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Efficiency and risks in global
value chains in the context
of COVID-19

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EFFICIENCY AND RISKS IN GLOBAL VALUE CHAINS IN THE CONTEXT OF COVID-19

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By Christine Arriola, Sophie Guilloux-Nefussi, Seung-Hee Koh, Przemyslaw Kowalski, Elena Rusticelli and Frank Van Tongeren

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ABSTRACT/RÉSUMÉ

Efficiency and risks in global value chains in the context of COVID-19

The COVID-19 outbreak and the resulting disruptions in supply chains of some manufacturing and medical products have renewed the debate on costs and benefits of globalisation and, particularly, on risks associated with international fragmentation of production in global value chains (GVCs). While GVCs helped addressing supply shortages in several cases already during the early stages of the COVID-19 pandemic, much of the policy debate has concentrated on whether the gains from expanding international specialisation in GVCs are worth the associated risks of transmission of shocks and even whether governments should use policy tools to 're-localise' GVCs. But re-localising may also mean less diversification and thereby limit the scope for cushioning shocks. This paper builds on on-going OECD analysis and aims at providing empirical evidence to inform and guide discussion on these questions. First, it reviews briefly the key issues and lessons learnt from the past, and identifies the main features of world trade and GVC participation that influence exposures to risks in supply chains. Subsequently, it presents key results of a set of economic model simulations conducted using the OECD's computable general equilibrium (CGE) trade model METRO to shed light on the consequences of a stylised re-localisation policy scenario. In this scenario, countries are less exposed to foreign shocks, but they are also less efficient and less able to cushion shocks through trade. Quantitatively, the latter effect tends to dominate: re-localising GVCs would make the economy in most countries both less efficient and less stable. The economic case for policy-induced reshoring of GVCs is therefore weak. There is nevertheless scope for governments to join efforts with businesses to improve risk preparedness.

JEL classification codes: F13, F23, F60.

Keywords: trade, global value chains, shocks, diversification, relocalisation

Efficacité et risques dans les chaînes de valeur mondiales à l'heure du COVID-19

L'épidémie de COVID-19 et les perturbations qui en ont résulté dans les chaînes d'approvisionnement de certains produits manufacturés et médicaux ont relancé le débat sur les coûts et les bénéfices de la mondialisation et, en particulier, sur les risques associés à la fragmentation internationale de la production dans des chaînes de valeur mondiales (CVM). Bien qu'au début de la pandémie, les CVM ont souvent permis de remédier aux pénuries d'approvisionnement, le débat politique s'est pourtant largement intéressé à la question de savoir si les avantages d'une spécialisation internationale grandissante dans les CVM valaient les risques de transmission de chocs associés, et sur l'opportunité pour les gouvernements de mettre en œuvre des politiques visant à "relocaliser" les CVM. Toutefois, la relocalisation peut aussi signifier une moindre diversification et donc moins de possibilités pour amortir les chocs. Ce document s'appuie sur les analyses en cours de l'OCDE et vise à fournir des éléments empiriques pour informer et guider le débat sur ces questions. Tout d'abord, il passe brièvement en revue les questions centrales et les enseignements tirés du passé, et identifie les principales caractéristiques du commerce mondial et des CVM qui influent sur l'exposition aux risques dans les chaînes d'approvisionnement. Ensuite, il présente les principaux résultats d'une série de simulations économiques réalisées à l'aide du modèle commercial d'équilibre général de l'OCDE, METRO, afin de mettre en lumière les conséquences d'un scénario avec une politique de relocalisation. Dans ce scénario, les économies sont moins exposées aux chocs étrangers, mais elles sont également moins efficaces et moins capables d'amortir les chocs par le biais du commerce. Quantitativement, ce dernier effet tend à dominer : la relocalisation des CVM rendrait l'économie de la plupart des pays à la fois moins efficace et moins stable. Les arguments économiques en faveur de politiques visant à rapatrier les CVM sont donc peu fondés. Il est néanmoins possible pour les gouvernements de joindre leurs efforts à ceux des entreprises pour être mieux préparés face aux risques.

Classification JEL : F13, F23, F60

Mots clés : commerce, chaînes de valeur, chocs, diversification, relocalisation

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By Christine Arriola, Sophie Guilloux-Nefussi, Seung-Hee Koh, Przemyslaw Kowalski, Elena Rusticelli, Frank Van Tongeren¹

1. Introduction and main findings

1. The COVID-19 outbreak has renewed the debate on costs and benefits of globalisation and, more specifically, on risks associated with international fragmentation of production. Disruption in the supply chains of few essential goods and shortages of key medical products have highlighted the interconnectedness between countries through global value chains (GVCs).

2. The efficiency gains stemming from GVCs are well-established. However, questions are being raised about whether the gains from deepening and expanding international specialisation in GVCs are worth the allegedly associated risks and instability.² Some claim that more localised production would provide greater security against disruptions that can lead to shortages in supply and high uncertainty for consumers and businesses, thus calling for reshoring GVCs or at least rethinking their organisation. But reshoring also means less diversification, which limits the scope for cushioning shocks, particularly those that may originate domestically. In addition, firms' assessments on risk mitigation and efficiency in GVCs may be different from those of governments, as are their tools to manage them. While firms manage supply chains on a day-to-day basis and may be more concerned about the financial costs of supply chain shocks and their ability to recover from them (i.e. resilience), governments may be concerned about a broader range of economic and social effects of such shocks and set broader policy incentive frameworks.

3. As the discussion about pros and cons of re-localisation of value chains intensifies, there is little empirical analysis quantifying costs and benefits associated with different policy options.³ This paper builds on on-going OECD analysis and aims at providing empirical evidence to inform and guide discussion on these questions.

4. First, it reviews briefly the key issues and lessons learnt from the past (Section 2), and identifies the main features of world trade and GVC participation that influence exposures to risks in supply chains

¹ Christine Arriola, Przemyslaw Kowalski and Frank Van Tongeren are members of the OECD's Trade and Agriculture Directorate. Sophie Guilloux-Nefussi, Seung-Hee Koh and Elena Rusticelli are members of the OECD's Economics Department. The authors would like to thank Laurence Boone, Luiz de Mello, Alain de Serres, Marion Jansen, Ken Ash, Julia Nielson, colleagues from the Economics Department and the Trade and Agriculture Directorate, participants at the: October 2020 Working Party No. 1 meeting of the OECD Economic Policy Committee; October 2020 meeting of the Working Party of the OECD Trade Committee; OECD Applied Economics WIP seminar and at the Banque de France "séminaire compétitivité" for useful comments and suggestions. Special thanks go to Sjef Ederveen and Noémie Lisack for their discussion of the paper. Many thanks also go to Veronica Humi and Isabelle Fakih for timely editorial assistance.

² Sustainability of international supply chains entails more than an ability to react to and recover from shocks, and covers dimensions such as environmental and social impacts, national security or security of supply concerns, which are highly important, but are not covered in this analysis.

³ Two recent studies, Bonadio et al. (2020) and Camatte et al. (2020), quantify the economic impacts of supply and demand shocks due to COVID-19 pandemic but they do not consider the balance of costs and benefits of GVCs in the face of economic shocks.

using detailed gross trade data as well as indicators derived from the OECD Inter-Country Input-Output data (Section 3). The results of this part of the analysis suggest that multiple features of GVCs that matter for production efficiency also determine the exposure to shocks and the propagation of these shocks along the chain. A high reliance of sales on foreign demand and high dependence on foreign value added in production govern respectively the exposure to foreign demand and supply shocks. High centrality of some "hubs" in GVC networks may magnify shock propagation, while these hubs are also key in driving the benefits from GVCs, especially knowledge spillovers. Concentration of suppliers or clients makes some firms and supply chains vulnerable to shocks although this is also often related to comparative advantage and specialisation. Finally, diversification of economic linkages across different partners which is another key feature of GVC integration, can also provide insurance against both foreign and domestic shocks

5. Subsequently, the paper presents key results of a set of economic model simulations conducted using the OECD's computable general equilibrium (CGE) trade model METRO (Section 4). The simulations are designed to serve as a stylised quantitative illustration of the purported trade-off between efficiency and risk management in GVCs. The model accounts for most of the characteristics of GVC participation and exposure to shocks. In addition, it enables a consistent comparison of the level (efficiency) and stability of macroeconomic variables in 22 countries or regions (referred to jointly as 'countries' afterwards⁴) exposed to a set of trade cost shocks similar in nature to the ones observed during the early stages of the COVID-19 pandemic under two GVC regimes: "interconnected" and "localised" economies. The localised regime, where economies are less interconnected via GVCs due to a combination of higher import tariffs, subsidies to domestic production and less flexible sourcing possibilities in GVCs, has significantly lower levels of economic activity and lower incomes. Furthermore, the localised regime is also found to be more - not less - vulnerable to shocks, as shown by greater instability of key economic variables such as real GDP. The majority of countries are better off in the interconnected regime, both in terms of levels and stability of economic activity. Some countries could be more sheltered from shocks in the localised regime but these are also the countries that tend to draw the largest benefits from GVC participation and the 'price' to pay for such stability is relatively high.

6. The empirical analysis suggest that the economic case for significantly re-localising GVCs is weak, while pointing to benefits of a range of other ways in which governments can join efforts with businesses to improve risk preparedness, particularly in what could be considered essential 'supply chains'. Possible government policy options include: mapping the local and international players involved in different segments of such chains to identify the range of potential threats; developing stress tests; calibrating stockpiles of essential goods; and, more generally, facilitating the functioning of supply chains, for example, by introduction of simplified procedures, reducing unnecessary heterogeneity of norms and standards and reviewing transport, logistics and border process regulations to enable flexible responses to disruptions.

⁴ When referring to the modelling results, 'countries' can refer to individual countries or groups of countries (regions) which have been aggregated together for computational and presentational reasons.

2. Efficiency and risks in GVCs: key issues and past lessons

2.1. GVCs generate significant gains for firms but can also increase risk exposure

7. GVCs generate significant economic gains to both participating firms and countries that host GVC activities (e.g. OECD, 2013). The geographical separation of tasks and business functions in GVCs enabled by the reduction of trade and information and communication costs, and led by efficiency-seeking and risk-managing companies, has allowed yet finer specialisation, greater economies of scale and thus productivity gains for GVC participants (Baldwin, 2012) as well as lower production prices (Andrews, Gal and Witheridge, 2018). GVCs have also created new opportunities for smaller firms and participants from emerging-market economies and developing countries as they no longer have to master all the stages of complex production processes in order to participate in the global economy. This has benefitted companies employing advanced technologies and opened new possibilities of technology and know-how transfer to developing economies, offering them an opportunity to grow and catch up with their more developed peers (World Bank, 2019). More generally, at the country level, GVC participation brings cheaper goods and services, and favours new growth and wellbeing opportunities.

