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SPECIAL ISSUE ON THE COVID-19 PANDEMIC

ARTICLES IN THIS ISSUE

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Disruptions in global value chains due to COVID-19: stylized facts and policy lessons

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This paper provides an early assessment of global value chains (GVCs) amid the disruptive effects of COVID-19 on world trade. Using the Asian Development Bank's updated Multiregional Input-Output Table, key indicators were estimated to identify important stylized facts about the contraction of GVC activities in 2020. Econometric models were also estimated to analyze the disruptive effect of COVID-19 outbreaks and stringent containment measures on GVC trade. The input-output analysis confirms that all major economic sectors suffered large losses, especially services. However, the bulk of the decline in overall GVC trade can still be traced to lower backward transactions in manufacturing. On the aggregate level, stronger backward GVC participation was associated with relatively milder contraction while the opposite was observed for forward participation. The regressions showed that positive growth of GVC trade was less likely in sectors with relatively larger exposure to foreign downstream shocks. Further, the combined effects of stringent containment measures and severe COVID-19 outbreaks also reduced the probability of growth in both backward and forward GVC transactions. These findings indicate that on top of foreign suppliers' internal disruptions (foreign supply shock), weak global consumption (foreign demand shock) and local producers' domestic sourcing problems (local supply shock) contributed to the steep contraction of GVCs in 2020. Against this background, the major challenges to robust recovery were also identified. These include the downside risks of a prolonged pandemic, the resurgence of protectionist tendencies, the strength of global demand, the reconfiguration of broken supply chains, and the ability of countries to coordinate their actions especially with respect to vaccination.

JEL: C64, F14, F60
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1. Introduction

The COVID-19 pandemic is a global crisis like no other.[1] The exponential spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) across national boundaries forced countries to close borders and impose strict containment measures in infected communities. The so-called "Great Lockdown" limited the mobility of people and disrupted economic activities in a wide range of sectors. At the extreme, many industries were temporarily paralyzed by economic "sudden stops" due to uncertainties surrounding workplace safety and the availability of inputs and logistics services. Production organized within global value chains (GVCs) was particularly affected as the pandemic transformed efficient supply networks into a coordination nightmare. Manufacturers strongly connected to GVC hubs in East Asia were especially hit, with the region being the first epicenter of COVID-19 outbreaks and among the earliest sites of citywide lockdowns and emergency suspension of factory operations. These hard stops, albeit temporary and short-lived, sent shockwaves across the world economy given the region's central role in many globally-fragmented industries. In its full swing, the pandemic also hit key industrial centers around the world such as the United States (US), Germany, Italy, Spain, Brazil, and India. As a result, cross-border production activities were temporarily suspended or downsized due to the extraordinary challenge of moving goods and services through pandemic-stricken supply chains. Lower spending on "postpone-able" consumption also produced global demand shocks that further dragged GVC operations.

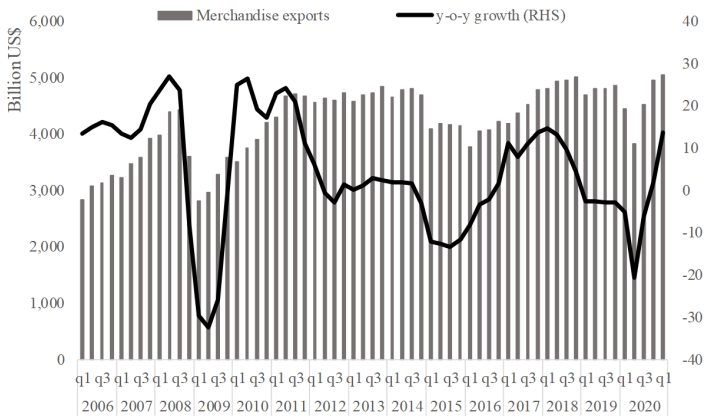
The aftermath of this public health emergency turned global economic crisis has been devastating. Global gross domestic product (GDP) fell by 3.3 percent in 2020, owing to the broad-based downturn in advanced (-4.7 percent) and developing economies (-2.2 percent) [IMF 2021]. Consequently, millions suffered from loss of productive employment and income as multiple establishments were driven out of business. Airlines, transport and shipping companies, hospitality and tourism-related sectors, and manufacturers of postpone-able goods were the early victims of lockdowns. Small and medium enterprises were disproportionately hit than large corporations.

The pandemic exacerbated the excessive volatility of global trade caused by the US-China tariff wars in 2019. According to the World Trade Organization (WTO) [2021], world merchandise exports in nominal dollar terms fell by 8 percent in 2020, the worst decline since the 22-percent collapse in 2009. This contraction reflects the synchronous fall of exports and imports across countries due to the combined effects of supply chain disruptions and weak demand (e.g., petroleum, automotive, consumer and capital goods, and industrial supplies),

[1] According to the World Health Organization (WHO), there are more than 200 million confirmed COVID-19 cases around the world, including more than four million deaths as of July 2021. Close to four billion vaccine doses have been administered worldwide.

especially during the second and third quarters of 2020. Exports of commercial services plunged by 20 percent as international mobility restrictions depressed the travel and transport sectors [WTO 2021]. Figure 1 shows that global merchandise exports have bounced back to pre-pandemic levels although the speed of recovery varies greatly across sectors and regions. Trade in services remains weak, especially with emerging virus variants (e.g., delta and lambda) causing new waves of COVID-19 surges and lockdowns. The uneven access to vaccines and other medical resources also poses threats to global efforts to end the ongoing twin health and economic crises. Calibrated containment measures, efficient testing, tracing, and treatment (T3), and speedy vaccination are key ingredients to rebuild broken supply chains and sustain a robust recovery of GVC trade.

FIGURE 1. Level and growth of world merchandise exports, 2006-2021



Source: WTO.

In an unprecedented turn of events, the pandemic transformed efficient supply chains into a series of hurdles for globally-oriented manufacturers. However, the possibility of this remote event is not totally unthought of. In a World Economic Forum (WEF) survey in 2012, supply chain managers ranked pandemics as the third most serious environmental event (next to natural calamities and extreme weather) that could cause system-wide disruptions to production networks [Doherty and Botwright 2020]. Compared to natural disasters that cripple areas of production in specific locations, global contagions have the potential to halt all types of economic activities in all countries.

We have seen similar systemic disruptions in the past. The collapse of world trade in 2009 was traced to demand shocks from Europe and the US that adversely affected global production through a complex web of financial and trade transactions. Weak output and consumption in major global markets translated to a downward spiral of production in export-oriented emerging economies. In 2011, the flooding in Thailand and the tsunami in Japan caused severe damage in

East Asia's automotive and electronics supply chains. This paralyzed industrial production and resulted in several months of negative export growth in the region. The recent trade tensions between China and the US also slowed down trade and threatened the stability of global production networks due to costly adjustments in world prices, exchange rates, investments, and productivity [Robinson and Thierfelder 2019]. These examples show that the propagation of initially local shocks into a full-blown global crisis has become common in the age of globalization. Seemingly minor risks can have ripple effects through various international transmission channels. As countries grew more interconnected through commercial, financial, and cultural linkages, they also became sensitive to global business cycles and local events that have potential systemic repercussions. Therefore, it is not only when the US or China sneezes that the world catches cold; the trouble may virtually come from anywhere in any form. This time around, it started with a virus.

