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Examining Global Value Chains in Times of International Shocks

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1.1 Introduction

Even before the beginning of the coronavirus disease (COVID-19) pandemic in early 2020, the pace of globalization had already slowed. What once was an era of booming cross-border transactions, pushing the frontiers of international trade at the turn of the century, became—quite abruptly—a period of stagnating export and import activity. This dramatic shift from "hyperglobalization" (Subramanian and Kessler 2013) to "slowbalization" (The Economist 2019) occurred as the world dealt with the vestiges of the 2008 global financial crisis (GFC). The crisis ushered in skepticism towards globalization, along with renewed motivation to reconfigure the emerging architecture of international trade known as global value chains (GVCs). Global trade would then be disrupted further by trade tensions between the People's Republic of China (PRC) and the United States (US), with these two economic powerhouses and major players in GVCs imposing tariffs against each other to reshore manufacturing jobs. By 2019, these tensions had escalated and threatened to stifle export activities at a global scale.

A global pandemic was officially declared by the World Health Organization (WHO) on 11 March 2020, as COVID-19 spread rapidly worldwide. Along with it came unprecedented, and at times radical, modifications to economic and social activities, each geared towards the unified goal of controlling the speed and extent of COVID-19 transmission. Mobility restrictions such as lockdowns, quarantine and isolation, curfews, and travel controls were instituted in certain parts of the world, severely impacting key service sectors such as entertainment, leisure, and tourism. Some businesses that were deemed "nonessential" were even ordered to close, while a few others were allowed to operate at only limited capacity.

Note: Chapter contributed by the Asian Development Bank (ADB). The views expressed are those of the authors and do not necessarily reflect the views and policies of ADB or its Board of Governors or the governments they represent.

Industries that did not face such stringent constraints did, however, also face their own issues. For instance, the purchasing managers' index of supplier delivery times in the manufacturing sector showed a decline from 49.4 in January 2020 to 37.7 in April 2020, indicating longer lead times and capacity constraints, e.g., intermediates and labor supply shortages and transportation delays (CEIC 2022; Attinassi et al. 2021). In addition, the shipping and distribution industry—one of the main components of international logistics and playing a fundamental role in the functioning of supply chains—had to curtail its capacity at the start of the pandemic to adjust for an observed drop in demand. Then, however, came a surge in logistics demand attributed to national stimulus policies and an increase in purchases of household goods and electronics, causing an imbalance and leading to notable port congestion and record container freight rates soon after (UNCTAD 2022).

Concerns about the risks and uncertainties surrounding GVCs were reinvigorated because of pandemic policies and events. While such risks have always been present, even in the absence of shocks, multiple crises since the turn of the millennium have made them more salient over time. Chapter 1 of the GVC Development Report 2021 left readers wondering whether the same trend of stagnation in supply chains would persist, or even worsen, during the pandemic. This was especially concerning since the expansion of GVCs relies heavily on large-scale investments, which are fundamentally built on confidence derived from a good, stable, and predictable business environment.

Fortunately, signs of recovery in GVCs have already been reported due to concerted efforts to fend off the spread of COVID-19, worldwide adoption of digital technologies, and a return to past conceptions of "normalcy" that ultimately saw suspended economic and social activities resume. This renewed stability, however, is once again threatened by the Russian war in Ukraine, which has triggered an increase in commodity prices since the beginning of 2022.

This first chapter of the *Global Value Chain Development Report 2023* is based on the premise of successive shocks. The structure of gross exports and trends in GVC participation are first examined in the context of major recent disruptions to the global economy. During the initial years of the Global Financial Crisis (GFC), PRC–US trade tensions, and the COVID-19 pandemic, significant declines in exports were observed alongside decreasing shares of GVC-related trade to gross exports. A general shortening of GVCs also occurred from 2007–2009 (GFC) while a lengthening transpired from 2018–2020 (combined PRC–US trade tensions and COVID-19 pandemic). As considerable price changes were commonly experienced during these periods, a comparison of GVC-related metrics in nominal and real terms is also conducted to determine if any noticeable deviations occurred in instances of "abnormal" trade activity.

The chapter also investigates the evolving discourse on risks surrounding international trade and GVCs. Three characteristics that can give way to vulnerabilities are explored: trading of risky products, concentration in sources of value-added, and concentration in frequency of engagement in supply chains. The annual aggregate export value and share of potential bottleneck products—based on market concentration, market relevance, and market substitutability—had been increasing since 2000. On the other hand, there has always been considerable concentration in sources of foreign value added and pass-through frequency in supply chains—an observation that holds true before, during, and after periods of global shocks. Lastly, the chapter discusses reconfiguration strategies that governments and enterprises can explore to help mitigate negative impacts associated with shocks to GVCs, namely replication, diversification, regionalization, and reshoring. It is shown that while export diversification across economies worldwide remained quite high over time, agglomeration indices—in general—provided little evidence of reshoring activities.

1.2 Global Value Chains During Periods of Shocks

Already this century, there have been four major global shocks to international trade.

The first major shock was the GFC, which is widely considered to have reached its peak in 2008. Its origins can be traced back to the mid-2000s, when the housing bubble—driven by a combination of improved access to credit and low-interest rates on mortgages—took place in the US. As financial institutions witnessed the ensuing increase in mortgages, they began offering subprime mortgages, even to borrowers with poor credit histories (Loo 2020). These instruments, called "mortgage-backed securities", were sold globally to investors as more complex securities, making them difficult to assess in terms of value and risk. Eventually, homeowners, who had no true means to keep up with their mortgages in the first place, started defaulting on their mortgages. This caused significant drops in the value of mortgage-backed securities and, subsequently, enormous losses for the global financial system, which had become highly interconnected.

The subsequent freeze in lending and loss of confidence in the financial sector developed into a worldwide recession, characterized by depressed demand for highly tradable goods, plummeting business revenues, and widespread job losses. In fact, the fallout from the GFC led to global gross domestic product (GDP) contracting by 5.2%, as well as a decline of around 10.4% in global trade of goods and services in 2009. This drop in world trade was even more abrupt than the decline during the start of the Great Depression in 1929 (Eichengree and O'Rourke 2009). The immediate, simultaneous impacts on incomes worldwide can be attributed to the increasing synchronization of economic activity, with national GDP being correlated globally (Baldwin 2009; World Bank 2020).[1]

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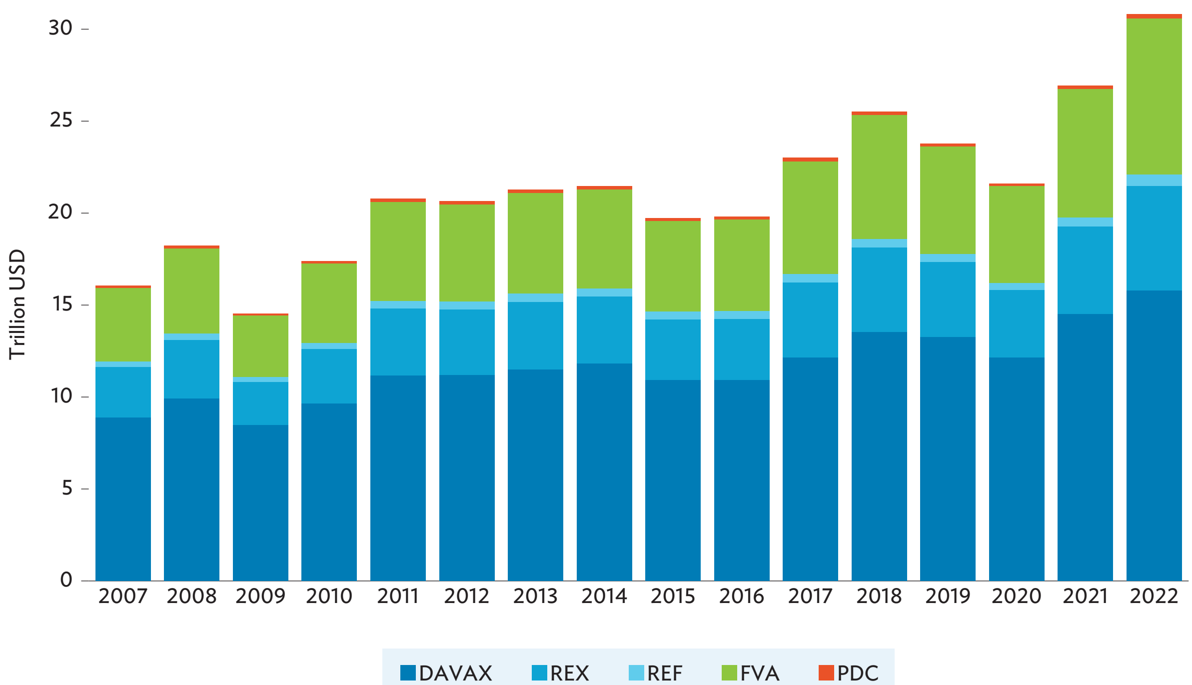
1 This is in line with studies that investigated the pattern of higher business cycle correlations among economies with deeper integration in GVCs (Burstein, Kurz, and Tesar 2008).

A closer look into the structure of exports provides valuable insight into how GVCs fared during and after the GFC. Applying the decomposition framework of Borin and Mancini (2019), it can be seen in Figure 1.1 that gross exports increased from around $16 trillion to $18 trillion from 2007 to 2008. At the time, domestic value-added that is directly absorbed by the importer (DAVAX) held the lion's share, comprising more than 50% of the value of gross exports, while foreign value-added (FVA) took up around 25%. By 2009, however, exports had contracted by around 20%, with the share of DAVAX increasing by 3.805 percentage points and that of FVA, domestic value-added sent to the importer then reexported and eventually absorbed abroad (REX), and domestic value-added sent to the importer then reexported and eventually absorbed back by the exporter (REF) decreasing by 2.338, 1.155, and 0.114 percentage points, respectively. World trade showed signs of improvement in the years that followed, and even surpassed pre-crisis levels (in nominal terms) as early as 2011. In addition, shares of all value-added components became more stable and predictable.

Figure 1.1: Decomposition of World Exports, 2007–2022



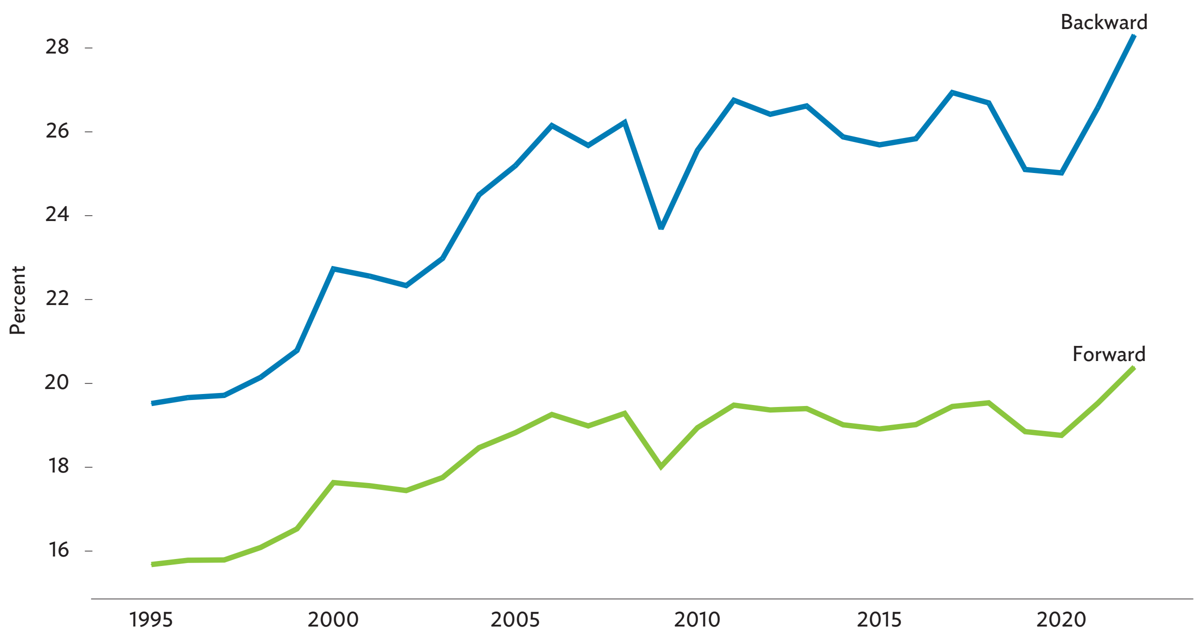
$ = United States dollars, DAVAX = domestic value-added directly absorbed by the importer, FVA = foreign value-added, PDC = pure double counting, REF = domestic value-added sent to the importer then reexported and eventually absorbed back by the exporter, REX = domestic value-added sent to the importer then reexported and eventually absorbed abroad.

Note: Gross exports decomposition follows the framework of Borin and Mancini 2019.

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Also following the framework of Borin and Mancini (2019), Figure 1.2 depicts the world's trade–based GVC participation rates from the perspective of backward and forward linkages. Forward GVC participation refers to the share of REX and REF in total exports: it is indicative of how an economy exports domestically produced inputs to its trading partners for further processing in downstream production stages (WTO n.d.). Backward GVC participation takes the share of FVA and the pure double counting[2] (PDC) term in total exports: it is an indicator of the extent of an economy's use of foreign-sourced intermediates in the production of goods and services for export.

Figure 1.2: Backward and Forward Global Value Chain Participation Rates, World, 1995–2022



Notes: Global value chain (GVC) participation rates are calculated following the framework of Borin and Mancini 2019. Backward GVC participation is the ratio of the sum of foreign value-added (FVA) and pure double counting (PDC) to exports. Forward GVC participation is the ratio of the sum of domestic value-added sent to the importer then reexported and eventually absorbed abroad (REX) and domestic value-added sent to the importer then reexported and eventually absorbed back by the exporter (REF) to exports.

Sources: For 1995–2006: World Input-Output Database, 2013 Release. For 2007–2022: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Figure 1.2 shows that, from 1995 until the peak of the GFC in 2008, the phenomenon of hyperglobalization was quite apparent, with forward GVC participation increasing from 15.68% to 19.28% and backward GVC participation growing from 19.52% to 26.22% over the 13-year period. In 2009, as the world attempted to deal with the aftermath of the GFC, both participation rates decreased and seemed to have stagnated in the years that followed. As mentioned above, the subprime mortgage crisis led to a sharp contraction of consumer durable goods, such as automobiles and machineries, especially in developed economies (Eaton et al. 2016). This reduction in demand for final goods also drove trade trends via intermediate parts and components required to manufacture those goods (Ferrantino and Larsen 2009), which was reflected by the drop in both GVC participation

2 These are value-added items that are recorded more than once in a gross trade flow resulting from the back-and-forth transactions involved in cross-border production processes (Koopman, Wang, and Wei 2014)

rates. In terms of overall GVC participation[3] almost all economies' rates fell compared to 2007 as seen in Figure 1.3. However, GVC-related trade seemed to have recovered quite speedily as these rates rebounded in 2010, with a few exceptions including Cambodia, Fiji, Kazakhstan, Lao PDR, Maldives, Philippines, and Thailand.

For each economy-sector pairing, the average GVC production length was also calculated using the methodology of Wang et al. (2017). This gives the average number of stages that separate domestic value-added creation in intermediate products to its final consumption (ADB 2023a). World level measures were derived as weighted averages, with each economy's share in global total value added used as shares.

