



**Asia-Pacific  
Economic Cooperation**

**Advancing** Free Trade  
for Asia-Pacific **Prosperity**

# Quantitative Analysis of Value Chain Strength in the APEC Region



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**APEC Policy Support Unit**  
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The views expressed in this paper are those of the authors and do not necessarily represent those of APEC Member Economies.

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## EXECUTIVE SUMMARY

Global Value Chains (GVCs) are an increasingly common way of organizing production in the Asia-Pacific, and elsewhere in the world. Goods are moving across borders multiple times before being shipped to the final consumer at the end of this complex production process. GVCs allow businesses to work together across borders to capitalize on the advantages that different economies offer.

A number of factors lie behind the Asia-Pacific's success in supporting the establishment and growth of GVCs over recent years. One is that Value Chain Risk is managed effectively by governments and the private sector, thereby making it possible for lead firms to invest in a climate in which uncertainty is limited. Another is that Value Chain Strength in the region is high: the Asia-Pacific's value chains are resilient to external shocks, including the occurrence of systemic risks. The propagation of shocks within value chains is an extremely complex process due to their nonlinear nature, which means that small perturbations in one link can lead to large disruptions in final production. Ensuring that value chains are strong enough to deal with such issues is a major objective for policymakers and businesses alike.

This report aims to provide stakeholders with additional information on Value Chain Strength in the APEC region, by combining qualitative and quantitative approaches. In particular, it aims to place APEC's performance on Value Chain Strength in comparative context by also looking at performance in other economy groups, such as ASEAN, the G-8, the G-20, and the OECD. Value Chain Strength is defined as the set of measures that increase the resilience of value chains to the occurrence of unexpected negative events ("shocks"), in the sense of allowing for a full and rapid recovery of value chain activity.

This report is the output for Phase Two of APEC's project on Value Chain Resilience. That four phase project aims to examine the following interconnected issues, which affect the decision of GVCs to establish themselves in particular APEC economies, and their subsequent ability to grow and prosper:

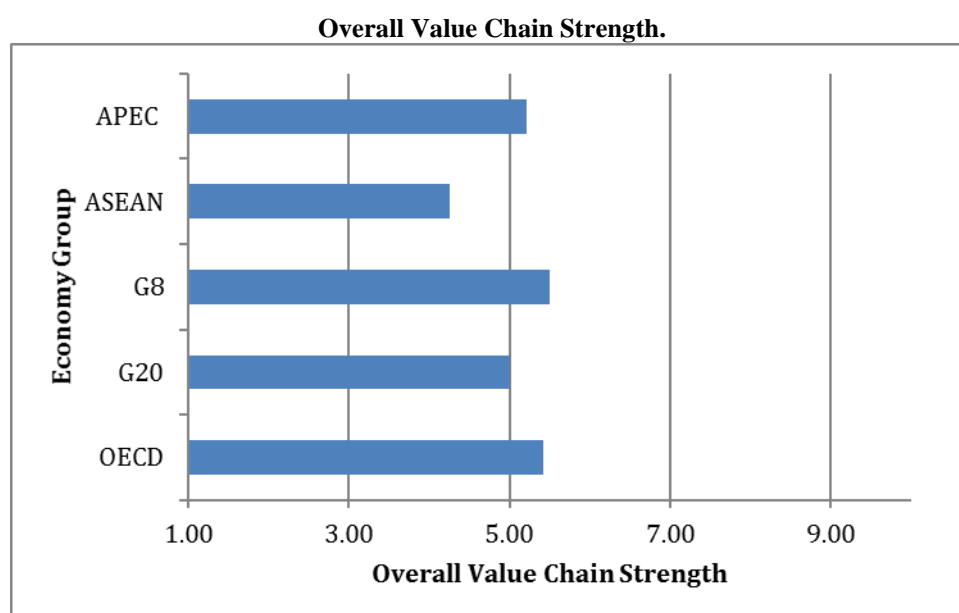
1. Phase One involved a quantitative analysis of Value Chain Risk in the APEC region.
2. Phase Two will evaluate Value Chain Strength in the APEC region.
3. Phase Three will evaluate Value Chain Connectedness in the region.
4. Phase Four will involve the creation of a comprehensive model to evaluate the possible impact of Value Chain Resilience by utilizing results from the earlier three phases on Value Chain Risk, Value Chain Strength, and Value Chain Connectedness.

The first three phases, although independent pieces of research, are all inter-related, as their joint inclusion in Phase Four indicates. Risk and strength have a circular relation: economies at greater risk of the occurrence of particular negative events have an incentive to develop greater response capacities, i.e. increased strength. Over time, this tends to reduce their risk profile as even though negative events occur, their economic and human costs are smaller. Moreover, risk and strength both influence connectedness, because all other things being equal, value chain lead firms prefer to invest in economies where risk is low and strength is high. Such economies therefore tend to become more connected. However, more connected economies are themselves at greater risk of feeling the effects of systemic risk, as shocks in one economy are more likely to be felt at a distance in better connected economies.

This phase examines the inverse of Value Chain Risk, i.e. Value Chain Strength, or the range of factors that determines an economy's ability to respond to risks and limit their economic and social impacts. Following the categories set out for Value Chain Risk in the Phase One report, Value Chain Strength is defined in terms of five dimensions:

- Strength against natural disaster risks.
- Strength against logistics and infrastructure risks.
- Strength against market risks.
- Strength against regulatory and policy risks.
- Strength against political risks.

