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Learning from Tumultuous Times

An Analysis of Vulnerable Sectors in International Trade in the Context of the Corona Health Crisis

Authors: Oliver Reiter und Robert Stehrer (wiiw)

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Keywords: supply chains, vulnerability, resilience, robustness, global extraction method
JEL-codes: F14, F17, F52

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This work was commissioned by the Austrian Federal Ministry for Digital and Economic Affairs.

Abstract

The COVID-19 pandemic marks an unprecedented shock to global growth and trade and brought international dependencies into the spotlight. This triggered discussions on resilience and robustness of global value chains. In this paper we assess which products can be considered as vulnerable to trade shocks at the global level – referred to as 'risky' products – by constructing a 'product riskiness indicator' for 4700 globally traded products based on components such as market concentration, clustering tendencies, network centrality of players, or international substitutability. In a second step the bilateral imports of risky products are matched to multi-country input-output tables enabling the analysis of the importance of internationally sourced risky products by country and using industries. Higher-tech industries are more prone to supply-chain vulnerability given the large share of risky products in high-tech product categories. Third, we apply a 'partial global extraction method' to assess the GDP impact of reshoring. Assuming that imports of risky products are re-shored from non-EU27 to EU27 countries suggests an increase in the EU27 GDP of up to 0.5%. The non-EU27 countries lose from such re-shoring activities accordingly. This suggests that it is also in the interest of the supplier countries and industries to assure robust or at least resilient supply chains. Finally, selected policy aspects in the context of the envisaged EU Open Strategic Autonomy are debated.

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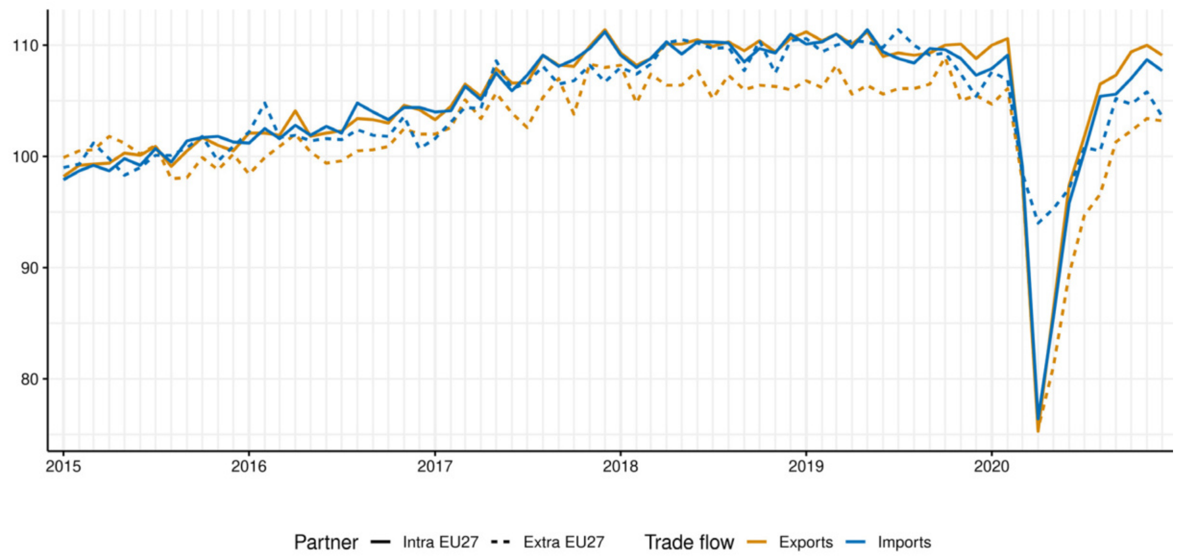
1. Introduction

The COVID-19 pandemic showed that international production networks and global supply and value chains can be fragile and vulnerable to various shocks. This is also reflected in the fact that trade is more volatile than GDP, given the many interlinkages as already known from previous crises. As Figure 1 shows, trade volumes collapsed in the first months of 2020 and partially recovered in the second half of 2020. Overall, exports of the EU27 were 8.6% below values for 2019 while imports fell by 9.6%. Splitting total trade into intermediate, consumer and capital goods trade, we find that exports and imports of intermediate inputs declined by 10.1% and 13.4% respectively, consumer goods by 6% and 4.6% and capital goods by 9.9% and 6.3%. The latest estimates for annual GDP growth are declines of 6.8% for the euro area and 6.4% for the EU27 for 2020.[1] For the US, real GDP is projected to have declined by 3.5% in 2020.[2].

Figure 1 / Seasonally adjusted monthly trade volume index, 2015 = 100



Source: Eurostat.

In response to the health crisis and the threat of shortages of critical supplies, countries around the globe quickly began to restrict the export of specific products like masks and other health related equipment (as well as the cross-border mobility of people), resorting to a kind of "emergency protectionism" at least in the short run. In addition, various supply side shocks emerged due to severe lockdowns in various regions or countries, hampering production activities and transport facilities. However, in a world where production

1 See https://ec.europa.eu/eurostat/documents/portlet_file_entry/2995521/2-02022021-AP-EN.pdf/0e84de9c-0462-6868-df3e-dbacaad9f49f (accessed 29.3.2021)

2 See https://www.bea.gov/news/2021/gross-domestic-product-4th-quarter-and-year-2020-advance-estimate (accessed 29.3.2021)

is organised along global value chains (GVCs) the frictionless flow of goods is necessary to preserve the supply of needed commodities.

In addition to the many regionalised production and supply shocks, the pandemic particularly made various strong dependencies on Chinese manufacturing obvious. For example, as many producers in the pharmaceutical industry had moved parts of their production to low-cost destinations such as China and India, the sudden stop in international shipments left many hospitals with shortages of needed equipment.[3] As a result, for example, the Environment, Public Health and Food Safety Committee of the European Parliament has urged the Commission "to find ways to restore pharmaceutical manufacturing in Europe".[4] These developments raise the obvious questions of how vulnerable our economies are to demand and supply shocks – both apply in the case of the COVID-19 health crisis – from within and outside the EU in general, and what role GVCs play in the transmission of these shocks. Therefore, the issue of resilience of international trade and production integration is again becoming a topic of economic research and an objective of public policy to mitigate economic and health risks. This applies on the level of individual firms and the way international production integration is organised along regional and global supply chains, but also to public sector activities (whether they be organised market-oriented or operated by government institutions) as the examples of the supply of critical supplies (like drugs, medicines, masks, etc.) show.

This study contributes to this literature by identifying potential vulnerabilities of global value chains at the product level. First, an assessment is made of the vulnerability of product supplies concerning internationally traded products, by developing a product riskiness index. This index allows us to identify possible vulnerabilities of industry sectors and dependencies on trading partners. Based on this, policy aspects concerning the resilience and security of (strategic) supply chains are discussed. As will be outlined, however, this is a complex issue as it includes many dimensions with blurred boundaries between them and therefore the results can only lay the groundwork for further discussions.

In Section 2, following the recent literature, the method for identifying ‘risky’ products is outlined. The method is applied at the level of detailed trade data (Harmonised System HS 6-digit products) including about 5000 products. A summary of the most important results is then shown descriptively. The index for product riskiness is also compared to the development of imports in 2020 with a focus on the products essential to combatting the health effects of the pandemic.[5] Further, the bilateral trade data for risky products are aligned with multi-country input-output tables to assess the role of ‘risky’ products in imported intermediates and to assess potential effects of re-shoring activities. Section 3 is then devoted to providing an overview of potential measures to reduce vulnerabilities and increase resilience based on recent contributions to the literature.

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3 For Austria, see e.g.: https://orf.at/stories/3158930/

4 See https://www.europarl.europa.eu/news/en/press-room/20200712IPR83214/covid-19-eu-must-step-up-efforts-to-tackle-medicine-shortages (accessed 13.4.2021)

5 Unfortunately, at present it not possible to differentiate the trade disruptions that happened in 2020 in terms of the various specific causes like shocks to the production and supply side (e.g., the effects of lockdowns and production shut-downs in the exporting countries), obstacles to international transportation, policy-induced measures like export restrictions for specific (critical) products, or general trade protection measures. Concerning these aspects decent data for 2020 that would enable a systematic analysis of the factors behind supply disruptions, are not yet available. As of 11.1.2020: The Global Trade Alert data only provide a few observations for 2020. The WTO I-TIP database for non-tariff measures does not (yet) report any quantitative restrictions (export restrictions would fall into this category). The list of export restrictions on the ITC MacMap Website is not machine-readable available (yet).

2. Assessing the vulnerability of product trade

In this section we first introduce the methodology of how to define the 'riskiness' of trade in products at the detailed HS 6-digit level (Section 2.1). This method identifies more than 400 products as 'risky' or vulnerable to supply shocks. A descriptive assessment of the magnitudes of these products and their composition focussing on the EU27 and Austria is presented in Section 2.2. In the following Section 2.3 we validate our findings with results from the existing literature and compare them with the products identified as being 'risky' during the COVID-19 pandemic (which also highlights the distinction between 'risky' and 'essential'). Linking the import of these products to a multi-country input-output table, the WIOD, we then assess the importance of these risky products as imported intermediate inputs in the industry's production, indicating the vulnerability of global value chains (Section 2.4). Finally, in Section 2.5 we apply a 'partial hypothetical extraction approach' to assess the impact of supply and demand shocks with respect to the risky products identified.

2.1. METHODOLOGY

As a first exercise, we replicate the product fragility indicator developed by Korniyenko, Pinat and Dew (2017), abbreviated henceforth as KPD. The indicator is constructed based on three separate components – the outdegree centrality, the tendency to cluster, and international substitutability – that capture structural dependencies or weaknesses which make the products potentially "risky", "fragile" or "volatile". In addition, we add two more components – the Hirschmann-Herfindahl index and accounting for non-tariff measures - which we expect should make this indicator more robust and more accurate. As in KPD we exclude products that are not reported in all years. Contrary to KPD however, we also consider final or consumption products according to the UN BEC classification: while KPD is mainly concerned with shocks that affect supply chains, we are also interested in shocks that might affect end consumers.

In the next subsections we present the method for the components of the indicator. Most calculations below are carried out separately for every product. For ease of presentation we exclude the product index *k* where possible.

2.1.1. Outdegree centrality

The first component 'outdegree centrality' detects the presence of central players. Central player refers to a country that exports to many countries and has a high market share in the importing countries. As the name suggests, this component is based on the outdegree centrality of all countries, for a given product defined as

$$C_i = \sum_{j=1}^{n} \frac{w_{ij}}{\bar{w}_j}$$

Here, w_{ij} is the value of country *i*'s exports to country *j*, and $\bar{w}_j$ is the average value of country *j*'s imports. Based on this, KPD define the standard deviation of the outdegree centrality

$$c_1 = \sqrt{\tfrac{1}{n}\sum_{i=1}^{n}(C_i - \bar{C}_i)^2},$$

where $\bar{C}_i$ is the average outdegree centrality, as the first component c_1 of their index. In a situation where one country *i* is the supplier of all other countries for a specific product, that country will have a high outdegree centrality, while the other countries have an outdegree centrality of 0. In this case the standard deviation for country *i* has a high value. On the contrary, in a situation where all countries export to all other countries and no country stands out, the outdegree centralities will be similar and the standard deviation will be low.

2.1.2. Tendency to cluster

The second component of the KPD product fragility index is the 'tendency to cluster'. If countries form clusters characterised by trade only within this cluster, then a supply disruption within a cluster can have severe effects on the countries in the cluster. To capture this, KPD propose to use the clustering coefficient – which is a commonly used metric in network analysis – to assert the tendency of countries to trade within groups. This clustering coefficient is defined as

$$CC_i = \frac{1}{k_i(k_i - 1)}\sum_{j,k}\frac{1}{\bar{w}_i}\frac{w_{ij} + w_{ik}}{2}T_{ij}T_{ik}T_{jk}$$

where k_i refers to the number of countries that are connected to node *i*, w_{ij} is the weight of the connection between *i* and *j*, $\bar{w}_i = \sum T_{ij}/k_i$ is the average weight of *i*'s connections and T_{ij} is an indicator variable that takes a value of 1 when a connection between *i* and *j* exists and 0 otherwise. This cluster coefficient is then averaged and multiplied by the diameter d of the network. The diameter is the longest distance between two nodes that exist in a network. The second component of the product fragility index is then

$$c_2 = \sum_{i=1}^{n} CC_i/n \cdot d$$

The more countries that form clusters and the larger "apart" countries are from each other (i.e., the diameter has a high value), the more fragile is this product network.

2.1.3. International substitutability

The third component of the product fragility index captures international substitutability. For this, KPD use the "revealed factor intensity" methodology of Shirotori, Tumurchudur and Cadot (2010) to compute human capital intensities per country and product. They calculate Balassa-style weights from the trade data (x_i^k are the exports of country *i* and product *k* and x_i are the total exports of country *i*):

$$v_i^k = \frac{x_i^k/x_i}{\sum(x_i^k/x_i)}$$

The revealed human capital intensity can then be computed as $L_i^k = v_i^k \cdot H_i$ where H_i refers to a human capital measure (such as years of schooling) in country *i*. The third component of the fragility index is then again defined as the standard deviation of the revealed human capital intensity (as before, $\bar{L_i^k}$ is the average human capital intensity for product *k*):

$$c_3 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(L_i^k - \bar{L_i^k}\right)^2}$$

Trade between countries with very different revealed human capital intensity implies a larger component for the product fragility measure.

2.1.4. Hirschmann-Herfindahl Index

In addition to these three components suggested by KPD we add an additional component that captures the situation when an importer country is dependent on just a few exporting countries, meaning that the market concentration among the exporting countries is high. For this we calculate the Hirschmann-Herfindahl index (HHI) that is commonly used to quantify the market concentration of firms in a market. First, we compute the HHI, for a given product, for every importing country in our sample, i.e.

$$HHI_j = \sum_{i=1}^{n}\left(\frac{x_{ij}}{x_j}\right)^2$$

Here, x_{ij} is the trade flow from country *i* to country *j* and x_j are total imports of country *j*. Then we aggregate these country-level HHI values with a weighted average, where the weights are the total imports of a country. This yields the fourth component c_4 which is defined as

$$c_4 = \sum_{j=1}^{n} HHI_j \cdot w_j$$

where $w_j = x_j / \sum_{j=1}^{n} x_j$ so that the weights sum up to one.

2.1.5. Non-tariff measures

In our second addition, we want to identify products that are often targeted by non-tariff measures. As Grübler and Reiter (2021) show, TBT STC and SPS STC[6] are the two types of non-tariff measures that have the most consistently negative effect on trade flows. We compute the fraction of world trade (for a given product) that is affected by one of the two measures as

$$c_5 = \sum_{i=0}^{n}\sum_{j=0}^{n} x_{ij} \cdot NTM_{ij} \Bigg/ \sum_{i=0}^{n}\sum_{j=0}^{n} x_{ij}$$

[6] TBT STC are special trade concerns (STC) of technical barriers to trade. Specific trade concerns to Sanitary and Phytosanitary measures (SPS STC)

where NTM_{ij} is a dummy variable indicating whether the flow between exporter *i* and importer *j* is affected by a TBT STC or SPS STC.

2.1.6. Constructing the 'product riskiness indicator'

To calculate the 'product riskiness index (PRI)'[7] the five components are normalised. The normalised scores of the components are then used by the k-means algorithm to find four groups of similar products. The group of products that shows the highest values in all five components over the whole period is considered as the group of risky products. The other three groups of products are considered non-risky. The resulting product riskiness index is thus defined on product level and has no time dimension. That means that short run fluctuations in the trade data have only a limited impact on the product riskiness index. We assess however how the relative importance of these thus defined risky products has evolved over time.

There is one caveat to consider: As the product riskiness index is based on global trade data, it identifies structural weaknesses on the global level. These weaknesses may or may not apply to every single country individually.[8] Thus further and more detailed information may be required when applying the product riskiness index to the trade flows of a single country (or region like the EU-27).

2.2. DATA AND DESCRIPTIVE RESULTS

The components of the product riskiness index are calculated using the BACI dataset.[9] To calculate the 'International substitutability' and the 'Non-tariff measures' components we additionally make use of the following two datasets: First, information on human capital on a country-year level is based on the 'mean years of schooling' variable reported in the 'Human Development Report' by UNDP (2019). Secondly, data on non-tariff measures is sourced from the wiiw NTM data.[10]

The results of the analysis presented below are based on the BACI dataset. This database spans a period of 23 years (from 1996 to 2019), includes 4706 products and contains more than 200 countries as both exporters and importers. The main advantage of the BACI database is that it provides reconciled trade flows on detailed HS 6-digit level across countries (see Gaulier and Zignago (2010) for a description of the process), which means that differences in the reporting of trade flows from importer or exporter countries have been eliminated.

7 We refer to this index as the 'product riskiness index' as it includes more components than the original 'product fragility index' suggested by KPD.

8 E.g. even if the Hirschmann-Herfindahl index shows a high concentration in exporting countries (on average), this may not apply equally to every importing country.

9 The BACI trade data is provided by the CEPII institute free of charge: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=37

10 The wiiw NTM data is available from https://wiiw.ac.at/wiiw-ntm-data-ds-2.html. See Ghodsi, Grübler, Reiter and Stehrer (2017) for a description of the data.

2.2.1. Characteristics and import shares of risky products

In this section we describe some selected aspects of the risky products. Our product riskiness index identifies 435 out of 4706 products as risky (9%). Of these, 294 risky products are intermediate products (68%) and the remaining 141 goods are classified as final or consumption goods according to the BEC classification.

Table 1 shows ten risky products with the highest share in world trade. The products belong mainly to the HS-section 84 (machinery and mechanical appliances) and group 85 (electrical machinery and equipment); all of them are intermediate products. Interestingly however, a risky final product tops the table. This product (HS code 300490) consists of medicaments and takes the first position. The other two final goods that are in the top ten are television receivers (852812) and other plastic articles (392690).

