

**Managing Risks in Global Value Chains:
Strengthening Resilience in the APEC Region**

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Abstract

This policy brief aims to replicate a key study conducted by APEC in 2014 where a quantitative evaluation of the Strength of Value Chains was conducted. As an update to this study, the policy brief we are currently finalizing provides updated results on the extent of resilience against 5 key risk areas (Natural disaster risk; Logistics and Infrastructure Risk; Market Risk; Regulatory and Policy Risk; and Political Risk) that are relevant to Value Chain Strength in the APEC region. This study is important as it quantifies the region's performance in terms of Global Value Chains resilience, an issue being exemplified in recent months. The paper makes use of the Principal Component Analysis method to calculate a Value Chain strength index that quantifies the resiliency of the Global Value Chain environment of the APEC region in comparison to other inter-governmental bodies such as ASEAN, G20, OECD and the European Union. Furthermore, considering the recent pandemic, a section of this report has highlighted instances where businesses or governments have shown resilience to this pandemic and the areas within which improvements can be made. More importantly, this study helps shed light on how governments can be more prepared to face unexpected crisis like COVID-19 in the future.

KEY MESSAGES

- While businesses may be able to mitigate against some risks through measures like diversification and hedging, they are likely to struggle when faced with systemic, economy-wide risks to global value chains, particularly those

resulting from unexpected events like the COVID-19 pandemic and natural disasters.

- Resilience, or as conceptualised in this study, the strength of an economy or a regional grouping against systemic risks, must therefore be a priority for businesses and government.
- The quantitative analysis done in this study suggests that the APEC region has performed relatively better compared with most regional/economic groupings in terms of: (1) market risk and (2) regulatory and policy risk.
- Even where the APEC region compares relatively well to the other regional or economic groupings studied, a deeper look shows a wide gap between the highest-performing economy and the lowest.
- COVID-19 was largely an unanticipated systemic event that has been estimated to affect global trade and value chains significantly. APEC economies have developed a strong foundation to deal with the crisis but more needs to be done.
- All in all, this policy brief reinforces the message that, while it is not always possible to anticipate all risks, economies should aim to be more resilient should unexpected shocks occur. The APEC region should thus redouble its commitment to strengthening the institutions, structures and facilities that are key to greater economic resilience in the face of systemic risks.

Introduction

Value chains have become an important aspect of trade and globalisation today. They gained in importance over the last decade as trade barriers fell, incentivising firms to unbundle production to different locations where costs may be lower.¹ Indeed, on average, the global- value-chain participation rate² in the APEC region has reached more than 0.5 as of 2018³. However, considerable risks exist due to the global nature of these production networks. In general, firms encounter two main types of risks in the global network: systemic and non- systemic. One definition of systemic risk is ‘the

¹ Anna Ignatenko, Faezeh Raei, and Borislava Mircheva, “Global Value Chains: What Are the Benefits and Why Do Countries Participate?” (working paper, IMF, 2019), <https://www.imf.org/~/-/media/Files/Publications/WP/2019/wp1918.ashx>.

² This rate is a measure of the extent of an economy’s integration into global value chains.

³ B. Casella, R. Bolwijn, D. Moran and K. Kanemoto. “Improving the Analysis of Global Value Chains: The UNCTAD-Eora Database,” *Transnational Corporations* 26, no. 3 (2019).

risk or probability of breakdowns in an entire system, as opposed to breakdowns in individual parts or components, and is evidenced by co-movements (correlation) among most or all the parts'.⁴ The World Economic Forum has identified a core set of 31 such global risks, including global pandemics, financial crises, and infrastructure disruptions.⁵ Firms often struggle when faced with systemic risks, which are economy-wide risks that cannot be addressed through firm-level risk mitigation strategies used with non-systemic risks such as diversification. Systemic risks are also usually not within firms' control, being often linked to unexpected events at a global scale. A survey by the World Economic Forum reinforces the impact on firms, observing that, of the risks faced by global supply chains, the uncontrollable ones (e.g., natural disasters, extreme weather) were the most significant.⁶

Furthermore, given how integrated and connected many value chains have become, local systemic risks could easily turn into regional or even global ones. A local incident may find multiple transmission channels, which could amplify the initial impact to the global level across multiple stakeholders and across economies. Indeed, Burstein et al. find higher business cycle correlations among economies with strong global value chain linkages.⁷ Given that firms and economies are exposed to systemic risks as they engage in global networks, there is a need to build resilience into their value chains. Resilience here refers to the ability to return to normal operations quickly and it is of particular importance for the APEC region where several key business hubs exist.

The economy-wide and global implications of disruptions in supply chains suggest that governments need to support firms in managing such risks. Recent events such as the trade tensions between certain economies and the COVID-19 pandemic have only underlined the importance of this. The COVID-19 pandemic in particular has been devastating to economies in the APEC region, as the pandemic-related movement restrictions brought some supply chains to a halt, and stalled the manufacturing of

⁴ George G. Kaufman & Kenneth E. Scott, "What Is Systemic Risk, and Do Bank Regulators Retard or Contribute to It?" *The Independent Review* 7, no. 3 (2003): 371–91.

⁵ World Economic Forum (WEF), "Global Risks 2014" (Geneva: WEF, 2014).

⁶ WEF, "New Models for Addressing Supply Chain and Transport Risk" (Geneva: WEF, 2012).

⁷ Ariel Burstein, Christopher Kurz, and Linda Tesar, "Trade, Production Sharing, and the International Transmission of Business Cycles," *Journal of Monetary Economics* 55, no. 4 (2008): 775–95.

several products (e.g., automotive, electronics, medical goods).⁸ It is thus timely to provide an update of the 2014 report presenting a ‘Quantitative Analysis of Value Chain Strength in the APEC Region’. By doing so, this policy brief hopes to provide APEC economies with a better gauge of the region’s performance in comparison with other regional/economic groupings such as the Organisation for Economic Co-operation and Development (OECD), the European Union (EU), the Association of Southeast Asian Nations (ASEAN) and the G20; and through the analysis, identify areas for improvement. Structurally, this policy brief covers: (1) a literature review of the efforts taken to measure resilience in global value chains; (2) an outline of the areas that are important to measuring value chain strength; (3) a quantitative analysis of APEC’s value chain strength in comparison to other groupings; (4) a qualitative analysis of the region’s value chain strength in relation to the COVID-19 pandemic.

Literature Review

There has been a great deal of research on supply chain resilience, with several attempts to define it. Rice and Caniato define supply chain resilience as the ability to ‘respond to unexpected disruption and restore normal supply network operations’.⁹ Similarly, Ponomarov and Holcomb describe it as ‘the adaptive capability of the supply chains to prepare for unexpected events, respond to disruption, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function’.¹⁰ Daysupports a similar definition while also including the need to predict risk and minimise the impact.¹¹

In the same vein, this study defines value chain strength as ‘the inverse of risk: the range of factors that determines an economy’s ability to respond to risks and limit their economic and social impacts’, in particular to recover to pre-crisis level

⁸ Simone McCarthy, “Coronavirus Could Cause Global Medicine Shortages as China’s Factory Closures Hit Supply Chains,” *South China Morning Post*, 4 March 2020, <https://www.scmp.com/news/china/society/article/3064989/coronavirus-could-cause-global-medicine-shortages-chinas-factory>.

⁹ James B. Rice and Federico Caniato, “Building a Secure and Resilient Supply Network,” *Supply Chain Management Review* 7, no. 5 (2003): 22–30.

¹⁰ Serhiy Y. Ponomarov and Mary C. Holcomb, “Understanding the Concept of Supply Chain Resilience,” *The International Journal of Logistics Management* 20, no. 1 (2009): 124–43. <https://doi.org/10.1108/09574090910954873>.