The methodological strategy of this report is two-pronged. The quantitative section uses internationally-comparable data for APEC economies to measure performance in each area, and in all areas together through an overall index. Results indicate that APEC is generally a strong performer in relation to Value Chain Strength, particularly in the case of developed member economies, but also for developing member economies in some cases. Results in some areas indicate that APEC is at, or very close to, the global best practice frontier.



*Source: Authors' calculations.*

The qualitative section complements the static approach of the quantitative section by conducting dynamic case studies of three major value chain disruptions, from which the APEC region recovered rapidly: the Global Financial Crisis (GFC) of 2008-2009; the Thai floods of 2011; and the Great Tohoku Earthquake of 2011. The focus of the case studies, by contrast with the public-sector variables favored by the quantitative analysis, is on private sector strategies. Results indicate that value chains in the Asia-Pacific are very robust, even to extreme shocks. Performance quickly returns to pre-crisis levels, which indicates that value chains are strong and resilient. However, a number of factors determine that overall result. One is substitution: lead firms sometimes switch to different suppliers (firms or economies) when there are disruptions. It is therefore important to distinguish value chain resilience from the resilience of particular firms or economies taking part in value chains. For example, a value chain as a whole can demonstrate resilience by changing suppliers if there is a disruption affecting an existing one; however, that existing supplier may not be able to

recover itself from the disruption, because all or part of its market share has been acquired by another firm. Second, the nature of the shock is important (supply-side or demand-side). Firms respond differently in each case, although results show that APEC value chains are resilient to both kinds of disruption. Finally, the presence of product-, economy-, or value chain-specific investments is important as a determinant of value chain resilience. When lead firms have made significant investments, they have an interest in ensuring continued operation of the value chain after a shock. Encouraging such investments, through technology transfer or other linkages, for example, is therefore an important policy objective for many economies.

The first phase of this project concluded that APEC economies overall faced a moderate level of Value Chain Risk, but that particular action was required to deal with some of those risks where levels were higher relative to comparator regions. This second phase, focusing on Value Chain Strength, shows that APEC economies have indeed been active in this area. They have put in place supporting environments that enable their firms to effectively manage Value Chain Risk. The policy environment is supportive of a combined public-private approach to risk management, which makes it possible to conclude that the overall risk-strength balance in APEC is positively turned towards the greater establishment and development of value chains.

The conclusion to be drawn from the first two phases of this project is that although some risks are significant in the Asia-Pacific region due often to circumstances outside governments' control, the response has been a robust one, which results in a climate in which overall Value Chain Resilience appears to be strong relative to comparator regions. Indeed, APEC's performance appears to be on a par with some developed economy groupings, and is significantly better than that of regional partners made up primarily of developing economies.

Results from the quantitative and qualitative analyses agree on these points. Overall, the evidence suggests that because of the elements of Value Chain Strength that economies have put in place, value chains rebound rapidly even from such major crises as the GFC, the Thai floods, and the Great Tohoku Earthquake. The strong reaction to these extreme events suggests that more common occurrences of value chain risk are also managed effectively by value chain participants, thanks in part to the supportive environment established by the public sector.

In terms of policy implications, there are three main findings from this study:

- Managing the occurrence of value chain risk is typically an activity that involves more than one economy. As a result, a regional approach in which governments and firms coordinate their responses to the occurrence of risks is often appropriate.
- Although risk management is primarily a private sector activity, there is much that the public sector can do to put in place an environment that is conducive to reinforcing Value Chain Strength and promoting resilience.
- Although APEC's results on Value Chain Strength are generally very strong by world standards—and this is reflected in the rapidity with which its private operators resume and expand activity following negative events—it is necessary to ensure continuous improvement. APEC governments and firms need to work together to ensure that Value Chain Strength remains high, and increases over time.

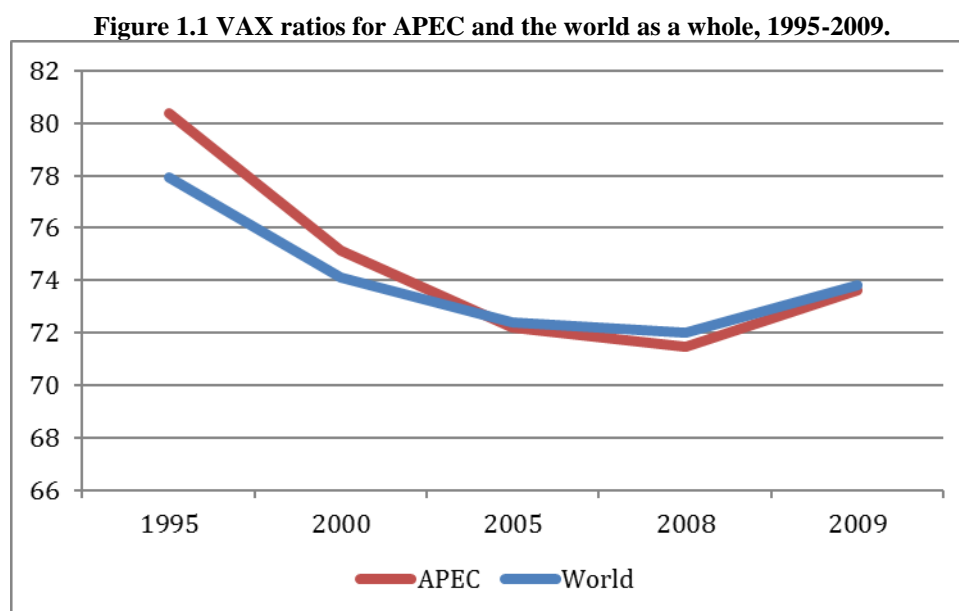
Given the generally strong level of performance in the region, APEC economies are well placed to maintain and increase Value Chain Strength. These objectives fit well with broader APEC work on trade and investment, such as improving connectivity in the region.