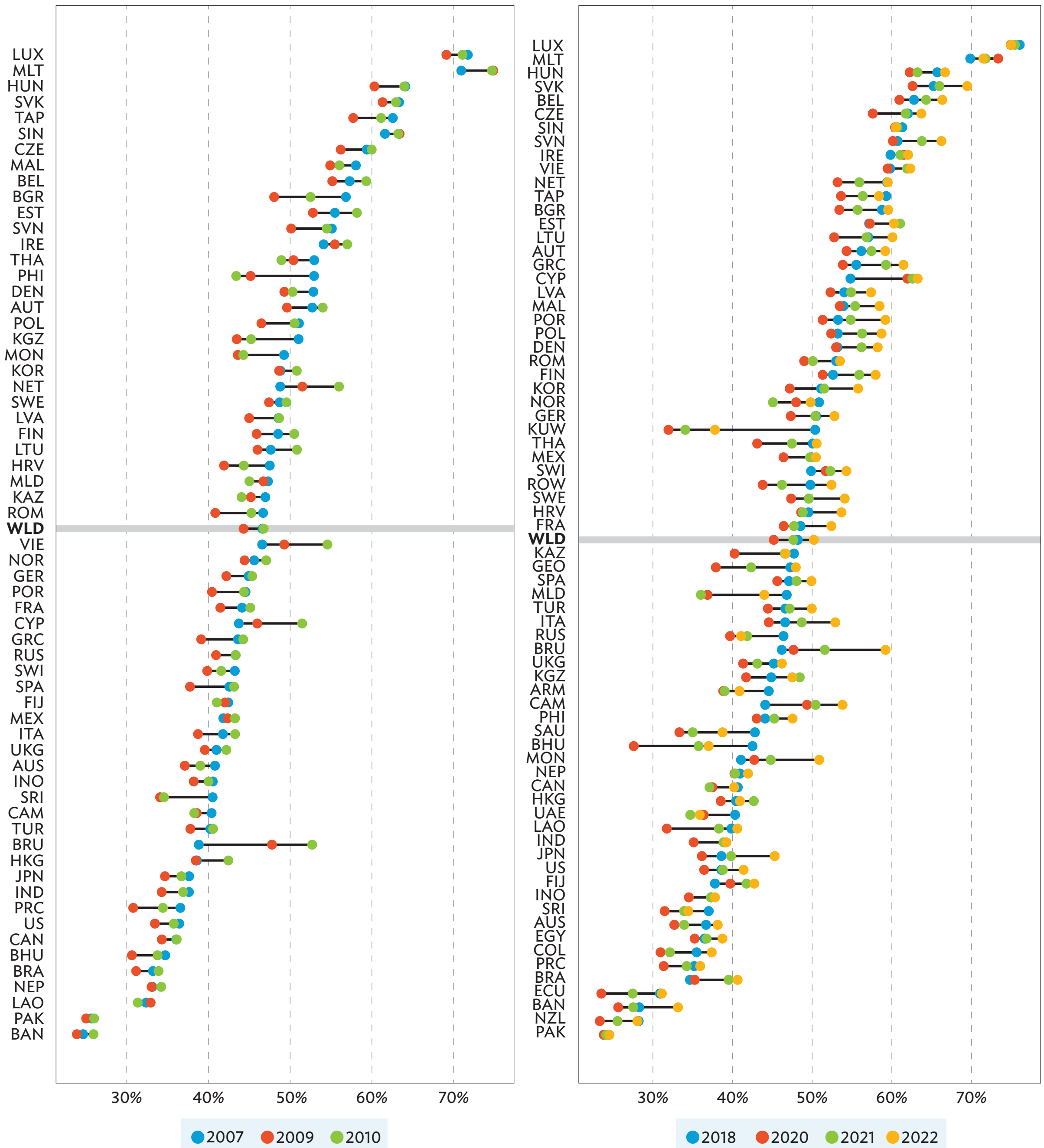
From 2007 to 2009, average GVC production lengths of sixteen sectors, comprised mostly of services and low-technology manufacturing sectors, shortened (Figure 1.4). As an aggregate, a shortening is also observed with the GVC production length going down from 8.75 in 2007 to 8.73 in 2009. This could have resulted from the decline in GVC participation, possibly characterized by increased reliance on domestic sources of value-added or even a temporary concentration of production processes towards a few economies. On the other hand, a lengthening of GVC production lengths was recorded for all sectors classified as medium- to high-technology. By 2010, a general lengthening of GVCs occurred with a large majority of sectors recording higher production lengths compared to 2009.

The second major global trade shock was caused by trade tensions between the PRC and the US, which began in 2018 before intensifying in 2019. The US administration's concern with the longstanding trade deficit it had with the PRC—alongside a gamut of other apprehensions related to intellectual property, national security, and quality of trade policies—gradually escalated into US imposition of tariffs and trade barriers on a few products from the PRC, which then retaliated with its own tariffs on US goods and services. This initial exchange was eventually extended with tariffs from both economies on a wider range of products, negatively impacting industrial sectors and significantly hurting trade between the two. With the PRC's role as a supply-and-demand hub in simple GVC networks, and the US being an important hub in complex GVC networks (Li, Meng, and Wang 2019), supply chains and markets worldwide were disrupted soon after.

The impacts of PRC–US trade tensions on GVCs are demonstrated back in Figure 1.1, which shows world exports falling by around 6.8% ($25.52 trillion to $23.78 trillion) from 2018 to 2019. In 2017, the share of DAVAX went down by 2.417 percentage points, but then increased as the PRC–US trade tensions commenced (by 0.336 percentage points in 2018 and by 2.757 percentage points in 2019). FVA, on the other hand, registered an increase of 1.643 percentage points in 2017, before consecutive dips of 0.245 and 1.747 percentage points in 2018 and 2019, respectively. Declines in REF and REX can also be seen in 2018 and 2019, respectively.

3 This is simply derived by adding the backward GVC participation rate and forward GVC participation rate of an economy

Figure 1.3: Global Value Chain Participation of Economies, 2007–2010 and 2018–2022

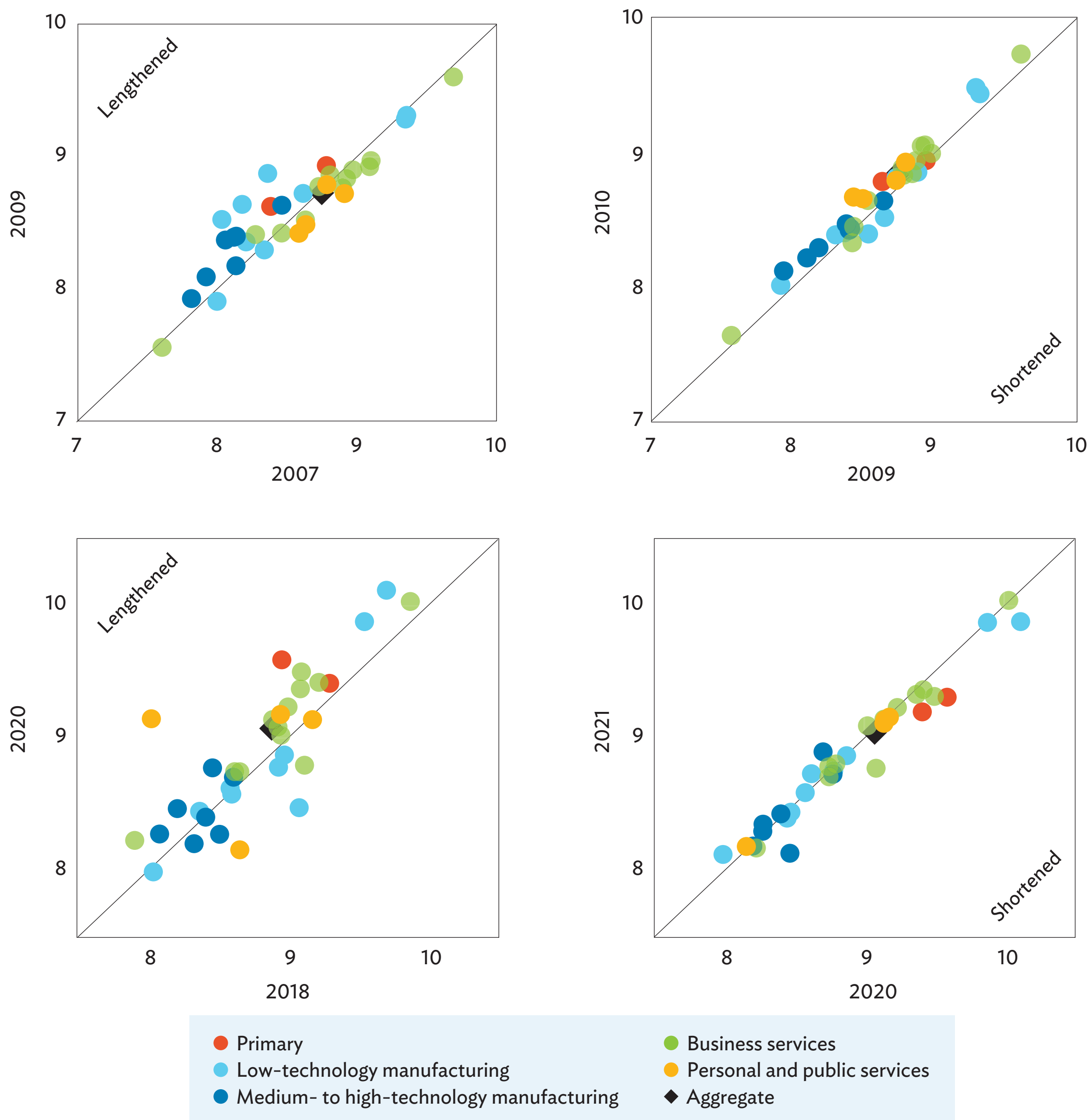


ARM = Armenia; AUS = Australia; AUT = Austria; BAN = Bangladesh; BEL = Belgium; BGR = Bulgaria; BHU = Bhutan; BRA = Brazil; BRU = Brunei Darussalam; CAM = Cambodia; CAN = Canada; COL = Colombia; CYP = Cyprus; CZE = Czech Republic; DEN = Denmark; ECU = Ecuador; EGY = Egypt; EST = Estonia; FIJ = Fiji; FIN = Finland; FRA = France; GEO = Georgia; GER = Germany; GRC = Greece; HKG = Hong Kong, China; HRV = Croatia; HUN = Hungary; IND = India; INO = Indonesia; IRE = Ireland; ITA = Italy; JPN = Japan; KAZ = Kazakhstan; KGZ = Kyrgyz Republic; KOR = Republic of Korea; KUW = Kuwait; LAO = Lao People's Democratic Republic; LTU = Lithuania; LUX = Luxembourg; LVA = Latvia; MAL = Malaysia; MEX = Mexico; MLD = Maldives; MLT = Malta; MON = Mongolia; NEP = Nepal; NET = Netherlands; NOR = Norway; NZL = New Zealand; PAK = Pakistan; PHI = Philippines; POL = Poland; POR = Portugal; PRC = People's Republic of China; ROM = Romania; RUS = Russia; RoW = Rest of the World; SAU = Saudi Arabia; SIN = Singapore; SPA = Spain; SRI = Sri Lanka; SVK = Slovak Republic; SVN = Slovenia; SWE = Sweden; SWI = Switzerland; TAP = Taipei,China; THA = Thailand; TUR = Türkiye; UAE = United Arab Emirates; UKG = United Kingdom; US = United States; VIE = Viet Nam, WLD = World average.

Notes: Global value chain (GVC) participation rates are calculated following the framework of Borin and Mancini 2019. It is the ratio of GVC-related trade—i.e., sum of domestic value-added sent to the importer then reexported and eventually absorbed abroad (REX), domestic value-added sent to the importer then reexported and eventually absorbed back by the exporter (REF), foreign value-added (FVA), and pure double counting (PDC)—to exports.

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Figure 1.4: Global Value Chain Production Lengths by Sector, World, 2007–2010 and 2018–2022



Notes: Global value chain production lengths are the sum of backward and forward lengths. These are computed following the methodology of Z. Wang, S. Wei, X. Yu, and K. Zhu. 2017. Characterizing Global Value Chains: Production Length and Upstreamness. *NBER Working Paper*. No. 23261. Cambridge, MA: National Bureau of Economic Research.
Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

When it comes to GVC participation, as shown in Figure 1.2, backward rates went down by a total of 1.835 percentage points from 2017 to 2019, while forward rates decreased marginally from 19.45% to 18.85%. The impacts of the PRC–US trade tensions—at least from the perspective of GVCs—appear to be less than those caused by the GFC. This may be due to a variety of factors, including trade redirection and the extent of digitalization.

The third major shock to international trade was the COVID-19 pandemic, which emerged while PRC–US trade tensions were still present. The shock began as a negative supply crisis, with infection containment measures disrupting the normal functioning of businesses, logistics, and supply chains, while also limiting the availability of labor. It eventually spread to demand channels (Brinca, Duarte, and Faria-e-Castro 2020; Del Rio-Chanona et al. 2020) as consumer spending and investment declined. In contrast with the GFC, which saw depressed demand in durable and investment goods, the decline in services trade was more severe during the pandemic (World Bank 2021; WTO 2021). However, with emphasis on public health and safety requiring the sudden confinement of social activities to people's homes, the demand for consumer electronics and home appliances, along with medical supplies, surged (Ossa and Le Moigne 2021). Computers and laptops, for instance, recorded the largest growth in exports from 2019 to 2020, reaching roughly $28 billion (ADB 2022).

The increased global adoption of digital technology is also widely regarded as a key development during the COVID-19 pandemic. Digitalization enabled enterprises to maintain operations and even accelerate commercial trends in consumer electronics, thereby mitigating trade shocks from both the supply and demand sides (OECD 2020; WTO 2021). Even though not all e-commerce sales entail cross-border trade, the expansion in retail trade via mail orders or the internet resulted in remarkable development in the e-commerce sector throughout 2020 (WTO 2021). Companies such as United Parcel Service (UPS) and PayPal reported substantial growth in cross–border shipment volumes (Fitzpatrick et al. 2020).

Another prominent trend observed during the pandemic was the considerable level of government response, with stimulus packages and labor market support, e.g., employment retention programs, helping to prevent worst-case scenarios from eventuating. Accumulated fiscal and monetary stimulus in 2020 and early 2021 reached a historic level of more than 15% of global GDP (IMF 2021). In fact, in advanced economies, the value of fiscal and monetary support was equivalent to about 25% of their GDP. In low-income economies, the equivalent figure was below 3% of GDP, suggesting a degree of heterogeneity according to the economies' development status. By contrast, during the GFC, the financial sector disruptions made it more difficult to obtain the trade finance necessary to jumpstart recovery of international business activities (Ahn, Amiti, and Weinstein 2011; Chor and Manova 2012; WTO 2021).

As a side note, due to the overlapping timelines between the PRC–US trade tensions and the COVID-19 pandemic, it is challenging to attribute observations for 2020 onwards to one or the other of these crises—at least from a measurement perspective. It is reasonable to treat observations on economic trends and patterns as the compounded effects of both crises, especially in the absence of a carefully crafted way of disentangling their impacts.

With this in mind, world exports declined by only 9.12% in 2020, which is around 11 percentage points lower (in absolute value) compared to 2009 (Figure 1.1). The share of DAVAX also increased marginally (0.398 percentage points) in the same year, while those of FVA, REX, and REF all decreased. In 2021, exports suddenly grew by around 24.57%, with the total value reaching a peak (in nominal terms) of approximately $26.92 trillion. The trends in the shares of DAVAX and other value-added components of gross exports were also reversed for the year. Meanwhile, GVC participation rates continued to decline from 2019 to 2020, albeit quite marginally at 0.1 of a percentage point (Figure 1.2). This may be due to the considerable slumps in GVC participation in 2019, which left little room for further contraction. Recovery in 2021 was quite instantaneous as both backward and forward rates came very close to reaching their values from 2018 and before.

It is also worth noting that, except for a few (e.g., Bangladesh, Kazakhstan, Maldives, Nepal, Sri Lanka, Taipei,China, and United Kingdom) economies with large business service sectors, almost all registered higher overall GVC participation rates in 2021 relative to 2019 as seen in Figure 1.3. This signifies that the service sector lagged in terms of recovery relative to its manufacturing counterparts, thereby having a prolonged impact on service-oriented economies.

In contrast to the GFC, a general lengthening of GVCs took place from 2018 to 2020 (Figure 1.4). Twenty-three sectors across all aggregate categories (i.e., primary, low-technology manufacturing, medium- to high-technology manufacturing, business services, and personal and public services) had higher GVC production lengths, which indicates that the combined impact of the PRC–US trade tensions and COVID-19 pandemic were felt across the board. Such a lengthening could be attributed to the trade redirection resulting from the imposition of tariffs as well as the issues of port congestion and border closures that occurred during this period. This would have added additional layers/stages to a production process as it looked for alternative options in response to a deviation from established procedures. By 2021, GVC production lengths shortened vis-à-vis a return to previous patterns of GVC participation.

The last and most recent shock to the global economy was the Russian war in Ukraine. While the beginnings of this crisis can be traced back to the 1990s, tensions are generally recognized to have intensified in early 2014 amid political turmoil that saw then Ukrainian President Viktor Yanukovych flee the country. This was followed by Russian troops taking over Crimea to "protect the rights of Russian citizens and speakers" in the region (CPA 2023 para. 2), with armed conflict breaking out soon after. In the years that followed, initiatives to resolve the situation were put forward but were mostly ineffective. Deployment of battalions in other Eastern European areas, as well as sanctions on Russian individuals and companies linked to the conflict, were also made (CPA 2023). In February 2022, President Vladimir Putin started the Russian war in Ukraine, and with it came a host of economic sanctions on Russia by the US, Canada, and the European Union (EU). Sanctions against several economies were also imposed by Russia. This impacted the world economy through higher commodity prices, supply chain disruptions, and further reduction of business confidence (Kammer et al. 2022).

It remains difficult to quantify the immediate impacts of the Russian war in Ukraine on the value-added structure of exports and GVC participation since multi-economy input-output tables for 2023 were not available at the time of writing this report. Reflecting patterns observed for the other three major shocks, significant trade impacts were not seen during the first year of the Russian war in Ukraine: world exports grew by 14% in 2022, leading to a new record high value of $30.83 trillion. DAVAX continued to fall (–2.591 percentage points) while FVA, REX, and REF all increased. GVC participation indices also peaked in 2022, with the backward rate increasing by 1.73 percentage points and the forward rate growing by 0.86 percentage points. Lastly, overall GVC participation rates of almost all economies were higher in 2022 compared to their pre-crises levels in 2018 (Figure 1.3). It will be interesting to see if these surges were sustained for 2023, which would be in contrast to what was observed during past crises.