¹¹ Jamison M. Day, “Fostering Emergent Resilience: The Complex Adaptive Supply Network of Disaster Relief,” *International Journal of Production Research* 52, no. 7 (2014): 1970–88.

operations.¹² Some studies have focused on a survey approach towards identifying areas of supply chain resilience. For instance, the World Economic Forum, through a survey of executives, identified five top measures of resilience: (1) improved information sharing between governments and businesses; (2) harmonised legislative and regulatory standards; (3) building a culture of risk management across suppliers; (4) common risk assessment frameworks; (5) improved alert/warning systems.¹³ Another approach used is the identification of key performance indicators (KPIs) at the firm level. This approach relies on introducing measures that are quantifiable and can be used by firms to monitor processes over time and evaluate them. An example is Resilinc's R ScoreTM, which measures supply chain resiliency factors such as transparency, network resiliency, continuity, robustness, performance, and supply chain resiliency programme maturity.¹⁴ Others have used a simpler methodology, examining possible indicators that could be used to measure supply chain resilience. For instance, Singh, Soni and Badhotiya used a literature review to identify 17 indicators that could be used to measure resilience, including agility, flexibility, robustness, redundancy, visibility, IT capability, collaboration, sustainability, awareness, supply chain risk management culture, and velocity.¹⁵ The study described in this policy brief aims to add to the work in this area by focusing on five areas of resilience that are applicable to systemic risks, as presented in Box 1 and elaborated further in the next section.

Developing an Index of Value Chain Strength

Measuring the resiliency of global supply chains, particularly those related to systemic risks, is difficult. Much of the challenge lies in assigning appropriate quantitative

¹² APEC Policy Support Unit (PSU), "Quantitative Analysis of Value Chain Strength in the APEC Region" (Singapore: APEC, 2014), <http://publications.apec.org/-/media/APEC/Publications/2014/10/Quantitative-Analysis-of-Value-Chain-Strength-in-the-APEC-Region/VC-Strength-Draft-Report-v6.pdf>.

¹³ WEF, "Building Resilience in Supply Chains" (Geneva: WEF, 2013), http://www3.weforum.org/docs/WEF_RRN_MO_BuildingResilienceSupplyChains_Report_2013.pdf.

¹⁴ Resilinc, "A New Metric for Measuring Supply Chain Resiliency: An Introduction to Resilinc R ScoreTM and Its Application to the High-Tech Industry Supply Chain" (Resilinc and Global Supply Chain Resiliency Council, 2017), https://info.resilinc.com/hubfs/R%20Score%20Whitepaper%20March%202017_Latest%20.pdf.

¹⁵ Chandra S. Singh, Gunjan Soni and Gaurav K. Badhotiya, "Performance Indicators for Supply Chain Resilience: Review and Conceptual Framework," *Journal of Industrial Engineering International* 15 (2019): 105–17 <https://doi.org/10.1007/s40092-019-00322-2>.

indicators that could accurately reflect different dimensions of resiliency, or as referred to in this study, ‘valuechain strength’. While several other areas may also contribute toward measuring value chain resilience, this study identifies five areas as the best proxies for quantifiable and significant aspects of supply chain resilience in the face of systemic risks, this is as summarised in Box 1. These five areas contribute toward constructing an index that evaluates the resilience of economies. The quantitative evaluation will be complemented with a qualitative analysis that will identify examples of resilience within the context of the current COVID-19 pandemic (see page 8).

Box 1. Components of supply chain strength or resilience

- ***Strength against logistics and infrastructure risk:*** Measures that limit the economic and social disruptions that can occur to supply chain processes when the markets or actors that connect supply chain operators to each other do not perform as expected.
- ***Strength against market risk:*** Measures that limit the *economic* and social effects of economic fluctuations that disrupt prices, output or other economic fundamentals.
- ***Strength against natural disaster risk:*** Measures that limit the economic and social consequence of the occurrence of a natural disaster.
- ***Strength against political risk:*** Measures that limit the economic and social effects of the possibility that economic activity may be impeded by the occurrence of political or violent conflicts inside or outside the economy.
- ***Strength against regulatory and policy risk:*** Measures that limit the economic and social effects of unexpected changes in regulatory stance, or inconsistency in enforcement, which would otherwise increase business uncertainty, and thus the transaction costs associated with value chain processes.

Methodology

This study identifies key indicators for the respective strength areas, and uses principal component analysis (PCA) to construct an overall composite index for evaluating the strength of global value chains in the APEC region. PCA is a popular

method used within economics to help summarise information across a large number of variables. This method recognises that some variables are likely to be more correlated with each other than with others, and is a method to capture that variation to create a more representative index. Also, with PCA, the more important a variable, the greater its proportion in the composite index. Given that the analysis in this brief consists of 21 variables, it is important to identify the most relevant individuals as not all of which will contribute equally to the overall index. In this regard, PCA helps identify for inclusion the variables that are most important to the overall composite index and best represent resilience.

In addition to quantifying APEC's resilience against risks affecting global value chains, this study also makes a comparison against four other regional/economic groupings, namely, the OECD, EU, ASEAN and G20. These groupings were selected because they represent a diverse set of economies. ASEAN for example consists mainly of developing economies while the OECD and G20 consist predominantly of developed ones. A more detailed account of the methodology is provided in the technical notes accompanying this brief (see Annex A).

Data

An overview of the indicators used and the data can be found in Table A2 (Annex A) along with the relevant summary statistics. The mean of most indicators within the evaluation generally clusters around 0.5. For certain indicators (e.g., access to electricity, percentage of individuals using the internet), a large proportion of economies were close to the maximum possible value. In terms of standard deviation,¹⁶ the largest value of 0.291 is noted within the indicator measuring the rule of law followed by the indicator measuring the depth, access and efficiency of financial markets (0.286). This shows that significant gaps exist between economies. When disaggregated into regions, the OECD registered the highest mean across most variables (see Table A3 in Annex A, highlighted in green). The APEC region continues to trail behind the other regions for most indicators with the exception of the

¹⁶ Standard deviation refers to the extent that economies differ from the mean of the variable. The higher the value, the more dispersed economies are.

indicators measuring market capitalisation of listed companies as a percentage of GDP; depth, access and efficiency of financial markets; and efficiency of settling disputes.

Output of the principal component analysis

Upon carrying out PCA on the identified indicators, components were included based on three conditions: (1) the eigenvalue of the component has to be greater than 1; (2) the component should add to the overall explained variance; (3) the number of components to include was determined through a scree plot (see Annex C).¹⁷

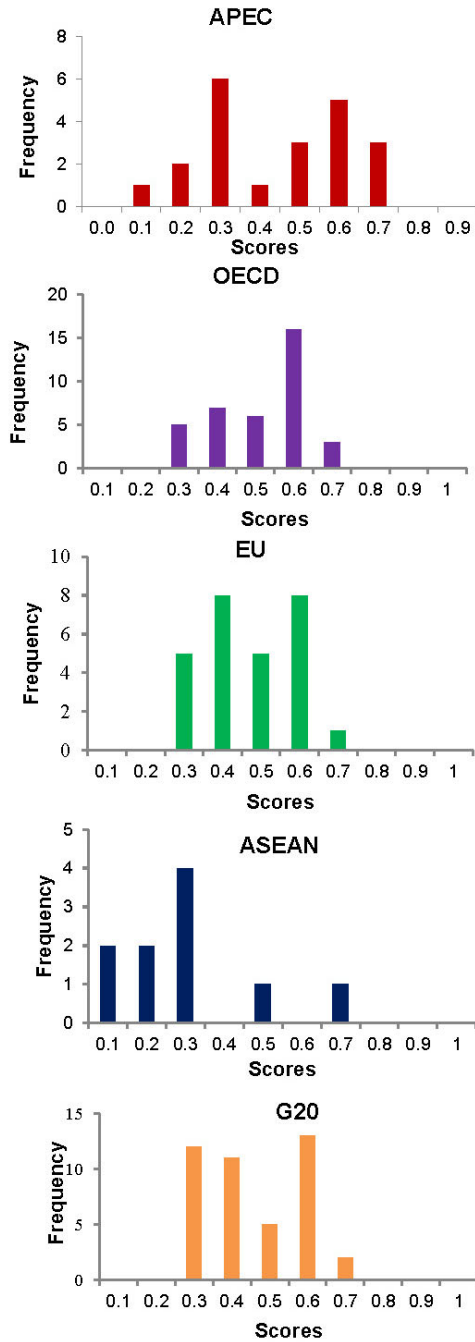
Table 1. Weights for each area of strength

Strength against:	Weight in the overall index (%)
Logistics and Infrastructure Risk	25.3
Market Risk	13.8
Natural Disaster Risk	19.2
Political Risk	15.6
Regulatory and Policy Risk	26.1

Development Bank (ADB) in creating their Asia-Pacific Regional Integration Index. To be specific, the following steps were undertaken: (1) loadings of each component were squared; (2) squared loadings of each component were then proportioned based on the proportion of variation to calculate weights; (3) calculated weights were multiplied to each observation and summed to create the overall index

¹⁷ Components with eigenvalue greater than 1 and before the curve levels reaches the inflexion point are included.