## 1. INTRODUCTION AND PROJECT OVERVIEW

Global Value Chains (GVCs) are an increasingly common way of organizing production in the Asia-Pacific, and elsewhere in the world. Goods are moving across borders multiple times before being shipped to the final consumer at the end of this complex production process. GVCs allow businesses to work together across borders to capitalize on the advantages that different economies offer.

The increasing importance of GVCs is reflected in international trade statistics. Figure 1.1 shows the value added to gross exports (VAX) ratio for APEC economies and the world as a whole for the period 1995-2009. It is based on the OECD/WTO Trade in Value Added (TiVA) data. The decline of the ratio through 2008 is consistent with a higher proportion of intermediate goods in exports, which is a characteristic of the GVC production model. APEC's VAX ratio declined more rapidly than that of the world as a whole, and reached a lower minimum point in 2008, before increasing slightly in the light of the disruption caused by the financial crisis. Still, in 2009, APEC's VAX ratio was slightly lower than that of the world as a whole, which indicates that value chain trade is particularly important for the region.



Source: OECD/WTO, and author's calculations.

A number of factors lie behind the Asia-Pacific's success in supporting the establishment and growth of GVCs over recent years. One is that Value Chain Risk is managed effectively by governments and the private sector, thereby making it possible for lead firms to invest in a climate in which uncertainty is limited. Another is that Value Chain Strength in the region is high: the Asia-Pacific's value chains are resilient to external shocks, including the occurrence of systemic risks. The propagation of shocks within value chains is an extremely complex process due to their nonlinear nature, which means that small perturbations in one link can lead to large disruptions in final production. Ensuring that value chains are strong enough to deal with such issues is a major objective for policymakers and businesses alike. This report aims to provide both communities with additional information on Value Chain Strength in the APEC region, by combining qualitative and quantitative approaches. In particular, it aims to

place APEC's performance on Value Chain Strength in comparative context by also looking at performance in comparator groups, such as ASEAN, the G-8, the G-20, and the OECD.

Value Chain Strength is defined as the set of measures that increase the resilience of value chains to the occurrence of unexpected negative events ("shocks"), in the sense of allowing for a full and rapid recovery of value chain activity. This definition is used as the motivation for the quantitative and qualitative analysis undertaken in this report.

This report is the output for Phase Two of APEC's project on Value Chain Resilience. That four phase project aims to examine the following interconnected issues, which affect the decision of GVCs to establish themselves in particular APEC economies, and their subsequent ability to grow and prosper:

1. Phase One involved a quantitative analysis of Value Chain Risk in the APEC region.
2. Phase Two will evaluate Value Chain Strength in the APEC region.
3. Phase Three will evaluate Value Chain Connectedness in the region.
4. Phase Four will involve the creation of a comprehensive model to evaluate the possible impact of Value Chain Resilience by utilizing results from the earlier three phases on Value Chain Risk, Value Chain Strength, and Value Chain Connectedness.

The first three phases, although independent pieces of research, are all inter-related, as their joint inclusion in Phase Four indicates. Risk and strength have a circular relation: economies at greater risk of the occurrence of particular negative events have an incentive to develop greater response capacities, i.e. increased strength. Over time, this tends to reduce their risk profile, as even though negative events occur, their economic and human costs are smaller. Moreover, risk and strength both influence connectedness, because all other things being equal, value chain lead firms prefer to invest in economies where risk is low and strength is high. Such economies therefore tend to become more connected. However, more connected economies are themselves at greater risk of feeling the effects of systemic risk, as shocks in one economy are more likely to be felt at a distance in better connected economies.

The purpose of each of the first three phases of the project is to consider a particular aspect of Value Chain Resilience, before they are brought together in Phase Four. Phase One examined Value Chain Risk. It identified five categories of risk, covering the full range of value chain activities, and their determinants. This phase examines the inverse of risk, i.e. Value Chain Strength, or the range of factors that determines an economy's ability to respond to risks and limit their economic and social impacts.

Against this background, the report proceeds as follows. The next section provides a literature review. Section 3 discusses the quantitative and qualitative (case study) methodologies used to examine Value Chain Strength in this report. The following section contains results of the quantitative analysis, dealing with each aspect of Value Chain Strength individually, and then bringing them together through an overall index. Section 5 contains three case studies that show the ability of value chains in the Asia-Pacific to rebound after the occurrence of serious negative events. The relationship between Chapters 4 and 5 is that the former sets the scene, in terms of analyzing measures that should assist value chains to continue functioning after shocks, while the latter provides concrete examples of how the private sector uses those measures to maintain and improve value chain performance when serious risks are realized. Section 6 concludes, and discusses policy implications of the report's findings.



