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Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

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Empfohlene Zitierung / Suggested Citation:
Pahl, S., Brandi, C., Schwab, J., & Stender, F. (2021). Cling Together, Swing Together: The Contagious Effects of COVID-19 on Developing Countries through Global Value Chains. *The World Economy*, *45*(2), 539-560. https://doi.org/10.1111/twec.13094

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Diese Version ist zitierbar unter / This version is citable under:
https://nbn-resolving.org/urn:nbn:de:0168-ssoar-92590-4

Check for updates

Received: 8 July 2020 | Accepted: 29 December 2020

DOI: 10.1111/twec.13094

ORIGINAL ARTICLE

The World Economy WILEY

Cling together, swing together: The contagious effects of COVID-19 on developing countries through global value chains

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KEYWORDS

COVID-19, global value chains, input-output analysis, international trade, shock spillover, supply and demand-side dependency

1 | INTRODUCTION

The entire world has been hit hard by the consequences of the COVID-19 pandemic and the political, social and economic measures to contain it in the recent months. While the global long-term economic effects of the disease still remain unpredictable, some countries, however, are currently affected more strongly by it, and there is considerable heterogeneity in underlying causal chains. Notably, adding to the immediate adverse consequences due to countries' own economic lockdowns, many countries are increasingly facing additional hazard in the highly interconnected global economy stemming from their integration in global value chains (GVCs). Despite the positive effects associated with the participation in GVCs (e.g. Stolzenburg et al., 2019; Pahl & Timmer, 2020; World Bank, 2020), the interdependencies they create also make developing countries vulnerable to shocks in major economies. This paper aims to document these interdependencies within GVCs in the context of the ongoing pandemic for a set of 12 developing and emerging economies in Sub-Saharan Africa, East and South-East Asia and Latin America.

A key characteristic of GVCs is that firms are linked to other producers and consumers through production networks spanning multiple countries. A demand shock in a specific consumer market therefore affects all (foreign) upstream suppliers delivering to this market, which goes well beyond a country's direct trade partners (in the spirit of Bems et al., 2011; Johnson & Noguera, 2017). Furthermore, a shock to a specific key input supplier can cause major bottlenecks in production, affecting not only directly linked firms but the entire value chain. Both types of shocks are currently looming large due to COVID-19-related lockdowns in many places around the world, in particular, in

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the major demand and supply hubs China, Europe and North America. Since there is a strong reliance on Chinese inputs in particular around the globe, the Chinese industrial disruption due to the pandemic has caused widespread adverse effects. In light of COVID-19 containment policies in other manufacturing hubs like the EU and North America; however, there are likely to be even more far-reaching repercussions via trade-based contagion links (Baldwin & Freeman, 2020a; Seric et al., 2020). While there are first analyses on the repercussions for trade in value-added (Baldwin, 2020; Baldwin & Freeman, 2020b), we still lack a detailed understanding of how the pandemic transmits through GVCs, especially in developing countries.

In this paper, we explore the vulnerability of developing countries to both the demand and the supply shock of the pandemic occurring in major economic hubs. Using global input-output tables, we map countries' value added to final demand in specific consumer markets (as in Johnson & Noguera, 2017) and to the production within specific value chains (in accordance with Los et al., 2015; Pahl et al., 2019; Timmer et al., 2013). This allows us to provide first estimates on potential GDP effects of the demand and supply shock, running through trade in GVCs.

We implement our analysis using a new set of global input-output tables from Pahl et al. (2019), constructed for country-specific analyses of a set of lower-income countries in the world economy. The data are constructed using highly country-specific sources, strictly following the methodologies of the World Input-Output Database (WIOD; Timmer et al., 2015) and can therefore be used in conjunction for global analyses. To estimate the strength of the effects of the sectorally diverse final demand contractions in the important markets for each of these developing countries, we combine the sectoral value-added data with estimates of sectoral final demand changes (from Coibion et al., 2020; Eurostat, 2020; NBS, 2020b) and cuts in industrial production as a result of COVID-19 (Eurostat, 2020; FRED, 2020; NBS, 2020a). While precise pandemic-induced economic effects are still uncertain, by using early estimates from the literature, we provide a ballpark figure for the size of the trade-induced shocks to developing countries due to the ongoing crisis.

With regard to the demand shock, we find that there are stark differences across developing countries, particularly in terms of the importance of hub markets for their own production and with regard to the sectors that they deliver to. In Bangladesh, for example, 6.1 (2.7) per cent of GDP depends on final demand in Europe (North America), of which more than 90 per cent are demand for textiles. In Vietnam, an even greater share, namely 8.1 (9.4) per cent of GDP depends on final demand in Europe (North America). At the same time, however, the Vietnamese export sector is more diversified, with only roughly a quarter to one third of the value added being concentrated in one sector at maximum. Combining these dependencies with changes in final demand, we find that 4.5 per cent of Bangladesh's GDP are at risk alone through the demand shock in Europe. 1 per cent of GDP is at risk due to the demand collapse in North America. For Vietnam, overall 3.5 per cent of GDP are at risk through declining demand in GVCs, almost equally due to the demand slumps Europe and North America. Sub-Saharan African countries tend to be more dependent on their home market and as such less affected by changes in final demand in the major hubs.

On the supply side, shock analysis reveals a more complex picture. A number of countries generate a sizeable share of their GDP in GVCs in which the respective hubs are key inputs suppliers (responsible for more than 5 per cent of value added in the entire GVC). This dependence amounts to countries' GDP at risk of up to 18 per cent (Vietnam) and 19 per cent (Senegal). Yet, Vietnam and other South-East Asian countries tend to be relatively diversified in terms of input suppliers from the major hubs, which might allow these countries to benefit from the temporal differences of economic lockdowns across different hubs. Others, such as Ethiopia, Mexico and Senegal are dependent on a single hub and therefore possibly more vulnerable to shocks in specific regions. Brazil, India and Kenya, on the other

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hand, generally seem less integrated through supply side linkages and therefore much less affected through this channel.

Our results inform the debate on COVID-19-related shocks by documenting the dependencies through trade in GVCs. This, however, is not to hide that the countries most affected through trade in GVCs are not necessarily the ones hit hardest overall. Yet during the recovery, those with strong linkages in GVCs need to consider both supply and demand at home, as well as in their GVC-linked partner countries. The results of this exercise do not only contribute to our understanding of the impacts of the current pandemic and potential future global demand or supply shocks but also make a contribution to the discourse about the potential role of supply chains in a post-COVID world. The pandemic and the asymmetric structure of its impacts show that in order to diversify risks, a simple detachment from direct links with China, as is currently discussed (Seric & Winkler, 2020), is not productive. Rather, diversification both with respect to sectoral specialisation patterns and to the regional dispersion of input suppliers appears promising to reap the gains from an international division of labour and still to cushion contagious cross-border spillovers.

