North America declined by almost three percentage points in gross terms to 8 % and by two percentage points to 13 %. While Europe and India recorded only minor changes, RoW participation significantly increased in Chinese supply chains.

For Indian supply chains, the input shares of the EU and North America decreased, with the latter recording a notable reduction of six percentage points to 7 % for gross inputs and five percentage points to 11 % for value-added inputs. China meanwhile provided a larger share of inputs to the Indian manufacturing sector, with its share rising by two percentage points to 11 % in gross terms and three percentage points to 13 % in value-added terms. India also became more tightly integrated with the global south as the RoW bloc increases its participation in Indian supply chains.

³ For discussion of the complex China-South Korea relationship, see <https://thedi diplomat.com/2024/06/reality-check-south-korea-and-china-face-more-complex-economic-dynamics/>.

4. Trends in physical length of manufacturing supply chains

We examine the lengths of manufacturing supply chains for the US, EU, China, and India using a weighted average of the physical distances associated with all imported inputs, considering only the foreign content in manufacturing supply chains. Changes in the physical length of the manufacturing supply chain between 2018 and 2023 can uncover potential near-shoring dynamics as shorter length implies that inputs are being sourced closer to home, as well as imply diminished vulnerabilities related to transport disruptions. It is also worthwhile to compare these developments in gross and value-added terms. During times of elevated supply-chain risk, countries import from nearby countries to reduce the risk of disruption. Value-added data can reveal if such near-shoring is actually taking place or whether inputs are simply transiting other countries to disguise their true origin.

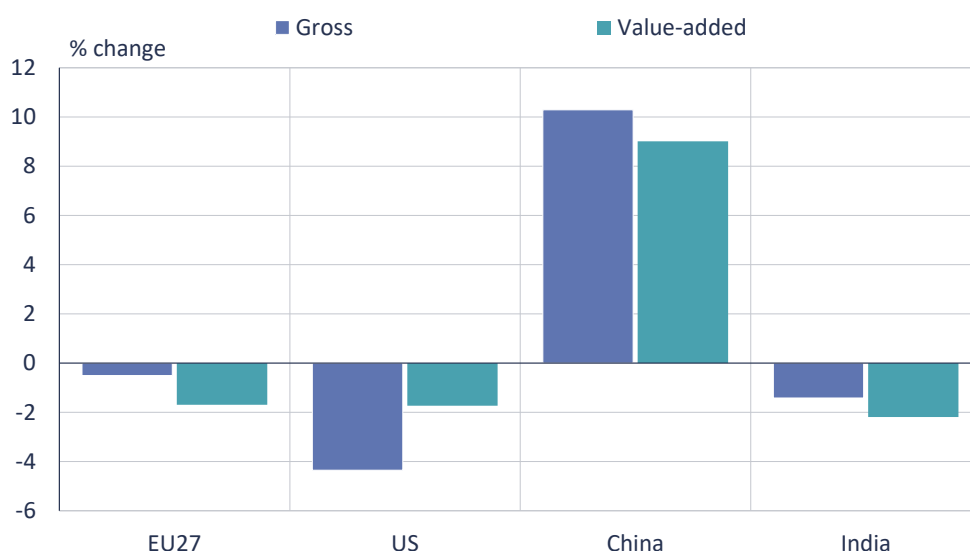
The distance data are taken from the GeoDist database provided by le Centre d'études prospectives et d'informations internationales (CEPII).⁴ The distance variable measures the bilateral distance between the value-chain owner (US, EU, China, or India) and the supplier country in kilometers, calculated with the great-circle distance formula, which uses latitudes and longitudes of the supplier country's most important city (in terms of population) or its official capital.⁵ For the EU's distance from other countries, we calculate a simple average distance of the EU bloc's five main port countries (the Netherlands, Belgium, Germany, Spain and Greece) from the supplier country. The RoW bloc's distance from the US, EU, China, and India is a simple average distance of all remaining countries for which distance data are available.

The EU's average foreign manufacturing supply chain has shortened between 2018 and 2023 (Figure 3). When we examine inputs by gross imports, the representative supply chain was 5,880 km long in 2023, 1 % shorter than in 2018. Based on the value-added methodology, the supply chain length was 6,210 km in 2023, 2 % shorter than in 2018. Even though the input shares of Asian countries increased, the shortening reflects the fact that the share of non-EU European inputs increased notably, while the RoW share decreased (as discussed in the previous section). Among the EU's most important manufacturing subsectors (measured by total value-added in 2023), the most notable change was within the "electrical and optical equipment" category. This supply chain shortened by 5 % between 2018 and 2023 on the back of a larger participation by European and North American countries and lower participation by Asia (excl. China and India) and the RoW bloc.