In summary, an interesting pattern is seen during periods with significant fluctuation in exports, as was the case in the years following the four major global shocks:

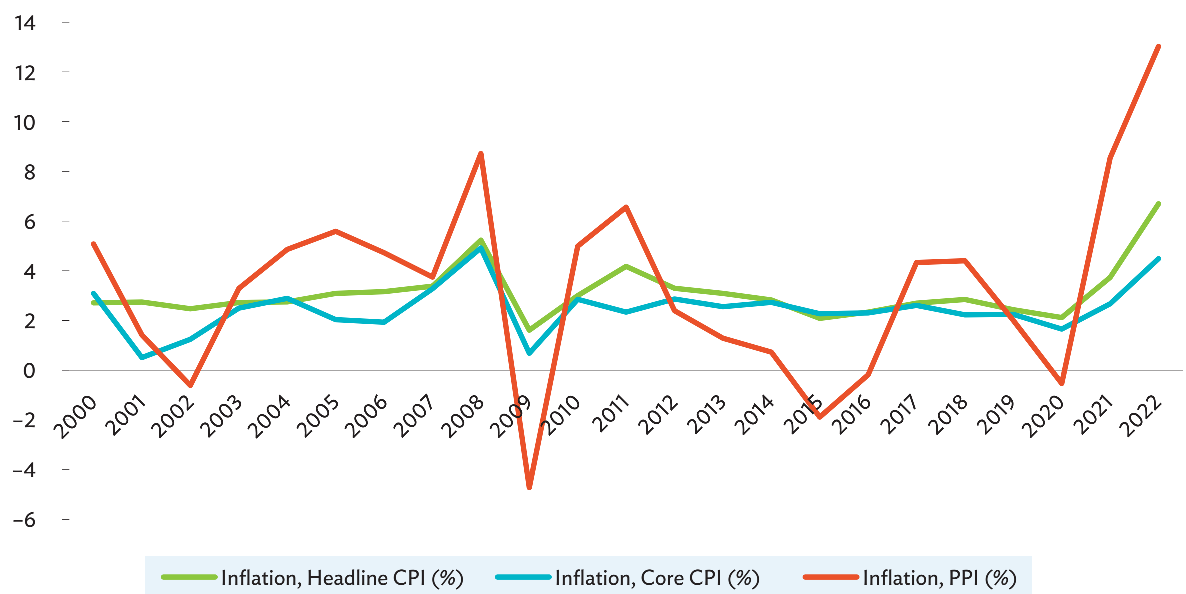
- During years of notable export growth, the relative share of DAVAX decreased vis-à-vis an increase in FVA, REF, and REX.
- As a corollary, periods with substantial declines in exports were characterized by increasing DAVAX and decreasing shares of FVA, REF, and REX.

This pattern suggests that GVC-related trade (which undergoes multiple border crossings and is constituted by FVA, PDC, REF, and REX) is cyclical with major changes in exports: such trade increases with significant growth in exports and declines with significant contraction in exports. It follows that traditional trade (which undergoes only one border crossing) is elevated in periods when export activities become more challenging, and vice versa. Such an observation may simply be coincidental and due to circumstances (e.g., port congestion and border closures in 2020) that make it more difficult for enterprises to successfully trade intermediates worldwide. On the other hand, this may reflect certain characteristics of the structure of international trade and GVCs that make them vulnerable (or at least sensitive) to shocks. Lastly, the pattern observed may be indicative of adjustment mechanisms being implemented by governments and firms worldwide in response to higher perceived risks in GVCs and suboptimal conditions related to participation (these aspects are explored in detail in subsequent sections of this chapter).

1.3 Dollar Prices and Global Value Chains

There seems to be an inextricable link between price levels and the occurrence of economic shocks. During the GFC, what began as a surge in housing prices in 2008 turned into deflationary pressures that were experienced worldwide due to reduced consumer spending, a slowdown in business investment, and an overall reduction in demand. In Figure 1.5, these trends can be clearly seen across different measures of inflation.

Figure 1.5: Global Inflation Rates, 2000–2022
(%)



CPI = consumer price index, PPI = producer price index.
Note: Gross domestic product-weighted global headline and core CPI (%) and PPI year-on-year growth rate (%).
Source: J. Ha, M. Kose, and F. Ohnsorge. 2021. One-Stop Source: A Global Database of Inflation. *Policy Research Working Paper, No. 9737.* Washington, DC: World Bank.

Meanwhile, Naisbitt and White (2020) noted that the increases in tariffs that were commonplace during the PRC–US trade tensions acted as a negative supply shock, which raised the prices of intermediates as well as final output. Since 2020, as economies worldwide have learned how to navigate their paths to normalcy following the peak of the COVID-19 pandemic, a surge in inflation has also been observed. This was made worse by the compounding effect of the Russian war in Ukraine on global commodity prices. Global headline consumer price index (CPI) inflation, which includes food and energy prices, increased in 2021 and reached up to 6.7% in 2022. Even if food and energy prices are unaccounted for (core CPI), inflation was still at its highest in 2022, at least for all years considered. The producer price index (PPI), which captures price changes received by manufacturers and producers, spiked in the years following the onset of the COVID-19 pandemic, reaching 13% in 2022.

Understanding the impact of global economic shocks on price levels, a main point of inquiry is whether trends and patterns captured in GVC statistics are dictated by price changes and not by structure. This means it could be possible that dependence on foreign-sourced inputs and the provision of intermediates along global supply chains have remained relatively stable over time (in terms of volume and number of transactions) and that price changes may have framed a different scenario from what actually happened. To account for this, the Asian Development Bank (ADB) developed multiregional input-output tables (MRIOTs) in nominal and real terms for 2000–2022. These tables can be used for deriving separate sets of GVC indicators. Thus, trends in GVC indicators in nominal terms reflect changes in production technology, prices, and exchange rates over time, while those in real terms only indicate technological and structural changes. Any differences between these metrics can therefore be ascribed to dollar price changes, which capture the combined effects of movements in price and exchange rate, since all MRIOTs are expressed in US dollars (ADB 2023).

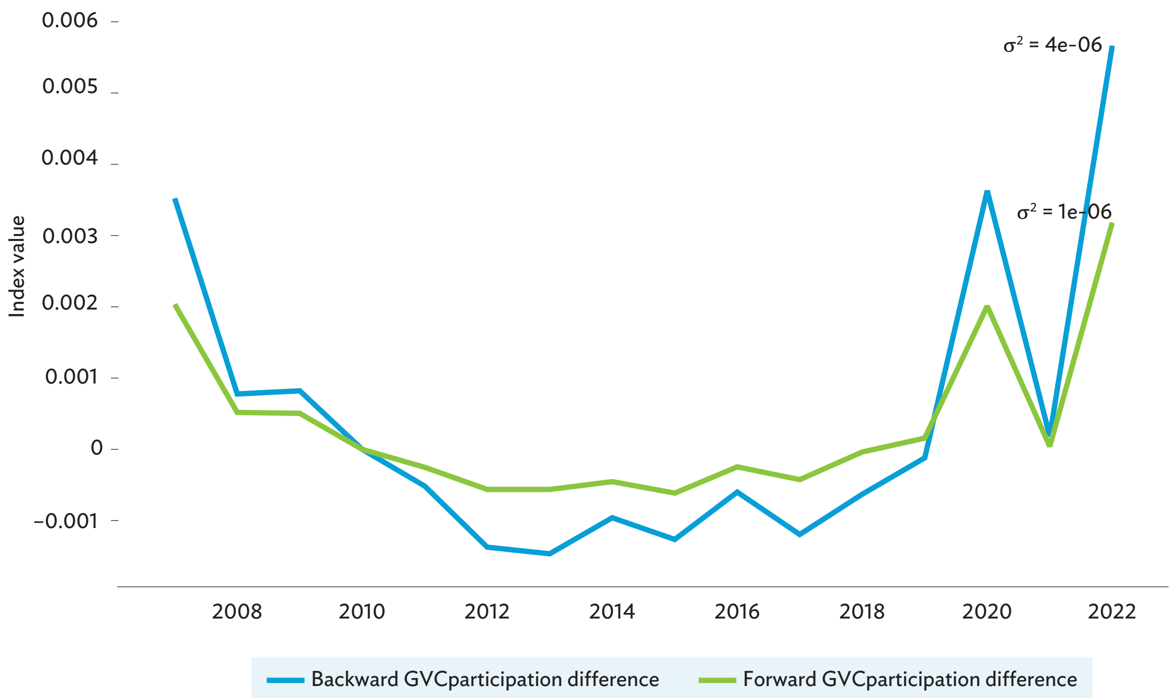
ADB (2023b) showed that there is stability in the breakdown of gross exports into traditional trade and GVC-related trade and this holds true whether or not dollar price changes are accounted for. However, during the 2021–2022 surge in inflation, the gap between gross exports in nominal and real terms increased to as high as 8% in 2021 and 7% in 2022. This may ultimately impact analysis of global trade. At the global level, GVC participation rates in nominal and real terms were also shown to be consistent with each other over the 15 years from 2007 to 2022. Figure 1.6 displays the differences between these estimates for both forward and backward GVC participation, which were simply calculated by subtracting the estimate in real terms from that in nominal terms. Though the range in differences was quite small, and the variances were both close to zero, it is interesting to see a considerable increase from 2021 to 2022, which meant that nominal rates were possibly overestimating actual participation during the recent inflation surge.

At a national level, such consistency is not preserved across all economies: some, such as Singapore and Türkiye, registered notable discrepancies between real and nominal estimates; while Kazakhstan and the US had relatively uniform trends.

To further examine the interplay of real and nominal GVC participation, a few additional indicators have been considered in this report: namely, the level of discrepancy, the variability of discrepancy, and occurrences of divergence (Box 2.1). Based on the first two indicators, a grouping of economies was established relative to their median values as seen in Figure 1.7.

Quadrant 1 of Figure 1.7 represents the group with low discrepancy and high variability. Hong Kong, China; the Lao People's Democratic Republic; and Singapore are among the economies that fell into this quadrant, signifying trends in current and constant prices that are not too far apart in levels but possess a considerable degree of variability in terms of their differences.

Figure 1.6: Differences in Backward and Forward Global Value Chain Participation Rates, Nominal vs Real, 2007–2022



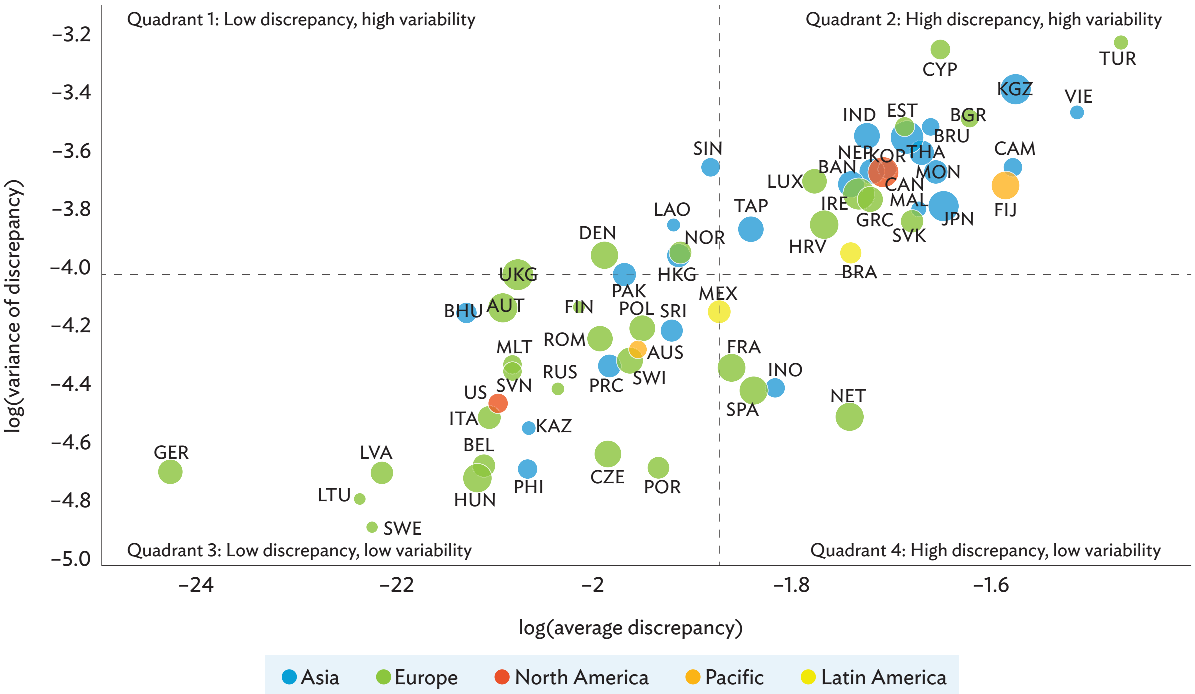
σ² = variance, GVC = global value chain.
Note: The difference is calculated by subtracting the estimate in real terms from the estimate in nominal terms.
Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Quadrant 2 of Figure 1.7 corresponds to those economies with differences in GVC participation rates that are higher (on average) and more variable than the median. Thus, not only do they have considerable differences between current and constant price estimates, they are also more volatile than the central value (i.e., median). Türkiye, Viet Nam, and the Kyrgyz Republic are notable examples as they are the farthest away from the median values. Some of these economies also had several instances of diverging trends (as indicated by the size of the bubble), with notable examples being Maldives (5 diverging trends), Japan (4), and the Kyrgyz Republic (4).

Quadrant 3, on the other hand, corresponds to the group of economies with differences in GVC participation rates that are lower (on average) and less variable than the median. In essence, these economies are more “stable” in the sense that their current and constant price estimates are closely aligned and are relatively more predictable. The PRC and the US, two powerhouse economies in international trade and GVCs, belong to this group, with the latter exhibiting more consistency than the former. Among all economies in this group, the PRC and Sri Lanka recorded the highest number of instances of diverging trends at 3 each.

Meanwhile, Quadrant 4 contains the group with high discrepancy and low variability. Only four economies fell into this quadrant, namely France, Indonesia, the Netherlands, and Spain. This means that these economies had relatively high but consistent levels of discrepancy between their current and constant price estimates of GVC participation.

Figure 1.7: Discrepancy, Variability, and Divergence of Real and Nominal Global Value Chain Participation



AUS = Australia; AUT = Austria; BAN = Bangladesh; BEL = Belgium; BGR = Bulgaria; BHU = Bhutan; BRA = Brazil; BRU = Brunei Darussalam; CAM = Cambodia; CAN = Canada; CYP = Cyprus; CZE = Czech Republic; DEN = Denmark; Developing Asia = DevAsia; EST = Estonia; Europe = Europe; FIJ = Fiji; FIN = Finland; FRA = France; GER = Germany; GRC = Greece; HKG = Hong Kong, China; HRV = Croatia; HUN = Hungary; IND = India; INO = Indonesia; IRE = Ireland; ITA = Italy; JPN = Japan; KAZ = Kazakhstan; KGZ = Kyrgyz Republic; KOR = Republic of Korea; LAO = Lao People's Democratic Republic; LTU = Lithuania; LUX = Luxembourg; LVA = Latvia; MAL = Malaysia; MEX = Mexico; MLD = Maldives; MLT = Malta; MON = Mongolia; NEP = Nepal; NET = Netherlands; NOR = Norway; PAK = Pakistan; PHI = Philippines; POL = Poland; POR = Portugal; PRC = People's Republic of China; ROM = Romania; RUS = Russia; SIN = Singapore; SPA = Spain; SRI = Sri Lanka; SVK = Slovak Republic; SVN = Slovenia; SWE = Sweden; SWI = Switzerland; TAP = Taipei,China; THA = Thailand; TUR = Türkiye; UKG = United Kingdom; US = United States; VIE = Viet Nam

Notes: Average discrepancy refers to the mean of the absolute values of differences between current and constant price estimates across time. Variance of discrepancy refers to the variance of the absolute values of differences between current and constant price estimates across time. Log base 10 of average discrepancy and variance of discrepancy are presented for visualization purposes. The vertical dashed line represents the median log base 10 average discrepancy, while the horizontal dashed line signifies the median log base 10 variance of discrepancy. Bubble sizes correspond to the number of instances when current price trends diverge from constant price trends (i.e., if one increases and the other decreases, vice versa).

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

The size and variability of differences in real and nominal measures of GVC participation can vary considerably, depending on whether backward or forward GVC participation is measured.[4] The extent to which an economy provides intermediate inputs to production processes across the globe may be consistent when measured across real and nominal rates, which indicates that GVC participation from the forward perspective is relatively unaffected by dollar price changes. At the same time, the economy may depend on foreign intermediates that face significant variation in dollar prices, which could lead to considerable differences in real and nominal GVC backward participation rates. On the other hand, an economy's provision of intermediates across supply chains may be subject to more irregularities in terms of dollar prices relative to its dependence on intermediates, which would lead to better consistency in terms of backward rates compared to forward rates.