The remainder of the paper is structured as follows. The next section provides a brief review of the trade effects of the COVID-19 pandemic and discusses the literature on how GVCs were affected by previous crises. Section 3 presents the method to compute the sector-regional demand- and supply dependencies through analysing the value-added trade of the developing countries in the sample and the respective data. In Section 4, we present the estimations of the shock for developing countries through the decreasing demand downstream in GVCs. Section 5 then discusses the impact through the contraction of supply. Section 6 concludes.

2 | RELATED LITERATURE

In addition to the threats inflicted by the pandemic on individual physical and mental well-being, widespread long-term effects are expected to arise from the decline in economic output and trade. As regards the latter, the pandemic spread of COVID-19 is disrupting international trade in an unprecedented manner (Baldwin, 2020; WTO, 2020). In 2020, global merchandise trade is expected to fall by between 13 per cent and 32 per cent due to the pandemic. While almost all word regions will be hit by double-digit declines in trade volumes, with exports from North America and Asia expected to be affected most intensely, a glimmer of hope comes from a predicted global trade recovery of up to 24 per cent in 2021 (Bekkers et al., 2020).

Despite increased integration in global goods trade, many, especially African, developing countries have undergone economic transition towards services, exposing them dramatically to the fluctuations in international services trade in the wake of the pandemic. Among the countries predicted to be most negatively affected are those concentrating on the export of travel and transportation services, such as Ethiopia, Mauritius and Morocco (Mendez-Parra, 2020; UNCTAD, 2020a). An additional burden to developing countries comes from the development in commodity markets where prices are recorded with a historical drop of 20 per cent in March (UNCTAD, 2020b). Moreover, an early World Bank study by Maliszewka et al. (2020), concentrating on shocks to labour supply and the tourism sector, predicts global GDP to fall by up to 3.9 per cent. Clearly, however, while all of the above figures draw a comprehensive initial picture of crisis outcomes, they cannot hide the immense degree of uncertainty underlying their estimations.

While it is important to understand the effects on gross trade flows in (final) goods and services, it is also essential to study the effects of the pandemic that run through GVCs as much of world's production is organised in such production chains. According to the WTO (2020), trade is likely to

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decline more strongly in sectors with complex value chains such as electronics and automotive products. Based on the OECD's inter-country input-output (ICIO) tables, Baldwin and Freeman (2020a) have computed larger countries' total direct and indirect exposure of each nation's manufacturing sector to the manufacturing sector of other nations. While their findings that 'supply disruption in the US, Germany, China, Korea, and Japan will have large effects on consumers and firms in all the major economies' (Baldwin & Freeman, 2020a) are highly relevant for understanding the trade-based contagion effects throughout supply chains, their evidence leaves us in the dark when it comes to the question how less developed countries might be affected by these value chain effects. Our paper aims at filling this gap.

In related analyses of supply side disruptions and its transmission through GVCs, Bonadio et al. (2020) investigate the question of nationalised versus globalised GVCs, and Guan et al. (2020) focus on the length versus intensity of lockdowns. Both of these works simulate the potential contagion effects through GVCs in various different lockdown scenarios, focussing on the effects stemming from breakdowns on the supply side, given hypothetical lockdown measures. In contrast to these papers, we also consider shifts in and shocks to final demand, using actual economic data on disruptions of both supply and sectoral demand. Furthermore, on the supply side, Bonadio et al. (2020) and Guan et al. (2020) compute their figures on the basis of a general equilibrium model, implying substitutability between inputs. We, in contrast, study the complete breakdown of GVCs that have a strong dependence on production from countries in lockdown. Thus, our approach speaks more to short-run effects, as we will highlight in the next section.

The world has seen various pandemic spreads of infectious diseases before COVID-19. Among them, the Spanish Flu ranks as the most prominent and devastating example, costing up to 50 million lives between 1918 and 1920. Due to much less developed trade ties between countries and geographical fragmentation of production processes than today, however, the economic consequences of the Spanish Flu arguably had little in common with the dynamics surfacing within the context of COVID-19. In contrast, while the 2008–09 'Great Trade Collapse' emerging in the wake of the global financial crisis shares only partial similarity with the ongoing pandemic in terms of cause, insofar as it hardly cut on supply, it does hold important implications for the consequences of particularly developing countries' participation in the global trading system. Echoed by, for example, Bems et al. (2013) and Eaton et al. (2016), most academic commentators generally name the drop in aggregated expenditure in trade-intensive durables and capital goods as the origin of the massive plunge in 2008–09 international trade. In line with this view, empirical evidence by Berkman et al. (2012) attests a relatively unscathed escape of the trade collapse to developing country food exporters whereas especially open developing countries are generally found to have suffered from declining exports. Adding to the descriptive analysis rolled out in Baldwin (2009), whose findings point towards a 'severe, sudden and synchronized' negative trend in goods trade across nearly all product categories between mid-2008 and early 2009 but with a skewness towards commodities (especially in minerals and oil), Meyn and Kennan (2009) observe a severe aggravation of price volatility of selected commodities. In the absence of a balanced cushioning mechanism, not only were those developing countries hit hardest whose export performance relied on only a small range of products but, in particular, those dependent on commodities, among them most of the African, Caribbean and Pacific (ACP) countries. In a similar vein, empirical evidence for sectoral export patterns across Latin American during the financial crisis by Camanho da Costa Neto and Romeu (2011) suggests that diversification of export activity across industries rather than sectoral concentration has significantly helped cushioning countries' export declines.

A number of studies have paid special attention to the role of GVCs during the financial crisis. Here, one of the empirical insights brought forward in the widely acclaimed article by Levchenko

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et al. (2010) is that trade (imports and exports alike) in sectors categorised as intermediates declined disproportionally stronger than in other sectors. As processed sectoral inputs cross-borders multiple times in the production of final goods organised in GVCs, the authors' findings could be read in support of a widespread (at least partial) explanation for the overshoot of the global trade relative to global GDP decline during the financial crisis. While there exists some empirical evidence underpinning this perception (e.g. Anderton & Tewolde, 2011; Nagengast & Stehrer, 2016), it is far from being generally accepted, and likewise challenged (e.g. Bems et al., 2011; Bénassy-Quéré et al., 2009). Analysing the impact of the global financial crisis on global apparel value chains, Gereffi and Frederick (2010) find that the massive decline in global demand for apparel has led to a surge in unemployment across the industry's supply chain, borne mainly by those located in developing countries.