Similar to the dynamics in the EU, the length of a representative manufacturing supply chain in the US shortened between 2018 and 2023. When we study the gross imported inputs, the US supply chain was 6,280 km long in 2023, 4 % shorter than in 2018. In value-added terms, the chain shortened by 2 % to 7,060 km in 2023. The main reason is that the share of other North American content (Canada and Mexico) increased notably, while RoW content decreased. Within the most important categories of the manufacturing sector in the US, the most notable shortening of the supply chain (4 %) took place in the "transport equipment" subsector on the back of increased participation by North American partners and a lower share of the RoW bloc. Meanwhile, the supply chain for the "coke, refined petroleum, and nuclear fuel" subsector lengthened by 4 %, reflecting a higher participation by Asian suppliers and lower participation by North American suppliers.

⁴ CEPII GeoDist Database, www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=6

⁵ For China, distances are calculated from Beijing, while for the US they are calculated from New York. For the following countries, the most populous city is used instead of the country's official capital: Australia, Benin, Bolivia, Brazil, Canada, Côte d'Ivoire, Germany, Kazakhstan, Nigeria, South Africa, Tanzania, and the US.

Figure 4. Change in the manufacturing value chain length between 2018 and 2023, foreign content only.

Source: Authors' calculations based on ADB data.

In contrast to the EU and the US, China's manufacturing supply chains lengthened both in gross and value-added terms. As measured by gross inputs, the length of a representative Chinese supply chain was 7,820 km in 2023, or 10 % longer than in 2018. In value-added terms, the supply chain length increased by 9 % to 7,880 km in 2023. North American and EU countries provided less inputs, while the RoW share increased. The notable reduction in South Korea's participation in the Chinese supply chains seems to explain the lengthening. Noteworthy changes within the most important areas of the manufacturing sector took place in the "machinery, nec. and electrical and optical equipment" subsectors, as the supply chain lengthened in both categories by 9 % between 2018 and 2023. Again, a reduction in South Korea's participation was the key driver for the increase.

India's supply chains shortened only modestly. In gross terms, the representative manufacturing supply chain was 7,610 km in 2023, a 1 % decrease in length. In value-added terms, the Indian supply chain shortened by 2 % to 7,500 km by 2023. The shares of the EU and North America have decreased, while the RoW bloc increased its participation in the Indian supply chain. Reduced participation by Asia (excl. China and India) caused the supply chain for "food, beverages, and tobacco" to lengthen most (3 %), while the chain for "textiles and textile products" shortened by 3 % due to smaller shares of inputs from the EU and North America and a larger share from China.

We find evidence of near-shoring in the EU and US. In both cases, manufacturing supply chains for foreign inputs (in gross and value-added terms) shortened after 2018. As a result, the physical vulnerabilities to supply chain disruption decreased. The supply chains of US shortened more in gross terms than in value-added terms, pointing to the possibility that some inputs (e.g. inputs from China) entered the economy via third countries. Nonetheless, it is worth keeping in mind that while the foreign inputs in the EU's supply chains were sourced closer to home, the EU's domestic content was simultaneously decreasing. The evidence of near-shoring for the US is stronger as domestic content increased and foreign inputs were sourced from locations closer to home. China's supply chains lengthened, which may be a result of the US-China trade war forcing China to reroute inputs through additional countries. India's supply chain shortening points to modest near-shoring dynamics.

5. Changes in political distance of manufacturing supply chains

We measure political distance between countries with widely used ideal point estimates based on voting behavior at UN General Assembly sessions (Bailey et al., 2017). The vulnerability indicator is constructed by calculating a weighted average of the distance in ideal point estimates between the importing country and supplier countries with import shares as the weights. Only the foreign content in manufacturing supply chains is considered. For the RoW bloc, we employ a simple average across all countries for which UN voting data are available.