8. In terms of risk exposure, firms operating in highly interconnected and complex value chains face higher probability of disruptions since each partner in the network can potentially be hit by a shock from abroad. However, higher risk exposure does not necessarily translate into higher economic losses. Firms' GVC participation can also support their ability to mitigate the effects of external and internal shocks thanks to greater diversification. Beyond diversification, firms can build resilience by investing in developing specific capabilities to absorb shocks (flexibility, agility, visibility, collaboration, etc.).

2.2. The COVID-19 outbreak occurred in a context of slowing GVC expansion

9. Approximated by the share of intermediate goods and services in world trade, GVC participation grew rapidly over the 1990s and 2000s (Figure 1, Panel A). Many factors contributed to the rise of GVCs, including trade liberalisation, reduction in transport costs (thanks to containerisation), reductions in information and communication costs, and China's accession to the WTO. However, over the past ten years, the expansion of GVCs has slowed and trade of intermediate products has accounted for about half of world trade since then. Structural forces can partly explain the plateauing of the GVC expansion. The increases in emerging market economies' wages, digitalisation and the increased service orientation of the economy (with a growing content of services embedded in goods) might have partly contributed to tempering off-shoring of production activities. Consumer preferences for more sustainable production patterns and fluctuations in transportation costs might also have prompted firms to locate production closer to the consumer. However, the rise in trade tensions and protectionism, and, indeed, unpredictable supply chain disruptions over the past decade, also contributed to weaken GVCs growth (Figure 1, Panel B).⁵

10. The COVID-19 outbreak occurred in this context of the plateauing of GVC expansion, and growing protectionist and anti-globalisation sentiments around the world, in the recent years. However, there were also some differences across countries. China, Japan and the United States have experienced some of the largest declines in GVC participation in the past decade while the European Union and Korea deepened their integration further (Figure 1, Panel B).

⁵ See [OECD Policy Responses to Coronavirus \(COVID-19\)](#), *COVID-19 and global value chains: Policy options to build more resilient production networks*, June 2020 and McKinsey (2020).

Figure 1. Trade growth in intermediate goods and services has been slowing or receding over the past decade

Note: Following Haugh et al. (2016), the GVC indicator is computed as the ratio of intermediate goods imports to final domestic demand. The structural GVC indicator is the same index corrected for trade price fluctuations and business cycle movements. Dynamic Asia includes Hong Kong (China), Chinese Taipei, Singapore, Malaysia, the Philippines, Thailand and Viet Nam. European Union corresponds to the weighted average of the index value across the 27 member states, where the weights are represented by the share of nominal imports of goods and services in 2019.

Source: OECD Economic Outlook 106 database; OECD Structural Analysis database; and OECD calculations.

2.3. Economic effects of the COVID-19 pandemic have renewed questions about the resilience and vulnerabilities of GVCs and prompted policy reaction

11. The economic effects of the COVID-19 pandemic have renewed debate on how certain features of GVCs can lead to the propagation of economic shocks across different industries and geographical locations, as well as the role they play in managing these shocks (OECD, 2020a; McKinsey, 2020).⁶ The risks associated with GVCs were first revealed in the first phase of the pandemic, in early 2020, when the public health situation in China resulted in lockdowns. Most global manufacturers have some operations in China and many businesses reported disturbances to production and trade from this important GVC participant. However, while it is sometimes difficult to distinguish between demand and supply disruptions and while the effects of the crisis continue to unfold, it seems that some of these disruptions have proven to be temporary. For example, Chinese exports of medical products have rebounded, GVCs in the electronics or machinery industries have continued to operate during the COVID-19 crisis (although on a smaller scale).⁷ GVCs in the food industry have also proven to be quite robust, with only some bottlenecks observed, and those mostly in the domestic part of value chains such as domestic processing and retail distribution.⁸

⁶ Resilience and vulnerabilities of GVCs to unpredictable shocks were already debated in the aftermath of previous disruptions, particularly after Japan's Fukushima disaster and Thailand's floods in 2011 (McKinsey, 2020).

⁷ See OECD (2020a) for a description of the production of smartphones. Apple launched a new model (the iPhone SE) in April 2020, which was sold mostly on-line and then four new iPhone 12 models in the fall of 2020, with production delayed by only one month. Its main competitor, Samsung, reported not having any meaningful production disruptions.

⁸ See OECD (2020b).

12. Shortages of supply in personal protective equipment (PPE) as well as key respiratory medical devices, such as ventilators, have raised greater concerns. Importantly, the global shortage in medical devices stemmed from the unprecedented demand shock induced by the spread of the pandemic to the world, rather than from the supply side. In that respect, GVCs have helped countries alleviate pressures on demand for essential supplies.⁹ The shortage in facemasks, for instance, was addressed by China ramping up its production to supply countries in need.

13. Foreign trade and investment policy responses to the COVID-19 crisis have so far also been mixed: while some countries initially restricted trade in medical supplies or components used to produce them, other countries introduced trade-liberalising measures and used GVCs to quickly react to the health crisis (OECD, 2020a; Global Trade Alert, 2020). Foreign direct investment regulations on the other hand have been made more restrictive in a number of countries and several countries have extended various forms of financial support to their national companies, including through equity-related instruments, resulting in increased role of the state in business, particularly in industries considered of national security importance (OECD, 2020d).

2.4. Lessons from past crises so far do not point to GVCs being a weakness but rather a strength

14. The lessons from the COVID-19 crisis and other recent cases of supply chain disruptions so far do not unequivocally point to GVCs being a weakness but rather a strength in adjusting to shocks inherent in the global economy. Instead, they seem to suggest that the impact of disruptions depends on their nature, on characteristics of the supply chains considered as well as on location of particular actors within a supply chain (OECD, 2020a; McKinsey, 2020, Méjean, Martinez and Gerschel, 2020). Yet, broad questions continue being raised about whether the gains from deepening and expanding international specialisation in GVCs are worth the associated risks, and whether more localised production would provide greater security against disruptions that can lead to shortages in supply and greater uncertainty for consumers and businesses (e.g. OECD, 2020c).

15. Some have suggested that there might be a need to rethink GVCs by making them more domestic or regional, shifting them to less risky locations, or diversifying their supplier base (e.g. Javorcik, 2020). At the same time, others argue that the interconnected nature of GVCs limits the economic case for large-scale changes in their physical location (McKinsey, 2020). Many multinational enterprises have started reassessing risks in their supply chain. Some companies had initiated this even before the COVID-19 outbreak in the face of other shocks, including natural disasters, political risks and terrorist attacks, and the trend might be spreading more broadly now.¹⁰ It is, however, too early to tell to what extent this risk-management reappraisal will ultimately result in re-shoring or diversification of supply sources.

3. Which features of GVCs can influence the exposure to risks?

16. Different sets of indicators offer complementary insights into the sources of exposure to shocks in GVCs or the propagation mechanisms. The analysis of highly disaggregated trade data allows capturing potential bottlenecks due to high concentration of suppliers or clients at the very granular product level. To

⁹ For example, several countries ramped up orders of foreign intermediate and final products as well as services to address the public health situation. Korea, for example, drew on GVCs to quickly step up production of medical test kits used during the pandemic (OECD, 2020a).

¹⁰ See McKinsey (2020).

identify which part of value added is created in the exporting country and which part is imported from abroad, supplementary indicators from inter-country input-output tables show the origin and destination of international trade flows in value-added. These statistical measures can be used to characterise some of the features of GVCs that matter for risk exposure and transmission of shocks.¹¹ A general equilibrium modelling in turn adds a layer of economic mechanisms and embeds these complex trading relationships in a consistent analytical framework (Section 4).

3.1. The degree of concentration can amplify or dampen international shocks

17. Supply chains characterised by low diversity of suppliers or buyers can increase the probability of disruption and can magnify the propagation of shocks. For example, for some parts of line telephone equipment (product 851790 in the harmonized system (HS) classification), three-quarters of world supply is provided by three countries: China, Viet Nam and Korea. Downstream firms relying on these specific inputs have not much leeway to switch towards new supply sources in case of shortage, at least in the short term. Concentration of suppliers reduces the scope for diversifying away from a supplier facing disruptions. Likewise, on the demand side, reliance on too few customers may be a source of fragility. In this case, a demand shock in a destination market cannot be buffered and may have large consequences on the upstream firms serving this market. However, concentration is often also a manifestation of comparative advantage, specialisation and economies of scale, and it is not clear that it should be reversed, or what would be the wider implications of the policy tools and incentives used to do so.

18. In many markets, exports tend to be concentrated in a few supplying countries. Import destinations, in contrast, tend to be more diversified. For two commonly used measures of concentration – the top 5 countries (CR5) and the Herfindahl-Hirschmann index (HHI) (see Annex C) – the distribution of export concentration across products is tilted to the right compared to the concentration of imports. The supply side is quite concentrated with a few countries specialising in producing and selling abroad each HS6-product, but the supply ultimately serves final demand in a diversified range of countries (Figure 2).¹²

¹¹ A similar approach has recently been employed by Government of Canada (2020) in its assessment of vulnerability of Canadian industries to disruptions in global supply chains (see Chapter 3).

¹² This reflects an observation that countries differ more with respect to what they supply to world markets than with respect to what they consume. This is in line with key conventions of standard trade models where consumption preferences are assumed equal across countries but endowments or technologies differ.

Figure 2. Exports are concentrated on fewer countries than imports

Note: Using bilateral exports and imports flows from the BACI database, indicators of concentration have been constructed for 2018, at the 6-digit level of the Harmonised system (HS) classification. For each of the 4726 products traded internationally, an exporting country is defined as a supplier and an importing country is a customer. The concentration ratio of the top five supplier-countries gives the cumulative market share accounted for by the 5 biggest countries to total world exports (for a given HS6-product). The distribution reports this statistics for 4726 HS6 products. The concentration ratio of the top five importer-countries is the share accounted for by the 5 biggest countries in total world import (for a given HS6-product). The Herfindahl index is the sum of squared market shares and takes into account the full distribution (not the top-5 countries only). "Fractions of products" represent the percentage of traded products with a given concentration measure. By construction the sum of these fractions over all bins is equal to 100%.

Source: BACI 2020 version and OECD calculations. For details on the database construction, see Guillaume Gaulier and Soledad Zignago, "BACI: International Trade Database at the Product-Level. The 1994-2007 Version", *CEPII Working Paper*, N°2010-23, October 2010.