The trade effects associated with the global financial crisis for developing countries have revived research on both their international linkages and thereof arising spillover mechanisms with global trade hubs, however, leaving behind an inconsistent picture of evidence. For example, while the positive nexus between income and import demand already resonates in Forbes (2002, 2004), Bems et al. (2010) explicitly emphasise the impact of United States and EU demand shocks on cross-border intermediate goods linkages. More specifically, employing a global input-output framework, their empirical findings suggest that demand declines induced by the financial crisis in both hubs largely came at the cost of falling exports in NAFTA integration partners and emerging Europe. Accounting for international production networks, Cheewatrakoolpong and Manprasert (2014) find that the severity of the adverse effects arising from the financial crisis in developing countries was linked significantly to US export dependency. Moreover, while Yamamoto (2014) emphasises that US spillover shocks generally account for around 50 per cent of Asian production fluctuation owing to financial and trade linkages, the author finds that both types of linkages posed a considerable negative impact on the production in Asian economies during the financial crisis, yet with a larger impact of the former. By contrast, Rose and Spiegel (2010) as well as Pentecôte and Rondeau (2015) attribute only secondary importance to trade linkages for the adverse spillover effects during the financial crisis. In fact, based on their empirical analysis, Rose and Spiegel (2010) reject a positive nexus between economic exposure to the United States and financial crisis contagion. Similarly, empirical findings in Pentecôte and Rondeau (2015) suggest that stronger trade linkages with the United States may have even helped to mitigate output loss in developing countries during the financial crisis.

A related and growing strand of literature analyses transmission channels and spillover effects explicitly arising from China. For example, addressing the implications of China's pre-COVID-19 growth slowdown for the exports of its ASEAN-5 neighbours, Diziolo et al. (2016) find that both generally closer trade ties to and commodity export dependency on China would translate in declining growth rates between 0.2 and 0.5 percentage points, respectively, resultant from China's growth falling by 1 per cent. Similar insights are provided in input-output data analysis for the years 2002–06 by Escaith (2009) who notes that China had notably increased its role as an exporter of manufacturing intermediates already prior to the global financial crisis, thus making it a major exporter of adverse supply shocks in global value chains. Given their concentration on GVC-integration in manufacturing sectors and their dependency on imported manufacturing inputs, both Malaysia and Thailand are linked to China's economic performance to a special degree. Emphasising China's impact on commodity prices given its role in world trade as well as sub-Saharan Africa's ever closer becoming cooperation with China particularly in terms of trade, Anderson et al. (2015) provide evidence confirming that the degree of spillover effects arising from an output drop in China heavily depends on whether sub-Saharan countries are importers or exporters of commodities.

Accounting for the direct as well as rebounding second-round trade effects, Andritzky et al. (2019) show in an input-output framework that a final demand shock occurring in China does less harm to

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the global economy than shocks originating in the EU or the United States because of the latter two's comparatively larger share of imports of final goods. Unsurprisingly, with close trade ties in mind, a Chinese final demand shock generally affects the output of its Asian neighbours strongest in negative terms, outpacing economic turmoil caused in Europe and the United States. In more depth, however, the authors demonstrate that demand shocks specifically to investment in primary and secondary sectors, that is, allegedly import-intensive sectors of China, have an even stronger spillover elasticity than broad-based final demand shocks. The latter finding attracts particular attention in view of China's gradual transition of replacing investment and exports as drivers of its economic growth by consumption. Most recently, Cao et al. (2021) compare the spillover effects of import fluctuations in China and the United States. While the authors find that Europe and Asia would be most negatively affected through import declines in China and the United States, that is, by implication revealing less impact on Latin America or Africa, export changes on GDP were felt more severely when caused by falling US imports.

It is well beyond question, that the ongoing pandemic already poses the greatest challenge to the world community since the 1930s Great Depression. It is therefore all the more to be seen whether the well-documented insights from the latest, allegedly moderate, global financial crisis just a decade ago can be transferred to the current context. As the nature of the COVID-19 crisis is different insofar as sectors of household consumption are affected very heterogeneously due to social distancing measures, and that some supply chains may be interrupted fully for certain periods of time, the expected hazardous effects from this inflicted on developing countries remain an empirical puzzle.

3 | METHOD AND DATA

To study GVC-induced demand and supply shocks on developing countries, we map individual country's value added to demand for and production of specific value chains. Following Los et al. (2015) and Timmer et al. (2013), we define a value chain by the finalised products, that is, by final industry grouping and country of completion, for example, textiles finalised in Bangladesh. To trace each country's contribution to this value chain, we need to find the output and value added associated with the production of textiles in Bangladesh. In the last stage of production, output and value added is by definition generated in the textiles sector in Bangladesh. Yet, textiles production requires intermediate inputs, such as cotton from the agricultural sector. This will generate output and value added in the agricultural sector, which can be in Bangladesh or in any other country from which the intermediate is imported. Those first-tier agricultural intermediates may require intermediate inputs themselves, which again generates output and value added in a specific country-industry, depending on the source of those second-tier intermediates. To get a complete characterisation of the value chain, we trace the entire chain of intermediate suppliers across countries and industries.

To do so, we make use of the global system of input-output relationships. We define a column vector $\mathbf{F}$ for final demand for finalised products grouped by industry (e.g. textiles) and country of completion (e.g. Bangladesh). With $\mathbf{A}$ being a matrix of intermediate input coefficients, we can trace the contributions to the production of $\mathbf{F}$ making use of the well-known Leontief-inverse $(\mathbf{I}-\mathbf{A})^{-1}$. $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}$ then describes the output generated in any country-industry to produce the vector of final demand $\mathbf{F}$.[1] Multiplying by a matrix $\mathbf{V}$ of value added to gross output ratios for each country-industry

[1] $(\mathbf{I}-\mathbf{A})^{-1}$ is a geometric series. That is, $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}$ can be written as $(\mathbf{F}+\mathbf{AF}+\mathbf{A}^2\mathbf{F}+\mathbf{A}^3\mathbf{F}+\cdots)$. $\mathbf{AF}$ then describes the first-tier intermediate use, $\mathbf{A}^2\mathbf{F}$ the second tier use and so on. Therefore $(\mathbf{I}-\mathbf{A})^{-1}\mathbf{F}$ gives the output in any country-industry in the system that participates in production of $\mathbf{F}$. in For details, see Miller and Blair (2009).

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on the diagonal, we further obtain the value added by each country-industry (vector VA) generated in the production of **F**. That is,

$$\mathrm{VA} = \mathbf{V}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}. \quad (1)$$

By appropriate definition of **F**, we obtain value added generated in a specific country-industry related to finalisation of a specific product or to final demand by consumers in a specific region or country. For example, setting all elements to zero in **F** except those for Chinese consumers, we obtain value added generated in any country-industry associated with final demand in China. In a similar vein, setting all elements to zero except those for final demand (anywhere in the world) for products finalised in China, we obtain value added in any country-industry associated with production for goods finalised in China.