[4] In a similar presentation to Figure 1.7, this would be reflected in economies being in different quadrants when backward participation is measured compared to when forward participation is measured.

Overall, 20 of 62 economies showed a change in grouping. Four economies (Hong Kong, China; the Lao People's Democratic Republic, Pakistan, and the Philippines) shifted from a forward participation rate in Quadrant 2 (high discrepancy, high variability) to a backward participation rate in Quadrant 3 (low discrepancy, low variability). This indicates a considerable level and variability of the gap between current and constant price estimates from a forward perspective, accompanied by relative steadiness and proximity from a backward perspective.

Box 1.1: Characterizing Economies Based on Differences in Current and Constant Price Estimates

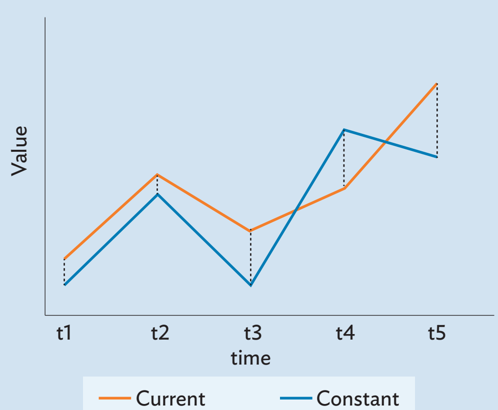
To group economies based on the trends in their respective current and constant price estimates of global value chain (GVC) participation, the following dimensions were considered: (i) level of discrepancy, (ii) variability of discrepancy, and (iii) occurrences of divergence. To explain how both price estimates are measured, an illustrative example is provided below. At each point in time (i.e., t1, t2, t3, t4, t5), the difference between current and constant price estimates (represented by the dashed lines) can be derived by subtracting one from the other. For the purposes of this analysis, the sign and/or direction of this difference was not a point of interest, thus absolute values of the discrepancies were taken. These are then averaged across time to get the average discrepancy, which is provided in the equation below:

$$\mathrm{avgDisc_i} = \frac{\sum_{t=1}^{T}\left|\mathrm{CurrentGVCParticipation_{i,t}} - \mathrm{ConstantGVCParticipation_{i,t}}\right|}{T}$$

where $avgDisc_i$ refers to the average discrepancy of economy i's GVC participation rates, t is period, and |x| refers to the absolute value of any number x. Intuitively, this measures how far apart (on average) the estimates in current and constant prices are from each other across time. The variability of discrepancy is simply the variance of absolute values of differences, which is represented in the equation below:

$$\mathrm{VarDisc_i} = \sum_{t=1}^{T}\left(\left|\mathrm{CurrentGVCParticipation_{i,t}} - \mathrm{ConstantGVCParticipation_{i,t}}\right| - \mathrm{avgDiscrepancy_i}\right)^2$$

where $VarDisc_i$ refers to the variance of discrepancies of economy i's GVC participation rates. Intuitively, this measures how variable the differences of estimates in current and constant prices are over time.



Source: Conceived by the authors of the Asian Development Bank's *Global Value Chain Development Report 2023.*

At period t5 in the illustration above, the current price trend increases while the constant price trend decreases. This indicates that, if prices and exchange rates are included in the analysis, growth is recorded from t4 to t5. However, if prices and exchange rates are controlled for or removed, a reduction in the measure is observed. This divergence has a potential impact on decision-making processes as the conceptualization of potential policy interventions may rest on the movement of a set of indicators across time. For this reason, the third dimension for grouping economies is measured by counting the number of instances of these divergences that occurred over the study period.

Conversely, four economies (Bangladesh, Canada, Greece, and Nepal) shifted from a forward participation rate in Quadrant 3 to a backward participation rate in Quadrant 2. As for other changes in grouping when shifting from a forward to a backward perspective, three economies (the Netherlands, Poland, and the PRC) moved from Quadrant 2 to either Quadrant 1 or Quadrant 4; two economies (Belgium and Sri Lanka) moved from Quadrant 1 to either Quadrant 3 or Quadrant 4; three economies (Croatia, Finland, and the UK) moved from Quadrant 3 to either Quadrant 1 or Quadrant 4; and four economies (Australia, Kazakhstan, Thailand, and Viet Nam) moved from Quadrant 4 to either Quadrant 2 or Quadrant 3.

GVCs are associated with the fragmentation of production and relocation of processes to areas where tasks are optimally delivered. With development of GVCs comes the expansion of production networks that inch ever closer to involving every economy in the world. Naturally, such modifications in the architecture of production also introduce new and evolving interdependencies among players participating in international trade, which become more salient during periods of crisis as disruptions in supply are felt across the board. The next two sections of this chapter explore risks surrounding international trade and GVCs by examining three characteristics that possibly contribute to the vulnerability of value chains to shocks: (i) trade of potential bottleneck products, (ii) concentration in sources of value-added, and (iii) concentration in pass-through frequency in supply chains.

1.4 Potential Bottleneck Products in International Trade

The impact of crises can be amplified if production is limited to a few locations. Trade tends to protect individual economies from volatility and shocks by enabling the diversification of sources of supply and demand (WTO 2023a). However, when trade in certain critical products is concentrated at a global scale, this diversification channel is muted and trade can instead exacerbate crises. Different studies have proposed ways to identify such potential bottlenecks in global trade. Majune and Stolzenburg (2022) defined these products as having a limited number of suppliers and few substitutes, yet constituting a relevant share of global trade.

One case in point is medical equipment such as face masks, for which Germany, the PRC, and the US accounted for almost half of global supply in 2019 (Hayakawa and Imai 2022). As demand for face masks skyrocketed in 2020, the reliance on these three economies increased exponentially. However, as the economies confronted challenges in production and logistics during the COVID-19 pandemic, their capacity to meet global demand became limited. The Russian war in Ukraine also highlighted the inherent risks associated with the world's reliance on a few economies to produce goods, as price hikes of oil and agricultural commodities led to the worsening of food and energy insecurity, even though the trading system adjusted swiftly to restrict negative impacts (WTO 2023b).

The literature on potential bottlenecks in trade has been growing. Korniyenko, Pinat, and Dew (2017) assessed the fragility of all globally traded goods and identified "100 risky import products" based on three dimensions: (i) presence of central players, (ii) tendency to cluster, and (iii) international substitutability. From here, the authors also discovered that virtually all economies import potential bottlenecks but at varying degrees. Building on this study, Reiter and Stehrer (2021) constructed a product riskiness index that uses five components: (i) outdegree centrality[5], (ii) the tendency to cluster, (iii) international substitutability, (iv) the Hirschmann-Herfindahl index (HHI), and (v) nontariff measures. This approach resulted in 435 of 4,706 products being identified as risky, representing around 26% of world import values.

Attempts to identify potential bottleneck products have also been conducted at the regional and economy levels. In 2021, for example, the European Commission classified 137 of 5,000 products as being risky for the EU based on concentration, importance of extra EU imports in total EU imports, and substitutability of extra EU imports with EU production (European Commission 2021). Jiang (2021) constructed a measure of dependency from four indicators covering import diversification, import substitutability (internal and external), and end-use category. The methodology was applied to Canada's 2019 import data and resulted in 500 of 5,331 products being classified as vulnerable. Bonneau and Nakaa (2020), on the other hand, assessed France's vulnerability to products from non-European economies, which was measured by the degree of concentration of non-EU-27 supplier economies in imports and the number of suppliers of the product. Of the 5,000 products that were analyzed, 121 were identified as vulnerable.

A new framework proposed by Majune and Stolzenburg (2022) to identify potential bottleneck products across the world will now be discussed in detail. This will help demonstrate the general idea behind analyses that belong to this body of literature and highlight that concentration is a relevant concern in global trade. Doing so helps form a better appreciation of these approaches in widening the understanding of risks and vulnerabilities present within international trade and GVCs. Potential bottlenecks, together with their respective operationalization, have been identified based on the criteria shown in Table 1.1.

To classify a product category as a potential bottleneck, the following rules are made under each criterion in Table 1.1:

(i) The HHI is at least 0.25. This follows the US Department of Justice and the Federal Trade Commission's definition for concentrated industries (US DoJ and US FTC 2010).

5 In network analysis, outdegree centrality refers to the number of outgoing connections a node has in a directed network. This number is often normalized by dividing it by the total number of possible outgoing connections this node can have.

(ii) The annual export value exceeded $30 million in 2000, inflated by annual global trade growth for the following years. This is based on export values of a selected list of products where concentration has led to disruptions in the past.

(iii) The elasticity of substitution (EoS) score is greater[6] than the average EoS for a given year indicating limited substitutability.

Table 1.1: Criteria for Classifying Product Categories as Potential Bottlenecks

Criterion	Definition	Metric/s
Market concentration	Refers to the number of suppliers of and their respective shares in total exports of a given product category.	Hirschmann-Herfindahl index (HHI)
Market relevance	Refers to the importance of a product category in global trade based on export value and the number of importers.	Annual export value
Market substitutability	Refers to the degree of substituting a product category for another	Product-level elasticity of substitution (EoS) scores from Fontagné, Guimbard, and Orefice (2022a; 2022b)

Source: S. Majune and V. Stolzenburg. 2022. Mapping Potential Bottleneck Products in the World. Paper prepared for the *Global Value Chain Development Report 2023* workshop. Geneva. 7–11 November.

As significant estimates of EoS scores are not available for all products, results that include and exclude the third criterion are provided, which exhibit consistency. Therefore, the following section focuses only on the results that exclude the EoS.

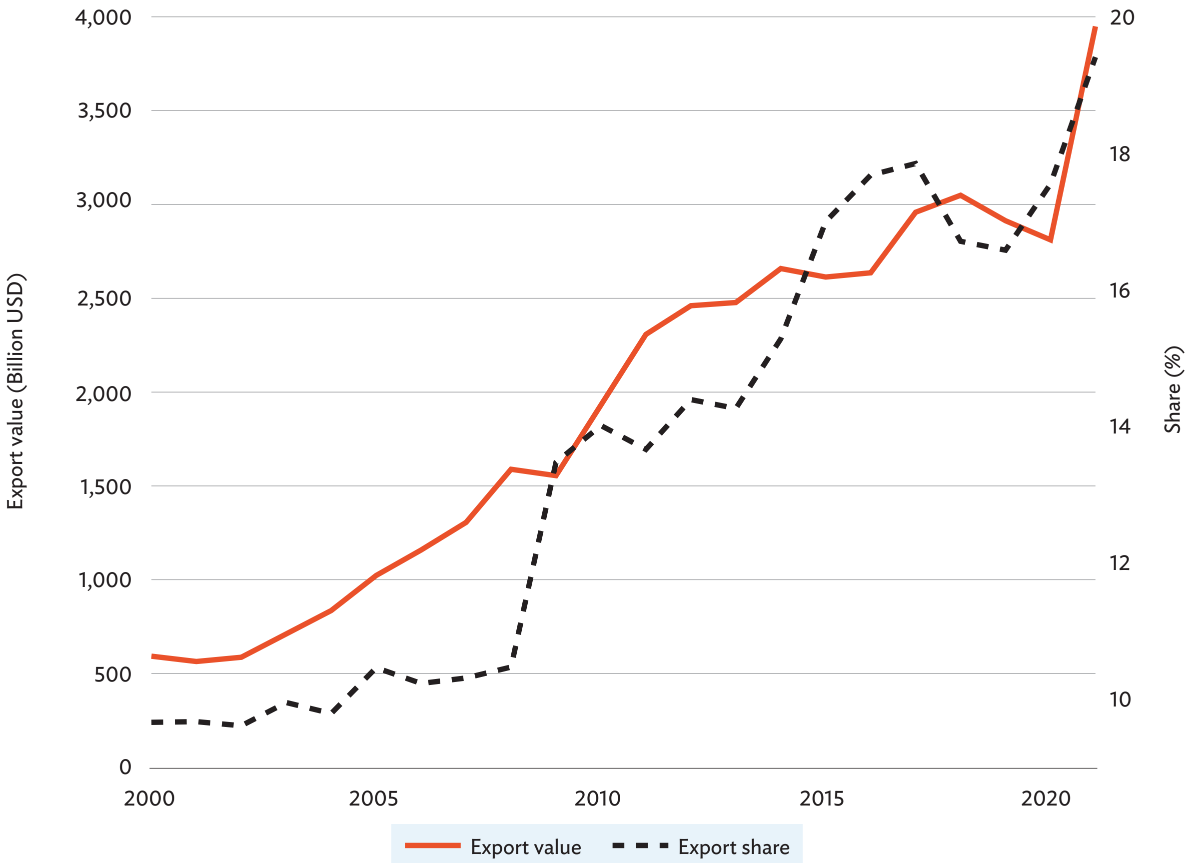
Applying their methodology to annual economy-product-destination data from the United Nations Comtrade Database[7] for the period 2000–2021, Majune and Stolzenburg (2022) describe potential bottlenecks in terms of trade flows, dynamics, and usage. A total of 1,075 (about 20%) of the 5,384 analyzed products were identified as potential bottlenecks in 2021, up from 778 in 2000. Their annual aggregate export value increased over the same period from just below $600 billion to about $4 trillion. This means that the share of global trade covered by potential bottlenecks more than doubled from 9.66% in 2000 to 19.41% in 2021 (Figure 1.8). While the share was relatively steady at around 9%–10% before the GFC, concentration has increased steadily since, with only a short disruption before the COVID-19 crisis.

Assessing individual geographic regions, potential bottleneck products are found mostly to be exported by East Asia and the Pacific, with their combined share of the global export value in these products increasing from just over 33% in 2000 to almost 66% in 2021. This is followed by Europe and Central Asia, North America, and Latin America and the Caribbean. Among these top regions, the role of Europe and Central Asia and of North America has steadily decreased to the benefit of East Asia and the Pacific.

6 EoS values are negative.

7 Products are at the 6-digit level classification of the Harmonized System (HS) and concorded to the 2017 HS revision.

Figure 1.8: Export Value and Share of Potential Bottlenecks in the World, 2000–2021



Sources: United Nations Comtrade data, 2000–2021; and World Trade Organization estimates.

Table 1.2 lists the top 10 economies exporting potential bottleneck products for 2000, 2005, 2010, 2015, and 2021. The PRC and the US were clearly the main players in the supply of these commodities across 2000–2021, although the US share gradually diminished (seemingly to the advantage of the PRC). The PRC averaged close to 33% of the global export value of these products for the study period, thereby reinforcing the dominance of that economy in supplying the risky products established in related literature. European economies (i.e., France, Germany, Italy, the Netherlands, and the UK) as well as Canada also played considerable roles. The Republic of Korea emerged as one of the main suppliers of these potential bottleneck products, with consistently rising shares leading to it ranking third among all economies in 2021. Australia's contribution increased along similar lines. Around 70% of the global export value of these commodities was generated by the top 10 suppliers over the 21-year period.

In terms of industries, electrical equipment accounted for by far the highest proportion of the export value of potential bottlenecks: the sector's share more than doubled from 20% in 2000 to 47% in 2021. This was driven mostly by demand for mobile phones and semiconductors. The second-most dominant sector was fuels, which accounted for 10% of export value in 2021. When looking at industry shares by the number of products,

Table 1.2: Top Exporters of Potential Bottleneck Products, 2000–2021
(%)

2000		2005		2010		2015		2021	
Economy	Share	Economy	Share	Economy	Share	Economy	Share	Economy	Share
PRC	19.1	PRC	32.2	PRC	35.7	PRC	39.5	PRC	36.3
US	18.4	US	10.0	US	8.5	US	8.3	US	6.4
Japan	9.4	Japan	7.2	Germany	4.4	Germany	4.3	Rep. of Korea	5.0
France	6.2	Germany	5.2	Japan	4.3	Rep. of Korea	4.0	Australia	4.2
Canada	5.2	France	4.9	France	3.6	France	3.2	Viet Nam	4.2
Germany	5.1	Netherlands	3.0	Brazil	3.6	Australia	3.2	Germany	3.4
Italy	3.4	Malaysia	2.8	Australia	3.0	Japan	3.0	Brazil	3.3
UK	3.3	Italy	2.6	Rep. of Korea	2.7	Viet Nam	2.8	Japan	2.7
Netherlands	2.2	Ireland	2.4	Netherlands	2.2	Brazil	2.2	Indonesia	2.4
Malaysia	1.6	UK	2.3	Malaysia	1.9	Netherlands	2.0	France	2.2
Total	74.0		72.5		69.8		72.5		70.2

PRC = People's Republic of China, Rep. = Republic, UK = United Kingdom, US = United States.
Sources: United Nations Comtrade data, 2000–2021; and World Trade Organization estimates.

rather than by trade value, particular sectors feature prominently. These include textiles, chemicals (particularly lithium and nickel), and vegetables (particularly cereals). This corresponds to discussions surrounding the Russian war in Ukraine and the ongoing transition to a green economy globally.