## 2. LITERATURE REVIEW

With the increasing segmentation of global production and the prevalence of trade in intermediate goods and services that represents more than half of global trade (Miroudot et al., 2009; Sturgeon and Memedovic, 2010), GVCs have become a mainstream model for global business operations. The Global Value Chains Initiative ([www.globalvaluechains.org](http://www.globalvaluechains.org)) defines a value chain as including the full range of activities undertaken to bring a product from the conception stage to the end user, and even beyond.

Economies are more interconnected and interdependent than ever before. New systemic risks have appeared: an event affecting one segment of a GVC could easily be transmitted to other segments of the chain and disrupt the whole production process. Disruption could take place at the company level, but could expand to other companies, a whole sector, economy, region, or globally.

Business and governments alike have recently focused on the analysis of those risks, and attempted to design strategies to reduce them. The objective is to better assess the risks and identify individual as well as cooperative solutions to “enhance the resilience” of value chains (see e.g., Ministerial Statements at the APEC MRT 2013 pointing to the “importance to enhance value chain resilience”, or the World Economic Forum Risk Response Network’s Initiative towards “Building Resilience in Supply Chains”).

In its efforts to conceptualize and quantify systemic risks affecting value chains, APEC has identified five risk categories:

- Natural disaster risks.
- Market risks.
- Infrastructure and logistics risks.
- Regulatory and policy risks.
- Political risks.

This report conceptualizes 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. Of course, risk management is primarily a private sector responsibility, and the case studies presented in Chapter 5 focus on private sector responses to the occurrence of risk. However, governments also put in place a range of policies and other measures that provide the backdrop against which private sector risk management takes place. Chapters 3 and 4 focus on the analysis of those measures within APEC in comparative perspective, using international data sources that provide information on an economy-by-economy basis (see also Appendix 1 for economy-level results).

The previous literature dealing with concepts related to Value Chain Strength does not identify the concept as such in a way that is directly pertinent for the present exercise. The World Bank’s Logistics Performance Index (LPI) reports (2007-2014) stress the fact that supply chains—upon which value chains depend—are only as strong as their weakest link. The LPI measures six dimensions of logistics performance that are considered to be crucial to the performance of supply chains: efficiency of the border clearance process; quality of trade and transport infrastructure; ease of arranging competitively priced shipments; competence

and quality of logistics service providers; ability to track and trace consignments; and timeliness of shipments in reaching their destination. The approach to value chain strength set out above draws on these areas—and, indeed, on the LPI dataset—in terms of quantification.

The Phase One report analyzes the available literature relating to Value Chain Risk, which, from an inverse point of view, is also relevant to the assessment of value chain strength. Again, there is no contribution that can be directly used as a template for the methodology to be used for this assignment. Nonetheless, the available literature suggests that the crucial perspective for assessing value chain performance—either from the point of view of risk or strength—is the firm level. That is, economies can only put in place policies that favor the emergence of economic environments in which strong value chains can prosper within the private sector; they do not themselves create or operate strong value chains. The issue for policymakers is therefore to identify the factors that make an economy more or less attractive to operators within the cross-border value chain context, and to deal with potential issues that dissuade investors or traders from operating such structures in particular cases.

One factor that is relevant to assessing Value Chain Strength is the way in which shocks are transmitted through the trade channel in value chains. Errico and Massara (2011) do not examine transmission as such, but use network analysis methods similar to those that will be applied in Phase Three of this project to examine the relative positions of economies. It is expected that economies with higher Value Chain Strength scores will be better placed in global and regional value added trade networks than those with lower scores, due to their increased risk resilience. Although better network placement implies higher susceptibility to external shocks transmitted through the trade channel, the case studies presented in Chapter 5 suggest that it also makes recovery quicker.

The bulk of existing literature on Value Chain Strength and Value Chain Resilience focuses on firm-level risk management strategies. WEF (2013) is representative. The case studies in Chapter 5 draw on these contributions in describing the ways in which firms have responded to the dynamic situations brought on by the occurrence of major risks. However, they are not directly relevant to the assessment of Value Chain Strength at the economy level, as they deal with questions of business strategies that cannot be assessed using international data, which is one of the primary objectives of this report.

In light of the nature and scope of the existing literature, the focus of this report is on building on and extending it, rather than applying it directly. The report takes a novel approach to Value Chain Strength. It is based on the Phase One report for this project, and conceives of a variety of strength measures that can be easily quantified using existing, internationally comparable data. The case study section of the report (Chapter 5) delves into further detail regarding the interaction between public policies and private sector practices, and provides harmonizing frameworks for understanding this complex relationship. The methodology is discussed in full in the next chapter.

### 3. METHODOLOGY

Analyzing Value Chain Strength is a complex undertaking. The concept itself is many-faceted, which makes it difficult to encapsulate in a single number. The methodological approach of this report is therefore twofold: quantitative and qualitative. The qualitative methodology is based on case studies (Chapter 5). Three examples are taken of major occurrences of different types of Value Chain Risks in the APEC region, covering developed and developing economies. In each case, the shock is described, its impact on trade examined, and factors of value chain disruption and resilience identified. Policy implications for APEC economies are then presented by way of conclusion for each case study. The idea of using a qualitative methodology in this way is to allow an examination of the dynamic way in which value chains respond to the occurrence of risks, and highlight the speed with which adjustments take place due to the favorable risk management environment in the Asia-Pacific.