19. Focusing on product groups¹³ shows that computer and phones exhibit by far the highest degree of concentration in the global export market (Figure 3). It is difficult to assess from such measures what is the threshold above which concentration becomes a problem. Indeed, many structural characteristics can explain the degree of concentration in an industry. These statistics merely aim at shedding light on the structure of the world market for each product and point out potential bottlenecks. On average, 79% of the market share of computer-related products is accounted for by 5 countries only¹⁴ and the top-five countries account for 75% of world exports of phones. This is remarkable given the increase in reliance on the digital means of work and communication during the COVID-19 pandemic.

20. For capital goods and final consumption goods, the mean of the top-5 exporters concentration is around 67% and 65% respectively, slightly higher than for intermediate goods (62%) and significantly greater than the concentration of imports (respectively 46%, 47% and 51%). The difference in concentration of exports compared to imports is smaller for intermediate goods, highlighting that an important characteristic of GVCs is that relatively few GVC hubs rely on multiple source countries.¹⁵ This is also supported by the finding that supply of intermediate goods is less concentrated than supply of final goods, suggesting that possible bottlenecks may occur more downstream in the value chain, while a broader range of intermediate suppliers can be drawn upon in case of a disruption. Car-related goods and precious goods are the only categories where the demand side is as concentrated as the supply side or even more concentrated (precious goods).

¹³ Based on the OECD BTDLxE. Bilateral flows are classified into nine categories of products by their end-use. The flows are also broken down later on by economic activities according to ISIC 4.

⁹ The top-5 countries can be different for each product within the end-use category.

¹⁰ Another OECD study looking at network equipment goods, ICT computer and peripherals and ICT communication equipment obtains similar findings, see OECD (2020e).

Figure 3. Exports of final consumption goods are highly concentrated amongst a few countries

Note: Boxplots represent the value of the weighted first quartile, median and third quartile of concentration indices across products belonging to each end use category. The diamonds indicate the weighted mean. Ponderation weights are the share of each product in total exports (or imports) of the end-use category. The capital goods category comprises 621 HS6-products, 1159 products belong to final household consumption and 2900 to intermediate inputs. Out of these three very large end-use categories, the other categories comprise fewer HS 6-products, thus only the mean and the median are reported for cars (8 HS6-products), packed medicines (8), miscellaneous goods (9), personal computers (6), phones (1) and precious goods (14). Precious goods include different types of diamonds, gold, pearls, and precious stones.

Source: BACI 2020 version and OECD calculations. For details on the database construction, see Guillaume Gaulier and Soledad Zignago, "BACI: International Trade Database at the Product-Level. The 1994-2007 Version", *CEPII Working Paper*, N°2010-23, October 2010.

21. A few sectors appear to be particularly exposed to potential disruptions on the supply side (Annex D Tables A.D1 and A.D2). The market share of the top-5 countries exporting goods in the textile industry is 74% on average while they are servicing a broad customer base (import share of the top-5 importers in the textile industry is 45%). Leather goods exhibit the same pattern, with the concentration on the world export market much higher than for imports. Electronic products are extremely concentrated both on the supply side and on the demand side. This makes the industry particularly vulnerable to shocks and disruptions stemming either from suppliers or from consumers. Medical instruments show the same feature, but to a lesser extent: high concentration both on the supply side and on the demand side.

3.2. Countries are exposed differently to foreign demand and supply shocks

22. While the concentration measures computed on the basis of detailed trade data can point to exposure to shocks and bottlenecks at a fairly granular level of product aggregation, they are based on gross trade figures and do not account for the key GVC characteristic: only a part of value is added by the exporter—the rest comes from other GVC participants which are often located abroad. This observation, combined with development of international inter-country input-output tables and the associated techniques used for decomposition of the value of traded products according to their origin (see OECD, 2013), has allowed a more accurate measurement of GVC participation, albeit at a more aggregated level.

23. More insights into exposure to shocks in supply chains can therefore be gained by looking at country-level GVC participation indices. Exposure to shocks *per se* does not determine what will be the impact of those shocks or the ability to manage them, but it helps understanding the different situations of countries and industries. While the way shocks propagate along the supply chain depends on the degree of substitutability across inputs and the complexity of production networks (as investigated in the CGE modelling in Section 4), a relatively higher share of foreign value added from foreign input providers (so-called 'backward' GVC linkages) can indicate a higher exposure to supply shocks affecting vendors of

raw materials and intermediates.¹⁶ Conversely, a higher reliance of exports of a given country on demand from foreign countries (so called ‘forward’ GVC linkages) can mean higher exposure to demand shocks coming from final consumers or distributive services.

24. Connectedness to global markets enables smaller countries to reach a bigger customer base, but they are also more exposed to demand shocks in GVCs than large countries. This is particularly the case for manufacturers in Central and East European countries that provide inputs into the European automotive industry, or Irish firms supplying the global information technology sector. These countries export between 60% and 80% of the total amount of value added produced domestically (Figure 4). Re-shoring would present a particular risk for small countries that are integrated in supply chains. Upstream natural resource producers such as Brazil, Australia, Indonesia or Russia, as well as large upstream producers of manufacturing intermediates like United States and Japan, appear to be less vulnerable to demand disruptions in foreign markets.¹⁷ These countries tend to be specialised in the production of raw materials or intangibles (e.g. R&D, design, marketing) involved at the beginning of production processes, therefore being further away from final demand (Koopman et al., 2014; Antras et al., 2012; Fally, 2012).

25. The exposure to foreign supply shocks also tends to be larger for smaller countries where production depends on foreign inputs to a larger extent (Figure 5). The European Union, the United States, China and other Asian countries provide high portions of foreign inputs used in manufacturing across the world. Still, key suppliers of foreign inputs in manufacturing (potential sources of shocks) are distributed relatively more widely (Figure 5, Panel A) than in the business services sector where intermediate services trend to be sourced mainly from Europe and United States and reliance on providers from Asia is lower (Figure 5, Panel B).

Figure 4. Small economies are most exposed to demand shocks abroad

¹⁶ Note, however, that in the case of positive shocks occurring abroad, countries with high participation might also be in a better position to benefit.

¹⁷ Natural resource producers are prone to sharp price fluctuations and natural perils impacting on domestic supply. From a policy-making perspective, it is important to look at the mix of all risks (supply and demand shocks). This dimension is taken into account in Section 4.

Note: The degree of exposure to a demand shock is computed as a share of domestic value added in foreign final demand in total domestic value added in 2015. It includes exports of final goods or services directly reaching foreign markets, but also intermediates reaching foreign final consumers only indirectly. Other Asia includes Japan, Korea, India and ASEAN countries.
Source: OECD Trade in Added Value dataset; and OECD calculations.

Figure 5. Exposure to supply shocks across OECD and major EMEs in 2015

Note: The degree of exposure to a supply shock is computed as a share of foreign value added in gross output of the sector. Other Asia includes Japan, Korea, India and ASEAN countries.

Source: OECD Trade in Added Value dataset; and OECD calculations.

3.3. GVC participants likely to be at the centre of systemic shocks

26. While the exposure indices introduced in the previous section proxy countries' degrees of exposure to supply or demand shocks possibly transmitted by trade partners, they do not account for the network nature of GVC interdependencies which implies that shocks affecting crucial production hubs may have more systemic implications. The concept of centrality in a network aims at capturing the influence of a country or sector in the GVC network. GVC centrality measures have been computed¹⁸ following Criscuolo and Timmis (2018). This indicator accounts not only for the direct participation of countries in global value chains but also for participation in GVCs of their value-chain partners and their relative influence. Countries and industries are central because they trade in GVCs with other central hubs and their centrality is higher when they are major suppliers or customers of the hub.¹⁹

27. Since the mid-2000s, the weight of China as main manufacturing hub in several sectors, both in terms of backward and forward integration, has grown significantly. In some industries such as smelting, refining and casting ferrous and non-ferrous metals and in the manufacture of textile fabrics, wearing apparel and leather products, China displays the highest degree of centrality for the year 2016 and the largest increase in the centrality metrics since mid-2000s (Figure 6, Panel A). Having started from the fifth position as the most central producer of basic chemicals and pharmaceutical products in mid-2000s, China currently holds the top position in the network as supplier of value-added. The computers and electronics manufacturing has also undergone profound changes, with the core shifting from the United States and Korea towards China, which currently is the most central buyer and supplier of inputs in the whole industry.

¹⁸ The GVC centrality measure is computed for 37 OECD countries and 27 non-OECD economies, 16 manufacturing and 14 service industries, using the most up-to-date OECD Inter-Country Input-Output (ICIO 2018) data.

¹⁹ The complexity of the network structure and the multi-directionality of trade flows is summarised in the centrality measure by the recursive inclusion of all direct and indirect linkages of a country/industry plus all higher-order linkages across its partner countries/industries. Moreover, industries can be central either because of their linkages to domestic sectors or to foreign sectors although the analysis here focusses on foreign components of centrality and their role in the propagation of shocks internationally (see Annex B).

The German and US motor vehicle industries remain two of the most central manufacturing hubs globally. For both, backward linkages are much stronger than upstream linkages, reflecting their global importance in purchasing value added in intermediates for their own production and exportation of automobiles.

28. The centrality metrics for 2016 confirm the central position of high-income countries, such as the United States, the United Kingdom, Germany and France, as key hubs in the service sector (Figure 6, Panel B). The United States, in particular, is the most central provider of business services, including financial and insurance services, legal and accounting activities, wholesale and retail trade, and R&D. At the same time, the United States is also the largest receiver of services provided by foreign medical personnel, social workers and workforce in defence and safety, public administration and foreign affairs. The most sizeable changes in the structure of networks are represented by the rise of the French R&D and business support industry, from the 17th most central position in 2005 to the 6th in 2016, and the decline of the UK financial and insurance sector, from the 7th in 2005 to the 13th position in 2016.

29. Ranking key industries across all countries, scientific and business support services, transportation and retail trade represent the most central nodes across all global supply chains, i.e. these sectors appear to be important suppliers to several other customer sectors at the same time (Figure 7). Strong backward linkages and a large amount of foreign value added used make the construction sector a key customer of foreign inputs and the second most central sector after business services. Among manufacturing activities, the production of chemicals and pharmaceutical goods as well as metal forging have the highest degree of centrality. At the bottom of the ranking are a few industries mainly serving domestic markets and with minimal inputs from foreign partners, like recreational activities, education and mining and quarrying support.

30. The key hubs across international production networks are large countries: the G7 countries plus China and Russia (see also Cingolani et al., 2018; Criscuolo and Timmis, 2018; Altomonte et al., 2019). The United States is the most important global supplier and importer of value added, followed by Germany and China. Having started from the 8th position in the ranking of most central nodes in 2005, China is now the 3rd most central trader of value added for foreign sectors and the 1st for domestic sectors in 2016 (Figure 8).