Table 1 / Top 10 Risky import products

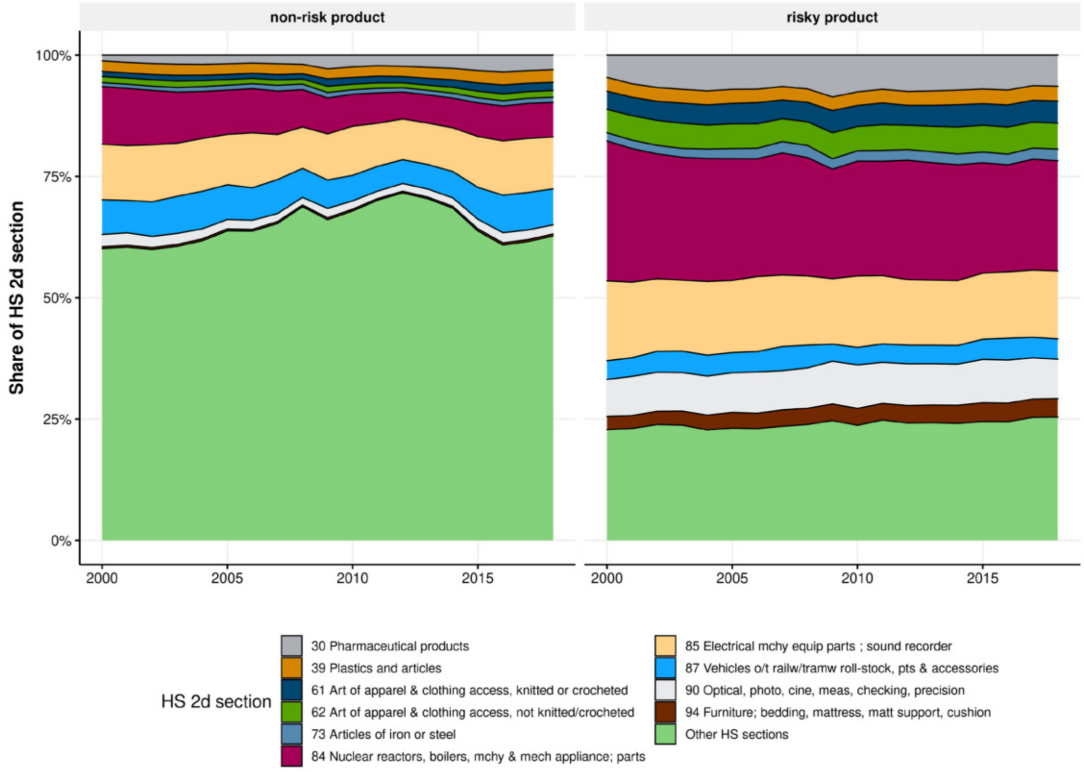
Product code (HS1996)	Share in world trade, in %	Product description
300490	1.62	Medicaments: consisting of mixed or unmixed products n.e.s. in heading no. 3004, for therapeutic or prophylactic uses, packaged for retail sale
847130	0.75	Data processing machines: portable, digital and automatic, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display
851790	0.49	Line telephony or telegraphy apparatus: electrical, parts of the apparatus of heading no. 8517
847170	0.48	Data processing machines: storage units
852812	0.44	Television receivers: colour, whether or not combined, in the same housing, with radio-broadcast receivers or sound or video recording or reproducing apparatus
847160	0.43	Data processing machines: input or output units, whether or not containing storage units in the same housing
880330	0.40	Aircraft and spacecraft: parts of aeroplanes or helicopters n.e.s. in heading no. 8803
852990	0.38	Reception and transmission apparatus: for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors
901380	0.33	Optical devices, appliances and instruments: n.e.s. in heading no. 9013 (including liquid crystal devices)
392690	0.31	Plastics: other articles n.e.s. in Chapter 39

Source: BACI, wiiw calculation.

In Appendix Table A.1 we list the number of risky and non-risky products in each of the 96 HS 2-digit product groups. This confirms the product specific results in Table 1. In HS group 8 (which consists of articles of base metals, machinery and mechanical appliances, vehicles, and transport equipment) almost 30% of products are classified as risky. The share is particularly high in HS85 (Electrical machinery and equipment and parts thereof; sound recorders) where more than 40% of the products are classified as risky. The highest number of risky products is reported in HS group 84 (Nuclear reactors, boilers, machinery & mechanical appliance; parts) with 147 out of 475 products (31%). This product group alone accounts for about one third of the number of risky products. A very high share of risky products is also found for HS group 90 (Optical, photo- and cinematographic, measuring, checking, precision instruments) with 57 out of 128 (44%). Note that almost two thirds of the products characterised as risky are part of HS group 8 (including the products from HS group 90 this share increases to 77%) which indicates that high-tech products are mostly considered as being risky products.

In terms of trade values, Figure 2 shows the shares of global trade. This basically confirms the above results: HS section 84 (Nuclear reactors, boilers, machinery, and machinery appliances, etc.) account for about 25% of the traded values, followed by HS section 85 (electrical machinery, etc.), then HS section 90 (furniture, bedding, mattress, etc.), 30 (pharmaceuticals), and 62 (apparel & clothing).

Figure 2 / World trade in HS 2d sections by product riskiness index



Source: BACI, wiiw calculation.

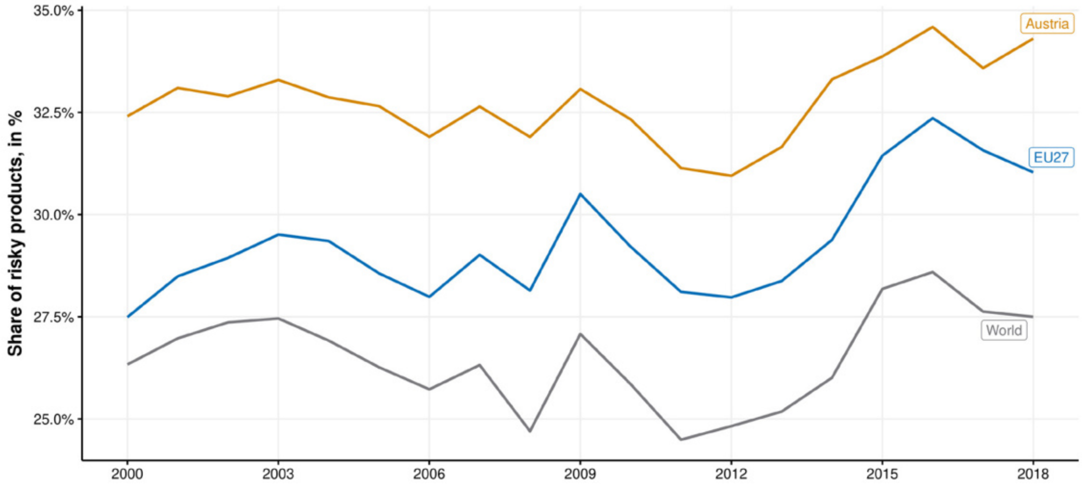
2.2.2. Risky products in the overall import flows of Austria and the EU27

Having defined the risky products, we then calculate the share of these in each country's imports. In Figure 3 we plot the share of the value of risky products in the total value of imports for Austria, the EU27, and the world.

As can be seen below, over time the share of risky products as defined by the product fragility index behaves similar for the three different regions. According to this, the share of risky products in world trade, depicted in grey, amounts to 26%, i.e. almost a quarter of the value of traded products can be considered as 'risky' according to this method. Austria shows a much higher share of risky products (between 31 and 35%) throughout the period. The shares for the EU27 are below the Austrian figures with around 30-32%. Over time, the share of risky products had been declining (it peaked in 2003) for the world economy until the crisis, but since then it has increased. For the EU27 and Austria this share was relatively stable before the crisis, but has also started to increase since then.[11]

[11] These trends can be driven either by price effects or changes in quantities which is not assessed here.

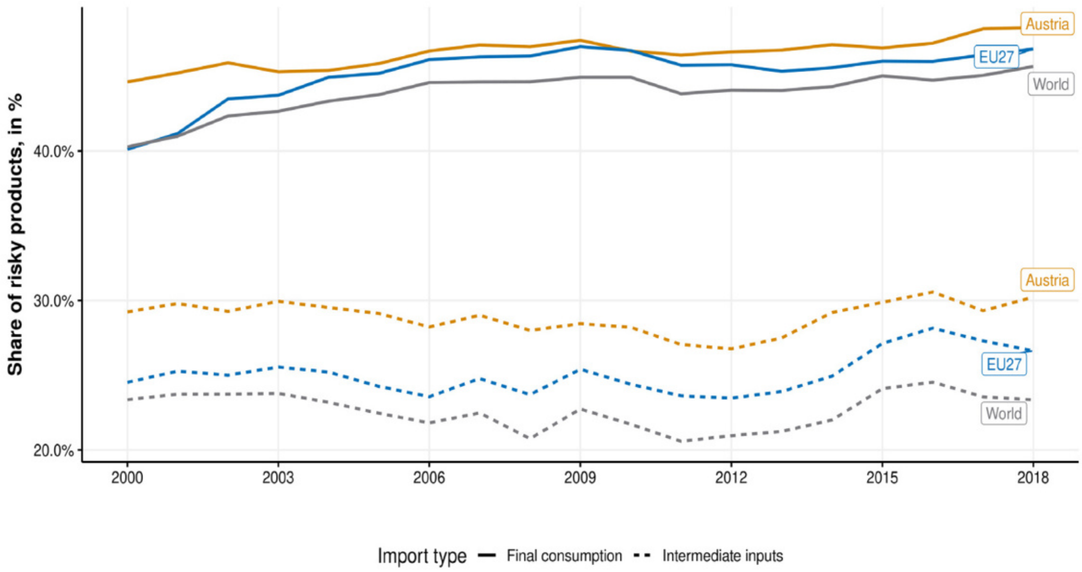
Figure 3 / Development of the share of risky products in imports by region



Note: Including intra-EU trade
Source: BACI, wiiw calculation.

Figure 4 differentiates these import shares by use category, i.e. whether classified as an intermediary product or for final use. First, one can see that the share of risky products in final goods imports at 40-50% is higher than their share in intermediary imports with a range between 20 and 30%. Second, the shares of final goods imports are more similar across the regions considered than intermediates imports. These results are in line with the fact that GVC trade is more regionalised than final goods trade (see Baldwin and Freeman, 2020b, for example).

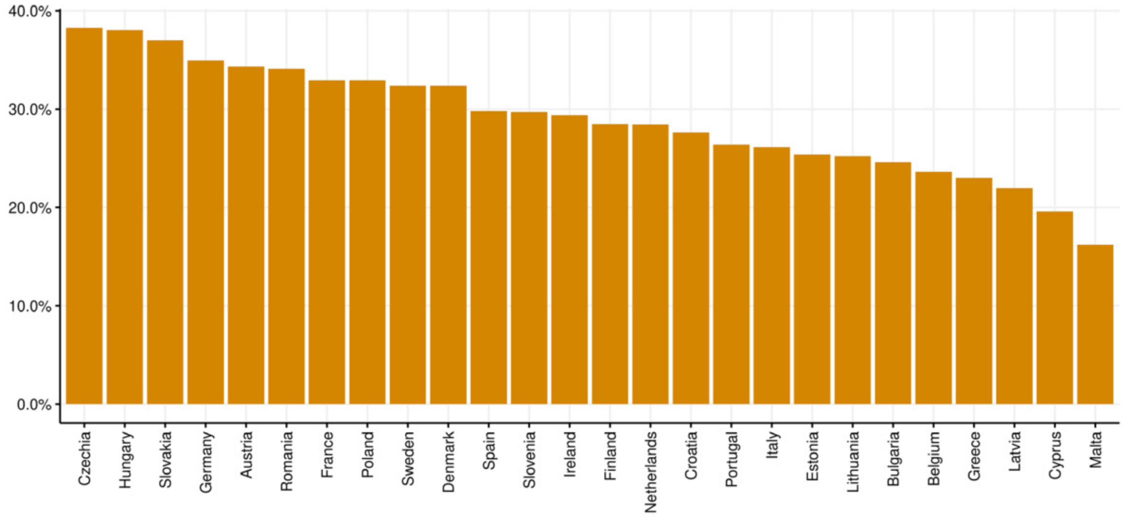
Figure 4 / Development of the share of risky products in imports by region and use category



Note: Including intra-EU trade
Source: BACI, wiiw calculation.

Figure 5 then indicates the share of risky products in imports for the European member states in 2018. The shares range from 35-40% in Czechia, Hungary, Slovakia, Germany, and Austria to less than 20% in Cyprus and Malta. As one can see, countries with a still sizeable share of manufacturing have a higher share of risky imports which is due to the larger proportion of high-tech goods classified as risky.

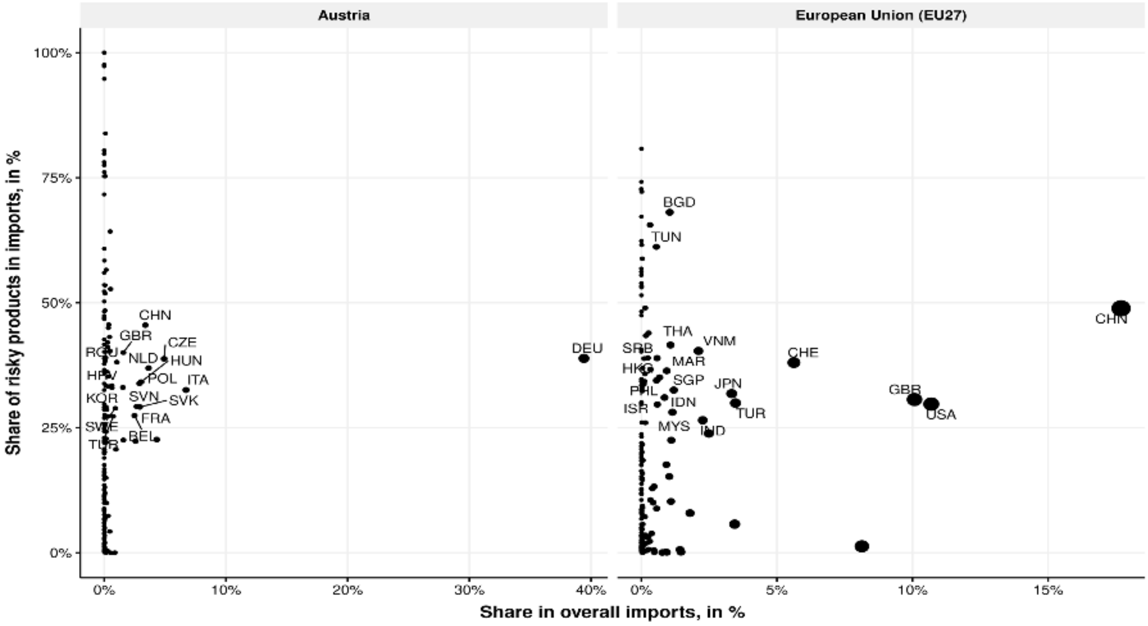
Figure 5 / Share of risky products in imports, 2018



Note: Including intra-EU trade
Source: BACI, wiiw calculation.

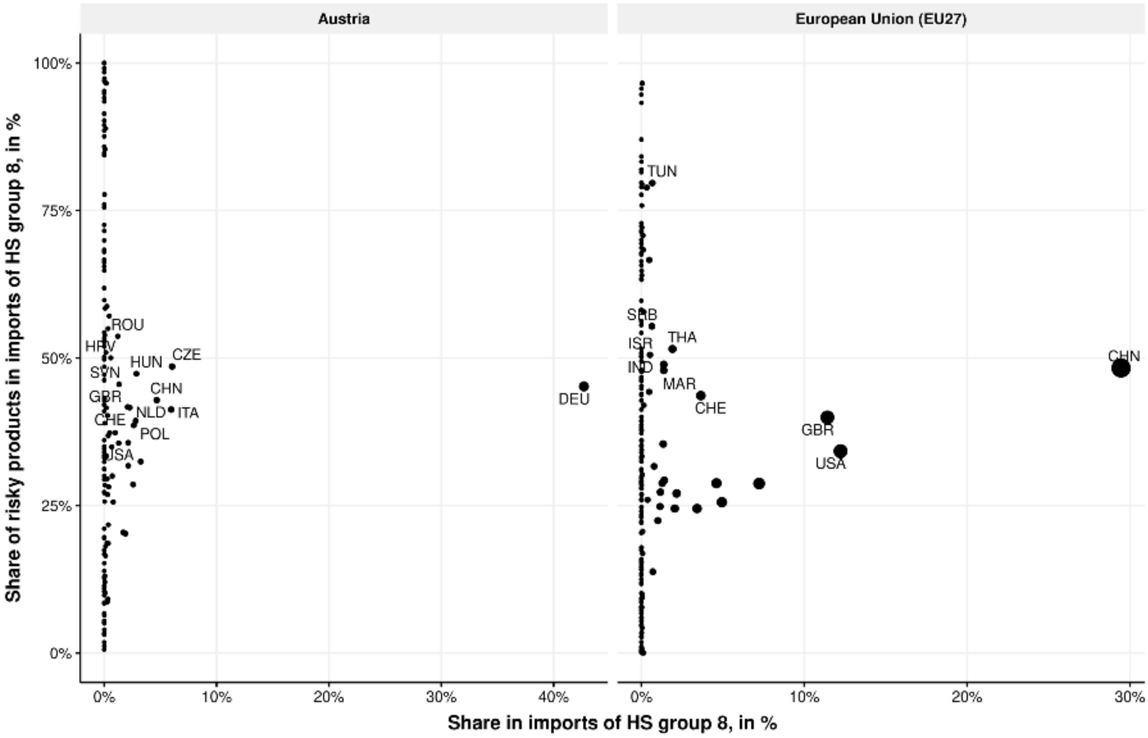
In Figure 6 we contrast the share of imports with the share of risky products for every trading partner of Austria and the EU27 in 2018. The size of the points is proportional to the total trade flow between Austria (or the EU27) and the specific country in 2018. In this graph we only label countries that have both a higher-than-average share of imports and a higher-than-average share of risky products. In the panel for Austria, the obvious outlier is Germany, where almost 40% of imports are sourced. There are several other EU countries highlighted (Italy, Czechia, Hungary, the Netherlands, …), while the only non-European countries are the major economies of China, Japan, and South Korea. China occupies a special position as it has a respectable share of imports (3%) and a high percentage of risky products (45%). Relatively high shares of Austrian imports of risky products stem mostly from the UK and other EU member states. China has a similar special position in the EU27 panel, where it is both the country with the biggest share of imports (exports from China account for about 17.3% of European imports) as well as having the highest share of risky products (among the highlighted countries) with 48.8% of imports being risky products). Also, the share of risky products from the US and the United Kingdom (GBR) which account for about 10% of EU27 imports lies at around 27%. Figure 7 graphs this for the products in HS group 8. Overall, the patterns are pretty much the same which indicates again that these higher-tech products account for an important part of risky trade.

Figure 6 / Share of imports versus share of risky products in the EU27 and Austria, 2018



Note: including intra-EU trade.
Source: BACI, wiiw calculation.