An indication of possible friend-shoring could be the situation where inputs are sourced from like-minded countries to reduce geopolitical risks. In such case, vulnerabilities are reduced due either to a supplier country's smaller share in the value chain or a decline in the political distance (e.g., UN voting behavior of the supplier country and the producer of the final good became more similar by 2023). It is also useful to compare the developments in gross and value-added terms. Companies considering friend-shoring are more likely to look at the direct source of the imported inputs (gross imports), not the ultimate origin of value-added in the inputs as the latter is not readily observable. However, the risk reduction achieved by friend-shoring in gross terms could be diluted if the value-added embodied in imported goods actually originates from more politically distant countries.

Here, our results seem to be affected by the RoW bloc due to its lack of any consistent political perspective. When we exclude the RoW bloc, the results are clearer. Thus, our analysis focuses on chains excluding the RoW bloc.

The results suggest that between 2018 and 2023 the political distance related to supply chains slightly increased for the EU and China, and slightly decreased for the US and India (Figure 5). For China, the changes are more pronounced in value-added terms. For other economies, the changes are slightly smaller in value-added terms.

Figure 5. Change in the political distance measure in the supply chains between 2018 and 2023.



Source: Authors' calculations based on ADB data.

To some extent, the increase in political distance for China reflects a general increase in the political distance between China and most economies included in the sample. Regarding individual countries, notably large contributions come from Australia, Japan, and Germany. The political distance of these countries from China increased, which mattered given their rather large shares in Chinese production chains. The developments are similar across industries, but slightly more

pronounced in the “electronics” and “transport equipment” manufacturing categories. Within these industries, there are various shifts. The shares of the US and Korea declined and were replaced by Japan and others.

In the case of the EU, the changes were small both in gross and value-added terms, with a minor increase in the average political distance associated with the EU manufacturing supply chains. Here, we are looking basically at the effect of China. The share of China grew slightly in the EU’s value chains, while the political distance between China and the EU increased. The increase arising from China was offset by declines due to Russia and the US. Russia’s share in EU value chains declined, while the US and EU become politically closer. At the industry level, political distance increased most in the “electric equipment” and “electronics” manufacturing categories. For chemical industry chains, the political distance declined.

For the US, the aggregate political distance declined between 2018 and 2023. This partly reflects the decline in the share of Russia as a supplier for US manufacturing. In addition, the political distance between Canada and the US declined slightly in 2018–2023, while the share of Canadian inputs increased a bit. Canada’s share, however, increased less in value-added terms than gross terms. This is reflected in the slightly smaller decline in the political distance in value-added terms. A similar development is also seen for Korea and Vietnam, but the opposite is seen for China, suggesting that some Chinese value-added exported to the US was embodied in the exports of these economies. Across industries, the supply chain for electronics manufacturing experienced the largest contraction in political distance.

India’s manufacturing chains also saw a slight decrease in the average political distance in gross and value-added terms. This mainly reflects the decline in the share of the US in Indian supply chains. On the other hand, the share of China increased in Indian value chains, thus increasing the political distance associated with them. In India, the development varies across industries. For example, the transport equipment manufacturing experienced one of the largest reductions in political distance.

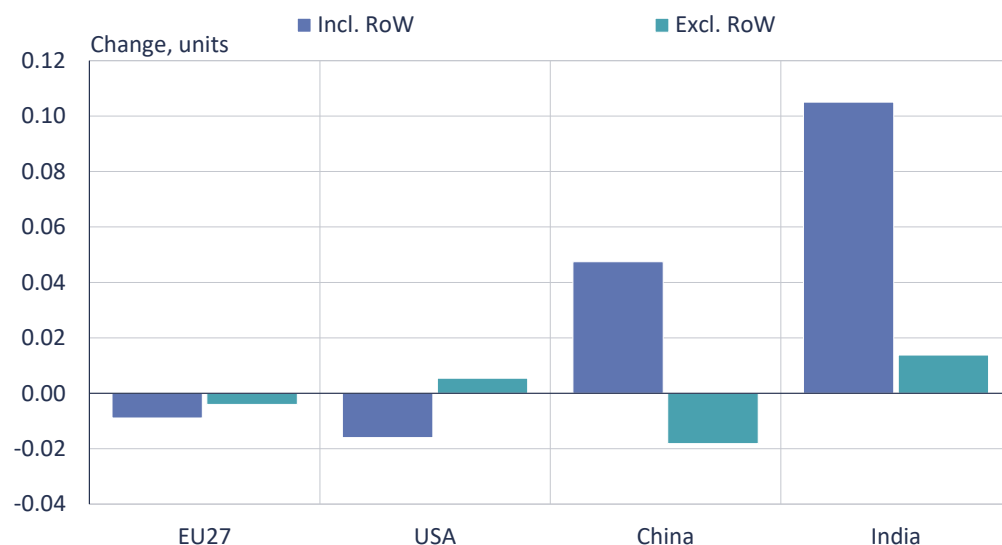
Overall, we find that signs of friend-shoring, particularly for the US, are mainly related to China’s falling share in US value chains. The friend-shoring effect appears to be a bit milder in value-added terms pointing to potential re-routing of Chinese value-added through Vietnam, for instance. There were also indications of friend-shoring in the declining share of Russia in the US and EU value chains.