Figure 1. Frequency charts of regional grouping score



Note: Scores have been normalised in this index where 0 is the lowest possible score and 1 is the highest.

The components and their relevant loadings can be found in Annex B. Following the criteria outlined above, this analysis takes into consideration five components (areas of strength against risk) of the PCA outputs to create an overall composite index measuring the strength of value chains within each of the regional groupings.¹⁸ The weight for each area of strength, derived through PCA, is as noted in Table 1. Among the strength areas analysed, resilience against regulatory and policy risk (26.1%) is determined to have the largest weight in the overall index followed by resilience against logistics and infrastructure risk (25.3%) and natural disaster risk(19.2%).

Results Overall index

Comparing overall scores across the different regions, the OECD has the largest proportion of its members (67.6%) with scores greater than 0.5, followed by APEC (52.3%) and the EU (51.8%). While APEC may have the second highest proportion of members with scores about 0.5, it is important to note that approximately 42.9 percent of the region continues to score equivalent or below 0.3. This indicates significant disparity within the region with almost half of the economies registering a rather weak performance in terms of value chain strength (Figure 1). Within the APEC region, performance has been varied with overall scores extending from lows of 0.15 to highs of 0.77. Hong Kong, China was the best performer. Although, it registered scores greater than 0.5¹⁹ across all five pillars of strength, it performed the best in terms of strength against regulatory and policy risk, and against market risk. This is unsurprising considering its well-developed financial markets and its legal systems that provide more legal certainty for firms.

Although scoring well within pillars that have larger weights in the overall index helps economies register a higher score, it is important to note that economies who performed well on the whole also did well across all areas of strength, not just ones

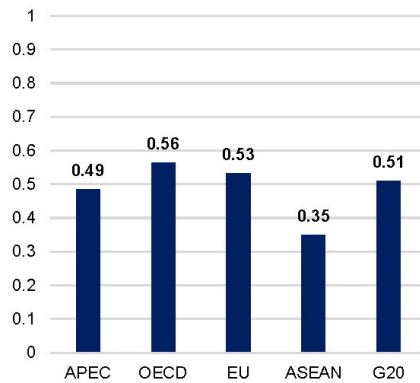
¹⁸ The calculation of the overall index based on these five components follows the same methodology used by the Asian Development Bank (ADB) in creating their Asia-Pacific Regional Integration Index. To be specific, the following steps were undertaken: (1) loadings of each component were squared; (2) squared loadings of each component were then proportioned based on the proportion of variation to calculate weights; (3) calculated weights were multiplied to each observation and summed to create the overall index.

¹⁹ After normalisation based on weights contributed to the overall index

that have a higher weightage in the overall index. For instance, Singapore, while boasting the second highest score in the region, not only performed well in terms of regulatory policy risk but had scores greater than 0.6²⁰ for four out of the five indicators. In terms of the overall index, the APEC region (0.49) performed moderately well, slightly behind the EU (0.53) and the G20 (0.51) as depicted in instance, although the OECD ranks the best across the groupings analysed, it's score of 0.56 is only slightly more than half of the maximum possible score (Figure 2).

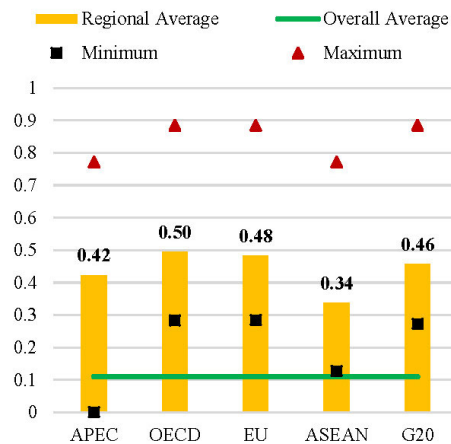
Figure 2. The value of the index ranges from 0 (lowest performance) to 1 (highest performance). As such, all of the groupings analysed continue to have much room for improvement. For

Figure 2. Overall value chain strength index



Note: Scores have been normalised this index where 0 is the lowest score and 1 is the highest

Figure 3. Logistics and infrastructure strength index



Note: Scores have been normalised this index where 0 is the lowest score and 1 is the highest

²⁰ APEC, “E highest score within the APEC region but also did so across all economies analysed.

Strength against logistics and infrastructure risk

Further analysis can be conducted by disaggregating the overall score into logistics and infrastructure related strength. Performing well in this indicator signifies that the economy is relatively resilient against physical disruptions to infrastructure that support the operation of supply chains. Within the APEC region, scores extend from values close to 0 to highs of 0.77. The best performers under this pillar were: Singapore (0.77); Hong Kong, China (0.64); and New Zealand (0.58). Possible reasons include their relative openness to trade as well as the extensive investment in transportation infrastructure and in improving customs processes and logistics. With respect to other regional/economic groupings, the APEC region (0.42) ranks fourth among the five regions analysed (Figure 3). Although it could be argued that the G20 generally consists of developed economies while APEC consists of a mix of developed and developing economies, more efforts are still required by the APEC region to ensure concerted development in the area of logistics and infrastructure. Furthermore, the APEC region only registers slightly more than one-third of the maximum possible score attainable, which signifies vast room for improvement.

All indicators under this strength area generally contribute equally to the overall logistics and infrastructure index (see Annex B for the individual weights for each indicator). This suggests that it is important for economies to be well rounded in this regard. In fact, the APEC region's best performers in this index performed relatively well in all the indicators evaluated. Singapore, which topped this strength area, has similar scores across all the sub-indicators within this pillar, with its best performance found to be within the 'Logistics performance index: Competence and quality of logistics services' indicator.

Strength against natural disaster risk

This indicator is particularly relevant considering the high risk of natural disasters within the APEC region, with several economies nested along the Pacific Ring of Fire, which has been known to experience large-scale natural disasters such as tsunamis,

earthquakes and volcanic eruptions, or in areas prone to storms and typhoons.²¹ Examples include the Great Tohoku Earthquake and the floods in Thailand in 2011. This pillar is not only relevant for natural disasters but also to health-related calamities. Within this index, the indicators contributing the largest share of this index is ‘physicians (per 1,000 people)’, ‘current health expenditure’ and ‘fixed telephone subscription’. In the context of the COVID-19 pandemic, these indicators are seen to be particularly important and are aspects that contribute greatly toward the resilience of an economy.

There is wide disparity within the APEC region where scores ranging from lows of 0.05 to highs of 0.72 (Figure 4). The lower bound is particularly concerning as the economy registered the lowest score across all economies analysed within this report. Additionally, given that the economy is often plagued by natural disasters, the lack of resilience in this area necessitates a concerted and cooperative effort by the region to narrow the gap. When compared to other groupings, APEC ranks fourth with a score of 0.42 and shows significant gaps with other regional groupings, except for ASEAN (0.25). Considering that the highest scores in the APEC region are similar to those registered in these other groupings, its relatively poor performance in comparison to the other groupings is likely due to the wide disparities within the APEC region.