Figure 6. Top ten most central hubs

Panel B: Services sector
Total foreign centrality measure

Note: Total centrality is computed as average of forward and backward centrality. Forward centrality metrics capture the importance of a country or a sector as a seller of value added in intermediates for the production of exports of a specific partner while backward metrics measure the importance of a country as a buyer of value added in intermediates for the production of its own exports. The manufacturing sector excludes construction while the service sector excludes electricity, gas, water supply services. The "Rest of the world" has been excluded from the chart as it represents an aggregate of several heterogeneous countries whose distinct trade flows are not disentangled.

Source: OECD (2018) Inter-Country Input-Output (ICIO) database; and OECD calculations.

Figure 7. Industry-level centrality

Note: Industry-level centrality is computed as an average across all countries' total foreign centrality in each single sector. For sake of clarity, only the first 10 most central and least central industries are displayed.

Source: OECD (2018) Inter-Country Input-Output (ICIO) database; and OECD calculations.

Figure 8. Country-level centrality

Note: Countries centrality is computed as an average across all sectors' total foreign centrality for each single country.

Source: OECD (2018) Inter-Country Input-Output (ICIO) database; and OECD calculations.

4. Costs and benefits of GVCs in the face of shocks: some insights from the OECD CGE METRO model²⁰

31. While the discussion about pros and cons of re-localisation of value chains intensifies, there is little empirical analysis quantifying costs and benefits associated with different policy options. Specifically, few studies attempt to quantify the purported trade-off between efficiency and security (resilience) of supply in GVCs. Two recent studies quantify the economic impacts of supply and demand shocks due to the COVID-19 pandemic. Bonadio et al. (2020) estimate the part of the real GDP reduction which is due to transmission through global supply chains and they show that the contraction of GDP would have been worse with re-nationalised GVCs. Camatte et al. (2020) in turn quantify the transmission of price shocks through GVCs. But neither of these studies considers the balance of costs and benefits of GVCs in the face of economic shocks.²¹

32. To contribute to the analysis of these issues, a set of economic model simulations has been conducted using the OECD's computable general equilibrium (CGE) trade model METRO.²² The model incorporates many of the interdependencies through GVCs discussed above and embeds them in economic theory while employing standard values of key parameters, such as, for example, for production

²⁰ This section of the paper draws significantly and expands on the findings of the work presented in the OECD Trade and Agriculture Directorate's June 2020 policy brief with the same title, available on-line at: <https://issuu.com/oecd.publishing/docs/metro-gvc-final>

²¹ Other relevant studies are WTO (2020), Maliszewska, M, Mattoo, A, and D. van der Mensbrugghe (2020). These studies quantify the economic impacts of various supply and demand shocks due to COVID-19 pandemic and do not consider the costs and benefits of GVCs in the face of economic shocks.

²² The METRO model is a multi-country, multi-sector computable general equilibrium (CGE) model that traces international interdependencies in a theoretically and empirically consistent framework, and incorporates several features of GVC participation such as trade of intermediate and final products and trade in value added (TiVA) concepts. More information can be found at <https://www.oecd.org/trade/topics/metro-trade-model/>

functions, and income and trade elasticities. While the simulations are based on certain stylised assumptions, they feature the main characteristics of supply chain disruptions during the COVID-19 pandemic and past attempts at using policies to re-localise GVCs, and allow broad comparisons across different countries, sectors and value chains. Importantly, they allow an investigation of the general nature of relationship between efficiency and exposure to shocks in GVCs in a consistent quantitative framework. Two stylised versions of the global economy (regimes) are explored in this comparative static model (for details, see Annex A). The *interconnected* regime represents production fragmentation in GVCs, much as is seen today, accounting also for the so far identified effects of the demand and supply changes during the COVID-19 crisis.²³ The *localised* economies regime also takes into account the effects of the COVID-19 crisis and adds to it a stylised representation of some potential policy responses to the COVID-19 crisis with the aim of making value chains more domestic, and thus supposedly more resilient to shocks, and businesses and consumers less dependent on foreign suppliers.

33. First, the analysis explores effects of shifting towards the *localised* regime on key economic variables such as trade, production and real GDP, i.e. the overall cost of ‘making the supply chains more ‘local’ or the ‘efficiency’ side of the purported trade off. The *localised* regime reflects a situation where, on top of the effects of the COVID-19 crisis, incentives to source inputs from abroad are reduced through two mechanisms. First, there is a global rise in import tariffs on all traded merchandise products to 25% in all countries. The imposition of a 25% import tariff is a stylised scenario which approximately moves import tariffs back to the level seen in advanced countries in the first years following the Second World War. Second, this is combined with national value added subsidies equivalent to 1% of GDP directed to labour and capital in domestic non-services sectors in each country in order to mimic rescue subsidies that favour local production.²⁴ These subsidies aim to approximate the scale of COVID-19 rescue packages directed to national economies by OECD countries to date, and it is assumed that subsidies of a similar magnitude are deployed by other countries.

34. In addition, it is also assumed in the *localised* regime that firms are more constrained in switching between different sources of products they use, making international supply chains more ‘rigid’. This is designed to reflect key implications of a situation where some of the value added subsidies would be conditioned on sourcing domestically or where lower fragmentation of production in GVCs resulting from re-localisation policies would make substitution in them more difficult.²⁵ Although the impact on results of

²³ This baseline takes into account the economic effects of the COVID-19 crisis resulting from reductions in supply and productivity of labour, reductions in demand for certain goods and services, and a rise in trade costs related to new customs procedures for goods and restrictions on temporary movement of people in services. It has been summarised in a recent policy brief (<https://issuu.com/oecd.publishing/docs/metro-gvc-final>). A detailed discussion of effects associated with changes to the OECD’s METRO baseline implied by the COVID-19 crisis will be documented in a dedicated forthcoming paper. Note that the COVID-19 crisis, as reflected in this baseline, while having quite significant impact on the overall level of economic activity, does not result in large compositional effects when it comes to trade. The results of the analysis presented here would therefore not be expected to be qualitatively different had it been performed using the pre-COVID-19 baseline.

²⁴ This is implemented through an imposition of an additional subsidy (an opposite of a tax) on the value of labour and capital employed equivalent to 1% of a country’s GDP using the base GDP, and employed labour and capital values. The additional subsidy rate is uniform across factors and sectors. While the scale of subsidies implemented in the model approximates the estimated size of post-COVID-19 responses, the modelled subsidies do not reflect some important features of these responses, such as their temporary nature or the fact that they are in most cases designed to support existing production rather than capacity expansion.

²⁵ This is achieved by lowering export transformation elasticities and import substitution elasticities between domestic and foreign varieties of products and elasticities of substitution between different varieties of foreign products (i.e. the so-called Armington elasticities) in simulations departing from the *localised* regime base. Armington elasticities are core parameters of the model and capture the ability to switch between domestic and different foreign sources of

such assumption is not *a priori* known,²⁶ because these are some of the core parameters of the model used, an additional set of simulations without the assumption of lower trade elasticities was run to analyse the sensitivity of results to this assumption.²⁷

35. The simulated policy assumptions in the *localised* regime create strong incentives to increase domestic production and rely less on international trade. National value-added subsidies combined with import tariffs in the *localised* regime increase prices of imported products relative to domestic ones and make producers in all countries and in all sectors less reliant on foreign inputs for their production and exports than in the *interconnected* regime (Figure 9). On average, GVC participation indices are consistently lower in the *localised* regime,²⁸ and the largest declines are recorded for the most GVC-integrated countries (e.g. Southeast Asia) and sectors (e.g. *Motor vehicles* and *Transport equipment*). The drop associated with the *localised* regime simulated here is more than three times larger than the decline in import intensity of intermediate inputs that has been observed since 2011.²⁹

products within international supply chains. Similar assumptions about them have been made in the context of modelling the transmission of effects of the COVID-19 pandemic in GVCs (e.g. Maliszewska, M, Mattoo, A, and D. van der Mensbrugghe, 2020). In addition, the recent literature on historical estimates of Armington elasticities suggests that these have increased over time during the era of GVC expansion, i.e. from early 1990s, although it is not clear whether this is not due to changes in empirical methods used to estimate them or due to more flexibility in sourcing (e.g. Bajzik et al., 2020).

²⁶ In general, the impact of lowering trade elasticities on the ability to sheltering a domestic economy from shocks will depend on the origin of shocks: foreign shocks may have a higher impact on domestic GDP (it is more difficult to substitute away from foreign sources of imports and export destinations) but the opposite will be the case in the case of domestic shocks, which, with the characterisation of shocks adopted in this paper (see the next sub-section), tend to have larger effects on domestic economies. The overall impact on transmission of shocks thus depends on economic structures and is not known *a priori*.

²⁷ The results of these simulations are discussed in the results section and presented in more detail in the Annex. They do not significantly alter the conclusions from the analysis of the *localised* regime, in the sense that without this assumption the *localised* regime does not yield more stable responses to shocks than the *interconnected* one. However, the sensitivity analysis shows also that the lesser flexibility in switching between different sources of imported products is indeed a key factor behind greater vulnerability to shocks in the *localised* regime (see Annex A, Section A.4).

²⁸ For the method of calculating these indices in the OECD METRO model, see OECD (2018).

²⁹ For a documentation of the slowdown of GVC expansion see Miroudot, S. and H. Nordström (2019), who estimate a drop of about 2-3 percentage points in global import intensity of production for the period 2011–2017.

Figure 9. GVC participation falls in all countries and all sectors in the localised regime

Note: These are trade-weighted (using value added trade) average backward GVC integration indices calculated across all countries (Panel A) and sectors (Panel B). Backward participation shows the average share of foreign value added in gross exports of each country (sector). Forward participation shows the average share of domestic value added which serve as inputs to other countries' exports, expressed as percentage of a country's (sector's) gross exports. Total participation is the sum of backward and forward indices and describes overall engagement in GVCs. The grey bars represent total participation in the interconnected regime while orange bars represent the total participation in the localised regime. Source: OECD METRO database and simulations.

36. While the shift to the *localised* regime influences all sectors in the economy, in the discussion of results special attention is paid to results concerning *Food*, *Basic pharmaceuticals*, *Electronic equipment* and *Motor vehicles*, all of which have often been argued to be 'essential' or 'strategic' in recent policy discussions, albeit for different reasons. *Basic pharmaceuticals* are seen as essential for public health; access to *Food* is regarded as a basic requirement for food security; *Electronic equipment* has been essential for the continuation of economic activity during the confinement necessitated by the current sanitary crisis; and *Motor vehicles* have long been argued to be the cornerstone of industrial development and capable of providing the essential manufacturing base required to enable ramping up of other goods in situations of national need. *Food*, *Electronic equipment* and *Motor vehicles*, are also some of the manufacturing industries that have the most central position in GVCs, meaning that disruptions or other effects seen in these sectors are more likely to spill over to other parts of the GVC network through forward and backward GVC linkages (see above). Still, exposure to different types of disruptions in supply chains depends on the characteristics of the industry and its current geographical location. For example,

according to McKinsey (2020) estimates, *Electronic equipment* has the highest overall shock exposure, *Motor vehicles* are characterised by moderate exposure and *Food* and *Basic pharmaceuticals* by relatively low exposure.