The current structure of global production networks provides an efficient platform for propagating systemic shocks across borders. Despite the observed deglobalization after the financial crisis in 2008, GVC linkages have generally strengthened from three decades ago due to the internationalization of manufacturing, finance, and investments. For instance, Mendoza [2021] noted that an adverse shock on China's economy can generate a global impact more severe and contagious than twenty years ago. This is well demonstrated by the ongoing US-China tariff wars and the COVID-19 outbreaks which both increased trade costs and disrupted the flow of inputs in international supply chains. Baldwin and Freeman [2020] identified three main channels through which the economic contagion caused by COVID-19 was easily magnified by the current nature of GVCs. First, the major outbreaks happened in key industrial centers in Asia, Europe, and North America, causing disruptions to countries directly linked to these hubs. Second, the difficulty of trading with hard-hit countries affected the operation of domestic producers, and by extension, their local and foreign suppliers (and these suppliers' suppliers). In other words, the interdependence of firms across nations forms an intricate web of production linkages in which seemingly trivial interruptions can be amplified into a full-blown contagion. Third, lower production and escalated global uncertainty further reduced output and income and strained GVC activities due to the "bullwhip" effect of lower consumer and business spending.

This paper provides a preliminary assessment of the performance of GVCs amid the disruptive effects of COVID-19 on the global economy. In particular, this paper uses the updated Asian Development Bank-Multiregional Input-Output Table (ADB MRIOT) to measure key GVC indicators in 2020 and identify important stylized facts based on these estimates. This study also attempts to analyze the disruptive effects of COVID-19 outbreaks and stringent containment measures on GVC trade. To the author's knowledge, this is among the first studies to analyze

the performance of GVCs using inter-country input-output (ICIO) data generated in the full swing of COVID-19 in 2020. Given that the pandemic is still ongoing and supply chains remain disrupted in some sectors and countries, an early assessment of the major GVC trends in 2020 provides useful insights to inform new policies and evaluate the effectiveness of existing strategies.

The rest of the paper is organized as follows. The second section analyzes the major trends underlying the key GVC indicators calculated using the ADB MRIOT. In particular, GVC trade was decomposed to trace the sectors, countries, and transactions contributing to the sharp contraction in 2020. A simple econometric model was also estimated to establish a possible link between containment measures, COVID-19 outbreaks, and the performance of GVC trade. The third section discusses the main takeaways from key GVC-related policies implemented at the height of the lockdown. Major challenges to robust recovery were also identified. The paper ends with a summary of findings and some concluding remarks.

2. Global value chains amid COVID-19: some stylized facts

The analysis in this section is based on the framework and method developed in Borin and Mancini [2019], and Belotti, Borin, and Mancini [2020], as applied to the 2019 and 2020 editions of the ADB MRIOT.[2] This ICIO table has 35 sectors and covers 62 countries which collectively accounted for 90 percent of world GDP in 2020. The major advantage of the ADB MRIOT is that key GVC-oriented economies in Asia (e.g., ASEAN, China, Hong Kong, India, Japan, Taiwan, and South Korea) as well as large economies such as the US and Germany are well represented. Thus, it is straightforward to analyze the cross-country impact and spillovers of shocks originating from these global manufacturing hubs.

The definition of GVC trade adopted in the succeeding discussions is derived from Belotti, Borin, and Mancini's [2020] decomposition of a particular country or sector's gross exports using ICIO tables:

$$u_N E_{s*} = \underbrace{\underbrace{DAVAX_{s*} + IAVAX_{s*} + REF_{s*}}_{DVA_{s*}} + DDC_{s*}}_{DC_{s*}} + \underbrace{FVA_{s*} + FDC_{s*}}_{FC_{s*}} \quad (1)$$

where $u_N E_{s*}$ is the gross exports of country s, $DAVAX_{s*}$ is value-added exports (VAX) directly absorbed in the immediate destination, $IAVAX_{s*}$ is VAX indirectly re-exported to third countries, REF_{s*} is called reflection or the portion of VAX that is ultimately absorbed by country s itself, DDC_{s*} is domestic double counted, FVA_{s*} is foreign value added, and FDC_{s*} is foreign double counted. The sum of $DAVAX_{s*}$, $IAVAX_{s*}$, and REF_{s*} is collectively referred to as DVA_{s*} or the domestic

[2] This was implemented using the ICIO package in Stata.

value added in gross exports. The sum of DVA_{s*} and DDC_{s*} is called the domestic content of gross exports (DC_{s*}) while the sum of FVA_{s*} and FDC_{s*} is called the foreign content of gross exports (FC_{s*}). The total GVC-related trade of country s is defined as:

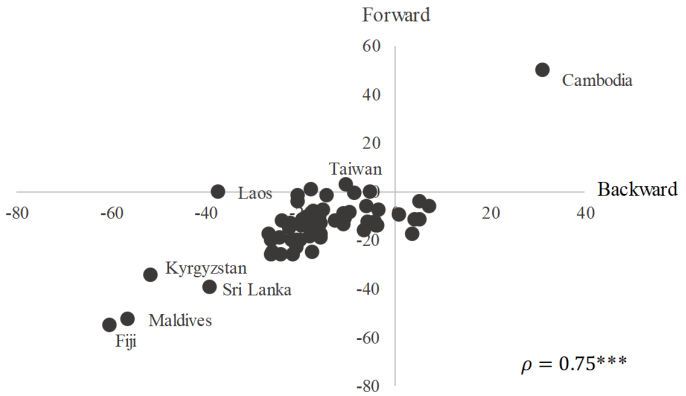
$$GVC_s = \Sigma_{r \neq s} (u_N E_{sr} - DAVAX_{sr}) \quad (2)$$

where $u_N E_{sr}$ is the total bilateral exports of country s to country r. In other words, GVC-related trade excludes the portion of the bilateral exports of country s to country r that is immediately absorbed by the latter. Underlying this formula is the definition of GVC trade as involving transactions that crossed borders more than once [Belotti, Borin, and Mancini 2020]. A country's overall GVC participation rate can be calculated by dividing GVC_s by $u_N E_{s*}$. Further, a standard practice in the literature is to decompose GVC_s into backward and forward GVC trade. The backward component loosely corresponds to the imported content of exports and is mainly comprised of FVA_{s*}. The forward component pertains to the portion of domestic production of country s that was first exported to country r then processed and re-exported. Note that $IAVAX_{s*}$ and REF_{s*} in Equation (1) fall under this category.[3]

Based on these definitions, the author used the updated ADB MRIOT for 2019 and 2020 to assess the performance of GVC trade amid the full swing of COVID-19. Except for Cambodia (34.5 percent), Ireland (4.9 percent), and Luxembourg (7.0 percent), all economies represented in the ADB MRIOT experienced huge declines in GVC transactions in 2020. Figure 2 shows that most countries also endured simultaneous contractions in backward and forward GVC trade. Most notably, small island economies (e.g., Fiji, Maldives, Sri Lanka) and landlocked countries (e.g., Laos and Kyrgyzstan) seem to be the worst hit. For the former, the shocks are mostly likely absorbed through the tourism and business travel channels which suffered major losses due to lockdowns and international travel bans. A key pattern suggested by Figure 2 is that the performances of backward and forward GVC trade seem synchronized. This implies that shocks propagated via GVCs affect a country through interconnected backward and forward channels. Therefore, what was initially a supply shock (e.g., difficulty of importing inputs) eventually hit a country again as a demand shock (e.g., reduced orders). Nevertheless, there were interesting cases where one grew while the other contracted. For instance, Taiwan's forward GVC trade managed to grow by 3.3 percent despite the 10.4 percent fall in backward transactions. This may be partly explained by the strong demand for Taiwan's technology exports due to major adjustments like shifting to online classes and work-from-home arrangements.