Figure 7 / Share of imports versus share of risky products in the EU27 and Austria for HS group 8, 2018



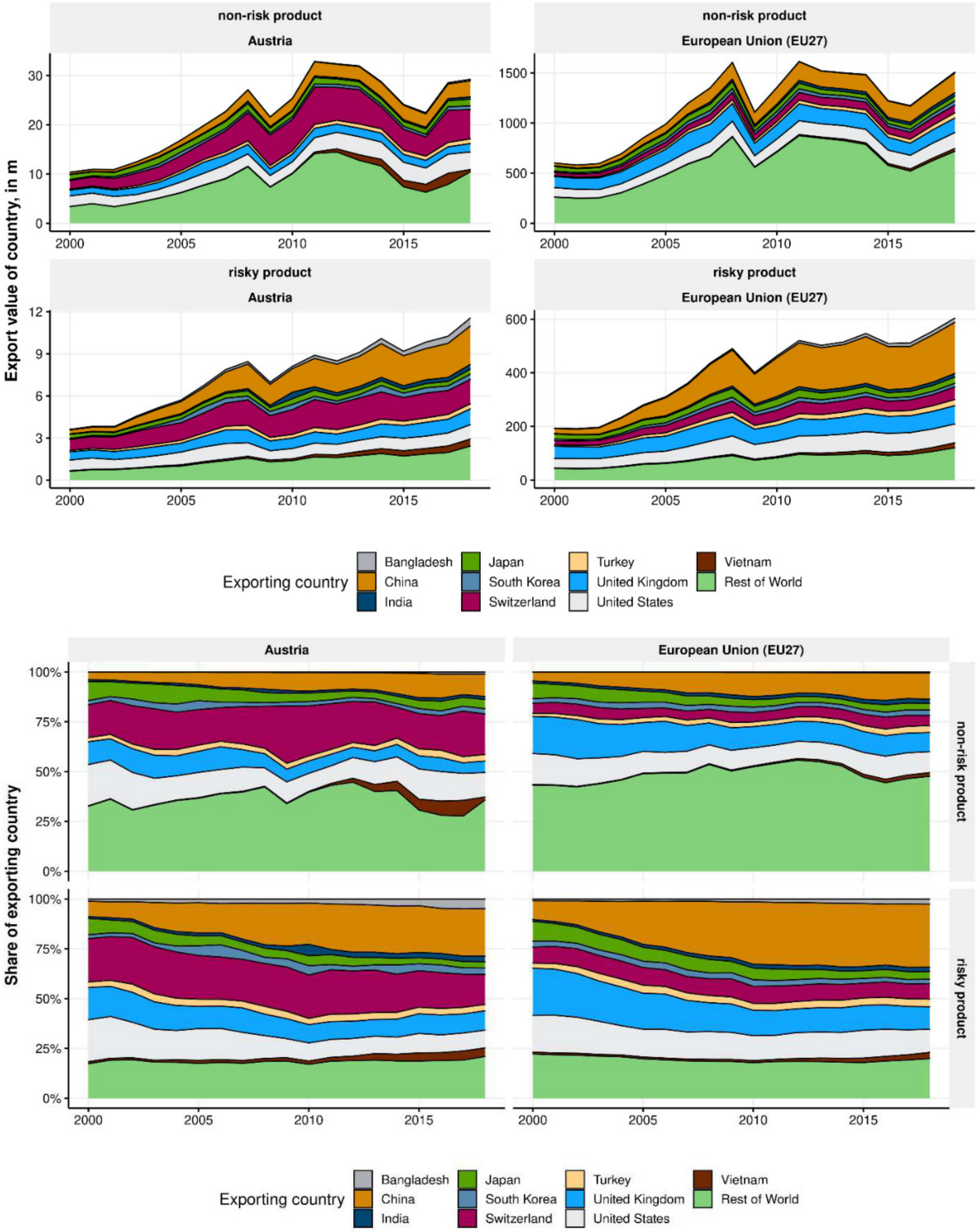
Note: including intra-EU trade.
Source: BACI, wiiw calculation.

This raises the question of where these risky products are imported from and how this has developed over time. Figure 8 presents the volume and shares of imports of risky products and non-risky products in the imports of Austria and the EU27. The upper graph shows the value of imported products and the lower graph the respective shares by partner country. There are two important facts: First, with respect to Austria one can see that the imports of risky products have become more important. These have increased by a factor of around four, whereas non-risky products increased by a factor of around three. This dynamic has become much stronger since the crisis in 2009 (see also Figure 2). The pattern has been less pronounced for the EU27 as a whole where both product groups have increased by roughly a factor of three. Again, one finds that the dynamics between these two product groups differentiated after the crisis.

The second important fact is the increasing role of China in these developments. These can be clearly seen in the lower part of the graph which presents the respective shares of imports by partner country. Whereas China's share has of course increased in overall trade flows, this has been particularly pronounced for risky products. For Austria the share of imports from China in this group increased from around 5% in 2000 to around 20% in 2018. This dynamic was even more pronounced for the EU27. For the other partner countries, the shares correspondingly decreased (or remained roughly stable), though in terms of imported values these shares also increased. Other important regions where Austria's or the EU27's imports are coming from (apart from the Rest of world with around 25%) are the United States and the United Kingdom with around 10-15%, and Switzerland with about 25% for Austria, though less for the EU27.

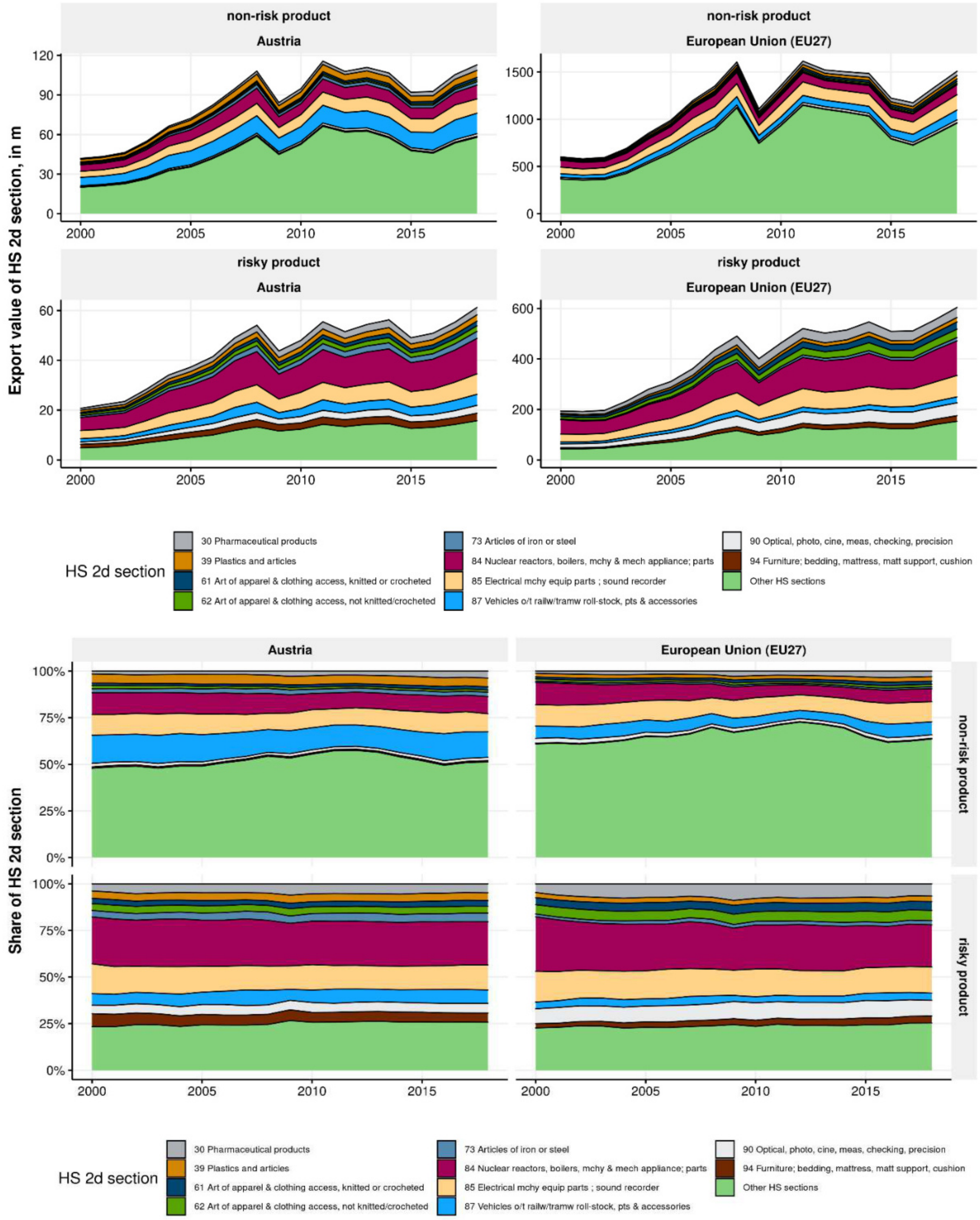
With respect to imported product groups the shares developed less dynamically, as can be seen in the lower part of Figures 9 and 10. These graphs show the imports of Austria and the EU27 of the ten most important HS sections for risky products for the global country sample. However, there are striking differences across product groups. Focussing on risky products one finds that product groups 84 (Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories) and 85 (Railway or tramway locomotives, track fixtures and fittings and parts thereof, rolling-stock and parts thereof; (electro-)mechanical traffic signalling equipment) dominate and together account for about 50% of imported risky products, but account for much less for non-risky products (around 15%). HS sections 30 (Pharmaceutical products) and 90 (Clocks and watches and parts thereof) make up another 10%. Finally, 'Other HS sections' account for about 25% of risky products but capture almost 50% of non-risky products.

Figure 8 / Imports of risky and non-risky products by partner



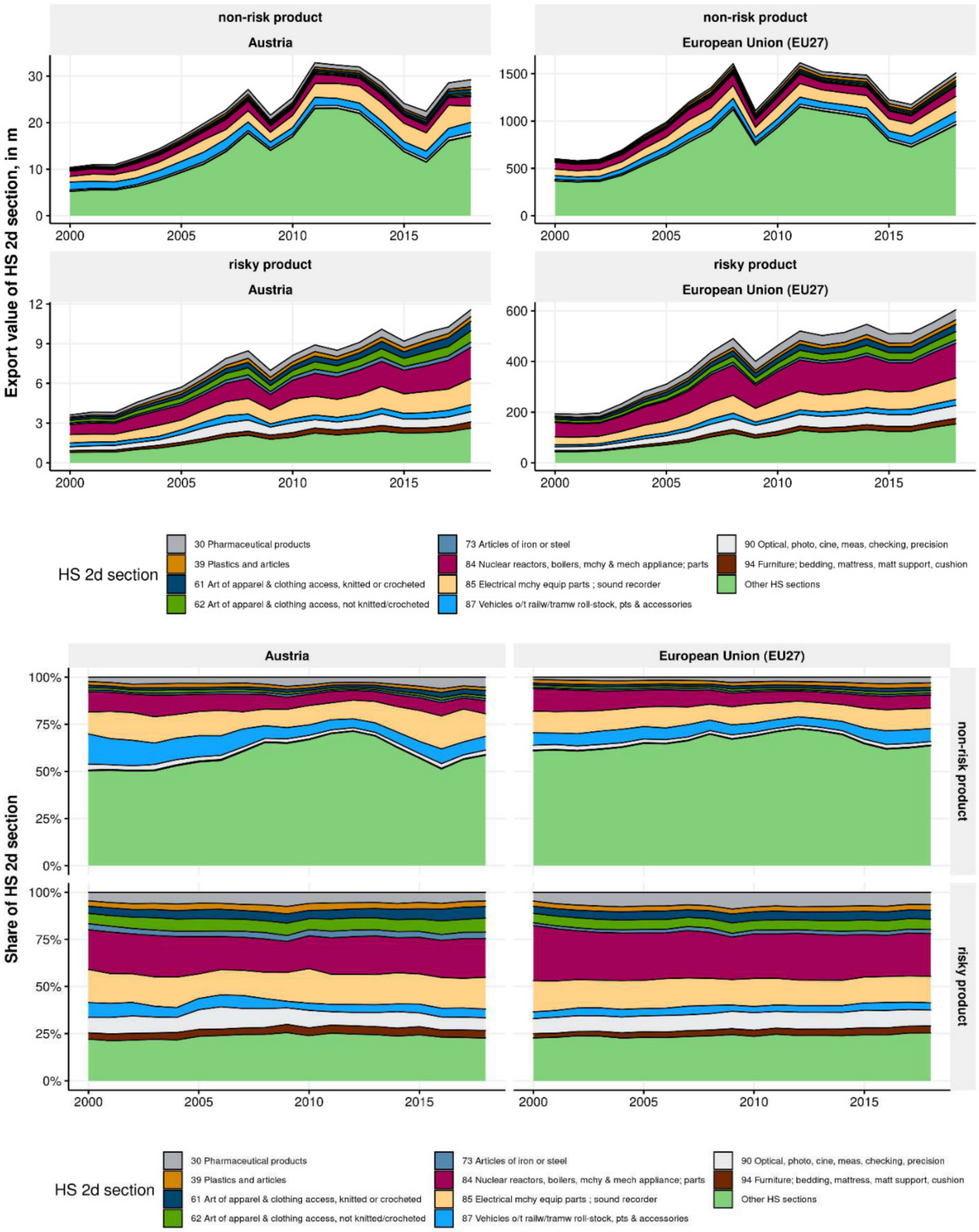
Note: For Austria, rest of world excludes intra-EU trade.
Source: BACI, wiiw calculation.

Figure 9 / Import flows and shares by HS section (all countries)



Note: Including intra-EU trade.
Source: BACI, wiiw calculation.

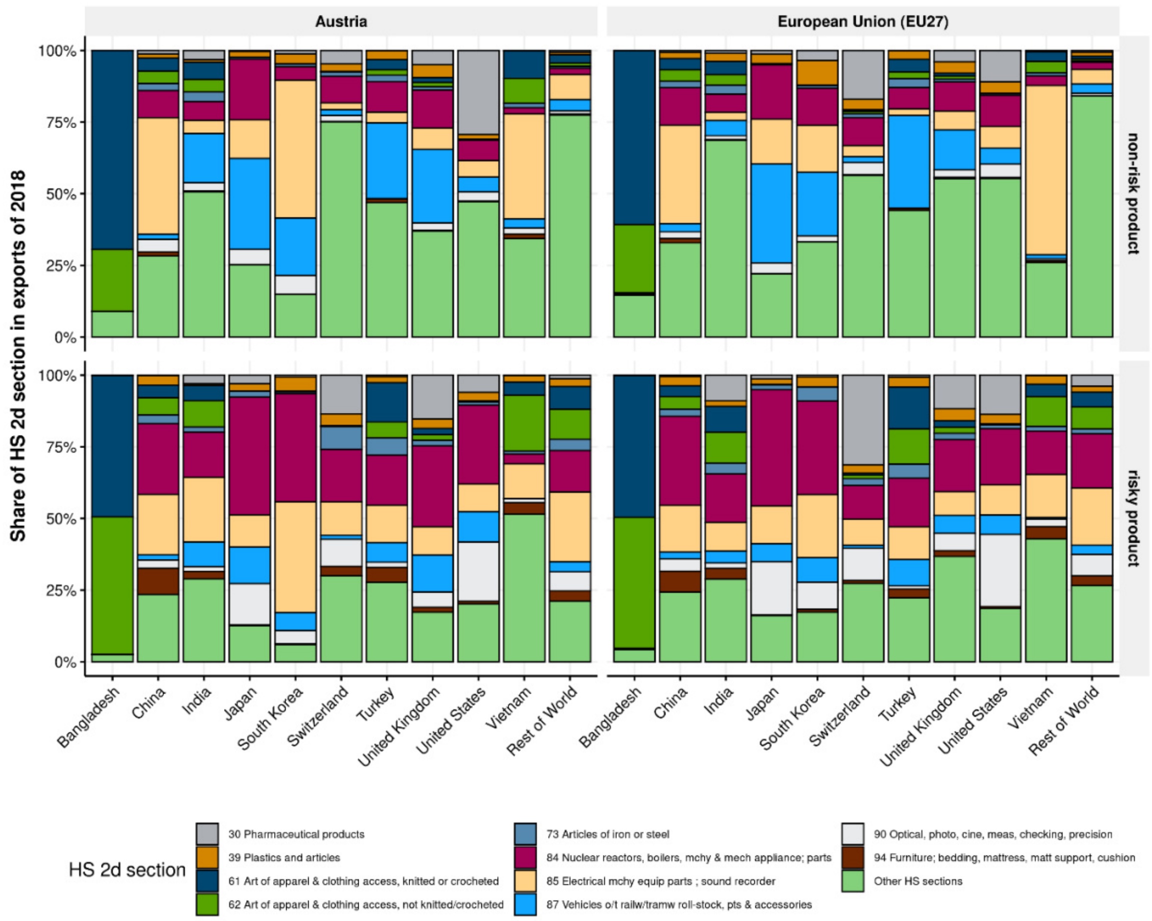
Figure 10 / Import flows and shares by HS section (extra-EU27 imports)



Note: Excluding intra-EU trade.
Source: BACI, wiiw calculation.

Figure 11 combines the information and shows the imports by the most important HS sections with respect to risky imports and partner countries. One can see that imports in the above discussed HS sections 84 and 85 stem mostly from China, Japan, South Korea, the United Kingdom and the United States, and HS section 30 (pharmaceuticals) from Switzerland and the United Kingdom. Imports of risky products from Vietnam and particularly Bangladesh consist mostly of products from HS sections 62 and 61.

Figure 11 / Share of risky products in imports by exporting country, 2018



Source: BACI, wiiw calculation.

2.3. VALIDATION

In this section we now provide a comparison of the results with other existing studies. Additionally, we analyse the impact of the pandemic crisis on trade and how this relates to the product riskiness of trade.

2.3.1. Comparison with other results

First, promisingly, our results are comparable to the result of KPD even though we use different data sources to achieve a wider coverage in terms of countries and years. For example, for the international substitutability component we use data on mean years of schooling from the UNDP (2019) which is available for more countries and more recent years, compared to the PWT9.1 data that KPD use. Also, for the underlying trade data we use the BACI HS1996 dataset since it is available for a longer period. In addition, we employ further indicators to identify the riskiness of products.

In their work KPD classify 421 products as being risky. With our extended framework and different data sources we find 435 risky products. Thus, in terms of the total number of products being considered as risky our two frameworks are very similar. Furthermore, KPD present two case studies: the 2011 Japanese earthquake and subsequent nuclear catastrophe and the floods in Thailand in the same year. For each of the two natural disasters they identify three products that were mentioned in the media as being severely affected and then check if their methodology had identified those products as being risky. Table 2 shows these six products (according to KPD) as well as the risk classification according to our methodology.