We obtain each country's demand dependencies by calculating that country's share of GDP that is generated in the production for final goods consumed in the three world regions Europe (EU28 as of 2014 plus Switzerland), North America (United States and Canada) and China. We obtain each country's supply dependency by calculating each country's share of GDP that is generated in GVCs that are dependent on the three hubs. We define a GVC as dependent on a specific hub if that hub generates at least five per cent of value added in production of the respective final good (defined by country of completion and sector grouping).[2]

The main advantage of our supply side approach is that it accounts for upstream as well as downstream dependencies. For example, let us assume that Ethiopia exports cotton to China where the cotton is processed and then exported to Europe as a textiles product. Ethiopian agriculture does not require any Chinese inputs in this value chain, but its production is nonetheless dependent on Chinese producers. By decomposing the value chain by its final product, we can trace all participants in that chain independent of their relative position.

To estimate the size of the effects of the COVID-19 pandemic, we combine these demand and supply dependencies with first estimates on the demand and supply shock. For the demand shock, we combine the data on sectoral value-added dependencies with estimations of the sectoral differences in the downturn in final demand. For Europe, we obtain sectoral retail consumption data from Eurostat (2020). For the sectoral demand effects in the United States (which we use for North America), we rely on estimates by Coibion et al. (2020). These authors use household survey data in the United States and exploit regional variation in the exposure to COVID-19 and measures to contain it to estimate the effect on different categories of consumption goods by households. The survey was held in April, and thus during the time when the US economy was hit the hardest by the pandemic. For China, we use data from the National Bureau of Statistics China (NBS, 2020b). The sectoral classifications differ slightly between the three sources. However, all the information can be straightforwardly mapped with the ISIC (International Standard Industrial Classification of All Economic Activities) Rev. 4 categories in the TiVA (Trade in value-added) data (see Table A1 in the Appendix A for the respective mappings and the estimated declines in regional sectoral demand).[3]

[2]In the data, each country delivers to up to 45 end markets with 28 sectors, such that there are 45 x 28 = 1260 value chains. By definition, the value-added shares of all countries that participate in the GVC add up to expenditure for the respective final product, see equation (1).

[3]Mostly for reasons of exposure, our analysis concentrated on those ISIC Rev. 4 categories for which final demand in the three hubs meaningfully contributed to GDP in the set of developing countries.

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For the supply shock, we use data on the drop in per cent of industrial production in the three hubs Europe, North America and China in the month of the largest drop in the first months of 2020.[4] The months with the largest drop were February for China (26.6 per cent), and April for Europe (27.0) and North America (16.6). China was the first country globally to be affected by COVID-19, and implementing a drastic lockdown, with other countries around the globe following in staggered sequence with the eruption of the disease, with the resulting effects on industrial production.

To implement this method to be applied to estimating both the demand and the supply shock, we need information on the global system of input-output relationships (depicted in **A**), information and value added to gross output ratios (**V**) and a vector of final demand (**F**). In particular, to obtain **A**, one needs to turn to global input-output tables, which describe the supply and use relationships between producers within and across countries. Global input-output tables are constructed combining a large amount of information on value added, gross output, trade flows (intermediates, final goods) and final demand categories. As this is a highly data-intensive exercise, a major bottleneck to studying the involvement of developing countries is the relatively poor coverage of less developed countries, in particular, in Sub-Saharan Africa. Some attempts have been made to bridge this gap. The construction of the EORA database (Lenzen et al., 2013) takes a global approach covering a large amount of countries since the 1990s, but naturally has to compromise with respect to a clear anchoring in official statistics and simplifying assumptions. As a country-specific alternative, we use the data constructed in Pahl et al. (2019). This construction closely follows the approach laid out in the construction of the World Input-Output Database (WIOD; Dietzenbacher et al., 2013; Timmer et al., 2015), but adds seven new developing countries for the time period 2000–14. These are as follows: Ethiopia, Kenya, Senegal, South Africa, Bangladesh, Malaysia and Vietnam. We base the estimates on the final year in that dataset, that is, 2014.

This country-specific approach (rather than a global one) allows for a number of improvements, which are particularly important when studying the value added or income effects related to GVCs. As is easy to see from equation (1), value added to gross output ratios in **V** are crucial to obtain a country's value added in global production. An advantage of using data from Pahl et al. (2019) is the yearly variation in the input data in those ratios for each of the covered sectors and industries. Second, the construction in Pahl et al. (2019) provides a careful treatment of trade flows (e.g. re-exports, missing trade flows, classification by use category), which is paramount to depicting the cross-country relationships in **A**. Moreover, to obtain the domestic supply and use relations in **A**, the data are built up from national supply and use tables or official input-output tables, and as such are highly country-specific. Lastly, **F** is consistent with national accounts, and split between household consumption, government consumption, gross fixed capital formation and inventories. As this paper assesses the impact of a reduction in final demand, mostly running through reduced household consumption, this distinction proves useful.

Using this dataset, we will analyse 12 developing and emerging economies: four countries in Sub-Saharan Africa (Ethiopia, Kenya, Senegal and South Africa), six in East and South-East Asia (Bangladesh, China, India, Indonesia, Malaysia and Vietnam) and two in Latin America (Brazil, Mexico).

[4]For Europe, we use data from the European Union, for North America from the United States. The data come from the respective national statistical bureaus.

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TABLE 1 Demand-side dependency by region (per cent of GDP)

	Europe	North America	China	East Asia	Other emerging	Rest of world	Home market
Bangladesh	6.1	2.7	0.2	0.4	0.7	2.6	87.2
China	3.2	3.6	-	2.1	2.1	7.7	81.3
India	2.1	1.7	0.9	0.5	0.8	7.3	86.7
Indonesia	2.3	2.6	2.4	3.3	1.7	7.0	80.7
Malaysia	4.7	4.8	5.3	6.5	4.9	24.1	49.7
Vietnam	8.1	9.4	5.3	6.0	3.6	15.5	52.1
Ethiopia	2.5	0.5	0.9	0.5	0.5	8.6	86.5
Kenya	3.0	0.7	0.2	0.2	0.5	14.8	80.6
Senegal	2.3	0.3	0.3	0.4	0.4	12.5	83.9
South Africa	4.7	2.5	2.6	1.5	2.0	13.9	72.8
Brazil	1.7	1.4	1.5	0.7	0.9	3.6	90.3
Mexico	1.4	13.8	0.6	0.5	0.6	2.1	81.0

Note: Figures for 2014. GDP as sum of value added in 2014 US$. Europe is all 28 member countries of the EU as of 2014 plus Switzerland; North America is USA and Canada; East Asia is Japan, Rep. Korea and Taiwan; Other emerging is Brazil, Mexico, Turkey, Russia, India and Indonesia. Each country's home market is included in the home market region such that columns add up to 100, except for rounding.