4.1. Localisation of GVCs would add further GDP losses to the economic hit caused by the pandemic

37. The results show that the localised regime, where countries are less interconnected via GVCs, has significantly lower levels of economic activity and lower incomes in all countries. This suggests that greater localisation of value chains would add further GDP losses to the economic slowdown caused by the pandemic.

38. A shift to the *localised* regime is estimated to decrease global real GDP by more than 5% relative to the *interconnected* regime (Table 1). Reductions in economic activity are significant across all countries, and in some of them reach double digits, which is notable given the static nature of this modelling exercise.³⁰ This underscores the gains in growth and jobs around the world from international specialisation that have been realised over the past decades, including through reductions in barriers to trade. Import and export demand fall in real terms proportionally more than real GDP and domestic production, with the result that, in the *localised* regime, exports and imports come to account for smaller shares of GDP.

4.2. Costs of localisation would be particularly high for those countries that are currently located more downstream in GVCs

39. Reductions in real GDP across national economies are a product of a complex of interactions in domestic and imported production and consumption but, as would be expected, they are correlated positively with backward GVC participation: the more the country relies on foreign inputs for production, the larger the drop in GDP when shifting to a localised regime. Canada and the United Kingdom, for example, which are highly integrated in the *motor vehicle and parts* value chains and where these activities account for important shares of economic activities experience large reductions in output in these sectors and also some of the largest GDP reductions in the countries analysed (see also Figure 12 below). Beyond GVC integration, high reliance on consumption of imported final products and low initial levels of import tariffs are also significant contributing factors.³¹ Countries with high backward GVC participation indices, such as Southeast Asia and, albeit to a lesser extent, Korea, tend to suffer larger losses (Figure 10, Panel A). At the same time, countries with high forward GVC participation, such as Russia, tend to suffer smaller losses, although the correlations are small (Figure 10, Panel B)³².

³⁰ The model does not account for dynamic effects concerning productivity (e.g. due to increased competition or trade-related technology transfer) or capital accumulation (e.g. higher investment rates or more FDI following trade policy reforms). Modelling of these effects in a CGE relies on less certain assumptions and has not been attempted here but, generally, these additional effects would be expected to render the effects of localisation even more negative.

³¹ The most affected countries experience also the largest increases in household consumption prices which encompass domestically produced (albeit often with foreign inputs) as well as imported final products.

³² For the method of calculating these indices in the OECD METRO model, see OECD (2018).

Table 1. Both the global economy and all national economies would be smaller in a localised regime

Country	Real GDP % change	Domestic production % change	Import demand % change	Export demand % change
Argentina	-2.9	-3.2	-13.5	-8.3
Australia and New Zealand	-8.8	-8.6	-21.7	-19.6
Brazil	-2.5	-2.5	-16	-15.2
Canada	-13.1	-15.1	-25	-30
China	-2.6	-2.4	-23.4	-18.4
France	-5.1	-5.6	-9.9	-12.5
Germany	-5.1	-5.4	-11.4	-9.6
United Kingdom	-12.2	-13.4	-24.4	-33
Italy	-3.2	-3.5	-9.6	-9
European Union (24)	-4.2	-4.4	-7.9	-7.4
Indonesia	-3.2	-3.8	-21.3	-18.6
India	-1.1	-0.7	-11.4	-14.8
Japan	-3.9	-4.8	-20.4	-21.8
Republic of Korea	-7.4	-9.1	-24.1	-22.5
Mexico	-5.9	-8.2	-23.1	-26.8
Russian Federation	-3.4	-2.9	-22.1	-11.2
South Africa	-6.9	-6.8	-22.2	-20.7
Turkey	-5.2	-7	-16.7	-29.5
United States	-6.9	-7.1	-20	-28.3
Latin America	-5.5	-6	-22.8	-21.8
South East Asia	-10.8	-15.2	-28.1	-28.8
Rest of the world	-6.3	-7.5	-20.2	-17.2
World	-5.5	-5.9	-18.1	-17.8

Note: The table shows simulated values of the different variables in the *localised* regime as a per cent of the corresponding values in the *interconnected* regime. See main text for the construction of the two regimes. South East Asia includes Brunei Darussalam, Cambodia, Malaysia, Philippines, Singapore, Thailand and Viet Nam. Latin America includes Chile, Colombia, Peru and Costa Rica.

Source: OECD METRO database and simulations.

Figure 10. Localisation is more costly for countries more downstream in GVCs

Note: Backward GVC participation denotes the share of foreign value added in gross exports. Forward GVC participation denotes the share of gross exports destined for processing and exports by other countries. Both of these GVC participation indices refer to the base in the interconnected regime.

Source: OECD METRO database and simulations.

40. This tendency is also observed at the industry level: those domestic industries that rely more on sourcing from abroad tend to shrink more as a result of a shift to the *localised* regime (Figure 11). There is also considerable heterogeneity in the impacts on production across the different industries and across countries (Figure 12).

- *Food*, which is characterised by a moderately high backward GVC participation and relatively low forward participation, records reduced production in almost all countries in the *localised* regime. Drops in global food production of this magnitude threaten food security and livelihoods in some parts of the world where food and agriculture are a big part of total economic activity. They also highlight that food systems, like other sectors, also depend on imports, exports and well-functioning GVCs – in agriculture, key imported inputs include animal feed, fertiliser, chemicals, seeds and machinery. Moreover, given geographical and climatic factors, countries also specialise in certain types of agriculture, and trade is essential to connect producers to diversified consumer demand around the world.
- *Motor vehicles*—the sector with the highest level of backward GVC participation globally—records output reductions in all but five countries. Countries which rely the most on foreign inputs in this sector, such as Mexico, the United Kingdom, and Southeast Asia, record the most pronounced reductions in production (Figure 12).
- In contrast, there is some reallocation among countries in *Basic pharmaceuticals* and *Electronics*, which are also highly integrated into GVCs. In these sectors, countries experiencing output increases tend to be those which not only rely extensively on foreign inputs, but also have significant domestic production. Yet, even these increases occur in the context of reductions in economic activity for the national economy as a whole.

Figure 11. Industries that rely more on sourcing from abroad shrink more

Source: OECD METRO database and simulations.

Figure 12. The *localised* regime has lower output in key sectors

Source: OECD METRO database and simulations.

41. The shift to the localised regime considered in this analysis would thus have high economic costs, which would be particularly acute for those countries that are currently located more downstream in GVCs. This is because prices of foreign intermediates go up due to tariffs and prices of competing domestic inputs also increase as domestic producers switch to domestic sources, reducing competitiveness further. Countries which participate in GVCs mostly through providing inputs, and which are located more upstream in GVCs (forward GVC participation), experience falling prices of their products, partly because of the wedge the tariffs create between the world and domestic prices in foreign markets, but these products also feed as inputs into production in their home markets. This diversion of trade towards domestic buyers in the face of dwindling export market opportunities dampens the overall negative economic effects for countries located more upstream in the supply chains, provided that they have domestic industries in place that absorb the products that were previously sent abroad.

42. The latter finding also illustrates a more general point about the benefits of GVC participation. While it is clear that countries located both upstream and downstream in GVCs gain from GVC participation, different forms of participation are associated with different economic mechanisms. For countries located downstream, the lowering of trade costs has unequivocally positive effects. However, for countries located upstream, lowering of trade costs has two opposing effects: they sell more to their downstream foreign partners, but this also drives up prices of domestic inputs. The increase in production costs diminishes the competitiveness of their domestic industries. This mechanism has been well known for natural resource rich countries for a long time, sometimes frustrating their efforts to diversify the economy into more downstream processing.

4.3. Would localisation of GVCs result in less vulnerability to supply chain shocks?

43. Since macro- and microeconomic stability is an important policy objective, it is not sufficient to consider just the efficiency impacts in terms of the overall level of production or incomes, but an analysis is also needed of the performance of these different economic regimes in terms of shock absorption.

44. To explore how the *interconnected* and the *localised* regimes compare in terms of the propagation of, or insulation from, shocks, a stylised set of ‘supply chain shocks’ is explored, based on a 10% increase in costs of bilateral merchandise exports and imports between a given country and all other countries.³³ Since countries experiencing the shocks are both sources and destinations of intermediate and final products, the set of shocks mimics the kind of disruptions experienced during lockdowns to contain the COVID-19 pandemic, when transport, labour and logistics disruptions affected both exports and imports of different products to a similar extent.

45. International supply chains can be exposed to a wide spectrum of shocks, some of which can be sector- and country-specific, or which can occur simultaneously in space and time (see e.g. McKinsey, 2020). For the purpose of this analysis and to facilitate discussion of basic concepts, mechanisms and results, the focus in this note is on a narrow set of stylised, equally probable and spatially uncorrelated, shocks. The shocks are *country-specific*, as was the case with COVID-19, where supplies across many industries were initially disrupted in China and subsequently in other countries. The shocks are *sector-generic* – that is, they are applied equally across all sectors to capture the fact that sectors source from a range of different industries (e.g. car producers do not just source from other firms in the car industry, but also from other sectors). The shocks are stylised but they feature the main characteristics of supply chain disruptions during the COVID-19 lockdowns and allow broad comparisons across different countries, sectors and value chains. Such shocks might occur due to natural or policy reasons in any location and their effects depend on structural characteristics of countries’ integration into the global economy.³⁴

46. In this context, the stability of an economic variable, such as real GDP is calculated for each country as the absolute value of an average percentage deviation from the initial base level of this variable (i.e. from the base level in either the *interconnected*, or the *localised*, regime) across all country-specific shocks, including the one originating in the domestic economy.³⁵

4.3.1. *Localised supply chains are found to be more - not less - vulnerable to shocks for most countries*

47. The results of the simulations show that contrary to some of the claims in the debate on costs of GVCs, in the *localised* regime, shocks do not result in a significant increase in the stability of GDP, production and consumption relative to the *interconnected* regime. On average, the stability of real GDP, real production and real consumption decline (Table 2). Domestic markets need to shoulder most of the adjustment pressures in the *localised* regime. Domestic prices and quantities have to adjust relatively more, which leads to less stable consumption for most countries, more so than real GDP and production. Put differently, trade helps smooth shocks to supply of globally consumed products. In the *interconnected* regime, domestic shocks account for about half of the variation in real GDP due to shocks, illustrating that domestic shocks may be at least as important as a source of instability as foreign shocks. The variation of

³³ Costs of all other bilateral trade flows are left unchanged in any given model simulation. A shock in an opposite direction, which would decrease trade costs by 10%, would have effects of the same magnitude, but in the opposite direction, allowing illustration of both the downside and upside stability of key economic variables in the two regimes. For this study, a total of 44 simulations were executed. For each of the two regimes, there are 22 different simulations such that each country or country grouping (region) is the origin of the shock: 2 (regimes) times 22 (country/region-specific shocks) amounts to 44 simulations.