6. Changes in concentration of supply chains

A high concentration of input sourcing can increase the vulnerability of supply chains to disruption. To measure this vulnerability, we employ the Herfindahl-Hirschman Index (HHI) calculated across input source countries. The higher the index value, the more geographically concentrated the supply chain (a maximum value of 1 indicates perfect concentration to a single supplier). We again calculate the indicator for both gross and value-added supply chains. Our results suggest that the overall concentration has not changed much in recent years, but there was a slight trend towards increased diversification. The developments are similar in gross and value-added terms.

At the first look, it seems that diversification trends are different across developed and emerging economies. The diversification of Chinese and Indian supply chains seems to have slightly decreased in recent years, but a closer look reveals that this was largely driven by the increasing RoW aggregate share (Figure 5). Thus, the diversification of Chinese and Indian chains increased as more inputs were sourced from the RoW. If we exclude the RoW bloc from the analysis, the changes in diversification are tiny, even for China and India. Chinese value chains are quite diversified. The HHI reading for 2023 was 0.06 (in both gross and value-added terms). India’s value chains were also quite diversified, with an HHI reading of 0.09 in 2023.

Figure 6. Change in the Herfindahl-Hirschman Index of (value added) supply chains of the US, the EU, and China in 2018-2023 (positive change refers to increase in concentration).



Source: Authors' calculations based on ADB data.

There was a slight increase in diversification of supply chains between 2018 and 2023 for the US and the EU, but again, this increase was mainly driven by the RoW bloc. If we exclude RoW from the analysis, the changes are miniscule. The EU and US manufacturing supply chains were generally quite diversified with an HHI reading of 0.11 in 2023. US chains were even slightly more diversified in value-added terms with an HHI reading of 0.08. This mild tendency of increasing diversification is in line with Arriola et al. (2024), who find declining average rates of import concentrations and bilateral import dependencies.⁶

7. Discussion of results

Our analysis of changes in international supply chains found some indications of re-shoring, near-shoring, and friend-shoring between 2018 and 2023. Overall, the evidence was mixed and the changes quite moderate (at least so far).

The share of domestic value-added in the supply chains increased particularly in the US. For the EU, US, and India, the physical distance associated with the foreign content in supply chains decreased, pointing to some near-shoring dynamics. The political distance associated with manufacturing chains slightly declined in the US, suggesting shifts related to friend-shoring. There were minor indications of increased diversification of supply chains, but the changes were relatively small.

Comparing supply chains developments in gross and value-added terms suggests that many of the above-mentioned developments are slightly diluted in value-added terms. This implies that the effect of de-risking measures can actually be smaller than anticipated due to value-added flowing through third countries.

⁶ Our analysis, which only gives an aggregate-level picture of the vulnerabilities related to concentration of inputs, focuses on the largest input classes. Substantial risks can also be related to unique or irreplaceable inputs (no available substitutes) that account for a tiny share of the supply chain.

Our results are largely in line with previous studies, finding limited evidence of near-shoring or friend-shoring. Kaarevirta et al. (2023) conclude that bilateral trade flows between the US and China have been damaged, but they find little signs of broad fragmentation. Blanga-Gubbay and Rubinova (2023), as well as Bosone et al. (2024), find no evidence of near-shoring. Alfaro & Chor (2023) detect signs of near-shoring for the US with the increasing share of inputs coming from Mexico. The authors, together with several other papers, attribute this increase largely to Chinese exports passing through Mexico.

The results are a bit more mixed for friend-shoring. Gopinath et al. (2024) find changes in trade flows at the bloc level after Russia's invasion in Ukraine but conclude that the extent of fragmentation is small (at least for now). Bosone et al. (2024) also conclude that the negative effect from the geopolitical distancing has become more apparent in recent years.

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