Table 2 / Risk classification of selected products in 2010

HS Code	Description	Risk classification
	Japanese earthquake	
840890	Combustion Engines # Other Engines	risky
853229	Electrical Capacitors # Other	risky
901380	LCDs # Other devices, appliances and instruments	risky
	Thailand floods	
847170	Computers # Storage units	risky
854121	Semiconductor devices # with a dissipation rate of less than 1 W	non-risky
870421	Delivery trucks # not exceeding 5 tonnes	risky

Source: KPD, wiiw calculation.

Our product fragility index identifies five out of the six products as risky, like the results in KPD. Only certain semiconductor devices are treated as non-risky. Since our index contains additional information, it is not surprising that our index considers fewer products as risky.

2.3.2. Comparison to COVID-19 related measures

Another aspect is the supply of critical goods to combat pandemics (which might be considered 'essential products'). The EU Commission published a list of medical products that are needed to deal with the COVID-19 pandemic, and which were relieved of import tariffs.[12] This list contains 103 products, 98 of which are contained in our risk/non-risk classification.[13] Table 3 states which of these 98 products are considered as risky or non-risky given our results by the HS section.

About one third of these 98 COVID-19 related products are classified as risky. As can be seen in Table 3, the largest number of risky COVID-19 products falls into HS Section 90 (Optical, photographic, cinematographic, measuring, checking, precision instruments) and contains products like breathing appliances and gas masks; surgical instruments (electro-cardiographs, ultrasonic scanning apparatus) and the like. The six products in HS Section 62 considered as risky are different types of track suits: hazmat suits worn by medical staff in hospitals when treating the infectious patients. Section 84 (Nuclear

[12] For the publication of the EU Commission decision, see: https://ec.europa.eu/taxation_customs/sites/taxation/files/03-04-2020-import-duties-vat-exemptions-on-importation-covid-19.pdf. The updated list of products can be found here: https://ec.europa.eu/eurostat/documents/6842948/11003521/Corona+related+products+by+categories.pdf.

[13] The product list contains 103 products in CN 8-digit codes. The conversion to HS 1996 classification (which is the basis for our product riskiness index) reduces the number of products to 98.

reactors, boilers, machinery & mechanical appliances; or parts thereof) contains another four risky products, such as sterilizers and machinery for filtering and purifying gases, but also data processing machines. Products from the COVID-19 list that are classified as non-risky by our methodology thus fall into Section 29 (Organic chemicals). One of the products in this section is pure alcohol. HS Section 39 (Plastics and articles) contains six products that are considered non-risky: these six products are different types of plastic tubes.

Table 3 / Risk classification of COVID-19 products

HS Section	Number of non-risky products	Number of risky products
22 Beverages, spirits and vinegar	3	0
28 Inorganic chemicals; compounds of precious metal, radioactive elements	2	0
29 Organic chemicals	4	0
30 Pharmaceutical products	4	1
34 Soap, organic surface-active agents, washing preparations	3	2
37 Photographic or cinematographic goods	2	0
38 Miscellaneous chemical products	1	3
39 Plastics and articles	8	3
40 Rubber and articles	3	1
48 Paper and paperboard; art of paper pulp	2	0
56 Wadding, felt and nonwoven; yarns; twine, cordage	2	0
61 Articles of apparel and clothing access, knitted or crocheted	2	0
62 Articles of apparel and clothing access, not knitted/crocheted	6	6
63 Other made up textile articles; sets; worn clothing	2	1
65 Headgear and parts	2	1
73 Articles of iron or steel	2	0
76 Aluminium and articles	1	0
84 Nuclear reactors, boilers, machinery and mechanical appliances; or parts thereof	3	4
85 Electrical machinery and equipment; parts thereof; sound and television image recorder	2	1
87 Vehicles other than railway or tramway roll-stock, parts and accessories thereof	2	0
90 Optical, photographic, cinematographic, measuring, checking, precision instruments	9	9
94 Furniture; bedding, mattress, matt support, cushion	1	0
Sum	66	32

Source: EU Commission, wiiw calculation.

An obvious question which arises is how trade dynamics for these product groups differ and whether there is an indication that trade of these groups was hampered or not.[14] Table 4 gives an overview of the growth rates of EU27 and Austrian imports (2019-2020) differentiating between the dimensions of non-risky and risky products and COVID-19 related or not.

This first shows that imports of non-COVID-19 related products fell significantly due the sharp recession and decline in trade flows. For these products, the declines amount to almost 10% and 8.1% for non-risky products and risky products respectively. For the EU27, the corresponding numbers are -11.8% and -7.6%. In stark contrast, imports of COVID-19 related products strongly increased and even more so for the products classified as risky. Specifically, Austrian imports of non-risky COVID-19 related products

[14] We consider here the longer run (2019-2020) and not short-term fluctuations (see Mirodout, 2020, for an assessment of short-term fluctuations for vital medical supplies).

increased by 12.4%, whereas those of risky products by 13.6%. The respective numbers for the EU27 are 14.8% and 17.5%. Thus, these figures suggest that the trade system for risky products has indeed been at least resilient (even though it might not have been robust at higher frequencies). Table 4 also shows the imports of the EU27 separated into extra-EU27 and intra-EU27 imports. Intra-EU27 seems to have increased less than extra-EU27, but also decreased less. Extra-EU27 imports of COVID-19 related risky products actually soared by 30.6% in 2020 compared to 2019.

Table 4 / Growth of imports from 2019 to 2020

		non-risky products	risky products
Austria	COVID-19 related	12.4%	13.6%
	Non-COVID-19 related	-9.8%	-8.1%
EU27	COVID-19 related	14.8%	17.5%
	Non-COVID-19 related	-11.8%	-7.6%
Austria (extra-EU trade)	COVID-19 related	15.6%	30.6%
	Non-COVID-19 related	-15.2%	-7.5%
EU27 (extra-EU trade)	COVID-19 related	14.1%	9.8%
	Non-COVID-19 related	-9.4%	-7.6%

Source: EU Commission, EU Comext, wiiw calculation.

2.4. RISKY PRODUCTS IN INDUSTRY SUPPLY CHAINS

So far we have considered the shares of risky products in imports based on product classification. However, for international production networks and GVCs it is also important to consider the industries using intermediary products in their production. Analysing which sectors show a high share of risky products in their imported intermediate inputs allows us to identify industries which are vulnerable to supply shocks and might destabilise an economy.

2.4.1. Risky trade by using industries

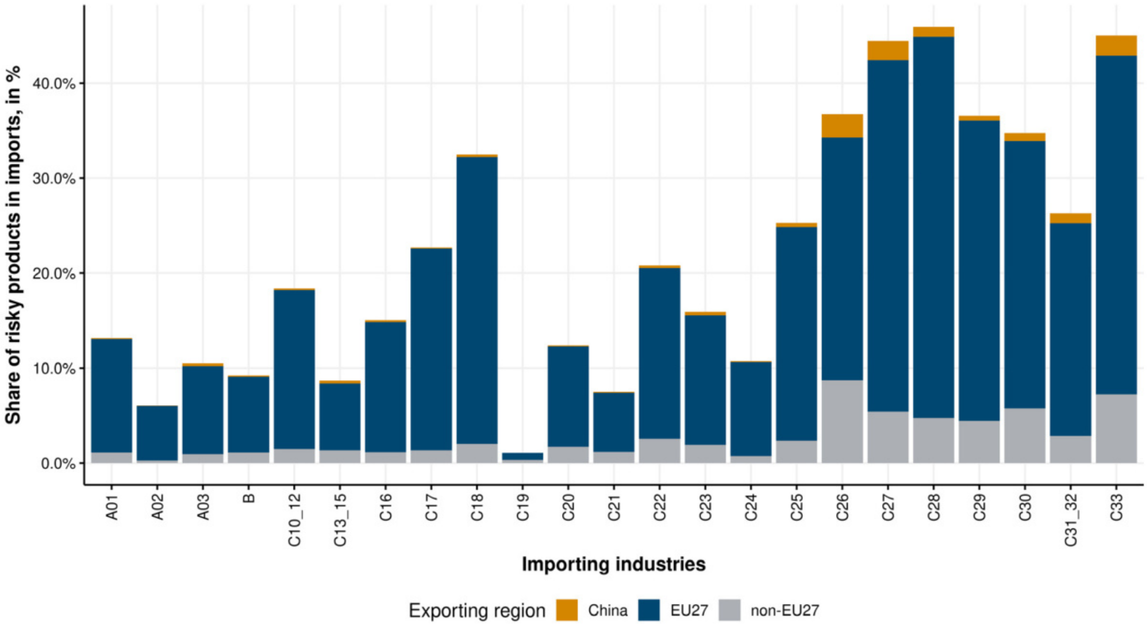
Trade data do not include such information on the using industry. We therefore proxy this by combining the trade data from BACI with the input-output data from the World Input-Output Database (WIOD) and by using a mapping from the HS product classification to the NACE Rev. 2 industry classification. In this way we can map the product fragility indices from all HS 6-digit products to the using industries.[15] This, for example, tells us how much and which electronic products Austria has imported from China. Further information from the world input-output database (WIOD) includes imports of the using industries in a bilateral dimension (i.e. for example how many products the Austrian automotive industry imports from the Chinese electronics industry). Assuming that the product mix of the Austrian automotive industry's imports is the same as the product mix of Austria's imports as a whole (i.e., using the 'proportionality' assumption that has also been applied to construct multi-country SUTs, see Timmer et al. 2015), we can calculate a risk score for every cell in the input-output table. By aggregating the share of imported risky products for

15 We use the same mapping as has been used for the WIOD.

one using industry across all its partner countries and industries we arrive at a riskiness index for each industry.[16]

Figure 12 shows how the shares of risky products in Austrian imports vary by industry as well as by exporting region.[17] Not surprisingly given the above results, high-tech sectors, defined as industries C26 (Manufacture of computer, electronic and optical products), C30 (Manufacture of other transport equipment), and C33 (Repair and installation of machinery and equipment) are characterised by a high proportion of risky products in their intermediate imports. Given the tight interconnection of the European member states, it is no surprise that the largest share of risky imports is still sourced from within the EU27. Furthermore, we see that - considering extra-EU trade flows - imports from non-EU countries and China account for a larger share of risky imports mostly in these higher tech industries which account for up to 10-12% in industries like C26 (Manufacture of computer, electronic and optical products) and C33 (Repair and installation of machinery and equipment).

Figure 12 / Austria, 2014: Share of risky imports in using industries' imports and selected partner country



Source: BACI and WIOD, wiiw calculation.

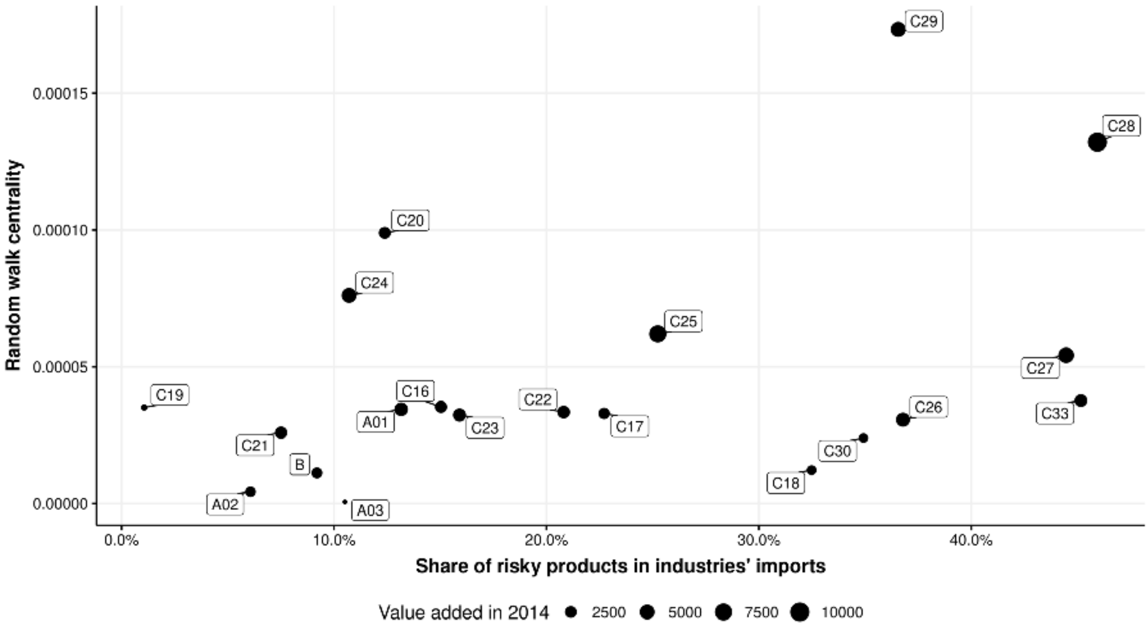
[16] There is an important caveat worth mentioning: The import product mix of an industry is, obviously, in general not the same as the import product mix of the country. But there is simply no way to aggregate the product level characteristics to industry level without further information. Furthermore, having to use proportionality assumption means that the share of risky products of a specific supply industry, e.g. the Chinese electronics industry, will be the same for all Austrian industries.

[17] We restrict the figure to show only agricultural, mining and manufacturing industries, as they are the main transmitter of shocks and the industries that are the most dependent on international trade flows. See e.g. Stehrer and Stöllinger (2015. p. 6ff) for a discussion of the importance of manufacturing sectors with respect to global value chain participation. A figure depicting the service industries can be found in the Appendix.

2.4.2. Random walk centrality

An input-output table can also be considered as a network, where the industries are the nodes and the trade flows are the (weighted) edges between them. Thus, we can characterise which country-industries are strongly interconnected, have a 'central' position in the network or are rather 'remote'. There are several ways to quantify the centrality of an industry in the network and there are even centrality measures specifically developed for economic input-output tables. Blöchl et al (2011) argue to use random walk measures. A random walk starts on a specific node in the network and then randomly follows an edge to another node, where it again randomly decides on an edge to take. The probability of walking along a certain edge is dependent on the weight of the edge (i.e. in input-output tables, the value of the respective trade flow). Blöchl et al (2011) develop two random walk measures, called random walk centrality and random walk betweenness. Random walk centrality can be interpreted as identifying which industries are most likely affected by and transmitting a supply shock while random walk betweenness reveals the nodes where a shock lasts the longest.

Figure 13 / Random walk centrality and share of risky products in Austria, 2014



Source: BACI and WIOD, wiiw calculation.

Figure 13 depicts an overall positive relationship between random walk centrality and the share of risky products in the imports of Austrian industries[18]: Industries that tend to have a high share of risky products also tend to have a high random walk centrality, i.e., are most likely to be affected by a supply shock. This is especially the case for industries in C29 (Manufacture of motor vehicles, trailers and semi-trailers) and C28 (Manufacture of machinery and equipment n.e.c.): as they show both a high share of risky products in imports and a high random walk centrality they exhibit vulnerability (a high share of risky imports) as well as elevated importance (a high random walk centrality). The corresponding figure for the random walk

[18] We compute the random walk centrality over the full WIOD, thus the computed values show the relative centrality position of an Austrian sector within the network defined by the whole WIOD and not only within Austria.

betweenness can be found in the Appendix, as the qualitative conclusions that can be drawn from it are like those in Figure 13.[19]

2.5. RESULTS FROM A 'PARTIAL GLOBAL EXTRACTION METHOD (PGEM)'

In this section we use the above results where for each cell in the input-output matrix we calculated the share of risky products in the respective trade flow. To recap, for example, we calculated the share of risky imports of the Austrian automotive industry from the Chinese electronics industry in the overall imports of this Austrian industry from the respective Chinese industry.[20] The same was calculated for each flow of the final demand matrix. The share of risky products for intra-country flows are zero by definition. In this section we apply these data to do various scenario analyses: (1) a final demand shock, (2) EU-re-shoring of the production of risky imports in final goods, (3) EU re-shoring of risky imports along global value chains, and (4) a partial re-shoring of risky imports along global value chains. Though these scenarios are based on various specific assumptions we argue that these span the range of potential for global and countries' GDP.

Methodologically we calculate these shocks using a global input-output model based on the WIOD Release 2016 (see Timmer et al., 2015). The basic relation in this model is given by $x = Lf$ where x denotes a country x industry vector gross output, L is the global Leontief inverse, and f is the country x industry vector of global final demand. This vector f is the row sum of a global final demand matrix F which includes the bilateral final demands for each industry. Pre-multiplying this equation with a diagonalized vector of value added coefficients (value added divided by gross output) results in the vector of value added created given the levels of final demand f. These can be summed up by country resulting in a country's GDP. Due to national accounting definitions it holds that the value of global GDP equals the value of global final demand which is a global balancing condition for world input-output tables.

2.5.1. Final demand shocks and EU final demand re-shoring

This scenario focusses on EU final goods imports from non-EU27 countries which are classified as risky (this implicitly assumes that products traded within the EU are not considered as 'risky'). We assume that the EU countries can no longer import these final products due to a disruption in trade or a disaster event (e.g. lockdown measures). This can be thought of as a sort of 'forced saving' and reduces the specific elements in the final demand matrix F. Technically, we reduce the final bilateral import demand of each EU country by the value of the risky products. As final demand is reduced, global GDP declines with a magnitude of 0.2%.