Source: Authors' calculation based on method and data from Pahl et al. (2019).

4 | DEMAND-SIDE VULNERABILITY

To study demand-side-related GDP effects for developing countries arising from the pandemic, we use the value-added trade data to compute how much of value added in each of the developing countries in the sample depends on final demand in the different regions in the world. Table 1 presents these results aggregated across sectors, where rows show individual developing countries. The first six columns list separate world regions, and the last column developing countries' home markets. The values then depict how much of value added in each country depends on final demand in each of these regions.[5]

As shown in Table 1, Vietnam and Malaysia are most strongly dependent on foreign demand, with only around 50 per cent of domestic value-added dependent on final demand in their home markets. For other countries, GDP dependence on foreign demand ranges between 27 (South Africa) to below 10 per cent (Brazil). At the same time, for example, Bangladesh's GDP is relatively strongly dependent on demand from Europe, with 6.1 per cent, and Mexico, unsurprisingly, on demand from North America, with 13.8 per cent. We would expect these countries to be most strongly affected by the economic downturn and plummeting demand in Europe and the United States. Considering regional differences, value added in Asian countries is on average more dependent on foreign final demand than that in African countries.[6]

[5]These numbers are related to the export to GDP ratio, but not equal. Differences arise in different shares of domestic value added to gross exports across the countries.

[6]For Latin America, the sample is quite small and particular, with Brazil as a large country with a large home market and Mexico, with a strong dependence on US final demand, which are not necessarily representative for other countries in the region, but who, on the other hand, make for interesting contrasts in this respect.

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TABLE 2 Demand-side dependency by product group within major hub (as per cent of GDP generated in respective region)

		Asia					Sub-Saharan Africa				Latin America		
		Bangladesh	China	India	Indonesia	Malaysia	Vietnam	Ethiopia	Kenya	Senegal	South Africa	Mexico	Brazil
Europe													
Agriculture, forestry and fishing	A	0.0	0.7	2.7	2.4	1.7	4.7	48.5	66.0	40.9	8.5	2.8	4.1
Food, beverages, tobacco	C10t12	3.1	4.0	7.4	14.3	8.8	14.9	27.0	20.4	18.9	9.6	8.3	25.6
Textiles	C13t15	94.1	13.5	20.1	13.2	4.1	24.2	3.1	1.5	2.5	1.9	1.8	3.3
Coke and refined petroleum	C19	0.0	1.1	2.1	3.5	2.7	0.7	0.2	0.5	2.3	4.6	8.6	3.4
Pharmaceuticals	C21	0.1	1.3	1.1	1.5	0.9	0.4	0.4	0.2	0.8	0.8	3.4	1.4
Computer and electronics	C26	0.1	15.9	1.9	7.1	18.6	26.4	0.5	0.4	1.5	3.0	5.2	1.6
Electrical equipment	C27	0.0	6.0	1.3	2.1	3.4	1.5	0.5	0.1	1.9	1.8	1.6	1.3
Machinery	C28	0.1	6.0	2.8	2.1	4.7	1.4	0.8	0.3	3.3	10.0	4.1	2.7
Furniture; other manufacturing	C31t33	0.1	6.4	3.2	5.8	6.1	6.6	0.9	0.8	3.0	3.7	4.9	3.4
Sum		97.7	54.9	42.5	52.0	50.9	80.7	82.0	90.3	75.0	43.8	40.8	46.8
North America													
Agriculture, forestry and fishing	A	0.1	0.3	2.0	0.8	0.5	5.1	7.7	11.6	2.7	2.2	4.9	1.8

(Continues)

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TABLE 2 (Continued)

		Asia					Sub-Saharan Africa				Latin America		
		Bangladesh	China	India	Indonesia	Malaysia	Vietnam	Ethiopia	Kenya	Senegal	South Africa	Mexico	Brazil
Food, beverages, tobacco	C10t12	1.3	3.2	7.4	13.0	6.0	11.6	33.2	8.7	8.6	5.6	7.0	11.0
Textiles	C13t15	94.9	16.1	22.5	26.5	5.2	37.8	10.8	57.4	9.3	2.7	3.4	4.5
Coke and refined petroleum	C19	0.0	0.8	2.3	2.2	1.8	1.0	1.2	0.8	3.4	5.0	4.8	4.7
Pharmaceuticals	C21	0.0	0.8	1.5	0.6	0.7	0.2	1.3	0.6	1.6	1.1	0.4	1.5
Computer and electronics	C26	0.2	18.5	2.1	6.0	20.6	11.4	1.6	1.2	4.5	3.9	6.3	2.3
Electrical equipment	C27	0.0	5.4	1.1	1.4	3.6	1.1	0.6	0.3	1.7	1.8	3.5	1.9
Machinery	C28	0.1	6.0	3.0	2.0	3.8	1.5	1.2	0.7	3.8	7.6	5.8	5.3
Furniture; other manufacturing	C31t33	0.6	6.9	6.0	7.1	7.0	10.7	3.4	2.0	21.7	4.3	4.4	5.3
Sum		97.3	58.1	48.0	59.7	49.2	80.3	61.1	83.2	57.4	34.2	40.3	38.3
China													
Agriculture, forestry and fishing	A	8.6		2.4	3.0	2.5	8.7	6.9	6.3	3.9	2.4	2.0	4.6
Food, beverages, tobacco	C10t12	3.7		6.5	11.7	7.2	20.8	19.8	10.0	17.9	4.3	4.8	19.4
Textiles	C13t15	48.6		4.6	3.6	1.7	6.5	4.1	4.4	3.0	1.5	1.5	3.3

(Continues)

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TABLE 2 (Continued)

		Asia					Sub-Saharan Africa				Latin America		
		Bangladesh	China	India	Indonesia	Malaysia	Vietnam	Ethiopia	Kenya	Senegal	South Africa	Mexico	Brazil
Coke and refined petroleum	C19	0.3		0.7	2.0	1.4	1.0	0.2	0.8	0.6	1.6	1.2	0.9
Pharmaceuticals	C21	0.4		0.5	0.5	0.4	0.2	0.8	0.8	0.7	0.4	0.7	1.0
Computer and electronics	C26	1.7		3.3	3.7	13.2	9.9	0.9	5.2	5.1	3.2	5.3	1.5
Electrical equipment	C27	1.2		2.5	3.5	4.0	2.9	1.3	3.3	3.4	3.6	4.2	2.1
Machinery	C28	2.6		5.1	5.0	6.8	4.0	2.7	5.5	7.1	6.9	7.3	4.1
Furniture; other manufacturing	C31t33	1.3		1.0	1.2	0.9	1.3	0.6	1.4	1.7	0.6	3.9	0.6
Sum		68.2		26.7	34.2	38.1	55.4	37.3	37.8	43.3	24.5	30.9	37.6

Note: Figures for 2014. Grey cells indicate 10 per cent or more in respective region. List of industries is not exhaustive but only shows industries for which we obtain demand shock (see Table 3). Europe is all 27 member countries of the EU plus Switzerland and the UK; North America is USA and Canada.