³⁴ Other, more specific, and perhaps more realistic, types of shocks, or a wide range of randomly distributed shocks, could be usefully studied in the future, and they could arguably yield different results.

³⁵ Taking the absolute value reflects the assumption that trade costs can be either positive or negative. Some countries which are positioned so that they can overall take advantage of raising trade costs (or so that they loose from lowering of such costs) can record a positive (negative) average real GDP change in the face trade cost increases (decreases).

real GDP due to foreign shocks triples when shifting to the *localised* regime (Table A.A.2), which underscores that trade is particularly effective when it comes to smoothing the impacts of foreign shocks.^{36,37}

Table 2. Shocks result in an overall drop in the stability of key economic variables in the localised regime

	Interconnected	Localised
Real GDP	0.63%	1.03%
Real production	0.66%	1.30%
Real consumption	1.77%	2.70%

Note: The table reports the average of absolute values of percentage deviations from regime's base across all shocks, countries and sectors (as % of base value). Using the absolute values captures the symmetry of the trade cost shocks, which in principle can be either negative or positive.

Source: OECD METRO database and simulations

48. However, these averages mask considerable heterogeneity across specific countries (Figure 13). For 16 out of 22 countries included in the model, real GDP stability falls when all shocks are considered. Countries affected the most negatively tend to be located upstream in GVCs. Countries such as Russia, Argentina, Brazil, other Latin American countries lose more than one percentage point in terms of real GDP stability in the *localised* regime when all shocks are considered. They tend to provide inputs into production for other countries and the concentration of their economies and trade patterns around natural resources and agriculture results in less adjustment domestically because of a less diversified economy that relies on less mobile factors of production.

³⁶ See also the recent work of Caselli, Koren, Lisicky, and Tenreyro (2020), who use a different trade model and show that openness to international trade can lower income volatility by reducing exposure to domestic shocks and allowing countries to diversify the sources of demand and supply across countries.

³⁷ Table A.A.2 shows also the impacts on stability when the assumption of lowered trade elasticities is dropped. On the one hand, these results show that this assumption drives most of the increase in instability. On the other hand, without this assumption the stability of real GDP does not increase, but stays at the same level, in the localised regime, and stability of real consumption still drops somewhat. The result that the costly (in terms of efficiency) shift to the localised regime does not generally improve stability in the face of shocks is upheld.

Figure 13. In the *localised* regime, shocks also result in lower levels and lower stability of real GDP for most countries

Note: All changes in variables are relative to the level of the interconnected regime base scenario which is set to equal 100. Blue dots show the base in the given regime relative to the interconnected base, and whiskers show average deviations for negative and positive trade cost shocks. Source: OECD METRO database and simulations.

4.3.2. Some downstream GVC participating countries could gain marginally in terms of stability in the *localised* regime, but at a high efficiency cost

49. In the six countries that gain marginally in terms of real GDP stability in the *localised* regime when all shocks are considered, this comes at the cost of a much lower level of economic activity. This group includes France, Korea, Mexico, Turkey, the United States and Southeast Asia. For example, stability is estimated to improve the most in Korea as this country ‘saves’ three-quarters of a percentage point of variation in real GDP in the *localised* regime. Still, Korea would experience significant reduction in the level of real GDP (by 7.4%) from shifting to the *localised* regime. The other five countries typically gain about one-fifth of a percentage point in terms of real GDP stability, which can also be seen as small compared to the costs of switching to the *localised* regime, which in all cases exceed 5% of real GDP.

50. The situation of these countries in terms of stability gains in the *localised* regime can be explained by the fact that these are some of the most open and GVC-integrated countries in the *interconnected* regime, and that they tend to be located downstream in GVCs. On the one hand, they are still more open in the *localised* regime than many other countries, meaning that adjustments in international markets still help them better adjust to the shocks. On the other hand, these countries also experience the largest reductions in trade (and thus sourcing of intermediates from abroad) as well as in incomes when shifting to the *localised* regime (Figure 14). The countries that could gain on stability in the *localised* regime pay the highest cost in terms of the level of real GDP when switching to the *localised* regime.

Figure 14. Those countries that could have lower GDP variation in the localised regime would pay the highest cost in terms of the level of real GDP when switching to the *localised* regime

Efficiency and stability effects of shifting to the localised regime

Source: OECD METRO database and simulations

4.4. Several per cent of GDP would have to be sacrificed in a shift to a localised regime in order to increase its stability by a fraction of a percentage point

51. In a way, these results indicate the existence of a trade-off between efficiency and exposure to shocks in GVCs for a limited number of countries. But already in this stylised analysis this trade-off is far from straightforward. First, the trade-off is relatively steep: several per cent of GDP would have to be sacrificed in a shift to a *localised* regime in order to increase its stability by a fraction of a percentage point, in the face of relatively significant trade cost shocks. Second, countries relying the most on GVCs for foreign inputs in their production, while gaining potentially the most in terms of insulation from shocks in the *localised* regime, would have to sacrifice higher portions of incomes to gain such security. Third, and related to the above points, countries located upstream in GVCs, would lose out relatively more from switching to the *localised* regime both in terms of level of income and of its stability.³⁸

³⁸ Figure A.A.1 corresponds to Figure 14 above but is based on results obtained when the assumption of lowered trade elasticities in the localised regime is dropped. On the one hand, these results show that more economies could gain in terms of stability from shifting to the *localised* regime with unchanged elasticities, and that the ordering of economies in terms of the size of stability gains would be different. However, the trade-off between stability and efficiency, for the countries for which it exists, would be even steeper: even the countries that experience the largest GDP declines when moving to the localised regime could not gain more than a quarter of a percentage point in terms

Some key sectors would be less stable in the localised regime

52. For individual sectors, both the average level and the deviations due to shocks show large disparities under the *localised* regime (Figure 15). For *Basic pharmaceutical* and *Electronics* the deviations are larger in the *localised* regime than in the *interconnected* one. This suggests that a *localised* regime does not in fact shelter output from external shocks in these sectors. However, for *Motor vehicles* and *Food*, the deviations are smaller in the localised regime but the levels of economic activities are also much lower in these two sectors in the *localised* regime.

Figure 15. For some key sectors, stability of output falls in the localised regime

Note: All changes in variables are relative to the level of the interconnected regime base scenario, which is set to equal 100. Blue dots show the base in the given regime relative to the interconnected base (red dots for the four 'strategic' sectors), and whiskers show average deviations for negative and positive trade cost shocks.

Source: OECD METRO database and simulations

5. Conclusions and Policy Implications: The economic case for localising GVCs is limited but governments can play a useful role in preventing some of their negative effects

53. The analysis of trade concentration and exposure to shocks in GVCs shows that some industries exhibit high concentration of exports or imports. This implies that there are fewer options in these industries to substitute between suppliers or consumers in case of a disruption. Relying on few suppliers when they are also concentrated geographically heightens supply shock risks. But re-configuring the supplier base is costly, and even more so when assets are specific: when there is high and specific knowledge capital involved or when the supply is linked to a natural resource base (e.g. mining). Labour-intensive activities are more easily re-configured. Measures of GVC integration suggest also that some countries and industries may be exposed to demand and supply shocks more than others. This is the case of small open economies that tend to rely more on foreign inputs and ship larger portions of their production to foreign markets. Large economies, such as the United States, Germany and China, on the other hand, tend to play central roles in GVCs both as providers and demanders of inputs and final products, suggesting that shocks occurring in these countries may have more systemic implications.

of GDP stability. Again, the result that the costly (in terms of efficiency) shift to the localised regime yield very little in terms of stability is upheld.

54. The modelling results, while based on stylised assumptions, suggest that the economic case for a significantly reshoring of GVCs is weak. In fact, the results suggest that GVCs, on top of generating efficiency gains, play an important role in cushioning economic shocks. While a small number of downstream GVC participating countries could gain marginally in terms of stability from localising GVCs, they are some of the main GVC beneficiaries and the costs of localisation would also be particularly high for them. This points to risks associated with using government policy to significantly alter the geography of GVCs. But it does not mean that governments have no role in helping to prevent any negative effects that may in some circumstances be associated with international supply chains (see OECD 2020a for further information on policy options to build more resilient production network).

55. While firms and governments may have a different assessment on some aspects of supply chain management and different tools to address them, some risks are shared and are most efficiently addressed in a co-ordinated fashion. For example, governments can work jointly with firms on improving risk preparedness by identifying the range of potential threats to essential activities, mapping the local and international players involved in some essential logistic chains, collecting and sharing information on potential concentration and bottlenecks upstream, or by developing stress tests for essential supply chains (including non-discriminatory criteria for robustness of supply chains for essential goods subject to government procurement).

56. Other actions to help ensure supply include prioritising shipments of essential goods; allowing simplified procedures for essential activities, facilitating investment and operational permits and extending certification procedures to encourage production; seeking upstream agreements with firms for the re-purposing of supply chains, when required.

57. Actions can also be taken to calibrate optimally stockpiles of essential goods, including on a regional basis. Stockpiles reduce instances of flying in emergency refills and bring greater resilience to negative supply shocks. But these buffers are costly and can magnify cyclicalities, and the choice of products can also be difficult. The current crisis saw pressures on face masks, but the next might be quite different. The optimal balance between benefits and the costs needs to be found.

58. At the border, governments can review transport, logistics and border process regulations to enable flexible responses to disruptions. They can promote the diffusion of digital technologies to improve information systems, risk management and trade facilitation (e.g., by ensuring that border processes are transparent and accessible to traders and require less physical contact, and that formalities can be expedited online). Reducing unnecessary heterogeneity of technical standards that underlie regulations and non-tariff measures can facilitate easier substitution between alternative suppliers. More broadly, governments can create a predictable regulatory, trade, and investment policy environment that alleviates uncertainty.

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Annex A. Modelling trade cost shocks in the interconnected and localised economy regimes in OECD's CGE METRO model

The interconnected economies regime

1. The *interconnected economies* regime uses an updated OECD METRO model baseline that incorporates assumptions about the global economy resulting from the COVID-19 crisis. Specifically, the changes to the base incorporate three assumptions about the pandemic and its associated containment measures: 1) there is a reduction of labour supply and productivity; 2) there is a reduction in the demand for products of certain sectors; and 3) there is a rise in trade costs for goods and services.