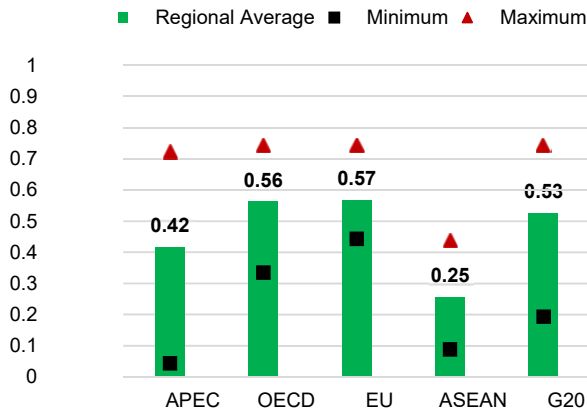
Strength against market risk

Strength against market risk is important as firms often depend on market mechanisms to deal with potential disruptions. This is particularly so with regard to financial markets, a focus of this strength area. Tools available through open and accessible markets include debt and equity instruments that firms can use to off-load certain risks. As such, ensuring that markets remain resilient during periods of crisis is very important for efficient value chain operations. In this pillar, the APEC region as a whole registered a score of 0.47. Much like the previous two strength pillars, the

²¹ Emergency Preparedness.” Last updated January 2020. <https://www.apec.org/Groups/SOM-Steering-Committee-on-Economic-and-Technical-Cooperation/Working-Groups/Emergency-Preparedness#:~:text=Most%20APEC%20economies%20are%20situated,5%20cyclones%2C%20or%20super%20typhoons.>

variation within the APEC region is wide where scores ranged from 0.14 to 0.82. One of the strongest performers under this strength area is Hong Kong, China, who not only registered the highest score within the APEC region but also did so across all economies analysed. Having said that, there continues to be a few economies that have registered weakness in this area. Although disparities in the region are expected considering the varying levels of development among member economies, there is a need for more targeted efforts to be taken toward narrowing this gap. It is encouraging to note the APEC region has shown a significantly strong performance here, ranking a close second among the groupings.

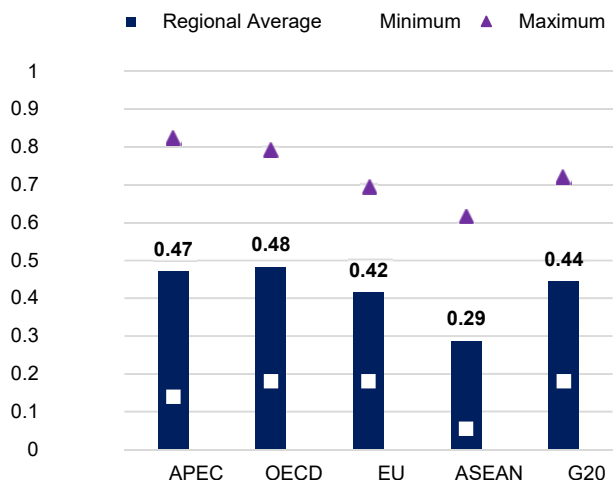
Figure 4. Natural disaster strength index



Note: Scores have been normalised in this index where 0 is the lowest possible score and 1 is the highest.

Having said that, there continues to be a few economies that have registered weakness in this area. Although disparities in the region are expected considering the varying levels of development among member economies, there is a need for more targeted efforts to be taken toward narrowing this gap.

Figure 5. Market risk strength index



It is encouraging to note the APEC region has shown a significantly strong performance here, ranking a close second among the groupings. The components and their relevant loadings can be found in Annex B. Following the criteria outlined above, this analysis takes into consideration five components (areas of strength against risk) of the PCA outputs to create an overall composite index measuring the strength of value chains within each of the regional groupings.²² analysed, with only a 0.01 gap with the OECD (Figure 5). While the average is likely skewed by some outperformers in the region, the performance is also underpinned by most economies in the APEC region having developed strong economic fundamentals. Not only does APEC have well-developed financial institutions and markets, it also has a strong presence of domestic firms.

Strength against regulatory and policy risk

Given that regulatory and policy issues are often beyond the control of firms and investors, resilience in this area is highly valued by value chains. In fact, it contributes

²² The calculation of the overall index based on these five components follows the same methodology used by the Asian Development Bank (ADB) in creating their Asia-Pacific Regional Integration Index. To be specific, the following steps were undertaken: (1) loadings of each component were squared; (2) squared loadings of each component were then proportioned based on the proportion of variation to calculate weights; (3) calculated weights were multiplied to each observation and summed to create the overall index

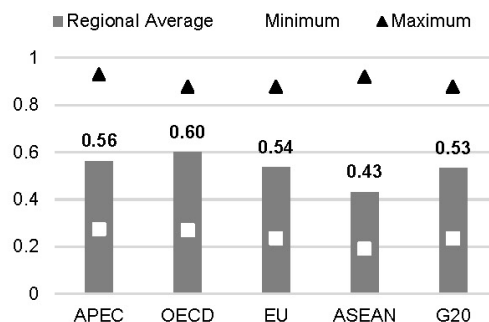
the largest weight toward the overall index. Under this pillar, the APEC region boasts an average score of 0.56. Economies performing well in this strength area include Hong Kong, China (0.93); Singapore (0.92); and New Zealand (0.85). Although some economies have performed well in this strength area, a few economies have registered very weak resilience to regulatory and policy risks with scores as low as 0.27.

The APEC average is noted to be close to the OECD who is a top-performer in this regard. Additionally, the difference between the two groupings is small, with the OECD scoring 0.60, a score 0.04 higher. The strong performance of some economies is likely to be driven by the consistency and predictability of regulations that have lowered business uncertainties as well as assuring firms and investors of access to efficient legal framework should disputes arise.

Strength against political risk

Although the pillar contributes only 15.6 percent to the overall index, the resilience of economies against political risk is an important aspect to consider as it captures the overall stability of an economy. If an economy is not resilient against political risk, this will impede businesses' long-run operations, and affect the overall business climate, and may even impose additional costs for businesses.

Within this indicator, Singapore performed best in the APEC region, boasting a score of 0.96. It performed relatively well on all three sub-indicators but its strong overall performance was primarily driven by the indicator measuring the rule of law within the economy. This pillar is one of the APEC regions strongest pillars where it has registered a score of 0.56 (Figure 7). Nevertheless, the APEC region continues to lag behind the OECD (0.69), EU (0.68) and G20.

Figure 6. Regulatory and policy strength index

Possible Impact of COVID-19 on Value Chains

This discussion on value chain resilience comes at an appropriate time given that supply chains in the APEC region have been negatively affected by COVID-19.

Description of the COVID-19 pandemic

Although COVID-19 may have started as a health crisis, it has since also become an economic one considering the lockdowns that economies have had to put in place. The closure of international and domestic borders has affected economies that are particularly dependent on tourism and has also led to a temporary standstill in manufacturing. Recovering from the pandemic not only requires economies to rebound economically but also to contain the spread of the virus through measures such as safe distancing or finding a vaccine. Given that the health aspect continues to be unresolved, the economic impact is likely to further intensify. Off the backs of the growing trade tension and weakening global demand as a result of the structural changes noted within China's growth model,²³ COVID-19 has led to large-scale unemployment and has further dampened consumer demand for goods and services as a whole. According to current estimates by the International Monetary Fund (IMF), COVID-19 will likely reduce real GDP year-on-year growth rates by 3 percent compared to the reduction of 0.1 percent recorded during the 2008–2009 global

²³ Allan Dizioli, Jaime Guadarjo, Vladimir Kiyuev, Rui Mano, and Mehdi Raissi, "Spillovers from China's Growth Slowdown and Rebalancing to the ASEAN-5 Economies," IMF eLibrary, August 2016, https://www.elibrary.imf.org/view/IMF001/23627-9781475524260/23627-9781475524260/23627-9781475524260_A001.xml?lang=en&redirect=true.

financial crisis (GFC).²⁴ Meanwhile, the Asian Development Bank (ADB) estimates that the global economic impact will reach USD 5.8 to 8.8 trillion, or 6.4–9.7 percent of global GDP, without taking into account policy impact.²⁵

It also predicts that job losses could amount to 158 to 242 million jobs with forgone labour income of USD 1.8 trillion should economies not enact appropriate policies. Further to this, global foreign direct investment (FDI) flows are forecast to fall by up to 40 per cent in 2020 (USD 1.54 trillion in 2019).²⁶ Meanwhile, the Asian Development Bank (ADB) estimates that the global economic impact will reach USD 5.8 to 8.8 trillion, or 6.4–9.7 percent of global GDP, without taking into account policy impact.²⁷ It also predicts that job losses could amount to 158 to 242 million jobs with forgone labour income of USD 1.8 trillion should economies not enact appropriate policies. Further to this, global foreign direct investment (FDI) flows are forecast to fall by up to 40 per cent in 2020 (USD 1.54 trillion in 2019).²⁸

COVID-19 is an unexpected exogenous event that has caused a simultaneous supply and demand shock as a result of the lockdowns halting production lines in several major manufacturing hubs, increasing uncertainty and unemployment. This has had a negative impact on the demand for goods and services. Its impact on supply chains has triggered a ripple effect and has affected several sectors such as automotive, textiles and electronics. For instance, Fiat Chrysler Automobiles had to temporarily stop car

²⁴ Gita Gopinath, “The Great Lockdown: Worst Economic Downturn since the Great Depression,” IMF Blog, 14 April 2020, <https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/>.