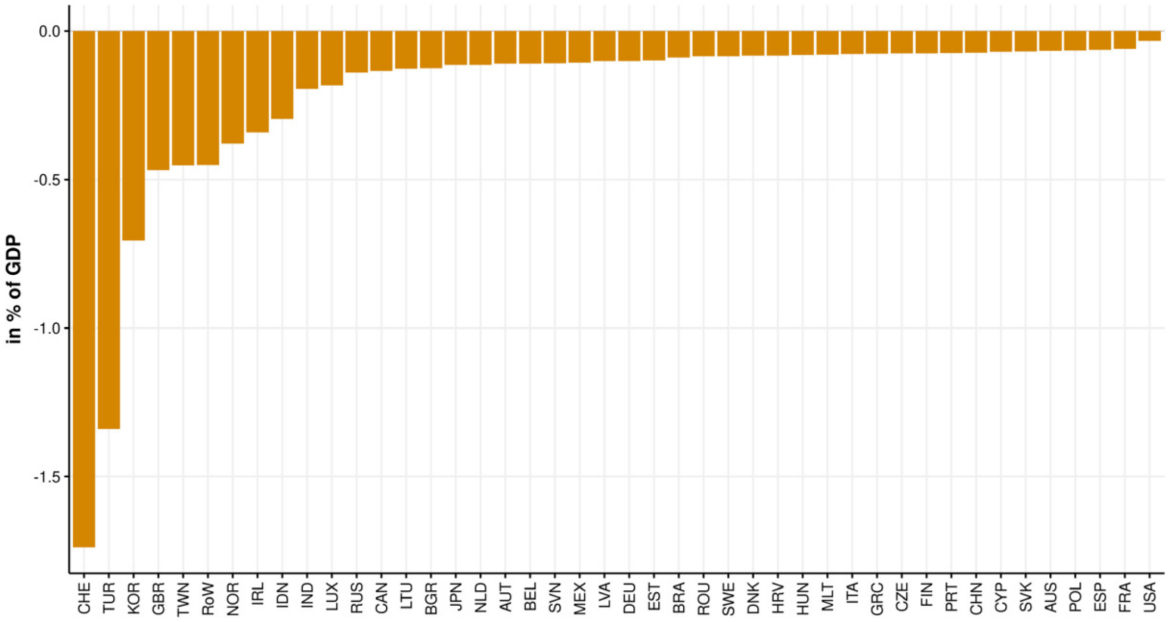
Figure 14 shows how this global decline impacts each country. The non-EU countries most affected by this final demand shock are Switzerland, Turkey, South Korea, and the United Kingdom together with Norway with declines of between 1.75 to 0.5%. The impact on the EU member states is much smaller (for the EU27 around -0.1%) which stems from the indirect effects of global value chains (note that only import

[19] In the appendix we also present graphs showing the relation between backward and forward linkages and the riskiness indicator. Again, the general conclusions are similar, though it is difficult to see clear-cut relations.

[20] See discussion of assumptions in Section 2.4.

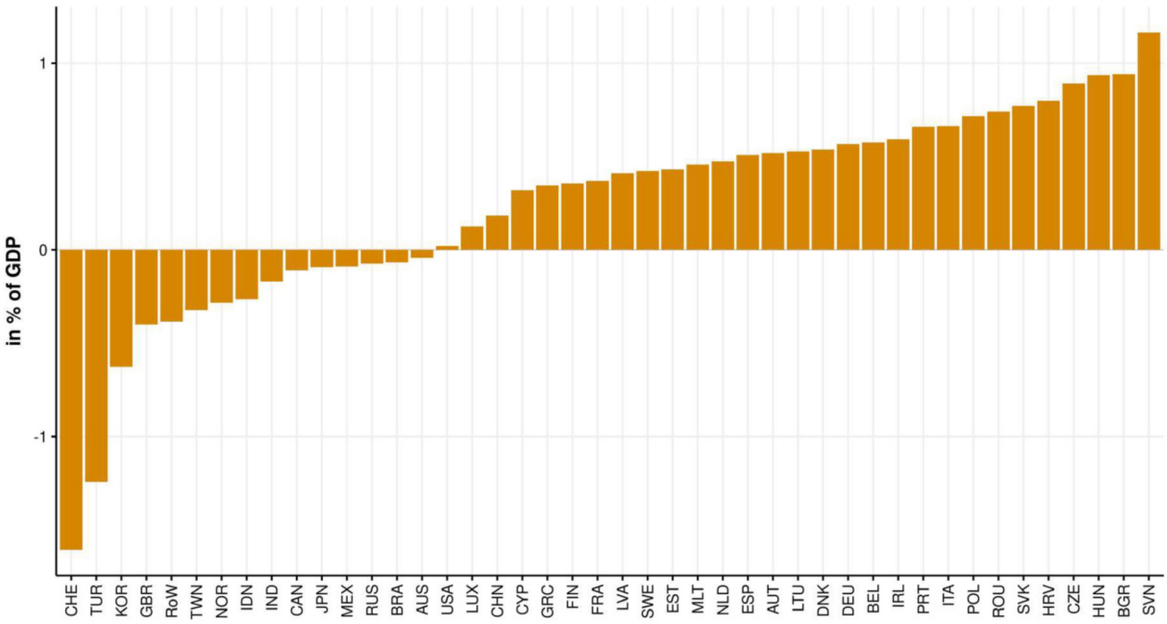
demand from non-EU countries is affected). The negative impacts are a bit stronger in Ireland and Luxembourg.

Figure 14 / GDP effects of a final demand shock



Source: WIOD; own calculations.

Figure 15 / GDP effects of final demand re-shoring



Source: WIOD; own calculations.

In a second scenario we model the effects when the production, i.e. final assembly, of these imports of risky final goods are re-shored to EU member states based on the (admittedly crude) assumption that this demand of risky final products is proportionally allocated according to the final demand structures in the EU countries. For example, the imports of risky products of a specific EU27 member state from the non-EU economies are proportionally allocated to the intra-EU demand of this member state. As the value of global final demand is unchanged, the impact on global GDP is by definition zero given national accounting definitions. Note that this scenario assumes that risky products from non-EU countries can still be imported as intermediary products (which is tackled in the next subsection). It should be emphasised that such re-shoring of final assembly activities in this model is not driven by measures implying trade distortions (such as tariffs) but should be interpreted as deriving from the effects of industrial policy measures, FDI attraction, or location policies and thus is driven by industrial competitiveness aspects.[21]

Figure 15 presents the results. The results suggest a modest positive impact on GDP in the EU27, of about 0.53%. The effect is stronger in the Central and Eastern European countries. Austria would gain 0.5% from this final demand re-shoring of risky final goods imports.

2.5.2. The impact of GVC re-shoring

Many of the risky imported products are used as intermediary inputs for further production. In disaster analyses the so-called hypothetical extraction method is often applied.[22] It assumes how much GDP is lost in a country if a certain input flow is interrupted (e.g. due to a natural disaster). This is done by nullifying the respective flow in the input-output matrix, recalculating the new Leontief inverse, and calculating the impact of a country's GDP by comparing the baseline with the perturbed Leontief. As pointed out by Dietzenbacher et al. (2019), this works well for single countries as one (implicitly) assumes that the missing value added is produced in foreign countries. However, for multi-country input-output matrices such an extraction strategy cannot be applied as it violates global balancing conditions and one therefore has to account for the missing flows. Dietzenbacher et al. (2019) suggest allocating the missing flows proportionally over the columns of the global input-output matrix as a crude assumption and refer to this as the 'global extraction method (GEM)'.

We adopt a similar strategy in the following way: we reduce the bilateral and sector-specific intermediary imports of each industry of the EU27 member states, using the information concerning the risky products in the supply structures (see Section 2.4.1) and we reallocate them proportionally over the intra-EU intermediary input flows of the respective EU27 member states and the respective industries. Note that this assumes that the risky products are partially produced by the respective EU27 country itself or imported from the other EU27 economies according to the country's respective intra-EU supply chains. We refer to this scenario as 'GVC re-shoring'. Having thus adjusted the input-output matrix, one can recalculate the Leontief inverse and, based on this perturbed Leontief, the new value added vector. Note that by assumption global value added remains constant (as final demand is unchanged): however gross output and therefore value added by country and industry can change. As above, in this model such changes in supply structures are not driven by trade-distorting measures but by industrial competitiveness policies (and thus no negative effects on global GDP arise due to trade distortions).

Figure 16 (upper graph) reports the results of this exercise. As more inputs are sourced from the own or other EU economies, GDP for the EU member states increases. These gains range from 0.15% of GDP

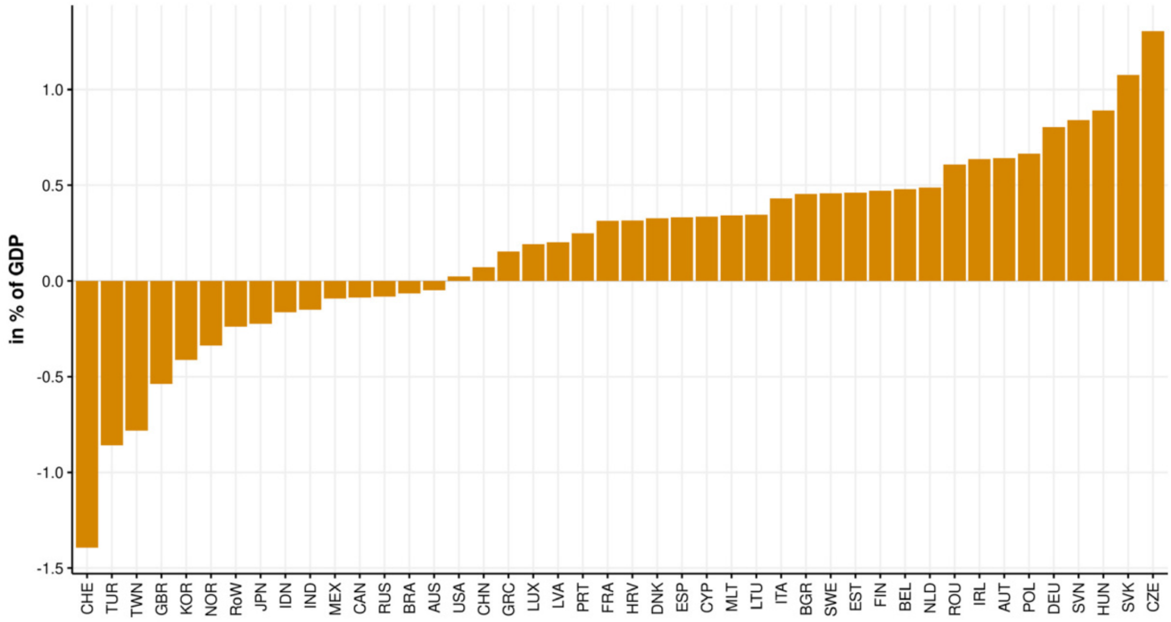
[21] For this reason no negative effects of GDP arise which is typical in trade models for trade distorting policy measures.

[22] For a technical discussion see Miller and Blair (2009).

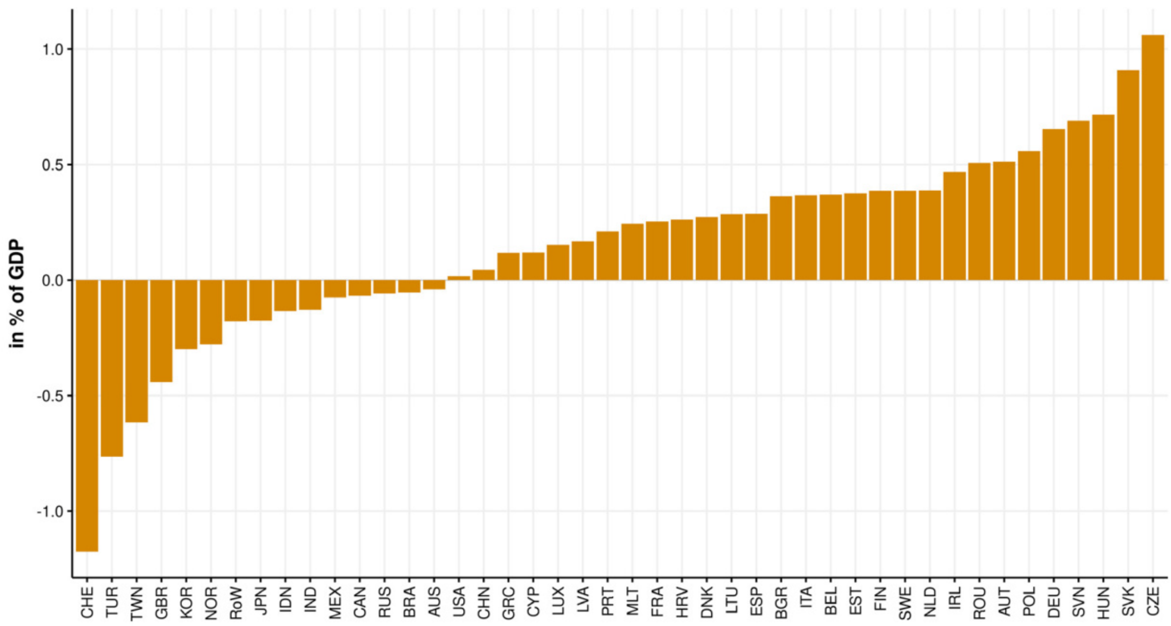
in Greece to around more than 1% in Slovakia (1.1%) and Czechia (1.3%). GDP in the non-EU27 economies declines. These declines range from 1.4% in Switzerland and 0.86% in Turkey to negligible impacts in Australia (very small positive effects are calculated for the US and China). Note that compared to final demand re-shoring (Figure 14) the GDP effect for the EU27 is at 0.52% very much comparable.

Figure 16 / Results from 'partial hypothetical extraction' exercise: GVC effect

Full re-shoring



Partial re-shoring



Source: WIOD; own calculations.

The lower panel shows the results of an alternative assumption such that only part of the risky imports is re-shored. Specifically, we subtract the imports of the risky products from EU27 sourcing but reallocate these across all partner economies (thus a part of these flows remains in the non-EU27 countries). In this case global supply structures for the risky products would remain generally intact (inducing some resilience or robustness for GVC shocks in the EU27 area), though partly re-shored to the EU27 member states. The GDP effect becomes a little smaller at about 0.43% with a similar ranking as for the full re-shoring scenario.

2.6. SUMMARY

To summarise, the results show that about 9% of the analysed products (435 out of 4706) are characterised as 'risky' according to the applied method. The largest number of risky products belongs to HS section 85 (Electrical machinery and equipment and parts thereof; sound recorder), section 84 (Nuclear reactors, boilers, machinery & mechanical appliance; parts) and section 90 (Optical, photo- and cinematographic, measuring, checking, precision instruments). Almost two third of the products characterised as risky are part of HS group 8 (including the products from HS group 90 this share increases to 77%) which indicates that mostly high-tech products are considered risky products. Further, a large number of these risky products are products considered important in combatting the health effects of the COVID-19 pandemic. Results indicate however that trade, and specifically EU-imports of these products from non-EU countries, has been resilient in general as indicated by the large growth rates of imports in these product categories.

Risky products account for about 30% of Austrian intermediary imports, and 45% of final products, while for the EU27 these shares are somewhat lower. These findings stress that not only firms, but also end consumers can be affected by supply disruptions of risky products. In section 2.4 we concentrate our analysis on intermediate imports, because they too can have serious knock-on effects on other, more downstream, industry sectors.

Table 5 / List of identified vulnerable industry sectors

C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C33	Repair and installation of machinery and equipment

Accordingly, with respect to using industries, mainly the six higher-tech industries listed in Table 5 show vulnerabilities in the three dimensions considered: First, they rely on high shares of risky products in their imports. Secondly, these industries are characterised by high centralities in the production network and, thirdly, they are relatively more backward linked. These identified vulnerabilities justify the fact that these industries receive specific attention from governments and public institutions to ensure that firms in these industries are able to do cross-border business in a stable regulatory environment.

In terms of partner countries, China accounts for more than 20% of Austria's imports of risky products (and more than 30% of the EU27's imports of risky products) and also shows the largest increase over time. This reflects the increasing importance of Austrian and EU27 high-tech imports from China and 'factory Asia'. As high-tech industries are especially dependent on these products (compared to other industry sectors) and will likely have a special role in future challenges (such as digitalisation and decarbonisation of the economy), relationships with crucial trading partners need to be monitored and reducing dependency on a few partner countries by diversifying trading relationships seems inevitable.

The result from the 'partial global extraction method (PGEM)' (assuming measures which are not trade distortionary) suggests modest gains from an industrial policy of re-shoring production of risky products to the EU27 countries, while at the same time reducing the GDP of non-EU27 countries. This finding suggests that non-EU27 countries could also have an interest in making supply chains more resilient.

The next Chapter will highlight some of the existing (economic, geopolitical) challenges and possible policy solutions.

3. Policy aspects

3.1. GENERAL ASPECTS

The COVID-19 pandemic and the resulting economic crisis brought to light the dependencies of a number of products on a few producer countries, and triggered a discussion on the resilience and robustness of global production networks and value chains. Such aspects were already being considered before the pandemic from the EU-perspective (see e.g. European Parliament, 2021). This discussion focusses on critical goods for combatting the pandemic, such as medical protective equipment, which is to a large extent produced outside the EU. Consequently, as the COVID-19 pandemic took hold in the EU, in some cases countries rushed to secure urgently needed medical equipment and pharmaceuticals and resorted to protectionism by hastily issuing export restrictions – albeit of short duration in most cases – to keep important products within country borders. However, in the literature it is also argued that those global production networks and value chains actually made it possible to cope with the surge in global demand for such products. Still, the crisis made it evident that in global production networks, economic sectors which are largely dependent on imports of certain inputs can be severely impacted by trade shocks or interruptions in the transport systems together with their respective downstream sectors (see e.g. Baldwin and Freeman, 2020a).

The COVID-19 pandemic has triggered discussions about the vulnerability and fragility of global value chains (GVCs) from the very beginning (see e.g. Baldwin and Freeman, 2020a) and potentially emerging trade conflicts (e.g. Baldwin and Freeman, 2020b). This vulnerability first became virulent in the supply of health-related products like face masks and other medical protective equipment for which several protectionist policies were imposed (for an overview see González, 2020, and Evenett and Fritz, 2020). Policymakers called for more self-reliance and shortening of global value chains. The EU argued for the necessity to increase the resilience of European value chains, although it is unclear how this increased resilience is to be achieved (European Commission, 2020a). Overdependence on individual suppliers has been identified as a risk factor in the current organisation of international supply chains. Javorcik (2020) hints at the critical aspect of the "just-in-time" principle, which aims to reduce logistics costs by minimising or eliminating warehousing. However, it is by no means clear that a world with reduced global value chains would be a better option. For example, one topic of debate is whether or not the ‘renationalisation’ of value chains could shield countries from the negative economic effects of COVID-19, because the supply bottlenecks due to the lockdown affect both international and national suppliers (Bonadio et al., 2020). It should also be noted that despite severe disruptions, many value chains – for example in the food industry – have continued to function during the crisis (Miroudot, 2020).

These developments have led to a couple of urgent policy-relevant questions, such as: which products entail such dependencies which, in the case of an unexpected disruption of international trade, could cause supply shocks to firms and end consumers? In particular, in the context of the COVID-19 pandemic this question also arises for products important for public interests like health equipment. Moreover, pandemics are not the only possible cause of import shortages. International relations are also increasingly volatile due to trade wars, the rise of economic nationalism, increasing geopolitical tensions, disruptions in transport routes, and environmental disasters like earthquakes, floods, etc. All these factors make global value chains vulnerable. For example, Sangaraju and Bayhaqi (2020) identify five pillars of supply chain strength or resilience: (i) strength against logistics and infrastructure risks; (ii) strength against market risk; (iii) strength against natural disaster risk; (iv) strength against political risk; and (v) strength against regulatory or policy risk. Box 1 presents some selected firm level evidence of potential GVC shocks.