To determine the usage rates of potential bottleneck products by industry, Majune and Stolzenburg (2022) concord the 2017 version of the Harmonized System (HS) classification to the 2012 input-output table from the US Bureau of Economic Analysis, allowing industries that are most dependent on inputs classified as potential bottlenecks to be identified. The results show that most heavily exposed industries are in the food and beverage sector. Hence, efforts to deconcentrate trade flows involving risky products could have significant contributions to achieving food security, as also highlighted by impacts of the Russian war in Ukraine.

1.5 Geographic Concentration in Value and Frequency of Trade

In the context of GVCs, a supply chain faces a considerable amount of risk if a significant volume of value-added in the goods and services it produces comes from or passes through only a few areas, with no clear viable alternatives.

Concentration in Foreign Value-Added Sources

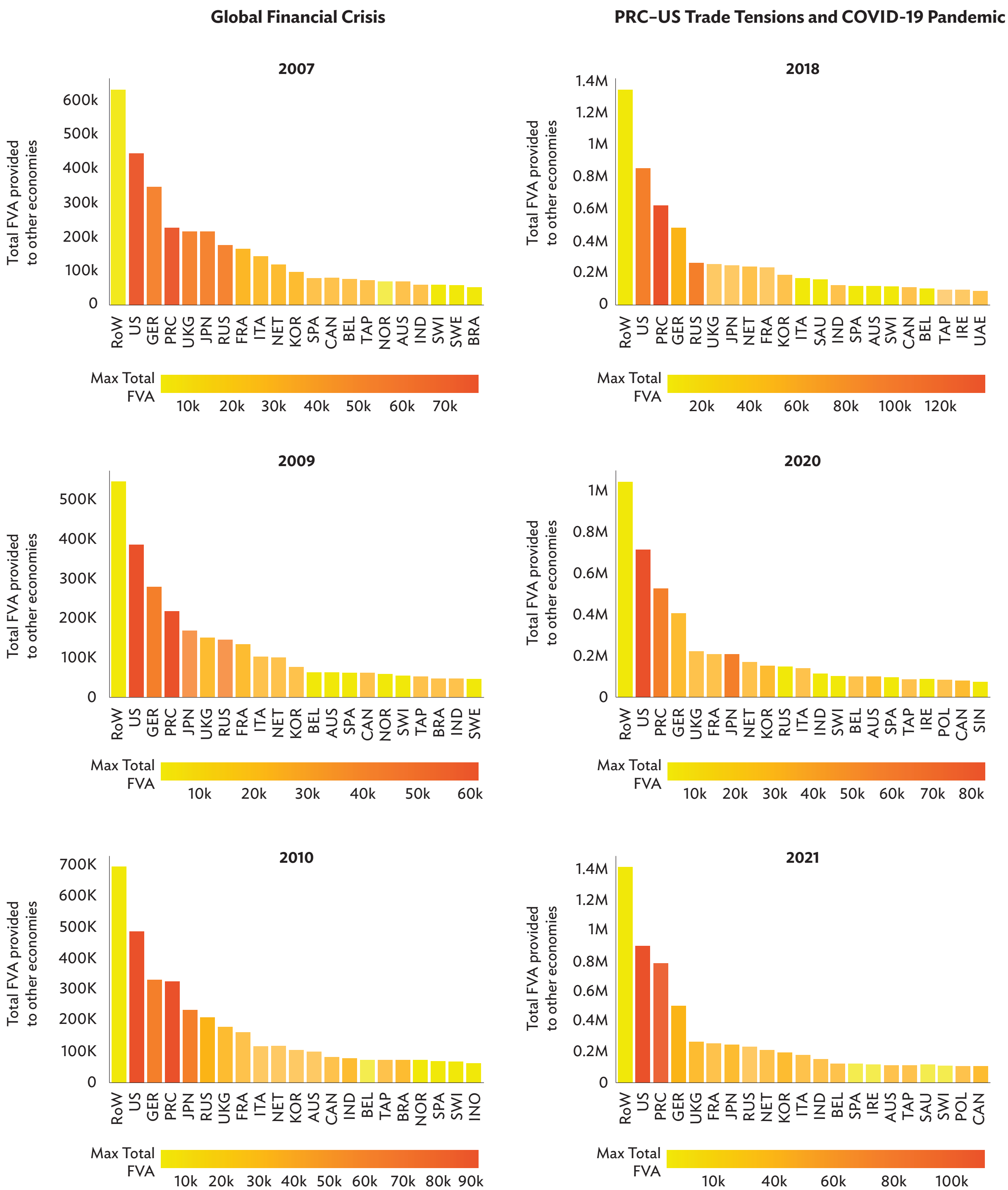
As shown earlier in this chapter, gross exports can be decomposed into a set of value-added terms. One of these components, foreign value-added (FVA), measures the amount of value-added embodied in an economy's (or an economy-sector's) exports that comes from its trading partners. For example, if economy A exports 100 monetary units to the world and 25% is comprised of FVA, then 25 monetary units worth of value-added do not originate domestically and therefore come from other economies. Using Borin and Mancini's (2019) framework, it is possible to disaggregate FVA into the source economies such that, following the example above, the 25 monetary units of FVA can be traced to the economies where they originated: say, 15 from economy B, 7 from economy C, and 3 from economy D. It then follows that a similar activity can be undertaken for economies B, C, and D, and that total FVA sourced from each can be derived.

Using this algorithm and ADB's multiregional input-output tables (MRIOTs) as the data source, FVA of an economy (say i) is first decomposed into its sources at the economy-sector level. The resulting matrix is then summed across all economies $j \neq i$ to get the total amount of FVA sourced from each of them in the production of economy i's exports. This is iterated for each economy in the MRIOTs, which totaled 63 for 2000–2017 and 73 for 2017–2022. The resulting aggregated matrices are joined and are further summed across all economies to derive the total amount of FVA that each economy provides to its global exports. This metric provides a good indication of backward dependence on an economy in GVC trade. If all players in international trade are playing equal roles as suppliers of value-added, some uniformity across economies should be observed. If not, and there is a skew toward a few economies, then there is evidence of concentration.

Figure 1.9 shows the results of the algorithm for two periods: (i) 2007–2010, i.e., the onset of the GFC (2007) and the two years (2009 and 2010) that immediately followed the peak of trade disruptions in 2008; and (ii) 2018–2021, i.e., the beginning of PRC–US trade tensions (2018), the overlap with the COVID-19 pandemic (2020), and the year immediately following the climax of disturbances in trade (2021). In the figure, the color scale indicates the highest value of FVA provided by one economy to another, with warmer colors corresponding to higher figures. For example, in 2007, the highest value-added supplied by the US to another economy was almost $78.5 billion.

In 2007, the top 20 sources of FVA contributed 81% of total world FVA, which means there was considerable concentration in backward dependence before the GFC hit. The US and Germany were the top providers of FVA for this year, with FVA from the US equaling almost 75% of that from all economies outside the top 20. Similarly, FVA from Germany was more than 50% of the value from the Rest of the World. In the following years, about the same level of concentration was still present, with the top 20 providers accounting for 80.87% of total world FVA in 2009 and 81.26% in 2010.

Figure 1.9: Backward Dependence on Value-Added, Top 20 Economies and Rest of the World
($ million)



$ = United States dollars; AUS = Australia; BEL = Belgium; BRA = Brazil; CAN = Canada; FRA = France; FVA = foreign value-added; GER = Germany; IND = India; INO = Indonesia; IRE = Ireland; ITA = Italy; JPN = Japan; k = 1,000; KOR = Republic of Korea; M = million; NET = Netherlands; NOR = Norway; POL = Poland; PRC = People's Republic of China; RoW = All other economies outside the top 20; RUS = Russia; SAU = Saudi Arabia; SIN = Singapore; SPA = Spain; SWE = Sweden; SWI = Switzerland; TAP = Taipei,China; UKG = United Kingdom; US = United States.

Notes: The vertical axis corresponds to the total FVA ($ million) provided by an economy in the production of all other economies' gross exports. Bar colors represent the maximum amount of FVA that an economy provides to a single economy to produce its exports.

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

By 2018, the PRC had overtaken Germany in the rankings, becoming the economy that supplied the second-most FVA to the world. With this change, not only did the two economies that had engaged in extensive trade restrictions now hold the two most significant positions in enabling GVC trade, but there was also a concentrated dependence on them by all others. It is therefore not surprising that GVCs were negatively affected by the disturbances resulting from these trade tensions.

The concentration of FVA was still apparent during the onset of the COVID-19 pandemic in 2020 and in 2021, when a considerable recovery in the value of gross exports was observed. During this period, the top 20 sources of FVA comprised around 78% of total world FVA.

It is worth noting that the list of economies appearing atop the rankings during both 2007–2010 and 2018–2021 remained relatively static. Overall, these findings indicate that the underlying structure of backward dependence in GVCs, characterized by concentration towards a few economies, was preserved despite the disruptions caused by the GFC, the PRC–US trade tensions, and the COVID-19 pandemic.

Concentration in Frequency of Engagement

The analysis of backward dependence has so far delved only into the volume dimension of concentration. There is also, however, a dimension of risk that stems from the frequency of engagement of one economy with another (Inomata and Hanaka 2023). To illustrate the concept, if an individual infected with COVID-19 interacts with a second person several times during a day, even for only short intervals, the second person may be as exposed to the risk of infection as anyone who interacts with the infected individual for longer periods. In global supply chains, even if a certain economy is not a major supplier of inputs to other economies in the production of their respective exports, it may still be possible for the supplier economy to be frequently engaged with production processes. This may include being a major entrepôt in certain trade routes and/or providing incremental inputs to different stages of a production process. These engagements, particularly when concentrated, increase the probability of being involved in unforeseen circumstances, such as natural, economic, or political shocks, and must therefore be considered in the holistic assessment of trade risk.

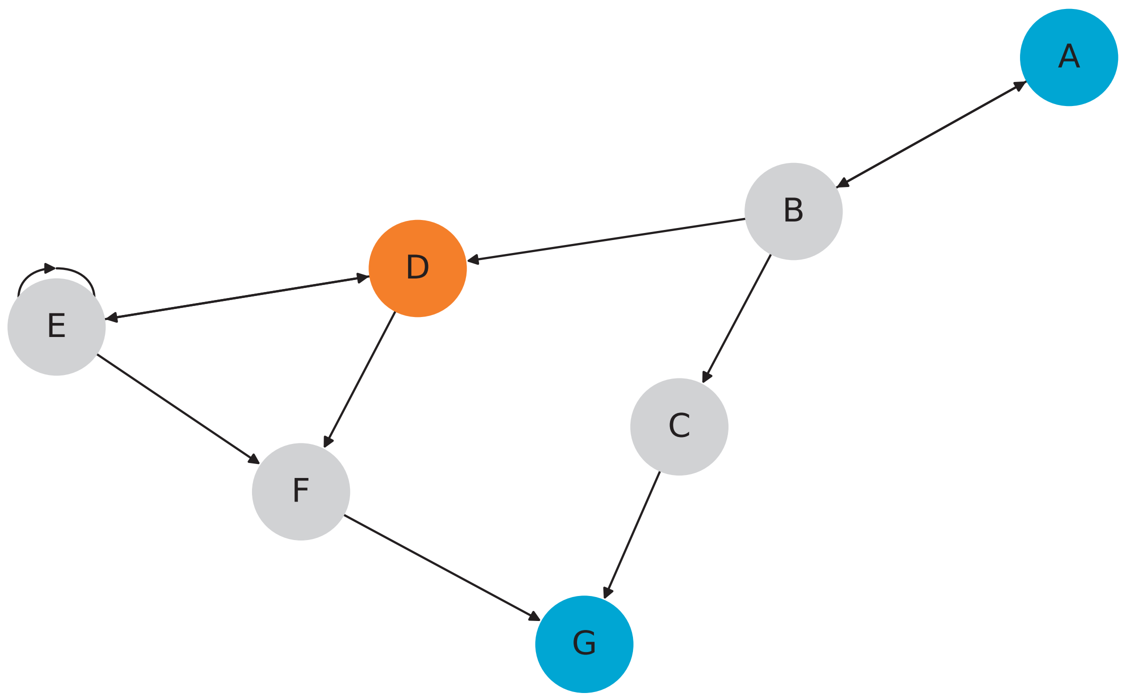
To further demonstrate the idea of frequency, consider the schematic example in Figure 1.10. Here, a supply chain can connect economy A with economy G via five different production paths that pass through economy D (which happens to be the risk economy in this example). Supply can also travel both ways through economy E. The five relevant production paths are therefore:

(i) A → B → D → E → E → F → G
(ii) A → B → D → E → F → G

(iii) A → B → D → E → D → F → G
(iv) A → B → D → E → E → D → F → G
(v) A → B → D → F → G

Note that economy A and economy G can alternatively be connected via economy B and economy C.

Figure 1.10: Trade in a Directed and Unweighted Network



Source: Conceived by the authors of the Asian Development Bank's Global Value Chain Development Report 2023.

Paths (iii) and (iv) pass through economy D twice, while the rest only do so once. If a crisis occurs in economy D, which may render trade that passes through it unsuccessful within a given probability, then it may be less risky to go through paths (i), (ii), and/or (v).

Real–world supply chains are, however, significantly more detailed and complex than the network shown in Figure 1.10, and it is virtually impossible to repeat the same simple exercise using actual trade patterns and relationships. Thus, a manageable way to measure more complex relationships—one that takes into consideration the direction and weights of trade links—is needed.

Liang, Qu, and Xu (2016) used the concept of "betweenness" in conjunction with key sector analysis to measure the importance of intermediate sectors (referred to as transmission sectors) in mitigating the environmental pressure brought about by supply chains. In network theory, any given network is comprised of nodes (vertices) that are connected by links (edges). Expanding on the earlier example, take the monitoring of coronavirus case transmission, which became especially prominent during the COVID-19 pandemic. Under this example, the nodes would be represented by individuals: those with confirmed infections; the people they interacted with; the family, friends, and work colleagues of those direct contacts; and so on. These relationships or interactions are then represented by the edges, establishing the links between the individuals that form the network.

In network analysis, the betweenness (or betweenness centrality) of a node refers to the extent to which it lies on the shortest path between other nodes, thereby indicating how it brokers or controls the flow of transactions among other nodes in the network (McCulloh, Armstrong, and Johnson 2013). In an unweighted and undirected network, the betweenness of any given node is derived by obtaining the ratio of the number of binary shortest paths between two nodes that pass-through the nominated node to the number of binary shortest paths between two nodes. The shortest path in this context refers to the path that has the least number of steps from one node to another. In Figure 1.10, for example, the shortest path between economy A and economy G is A → B → C → G.

Once directionality is introduced into a network, a slight modification to betweenness must be made since a node that lies on the shortest path from Node A to Node B does not necessarily mean that it lies on the shortest path going the other way from Node B to Node A. Thus, the normalization process is altered to account for the distinction between paths from one node to another, and vice versa.[8] When weights are introduced to a network, shortest path-based measures of centrality (e.g., betweenness and closeness) become more challenging to interpret, since the edges may indicate strength of a connection that could facilitate transmission of information and make transactions more efficient (Opsahl, Agneessens, and Skvoretz 2010). Therefore, these measures are adjusted to account for edge weights by using algorithms. For instance, the algorithms of Djikstra (1959) treat weights as costs of transmission, those of Newman (2001) and Brandes (2001) take the inverse of tie weights, and those of Opsahl integrate the number of intermediary nodes and inverse tie weights.

In an economy comprised of multiple sectors that interact with each other to produce their respective goods and services, network analysis offers promising applications. Liang, Qu, and Xu (2016) took advantage of this idea, but they had to consider self-flows, directionality, and weights. Given this, the authors resorted to structural path analysis to devise a structural path betweenness metric that measures a given sector's role and/or impact in transmitting environmental pressures within a supply chain. With a slight modification to the formula, this betweenness-based metric can be transformed into an indicator that tracks how many times a given supply chain passes through a sector of concern or, in the context of MRIOTs, an economy-sector of interest (Box 1.2).

8 In undirected and unweighted networks, a link from Node A to Node B is equivalent to the link from Node B to Node A. The link simply indicates that there's a connection between the two nodes, disregarding origin and extent of the interaction. The adjacency matrix for this type of network is thus binary and symmetric.