Source: Authors' calculation based on method and data in Pahl et al. (2019).

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TABLE 3 Demand-induced value-added effect (as per cent of GDP)

	Europe	North America	China
Bangladesh	−4.46	−0.93	−0.06
China	−0.52	−0.31	-
India	−0.37	−0.19	−0.04
Indonesia	−0.36	−0.36	−0.13
Malaysia	−0.38	−0.24	−0.21
Vietnam	−1.78	−1.68	−0.45
Ethiopia	−0.10	−0.05	−0.05
Kenya	−0.09	−0.16	−0.01
Senegal	−0.11	−0.03	−0.02
South Africa	−0.25	−0.11	−0.08
Brazil	−0.09	−0.07	−0.08
Mexico	−0.10	−0.63	−0.02

Note: Figures for 2014. GDP is sum of value added in 2014 US$. Europe is all 27 member countries of the EU plus Switzerland and the UK; North America is USA and Canada.

Source: Authors' calculation based on Table 2 (including all sectors) and demand-side estimates in Table A1.

However, economic lockdown measures do supposedly not lead to a homogeneous decrease in demand across all sectors. Social distancing measures affect those sectors much more strongly, which require direct personal interaction, besides the differentiated demand reductions due to an overall income plunge. Developing countries participating in GVCs for which final demand collapsed

TABLE 4 Supply side dependency (as per cent of GDP)

	Europe	North America	China	East Asia	Other emerging	Rest of world
Bangladesh	0.6	0.1	15.2	0.1	7.7	99.7
China	5.5	1.9	93.1	4.5	2.9	47.6
India	7.1	1.1	2.8	0.5	94.6	46.7
Indonesia	7.8	1.5	8.9	7.0	88.9	70.5
Malaysia	25.7	7.0	25.0	12.6	16.9	90.9
Vietnam	9.5	2.8	56.5	39.5	5.1	94.0
Ethiopia	4.3	0.6	23.5	0.4	3.3	97.9
Kenya	5.8	0.3	4.5	2.3	26.9	99.2
Senegal	69.7	0.2	1.8	0.1	2.3	98.9
South Africa	29.8	2.2	7.6	1.7	5.3	94.9
Brazil	5.4	1.7	3.4	1.4	94.2	11.8
Mexico	7.6	49.5	2.6	1.9	90.4	4.8

Note: Shares indicate value added in row country generated in value chains with contributions of 5% or more of column region. Europe is all 28 member countries of the EU as of 2014 plus Switzerland; North America is USA and Canada; East Asia is Japan, Rep. Korea and Taiwan; Other emerging is Brazil, Mexico, Turkey, Russia, India and Indonesia. Rows do not need to add up to 100%. Row countries included in respective column.

Source: Authors' calculation based on Pahl et al. (2019) and method as described in main text.

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TABLE 5 Supply induced value-added effect (as per cent of GDP)

	Europe	North America	China
Bangladesh	−0.2	0.0	−4.0
China	−1.5	−0.3	-
India	−1.9	−0.2	−0.7
Indonesia	−2.1	−0.3	−2.4
Malaysia	−6.9	−1.2	−6.6
Vietnam	−2.6	−0.5	−15.0
Ethiopia	−1.2	−0.1	−6.3
Kenya	−1.6	0.0	−1.2
Senegal	−18.8	0.0	−0.5
South Africa	−8.0	−0.4	−2.0
Brazil	−1.5	−0.3	−0.9
Mexico	−2.0	−8.2	−0.7

Note: Shares indicate value added in row country associated with supply drop column region (in value chains with contributions of 5% or more of column region). Europe is all 28 member countries of the EU as of 2014 plus Switzerland; North America is USA and Canada. Supply drop is estimated decline in industrial production as described in main text.

Source: Authors' calculation based on Pahl et al. (2019) and estimates on industrial production (Eurostat, 2020; FRED, 2020; NBS, 2020a).

comparatively more are therefore likely to be more vulnerable to COVID-19-induced demand shocks through global production links. To disclose these sectoral dependencies, we show how much of the value added in each developing country that depends on final demand in the foreign region (as shown in Table 1) arises from demand in individual sectors. Table 2 presents corresponding findings, where the depicted values represent shares in per cent of total value added in a developing country that depends on final demand in the respective foreign region, stemming from final demand in a given sector. Table 2 is not exhaustive but shows the end markets by sector grouping, for which we observe demand changes and which make up of a large share of developing countries' dependencies (as seen by the sums in the table). The displayed dependencies uncover quite stark differences between developing countries and regions in terms of how much of domestic production for foreign demand is concentrated in production for specific sectors.[7] For Bangladesh, 94 per cent of its value added embedded in European final demand is for the textiles goods, and this value is 95 per cent of its production for North American final demand. Other countries, such as Vietnam, are much more diversified: for all of Vietnamese production consumed in Europe, only 24 per cent are for textiles, but 26 per cent are for the electronics and 15 per cent go into the consumption of food. If consumption of textiles breaks down in Europe more than in other manufacturing sectors, as happened now in the COVID-19 pandemic (ILO, 2020), Bangladesh is thus likely to be relatively more affected by this than a more diversified country such as Vietnam.

In order to provide a ballpark figure for the adverse effects inflicted on sample developing countries by the demand slumps in Europe, the United States and China due to the COVID-19 pandemic,

[7]Note that the value added in the source country may be in other sectors, as long as they supply the respective sector of final demand. Conversely, production in a certain sector in a source country need not be for final demand in that sector in another country (or domestically).

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we combine the above results with data on how much final demand falls by sector. Table A1 depicts the collapse in demand by ISIC sector in the three hubs. These data cover the most relevant sectors for our set of developing countries, that is, food, textiles and advanced manufactures. For example, demand in the textiles sector indeed fell strongest of all manufacturing sectors, with 35.7 per cent (in North America) to 77.8 per cent (in Europe), whereas food consumption fell by 1.4 per cent (in Europe) to 14.7 per cent (in North America).

What does this imply for those developing countries located upstream in GVCs? To get a first impression about the dimensions of what the demand slumps could imply, we assume that each sectoral downturn is passed proportionally through the value chain, thus affecting value added in the supplying countries to the same extent.[8] This produces an approximation to the loss of value added in each developing country through its contribution to the respective final demand sectors. Table 3 shows these results.