²⁵ ADB, “An Updated Assessment of the Economic Impact of COVID-19” (ADB Briefs no. 133, Manila: ADB, 2020), <https://www.adb.org/sites/default/files/publication/604206/adb-brief-133-updated-economic-impact-covid-19.pdf>.

²⁶ United Nations Conference on Trade and Development (UNCTAD), “World Investment Report 2020: International Production Beyond the Pandemic.” (New York: UN, 2020), https://unctad.org/en/PublicationsLibrary/wir2020_en.pdf.

²⁷ ADB, “An Updated Assessment of the Economic Impact of COVID-19” (ADB Briefs no. 133, Manila: ADB, 2020), <https://www.adb.org/sites/default/files/publication/604206/adb-brief-133-updated-economic-impact-covid-19.pdf>.

²⁸ United Nations Conference on Trade and Development (UNCTAD), “World Investment Report 2020: International Production Beyond the Pandemic.” (New York: UN, 2020), https://unctad.org/en/PublicationsLibrary/wir2020_en.pdf.

production in Serbia as it was unable to procure parts from China; and Hyundai had to stop production lines in Korea.²⁹

Additionally, the scope of impact of COVID-19 has been much wider than with other crises, with almost all economies in the world affected. As an example, the GFC's impact was largely restricted to just a few markets, particularly those overly exposed to the financial markets of the United States. Although the GFC did eventually lead to a global downturn affecting many economies, some large economies were able to remain resilient through the crisis altogether given their limited exposure. For instance, in terms of trade, economies in the APEC region registered differing impacts, with Japan falling 26 percent in 2009 while Viet Nam only fell by 9 percent.³⁰ Similarly, an IMF study notes that while emerging and developing economies remained relatively unscathed during the GFC where they boasted positive real GDP growth rates, it is not likely to be the case for the current pandemic.³¹

That shows that a demand shock alone could significantly affect value chain activity. With COVID-19 having an effect on both demand and supply, a similar, if not more extensive, scenario is likely, even though global-value-chain participation rates have fallen since 2008. This scenario becomes even more plausible when the observations and indications during the onset of the COVID-19 pandemic are taken into consideration. The lockdowns in response to COVID-19 affected manufacturing activity and logistical services. It also required workers to stay home, and there was overcapacity on shipping containers, and a peak in blank sailings. These affected freight flow and timely container collection, delaying shipments and leading to low cargo rates.³² None of this had occurred during the GFC. Such observations suggest

²⁹ Rebecca Liao and Ziyang Fan, "Supply Chains Have Been Upended. Here's How To Make Them More Resilient," World Economic Forum, 6 April 2020, <https://www.weforum.org/agenda/2020/04/supply-chains-resilient-covid-19/>; "Coronavirus Exposes Cracks in Carmakers' Chinese Supply Chains (New York Times)," *Straits Times*, 5 February 2020, <https://www.straitstimes.com/business/companies-markets/coronavirus-exposes-cracks-in-carmakers-chinese-supply-chains>.

³⁰ APEC Policy Support Unit (PSU), "Quantitative Analysis of Value Chain Strength in the APEC Region" (Singapore: APEC, 2014), <http://publications.apec.org/-/media/APEC/Publications/2014/10/Quantitative-Analysis-of-Value-Chain-Strength-in-the-APEC-Region/VC-Strength-Draft-Report-v6.pdf>.

³¹ Gopinath, "The Great Lockdown."

³² Monique Giese, "Troubled Waters for the Shipping Sector," KPMG, 22 June 2020, <https://home.kpmg/xx/en/blogs/home/posts/2020/06/troubled-waters-for-the-shipping-sector.html>; S.L.

that the current crisis has disrupted firms more significantly and deeply compared to the GFC and would likely have a more detrimental impact on value chain activity. This is especially so considering that most economies continue to grapple with COVID-19 spread. Instead, it is likely that the economic impact will be far greater than those experienced during the GFC. Trade impact of the COVID-19 pandemic The COVID-19 pandemic has negatively impacted trade flows significantly. Although year-on-year growth has been on a decline since 2019, the steepest fall was noted in April 2020 where year-on-year change in exports and imports fell by approximately 12.2 percent and 13.5 percent respectively (Figure 8). The IMF has estimated that world trade volume in goods and services could shrink further by 11.9 percent in 2020, rebounding in 2021.³³ The WTO has similarly projected that, in 2020, trade volume is likely to contract by between 12.9 percent (optimistic scenario) and 31.9 percent (pessimistic scenario); in 2021, trade is expected to rebound, expanding by between 21.3 percent and 24 percent.³⁴ For the APEC region, the APEC Policy Support Unit notes the region is projected to contract by 3.7 percent in 2020, or an output loss of around USD 2.9 trillion, due to the negative economic impact of COVID-19. In 2021, APEC is expected to rebound to a growth of 5.7 percent.³⁵

While an evaluation of overall trade numbers does provide an overview of the general impact on value chains, it does not provide much granular information. Much of the challenge of measuring the impact of value chains is a result of the fact that conventional measurements often quantify the gross value of transactions and not the value of each individual transaction in a value chain.³⁶

Fuller, “FMC Detention, Demurrage Guidance Comes as Coronavirus Outbreak Aggravates Preexisting Port Problems,” 29 April 2020, <https://www.supplychaindive.com/news/fmc-detention-demurrage-final-guidance-ocean-shipping/577038/>.

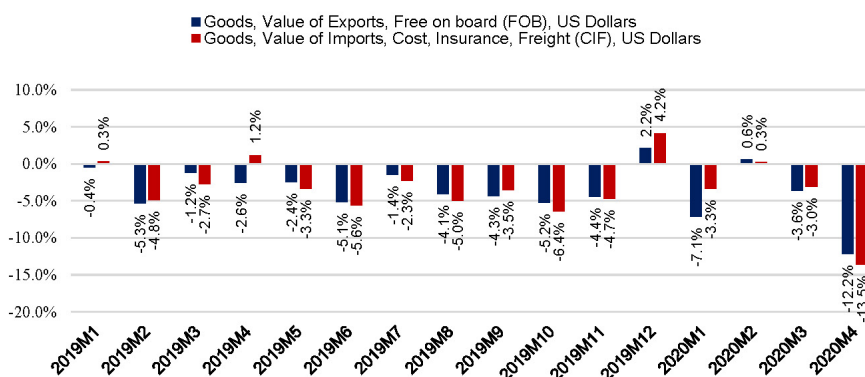
³³ International Monetary Fund (IMF), “A Crisis Like No Other, An Uncertain Recovery,” World Economic Outlook Update, June 2020, <https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020>.

³⁴ International Institute for Sustainable Development (IISD), “IMF Finds Deeper COVID Impacts than Previously Projected, WTO Forecasts Trade Rebound in 2021,” SDG Knowledge Hub, 2 July 2020, <http://sdg.iisd.org/news/imf-finds-deeper-covid-impacts-than-previously-projected-wto-forecasts-trade-rebound-in-2021/>

³⁵ Rhea C. Hernando, “Deeper Contraction Calls for Decisive Action,” APEC Regional Trends Analysis, July 2020 Update (Singapore: APEC, 2020), <https://www.apec.org/Publications/2020/07/APEC-Regional-Trends-Analysis-July-2020-Update>.

³⁶ World Bank, “Global Value Chain Development Report 2017: Measuring and Analyzing the Impact of GVCs on Economic Development” (Washington, DC: World Bank, 2017), <https://www.brookings.edu/wp-content/uploads/2017/07/tcgp-17-01-china-gvcs-complete-for-web-0707.pdf>.

Figure 8. Year-on-year change in exports and imports within the Asia-Pacific region



Source: International Monetary Fund – Direction of Trade Statistics; Chinese Taipei’s Ministry of Finance – Trade.