[3] Interested readers may refer to Borin and Mancini [2019] and Belotti, Borin, and Mancini [2020] for a more technical derivation of GVC-related indicators.

FIGURE 2. Growth of backward and forward GVC trade in 2020, by country



* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculation based on the ADB MRIOT 2019-2020.

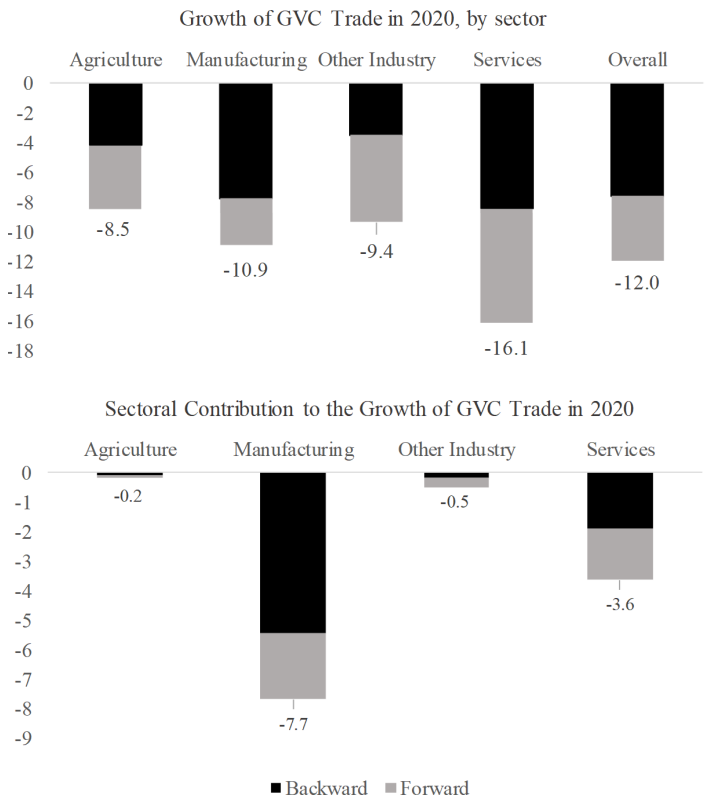
The growth of overall GVC trade in 2020 was then decomposed using the following formula:

$$\left(\frac{GVC_{2020}\text{-}GVC_{2019}}{GVC_{2019}}\right)=\sum_{g=1}^{2}\sum_{s=1}^{62}\sum_{j=1}^{35}\frac{GVC_{gsj,2020}\text{-}GVC_{gsj,2019}}{GVC_{2019}} \quad (3)$$

where g pertains to the type of GVC transaction (i.e., backward and forward), s is country, and j is sector. At the onset, it must be noted that the growth of total GVC trade was calculated based only on the GVC transactions of the 62 economies represented in the ADB MRIOT. The decomposition in Figure 3 shows that all major economic sectors suffered significant blows in 2020. GVC-related trade in services endured the biggest plunge of 16.1 percent. Manufacturing contracted by 10.9 percent while other industrial sectors (i.e., mining and quarrying, construction, and electricity, gas, and water) dropped by 9.4 percent. GVC-related agricultural trade experienced an 8.5 percent fall. However, in terms of contribution to the overall slide of GVC trade, the bottom panel of Figure 3 indicates that the bulk of the losses can still be traced to manufacturing, instead of services. In particular, backward manufacturing GVC trade accounted for 45.4 percent of the total contraction of GVC trade in 2020. This partly reflects the fact that manufacturing was initially hit by domestic supply chain disruptions which restricted the flow of inputs across borders. However, the slump in backward GVC trade in manufacturing may have been partly driven by final demand shocks which reduced the consumption of exports, and by extension, the demand for imported inputs needed to produce these exports. Forward GVC trade in manufacturing contributed an additional 18.8 percent to the overall drop mainly due to shocks from weaker global demand. Services also exerted a significant pull on GVC trade with a 30.5

percent share in the overall contraction. In addition to lost consumption in contact-intensive sectors due to mobility restrictions, weak demand for transport and logistic services also pulled the sector's performance at the height of the lockdowns. Agriculture had the smallest contribution to the slide of GVC transactions mainly due to the sector's limited direct participation in global production networks.

FIGURE 3. Growth of GVC trade in 2020, by sector



Note: The values are based only on the 62 economies represented in the ADB MRIOT
Source: Author's calculation based on the ADB MRIOT 2019-2020.

Somewhat contrary to the picture suggested above, Figure 4 indicates that economies with stronger backward GVC participation in 2019 endured relatively milder contraction of GVC trade in 2020. In contrast, economies with greater forward GVC participation experienced relatively larger declines in GVC trade. The first pattern suggests that greater access to foreign sources of inputs might have helped ease domestic constraints due to local supply chain disruptions. The second pattern implies that overall GVC trade in 2020 was probably weighed down by demand shocks originating downstream. The two figures highlight the

complexity of interconnected transactions inside GVCs. Although fragmentation has resulted in globally dispersed production networks that are linked by backward and forward trade in intermediate inputs, global demand still exerts a significant influence on the short run performance of GVCs.[4] To organize ideas, Espitia et al. [2021] identified two types of foreign GVC shocks from the perspective of a particular exporting country (i.e., home). Shocks to source affect home exports that depend on imported inputs (i.e., backward GVC trade). Shocks to destination affect home exports of inputs and final goods to the destination countries (i.e., forward GVC trade). However, via chain reaction, this may indirectly affect the demand for foreign inputs (i.e., backward GVC trade) of import-dependent home exports. Altomonte et al. [2012] call this magnification of downstream shocks the "bullwhip" effect which was also observed during the great trade collapse in 2009.

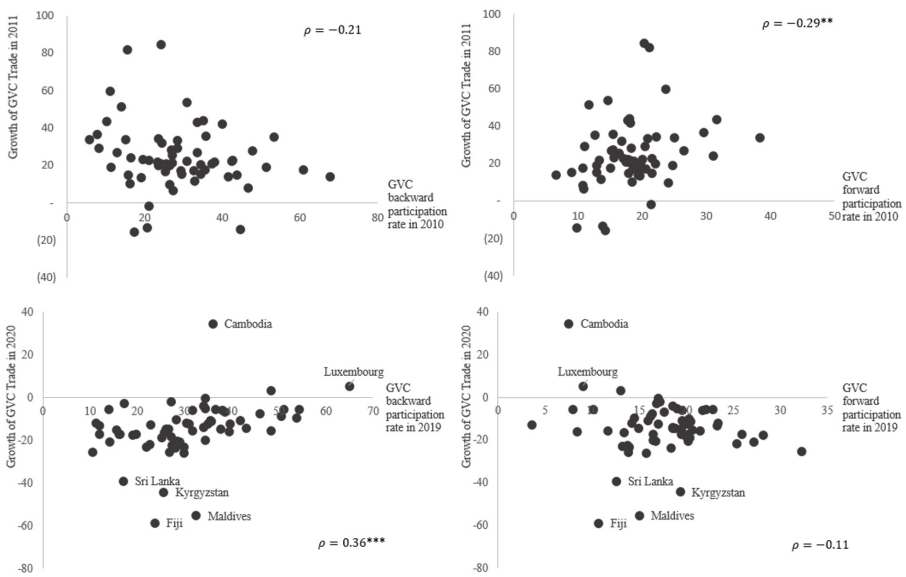
Another interesting observation based on Figure 4 is that the patterns in 2020 are a reversal of the relationships in 2011. Recall that East and Southeast Asia experienced supply chain disruptions in that year due to natural disasters affecting production in several GVC hubs in the region. In 2011, stronger growth of GVC trade was accompanied by higher forward GVC participation rate. The opposite was observed for backward GVC participation. The divergent trends in 2011 and 2020 suggest that the performance of GVC trade tends to vary depending on the nature of the shocks and the transmission channels of these shocks. In 2011, the disruptions were mainly supply-driven and concentrated in certain sectors and locations. In addition, the shocks did not progress into a full blown GVC crisis. This may partly explain the negative relationship between backward participation and GVC growth since the shocks originated from upstream suppliers. In contrast, limited interruptions downstream buoyed the GVC trade in countries with strong forward participation. In 2020, the shocks originated from temporary supply glitches but were soon followed by systemic GVC disruptions due to weak global demand and investments. Accordingly, downstream sectors became important sources of negative spillovers.