2. The METRO model is a comparative static model that calculates a new economic equilibrium following shocks, but it does not provide information on the transition path. The model is configured for this study to reflect adjustments over the medium term, which is taken to mean about five years between the initial and the new equilibrium. While the economic shocks are big during the lockdown period, they do not persist forever, and a gradual rebound towards pre-shock levels can be assumed. Fully weighing the non-permanent COVID-related shocks into the post-COVID global economy in the medium term would overestimate structural effects. With this in mind, the size of the shocks is adjusted to reflect an impact over five years. For example, if labour productivity declines initially by 5%, and then rebounds to initial levels, it is assumed that an average decline of 1% over the five year period remains. Such adjustments are made for all COVID-related shocks that are discussed in more detail below.

Labour Markets

3. Labour markets are affected by the lockdown in terms of available labour supply, as well as labour productivity. The COVID-19 illness itself can have a direct effect on a person's ability to participate in the labour market if that person falls ill and is required to stay at home or, in the worst case, dies from the illness. Additionally, a healthy person may be required to stay at home to be a caregiver, either to a sick relative or to a child whose school has been closed as a preventative measure or because of a lockdown. The reduction of labour supply applied in the COVID-19 interconnected economies baseline combines the labour supply reduction from McKibbin and Roshen (2020)³⁹, which assumed a global pandemic following an outbreak in China, with the WTO (2020)⁴⁰ estimates of labour supply changes due to school closures.

4. Moreover, as part of the containment measures, many governments have required teleworking from home whenever possible. For a variety of reasons – such as “lack of coordination, shirking, and a lack of interaction between people decreasing creativity” (WTO, 2020) -- there is a productivity loss for those who can work, but must work, from home. The interconnected

³⁹ McKibbin, W. and Fernando, R. (2020), “The Global Macroeconomic Impacts of COVID-19: Seven Scenarios”, CAMA Working Paper No. 19/2020. <http://dx.doi.org/10.2139/ssrn.3547729>

⁴⁰ WTO (2020). “Methodology for the WTO Trade Forecast of April 8 2020”. https://www.wto.org/english/news_e/pres20_e/methodpr855_e.pdf

economies COVID-19 baseline assumes a 5% labour productivity loss of office managers and professionals, as well as technical and assistant professionals, during eight weeks of lockdown over the five-year period covered by the METRO model.

Demand reduction

5. Social distancing measures have also forced closures of restaurants, gyms, “non essential” businesses and cancellation of travel, recreation and cultural activities. The containment measures put in place by governments translate into a decline in demand in many sectors, and the extent of the decline will depend on how long the sector remains under lockdown. The assumed changes in demand and the length of the lockdown are broadly in line with the OECD Economic Department’s ‘single hit’ projections and are summarized in Table A A.1.

Table A A.1. Assumed length of lockdown measures by sector

	Assumed period of lockdown measures			Assumed change in demand over 5 years (%)
	8 weeks	16 weeks	20 weeks	
Pharmaceuticals				0.33
Manufacturing of transport equipment	x			-0.55
Wholesale and retail trade	x			-0.45
Air, water, and other transport services			x	-0.50
1. Hotel and food service	2.	3.	4. x	5. -1.38
Communication services	x			-0.42
Business services	x			-0.49
Other services*	x	x	x	-0.38

Other services include construction, real estate and arts & entertainment. The decline in demand for other services is a weighted average of the assumed decline during the lockdown (weighted by the sectors share within the total final demand of the other services sectors).

Source: Authors’ own elaboration of assumptions used in the OECD Economic Outlook.

6. With the exception of basic pharmaceuticals, for sectors listed in Table A A.1, real demand is assumed to decline by 33%, with restrictions in place for eight weeks. Adjustments to this general assumption are made based on the number of weeks a sector is under lockdown and the extent to which products can be delivered electronically (retail trade, communication and business services, for example). Additionally, since the reduction in demand for transport services sectors is due to the decline in passenger traffic, the assumed 33% decline is applied only to final demand. Moreover, as with the assumptions in the labour market, the assumed decline in demand is distributed over the 5 years covered by the METRO model.

7. The decline in demand is applied in the model through a tax on consumption. The size of the tax is based on two factors: the expected decline in the sector and the elasticity of demand of each sector in each country. The latter is computed using a model simulation, which adds 1% to the existing value added tax. The resulting percent change in the equilibrium quantity demanded by households is then used as a proxy of the elasticity and is used to determine the size of the tax needed to achieve the expected change in consumer demand.

Trade costs for goods and services

8. The costs of transporting goods and services are expected to increase. Reinforced border controls, new protocols at the border, and additional documentation requirements for transporting goods across borders due to containment measure result in delays. While many measures are taken with the aim of controlling the spread of the virus and protecting the people handling and inspecting the goods, they can nevertheless translate into additional costs for traders. Using the OECD Trade Facilitation Indicators and information collected by the OECD Trade and Agriculture Directorate on COVID-19 related policies, ad valorem estimates of these delays are computed following the approach in OECD (2017)⁴¹, with the assumption that the measures remain in place for 20 weeks.

9. Regulatory restrictions on the movement of people across international borders have also been implemented as part of strategies to contain the spread of COVID-19. The simulations use the Services Trade Restrictiveness Indicator (STRI) and the OECD COVID-19 policy tracker⁴² to quantify the cost of the increase of restrictions on business travel, intra-corporate transfers, and mutual recognition of qualifications and licenses, along with other airport restrictions not related to the movement of people. The increase of restrictions on business travel and mobility are translated into ad valorem equivalents following Benz and Jaax (forthcoming)⁴³. The estimates are at the sector and country level and are assumed to be active for 20 weeks. As with the assumptions in the labour market and demand, the assumed increase in trade costs are distributed over 5 years.

The localised regime

10. The localised regime involves three additional changes:

- (1) imposition of import tariffs of 25% by all trading countries;
- (2) granting of subsidies to labour and capital in the agriculture and manufacturing sectors by each trading country;
- (3) lowering of import elasticities to mimic lower flexibility of firms and consumers in choosing between domestic and foreign intermediate and final products.

The combination of changes (1) and (2) attempts to mimic a stylised scenario where importing from abroad is made significantly more costly and, at the same time, domestic agriculture and industry are subsidised by national governments. Imposition of a 25% import tariff corresponds approximately to a shift to the average advanced country import tariff in the first years following the Second World War. The subsidy shocks are scaled for each country so as to add up to 1% of GDP for each country imposing the shock. These subsidy shocks aim to approximate the scale of COVID-19 rescue packages directed to national economies by OECD countries to date, and it is assumed that subsidies of a similar magnitude are deployed by other countries. These subsidies are applied to value added (i.e. they subsidise national labour and capital costs) and thus favour local production.

11. Elasticities which determine the flexibility of substitution between (i) domestic and imported intermediate and final products and (ii) different varieties of imported intermediate and final products, are halved in the new regime. This means that, in the *localised* regime, when, for example, an imported intermediate product becomes more (less) expensive, the decrease (increase) in its use is less pronounced than in the *interconnected economies* regime. This mimics the situation where

⁴¹ OECD (2017), "METRO Development: Modelling Non-Tariff Measures and Estimation of Trade Facilitation Impacts", TAD/TC/WP(2016)/20/FINAL.

⁴² <http://www.oecd.org/coronavirus/en/#policy-responses>

⁴³ Benz S. and A. Jaax (forthcoming), "The costs of regulatory barriers to trade in services: New estimates of ad valorem tariff", OECD Trade Policy Paper.

firms are less reactive to international price shocks -- as was the case in earlier stages of globalisation and GVC fragmentation, when firms, due to higher trade and information and communication costs, were more constrained in choosing between domestic and foreign sources source of inputs into production.

The nature of supply chain shocks

12. Supply chain risks can take many forms (e.g. trade or productivity shocks); they can occur in different geographic locations; and they can be either specific to individual value chains or generic. They can also be independent from each other (as can be the case with, e.g., natural disasters such as earthquakes or floods) or correlated with each other (as can be the case with, e.g., infectious disease pandemics). Supply shocks can also be either negative (when, e.g., access to intermediate inputs is disrupted) or positive (e.g., due to trade costs improvements, positive productivity or harvest shocks, or industrial inventions). With GVCs, firms and countries are, on the one hand, exposed to negative shocks but, on the other hand, they are also ready to profit from positive shocks.

13. The analysis in this note assumes that supply chain shocks are country-specific and affect equally the costs of importing and exporting to and from the specific country. It is also assumed that the shocks are independent from each other and have the same probability of occurring in a specific country. In the event of a negative shock, costs of importing by, and exporting to, the country experiencing the shock increase by 10%. The shocks are implemented as 'iceberg' trade cost shocks, which means that, in the event of a negative shock, only a proportion of the originally shipped product is assumed to arrive at its foreign destination (i.e. with a 10% negative shocks, only 90 USD of the originally shipped value of 100 USD of products arrives).

14. The simulated supply chain shocks have many elements of the supply chain disruptions experienced during the COVID-19 crisis when, during lockdowns, both exports and imports of different products were affected. The generic nature of the shocks (i.e. country rather than supply chain specificity, and symmetry between exports and imports and across countries) has the additional advantage of facilitating comparison of outcomes.

Selected results of sensitivity analysis with respect to the assumption of more rigid sourcing in supply chains (Armington elasticities) and origin of shocks

15. The assumption of lower trade elasticities in the localised regime, intended to mimic a lower flexibility of firms and consumers in choosing between domestic and foreign intermediate and final products, clearly has important impacts for the stability results (Table A.A.2). Without that assumption, stability of key macro variables in both regimes is roughly comparable. The driving force behind those results are price movements: with lower elasticities for import demand and export supply, firms are less reactive to international price shocks, as was the case in earlier stages of globalisation and GVC fragmentation, when firms, due to higher trade and information and communication costs, were more constrained in choosing between domestic and foreign sources source of inputs into production. In an event of a real trade cost shock modelled here, where 10% of the volume of products shipped disappears when they cross the border of the country experiencing the shock, prices must move more to accommodate the shock. Bigger price movements, in turn, have bigger impacts on real wages and returns to capital and land.

Table A A.2. The global impact of shocks in the two regimes on stability of key economic variables

All shocks	Interconnected	Localised	Localised (with unchanged trade elasticities)
Real GDP	0.63%	1.03%	0.62%
Real production	0.66%	1.30%	0.62%
Real consumption	1.77%	2.70%	1.83%

Foreign shocks only	Interconnected	Localised	Localised (with unchanged trade elasticities)
Real GDP	0.27%	0.93%	0.28%
Real production	0.27%	1.20%	0.27%
Real consumption	0.80%	2.40%	0.84%

Note: The table reports the average of absolute values of percentage deviations from regime's base across all shocks, countries and sectors (as % of base value). Using the absolute values captures the symmetry of the trade cost shocks, which in principle can be either negative or positive.