For instance, while imports of goods and services are often measured by economies, the types of transaction, as well as whether these goods are intermediate or final goods, are often not tracked, likely because it is administratively cumbersome to do so. Furthermore, data is often produced annually, which makes it difficult to evaluate the effect of a particular event on the functioning of global value chains. Another key challenge worth noting is that much of the crisis is still underway which makes it difficult to understand the full extent of its impact on global value chains.

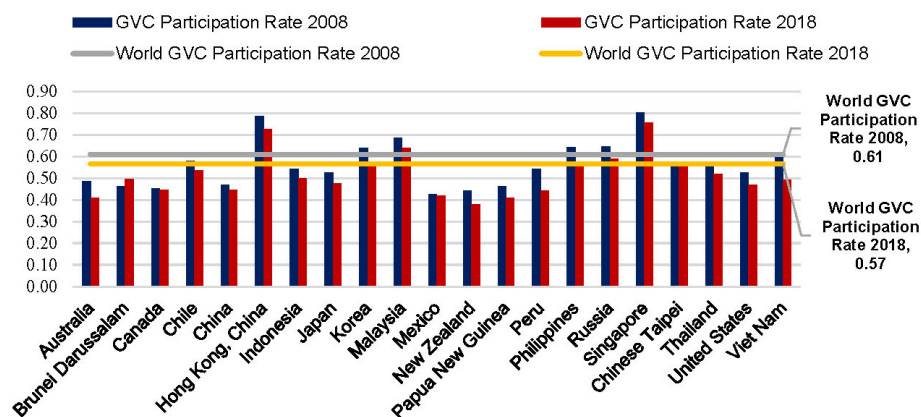
As a result of the difficulties involved with using data alone to measure supply chain resilience, this section will rely on anecdotal firm-level analyses and real-life examples. Considering the challenges in evaluating the value chain impact of the current pandemic, further assessments could be based on the experience of a past crisis. For instance, while the 2008 GFC was largely a demand-side crisis, an evaluation of its impact on trade can help proxy the potential impact of COVID-19. An investigation of the GFC’s trade impact notes that, in 2008, the year-on-year change in APEC’s exports and imports fell into negative territory for almost 13 months before registering positive growth rates.³⁷ Considering that the COVID-19 crisis is both a demand and supply-side shock, the rebound period could potentially be longer.

A further evaluation could be conducted based on global-value-chain participation

³⁷ International Monetary Fund – Direction of Trade Statistics; Chinese Taipei’s Ministry of Finance – Trade Statistics Database; APEC Secretariat, Policy Support Unit calculations.

rates. It has been found that when value chains are less connected with each other, a disruption in one economy is unlikely to affect another as extensively, making the impact on global trade smaller. Additionally, the impact of a disruption may become more easily transmitted when value chains are more interconnected. However, this should not be taken to mean globalised value chains are not beneficial to trade as they also allow for the quick reconfiguration of supply chains to other suppliers should disruptions happen. But it is worth noting that it is often difficult to do so within a short period of time, such as when hit by a systemic, unexpected crisis like COVID-19. Barriers include the legal contracts in place, and the complexities of response when the crisis affects a large number of economies.

Figure 9. Change in interconnectivity of value chains between 2008 and 2018

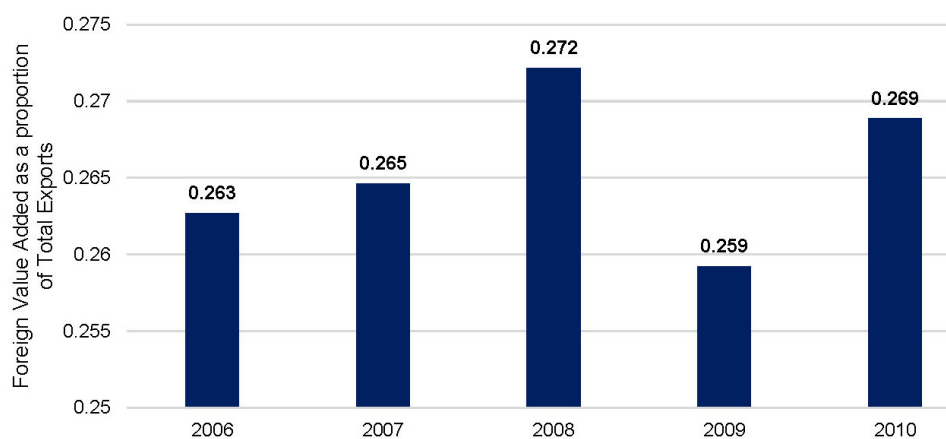


Source: UNCTAD-EORA Global Value Chain Database., <https://www.worldmrio.com/unctadgvc/>.

An evaluation of the change in the interconnectivity of supply chains between 2008 (during the GFC) and 2018 shows that value chains have become less interconnected with almost all APEC economies registering a fall in participation (Figure 9). While this may seem to suggest that value chains could be less adversely affected this time round, it needs to be considered that COVID-19 is unique in that, unlike other crises including the GFC, it has had an impact both on supply and demand. While our study does not attempt to model the impact of both a demand and supply-side shock, an approximation of the potential shock can be carried out by examining the impact of the GFC on value chains. The GFC, a largely demand-side shock, had a significant impact

on value chain activity. Between 2006 and 2008, years prior to the GFC, the average amount of foreign value added as a proportion of total exports in the APEC region had steadily increased from 0.263 in 2006 to 0.272 in 2008. However, as a result of the GFC and the demand shock to final goods and services, the average proportion fell sharply to 0.259 in 2009 (Figure 10)

Figure 10. Foreign value added as a proportion of total exports in the APEC region



Source: UNCTAD-EORA Global Value Chain Database, <https://www.worldmrio.com/unctadgvc/>.

COVID-19 and Factors of Value Chain Resilience

Given that the impact of COVID-19 on global trade and supply chains would likely be extensive, it is more important than ever that economies continue to build their supply chain resilience. While all five strengths areas introduced in this report are important to supply chain resilience as a whole, the two areas that are likely to be directly important in relation to the COVID-19 pandemic are strength against natural disaster risk, and against logistics and infrastructure risk.

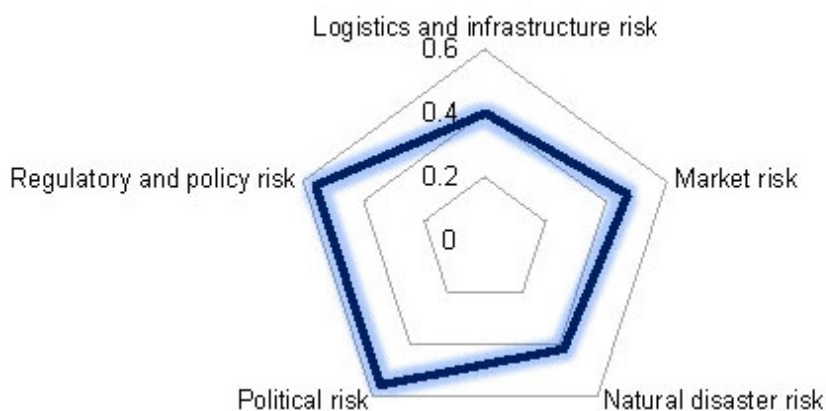
- Natural disaster risk

Under the strength against natural disaster risk pillar, several aspects relevant to the COVID-19 situation have been considered. It may be surprising to equate the COVID-19 pandemic to a natural disaster, but considering that the consequences of both events are very similar, the comparison makes sense. While some indicators under this strength area are not immediately relevant to the pandemic, such as access to physical infrastructure (e.g. electricity, telephone), those related to healthcare infrastructure and expenditure are of concern. This is especially so given that COVID-19 is not a natural disaster but a health crisis affecting a large proportion of the population within the Asia-Pacific.

Several economies in the region faced a range of challenges in their efforts to contain the pandemic, including the lack of capacity within healthcare facilities to deal with the growing number of patients and a shortage of healthcare professionals. To contain the pandemic, these economies had to impose lockdowns, which affected value chains. Resilience in this pillar is thus important to ensure fast recovery of value chains.