As Table 3 depicts, the likely contribution of demand downturns further downstream in GVCs to an overall GDP decrease differs significantly across the countries in our sample. The countries that we found to depend more on foreign markets, and among those the ones specialised in sectors with forecasted sharpest demand decreases, will be expected to suffer from comparatively stronger drops in own GDP through this channel. For example, Bangladesh's GDP may experience a drop of about 4.5 per cent only due to falling demand in Europe and 0.9 per cent in North America. This effect runs mostly through the sharp decline in demand for textiles. Vietnam is even more dependent on foreign demand overall, but in different sectors, and might therefore expect a decline of about 0.5–1.8 per cent through declining final demand in each of the three regions. By contrast, sub-Saharan African countries are much less integrated into the world economy through demand linkages and therefore only experience minor economic effects through GVCs.

5 | SUPPLY SIDE VULNERABILITY

With the role for some of the poorest developing countries in GVCs remaining to be restricted to the supply of commodities, others have managed to become important pillars further downstream in value chains, for example, in the assembly of final goods (World Bank, 2020). As such, the maintenance of output capacities in developing countries for both commodity exporters as well as downstream assemblers often relies on intermediate inputs from foreign sources, which can either be further upstream or further downstream. Analogously to Table 1, Table 4 presents this dependency for our selection of developing countries for an aggregation across sectors, where values indicate the share of value added in the row country (as per cent of GDP) generated in value chains with a minimum supply side contribution of 5 per cent at any stage in the production process by the column regions.[9] Defining a threshold contribution implies that substituting existing supply side relations (at least in the short-run) appears rather difficult and, with this, unlikely. This emphasises the displayed dependencies.

Table 4 reveals that the dependency of developing countries is far from being homogeneous with respect to supplying countries: indeed, geographical proximity appears to be a salient determinant (see also Baldwin & Lopez-Gonzalez, 2015; Johnson & Noguera, 2017). For example, while Mexico

[8]This assumes that the demand shock is uniform across varieties of final goods within sectoral aggregation (e.g. final good varieties from different countries), and that the production function remains unchanged (i.e. cost shares remain constant), see also Pahl et al. (2019).

[9]Unlike in Table 1, the two far-right columns aggregate supply dependency on both home producers and those not explicitly displayed (depending on where the country is included).

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generates nearly 50 per cent of domestic value added through value chains which depend on inputs from the United States and/or Canada, Bangladesh (15.2), Indonesia (8.9 per cent), Malaysia (25 per cent) and Vietnam (56.5 per cent) exhibit natural dependencies with China. Typically, these strong dependencies stem from the hubs' prominent role in key GVCs. For example, China is a key input supplier (11 and 10 per cent of value added) into textiles (C13t15) and computer products (C26) finalised in Vietnam. Those two GVCs alone account for about 12.5 per cent of Vietnamese total GDP. At the same time, however, Indonesia, Malaysia and to some extent also Vietnam are not exclusively tied to Chinese inputs. Instead, their value added appears to depend equally on inputs from other regions, suggesting a relatively well-diversified portfolio of suppliers. In view of the uneven temporal distribution of production bottlenecks across major GVC-hubs induced by COVID-19, that is still affecting Europe and North America while Chinese production capacities have started being ramped up again in the late spring of 2020, South-East Asian countries do not seem having to bear the full impact of supply shortages at the same time. Instead, it appears that their supply side diversification can at least partly contribute to a cushioning of the adverse spillover effects originating in major hubs. What is more, depending on both its duration and extent, South-East Asian countries not only benefit disproportionally from Chinese economic recovery. At the same time, their supply side diversification potentially allows them to partly circumvent adverse effects originating in Europe if Chinese supply growth were to outbalance declines in Europe.

In contrast to Indonesia, Malaysia and Vietnam, Bangladesh shows limited dependence on other regions than China, which is in sharp contrast to the country's deep integration in GVCs through significant demand-side dependencies with Europe and North America in textile industries (see Table 1). With the recovery of China, Bangladesh is thus likely to be relatively mildly hit by supply side effects, while its vulnerabilities stem from its obvious demand-side concentration on both the textiles sector and the European market. Similarly, Ethiopia is relatively dependent on Chinese suppliers, which is related to its increasing participation in textile GVCs and to China's role in Ethiopian construction activities, but Ethiopia is relatively less dependent on other hubs. Senegal and South Africa, on the other hand, are strongly dependent on European suppliers but much less on other regions. This concentrated dependence on specific hubs links those countries' economic fate closely to the recovery in those specific hubs. Brazil and Kenya are less exposed given their relatively weak supply side integration with all of the major hubs.

Underpinning our a priori findings, we use data from the national statistical bureaus of the European Union, the United States and China. The peaks in industrial production decline since the outbreak of the pandemic amount to 27 per cent (Europe in April), 16.6 per cent (United States in April) and 26.6 per cent (China in February). Assuming, for simplicity, that sectoral export activities of all three were hit proportionally, this implies that the same share of value added that uses more than 5 per cent of inputs from the respective hub as overall intermediates cannot produce anymore for this time span. A back-of-the-envelope calculation can then give a rough estimate of what effect this will have on GDPs in our sample developing countries, given the results presented in Table 4. Table 5 displays the results of this exercise. They show that, resulting from the enormous supply side dependencies on a specific hub, Malaysia, Vietnam and Senegal have sizeable shares of GDP at risk due to potential production shocks in the given regions. Despite Mexico's strong dependence on North American production, its GDP at risk is relatively low as the production shock in North America appears to have been relatively weaker. Brazil, India, Indonesia and Kenya appear to be much less affected due to their relatively lower integration with major hubs.

In this context, however, despite considerable shortages of intermediate supply in the most integrated countries due to economic lockdown across all major hubs, one might hypothesise that diversified countries, such as those in South-East Asia, might not have to bear the full costs of accompanying

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GDP declines. In fact, the staggered structure of COVID-19-induced supply shocks across hubs could well provide a remedy. As China has left behind its economic lockdown already in March, economic output is expected to ramp up shortly. With this in mind, adverse supply side spillovers inflicted on South-East Asia originating in Europe could thus be (more than) outbalanced by already increased Chinese supply.

6 | DISCUSSION AND OUTLOOK

Since international trade and trade policy are both part of the problem and part of the solution of many of the current challenges in light of the pandemic (Bown, 2020; Evenett, 2020; Evenett and Freeman, 2020b; Gonzalez, 2020), it is key to acquire a deeper understanding of how GVCs are affected by COVID-19. In this paper, we document the GVC-related vulnerabilities of a set of 12 developing and emerging economies, showing dependencies through demand and supply linkages. Confirming conjecture, we find that the most integrated economies tend to suffer most through those channels and we document that the highly integrated South-East Asian economies have substantial shares of GDP at risk. Countries that are much more dependent on their home market and have limited integration into GVCs are thus potentially less affected via this channel. For these countries, disruptions in supply and demand in the home market are the most pressing issue. Yet, for the highly integrated countries, the findings suggest that mitigating economic effects requires both a focus on the recovery of home market supply and demand, as well as a focus on trade in GVCs.