Chapter 4, by contrast, provides a quantitative overview of Value Chain Strength in the Asia-Pacific, focusing on economy-level performance, not firm-level activities. It provides the backdrop for Chapter 5, in the sense of setting out the primarily public sector measures against which private sector responses to the occurrence of negative shocks take place. The report proceeds by identifying major categories of Value Chain Strength, based on the categories of Value Chain Risk identified in the Phase One report for this project. The analysis is built up from that point. The approach adopted here focuses on achieving three goals for the resulting indicators: comprehensiveness; transparency; and ease of replication. All three objectives are important for indicators that are to be both policy-relevant and potentially useful to value chain researchers inside and outside the Asia-Pacific region. A set of indicators that satisfies all three criteria will be easily interpretable for policymakers. Moreover, such a set of indicators will facilitate future work by researchers and policy experts, as well as timely and cost-effective updates of this Report if member economies consider that to be a fruitful avenue for future work.

It is important to distinguish the exercise being undertaken here from the one completed in Phase One of this project. The first report focused on the concept of risk, namely the probability that an event occurs that has negative consequences for value chain performance. This report, by contrast, focuses on *strength*, namely the set of policies and processes put in place to respond to the occurrence of negative events, and limit their economic and social effects. For example, some economies in the region have significant earthquake risks due to their geological characteristics. However, they have put in place sophisticated systems of early warning and response to ensure that their economies can rapidly rebound from any disruption caused by earthquakes, and that value chains can continue functioning as before. This report is therefore more closely related to Value Chain Resilience, which is the overarching motivation for this project. However, resilience and strength can only be understood against a background of risk analysis, hence the need for Phase 1 of the project.

The remainder of this chapter discusses the report's quantitative methodology in detail. It presents each category of Value Chain Strength. Each section identifies a set of specific indicators designed to capture the essence of each category of strength. After this presentation of the basic data underlying the indicators, there is a discussion of the aggregation methodology used to produce indices of Value Chain Strength, as well as the treatment of

missing data points, which differs from the first report due to the larger number of data series included.

## **CATEGORIES OF VALUE CHAIN STRENGTH**

The literature review in Chapter 2 showed that there is no standard categorization of Value Chain Strength. The report therefore proceeds by treating strength as the inverse of risk: it is the ability to respond to the occurrence of a risk, and limit its economic and social consequences. Against that background, it is natural to use a categorization of Value Chain Strength that follows the same scheme as the categories of Value Chain Risk identified in the Phase One report. The categories are therefore as follows:

1. **Strength Against Natural Disaster Risks:** measures that limit the economic and social consequences of the occurrence of a natural disaster.
2. **Strength Against Logistics and Infrastructure Risks:** 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.
3. **Strength Against Market Risks:** measures that limit the economic and social effects of economic fluctuations that disrupt prices, output, or other economic fundamentals.
4. **Strength Against Regulatory and Policy Risks:** 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.
5. **Strength Against Political Risks:** 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.

It is important to emphasize that the word “measures” used in the preceding definitions refers not only to public sector actions such as policies and regulatory instruments, but also to private sector actions, such as the design of systems, and the putting in place of redundancies or other risk management strategies. Dealing with Value Chain Risks and enhancing Value Chain Strength is an area in which public-private cooperation is vital, and the two sets of actors can work together to achieve the desired outcome on an economy-wide basis. In recognition of this fact, Chapter 4 deals with economy-wide processes and policies focused more on the public sector, and Chapter 5 uses case studies to demonstrate the practices adopted by individual firms and groups of firms against the background of those public sector measures.

### **Strength Against Natural Disaster Risks**

The Phase One report identified a number of key natural disaster risks that account for the most important economic and social effects in APEC member economies. A number of factors are relevant to an economy’s ability to respond to the occurrence of such a risk. First among them is the quality of its health system: the data in the Phase One report measure the seriousness of a natural disaster according to its impact on human life, so a stronger health system is likely to limit the seriousness of a disaster of a given magnitude, as the injured will be better cared for. Another factor is better general infrastructure, outside the health sector. The availability of electricity and communications infrastructure will aid rescue and aid efforts, and again limit the impact of the disaster. Finally, a unifying factor that determines the extent to which the others can be effective in responding to the occurrence of a natural disaster is government effectiveness. Those governments that are more adept at turning

policy decisions and administrative directives into action on the ground will have a greater impact on improving economic and social conditions in the wake of a natural disaster.

With these considerations in mind, as well as the general objectives of this report in terms of the type of indices that are to be constructed, the following indicators are used to measure strength against natural disaster risks:

- Number of physicians per 1,000 population (World Development Indicators).<sup>1</sup>
- Number of hospital beds per 1,000 population (World Development Indicators).
- Health expenditure as a percentage of GDP (World Development Indicators).
- The quality of electricity and telephone infrastructure (Global Competitiveness Report).<sup>2</sup>
- Telephone lines per 100 population (World Development Indicators).
- Internet users per 100 population (World Development Indicators).
- Government effectiveness index (Worldwide Governance Indicators).