Figure 5 illustrates the relationship between the growth of GVC trade in 2020 and the potential exposure of countries to foreign demand and supply shocks before the pandemic hit. The left panel uses FVA's share in gross exports as a measure of potential shocks due to supply disruptions. Intuitively, countries whose exports are highly dependent on foreign inputs will be adversely affected by interruptions of supply from abroad. The right panel uses VAX's share in gross exports as an indicator of potential risks due to foreign demand shocks. While GVC integration allows countries to tap the global consumer base, this also makes them more vulnerable to sudden fluctuations of consumption in foreign markets. The patterns in Figure 5 are broadly consistent with Figure 4. Interestingly, countries with higher FVA share in gross exports experienced less severe GVC contraction.

[4] As Krugman [2015] argued, and in rebuttal of Say's Law, evidence from the global financial crisis shows that economies with persistently weak demand seem to have experienced large losses in potential and actual output.

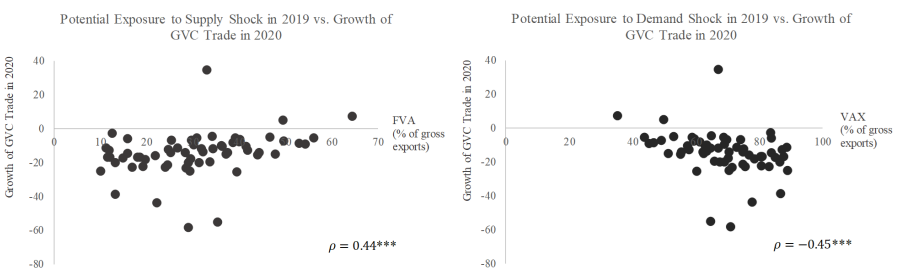
In contrast, the negative performance of exports, and of GVC trade in particular, were associated with shocks originating from the demand side. This is a combination of the reduced demand for inputs and final goods of a country's immediate trading partners as well as the indirect effect of lower consumption in third countries (i.e., the final destinations of value-added exports).

FIGURE 4. GVC participation rate vs. growth of GVC trade



* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculation based on the ADB MRIOT for 2010-2011 and 2019-2020.

FIGURE 5. Potential exposure to shocks in 2019 vs. growth of GVC trade in 2020



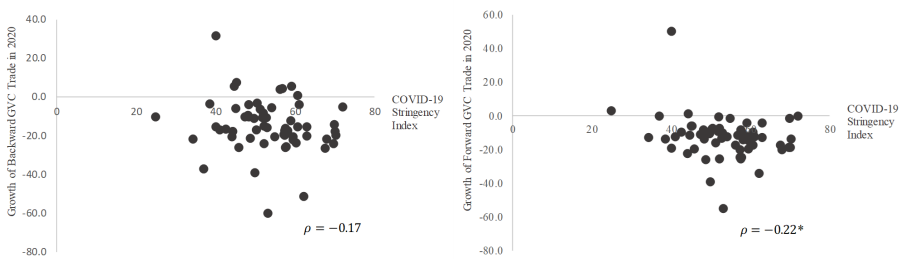
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculation based on the ADB MRIOT for 2019-2020.

To establish a possible link between lockdowns, supply chain disruptions, and GVC trade, Figure 6 correlates the growth of backward and forward GVC trade with the average COVID-19 stringency index for 2020. The stringency index is

a composite indicator developed by Hale et al. [2021] to provide a comparable cross-country measurement of the strictness of government responses to control COVID-19 outbreaks. The index includes various indicators of containment such as school, workplace and public transport closure, restriction on mass gathering and public events, restriction of internal movement and international travel, and stay-at-home requirements. In addition, the index also incorporates indicators on health systems and economic responses to the pandemic.

Figure 6 indicates that GVC trade contracted the most in countries where governments imposed stricter containment measures in 2020. Forward GVC trade was significantly negatively related with stringent government response to control the transmission of the virus. This may be explained by the fact that containment measures primarily affected domestic production through shutdowns of factories, reduction of operating capacity, and lost productivity of workers who could not report for work due to various reasons (e.g., lockdowns, COVID-19 infection, lack of transport services). This disrupted the operation of local firms, including their ability to supply inputs abroad (i.e., forward GVC trade). A similar negative relationship was observed between backward GVC trade and stringency although the correlation is weaker and insignificant. In line with the foregoing discussion, this suggests that widespread domestic rather than foreign supply chain disruptions aggravated the adverse effects of foreign supply shocks on local and GVC-oriented production.

FIGURE 6. COVID-19 stringency index vs. growth of GVC trade in 2020



* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculation based on the ADB MRIOT 2019-2020 and Oxford COVID-19 Government Response Tracker

To formalize the preceding observations, the author runs simple logistic regressions using the following binary indicators:

- $G_1 = 1$ if the backward GVC trade of sector j in country s experienced positive growth in 2020;
- $G_2 = 1$ if the forward GVC trade of sector j in country s experienced positive growth in 2020; and
- $G_3 = 1$ if the total GVC trade of sector j in country s experienced positive growth in 2020.

Country-sector pairs were used to increase the sample size. All models were estimated using the same set of three explanatory variables. First, the difference between a particular country-sector pair's VAX/gross exports and FVA/gross exports in 2019 was added as an indicator of the potential vulnerability to GVC shocks before the pandemic hit. A positive (VAX-FVA)/gross exports indicates that a particular country-sector pair has relatively larger exposure to downstream than to upstream shocks. For VAX and FVA, 2019 values were used to reduce the risk of reverse causality. The shock indicators were also combined due to high collinearity. Second, a control for the upstreamness of a country-sector pair in 2019 was added to test whether relative positioning in GVCs affected the growth of backward and forward transactions differently. Following Antras and Chor [2018], upstreamness is defined as the distance of a country-sector pair to final demand. This means that larger index values are associated with higher levels of upstreamness. Third, the containment stringency sub-index was extracted from the main stringency index then interacted with a country's number of COVID-19 cases per million (expressed in natural logarithm) as of December 31, 2020. This variable captures the combined effects of the strictness of the containment measures and the severity of the outbreak on a country-sector pair's GVC activities. The author hypothesizes that this effect is transmitted via the disruptions caused by outbreaks and the consequent loss of productivity due to lockdowns, workplace closures, and mobility restrictions. Table 1 summarizes the estimated marginal effects of the explanatory variables on $P(G_g = 1|x)$, where g pertains to the different types of GVC trade (i.e., backward, forward, and total).