- Logistics and infrastructure risk

Global trade is very much dependent on efficient logistics operations and good infrastructure around the world. With value chains in the Asia-Pacific increasingly fragmented, the functioning of one part of the value chain affects others as well. The lockdowns introduced around the world are testament to this: not only did manufacturing come to a halt but logistic channels faced considerable operational issues, affecting the production and distribution of final goods around the world. Within these two areas of strength, the average scores of the APEC region are considerably lower than other strength areas (Figure 11). Additionally, performance in this area has been largely uneven. For instance, in the case of strength against natural disaster risk, scores in the region range from lows of 0.044 to highs of 0.72. Similarly, for logistics and infrastructure, economies registered scores between 0.0008 and 0.77. The uneven level of development across economies in the region in these areas of strength affect the region's ability to rebound quickly in times of systemic supply chain disruptions.

Figure 11. APEC value chain strength index

Economies have identified the need to strengthen these areas by proactively intervening and introducing an extensive range of steps to manage the crisis. At the APEC level, several initiatives have been undertaken. For instance, in the area of logistics and infrastructure, some APEC economies have focused on expediting and simplifying customs procedures to avoid delays due to border and customs procedures and logjams at major ports.³⁸ This will have a significant impact on increasing resilience against logistics and infrastructure risk. At the individual economy level, economies have strengthened their resilience against natural disaster risk by bolstering healthcare capacity. For instance, Singapore’s healthcare sector expanded its information and communications technology (ICT) capacity in anticipation of the rising number of COVID-19 patients in April this year.³⁹ Similarly, Australia has increased healthcare expenditure by USD 2.4 billion in response to COVID-19.⁴⁰ These are just few examples of the efforts APEC economies have since undertaken. In terms of resilience against logistics and infrastructure risks, economies have introduced new initiatives, particularly with regard to expediting the clearance of medical goods. For instance, Singapore and New Zealand have signed the Declaration

³⁸ “Trade Facilitation Is Critical Response to COVID-19 Pandemic: APEC CTI,” *Antarnews.com*, 18 June 2020, <https://en.antarnews.com/news/150992/trade-facilitation-is-critical-response-to-covid-19-pandemic-apec-cti>.

³⁹ Min Zhang Lim, “Coronavirus: Hospitals Expanding ICU Capacity in Anticipation of Needs,” *The Straits Times*, 29 April 2020, <https://www.straitstimes.com/singapore/hospitals-expanding-icu-capacity-in-anticipation-of-needs>.

⁴⁰ “\$2.4 Billion Health Plan to Fight COVID-19,” media release, Prime Minister of Australia, 11 March 2020, <https://www.pm.gov.au/media/24-billion-health-plan-fight-covid-19>.

on Trade in essential goods for combating the COVID-19 pandemic. This agreement aims to keep trade channels between the two economies open and allow the efficient flow of medical goods. In the same vein, Korea used its vast global-value-chain network to provide COVID-19 test kits to economies around the globe within weeks of the crisis by shifting and pivoting its production.⁴¹

Beyond ensuring resilience against strength areas that are directly related to the pandemic, the APEC Business Advisory Council (ABAC) has also encouraged APEC economies to apply several measures to build resilience against indirect impacts on COVID-19 through policies that:

(1) keep markets for goods, services and investment open; (2) resist any approach toward de- globalisation and encourage diversification; (3) support micro, small and medium enterprises (MSMEs) in addressing operational challenges; (4) leverage digital connectivity; and (5) work collaboratively to plan for re-opening of borders.⁴²

While not directly strengthening resilience against natural disaster as well as logistics and infrastructure risk, these actions have an impact on other areas of resilience that are relevant to dealing with the pandemic, namely strength against market regulatory and policy risk. Despite the progress achieved within global supply chains, the COVID-19 pandemic has uncovered areas where resilience is low. Globally, the OECD notes that the pandemic has shown that economies around the world need to ensure the availability of a significant amount of resources for unexpected events. With the COVID-19 pandemic, several economies were noted to struggle to ensure sufficient

supply of medical equipment (e.g., masks, ventilators, tests) for their healthcare workers and population.⁴³

⁴¹ Sébastien Miroudot , “Resilience versus Robustness in Global Value Chains: Some Policy Implications,” VoxEU and CEPR, 18 June 2020, <https://voxeu.org/article/resilience-versus-robustness-global-value-chains>.

⁴² APEC, “ABAC COVID-19 Report: Laying the Groundwork for Economic Recovery and Resilience.” (2020/ESOM2/002, Singapore: APEC, 2020), http://mddb.apec.org/Documents/2020/SOM/ESOM2/20_esom2_002.pdf.

⁴³ OECD, “A Systemic Resilience Approach to Dealing with Covid-19 and Future Shocks” (OECD, 2020), https://read.oecd-ilibrary.org/view/?ref=131_131917-kpfefrdfnx&title=A-Systemic-Resilience-

For the APEC region specifically, it is clear that the region faces certain gaps (e.g. uneven development, weak resilience to logistics and infrastructure risks) compared to other regional/economic groupings based on the quantitative analysis reported by our study. Given that the economies in the APEC region are interdependent, particularly in terms of trade and global value chains, building resilience as a region is particularly important. This section suggests that the key focus areas for more concerted effort are in developing greater strength against natural disaster risk, and against logistics and infrastructure risk.

Concluding remarks and way forward

This policy brief aimed to better quantify supply chain resilience in the APEC region, particularly in areas related to resilience against systemic risk. Through this analysis, one key takeaway is that, among the five strength areas, **the APEC region performed significantly better than other regional/economic groupings in terms of strength against (1) market risk and (2) regulatory and policy risk**, ranking near-second among the economies evaluated. This is reflective of the region developing in the right direction in areas such as financial institutions and markets, growing presence of domestic firms, as well as appropriate regulatory and risk mitigation provisions.

Our analysis also shows that governments have taken steps to strengthen resilience in supply chains by using their global-value-chain network to fight the pandemic, and by expediting and simplifying customs procedures. Another important takeaway is that while the APEC region has done relatively well in developing a degree of value chain strength, it is important to note that there remain **inequalities in the level of value chain strength in the region**, with some economies performing significantly better than others. Economies in the APEC region are significantly exposed to disruptions in other APEC economies and are also increasingly dependent on these other economies. As such, while domestic efforts are important in ensuring supply chain resilience, it is also important to increase efforts toward increasing APEC regional supply chain resilience as well.

Lastly, value chain resilience today also refers to being able to **respond quickly to unexpected systemic events** that affect a large number of economies. Unlike supply chain disruptions caused by earthquakes or other natural catastrophes, the COVID-19 pandemic involves no damage to physical infrastructure. Instead, the current disruption is largely due to rising infection and death rates, and movement restrictions and closure of borders or lockdowns.⁴⁴ The movement restrictions have also halted supply chain operations and disrupted manufacturing production at major hubs. As production declines, incomes and productivity have been affected, and this has had an overall impact on global aggregate demand.

In the short run, firms will find it difficult to find alternative suppliers. It is also not easy to relocate or reconfigure business supply chains quickly, even for multinational corporations (MNCs). While some small and medium enterprises (SMEs) may be nimble enough to readjust their operations relatively easily, their access to finance may limit their options moving forward (during a crisis, cash is king). In the long run, stronger institutionalised collaboration is required between firms and governments to recover and emerge from this crisis stronger. Stiglitz et al. suggest that economies may need a better balance between globalisation and self-reliance.⁴⁵ Having a certain degree of self-dependency within the domestic economy could enhance resilience, based on the observation that with many international borders affected by lockdowns, aggregate demand is now mostly driven by domestic demand and electronic commerce. This is not to say that global value chains are no longer relevant; but that certain reconfigurations are necessary to ensure that the network would still be able to function or at least to recover quickly when unexpected disruptions occur.

All in all, the findings in this policy brief suggest the importance of continued work on cooperative measures such as capacity building and information transfers to enhance value chain resiliency to tame any future black swan event. In this regard, a broader systemic and strategic perspective based on the principles of robust and resilient

⁴⁴ Miroudot, “Resilience versus Robustness.”