These indicators capture each of the factors referred to above. They are based on standard, internationally comparable data. Of course, it is not possible to collect data for the full range of aspects of this category of Value Chain Strength, but the identified data series provide plausible proxy indicators for its key components.

### **Strength Against Logistics and Infrastructure Risks**

Logistics processes and the infrastructure upon which they depend in part determine the efficiency of operation of individual links in value chains. Better logistics and infrastructure make it possible to move goods more quickly, more reliably, and at lower cost. The Phase One report highlighted the uncertainty that can affect logistics operations, and the risk that poses for value chain activities. This report focuses on factors of strength that enable economies and private sector operators to respond to the challenges posed by logistics and infrastructure risks. A number of such factors are important. On the private sector side, the timeliness of delivery, and the competence and quality of logistics service providers shows the resilience of private sector operators in relation to the occurrence of this type of risk. In terms of public sector measures, infrastructure is key: better quality infrastructure means that, for example, private sector operators can develop workarounds when a problem arises in relation to one particular link in the chain. Finally, traffic loads show the capacity of an economy's transport system to sustain high throughput even in the face of logistics and infrastructure risks. Economies with higher levels of transport activity are better able to respond to risk.

Against this background, the following indicators are used as components of the strength against logistics and infrastructure risks index, which is a simple average:

- Timeliness of delivery (Logistics Performance Index).
- Quality and competence of logistics service providers (Logistics Performance Index).
- Road network length per unit population (World Development Indicators).
- Rail network length per unit population (World Development Indicators).

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<sup>1</sup> Data for Chinese Taipei are not available in the World Development Indicators. The report has therefore relied on national sources in all cases.

<sup>2</sup> An alternative indicator, the percentage of the population with access to electricity, is not available for recent years for a sufficient number of APEC economies.



- Air transport freight per unit population (World Development Indicators).
- Container port traffic per unit population (World Development Indicators).

The intention of using this set of indicators is to obtain reliable proxies for this category of Value Chain Strength, not to entirely cover the field of possible factors. The six indicators presented capture a strong cross-section of the relevant issues.

### **Strength Against Market Risks**

Market risks can have important implications for value chain activity, as discussed in the Phase One report. However, firms and economies have a variety of means at their disposal to confront the potential disruptions caused by market risks. On the one hand, private actors can have recourse to the markets themselves to cover the occurrence of risks, by using debt instruments and equity investment to cover temporary losses or instabilities. In addition, the public sector can contribute to the stability of the economy as a whole, and financial markets in particular, by maintaining public finances in good order, and putting in place appropriate interface regimes with the world economy.

With these points in mind, the following indicators are used as indicators of strength against market risk:

- Market capitalization of listed companies as a percentage of GDP.
- Bank capital to assets ratio.
- Cash surplus/deficit as a percentage of GDP.
- Central government debt as a percentage of GDP (converted to an inverse ratio).
- Total reserves in months of imports.

The proxies used in this case represent a good cross-section of the many factors that potentially influence strength against market risks.

### **Strength Against Regulatory and Policy Risks**

As set out in the Phase One report, unexpected regulatory and policy actions can cause problems for value chain actors, because they create uncertainty that carries business costs. However, many economies have put in place successful systems to balance the need for change and updating of regulations and other policy measures, with the need to ensure a certain level of predictability and transparency for businesses, including value chains. Ensuring the rule of law is an important part of that equation, and it includes the strength of the legal system when it comes to issues such as dispute settlement and administrative law. Protection of investors by the legal system is also important, as it indicates that the government is not able to easily diminish the value of investments made by lead firms in value chains, thereby increasing certainty. Finally, private sector developments are also relevant, such as the strength of auditing and accounting standards—they determine how reliable companies' reports are, and thus help create certainty for investors.

To measure strength against regulatory and policy risks, the following indicators are used:

- Rule of law index (Worldwide Governance Indicators).
- Efficiency of legal system in settling dispute (Global Competitiveness Report).

- Efficiency of legal framework in challenging regulations (Global Competitiveness Report).
- Strength of auditing and accounting standards (Global Competitiveness Report).
- Strength of investor protection (Global Competitiveness Report).

These five data series capture the most important dimensions of strength against regulatory and policy risk, covering both public and private sector perspectives.

### **Strength Against Political Risks**

In the Phase One report, political risk was identified as an important issue in APEC. It relates to the value chain risks posed by unexpected political developments either on the national or international level. Again, economies have developed sophisticated systems to respond to such risks, and this phase of the project takes account of the ways in which they both mitigate risk, and respond to its occurrence in such a way as to minimize economic and social costs. The most important dimension of Value Chain Strength in this regard relates to the capacity of emergency services, such as police and the military, to respond to domestic and international disturbances.

With this point in mind, this strength index comprises the following indicators, based on a simple average:

- Police officers per unit population (International Statistics on Crime and Justice).
- Military expenditure as a percentage of GDP (World Development Indicators).
- Reliability of policy officers (Global Competitiveness Report).
- In addition, it was proposed to include the World Values Survey's indicator of the percentage of the population having confidence in Parliament. However, data availability for this indicator was limited to less than half of the total economies included in the study, and so it was decided to exclude this indicator due to lack of coverage.