Source: OECD METRO database and simulations.

Figure A A.1. Efficiency and stability effects of shifting to the localised regime with unchanged trade elasticities

Source: OECD METRO database and simulations.

Annex B. Measures of Centrality

16. Following Criscuolo and Timmis (2018), the “Bonacich-Katz” eigenvector centrality metric has been applied to the OECD (2018) Inter-Country Input-Output (ICIO) data to identify central hubs in production networks. This measure takes into account both direct and indirect network linkages, thus capturing a much richer structure of intermediate trade flows where all linkages of all trade partners are recursively accounted for. Thus, the centrality of each sector is determined by the weight of the partner, whether a central hub or a peripheral industry, and by the strength of these trading relationships.

17. While forward metrics capture the importance of a country or a sector as a seller of value added in intermediates for the production of exports of a specific partner, backward metrics measure the importance of a country as a buyer of value added in intermediates for the production of its own exports. This note explores both directions and distinguishes between 16 manufacturing and 14 service sectors, it covers 37 OECD countries, 27 non-OECD countries and the zone “Rest of the world”.

18. Backwards centrality for country i and sector s is computed as the baseline centrality (η) plus the weighted average of upstream centralities, where the weights (ω_{ijs}) are the upstream input linkages. Similarly, forwards centrality is calculated as the baseline centrality (η) plus the weighted average of downstream centralities, where the weights (ω_{ijs}) are the downstream input linkages.

$$c_{is}^{back} = \eta + \sum_{j \neq i} \lambda * \omega_{ijs} * c_{js}^{back}$$

$$c_{is}^{forw} = \eta + \sum_{j \neq i} \lambda * \omega_{ijs} * c_{js}^{forw}$$

19. The parameter λ determines the rate of decay of higher order network linkages as well as the weight of each direct supplier of country i . It follows that each supplier of country i 's supplier will have a weight equal to λ^2 . Thus, first-order linkages are weighted by λ , second-order linkages are weighted by λ^2 and so on. A higher value of λ means that centrality is determined more by indirect linkages, while a lower value of λ implies that centrality is determined less by indirect linkages. As in the original study by Criscuolo and Timmis (2018), the parameter λ has been rounded to 0.5.

20. The parameter η is a scaling factor and it corresponds to the minimum level of centrality per country-sector in case λ is equal to zero for all nodes. It is set equal to $(1 - \lambda)$, i.e. equal to 0.5. The backward (forward) weights, reflecting input shares, are computed by dividing each input flow (z_{ijs}) by the sum of total input inflows (outflows) ($\sum_i z_{ijs}$).

Annex C. Measures of Concentration

21. Two types of indicators are constructed to evaluate the degree of concentration on the world export market (supply side concentration) and on the world import market (demand side concentration): the top-n Concentration (CR_n) and the Herfindahl- Hirschmann Index (HHI).

- **The Concentration Ratio (CR_n)** is the percentage of total world exports (resp. imports) of product k accounted for by the top n biggest exporters (resp. importers)

The concentration ratio on the world export market **CR_nX** measures the cumulative market shares of the top n exporting countries in total world exports. It is computed for each product k as:

$$CR_n^k = \frac{X_1^k + X_2^k + \dots + X_n^k}{X^k}$$
 where X stands for exports, k refers to the product, subscripts 1 to n identify the n countries with the largest shares in world exports of good k (X^k).

Symmetrically the concentration ratio on the world import market, **CR_nM**, is:

$$CR_n^k = \frac{M_1^k + M_2^k + \dots + M_n^k}{M^k}$$
 where M^k is the value of total world imports of product k, and subscripts 1 to n refer to the top n biggest countries.

- **The Herfindahl- Hirschmann index (HHI)** is the sum of squares of the market shares of all exporter (or importer) countries in total world exports (or imports). By construction, it gives more weight to a country with a large share.

HHI on the export market is $HHI_X^k = \sum_j \left(\frac{X_j^k}{X^k} \right)^2$ where X_j^k is the country j's exports of product k and X^k is the value of total exports of product k in the world.

HHI on the import market is $HHI_M^k = \sum_j \left(\frac{M_j^k}{M^k} \right)^2$ where M_j^k is the country j's imports of product k and M^k is the value of total imports of product k in the world.

The values of these indices are ranging from zero (perfect competition) to one (pure monopoly). The inverse of the HHI can be interpreted as the "equivalent number of competitors" (or clients) in a world where all countries were symmetric.

Annex D. Average concentration measures across industries

Table A D.1. Herfindahl index of concentration on the export and import markets in manufacturing Industries

World export market						World import market					
Manuf. Industries	N	mean	p50	p25	p75	Manuf. Industries	N	mean	p50	p25	p75
Textiles	494	0.25	0.21	0.14	0.34	Furniture, others	22	0.11	0.11	0.09	0.12
Leather	60	0.22	0.19	0.10	0.28	Electronic products	254	0.10	0.09	0.07	0.14
Electronic products	254	0.21	0.18	0.12	0.28	Medical instruments	181	0.10	0.09	0.08	0.10
Medical instruments	181	0.19	0.14	0.09	0.25	Motor vehicles, trailers	65	0.10	0.08	0.07	0.16
Furniture, others	22	0.18	0.12	0.11	0.24	Wood	63	0.10	0.09	0.07	0.11
Beverages	22	0.17	0.14	0.08	0.33	Basic metals	359	0.09	0.08	0.05	0.12
Other transport equipment	80	0.17	0.14	0.09	0.25	Other transport equipment	80	0.09	0.06	0.06	0.11
Other non-metallic mineral	156	0.16	0.12	0.08	0.19	Chemicals	741	0.08	0.06	0.04	0.09
Wearing apparel	237	0.15	0.13	0.10	0.17	Textiles	494	0.08	0.06	0.04	0.10
Electrical equipment	174	0.15	0.12	0.08	0.18	Beverages	22	0.08	0.07	0.06	0.10
Food	406	0.14	0.11	0.07	0.18	Pharmaceutical products	63	0.08	0.06	0.06	0.08
Wood	63	0.14	0.12	0.08	0.17	Wearing apparel	237	0.07	0.07	0.06	0.08
Chemicals	741	0.13	0.11	0.08	0.16	Paper	122	0.07	0.04	0.04	0.09
Fabricated metals	234	0.13	0.10	0.08	0.13	Food	406	0.07	0.05	0.04	0.09
Paper	122	0.12	0.11	0.07	0.14	Electrical equipment	174	0.07	0.06	0.05	0.07
Machinery and equipment	452	0.12	0.10	0.09	0.12	Leather	60	0.07	0.06	0.05	0.07
Pharmaceutical products	63	0.11	0.09	0.08	0.12	Other non-metallic mineral	156	0.06	0.05	0.03	0.07
Rubber and plastics	117	0.11	0.08	0.06	0.10	Machinery and equipment	452	0.06	0.05	0.04	0.07
Basic metals	359	0.11	0.09	0.08	0.12	Printing	4	0.06	0.04	0.04	0.04
Motor vehicles, trailers	65	0.10	0.11	0.08	0.12	Rubber and plastics	117	0.06	0.05	0.04	0.06
Tobacco	8	0.08	0.07	0.07	0.08	Fabricated metals	234	0.05	0.05	0.04	0.06
Printing	4	0.08	0.07	0.05	0.07	Tobacco	8	0.05	0.03	0.03	0.05
Coke	17	0.06	0.05	0.05	0.05	Coke	17	0.03	0.03	0.03	0.03
Total	4336	0.14	0.11	0.08	0.17	Total	4336	0.08	0.07	0.05	0.10

Table A D.2. Concentration CR5 on the export and import market in manufacturing Industries

World export market						World import market					
Manuf. Industries	N	mean	p50	p25	p75	Manuf. Industries	N	mean	p50	p25	p75
Textiles	494	74%	76%	67%	81%	Medical instruments	181	56%	53%	48%	66%
Other transport equipment	80	73%	72%	60%	89%	Electronic products	254	56%	53%	46%	67%
Electronic products	254	72%	72%	66%	75%	Furniture, others	22	53%	52%	51%	56%
Leather	60	70%	75%	61%	80%	Motor vehicles, trailers	65	53%	52%	45%	61%
Medical instruments	181	69%	69%	56%	80%	Wood	63	52%	54%	43%	55%
Beverages	22	66%	68%	50%	80%	Basic metals	359	51%	51%	39%	66%
Furniture, others	22	65%	64%	59%	74%	Other transport equipment	80	51%	45%	44%	61%
Other non-metallic mineral	156	65%	64%	54%	78%	Wearing apparel	237	48%	48%	44%	51%
Chemicals	741	64%	62%	53%	74%	Beverages	22	48%	50%	44%	54%
Electrical equipment	174	63%	60%	55%	72%	Pharmaceutical products	63	48%	42%	42%	51%
Food	406	63%	62%	50%	75%	Chemicals	741	46%	42%	35%	54%
Pharmaceutical products	63	62%	57%	52%	73%	Food	406	45%	43%	36%	54%
Machinery and equipment	452	62%	61%	56%	66%	Textiles	494	45%	44%	36%	52%
Wood	63	62%	66%	50%	67%	Leather	60	45%	44%	39%	48%
Wearing apparel	237	61%	61%	55%	66%	Electrical equipment	174	45%	45%	40%	48%
Paper	122	60%	62%	48%	72%	Paper	122	43%	39%	33%	51%
Fabricated metals	234	59%	59%	50%	67%	Machinery and equipment	452	41%	40%	36%	47%
Motor vehicles, trailers	65	59%	59%	48%	63%	Other non-metallic mineral	156	41%	39%	31%	49%
Basic metals	359	57%	53%	50%	63%	Fabricated metals	234	40%	39%	35%	43%
Rubber and plastics	117	54%	53%	45%	59%	Rubber and plastics	117	40%	38%	35%	44%
Tobacco	8	52%	49%	49%	51%	Printing	4	39%	34%	34%	36%
Printing	4	50%	48%	40%	48%	Tobacco	8	36%	30%	30%	42%
Coke	17	44%	42%	42%	42%	Coke	17	30%	28%	28%	28%
Total	4336	63%	63%	52%	73%	Total	4336	48%	46%	39%	54%

Note: the table reports the number of traded products within each industry (N), the weighted mean of the concentration index (CR5) over the N products belonging to each industry. The weights are the share of each product in total industry exports or imports. The weighted first quartile, median and third quartile of CR5 (across products belonging to each industry) are also reported.