BOX 1 / SELECTED FIRM LEVEL EVIDENCE ON GVC SHOCKS

Supply side effects

A US-based survey of companies undertaken by a global value chain resilience consultancy firm[23] states that while almost all responding firms experienced some form of supply disruption (only 2% did not report any supply disruptions), the risk factors leading to disruptions were very diverse:

› Fluctuations in supplier prices (44%)
› Orders delayed due to safety restrictions (44%)
› Orders delayed due to movement restrictions (41%)
› Drop in demand of companies' products (36%)
› Import/export restrictions (36%)
› Collapse of manufacturing supplier (34%)
› Bankruptcy of supplier (25%)
› Oil price fluctuations (24%)

A survey by DIGITALEUROPE[24], a trade association representing "digitally transforming industries" reports that while deliveries from China are the ones that have most often been discontinued (11% of the respondents that use supplies from China), highly limited (31%) or limited (44%), deliveries from Europe also faced substantial disruptions: discontinued (1% of the respondents that use supplies from Europe), highly limited (16%) and limited (57%) deliveries. Deliveries from the USA and South Korea were a little less affected. The questionnaire did not include questions about the type of supply disruptions that the companies experienced.

The EU Commission requested firms to complete a survey on supply disruptions[25], however the results of this survey are not yet public.

Demand side effects

A report by the International Trade Center (2020) stresses the fact that supply chain disruptions often start in the most downstream country/industry (e.g. due to a lockdown that dampens demand and reduces final goods exports) and then "trickle upstream" to the input producers. They estimate the effects that a potential two-month lockdown in the US, the EU and China (the report was published in June 2020) would have on global value chains. Due to the tight supply chain interconnections between the three regions, they themselves would be the

[23] See https://www.interos.ai/project/interos-2020-survey/ (accessed 15.1.2021)

[24] For the results of the survey, see: https://www.digitaleurope.org/resources/pan-european-survey-on-the-impact-of-covid-19-on-the-digital-industry/#deliveries (accessed 15.1.2021)

[25] The survey can be found here: https://ec.europa.eu/eusurvey/runner/DisruptionSurvey2020 (accessed 16.1.2021)

principal victims of such a lockdown: the EU's exports would drop by USD 26.8 bn, exports from the US by USD 22.1 bn and exports from China would decline by USD 71.4 bn.

Supply chain restructuring

In the context of COVID-19 a survey conducted by the Association of German Chambers of Industry and Commerce in March 2020 (DIKH, 2020) indicated that German companies expect supply difficulties especially from China (81%), but less so from other Asia (19%): 21% expected delivery problems from Italy. Almost half (46%) reported they would not adapt supply chains, 9% to shift their supply chains to Germany or other Asia, and 40% to other European countries.

On top of the discussions which emerged due to the pandemic, more longer-term challenges arise. Specifically, the supply of critical raw materials needs to be secured such that the economy can provide stable living conditions for the working population of the EU and the transition to green growth paradigm can be undertaken. Furthermore, all this is to be considered against the background of the weakening of rule-based multilateralism and international institutions, together with the rising importance of China (and 'factory Asia').

Thus, there is a need to evaluate policy options that can counter these developments by making international trade more resilient in order to shelter economies from disruptions from abroad. If these dependencies are posing significant challenges to the provision of important goods, the objective of policy (industrial policy, trade policy and others) should be to reduce dependency on a few producers (countries) and thus enhance the resilience of the European economy in the case of an adverse international trade disruption. For example, in June 2020, the EU Commission issued a note stating the goal of "pursuing a model of 'Open Strategic Autonomy'" (EU Commission, 2020b) by strengthening the EU's (productive) capabilities and capacities while still working with foreign partners on global issues such as climate change.

3.2. CLASSIFICATION AND ASSESSMENT OF GVC SHOCKS

The vulnerability of both global and regional production networks has many dimensions, which makes it impossible to provide comprehensive conclusions. On top of that, ultimately, the design of regional and global value chains as well as their adaptation or dissolution is a business decision that cannot and should not be taken directly by politics. Companies are therefore increasingly urged to rethink the strategic orientation of their value chains in terms of resilience. However, specific framework conditions can have considerable influence (see OECD, 2020).

Let us therefore indicate the most important dimensions concerning shocks and their impacts:

› **Geographical dimension:** The scope of the shock in terms of global (e.g. the COVID-19 pandemic) or regional (e.g. floods, earthquakes) coverage

› **Temporal dimension:** Whether the shock is short-term (or even a single event) or stretches over a longer time period

› **Systemic dimension:** The extent to which production or trade shocks bear a systemic or non-systemic risk to countries or societies

› **Product-specific dimension:** The extent to which the shock impacts 'essential' or 'non-essential' products (though the definition along these boundaries might be blurred)

› **Transmission dimension:** In terms of impacts along GVCs, the OECD (2020) identifies four channels:

- A direct impact which is the interruption of production, for example due to a natural disaster, or the lockdown measures in the course of the COVID-19 pandemic
- Indirect impacts including the effects of backward and forward linkages and disruptions in international transport networks
- A demand impact which can be both a demand surge for specific products (e.g. protective equipment or pharmaceuticals) or negative demand shocks arising from economic factors (like rising unemployment)
- Finally, there is the danger of shocks from trade and investment policies like export bans or discriminatory trade measures in response to a crisis

In terms of GVC vulnerabilities the risk management literature distinguishes between the following two dimensions:

› **Resilience** as the ability to return to normal operations quickly

› **Robustness** as the ability to maintain operations in crisis periods

In terms of resilience the literature is basically affirmative with respect to the performance of GVCs in the course of various crisis events, arguing that firms with extensive networks recovered faster and that manufacturers have diversified suppliers which help them to cushion the stoppage of one source of inputs. Specifically, with respect to the COVID-19 pandemic it is argued that many GVCs continued to operate during the pandemic (though there were short-term disruptions), and, more importantly, that global shortages of medical supplies and devices resulted from a global demand surge (rather than a fall in supply) where GVCs helped to resolve excess demand relatively quickly. Thus, GVCs in many cases are a solution to such events, rather than bottlenecks.

However, it also emphasised that governments and institutions can and should play an important role concerning the resilience and robustness of GVCs. This should be particularly the case for 'essential' or 'strategic' products or industry sectors which bear the risk of being the cause of systemic failures (like medical supplies or pharmaceuticals). In such cases not only the resilience of GVCs should be assured but also their robustness, e.g. through measures like stockpiling, creating supplier redundancy (even at the cost of loss of scale economies and efficiency) and shortening of geographical distances (e.g. if transport disruptions are feared). As companies may not have the necessary information (or personnel to collect such information), the role of governments and public institutions could lie in the provision of information (e.g. which products are risky in terms of concentration in a few exporting countries) and making companies aware of the potential measures they can take. For example, governments and institutions could encourage the search for and development of business connections with new suppliers from other exporting partner countries.[26]

Yet governments (or institutions associated with the government) usually are themselves producers, e.g. producers of health services. These services depend on domestic and foreign inputs, just as goods producing private firms do. Thus, the considerations above do, at least partially, also hold for publicly produced goods and services. Measures concerning the ‘resilience’ of value chains for critical supplies are therefore a delicate mix of issues concerning the products affected and the actors involved and their interactions (e.g. private firms serving public institutions), restricted by international regulations and multilateral (trade) rules as well as government actions.

3.3. POLICY ASPECTS AND CHALLENGES FOR THE ‘NEW NORMAL’

A lot of literature has already emerged which discusses policy aspects both for the short run to secure GVC operations – particularly for critical supplies – and the recovery phase, but also for the longer run (or the ‘new normal’ as it is sometimes called). The OECD (2020) summarised many aspects and the relevant policy issues of this discussion. From an EU perspective, the European Parliament (2021) is also focussing on longer-term strategies, for example with respect to the much wider debate of the EU open strategic autonomy discussion.

3.3.1. Main policy suggestions

The OECD (2020) effectively summarises what firms should do to make their supply chains more resilient in various steps. First, the identification and evaluation of risk differentiating between supply risks (if inputs are not delivered), demand risks (drops or surges in demand), and operational risks (breakdown of operations because workers are exposed to the event). As one can see these aspects are not necessarily limited to the impact of the COVID-19 pandemic but might be driven by other events (e.g. interruption of transport flows). Furthermore, these risks can be assessed along the dimensions of high/low probability and high/low impact. Second, based on the identified risks a design of risk management strategies is needed, which can cover a lot of activities. However, it is also emphasised that there is no ‘one size fits all’ approach for managing supply chains in general and to cope with the associated risks and mitigating strategies (i.e. having a management structure that is able to quickly respond to a changing environment). In essence it is each firm’s responsibility and interest to come up with ways to cope with such risks and manage the risk strategies. In general, the discussion is about the tension between efficiency and security in the production process, because both "supplier redundancy" (OECD 2020) and larger warehouses make value chains more robust, but also more costly.

The OECD (2020) differentiates their main policy recommendations into three dimensions: (i) during the crisis, (ii) recovery phase, and (iii) the ‘new normal’. For each of these dimensions, they develop a number of policy recommendations, which are reproduced in Table 6.

[26] Finding new suppliers can take two forms: either off-shoring to other, ‘new’ production destinations or re-shoring to (geographically or at least politically) closer countries. Re-shoring is elaborated further below.

Table 6 / Main policy recommendations for GVCs

Crisis Maintain operations of essential GVCs and increase supply	Recovery Help to restart GVCs	New normal Promote robustness and resilience of GVCs
• Facilitate trade by removing trade barriers and by ensuing the smooth functioning of international transport and customs	• Maintain an open trade and investment environment to reduce the time to recover and continue to support trade facilitation	• Create a stable regulatory environment (including through trade and investment agreements that can include provisions for the smooth operations of GVCs)
• Prioritise shipments for essential goods and adapt rules for movement of key personnel	• Address financial and other issues of firms that can delay the recovery of GVCs and support MSMEs	• Promote standards and certification procedures including risk awareness, review transport, logistics and customs clearance regulations to better mitigate disruptions
• Increase supply of essential goods by facilitating investment and operation permits and by expediting certification procedures	• Adapt health measures to the needs of firms operating in an international environment	• Develop stress tests for critical supply chains and include criteria for robustness of supply chains in government procurement procedures on a non-discriminatory basis
		• Promote the diffusion of digital technologies that can improve information systems for risk management (e.g. Internet of things)

Source: Reproduced from OECD (2020)

The OECD (2020) stresses that individual firms are in the best position to develop risk management and resilience strategies. However, governments can act to help overcome issues of information asymmetries in the following ways:

› Collect and share information on potential concentration and bottlenecks in supply chains

› For example, the public sector can support companies with information, e.g. on recognisable concentration tendencies within economic sectors or by carrying out stress tests (see e.g. Simchi-Levi and Simchi-Levi (2020)) for value chains, as has become common practice in the financial sector.

  - Particularly useful for critical supplies (pharmaceuticals, personal protective equipment)

  - Creation or need for (strategic) stockpiling, government procurement rules, …

› Create a conducive regulatory environment but ensure that this does not cause more policy-related risks. For example, policies like subsidies, tariffs, local content requirements, and investment restrictions to foster re-shoring activities are seen as distortive policies (reducing income and welfare) and are likely to cause losses in competitiveness, budgetary consequences (tax or budgetary incentives, race to bottom in standards, …). Additionally, it is emphasised that domestic supply chains are not necessarily better in terms of 'robustness' or 'resilience', and the additional costs of extensive re-shoring can outweigh any perceived gains in terms of security of supply.

From a longer term perspective, however, the European Parliament (2021) discusses many aspects concerning the upcoming international order and rising geopolitical shifts that have become a topic in EU politics as well in the context of an 'EU (open) strategic autonomy' focusing on re-shoring potentials, particularly for critical supplies (e.g. pharmaceuticals or medical products), products of (technologically) strategic relevance (e.g. semiconductors), or products related to the green transformation (e.g. solar panels).[27]

3.3.2. Challenges for the 'new normal' and EU policies

In this context the contribution of this study to the discussion above is to highlight potential concentration and bottlenecks in global trade, enabling the distinction between 'risky' and 'non-risky' import flows and – as exemplified for the list of COVID-19 relevant products – stressing the importance of distinguishing imports in terms of the following dimensions, as well as the respective policy actions focussing on the medium to longer run, i.e. the 'new normal'. Policy debates might have to focus on these issues in the various dimensions as outlined in the following table:

Table 7 / Supply risk vs. necessity matrix

	Essential products/sectors	**Non-essential products/sectors**
Risky import flows	Focus on *robustness of GVCs* Debates about • Possibly re-shoring (Boxes 3 and 4) and/or stockpiling activities (Box 2) • Increase of supplier redundancy • Relevance of distance and length of supply chains	Focus on *resilience of GVCs* Debates about • Increase supplier redundancy • Relevance of distance and length of supply chains
Non-risky import flows	Focus on stable regulatory environment • Promotion of standards • Screening and stress tests for critical supply	Focus on stable regulatory environment

Source: own elaboration

In Chapter 2, we extended the methodology by KPD that is able to identify products that can be considered 'risky': e.g., products that tend to be exported by just a few exporting countries or products that may be hard to substitute with imports from another country. With this risk classification, we can separate risky from non-risky import flows, thus accounting for the row dimension in Table 7.

The question of how one identifies essential products or sectors can only be answered in view of political or economic considerations, and these are being discussed in the course of the debate on the 'EU open strategic autonomy'[28]. Currently, medical products such as personal protective equipment (PPE), certain drugs, oxygen and other auxiliary products[29] (such as needles, tubes, etc.) necessary in hospitals could be considered 'essential' by policy makers, but also long-term strategic considerations concerning dependency on specific products in high-technology areas. Possible additional economic considerations would pertain to the number of affected jobs or the percentage of value added that is attributed to (the

27 In this study detailed case studies are provided.

28 See e.g. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_645

29 The EU Commission published a list of products that, as of March 2020, can be imported duty-free because the EU Commission considers them as being essential for combatting the corona virus. For further information, see https://ec.europa.eu/taxation_customs/sites/taxation/files/03-04-2020-import-duties-vat-exemptions-on-importation-covid-19.pdf

exports of) a certain product or sector. The random walk centrality presented in Chapter 2 can also serve as an indicator of the ‘essentiality’ of an industry sector (in the global production network).

Box 2 provides an overview of the stockpiling strategy. When applied to the case of COVID-19 products (which currently we deem to be essential products) and according to our methodology, we would have 66 non-risky products and 32 risky products (see Table 3). Based on Table 7, we propose to use more (governmentally planned) stockpiling and/or consider trying to re-shore production of these 32 products. Similarly, for the 66 essential but non-risky products, our proposal is to undertake stress tests to help identify possible bottlenecks and advise firms (and institutions) importing those products to take precautions against supply disruptions.

The study commissioned by the European Parliament (European Parliament, 2021) highlights the challenges for re-shoring supply chains for medical equipment: as this product group contains very different products (from high-tech MRI scanners to cheap, single-use face masks), the technological knowledge needed for production, the market structure, etc. varies accordingly. There is thus no single solution that fits for all medical equipment products. As it unclear how long the pandemic will last (and what effects vaccination and mutations of the virus will have) it is also unclear if re-shored industries would remain economically viable should the infections subside.

Re-shoring is also the topic covered in Box 3. Based on our results from Chapter 2 and our classification in Table 7, re-shoring is a strategy that could be applied to high-tech products (as high-tech products make up a large share of risky products, see Table A.1) and high-tech sectors (from C26 ‘Manufacture of computer, electronic and optical products’ to C33 ‘Repair and installation of machinery and equipment’, as they show a high share of risky import flows, see Table 5). Both products and sectors can be considered essential as they include (respectively produce) products that are crucial, e.g., for the ongoing digitalisation of the economy or for the decarbonisation of the economy, thus making them prime candidates for re-shoring. The European Parliament (2021) includes case studies for semiconductors and solar panels, which both fall into the high-tech category.

However, it should also be emphasised that for a number of cases there are limits to such efforts which make the reorganisation of value chains challenging if not impossible (this is highlighted in Box 4 for the example of rare earth metals) thus calling for the maintenance of a stable regulatory and multilateral environment to keep disruptions minimal and assessable.

From a longer-term perspective three important trends need to be considered which are related to the issues of resilience or robustness of value chains and dependencies on strategic or critical goods: the ongoing Chinese catching-up process, the future of the world trading system and multilateralism, and re-shoring tendencies over the longer run that may be accelerated by the pandemic.

BOX 2 / ASSESSMENT OF STRATEGIC STOCKPILING

- **Description:** The EU Commission issued a statement on 19.3.2020[30] declaring that it will create a 'strategic stockpile' covering medical equipment such as ventilators, protective masks, vaccines and laboratory supplies. The goal of this rescEU stockpile is to 'support Member States facing shortages of equipment needed to treat infected patients'. The rescEU stockpile is part of the EU Civil Protection Mechanism and the EU Commission will cover 90% of the expenses for the procured goods. In August 2020, the EU dispatched rescEU masks to Croatia, Montenegro and North Macedonia while rescEU ventilators were sent to Czechia in October[31]. Rule (2020) identifies the shortcomings of the US approach to emergency stockpiling, citing e.g., the need to better account for the different rotatabilities[32] of the stockpiled supplies to keep the emergency stockpiles up-to-date and in ready-to-use condition. Products that can expire quickly should be stockpiled privately: Rule (2020) proposes to incentivise private stockpiling in these cases. Furthermore, it argues that governments should support the build-up of domestic supply chains for products that are the least rotatable, such that production of these products can be swiftly increased in case of a crisis.
- **Possible policies:** (i) Increase budget for emergency stockpiling; (ii) Provide an emergency health kit for households.
- **Policy area:** Governmental action.
- **Level:** National, though can be carried out by any level of federal government (Zivilschutz).
- **Feasibility:** This is already being done for some commodities (e.g., medical products), see the rescEU initiative mentioned below.
- **Potential achievement of targets:** Fall-back storage of essential goods (e.g. masks and medical equipment) to buffer supply shortages from abroad.
- **Potential difficulties:** Technological change might make inventories outdated. So, there is a necessity to monitor current developments of these stockpiled goods, to know when reserves should be consumed, and stocks replaced (with new, more advanced products).
- **Costs:** The costs of this strategy are easily estimable as the product costs and storage renting costs are known. Costs arising from monitoring and rotating the stock should also be budgeted.
- **Time frame:** Short term

30 "COVID-19: Commission creates first ever rescEU stockpile of medical equipment." European Commission. Accessed November 13, 2020. https://ec.europa.eu/commission/presscorner/detail/de/ip_20_476.