Box 1.2: Deriving the Number of Times a Supply Chain Passes Through a Sector

Liang, Qu, and Xu begin their 2016 study with a presentation of the backward propagation of a final demand impact that starts from sector s, passes through r sectors $(k_1, k_2, \ldots, k_r)$, and ends at sector t. This is given by:

$$a_{sk_1} a_{k_1k_2} a_{k_2k_3} \ldots a_{k_rt} y_t$$

Here, sector t faces a final demand of y_t, thus requiring inputs from other sectors along the production chain, all of which may or may not rely on other sectors themselves. $a_{sk_1} a_{k_1k_2} a_{k_2k_3} \ldots a_{k_rt}$ are technical coefficients from **A**. Following Inomata and Hanaka (2023), the notation can be configured by (i) setting sector q as the target and assuming that it is one of the intermediate sectors along the production path above, and (ii) denoting upstream sectors relative to t as $u_1, u_2, \ldots, u_m$ and downstream sectors relative to t as $d_1, d_2, \ldots, d_n$, giving:

$$a_{u_1u_2} a_{u_2u_3} \ldots a_{u_{l-1}u_l} a_{u_lt} a_{td_1} a_{d_1d_2} \ldots a_{d_{m-1}d_m} y_{d_m}$$

The right half of this term (in blue) is the impact propagation from sector d_m to sector t, which may have different configurations, depending on the choice of $d_1, d_2, \ldots, d_{m-1}$. Thus, the total impact of all such paths is given by:

$$\sum_{d_1,\ldots,d_{m-1}} a_{td_1} a_{d_1d_2} \ldots a_{d_{m-1}d_m} y_{d_m}$$

Further, the left half of the term (in orange) is the higher–order backward propagation from sector t to sector u_1. Similarly, it may also have different combinations of sectors involved. Thus, the total impact for all such paths is derived by summing the term for all choices of $u_2, \ldots, u_l$. Therefore, the total impact delivered along all the paths that run through the production sequence from sector d_m to sector u_1 via sector t is given by:

$$\left(\sum_{u_2,\ldots,u_l} a_{u_1u_2} a_{u_2u_3} \ldots a_{u_{l-1}u_l} a_{u_lt}\right)\left(\sum_{d_1,\ldots,d_{m-1}} a_{td_1} a_{d_1d_2} \ldots a_{d_{m-1}d_m} y_{d_m}\right)$$

This can be expressed in matrix notation as:

$$[\boldsymbol{A}^l]_{u_1t} \, [\boldsymbol{A}^m]_{td_m} y_{d_m}$$

where $[\boldsymbol{A}^h]_{ij}$ refers to the i–j^th element of the h^th power of the matrix **A**, indicating the total amount of impacts from sector j to i across all paths with a length of h. As upstream and downstream paths may take on any length, getting the entire set of impact propagations for all paths that cross sector t must consider every possible combination of these lengths. This is given by:

$$\sum_{l=1}^{\infty} \sum_{m=1}^{\infty} (\boldsymbol{A}^l \boldsymbol{J}_{(t)} \boldsymbol{A}^m \hat{\boldsymbol{y}}) = \boldsymbol{T}\boldsymbol{J}_{(t)}\boldsymbol{T}\hat{\boldsymbol{y}}$$

where $\boldsymbol{T} = \boldsymbol{LA}$, L is the Leontief inverse matrix, $\boldsymbol{J}_{(t)}$ is an n x n matrix containing 1 for the t-t^th element and 0 elsewhere, and $\hat{\boldsymbol{y}}$ is a diagonalized version of the final demand vector. With some slight modifications, the term above can be reconfigured to represent the number of times a particular supply chain passes through and/or engages a target sector in the production of goods and services.

References

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The methodology is applied to the MRIOTs by setting each economy-sector as the target. In a given run, a matrix containing the pass-through indices of each economy-sector towards a selected area of concern is generated. This is then aggregated to an economy-level matrix by (i) adding all pass-through matrices generated for an economy[9], and (ii) reducing the dimension to economy-by-economy. Thus, the resulting

[9] There are 35 matrices for a given economy, corresponding to the number of sectors in the MRIOTs.

matrix now has elements that represent the number of times economies engage with each other in the production of final goods and services. Engagements of an economy with itself are zeroed out for this analysis, since it is outside the scope of interest. Figure 1.11 displays the results of these runs for the same periods as covered in Figure 1.9.

In 2007, the top three economies in terms of pass-through frequencies were Germany, the PRC, and Singapore. Although Singapore held a less prominent role in the provision of FVA to the world, its free trade zones are known to facilitate entrepôt trade as well as transhipment activities, which connect various parts of the world trade-wise. Due to the high volume of goods being re-exported in its ports, little value-added is added to trade despite the high instances of pass-throughs. In fact, Singapore eventually reached the very top of the rankings for pass-through frequencies in 2010. By contrast, the US did not rank as high as it did in terms of backward dependence, which may be due to the fact that the economy outsources some of its production processes to elsewhere in the world. Thus, a significant proportion of the US's value-added contributions to other economies' exports may not even pass through it at all. The top 20 economies accounted for 78.35% of the total pass-throughs worldwide, signalling concentration in the frequency of engagement even before the GFC reached its peak. These shares increased further to 78.94% and 79.46% in 2009 and 2010, respectively.

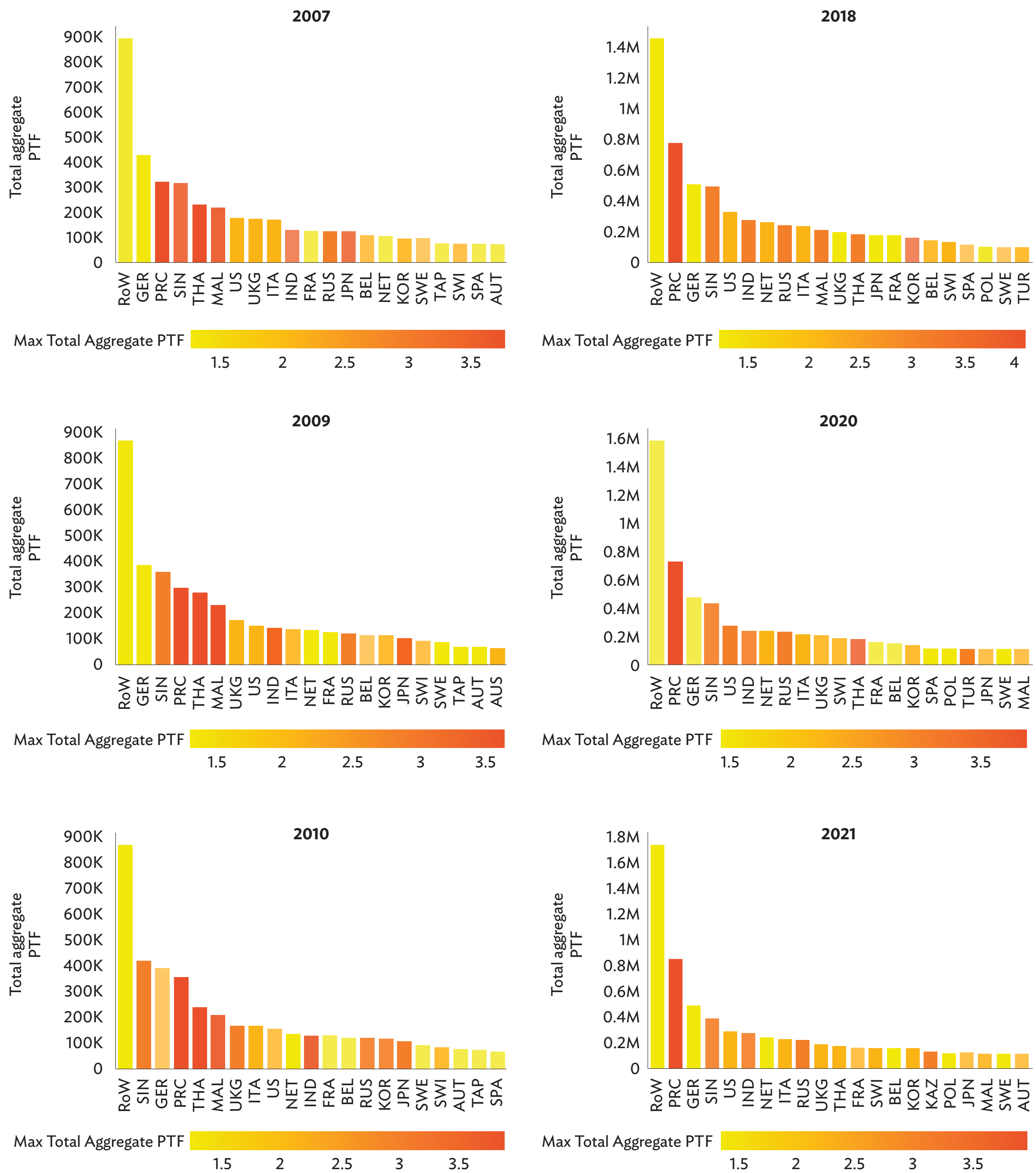
Before the peak of the PRC–US trade tensions, the PRC overtook Singapore and Germany to assume the world's top ranking in terms of pass-through frequency. It maintained this position even during the onset of the COVID-19 pandemic in 2020 and the initial period of recovery in 2021. Although concentration was still evident for 2018–2021, the shares of the top 20 economies were less than during the GFC and even decreased marginally each year. In 2018, 77.07% of total pass-throughs occurred in the top 20 economies. This concentration had decreased by around 3 percentage points by 2020, and it fell by another 0.83 percentage points in 2021. These falls may very well have been due to restrictions in trade and the pressures faced by the logistics sector at the height of the pandemic.

1.6 Adjusting to Shocks

As demonstrated earlier in this chapter, years of notable export decline—which typically occur shortly after the onset of a global economic crisis—are associated with an increase in the share of traditional trade and a decline in GVC trade. Concentration in value-added dependency and frequency of engagements may play an important role in this as they limit the number of viable alternatives in the short run. With a more evenly distributed set of roles in a supply chain, instances of bottlenecks occurring in an economy (or a group of economies) may be mitigated by passing on—at least in the interim—the responsibility of provisioning production inputs to other players in the network. However, when only a few players perform key roles, such as supplying value-

Figure 1.11: Pass-Through Indices, Top 20 Economies and Rest of the World

Global Financial Crisis | **PRC–US Trade Tensions and COVID-19 Pandemic**



$ = United States dollars; AUS = Australia; AUT = Austria; BEL = Belgium; FRA = France; GER = Germany; IND = India; ITA = Italy; JPN = Japan; KAZ = Kazakhstan; k = 1,000; KOR = Republic of Korea; M = million; MAL = Malaysia; NET = Netherlands; POL = Poland; PRC = People's Republic of China; PTF = pass-through frequencies; RoW = All other economies outside the top 20; RUS = Russia; SIN = Singapore; SPA = Spain; SWE = Sweden; SWI = Switzerland; TAP = Taipei,China; THA = Thailand; TUR = Türkiye; UKG = United Kingdom; US = United States.

Notes: The vertical axis corresponds to the number of times economies pass through a particular economy, excluding itself. For a particular economy, the color of the bar represents the maximum number of times another economy passes through it.

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

added to exports, the system becomes prone to short-circuiting[10] that could result in drops in GVC participation during periods of crisis.

The observed decline in GVC trade that took place during the GFC, the PRC–US trade tensions, and the COVID-19 pandemic may also be indicative of ensuing reconfiguration strategies implemented by governments and/or firms to lessen the reliance on cross–border trade of intermediates. Such initiatives or dialogues gather momentum during periods of extensive shocks, as GVCs—with their overly complex networks of production that both transmit and mitigate risk—come under greater scrutiny. It is important to note that, after the three crises mentioned above, recovery in terms of the value of gross exports and the return to usual structures of trade occurred quite quickly relative to the onset of the crises. Reconfiguration strategies could have very well played a large part in this.

Prospects for Global Value Chain Reconfiguration

International production is expected to undergo dramatic transformation in the near future. It will be enabled by technological change, driven by the evolving economics that those technologies will imply, and shaped by the interaction between policy and sustainability trends. These developments are expected to trigger a reconfiguration of the prevailing structure of GVCs. While transformation could take many directions, four likely trajectories arise in the academic literature: replication, diversification, regionalization, and reshoring (UNCTAD 2020). Overall, the direction taken by individual industries will depend on the starting point of their archetypical international production configurations.

Replication is characterized by centrally coordinated "distributed manufacturing", with production steps bundled together and replicated in many locations, thereby implying shorter value chains. Automation makes it possible to reproduce the same production processes in many locations, with minimal labor absorption and marginal costs, while digitalization is enabled by efficient central coordination of the network. Distributed manufacturing is generally associated with the application of additive manufacturing or 3D printing, a technology that combines automation and digitalization.

It should be noted that the replication trajectory is not applicable across all industries. UNCTAD (2020) observed that, among the four trajectories of international production, replication is least likely to lend itself to broad application across industries. In addition to constraints to applications of 3D printing in relation to raw materials, this trajectory

[10] Several circumstances may lead to this. In one of these, assume that there are nodes in the supply network that play a limited role in the provisioning of inputs and that dependence on a few nodes is present. If, for some reason, the minor nodes are unable to perform this task, the responsibility to provide their inputs may have no other alternative except for the nodes for which dependence is concentrated. If this happens, overloading may occur in these dominant nodes, which may negatively affect their efficiency. Furthermore, if the dominant nodes are the ones that lose their ability to supply inputs, then it is unrealistic to pass their responsibilities to those nodes that are used to playing only limited roles, thereby impeding the functioning of the network.

demands very specific business conditions. Overall, replication is expected to result in lower foreign direct investment; lower GVC trade; and increased trade in services, intangibles, data flows, and payments of royalties and licensing fees.

Diversification leverages GVCs (rather than dismantling them) to build resilience. This trajectory represents the main alternative to reshoring. Given that the concentration of production and supply chain dependence are central issues to the discussion on resilience, companies and economies may find diversifying internationally more effective than reshoring. This might imply giving up some economies of scale by involving more locations and suppliers in the value chain.

Resilience to shocks may be gained by diversifying inputs across economies and by making inputs from different economies more substitutable. Diversification substantially reduces global GDP losses in response to shocks in key upstream suppliers. It also reduces GDP volatility following productivity shocks to multiple economies that are interrelated. Thus, it is important to find avenues to expand trade opportunities, which can boost resilience in the world economy in the face of a variety of shocks. To further build resilience in GVCs, economies could diversify their suppliers of intermediate inputs internationally, sourcing them in more equal amounts across economies. Diversification could enhance resilience by reducing reliance on a single economy or by establishing relationships that can be tapped during a crisis (IMF 2021).

To examine the extent of diversification worldwide, Herfindhal-Hirschman Indexes (HHIs) were derived for each economy using this formula:

$$HHI = \sum_{n=1}^{E} \frac{(S_i^r)^2 - 1/N}{1 - 1/N}$$

where S_i^r is the share of value-added exports of economy r, sector i, and N is the total number of sectors in economy r. HHI is a measure of concentration of a given economy, as higher values correspond to an economy relying heavily on a few sectors for value-added exports. On the other hand, lower values of HHI indicate reliance on more sectors for value-added exports. In line with this, economies are considered more diversified if their HHIs are low, vice versa.

Apart from Brunei Darussalam, all economies had low (i.e., less than 0.5) HHIs at the start of the GFC in 2007. By 2009, world averages showed less concentration compared to 2007 before marginally increasing in 2010. This provides evidence that suggests diversification being practiced by economies worldwide prior to, during, and after the GFC. Looking at 2018, almost all economies still exhibited export diversification, with Brunei Darussalam's concerted efforts to achieve diversification appearing to have paid off. Interestingly, world averages show increasing HHI a year into the COVID-19 pandemic while economy-level measures reveal a trend towards lower diversification in 2022.

Figure 1.12: Herfindahl-Hirschman Indexes of Economies, 2007–2010 and 2018–2022

HHI = Herfindahl-Hirschman Index

Notes: HHI is a measure of an economy's export concentration. Thus, higher values of HHI correspond to lower levels of diversification. The HHI indices shown in the figure are computed using value-added exports, which allows contributions of other sectors in exports that may not be captured by traditional measures to be included.

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

Regionalization implies a geographic reconfiguration of GVCs to shorten the value chains present in the macro-regions, thus giving birth to regional value chains or RVCs (Elia et al. 2021). RVCs apply the standard model of fragmented and vertically specialized value chains at the regional or local level. This can be the result of either a retreat from GVCs, with multinational enterprises (MNEs) replicating value chains at the regional level, or the growth of international production on a regional basis, with MNEs structuring their operations nearshore. The shift from global to regional value chains brings the extremes of these chains geographically closer. At the same time, the geographical distribution of value-added would tend to increase (UNCTAD 2020).

In principle, GVC-intensive industries can also replicate their models at the regional level. This is already happening to some extent, e.g., in the automotive industry. The growth of a market for inexpensive consumer products (such as electronics or textiles) in developing economies will also push RVCs in these sectors. Barriers to the development of RVCs in GVC-intensive industries include the persistence of economies of scale and high capital costs of machinery as well as labor-cost differentials and the need for specialized labor or suppliers. Moreover, RVCs are not easy to establish. For a region to attract or develop an entire value chain is more difficult than for an economy to attract investment in a production task or industry segment where it has a competitive advantage. RVCs require regional coordination and conducive business systems and conditions. While the political momentum for a shift to regionalism is growing, implementation is not expected to be immediate.