This relates to the discussion on whether the recovery from economic crises is easier for countries that are highly embedded in GVCs. Brakman and van Marrewijk (2019) study the recovery from the financial crisis in relation to participation in GVCs, finding that countries with stronger linkages in GVCs recovered more slowly from the crisis. At the same time, integration into diverse GVCs can also have the advantage of risk diversification.

In our results, we show that countries like Malaysia or Vietnam tend to be relatively diversified from a demand and from a supply perspective. Given that the economic crisis may play out very differently across end markets as well as supplier countries, such diversification may prove beneficial. Mexico, on the other hand, is highly dependent on the United States and Canada. If the economic crisis in this region continues for much longer than in other regions, Mexico will find its own recovery to be much slower. This dependence has also, for example, lead to only minor growth in jobs in Mexico as expenditure growth was already relatively slow in North America since 2000 compared with more dynamic countries in Asia (e.g. Pahl et al., 2019). Countries that are mostly dependent on their home market demand and supply may face a similar problem in the recovery process if, for example, demand growth is weak in the home market but is already picking up in the three hubs.

Discussions about diversification might also become important in relation to adjustments to GVCs. At least for a subset of products, the crisis revealed the strong dependence on few, key suppliers often located in China. In the past, many lead firms in GVCs have indeed turned to fewer key suppliers in strategic locations, coinciding with the rise of China as a major hub in world manufacturing production (Gereffi, 2014; Haraguchi et al., 2017). One might hypothesise that the current crisis makes lead firms reorganise their GVCs to mitigate risks by reducing dependence on single, that is, Chinese, suppliers. Kilic and Marin (2020) argue that uncertainty in the global economy (e.g. due to trade tensions or pandemics) in combination with falling prices of automation (e.g. due to falling interest rates and prices for robots) reduces the cost advantage of offshoring to developing nations (see also Seric & Winkler, 2020). Such developments might further be fueled by demands of policymakers, calling for renationalisation of key industries. This would not only dispute China's role in global manufacturing

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production but also make it harder for other developing countries to develop through participation in GVCs. Yet, reshoring to home countries also means that value chains are dependent on single suppliers, which does not protect against disruptions in production. Risks such as that of a pandemic may hit any country alike, and many equally, even though somewhat consecutively. Our results show that the impacts of this for developing countries through GVCs may differ significantly depending on the character of their integration in these.

Javorcik (2020) points out that lead firms may need to show to shareholders that their supply chains are resilient to such shocks in the future. This might offer opportunities for to date less popular investment locations outside of China if countries can show that they are well equipped to address future disruptions. The diversification on the input side may be one important determinant for this. Miroudot (2020) indeed argues that more complex value chains were in fact better equipped to mitigate disruptions, as they could more easily adjust by using a larger network of diversified suppliers in multiple countries.

For some developing countries, in contrast, commodities make up for a larger share of exports and value added than for the ones included in the sample of the present study. Analysing the effects of falling commodity prices by including countries exemplary for that would be an interesting extension of the analysis to get a more comprehensive picture of the effects of the pandemic on developing countries through GVCs. Also, tourism as a final demand category of central importance for many developing countries is not included in this paper, but would deserve particular attention. Another interesting avenue for future research would be to study how well firms manage to substitute also within GVCs of physical goods, in order to cushion the effects of collapsing value chains. This is something that the partial equilibrium analysis in this paper cannot do, which makes it to be restricted to be a short-term perspective.

How smooth a rebound from the COVID-19 induced economic breakdown in the mid- to long term will be for developing countries, however, also depends on a global environment allowing for trade in GVCs. The complex web of GVCs highlights how detrimental pandemic-related trade restrictions can be, especially in times of crisis. Export restrictions of one country are restrictions on imports of another, aggravating the effects of such measures, above all for developing countries that depend on imports for being integrated into GVCs. The analysis of the upstream and downstream vulnerability of GVCs to demand and supply shocks underlines the importance of diversifying developing countries' reliance on demand and supply and, in particular, diversifying their own inputs further up the supply chains.

CONFLICT OF INTEREST

This is to acknowledge that no financial or other benefit, nor any competing interest has arisen from our research.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.

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How to cite this article: Pahl S, Brandi C, Schwab J, Stender F. Cling together, swing together: The contagious effects of COVID-19 on developing countries through global value chains. *World Econ*. 2022;45:539–560. https://doi.org/10.1111/twec.13094

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APPENDIX A

TABLE A1 Sectoral mapping

	Europe		North America		China	
ISIC Rev 4 Classification	**Sectoral classification in Eurostat (2020)**	**Demand drop**	**Sectoral classification in Coibion et al. (2020)**	**Demand drop**	**Sectoral classification in NBS (2020b)**	**Demand drop**
Agriculture, forestry and fishing (A)	Food, drinks, tobacco	−1.4	Food	−14.7	Grain and oil, foodstuffs, beverages, tobacco	−11.3
Food, beverages, tobacco (C10t12)	Food, drinks, tobacco	−1.4	Food	−14.7	Grain and oil, foodstuffs, beverage, tobacco	−11.3
Textiles (C13t15)	Textiles, clothes, footwear	−77.8	Clothing, footwear, personal care	−35.7	Garments, footwear, hats, knitwear	−48.9
Coke and refined petroleum (C19)	Automotive fuel	−43.2	Gasoline	−28.2	Petroleum and related products	−37.5
Pharmaceuticals (C21)	Pharmaceutical and medical goods	−12.4	Medical	−20.5	Traditional Chinese and Western medicine	−33
Computer and electronics (C26)	Computer equipment, books	−41.5	Durable goods	−9.5	Communication appliances	−28.6
Electrical equipment (C27)	Electrical goods and furniture	−34.8	Durable goods	−9.5	Communication appliances	−28.6
Machinery (C28)	Electrical goods and furniture	−34.8	Durable goods	−9.5	Cultural and office appliances	−40.4
Furniture; other manufacturing (C31t33)	Electrical goods and furniture	−34.8	Furniture, jewellery, small appliances and other small durable goods	−22	Furniture	−66.5

Notes: Column (1) lists the sectors of final demand used in this study with corresponding ISIC Rev.4 code. Columns (2), (4) and (6) list the sectors from the classifications in Eurostat (2020), Coibion et al. (2020) and NBS (2020b), respectively, that we map with the respective ISIC Rev. 4 sector. Columns (3), (5) and (7) list the estimated sectoral demand drops during the first wave of the COVID-19 pandemic from the same sources.

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