31 See https://ec.europa.eu/echo/news/more/306/5774_en

32 Rotatability depends on the degree to which a stockpile can be replaced or sold before the products diminish in value and quality.

BOX 3 / RE-SHORING VALUE CHAINS

- **Description:** Re-shoring is an ongoing trend, see Barbieri et al. (2018) for a recent overview of the state of literature.

The decision to re-shore is different from the decision to off-shore or, put another way, re-shoring is not just the reversal of off-shoring. The objective of off-shoring firm activities is often to reduce manufacturing costs. When a firm re-shores, it often seeks to increase product quality, decrease time to market (also more generally increasing market proximity) as well as increasing flexibility (Hilletofth et al. (2019), Dachs et al. (2019)). Re-shoring is sometimes also a consequence of misjudgements of previous location changes (Dachs et al. (2019)).

Furthermore, there are two more dimensions to consider. Whether or not a firm is likely to re-shore depends on (a) the industry sector and (b) the type of good it produces: high cost (and high-tech) product manufacturers are more likely to re-shore than low cost manufacturers, and final goods producers tend to re-shore more often than intermediate input producers (Dachs et al. (2019)). Raj-Reichert (2020) observes that a large portion of production in the fragmented electronics supply chains is often carried out by a few contract manufacturers, such as flex[33], jabil[34] and Foxconn[35]. flex and jabil already have manufacturing plants operating all over the world. Nevertheless, they faced supply-side constraints when the COVID-19 pandemic caused factory closures in China. In this setting, resilience can be met, e.g., at the factory-level (by maintaining multiple production locations).

Dachs, Kinkel and Jäger (2019) observe from a large sample of manufacturing firms that especially firms using 'Industry 4.0' technology do back-shore activities. Thus, domestic innovation policies can play an important role in firms' re-shoring decisions. Firms for which 3D printing (usually described by the more general term "additive manufacturing technologies") is a relevant production strategy find it easier to re-shore, according to a case study carried out by Fratocchi (2017).

- **Possible policies:** (i) Support of relocation costs: The Japanese government pays 70% of relocating costs for SMEs if they are producers of PPE or raw materials for drugs. (ii) Allowing for tax breaks (e.g., for a given number of years after relocation) is another possibility.
- **Policy area:** Re-shoring as a policy option can be undertaken at a national level, but it might be more worthwhile (for efficiency aspects) to organise it at the EU level.
- **Feasibility:** As re-shoring is a trend that is already happening, it is not a question of whether re-shoring is possible but rather if it can be fostered and accelerated. As stated in the description above, the decision to re-shore is firm-specific. Thus, it will take more research and policy evaluation to identify the cases in which a firm relocation is feasible.
- **Potential achievement of targets:** Increased re-shoring of firms and even whole supply chains to Austria or the EU.
- **Costs:** Relocation costs
- **Time frame:** Medium to long term

[33] See www.flex.com

[34] See www.jabil.com

[35] See www.foxconn.com

BOX 4 / RARE EARTH METALS[36]

› **Description:**

The definition of rare earth elements includes seventeen chemical elements which, despite their name, are not rare. They are, however, dispersed in the earths' crust and thus difficult to mine: Extracting the minerals from a deposit is an energy-intensive and environmentally damaging process and the subsequently needed refining requires extensive expertise, which is currently only abundant in China but scare elsewhere. The refined minerals are then often manufactured into permanent magnet synchronous generators (PMSG) which are used in many electronic devices (from mobile phones to electric vehicles (EVs) to wind turbines): A process which, again, is often done in China.

In sum, China controls 4/5 of the global mined supply of rare earths and dominates much of the refining and processing of the minerals. In 2010, prices for rare earths quadrupled when China abruptly cut its exports of rare earths. This move made clear the dependency of manufacturing firms and even whole industries in the industrialised countries on these materials: As China controls much of the supply chain producing EVs, the automotive sector in the 'manufacturing core' countries in the EU (Austria, Germany, and several CEE countries) is at risk of losing large parts of its market share should it miss the move to EVs.

China's ability to influence prices makes it too risky for private investors to invest in, e.g., a rare earths mine or processing plant (as China could just decrease prices to make it impossible for any potential entrant to operate profitably). Thus, setting up a rare earths supply chain will only work with substantial financial backing from a government, especially as there are high fixed costs and considerable uncertainty about the profitability of such an undertaking.

› **Policy options:**

(i) Developing a supply chain: The EU Commission created and subsidised the EURARE project with the goal of setting up a (prototype) value chain of rare earths that is exclusively based in EU Member States: There are test mining sites in Greenland, Sweden and Norway, extraction plants in Finland and refining plants in Finland and Germany. These are, however, only test sites and are still many years from actual industrial production of rare earth-based metals and magnets. Furthermore, as mining is potentially environmentally damaging, it will be a) challenging to convince the European public of the necessity to open mines on European soil and b) more expensive for mining companies as they must adapt the mining process to higher European environmental standards.

(ii) Substituting rare earths: The EU Commission is also supporting basic chemical research which aims to find elements that can potentially act as replacements for critical raw materials (CRM), such as rare earths elements, in manufacturing. Pavel et al. (2017) conclude that there exist viable substitution strategies for producing rare earth-free wind turbines. The adoption of these wind turbines depends however on the development of the price of rare earths.

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[36] See https://www.ft.com/content/5104d84d-a78f-4648-b695-bd7e14c135d6 and https://foreignpolicy.com/2020/05/25/china-trump-trade-supply-chain-rare-earth-minerals-mining-pandemic-tensions/ for an overview of this topic (accessed 16.1.2021)

(iii) Recycling rare earths: A further strategy to decrease dependency on rare earths could lie in better recycling of products that contain these materials and regaining some of the embedded materials. Recycling of such products is however still in its infancy and often requires additional materials and energy to be useful.

› **Policy area:** EU level
› **Feasibility:** All three policy options have a chance of success, but still require time and financial support throughout the process.
› **Time frame:** Long term

3.3.2.1. Future of multilateralism

A key issue is the future of the rules-based world trade system. During the Trump administration the US abandoned multilateralism and pursued an isolationist foreign and economic. It is yet to be seen how the US will behave under the new president Joe Biden. At the moment, US trade policy is straining international relations, both those with the EU and those with China. After the imposition of numerous punitive tariffs against China, an escalation of the trade dispute between the two countries was just barely prevented in January 2020 with the help of the so-called "Phase One" trade agreement. EU leaders were irritated by the US's decision not to allow exports of vaccines destined for the EU.

The future of global value chains also depends on the future of the multilateral trading system, anchored in the WTO, which is increasingly threatened with sinking into insignificance. At the same time, there is a global resurgence of nationalist and protectionist tendencies. This does not refer to the usual tension between open trade policy and active industrial policy, but to an actual shift in the orientation of the trade policies of the major players, especially the US, but also the EU and China. The study by the European Parliament (2021) also point out that “a decisive future re-shoring factor will be geopolitics”[37].

The EU is committed to free and fair trade but sends out ambivalent signals. On the one hand, the EU shows tireless commitment at the WTO level to make progress (despite de facto hopelessness) and continues to negotiate free trade agreements with partner states. On the other hand, however, it is clear that the EU's bilateral free trade ambitions have lost momentum (Grübler and Stöllinger, 2020) and that the numerous successes – the EU now has free trade agreements with 80 countries – have been joined by an increasing number of setbacks and breakdowns in negotiations.

In that sense, the EU itself is also in the process of adapting its trade policy strategy. Several aspects are worth mentioning here. First, the EU has already moved away from its approach of unilateral trade liberalisation (from which benefits were expected) if necessary and is increasingly relying on the principle of reciprocity. This can be seen, for example, in the 2017 reform of the EU's public procurement rules, according to which foreign companies can be excluded from public contracts in the EU's internal market if, conversely, EU companies are not granted access to public procurement in their home market. Even in the free trade agreements with developing countries, the Economic Partnership Agreements (EPAs), the principle of reciprocity applies.

[37] European Parliament (2021), p. 73

We see a stable multilateral framework built on trade rules as necessary prerequisite for increasing the resilience of supply chains for all kinds of products. Risky or non-risky, essential or non-essential products, a stable regulatory environment is an important prerequisite for stable trading relationships.

3.3.2.2. China's catching-up process

China's integration into the global economy is largely complete. China has achieved a systemically relevant role due to its acquired weight in world trade. After all, it is mainly thanks to China that the economic centre of gravity has shifted towards Asia (Quah, 2011). While the economic and technological catching-up process continues, China's importance as a trading partner, a target market for investments and increasingly also as a foreign direct investor, continues to grow. However, the investment activities of state-owned enterprises and companies close to the Chinese government are increasingly causing concern in the US and Europe. For example, China's numerous railway projects abroad, which are also being realised in Central and Eastern Europe as part of the "New Silk Road" (One Belt, One Road Initiative), are increasingly viewed with scepticism by Brussels and individual EU member states, as geopolitical interests are suspected of being behind them (see Bykova et al., 2018). In addition, the large market share of the Chinese tech-giant Huawei has caused a lot discussion in relation to the roll-out of the new 5G communication network. Rühlig and Björk (2020) argue that banning Huawei would at least reduce Europe's dependency on Chinese equipment, since arguments of increased network security in case of a ban are merely straw man arguments. They argue furthermore that the EU should diversify its supply chains for critical technological infrastructure, instead of striving for technological self-reliance. Increasing supplier redundancy is also a strategy we propose, especially for risky products.

Our results from Chapter 2 indicate that especially the Austrian high-tech sectors show high shares of risky products. Furthermore, they also show that imports from China in 2018, at 23.1% contained a large fraction of risky high-tech products.[38] Together, this implies that this trading relationship should be minutely monitored and analysed, and counteractive policy measures (such as diversification of supply chains) should be undertaken.[39]

However, dependence on Chinese exports is not confined to high-tech manufacturing sectors alone. Medical equipment products (whose demand has rocketed during the COVID-19 pandemic) are also often sourced from China. Thus not only private companies but also public institutions (such as health service providers) rely on products produced in the Far East. Supply disruption can then not only lead to production shutdowns but also to systemic failures and subsequently to public discontent. This has led policy makers to call for a 'decoupling' of the national economy from dependency on Chinese products[40].

Furthermore, China's ambitions in the context of the Silk Road project as well as the technology-oriented industrial strategy "Made in China 2025" mean that China is increasingly seen as a 'systemic rival' and

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38 High-tech products are products from HS groups 84 to 90. Imports from Czechia include with 23.2% slightly more risky high-tech products, but no imports of another top ten trading partner contain more than 20% risky high-tech products.

39 The EU member states have declared their intent to support and strengthen European value chains in the electronics and embedded systems industries: https://digital-strategy.ec.europa.eu/en/news/member-states-join-forces-european-initiative-processors-and-semiconductor-technologies

40 See, e.g., a report by the U.S. Chamber of Commerce: https://www.uschamber.com/sites/default/files/024001_us_china_decoupling_report_fin.pdf (accessed 21.4.2021)

less as a cooperation partner.[41] Even though the two parties have just signed the Comprehensive Agreement on Investment (CAI) there might be ongoing tensions in the background of the secular shifts in the world order and the geopolitical rivalry particularly between the US and China.

From an economic perspective there is every indication that China will be able to continue or even accelerate its impressive economic catching-up process. China's political system seems to have succeeded in containing the COVID-19 pandemic more effectively than western democracies, which is why China's economy did not come to a standstill in 2020. If we compare the GDP growth forecasts for the EU, China and other emerging markets, we see that while the COVID-19 pandemic reduced the growth difference between the EU and, e.g., Brazil and India, it increased the difference in growth rates between the EU and China. Thus, depending on the persistence of the effects of the COVID-19 pandemic, the catching-up processes of many emerging economies could slow down, while China could continue to develop comparatively dynamically.

3.3.2.3. Re-shoring tendencies and shortening of supply chains

International value chains are becoming more regional. Global value chains have always been primarily regional supply chains (Baldwin and Lopez-Gonzalez, 2015). Stöllinger et al. (2018) show that more than half of the EU's value chain-related trade contains exclusively value chain shares from EU countries, i.e. represent purely European value chains. From a European perspective re-shoring tendencies, e.g. the relocation of overseas production facilities to Europe, will also depend on incentive factors in possible target countries. These incentive systems of countries aiming for a higher degree of self-sufficiency could be designed more generously, at least in sectors classified as critical, such as medical equipment. In the EU, for example, the pharmaceutical industry is already calling for increased production of medicines in the EU, which is currently concentrated in China, India (and also Italy) (Fortunato, 2020). This is also intended to protect against the possibility of supply disruptions, e.g. from the imposition of export bans or natural disasters. Re-shoring can, however, lead to increasing costs and inefficiencies, as argued in OECD (2020).[42] Similarly, the European Parliament (2021) warns that “high expectations for re-shoring […] are unrealistic”[43] and further voices doubt that large scale re-shoring is going to happen.

The findings of Miroudot and Nordström (2019) indicate that the expansion of value chains already came to an end around 2011. Even though this could have been accelerated by the COVID-19 crisis, it is not because of it. There are other decisive influencing factors such as advancing digitalisation (Fortunato, 2020) that play a role here. A study of Austria, Germany and Switzerland showed that there is a positive correlation between the equipment of companies with digital technologies and the re-shoring of previously outsourced production processes (Dachs et al., 2019). In general, however, re-shoring is still a relatively rare phenomenon. Nevertheless, companies will continue to relocate parts of their business abroad. This trend could even be reinforced by the fact that companies want to serve these – possibly faster-growing – markets, but also that COVID-19-related sales and profit losses will force companies to make further cost savings. Thus, re-shoring, actively supported by countries (as already done by the UK in "Reshoring-

41 See https://ecfr.eu/publication/the_meaning_of_systemic_rivalry_europe_and_china_beyond_the_pandemic/ for an outlook of the EU-China relationship (accessed 4.4.2021).

42 According to the smile curve (see Stöllinger (2019)), companies have outsourced or offshored those parts of the production process that contains the lowest share of value added: manufacturing.

43 See European Parlament (2021), p.73

UK"), and off-shoring activities will likely continue in parallel. What could change is the relative strength of these two opposing trends, with more of a shift in favour of the former (see also Fortunato, 2020).

3.4. CONCLUSIONS

In Chapter 2 we applied the methodology of KPD to identify risky products and industry sectors that heavily rely on imports of such risky products. We find that high-tech sectors (the manufacturing of computers, electrical equipment, machinery, motor vehicles, etc.) are especially exposed as (i) their imports contain a large share of risky products, (ii) they are relatively central in the global production network and (iii) they show high backward linkages.

In the discussions in Chapter 3 we have outlined ongoing and future developments that may be especially relevant for the high-tech sectors: The dependence of the high-tech sectors on imports from China should be carefully monitored and attempts should be made to reduce it. The re-shoring of strategically important manufacturing (e.g. inputs to high-tech sectors or medical equipment) should be supported where possible and economically viable. In the face of geopolitical changes, trade flows of strategically important products (such as rare earths, which are important inputs to high-tech manufacturing processes) can face the risk of being subject to geopolitical tactics. Increasing supplier redundancy for these products means to decrease the dependency on a partner and thus to mitigate the risk that trade flows of these products are used as a political instrument.

Thus there are several overlapping challenges at work here:

› increase the resilience and robustness of global value chains,

› enhance competitiveness in industries and products which are deemed to be strategically (e.g. to gain or maintain leadership in key future technologies) or systemically (e.g. public concerns such as the provision of health services) important

These challenges go far beyond the narrow scope of trade policy alone: a combination of industrial policy, international diplomacy and trade policy is needed here. We see the role of trade policy mainly in providing a stable regulatory environment. Beyond that, in the longer run, the EU's aim of 'open strategic autonomy' (which after the pandemic may include additional aspects and products) needs to be filled with life. But it remains to be seen how exactly the EU's 'open strategic autonomy' (European Parliament, 2021) will be shaped and to what extent it will contain protectionist elements. In principle, however, the concept of 'open strategic autonomy' aims to secure the advantages of free trade while offering European companies protection against unfair trade practices. It is seen as a tool for stabilising strategic engagement with key trading partners in line with our values, interests, and objectives. It is also intended to expand existing relationships and help forge new alliances with like-minded states. Explicit mention is made of transatlantic relations and the relationship with China, which – as mentioned – is seen not only as a cooperation partner but also as a systemic rival.

By focussing on the dimensions of (i) risky versus non-risky products and (ii) essential versus non-essential products governments should aim to ensure *robust* GVCs particularly for risky and essential products and *resilient* GVCs for risky and non-essential products. Yet the boundaries within these two dimensions are blurred, such that robust GVCs may also be advisable for some essential but non-risky products. Robustness and resilience can, for example, be achieved by providing information on potential concentration and bottlenecks along GVCs, urging stress tests for value chains in these categories, or engaging in strategic stockpiling of such products. From a longer-term policy-perspective – i.e. the return to a 'new normal', in the context of the debated 'open strategic autonomy' or other geopolitical considerations – the results highlight two main points, which have actually been evident for some time: (i) the EU-27's dependency on imports of higher-tech products (of which parts are classified as 'risky' according to the results of our approach) and the dependency especially of the higher-tech industries on them, and (ii) from a geographical and geopolitical perspective, the importance of China and 'factory Asia' for these. For such structural dependencies, policies that enable the re-shoring of essential products (e.g. of pharmaceutical production or certain medical products) or for products of strategic importance in terms of technology and long-term competitiveness within the regulatory environment concerning multilateral trade and investments, are important. This should be in line with several EU policy agendas including the EU Industrial Policy, the European Green Deal, and the EU Digital Agenda and should be compatible with the EU's long-term budget plans coupled with NextGenerationEU as the largest stimulus package ever financed through the EU budget.