Reshoring implies the relocation of production activities back to the home economy (Fratocchi et al. 2014). In this trajectory, the most defining elements of modern GVCs—the fragmentation of tasks (unbundling) and geographic dispersion (offshoring)—are challenged. The direction is towards a simplification of the production process and the use of onshore or nearshore operations. Lower fragmentation and geographic dispersion, as well as more capital-intensive operations, will generally favor a return to more direct control by MNEs of their remaining overseas operations (insourcing). This model thus reverts the historical trends of international production; from unbundling to rebundling, offshoring to reshoring, and outsourcing to insourcing.

Advanced robotics-driven automation plays a key role in reshoring. By reducing the relevance of labor cost arbitrage opportunities, it disarms the most powerful driver of task fragmentation and offshoring to low-cost locations. Automation makes reshoring a sustainable option for many MNEs. In the manufacturing sector, this trajectory is primarily relevant for higher-technology, GVC-intensive industries, including the machinery and equipment, electronics, and automotive sectors (UNCTAD 2020). Reshoring is generally expected to result in lower foreign direct investment, reduced divestment and relocation, and lower GVC trade overall. Furthermore, Elia et al. (2021) note that relocation policies need to be supported by, and combined with, industrial policies that enforce the competitiveness of the production system of the home economy or macro-region. Such policies should aim to boost innovations aimed at improving product value and/or reducing production costs.

One way to examine possible evidence of reshoring[11] is by adopting the concept of agglomeration to global trade. The agglomeration indices developed by Baris et al. (2022) estimate a backward agglomeration index that captures the extent to which different sectors in the economy source value-added from domestic sectors for domestic consumption, along with a forward agglomeration index that measures the extent to which domestic sectors absorb value-added (Box 1.3). Examining trends in the backward agglomeration index reveals insights on reshoring activities as high values imply that more economy-sectors source a larger portion of intermediate inputs domestically.

In 2008, only one instance of a shift to a “reshoring economy” classification was observed (Italy—from a low agglomeration category). In fact, only two economies out of the 60 with data were classified under this category. Also during this year, Brunei Darussalam became a “low agglomeration” economy after being a “reshoring” economy in 2007. By 2009, only Kazakhstan remained in the latter category before being joined by the Russian Federation a year after. Interestingly, these economies are all known for their reliance on the natural resources and mining super-sector (i.e., mining, quarrying, oil and gas extraction) for their exports.

In 2018, only four out of seventy-two economies were part of the “reshoring” category. No instances of shifting categories occurred between 2018 and 2019. By 2020, Ecuador and Türkiye also became “reshoring” economies, joining Australia, Kazakhstan, Russian Federation, and Saudi Arabia. However, both economies no longer belonged in this category in the years that followed. Overall, there is little evidence of reshoring as most economies fell under “low agglomeration” (175 out of 248 possible instances from 2007–2010, 263 out of 360 possible instances from 2018–2022) and “high agglomeration” (47 out of 248 possible instances from 2007–2010, 65 out of 360 possible instances from 2018–2022) in the years studied.

Conducting an assessment of consecutive years from 2019 to 2021, the overlapping period when the combined impacts of PRC–US trade tensions and the COVID-19 pandemic were being felt worldwide, backward and forward agglomeration indices took a downward trend in many economies, providing little evidence of reshoring activities over these 3 years (Figure 1.14).

The decline in both agglomeration indices from 2020 to 2021 is consistent with the increase in GVC participation over the same period, as an overall decrease in the influx of activities to domestic economies generally implies that economies tend to rely more on global production processes. Furthermore, Baris et al. (2022) found that a negative correlation exists between backward and forward agglomeration and GVC participation.[12]

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[11] Conventional approaches include the use of the Kearney Reshoring Index, which is derived by calculating the year-on-year change in the manufacturing import ratio of the US.

[12] However, Baris et al. (2022) noted that a positive correlation exists between trade-based GVC participation and agglomeration for economies with high backward or forward agglomeration. This suggests that the relationship between agglomeration and GVCs is more complex than initially thought.

Box 1.3: Calculating the Value-Added Agglomeration Index

Agglomeration indices look at how much value-added is sourced from and/or absorbed in domestic economy-sectors, given the production of final goods in other sectors (Baris et al. 2022). Because the approach is based on value-added, it differs from more common approaches based on firm location. To construct, let $\mathbf{v}$ be the vector of value-added coefficients and $\mathbf{y}^d$ be the vector of domestic final goods sales. Moreover, let $\mathbf{A}^d$ be the matrix of domestic technical coefficients and $\mathbf{B}^d \equiv (\mathbf{I} - \mathbf{A}^d)^{-1}$. Then

$$V^D = \hat{\mathbf{v}}\mathbf{B}^d\mathbf{y}^d$$

captures the value-added generated in each economy-sector that ends up as final goods absorbed domestically, while

$$Y^D = \mathbf{v}\mathbf{B}^d\hat{\mathbf{y}}^d$$

measures the final goods of each economy-sector that are absorbed domestically and whose value-added also originated domestically. A hat on top of a vector, as in $\hat{\mathbf{x}}$, denotes its diagonalized version. Let $\mathbf{va}$ be the vector of value-added generated by each economy-sector and $\Phi_{(j,r,t)} = V^D_{(j,r,t)}/Va_{(j,r,t)}$. The forward agglomeration index for economy-sector (j,r) is given by:

$$AGG^F_{(j,r,t)} = \frac{\Phi_{(j,r,t)}}{\sum_{\tau=t-1}^{t}\sum_{r=1}^{G} 0.5\gamma_{(j,r,\tau)}\Phi_{(j,r,\tau)}}.$$

The numerator is the share of value-added generated in (j,r) to the total value-added generated that ends up as final goods absorbed domestically. The denominator is the 2-year moving average of the same share for all economies in the world, weighted by share of economy r to the total global output of sector j, $\gamma_{(j,r,\tau)} \in (0,1)$. Thus, the AGG^F index compares the value-added that is absorbed in domestic production relative to the world average.

Likewise, let $\mathbf{y}$ be the vector of final goods sales by each economy-sector and let $\Theta_{(j,r,t)} = Y^D_{(j,r,t)}/Y_{(j,r,t)}$. The backward agglomeration index for economy-sector (j,r) is given by:

$$AGG^B_{(j,r,t)} = \frac{\Theta_{(j,r,t)}}{\sum_{\tau=t-1}^{t}\sum_{r=1}^{G} 0.5\gamma_{(j,r,\tau)}\Theta_{(j,r,\tau)}}.$$

The numerator is the share of final goods consumed domestically in (j,r) whose value-added comes from the domestic sectors in the total final demand for (j,r). As with the previous index, the denominator is a 2-year moving average of the same share for all economies. Thus AGG^B measures how much value-added for sector originates from domestic sectors relative to the rest of the world. Being ratios, agglomeration in either perspective is said to be high if the index is greater than 1 and the converse is true if it is less than 1. An economy-sector may be profiled by whether it has high or low forward and backward agglomeration. The four possible types are presented in the "agglomeration map" below.

Reshoring economies $AGG^F < 1, AGG^B > 1$	High agglomeration $AGG^F > 1, AGG^B > 1$
Low agglomeration $AGG^F < 1, AGG^B < 1$	DVA-generating economies $AGG^F > 1, AGG^B < 1$

DVA = domestic value-added

A high backward agglomeration signals that domestic value-added embodied in final goods and services consumed domestically is high. Intuitively, this implies that domestic production for domestic consumption is higher than the world average. Meanwhile, a high forward agglomeration indicates that domestic sectors absorb a significant portion of value-added generated by an economy-sector. This means that value-added that goes to domestic production is higher than the world average. The classification presented in the agglomeration map combines these two effects to determine the form of domestic linkages taking place in an economy sector.

Reference

K. Baris, M. C. Crisostomo, K. Garay, C. Jabagat, M. Mariasingham, and E. Mores. 2022. Measuring Localization in the Age of Economic Globalization. *ADB Economics Working Paper Series.* No. 647. Manila: Asian Development Bank.

Figure 1.13: Agglomeration Classes of Economies, 2007–2010 and 2018–2022

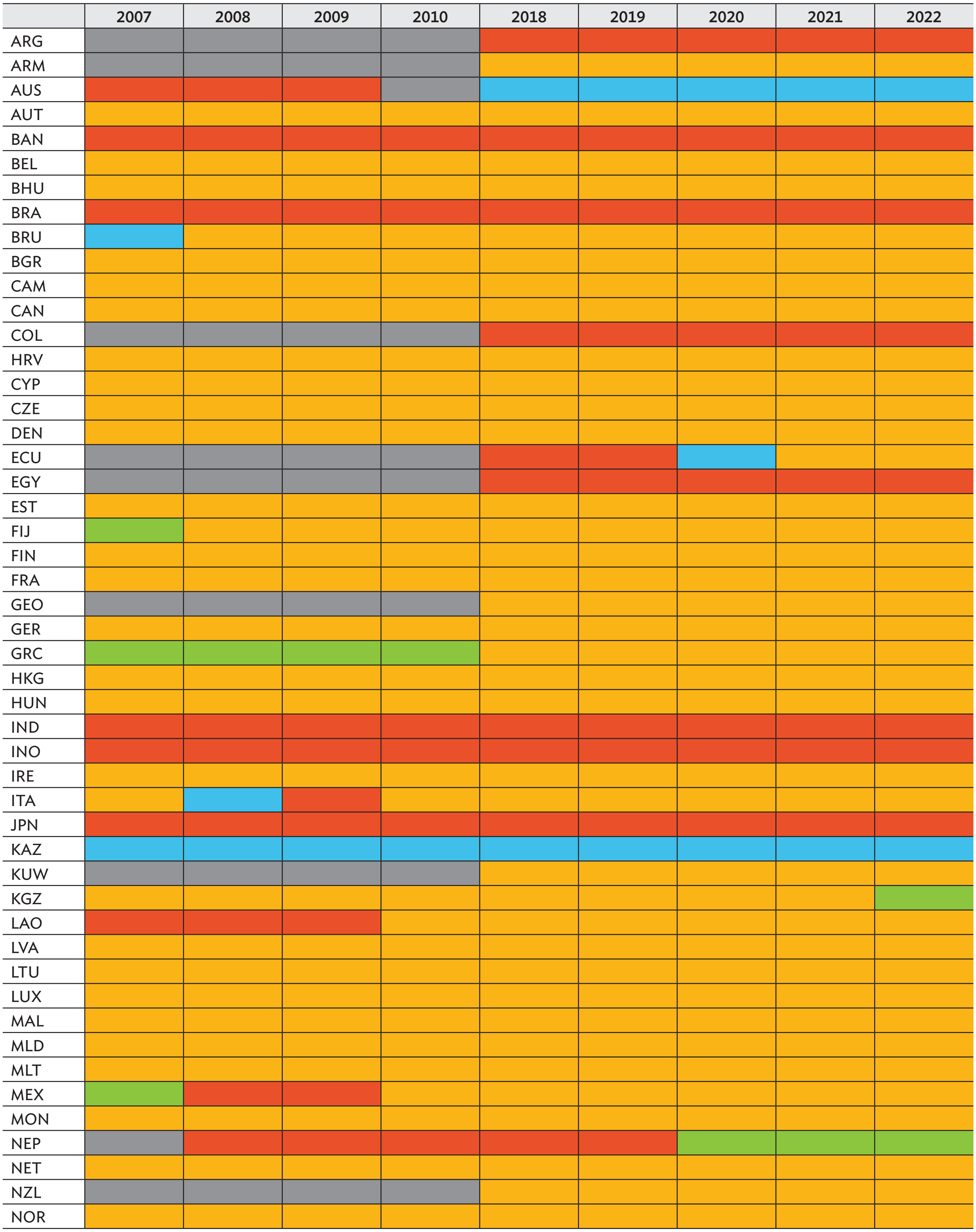

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Figure 1.13: continued

	2007	2008	2009	2010	2018	2019	2020	2021	2022
PAK	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration
PRC	Low agglomeration	No classification / No data	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration
PHI	Low agglomeration	Low agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	DVA generating economy
POL	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
POR	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
KOR	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
ROM	Low agglomeration	DVA generating economy	No classification / No data	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
RUS	Reshoring economy	No classification / No data	No classification / No data	Reshoring economy	Reshoring economy	Reshoring economy	Reshoring economy	Reshoring economy	Reshoring economy
SAU	No classification / No data	No classification / No data	No classification / No data	No classification / No data	Reshoring economy	Reshoring economy	Reshoring economy	Reshoring economy	Reshoring economy
SIN	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
SVK	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
SVN	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
SPA	Low agglomeration	DVA generating economy	No classification / No data	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
SRI	Low agglomeration	DVA generating economy	DVA generating economy	High agglomeration	DVA generating economy	DVA generating economy	High agglomeration	High agglomeration	DVA generating economy
SWE	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
SWI	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
TAP	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
THA	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
TUR	DVA generating economy	High agglomeration	Low agglomeration	High agglomeration	Low agglomeration	Low agglomeration	Reshoring economy	No classification / No data	No classification / No data
UAE	No classification / No data	No classification / No data	No classification / No data	No classification / No data	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
UKG	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration
US	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration	High agglomeration
VIE	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration	Low agglomeration

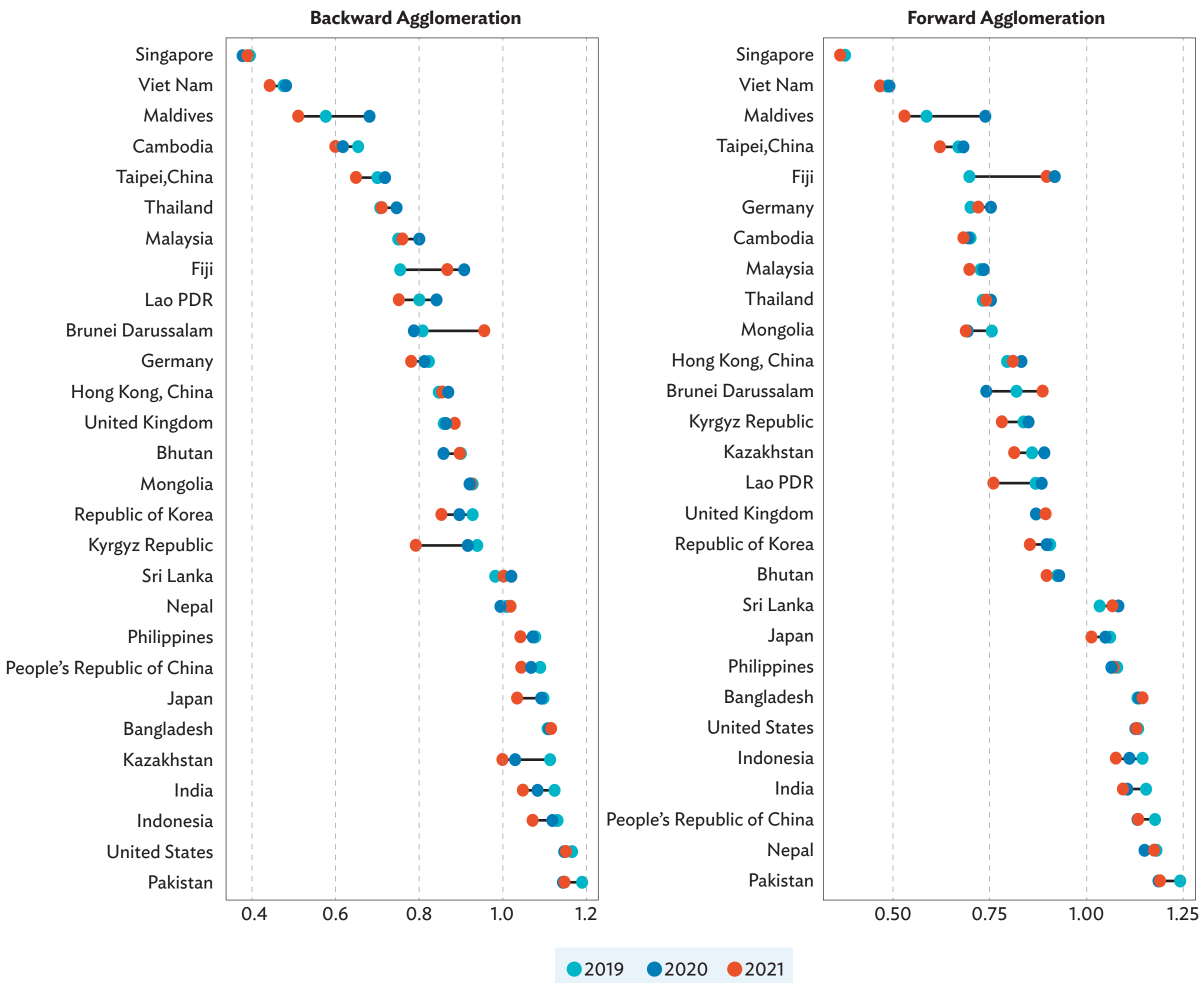
Reshoring economy
DVA generating economy
High agglomeration
No classification / No data
Low agglomeration

Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

The US is an interesting case in terms of agglomeration from 2007 to 2021, with its backward agglomeration index values increasing over this period while forward agglomeration decreased for almost all sectors. This suggests evidence of reshoring for some US sectors. The sectors with the highest backward agglomeration over the 14-year period were metal, paper, leather, water transport, transport, and electrical and optical equipment.