⁴⁵ Joseph E. Stiglitz, Robert J. Shiller, Gita Gopinath, Carmen M. Reinhart et al., “How the Economy Will Look after the Coronavirus Pandemic,” *Foreign Policy*, 15 April 2020, <https://foreignpolicy.com/2020/04/15/how-the-economy-will-look-after-the-coronavirus-pandemic/#>.

supply chains is needed.⁴⁶ To successfully mitigate the current global pandemic and to come out stronger will require concerted effort by all APEC economies.

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⁴⁶ Gereffi, Gary. “What Does the COVID-19 Pandemic Teach Us about Global Value Chains? The Case of Medical Supplies.” *Journal of International Business Policy* 3, no. 3 (September 1, 2020): 287–301. <https://doi.org/10.1057/s42214-020-00062-w>.

The authors would like to thank Dr Denis Hew, Emmanuel San Andres and Andre Wirjo for their comments and inputs.

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APEC#220-SE-01.14

Annex A: Technical notes on updates to methodology and indicators

This study on value chain strength builds on a 2014 analysis by APEC titled 'Quantitative Analysis of Value Chain Strength in the APEC Region'. This 2020 edition of the analysis incorporates several methodological updates and adjustments,

as outlined below.

Identification of indicators

Indicators for each strength area are shown in Table A1. The list is not exhaustive and aims to serve as a proxy of resilience for each strength area. Indicators were chosen based on applicability to quantifying resilience in the respective strength areas, data availability, coverage of economies across the different regions, and whether the indicators measure both the public and private sectors.

Several indicators used in the 2014 analysis have been discontinued, or show poor data availability for recent years. They have been excluded from this study.

New indicators have been introduced (noted as such in Table A1). Additionally, some indicators have been re-categorised into a strength area that better reflects the current global value chain landscape.

For each of these indicators, data from the latest possible year have been used. While the latest available data were taken from 2018 for some indicators, data for others were at times taken from earlier years depending on data availability.

Principal component analysis

Considering the relatively large number of indicators included in this analysis, we used principal component analysis (PCA) to reduce the dimensionality of the analysis. PCA is widely used to create composite indexes, including the ADB's Asia-Pacific Regional Integration Index and the IMF's Index of Financial Development.⁴⁷

As an overview, PCA reduces dimensionality through creating composite indexes (principal components). These principal components attempt to capture as much variation as possible. An overall index is then computed based on a selection of these components.

⁴⁷ ADB, "Asia-Pacific Regional Integration Index: Construction, Interpretation, and Comparison" (ADB Economics Working Paper, Manila: ADB, 2017); International Monetary Fund (IMF), "Introducing a New Broad-based Index of Financial Development" (working paper, IMF, 2016), <https://www.imf.org/external/pubs/ft/wp/2016/wp1605.pdf>.

The main goal is to capture as much of the variation within each of the individual indicators. Considering that the current analysis consists of a total of 21 indicators of which it cannot be said that they all contribute equally to the overall composite index, this method is relevant.

Upon calculating these composite indexes, comparisons were done across different regional groupings. The performance of each region in specific strength areas was then analysed. The scores contributing to the overall index were aggregated for each area and subsequently normalised to create the sub-indexes.

Dealing with missing data

In the 2014 publication, proportional re-weighting was carried out, where data for missing values were ignored. In that method, an average of all available indicators is taken to create the index regardless of whether data blanks exist. This is consistent with the practice in creating other indexes, such as DHL's Global Connectedness Index. However, a different approach has been taken in this study to better proxy missing data. Instead of ignoring missing values, blanks are replaced with regression estimated values through multiple imputations based on their respective income per capita.⁴⁸

⁴⁸ World Bank – World Development Indicators

Table A1. Indicators proxying resilience within risk area

Strength against:	Indicators
Logistics and infrastructure risk	<ul style="list-style-type: none"> • Air transport, freight (million ton-km). <i>World Bank</i> • Container port traffic (TEU: 20-foot equivalent units) per unit population. <i>World Bank</i> • Logistics performance index: Competence and quality of logistics services (1=low to 5=high). <i>World Bank</i> • Logistics performance index: Frequency with which shipments reach consignee within scheduled or expected time (1=low to 5=high). <i>World Bank</i> • Percentage of individuals using the internet. <i>ITU</i>
Market risk	<ul style="list-style-type: none"> • Market capitalisation of listed domestic companies (% of GDP). <i>World Bank</i> • Depth, access and efficiency of financial institutions. <i>IMF*</i> • Depth, access and efficiency of financial markets. <i>IMF*</i>
Natural disaster risk	<ul style="list-style-type: none"> • Access to electricity (% of population). <i>World Bank*</i> • Fixed telephone subscriptions (per 100 people). <i>World Bank</i> • Hospital beds (per 1,000 people). <i>World Bank</i> • Physicians (per 1,000 people). <i>World Bank</i> • Current health expenditure (% of GDP). <i>World Bank</i>
Political risk	<ul style="list-style-type: none"> • Reliability of police services (1–7). <i>World Bank</i> • Political stability and absence of violence index. <i>World Bank *</i> • Rule of law index. <i>World Bank</i>
Regulatory and policy risk	<ul style="list-style-type: none"> • Government effectiveness index. <i>World Bank</i> • Strength of auditing and accounting standards. <i>World Economic Forum – Global Competitiveness report</i> • Efficiency of legal framework in challenging regulations (1–7) <i>World Economic Forum – Global Competitiveness report</i> • Efficiency of legal framework to settle disputes. <i>World Economic Forum – Global Competitiveness report</i> • Strength of investor protection, 0–10 (best). <i>World Economic Forum – Global Competitiveness report</i>

Table A2. Overall summary statistics

Strength against:	Variables	Obs	Mean	Std.Dev.
Logistics and infrastructure risk	Air transport freight per unit population	63	0.024	0.127
	Container port traffic per unit population	63	0.1	0.213
	Quality and competence of logistics serviceproviders	63	0.607	0.223
	Timeliness of delivery	63	0.655	0.229
	Internet users per 100 population	63	0.743	0.217
Market risk	Market capitalisation of listed companies as apercentage of GDP	63	0.067	0.128
	Depth, access and efficiency of financialinstitutions	63	0.58	0.228
	Depth, access and efficiency of financialmarkets	63	0.5	0.286
Natural disaster risk	Access to electricity (% of population)	63	0.957	0.165
	Telephone lines per 100 population	63	0.432	0.276
	Number of hospital beds per 1,000population	63	0.27	0.194
	Number of physicians per 1,000 population	63	0.435	0.223
	Health expenditure as a percentage of GDP	63	0.347	0.189
Political risk	Reliability of policy officers	63	0.579	0.252
	Political stability and absence of violence	63	0.59	0.259
	Rule of law index	63	0.583	0.291
Regulatory and policy risk	Government effectiveness index	63	0.58	0.244
	Strength of auditing and accounting standards	63	0.543	0.246
	Efficiency of legal framework in challengingregulation	63	0.463	0.248
	Efficiency of legal system in settling dispute	63	0.508	0.238
	Strength of investor protection	63	0.597	0.206

IMF=International Monetary Fund; ITU: International Telecommunication Union.

‘*’ refers to indicators that have been introduced within this policy brief but had not beenincluded within the 2014 publication.

Annex B. Principal component analysis (PCA): Component loadings Table B.2.
PCA calculated weight of each indicator

	Weight in Overall Index
Air transport freight per unit population	4.7%
Container port traffic per unit population	5.0%
Quality and competence of logistics service providers	5.6%
Timeliness of delivery	5.1%
Internet users per 100 population	4.9%
Market capitalisation of listed companies as a percentage of GDP	3.4%
Depth, access and efficiency of financial institutions	5.2%
Depth, access and efficiency of financial markets	5.2%
Access to electricity (% of population)	3.1%
Telephone lines per 100 population	4.8%
Number of hospital beds per 1,000 population	2.7%
Number of physicians per 1,000 population	4.5%
Health expenditure as a percentage of GDP	4.1%
Reliability of policy officers	5.0%
Political stability and absence of violence	4.7%
Rule of law index	5.9%
Government effectiveness index	5.7%
Strength of auditing and accounting standards	4.9%
Efficiency of legal framework in challenging regulation	5.4%
Efficiency of legal system in settling dispute	5.6%
Strength of investor protection	4.5%

IMF=International Monetary Fund; ITU: International Telecommunication Union.

Annex C. Principal component analysis (PCA): Scree plot