TABLE 1. Logistic regressions for $P(G_g = 1|x)$, marginal effects

	$P(G_1 = 1\|x)$	$P(G_2 = 1\|x)$	$P(G_3 = 1\|x)$
(VAX-FVA)/gross exports in 2019	-0.0012*** (0.0003)	-0.0013*** (0.0003)	-0.0010*** (0.0003)
Upstreamness in 2019	-0.0399** (0.0187)	0.0063 (0.0185)	-0.0280 (0.0180)
Containment stringency*ln (COVID-19 cases/million)	-0.0004* (0.002)	-0.0008*** (0.0002)	-0.0007*** (0.0002)
Sector controls	Yes	Yes	Yes
n	2098	2098	2093
Wald's χ^2	195.20***	187.98***	183.10***
Pseudo R-squared	0.13	0.11	0.11
χ^2 for goodness-of-fit test	2088.28	2080.87	2066.65

*p < 0.10, **p < 0.05, ***p < 0.001.
Note: Figures in parentheses are standard errors.
Source: Author's estimates based on data derived from the ADB MRIOT, Oxford COVID-19 Government Response Tracker, and ourworldindata.org.

The results are broadly in line with the foregoing discussions. First, country-sector pairs that are relatively more exposed to foreign downstream shocks were less likely to experience positive growth of GVC trade in 2020. This indicates that downstream disruptions seem to have played a bigger role in the propagation of shocks due to COVID-19. Note that the early lockdowns both prevented individuals to go to work and to purchase from certain sectors (e.g., contact-intensive services or what de Dios [2020] calls the experience economy). Therefore, the economic sudden stops in 2020 have the elements of both supply and demand shocks which generated further uncertainties through loss of consumer and investor confidence and large-scale business exits. Guerrieri et al. [2020] argued that the economic disruptions initially induced by the pandemic were "Keynesian supply shocks" or supply shocks that generated changes in aggregate demand larger than the original shocks. An important feature that helps magnify this type of shock is the complementarity of activities across sectors and countries due to strong input-output linkages in modern economic structures such as GVCs. Therefore, a negative productivity shock such as lockdowns in key sectors or locations may generate chain reactions that transcend industries and national borders. Further, the employment and income losses due to these shocks may trigger consumption and investment fall, even in industries that are not connected to the affected supply chains.[5]

The econometric results also suggest that relatively upstream country-sector pairs are less likely to grow in backward GVC trade, other things constant. No similar effect was observed for forward GVC trade. This means that for more upstream country-sector pairs, the effect of foreign shocks will manifest mainly in the reduced likelihood of growing in backward GVC transactions (i.e., importing inputs). This seems counterintuitive if the shocks are indeed, for the most part, demand-driven. One possible explanation is that the most upstream country-sector pairs have stronger backward than forward participation to begin with.[6] This highlights the heterogeneous impacts of the supply disruptions across sectors, depending on the source and nature of the shocks on the one hand, and the position and strength of GVC participation on the other hand.

Lastly, the combined effects of stringent containment measures and severe COVID-19 outbreaks reduced the probability of growth in backward and forward GVC trade. This confirms that other things equal, the GVC activities of country-sector pairs operating in more restrictive environments were disrupted by local lockdowns, workplace closure, suspension of transport services, and travel bans. Intuitively, this impacted the ability of domestic producers to operate, and therefore, their demand for inputs. Further, fears of catching the virus resulted

[5] According to Guerrieri et al. [2020], the second important ingredient to generate Keynesian supply shocks is market incompleteness; that is, workers in affected sectors are not fully insured against the shock. Therefore, they become unable to consume from other sectors, even those that are not directly affected.

[6] For country-sector pairs with above average upstreamness, the mean backward and forward GVC shares in gross exports in 2019 are 29 percent and 21 percent, respectively.

in reduced mobility and lower consumption, especially of certain services such as transport, logistics, tourism, and hotel and restaurants. It is worth noting that the joint effect of strict containment measures and severe COVID-19 contagion is stronger for forward than backward GVC trade. This suggests that the effect of domestic supply chain disruptions impacted the ability of local suppliers to produce and export more than their ability to source inputs from abroad. For instance, two World Bank [2020] surveys conducted in July and November 2020 found that an average of 45.5 percent of Philippine firms, particularly in manufacturing, suffered from decreased supply of inputs due to the reduced availability of domestic suppliers. Further, an average of 40 percent and 29.5 percent of firms were affected by the reduced operations and delays experienced by local distributors, respectively. In contrast, only 8.5 percent of firms on average reported that they were affected by the reduced availability of international suppliers, while an average of 15 percent of firms experienced slow customs clearance. This suggests that the reduction in backward trade may not be due to the difficulties arising from foreign input sourcing per se but to the lower demand for imports induced by the combined effects of weak domestic industrial capacity and weak global consumption.

To summarize, the preceding discussion reveals the following stylized facts about the performance of GVCs amid the COVID-19 pandemic:

- The majority of economies suffered from large contractions in GVC trade in 2020, with small island economies and landlocked countries being the worst hit;
- All major economic sectors endured large losses, led by services-related GVC trade which dropped by 16.1 percent. In terms of contribution to overall contraction, the bulk of the losses in GVC trade can still be traced to lower backward transactions in manufacturing instead of services;
- The synchronous fall of backward and forward GVC trade confirms the interconnectedness of transactions in GVCs. The sudden stops in production and consumption generated supply and demand shocks that disrupted the global flow of goods and services. However, the spillovers have differential effects depending on the nature of the shocks and the propagation channels;
- Economies with stronger backward GVC participation in 2019 endured relatively milder contraction of GVC trade in 2020. This suggests that greater access to foreign sources of inputs might have helped ease domestic supply constraints. The opposite was observed for forward GVC participation which implies that demand shocks originating downstream were a major contributor to the disruption of GVC activities in 2020;

- GVC trade, especially forward, contracted the most in countries where governments imposed stricter containment measures in 2020;
- The regression results based on country-sector data further show that:
    - Country-sector pairs relatively more exposed to foreign downstream shocks were less likely to experience positive growth of GVC trade in 2020;
    - Relatively upstream country-sector pairs were less likely to grow in backward GVC trade; and
    - The combined effects of stringent containment measures and severe COVID-19 outbreaks reduced the probability of growth in backward and forward GVC trade.

The picture emerging from these findings is that the economic sudden stops caused by strict containment measures generated local supply disruptions and demand shocks which were propagated globally through the backward and forward trade linkages in GVCs. In addition to foreign suppliers' inability to export due to their own internal disruptions, local producers' scaled down operations due to domestic supply shocks and weak global demand also played big roles in the overall decline in GVC trade in 2020. In this case, stimulating trade will require unprecedented efforts to rebuild not only the production base but also business and consumer confidence.

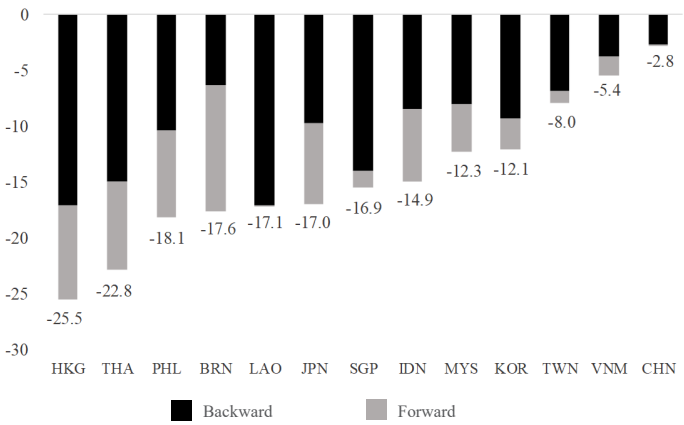
2.1. Performance of Philippine GVC trade amid the COVID-19 pandemic

With an 18.1 percent plunge, the Philippines joins Hong Kong (-25.5 percent) and Thailand (-22.8 percent) as the worst hit economies in East and Southeast Asia. This is in sharp contrast to Cambodia's 34.5 percent surge. Like the rest of the region, the slide in Philippine GVC trade was mainly traced to lower backward transactions which plummeted by 18 percent. As previously discussed, this may be explained by local supply disruptions that resulted in lower demand for imported inputs. Interestingly, China experienced the smallest contraction in the region, despite the country being one of the first sites of major COVID-19 outbreaks, citywide lockdowns, and factory closures. The modest decline of China's GVC trade was entirely due to lower backward transactions, with forward GVC trade even growing marginally by 0.2 percent. This may be partly traced to the fact that China has a very large domestic manufacturing base which allowed its local producers to resume operations despite the foreign supply shocks induced by lockdowns.