### **RESCALING AND AGGREGATION SCHEMES**

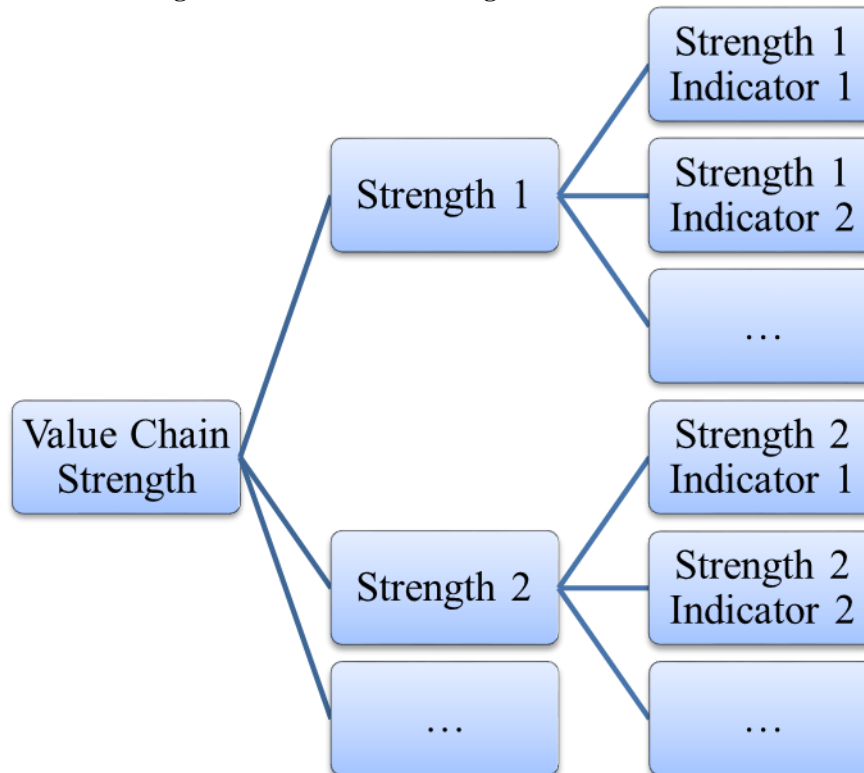
As discussed at the beginning of this Chapter, it is desirable to produce indicators that are simple, straightforward, and transparent. However, it is necessary to introduce an additional step into the analysis because of the presence of multiple indicators: rescaling and aggregation. By keeping these processes as simple as possible, without sacrificing quality or appeal to the end-user, the data product will be easier to interpret and reproduce. This approach also substantially reduces the costs associated with updating results in the future.

Rescaling is important because the underlying indicators are measured on different scales, so there is the possibility for one or more to act as dominant measures simply due to their size, rather than their economic importance. For purposes of enhanced transparency, it is important to apply the same rescaling scheme to all variables in the analysis. We therefore opt to apply a statistical technique, standardization, to rescale all variables prior to conducting any further analysis. Standardization subtracts each variable's mean (average) from each observed value, and then divides the result by the variable's standard deviation. The result is a set of variables each of which has an average value of zero, and a standard deviation of one. This rescaling technique can be applied to variables on any scale, including percentages and, importantly, indices with negative values. It is commonly used in statistical work. For example, it is usually applied prior to using techniques such as Principal Components Analysis (PCA),

which was the basis of APEC's approach to the measurement of multimodal connectivity in the Asia-Pacific (PSU, 2010).

It is also important that the aggregation scheme used to combine underlying indicators into summary indices be as simple, transparent, and easy to reproduce as possible. To that end, we propose two levels of analysis: indicators and indices. Indicators are individual data series taken from international sources, as discussed above. Indices are summary measures based on those indicators. Figure 3.1 illustrates the approach.

Figure 4.1 Value Chain Strength Information Tiers.



Source: Authors.

To aggregate indicators into summary indices, simple averages are used in all cases. The advantage of adopting simple averages is that they are transparent and easily replicable. An alternative methodology is to construct weighted averages, either based on professional judgment or on a statistical technique such as PCA. However, weighted averages suffer from the disadvantage that the choice of weights is never free from controversy, and it has the potential to significantly affect final results. In addition, it is difficult to exercise objective, professional judgment in this area because of the novelty of the exercise, and the difficulty of comparing economic impacts from one indicator to another at this stage of the Project (i.e., before impact analysis has been undertaken in Phase Four). The less complicated and more transparent approach is therefore preferred.

The fact that all indicators are rescaled to have mean zero and standard deviation one means that some of them, and by extension, some indicators, have negative values. These numbers are difficult to interpret from a policy point of view. To make the results easier to read, the report adopts a second rescaling procedure in which a simple linear transformation is applied to convert the data to a scale of one (lowest risk) to 10 (highest risk). This outcome is achieved by setting the minimum value of each index as observed in the data equal to one,

and the maximum value equal to 10. Observations between the extremes are then proportionately distributed between one and 10.

The final stage in the analysis is to produce an overall Value Chain Strength index. Rescaling is unnecessary at this point, because all of the strength indices are on the same scale (one to 10). To aggregate them into a final Value Chain Strength index, a simple average is again used. The advantage of a simple average over other possible aggregation schemes is that it is simple and transparent.