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Appendix

A.1 TABLES

Table A.1 / Non-risky and risky products by HS 2-digit

HS96 2-digit description (shortened)	Non-risky products	Risky products
01 Live animals	15	0
02 Meat and edible meat offal	10	0
03 Fish & crustacean, molluscs & other aquatic invertebrate	1	0
04 Dairy prod; birds' eggs; natural honey; edible prod n.e.s	7	0
05 Products of animal origin, n.e.s or included	15	0
06 Live tree & other plant; bulb, root; cut flowers	8	1
07 Edible vegetables and certain roots and tubers	1	0
08 Edible fruit and nuts; peel of citrus fruit or melons	5	0
09 Coffee, tea, mate and spices	2	0
10 Cereals	14	0
11 Prod. milling industry; malt; starches; inulin; wheat gluten	20	0
12 Oil seed, oleaginous fruits; miscellaneous grain, seed, fruit	35	1
13 Lac; gums, resins & other vegetable saps & extracts	10	0
14 Vegetable plaiting materials; vegetable products n.e.s	5	0
15 Animal/veg fats & oils & their cleavage products	35	0
16 Prep of meat, fish or crustaceans, molluscs	1	0
17 Sugars and sugar confectionery	12	0
18 Cocoa and cocoa preparations	7	0
19 Prep. of cereal, flour, starch/milk; pastry cooks' prod	2	0
21 Miscellaneous edible preparations	3	0
22 Beverages, spirits and vinegar	3	0
23 Residues & waste from the food industry; prepared animal fodder	20	1
24 Tobacco and manufactured tobacco substitutes	4	0
25 Salt; sulphur; earth & stone; plastering mat; lime & cement	67	0
26 Ores, slag and ash	31	0
27 Mineral fuels, oils & product of their distillation	38	0
28 Inorganic chemicals; compounds of precious metal, radioactive elements	154	1
29 Organic chemicals	283	1
30 Pharmaceutical products	15	4
31 Fertilisers	23	0
32 Tanning/dyeing extract; tannins & derivatives; pigments	34	8
33 Essential oils & resinoids; perf, cosmetic/toilet prep	8	2
34 Soap, organic surface-active agents, washing prep	6	6
35 Albuminoidal subs; modified starches; glues; enzymes	11	3
36 Explosives; pyrotechnic prod; matches; pyrophoric alloy	6	0
37 Photographic or cinematographic goods	25	2
38 Miscellaneous chemical products	46	7
39 Plastics and articles	90	27
40 Rubber and articles	51	13

(contd.)

Table A.1 (contd.) / Non-risky and risky products by HS 2-digit

HS96 2-digit description (shortened)	Non-risky products	Risky products
41 Raw hides and skins (other than furskins) and leather	21	1
43 Furskins and artificial fur; manufactures	9	0
44 Wood and articles of wood; wood charcoal	53	1
45 Cork and articles of cork	7	0
47 Pulp of wood/of other fibrous cellulosic mat; waste	20	0
48 Paper & paperboard; art of paper pulp	73	8
49 Printed books, newspapers, pictures & other product	3	2
50 Silk	8	0
51 Wool, fine/coarse animal hair, horsehair yarn & fabric	34	0
52 Cotton	121	0
53 Other vegetable textile fibres; paper yarn & woven fabrics	23	0
54 Man-made filaments	59	4
55 Man-made staple fibres	101	1
56 Wadding, felt & nonwoven; yarns; twine, cordage	30	0
58 Special woven fabrics; tufted textile fabrics; lace; tapestries	35	2
59 Impregnated, coated, cover/laminated textile fabric	19	3
60 Knitted or crocheted fabrics	15	2
63 Other made up textile articles; sets; worn clothing	10	1
65 Headgear and parts	3	0
66 Umbrellas, walking-sticks, seat-sticks, whips	2	0
67 Prepared feathers & down; artificial flowers; articles of human hair	3	1
68 Articles of stone, plaster, cement, asbestos, mica	37	8
69 Ceramic products	21	3
70 Glass and glassware	51	3
71 Natural/cultured pearls, precious stones & metals, coin	8	0
72 Iron and steel	167	0
73 Articles of iron or steel	83	21
74 Copper and articles	47	2
75 Nickel and articles	17	0
76 Aluminium and articles	32	2
78 Lead and articles	8	0
79 Zinc and articles	9	0
80 Tin and articles	5	0
81 Other base metals; cermet; articles	33	0
82 Tool, implement, cutlery, spoon & fork, of base metal	35	13
83 Miscellaneous articles of base metal	22	11
84 Nuclear reactors, boilers, machinery & mechanical appliance; parts	328	147
85 Electrical machinery and equipment and parts thereof; sound recorder	125	86
86 Railway/tramway locomotives, rolling stock & parts	23	0
87 Vehicles other than railway/tramway roll-stock, parts & accessories	53	20
88 Aircraft, spacecraft, and parts	13	1
89 Ships, boats, and floating structures	17	0
90 Optical, photo- and cinematographic, measuring, checking, precision instruments	71	57
92 Musical instruments; parts and access of such articles	5	0
93 Arms and ammunition; parts and accessories	11	0
94 Furniture; bedding, mattress, matt support, cushion	7	12
95 Toys, games & sports requisites; parts & access	1	2
96 Miscellaneous manufactured articles	18	3

Source: wiiw calculations.

Table A.2 / WIOD industries

WIOD 2016 industry code	Industry description
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying of coal, petroleum extraction
C10-C12	Manufacture of food, beverages, tobacco products
C13-C15	Manufacture of textiles, wearing apparel, leather
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply
E36	Water collection, treatment and supply
E37-E39	Sewerage, waste collection and disposal activities, waste management
F	Construction of buildings, civil engineering
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities
I	Accommodation and food and beverage service activities
J58	Publishing activities
J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; Programming and broadcasting activities
J61	Telecommunications
J62_J63	Computer programming, consultancy and related activities; Information service activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance, reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities
L68	Real estate activities
M69_M70	Legal and accounting activities; Activities of head offices; management consultancy activities
M71	Architectural and engineering activities; technical testing and analysis

(contd.)

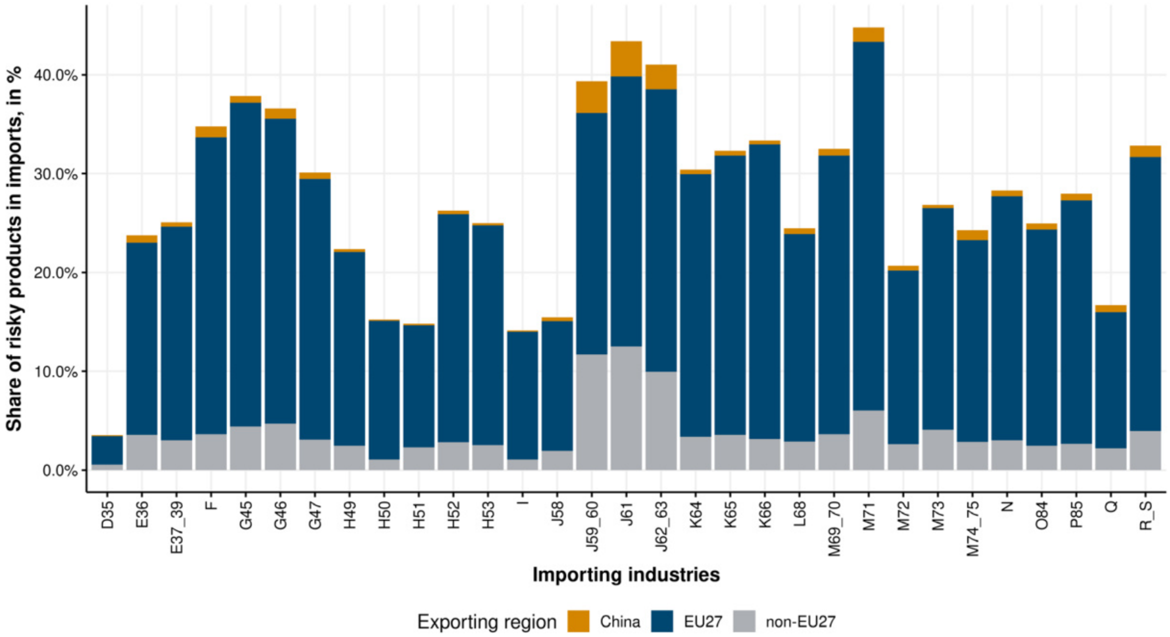
Table A.2 (contd.) / WIOD industries

WIOD 2016 industry code	Industry description
M72	Scientific research and development
M73	Advertising and market research
M74_M75	Other professional, scientific and technical activities; Veterinary activities
N	Rental and leasing activities; employment activities, travel agency, security and investigation; building and landscape activities; office administration
O84	Public administration and defence; compulsory social security
P85	Education
Q	Human health activities; Residential care activities; Social work activities without accommodation
R_S	Creative, arts and entertainment activities; Libraries, archives, museums and other cultural activities; Gambling; Sports activities; repair of computers and household goods; other personal activities
T	Activities of households as employers of domestic personnel
U	Activities of extraterritorial organisations and bodies

Source: WIOD.

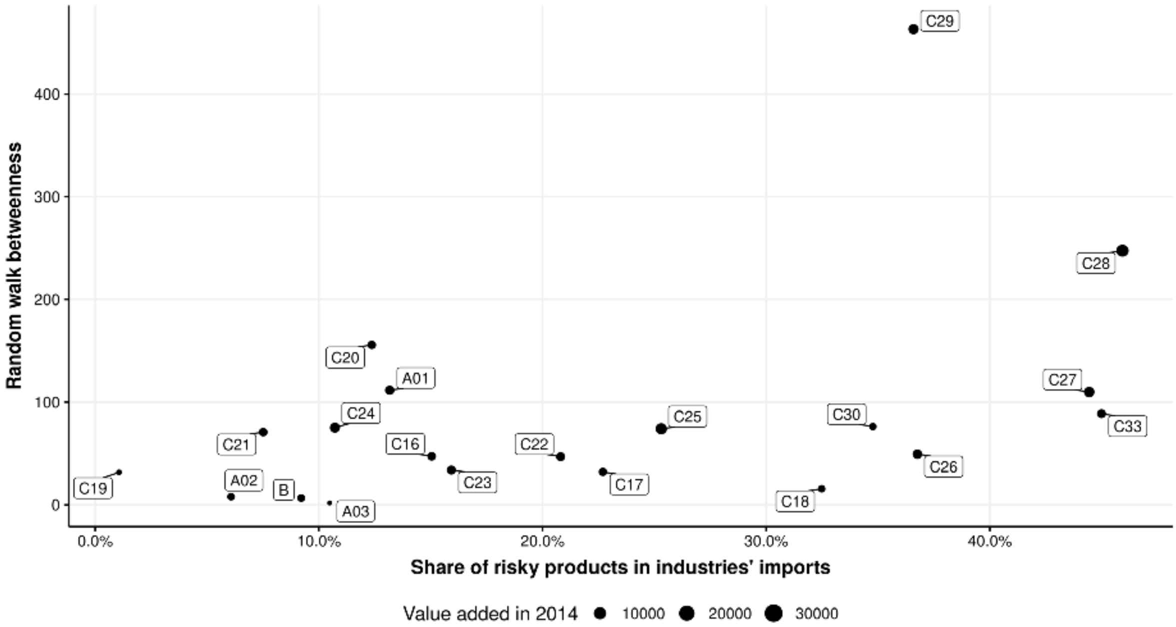
A.2 GRAPHS

Figure A.1 / Austria, 2014: Share of risky imports in using industries' imports and selected partner country, service industries



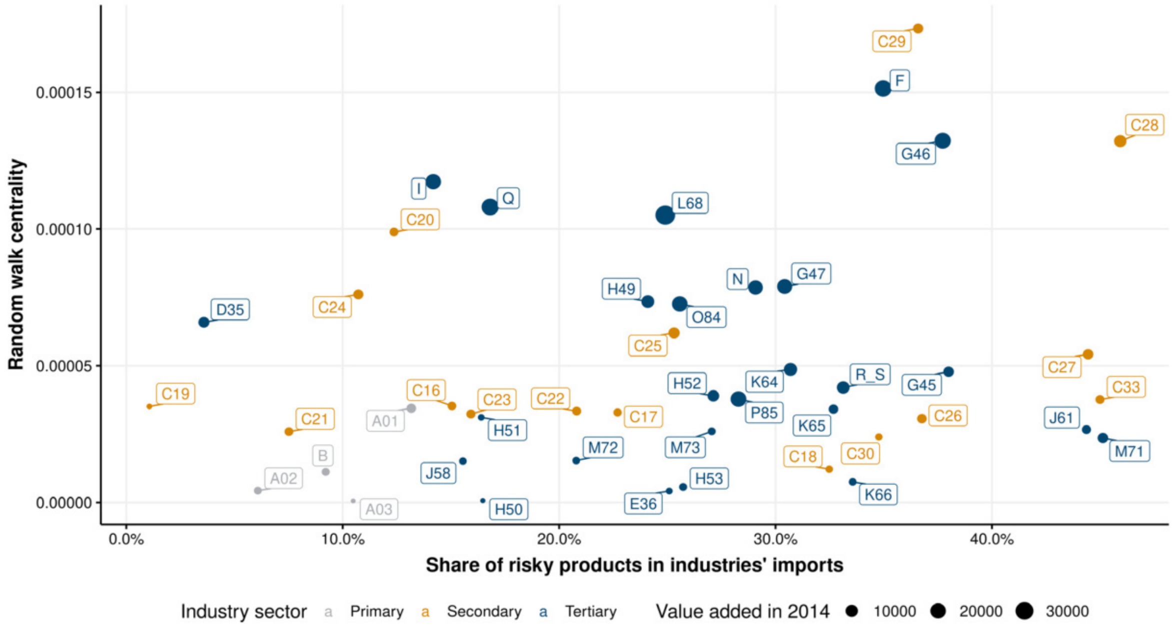
Source: BACI and WIOD, wiiw calculation.

Figure A.2 / Random walk betweenness and share of risky products in Austria, 2014



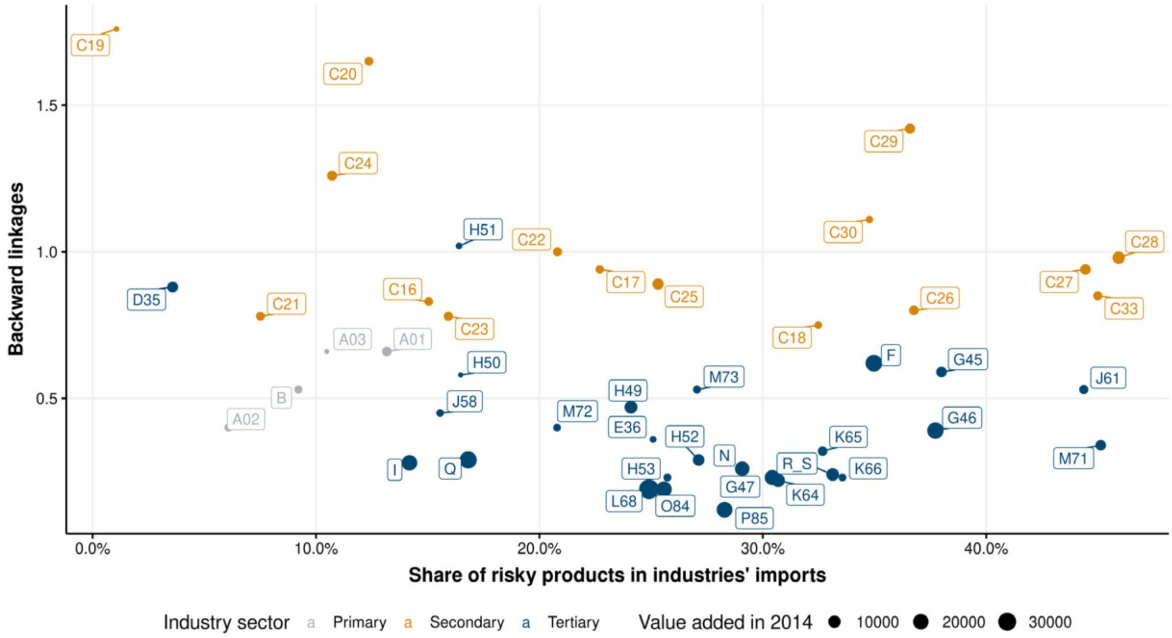
Note: The computation of random walk betweenness was restricted to the agriculture, mining and manufacturing sectors as a computation including all 56 sectors in the WIOD would have been too time-expensive.
Source: BACI and WIOD, wiiw calculation.

Figure A.3 / Random walk centrality and share of risky products in Austria, all industries, 2014



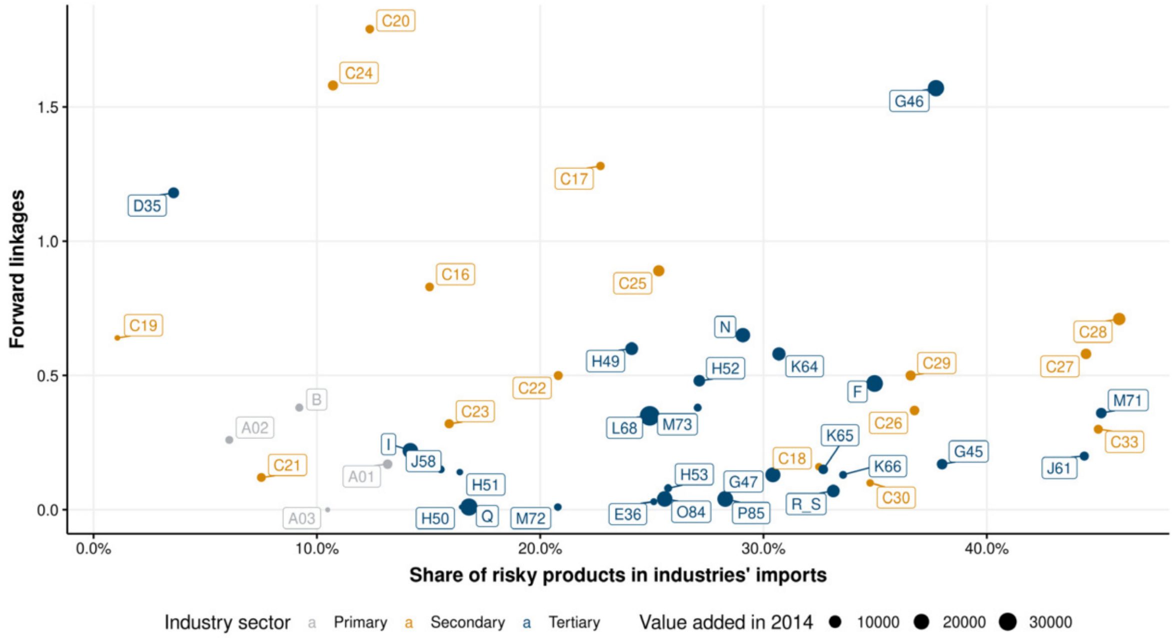
Source: BACI and WIOD, wiiw calculation.

Figure A.4 / Backward linkages and share of risky products in Austria, all industries, 2014



Source: BACI and WIOD, wiiw calculation.

Figure A.5 / Forward linkages and share of risky products in Austria, all industries, 2014



Source: BACI and WIOD, wiiw calculation.

IMPRESSUM

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