Table 2 summarizes the GVC performance of various Philippine sectors in 2020. It can be observed that the impact of the pandemic was broad-based, with the majority of the sectors experiencing double-digit contractions. This confirms that global shocks to GVCs can generate significant impacts on a wide range of economic activities, even in sectors that are not directly connected to global production networks. For instance, Philippine agricultural GVC trade still endured a 19.7 percent decrease despite the relatively limited direct participation in GVCs.

This was traced to lower forward transactions due to weak foreign demand. In manufacturing, both traditional and high-tech sectors suffered significant losses. In particular, GVC trade in food, beverages and tobacco dropped by 8.1 percent due to weak forward transactions. Textile and textile products (-25.1 percent) and leather, leather products, and footwear (-25.0 percent) also posted large declines on account of the sectors' lower usage of imported contents. High-tech manufacturing, which is largely GVC-oriented, also experienced huge drops. In particular, electrical and optical equipment fell by 16.2 percent while transport equipment plunged by 27.4 percent. These two poster industries of GVC trade suffered from the early throes of disrupted supply chains and eroded sales caused by lockdowns. However, the quick resurgence of the demand for auto and consumer electronics shifted the main strain to the supply side, with global production of cars and other electronic goods being held back by lingering global chip shortages [Wu, Savov, and Mochizuki 2021].

FIGURE 7. Growth of GVC trade in East and Southeast Asia in 2020



Source: Author's calculation based on the ADB MRIOT 2019-2020.

GVC trade in several industries still managed to grow in 2020. In particular, GVC transactions in mining and quarrying (6.8 percent) and pulp, paper, paper products, printing, and publishing (8.2 percent) expanded on account of increased backward and forward participation. GVC trade in chemicals and chemical products also soared by 34.5 percent due to higher backward transactions. This may partly capture the increased demand for pharmaceutical products during the early surges in COVID-19 infections.

Backward and forward GVC trade experienced significant losses across all major services sectors. In particular, hotel and restaurants, travel, and tourism were directly hit by lockdowns and international travel bans while the demand for logistics and telecommunication services contracted as manufacturing activities

receded. De Dios [2020] explained that the very nature of the lockdowns, i.e., restrictions on mobility and social gathering, adversely affected the consumption of experience goods, and by extension, their services components. Financial intermediation, renting of machinery and equipment, and other business services (e.g., business process outsourcing) also suffered from the interruption of economic activities worldwide. This synchronized fall of manufacturing and services trade in GVCs is consistent with Jones and Kierzkowski's [1990] argument that services form an important "glue" that connects the fragmented activities in global production networks.[7] Intuitively, transport and logistics, telecommunication, finance, and back-office support are essential auxiliary activities that facilitate the seamless flow of tangible and intangible inputs within multinational supply chains. Therefore, supply and demand disruptions in either manufacturing or services can easily imperil the efficient operation of entire GVCs.

TABLE 2. Growth of Philippine GVC trade in 2020, by sector

Sector	Total	Backward	Forward
All sectors	-18.1	-18.0	18.4
Agriculture, hunting, forestry, and fishing	-19.7	-9.9	-25.6
Mining and quarrying	6.8	5.2	7.8
Food, beverages, and tobacco	-8.1	8.8	-21.3
Textiles and textile products	-25.1	-27.0	-9.4
Leather, leather products, and footwear	-25.0	-23.2	-42.5
Wood and products of wood and cork	-16.1	-14.6	-19.2
Pulp, paper, paper products, printing, and publishing	8.2	17.5	1.9
Coke, refined petroleum, and nuclear fuel	-36.4	-58.0	39.7
Chemicals and chemical products	34.5	66.4	-25.0
Rubber and plastics	-21.5	-21.7	-21.2
Other nonmetallic minerals	-5.6	-5.2	-6.7
Basic metals and fabricated metal	-3.3	-6.0	4.1
Machinery, nec	-9.5	-8.8	-12.6
Electrical and optical equipment	-16.2	-17.8	-11.5
Transport equipment	-27.4	-26.1	-30.0
Manufacturing, nec, recycling	-21.7	-22.9	-14.4
Electricity, gas, and water supply	-3.6	-24.1	18.5
Construction	-18.3	-20.6	-10.7
Sale, maintenance, and repair of motor vehicles and motorcycles, retail sale of fuel	-30.1	-31.8	-28.6

[7] The increasing importance of services in the production process is often described as the "servicification" of manufacturing [Kommerskollegium 2010]. Others refer to this phenomenon as "servicizing" [Reisken et al. 1999] and "manuservice" [Bryson and Daniels 2010]. This implies that products manufactured in GVCs can be considered as bundles of goods and services consolidated from various sectors and countries.

TABLE 2. Growth of Philippine GVC trade in 2020, by sector (continued)

Sector	Total	Backward	Forward
Wholesale trade and commission trade, except of motor vehicles and motorcycles	-27.0	-31.7	-25.4
Retail trade, except of motor vehicles and motorcycles, repair of household goods	-30.8	-34.5	-29.4
Hotels and restaurants	-24.3	-24.3	-24.3
Inland transport	-25.2	-30.0	-17.2
Water transport	-36.2	-47.3	-27.7
Air transport	-33.5	-38.8	-18.3
Other supporting and auxiliary transport activities, activities of travel agencies	-25.9	-29.2	-24.7
Post and telecommunications	-26.2	-26.3	-26.1
Financial intermediation	-26.4	-33.3	-24.9
Real estate activities	-28.5	-36.0	-27.4
Renting of M&Eq and other business activities	-24.7	-32.3	-23.0
Public administration and defense, compulsory social security	-19.5	-25.3	-17.9
Education	-22.3	-30.4	-20.6
Health and social work	-20.4	-15.5	-25.5
Other community, social, and personal services	-22.7	-24.3	-21.6

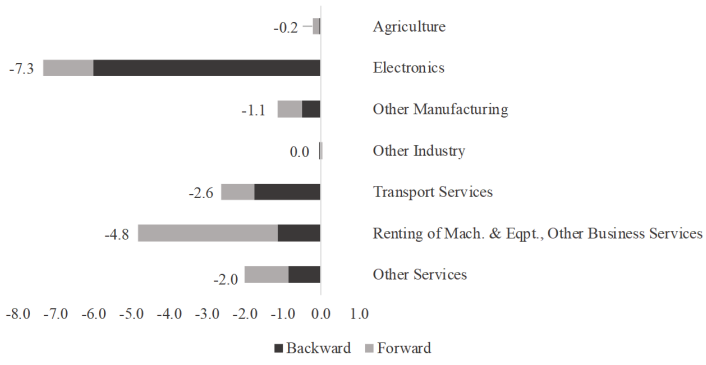
Source: Author's calculation based on the ADB MRIOT 2019-2020.