Overall, while the values of backward agglomeration suggest reshoring activities have taken place in several sectors of selected economies since 2007, aggregate trends on backward domestic linkages are inconclusive as to the existence of a wave of reshoring across many economies. Due to the significant costs of relocation, reshoring takes time, planning, and coordination. Furthermore, because of the interconnectedness of value chains, economies that are considered offshoring destinations for higher-income economies can simultaneously offshore to, or reshore from, other less-developed economies (Krenz and Strulik 2020). This makes it difficult to conclude patterns of reshoring behavior at the macro level.

Figure 1.14: Backward and Forward Agglomeration of Selected Economies, 2019, 2020, 2021



Sources: Asian Development Bank Multiregional Input-Output Database; and Asian Development Bank estimates.

It is also difficult to quantify trends toward reshoring without readily available firm-level datasets that capture the relocation intentions of MNEs. Existing micro- and firm-level studies on the restructuring of GVCs reveal two divergent patterns of behavior. The first is that MNEs are restructuring their production processes less than initially expected: the length of GVCs has not been reduced, future investment plans have not changed much, and there is no sign of a wave of reshoring (Di Stefano et al. 2021). Furthermore, while MNEs are considering organizational changes to improve their resilience to global shocks, these changes often do not imply a halt in international production and investment. The second pattern shows that several governments have enacted policies to encourage reshoring, nearshoring, or regionalization of production, whether through fiscal incentives, lower tariffs, relocation subsidies, support for innovation and human capital, or a combination of all these (Elia et al. 2021).

Localization Policies in the People's Republic of China

The fragmentation of production that materialized with the rise of GVCs allowed developing economies to insert themselves into complex production processes that facilitated the transfer of knowledge and technology from MNEs to local firms, helping set the blueprint for industrialization. The PRC took extensive advantage of these developments to become one of the largest economies and major players in international trade, consistently placing atop the rankings for GDP and gross export value worldwide. Recently, however, the outlook for the international economic environment of the PRC has started to become less favorable. The trade tensions between the PRC and the US led to the imposition of strict export controls toward the former, aiming to cut off supply of high-tech components to its high–technology manufacturing firms such as Huawei (Cai and Wang 2022). In addition, movements toward "ally shoring"—wherein Western firms are being convinced to reduce their economic dependence on the PRC by partnering with firms within member economies of a network (e.g., the Economic Prosperity Network)—are now being made.

In response to this, the Government of the PRC unveiled its dual circulation economic strategy, which puts the onus on domestic consumption to be the major vehicle for economic development. Under this strategy, it is envisioned that dependence on foreign economies for key technology and products is eliminated and that domestic firms will augment their capacity for innovation to become frontrunners in advanced technologies (Cai and Wang 2022). It could be argued that this decoupling strategy originated before the beginning of the trade tensions, as the PRC was pursuing its own form of "Made in China" as early as 2012. In any case, the current goal of the government is centered on technological independence from the West, and several measures have already been put in place to realize this goal.

In their 2022 paper, Cai and Wang listed new local content requirement (LCR) policies in the PRC. Such policies refer to measures encouraging the use of local inputs in production as a prerequisite for obtaining financial incentives or gaining market access, thereby creating incentives for firms to select suppliers based on their nationality instead of quality and cost factors. Prior to the PRC's accession to the World Trade Organization, these policies were explicit as trade preferences, while tax incentives were granted based on the usage rates of local inputs. In addition, under the rules and regulations of the Government of the PRC, foreign firms were mandated to follow technology transfer requirements. Though these were gradually lifted by 2002, a host of implicit LCR policies soon emerged, which masked localization strategies and/or objectives under the guise of equal treatment of enterprises regardless of nationality. Due to their covert nature, these LCRs may be difficult to identify (Cai and Wang 2022).

To assess the effectiveness of LCR policies on furthering the localization goals of the Government of the PRC, looking into the domestic content in production may be a sensible first step. Finding evidence that suggests considerable increases DVA, particularly in the economy's own products, may warrant further statistical analysis.

DVA embodied in the PRC's output is estimated by Cai and Wang (2022) in two ways. First, in a standard input-output model (Part A of Box 1.4), the decomposition of each industry's DVA is given by:

$$DVA = GDP = \boldsymbol{A}_v(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\boldsymbol{Y}^f + \boldsymbol{A}_v(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\boldsymbol{Y}^{ef} + \boldsymbol{A}_v(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\boldsymbol{Y}^{ei}$$

In the equation above, the first term refers to value-added that is domestically produced and consumed, the second is DVA embodied in traditional exports, and the third is DVA embodied in GVC-related trade. Detailed trade data from the General Customs Administration of PRC distinguishes between processing exports and ordinary exports. Processing exports differ from ordinary exports as they are mainly produced with imported intermediates. If such a distinction is of analytical importance, an extended input-output model is used (Part B of Box 1.4), which results in an adjusted decomposition of an industry's DVA given by:

$$\begin{aligned} DVA = GDP = {} & \boldsymbol{A}_v^D(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\boldsymbol{Y}^f + \boldsymbol{A}_v^D(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\left(\boldsymbol{Y}^{ef} - \boldsymbol{E}^{Pf}\right) + \boldsymbol{A}_v^D(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\left(\boldsymbol{Y}^{ei} - \boldsymbol{E}^{Pi}\right) \\ & + (\boldsymbol{A}_v^D(\boldsymbol{I} - \boldsymbol{A}^{DD})^{-1}\boldsymbol{A}^{DP} + \boldsymbol{A}_v^P)\boldsymbol{E}^P \end{aligned}$$

The first three terms have the same interpretations as in the standard input-output model, while the additional fourth term refers to direct $(\boldsymbol{A}_v^P\boldsymbol{E}^P)$ and indirect $(\boldsymbol{A}_v^D(\boldsymbol{I} - \boldsymbol{A}^{DD})^{-1}\boldsymbol{A}^{DP}\boldsymbol{E}^P)$ domestic value-added embodied in processing exports.

Using the PRC's 2007, 2012, and 2017 benchmark input-output tables—published by the National Bureau of Statistics and detailed trade data for 2007–2017 from the General Customs Administration— Cai and Wang (2022) estimated that the share of DVA in the PRC's gross exports was 64.6% in 2007, 65.3% in 2012, and 69.9% in 2017 (Table 1.3). This indicates that, even before the start of the PRC–US trade tensions, the domestic content in the PRC's exports was already on an upward trend.

From 2007 to 2017, the shares of DVA in the PRC's processing and normal exports moved in opposite directions. DVA fell from 37.4% to 28.4% of the value of processing exports, while the DVA share in normal exports increased by 2.2 percentage (85.2% to 87.4%) points over the period. Since the overall objective of localization policies introduced by the Government of the PRC is to decrease reliance on foreign economies for production of goods and services, one indication of their effectiveness is increased DVA generation in the economy's exports. This is clearly seen as early as 2012—when the economy implemented its decoupling strategy—in the form of marginal increases in DVA shares in normal and gross exports. However, the new information gathered from data that split processing exports from normal exports at the aggregate level suggest otherwise, at least for the period studied (Cai and Wang 2022). Though these exports are, by definition, mainly produced with imported intermediates, the fact that the shares of DVA have not only been inconsistent but are also decreasing may be worth noting in assessing the success of PRC's localization policies.

Box 1.4: Standard and Extended Input-Output Models

Part A: Standard Input-Output Model

The standard or "noncompetitive" input-output model is given by:

$$\boldsymbol{A}^D\boldsymbol{X} + \boldsymbol{Y}^D = \boldsymbol{X}$$
$$\boldsymbol{A}^M\boldsymbol{X} + \boldsymbol{Y}^M = \boldsymbol{M}$$

where $\boldsymbol{A}^D$ corresponds to the technical coefficients matrix for domestic products while $\boldsymbol{A}^M$ is a matrix of direct input coefficients of imported products. $\boldsymbol{Y}^D$ and $\boldsymbol{Y}^M$ are n x 1 vectors of final demands for domestically produced and imported products, respectively. X is a n x 1 vector of gross outputs while M is a n x 1 vector of imports. Rewriting the first equation gives:

$$\boldsymbol{X} = \left(\boldsymbol{I} - \boldsymbol{A^D}\right)^{-1}\boldsymbol{Y}^D$$

where $\left(\boldsymbol{I} - \boldsymbol{A^D}\right)^{-1}$ is the Leontief inverse giving the total domestic requirements for meeting final demands faced by sectors. Letting $\boldsymbol{A}_v$ be a 1 x n vector of each sector's ratio of total value-added to gross output, i.e., v_i/X_i where v_i pertains to the value-added of sector I, domestic value-added (DVA) or gross domestic product (GDP) by industry can be calculated as:

$$DVA = GDP = \boldsymbol{A}_v(\boldsymbol{I} - \boldsymbol{A}^D)^{-1}\boldsymbol{Y}^D$$

Expressing $\boldsymbol{Y}^D$ as the sum of vectors of domestic final demand, exports of final products, and exports of intermediate products leads to decomposition equation of DVA in a standard input-output model.

Part B: Extended Input-Output Model

These models are used when processing exports are of analytical importance. The extended input-output table accounting for processing exports is represented in the figure below:

			Intermediate use			
			Production for domestic use and normal exports	Production of processing exports	Final use (C+I+G+E)	Gross Output or Imports
		DIM	1,2,..., N	1,2,..., N	1	1
	Production for domestic use and normal exports (D)	1 . . . N	Z^{DD}	Z^{DP}	$Y^D - E^P$	$X - E^P$
Domestic Intermediate Inputs	Processing Exports (P)	1 . . . N	0	0	E^P	E^P
Intermediate Inputs from Imports		1 . . . N	Z^{MD}	Z^{MP}	Y^M	M
Value-added		1	V^D	V^P		
Gross output		1	$X - E^P$	E^P		

Source: K. Cai and Z. Wang. 2022. Local Content Requirement Policies in China and Their Impacts on Domestic Value-Added in Exports. Paper prepared for the *Global Value Chain Development Report 2023* workshop. Geneva. 7–11 November.

Using this information, the input-output model is now given by:

$$\begin{bmatrix} \boldsymbol{I} - \boldsymbol{A}^{DD} & -\boldsymbol{A}^{DP} \\ \boldsymbol{0} & \boldsymbol{I} \end{bmatrix}\begin{bmatrix} \boldsymbol{X} - \boldsymbol{E}^P \\ \boldsymbol{E}^P \end{bmatrix} = \begin{bmatrix} \boldsymbol{Y}^D - \boldsymbol{E}^P \\ \boldsymbol{E}^P \end{bmatrix}$$
$$\boldsymbol{A}^{MD}(\boldsymbol{X} - \boldsymbol{E}^P) + \boldsymbol{A}^{MP}\boldsymbol{E}^P + \boldsymbol{Y}^M = \boldsymbol{M}$$

continued on next page

Box 1.4: continued

The solution of this model is

$$X - E^P = (I - A^{DD})^{-1}(Y^D - E^P) + (I - A^{DD})^{-1}A^{DP}E^P$$

where A^{DD} and A^{DP} are the technical coefficients matrices for domestic products and normal exports as well as for the production of processing exports, respectively. Letting A_v^D and A_v^P be direct value-added coefficient vectors for domestic sales and normal exports as well as processing exports, respectively, DVA or GDP by industry can be calculated as:

$$DVA = GDP = A_v^D(I - A^{DD})^{-1}(Y^D - E^P) + A_v^D(I - A^{DD})^{-1}A^{DP}E^P + A_v^P E^P$$

Once again, expressing Y^D as the sum of vectors of domestic final demand, exports of final products, and exports of intermediate products leads to decomposition equation of DVA in an extended input-output model.

Reference

K. Cai and Z. Wang. 2022. Local Content Requirement Policies in China and Their Impacts on Domestic Value-Added in Exports. Paper prepared for the *Global Value Chain Development Report 2023* workshop. Geneva. 7–11 November.

Table 1.3: Domestic Value-Added in Processing Exports v Normal Exports, People's Republic of China; 2007, 2012, 2017
(%)

	Normal Exports			Processing Exports			Weighted Sum		
	2007	2012	2017	2007	2012	2017	2007	2012	2017
Total Exports									
Total FVA	14.8	14.5	12.7	62.6	69.8	71.7	35.4	34.7	30.2
Direct FVA	4.5	4.5	4.8	57.9	66.3	69.2	27.5	27.0	23.9
Total DVA	85.2	85.5	87.4	37.4	30.2	28.4	64.6	65.3	69.9
Direct DVA	28.5	30.4	30.4	10.9	8.9	9.3	21.0	22.5	24.1
All Merchandise									
Total FVA	16.0	16.8	14.9	62.7	70.0	71.8	39.4	40.8	35.8
Direct FVA	5.0	5.4	5.9	58.0	66.5	69.4	31.6	33.0	29.2
Total DVA	84.0	83.2	85.1	37.3	30.0	28.2	60.6	59.2	64.2
Direct DVA	23.4	22.0	22.3	10.9	8.8	9.2	17.1	16.1	17.5
Manufacturing Goods (food-processing sectors excluded)									
Total FVA	16.4	17.2	15.3	63.0	70.2	72.0	40.3	41.8	36.7
Direct FVA	5.2	5.6	6.1	58.3	66.7	69.6	32.4	33.9	30.0
Total DVA	83.6	82.8	84.7	37.0	29.8	28.0	59.7	58.2	63.3
Direct DVA	22.4	21.3	21.6	10.9	8.9	9.2	16.5	15.6	16.9

DVA = domestic value-added, FVA = foreign value-added.
Sources: Data from the National Bureau of Statistics and General Customs Administration; and estimates in K. Cai and Z. Wang. 2022. Local Content Requirement Policies in China and Their Impacts on Domestic Value-added in Exports. Paper prepared for the *Global Value Chain Development Report 2023* workshop. Geneva. 7–11 November.

Conclusion

This report provides an overview of recent developments in GVCs from the perspective of prevailing trends and patterns in international trade, while also considering emerging methodologies and approaches related to the evolution of value chains. Recent data show some signs of recovery for GVC participation, particularly from 2020 to 2021. However, the presence of ongoing global shocks—including the lingering economic effects of PRC–US trade tensions and the COVID-19 pandemic as well as the impacts of the Russian war in Ukraine—may threaten to derail this positive trajectory.

The tendency to form clusters or production hubs contributes to the negative impacts global shocks have on GVCs. Acknowledging that the first step in addressing risk is to understand and measure it, new methods that identify potential bottlenecks or "choke points" and measure the extent of concentration (e.g., in the supply of value-added and frequency of engagements) in international trade have started to emerge. The hope is that these techniques will help guide researchers and policymakers alike to arrive at sensible recommendations towards participation in GVCs.

The report has also examined the calls for GVC resilience through an analysis of trajectories for GVC reconfiguration. Particular focus is given to reshoring, a phenomenon that is aptly captured by the agglomeration indices of Baris et al. (2022). Looking at the case of the PRC, which recently enforced measures to encourage furthering the domestic content of its products, mixed results are seen across different types of exports, trade destinations, and sectors. Ambiguity surrounding the impact of such policies warrants further statistical analysis to reveal the facilitating factors as well as barriers for realizing the goal of localization.

To complement this analysis, it is suggested that future research looks at MNEs' participation in GVCs through the lens of trade in factor-income (TiFI). Several studies, including Gao et al. (2023), found that dissimilarities exist in the activities of domestically owned versus foreign-owned firms along global supply chains. For example, regional characteristics of current GVCs were discovered to be mostly attributable to domestically owned firms in each economy, and that these enterprises were mostly involved in the three regional centers of North America (centered on the US), Europe (centered on Germany), and East Asia (centered on the PRC). This can serve as the driving force for the regionalization of current supply chains. On the other hand, the value-added creation of foreign-owned MNEs typically exhibited more global characteristics. As updates on databases that distinguish the activities of MNEs from the rest become available at the intercountry level, it will be interesting to see if the findings of previous papers and reports that utilized the TiFI approach still hold true, even after facing wide-ranging shocks. For instance, updates to the Organisation for Economic Co-operation and Development's Analytical Activities of MNEs Inter-Country Input-Output Tables may reflect on the findings around TiFI in the GVC Development Report 2021, Suder et al. (2015), Suder et al. (2022), and other academic texts.

The COVID-19 pandemic remains unresolved due to the unknown potential of new subvariants, and this is coupled with ongoing economic uncertainty stemming from geopolitical tensions between the PRC and the US as well as from the Russian war in Ukraine. It remains to be seen whether these headwinds will trigger a long-term reconfiguration of GVCs. At the very least, governments worldwide must arm themselves with the capacity to understand the existing issues around GVCs. They must use a vast array of approaches and determine which issues are most applicable in certain situations, so they can minimize negative economic and social impacts in the event of future crises.

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