Figure 8 shows that the decline of Philippine GVC trade in 2020 was mainly traced to electrical and optical equipment, with electronics being the country's largest export item and the sector being deeply seated in the supply chains of large multinational companies. In 2020, electronics accounted for 46.4 percent of the country's total GVC trade. In addition, two-thirds of electronics trade were transacted within GVCs. This made the sector highly exposed to uncertainties in the global electronics market due to factory shutdowns, shortages of raw materials, and sudden fluctuations of demand. Prior to the pandemic, the industry already bore the brunt of the tariff wars. Owing to the "servicification" of manufacturing, transport services, renting of machinery and equipment, and other business services also weighed down the country's GVC activities.

Finally, Figure 9 decomposes the decline of Philippine GVC trade by main partners. Not surprisingly, the country's GVC performance was weakened by lower backward and forward trade with East Asian economies, the region hit hard by the disruptions caused by COVID-19. In particular, China, South Korea, Taiwan, Japan, and Hong Kong collectively accounted for 39.6 percent of the overall drop of Philippine GVC trade in 2020. Figure 9 suggests that East Asian economies contributed to the decline of Philippine GVC trade through lower backward transactions while end markets such as the US and Europe depressed the

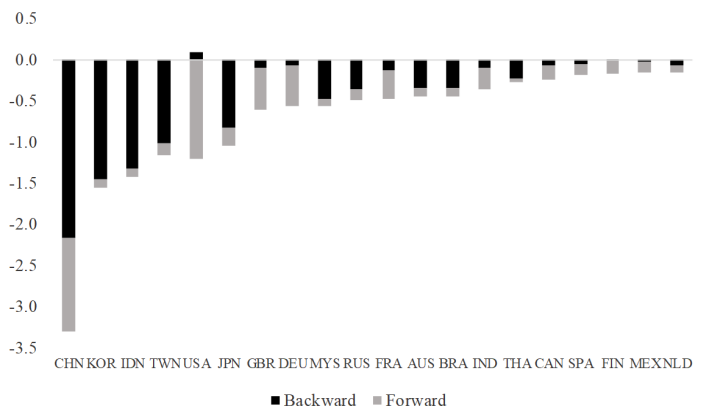
Philippines' forward GVC trade. This highlights the fact that a country, like the Philippines, that is strongly integrated to GVCs can assimilate global shocks from both the demand and supply sides. This also reveals the nature of the Philippines' vulnerabilities to GVC shocks: highly susceptible to regional supply disruptions and directly and indirectly exposed to demand fluctuations in developed countries.

FIGURE 8. Contribution to growth of Philippine GVC trade in 2020, by sector



Source: Author's calculation based on the ADB MRIOT 2019-2020.

FIGURE 9. Contribution to growth of Philippine GVC trade in 2020, by partner



Source: Author's calculation based on the ADB MRIOT 2019-2020.

3. Challenges to recovery

Recovering fully from the slump of GVCs due to COVID-19 is a tough challenge. This will depend on the duration of the pandemic, the downside risks from protectionist tendencies, the strength of the rebound of global demand, the reconfiguration of broken supply chains, and the ability of countries to coordinate policies.

Until the global public health crisis due to COVID-19 is completely under control, resumption to the pre-pandemic economic order is not likely. Although the tradeoff between health and wealth presents a seeming dilemma, experts and policymakers agree that containing the contagion should be the priority and that governments must "do whatever it takes" to put an end to the pandemic. A popular view among economists is that the health and economic objectives should be treated as complementary. As Baldwin [2020] argues, shutting down commercial activities and inducing an economic recession were necessary steps to enforce social distancing and reduce the spread of SARS-CoV-2. Countries that have implemented effective containment measures were able to gradually but cautiously reopen the economy as their epidemic curves started to flatten.

However, going back to business as usual without systematic T3 policies, health interventions, and effective vaccination strategies will only heighten the risks of new outbreaks. This is evident in the experiences of many developing countries like the Philippines, where stringent containment measures remain important instruments in the pandemic response toolkit. However, while lockdowns and social distancing are important measures to control the spread of the virus, the prolonged industrial disruptions that these drastic measures entail can inflict deep scarring on firms' productivity, especially in countries that have not ramped up vaccination efforts. Production lines will remain below capacity as long as some workers are involuntarily prevented from reporting for duty. Even with increased worker mobility or with automation, returning to full operation is difficult when some segments of supply chains continue to be distorted. Firms whose supplies remain interrupted by lockdowns and logistics bottlenecks have no choice but to scale down production until new input sources have been secured. Worse still, the potential spate of bankruptcies and firm exits may exacerbate the rigidity of supply. The multi-speed economic recovery across countries can sustain the lingering volatility in demand.

In the age of geographically fragmented production, malfunctioning supply chains mean broken linkages and interrupted trade flows. While controlling the spread of COVID-19 should be the most critical component of any short-term strategy to lead global factories to recovery, lessons from past supply chain disruptions provide additional insights on how to weather the current crisis. For instance, a WEF study in 2012 suggested the following recommendations to effectively manage supply chain disruptions [Doherty and Botwright 2020]. First, governments and lead firms should jointly conduct rapid and frequent assessments of current and potential risks to production bases and distribution networks. Identifying the sources of these risks is a key step towards implementing coordinated business and policy actions. Second, information sharing is very important given that one's failure can paralyze other firms. In a complex web of production linkages in GVCs, every participating firm may be "too big to fail." Therefore, access to reliable real-time data is important to let suppliers recognize

potential risks and emerging threats. Standardized risk measurements should be developed so that red flags can be easily detected. Based on these indicators, suppliers can plan ahead, revise projections, and prepare calibrated responses to various contingencies. Lastly, transparent and effective risk communication is needed to preserve synchrony among all stakeholders. In the current structure of production networks where glitches have inherent systemic effects, the one thing that governments and lead firms should avoid is releasing information that causes disjoint, confusion, and panic within supply chains and beyond. Using standardized indicators and protocols may simplify inter-firm communication.

Another important lesson from this crisis is that protectionist tendencies did not only undermine global efforts to control the contagion, they also pushed GVCs into greater volatility. For instance, the early stages of the outbreaks were accompanied by export restrictions and import duties on essential pharmaceutical and medical supplies such as face masks, protective garments, disinfectants, soaps, and ventilators. The bad news is that health systems around the world rely on personal protective equipment (PPE) trade. For instance, China and the US are each other's major trading partners in terms of PPEs while 90 percent of PPEs sold in EU are imported [Baldwin and Evenett 2020]. However, as Evenett [2020b] puts it, these trade distortions "sickened thy neighbor" by depriving many countries of the critical medical products needed to treat COVID-19 patients and prevent new infections. The double whammy of lower global supply and higher prices disproportionately hurt poorer nations that have inefficient health systems to begin with. Export curbs in big producers also undermined the unilateral reduction of import barriers in some countries. These risks compromised the ability of a country to contain the contagion, which in turn created additional health risks that transcended trade borders. As a result, this generated new waves of outbreaks that led to extended lockdowns, new batches of business closures, and protracted disruptions of domestic and international supply chains.

In addition to pharmaceutical and medical products, many countries also put up different types of barriers in the name of protecting domestic health and food security. As of July 2021, the WTO documented 312 goods-related and 137 services-related trade measures implemented across 116 customs territories.[8] As of August 2021, the WTO has already received 405 notifications related to COVID-19. Ninety percent of these notifications pertain to technical barriers to trade, sanitary and phytosanitary standards, and market access.[9] While some are related to trade facilitation measures that simplify documentary processes (e.g., Australia, New Zealand, EU, South Africa, Brazil, Chile, Costa Rica) and others moved to temporarily relax import restrictions on essential products (e.g., Switzerland, Canada, Bangladesh, Colombia, Brazil, and Ukraine), a handful of notifications explicitly hampered agricultural and medical exports or restricted "high-risk" imports.

[8] See https://www.wto.org/english/tratop_e/covid19_e/covid19_e.htm.
[9] See https://www.wto.org/english/tratop_e/covid19_e/notifications_e.htm.

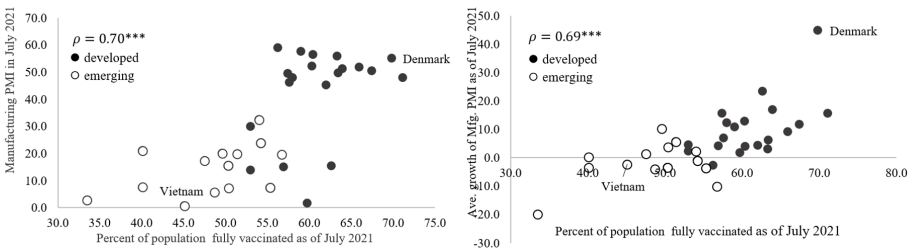
However, lessons from past crises suggest that export restrictions are bad policies. They distort global supply, create artificial shortages in importing countries, and unnecessarily increase the price for everyone. They may also inadvertently discourage local mass production when there are no foreign markets to absorb domestic surplus [Evenett 2020a]. In the case of raw materials and intermediate goods, trade restrictions create bottlenecks in the operations of global production networks that rely heavily on the unhampered flow of inputs within supply chains. Lessons from the US-China tariff wars suggest that the disruptive effects of protectionist policies have the potential to inflict damages not only on the disputing parties but also on peripheral countries that absorb the spillovers via GVC linkages. Putting up trade barriers in the middle of a pandemic is not a good gesture of being one with the international community. They magnify the stress to already fragile trade linkages and negate global efforts to keep GVCs functioning despite supply disruptions. Luckily, the fall of world trade in 2020 was less severe than expected partly due to the overall restraint and prudence of individual countries. As documented by the WTO [2021], many restrictive measures put up at the onset of the pandemic were eventually retracted and new policies supporting freer trade were introduced.

Instead of turning inward, countries should embrace multilateral cooperation as a key component of global efforts to recover from the COVID-19 crisis. The pandemic will persist unless all nations jointly strategize to end the crisis. Instead of export restrictions, trade wars, and competition for vaccines and other medical supplies, governments should realize that coordination is key to make the current structure of globalization work in emergency situations. Still, while everybody loses from coordination failure, world leaders need to demonstrate that smaller nations will have a fair share of the gains from the recovery of global trade and the world economy.

A perfect illustration of this last point is the current state of COVID-19 vaccination around the world. Immunization rates have been uneven, with advanced economies proceeding with their vaccination programs with greater speed and success than developing countries. While several governments in the developed world have started inoculating third booster shots, millions of people in low-income countries have not had their first jabs yet. A key determinant of this disparity is vaccine access which puts poorer nations at a disadvantageous position. Brand consciousness adds another layer of complication, with several countries not keen on accepting workers, tourists, and business travelers inoculated with certain vaccine brands. But these brands, especially Chinese-manufactured shots, are the most widely available vaccines in developing countries. This situation is problematic and undermines the recovery of the global economy in general, and GVCs in particular. For instance, Figure 10 shows that manufacturing purchasing manager's index (PMI) has rebounded stronger and faster in developed countries with higher vaccination rates. In contrast,

manufacturing remains relatively weak in developing countries where immunization rates are low. As long as emerging economies stay plagued by recurring outbreaks and lockdowns, their segments of international supply chains will remain volatile which translates to lingering disruptions of global manufacturing. The link between vaccination and GVC resurgence is straightforward. Vaccine inequality heightens the risk of new outbreaks and virus variants, especially in poorer countries with fragile health systems. A protracted pandemic in vaccine-deficient areas means that strict containment measures have to stay in place. But prolonged lockdowns and social distancing can cause a vicious cycle of supply chain disruptions whose spillovers can easily be propagated worldwide through GVC linkages. Therefore, vaccine nationalism and hoarding are counterproductive since the tides of globalization will lead the repercussions home.

FIGURE 10. Vaccination rate vs. manufacturing PMI across countries as of July 2021



* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Sources: CEIC and ourworldindata.org

It is worthwhile reiterating the first law of ecology: everything is connected to everything else. In the context of the current crisis, every thoughtful or reckless action by individuals, businesses, and governments can have repercussions on the global fight against SARS-CoV-2. The COVID-19 pandemic is a global threat that requires global solutions. Unfortunately, the current lack of international cooperation seems harder to resolve than the contagion itself. Critics argue that cooperation deadlock in the face of shared risks is the inherent weakness of global interconnectedness. This argument has merits and must be dealt with in future reconfigurations of GVCs. Until then, teamwork is the best survival strategy available at the world's disposal. That a country puts itself and others in danger by refusing to harmonize its policies should be good enough incentive to cooperate. The message is clear: no country is completely safe until all are safe. Only then can we talk meaningfully about repairing broken trade linkages and building robust supply chains.

4. Concluding remarks

The COVID-19 crisis has exposed both the beautiful and the ugly sides of the current organization of world trade. Owing to the growing interconnectedness of production and consumption in GVCs, seemingly minor risks such as a viral disease can generate ripple effects through the complex web of input and output linkages in global supply chains. We have also seen that the spillovers of systemic GVC disruptions spare no one, even the sectors that are not directly participating in global production networks. This is evident in the synchronous fall of backward and forward GVC trade across countries and major economic sectors, but especially in manufacturing and services. Nevertheless, the severity of the impact still varies depending on the type of GVC participation, the nature of the shocks, and the channels through which the spillovers are propagated.

Given the heightened exposure and sensitivity to global shocks, the COVID-19 pandemic and the US-China trade wars before that have renewed debates on the merits of interconnectedness in GVCs. Arriola et al. [2020] argued that exposure to supply chain risks does not automatically translate into actual economic losses, especially when firms and countries know how to manage these risks. In general, the idea that going inward will make domestic production more resilient and less exposed to foreign shocks has little support in the literature. This is because manufacturers actually lose flexibility by foregoing foreign alternatives and relying solely on local supply chains that are also not immune to obstructions [Miroudot 2020]. Within the context of supply chain disruptions induced by COVID-19, Espitia et al. [2021] found that GVC participation expectedly increased traders' vulnerability to foreign shocks but it also moderated their vulnerability to local shocks. Arriola et al. [2020] noted that re-localizing supply chains may lead to higher costs and heightened output volatility given the limited headroom for adjustments when shocks hit. Evidence from the global recession in 2009 also shows that while countries connected to GVCs were exposed to larger foreign shocks, they also recovered faster after the crisis [Altomonte et al. 2012].

Despite the risks of supply disruptions and demand fluctuations, the available evidence suggests that building more robust supply chains does not mean abandoning their global scope. The danger posed by interconnectedness in GVCs is not the exposure to shocks per se but the lack of strategic harmony among the actors involved. While producers have long recognized the potential gains from linking with international suppliers with established comparative advantage in certain activities, governments have generally been slow to acknowledge the value of policy synchronization in the age of globalization. But a crisis of this magnitude requires the collective action of all nations, not nationalism and protectionism. There is no better time to prove that interconnected economies must be supported by strong global coordination. As they say, don't let a good crisis go to waste.

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