### **TREATMENT OF MISSING DATA**

The Phase One report dropped observations with missing data. In other words, only those economies with complete data for all indicators could receive an index score. That approach was appropriate in light of the relatively small number of indicators used for each index in that report. However, it is no longer necessary for the present report, where the number of indicators going into each index is considerably larger. Instead, proportional reweighting is used. Under this procedure, an economy that has data available for four out of five series receives an index score that is the simple average of those four series. An economy that has all five series available receives an index score that is the average of all five series. In the former case, the underlying series are effectively slightly reweighted so as to make calculation of the index possible. The greater the number of indices, the more slight the reweighting is. It is an appropriate approach here given the number of series involved, and reflects international practice, for instance in DHL's Global Connectedness Index, which also applies proportional reweighting.

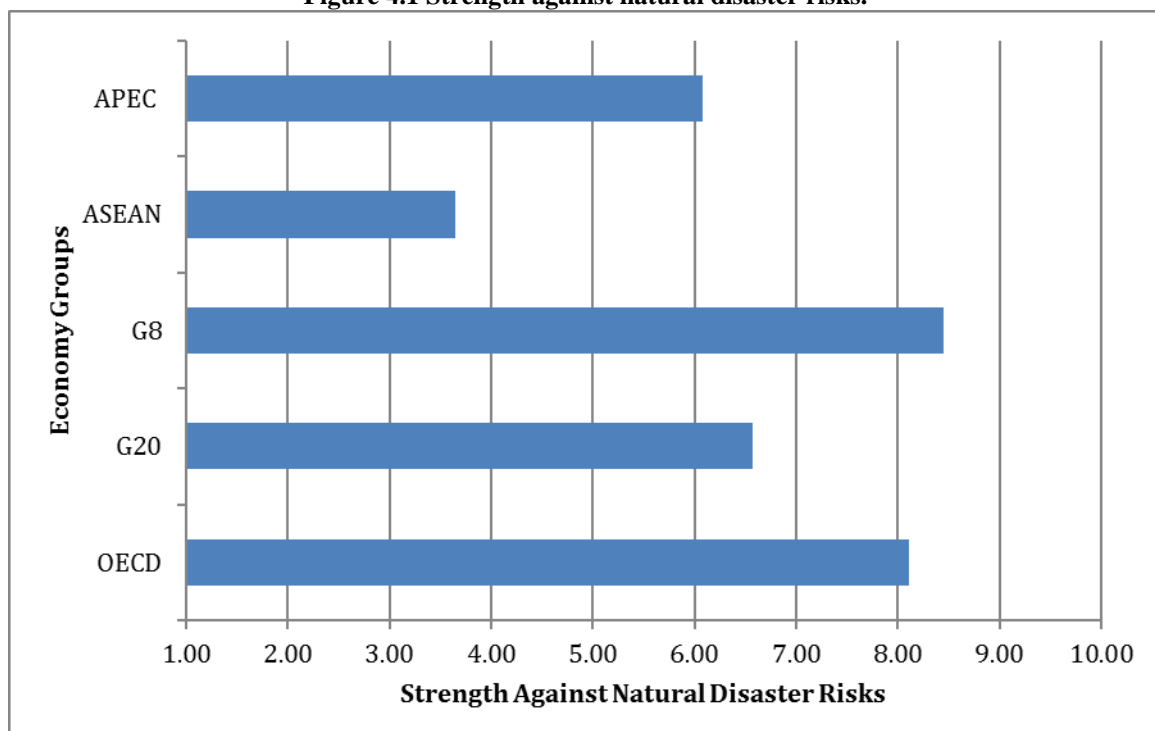
## 4. RESULTS OF QUANTITATIVE ANALYSIS

This chapter reviews the results of the data collection and quantitative analysis exercise described in Chapter 3. Each category of Value Chain Strength is dealt with separately, before discussion of an overall index that combines the five categories. Performance in the APEC region is measured by calculating scores for each economy individually, and then taking the regional (simple) average. To put APEC's performance in comparative perspective, results are also presented for the OECD, the G-8, the G-20, and ASEAN. The purpose of this analysis is to provide a general picture of APEC's performance, based primarily on public sector data; Chapter 5 shows how those measures are used in practice by firms to ensure that value chains are resilient in the face of unexpected events. Although individual economy results are not presented in the main text of this chapter, they are available in Appendix 1 to enable individual economies to conduct their own diagnostic exercises, in order to come to a better understanding of the nature and extent of Value Chain Strength in their own contexts.

### STRENGTH AGAINST NATURAL DISASTER RISKS

As discussed in the previous chapter, the natural disaster strength index is a simple average of the following indicators: number of physicians per unit population; number of hospital beds per unit population; the WGI government effectiveness index; the GCR indicator of electricity and telephone infrastructure; the number of fixed telephone lines per unit population; the number of internet users per unit population; and health expenditure as a percentage of GDP. The natural disaster strength index is measured on a scale of one through ten inclusive, with one being assigned to the least risky economy in the sample, and ten being assigned to the riskiest economy. Comparative results are in Figure 4.1.

Figure 4.1 Strength against natural disaster risks.



Source: Authors' calculations.

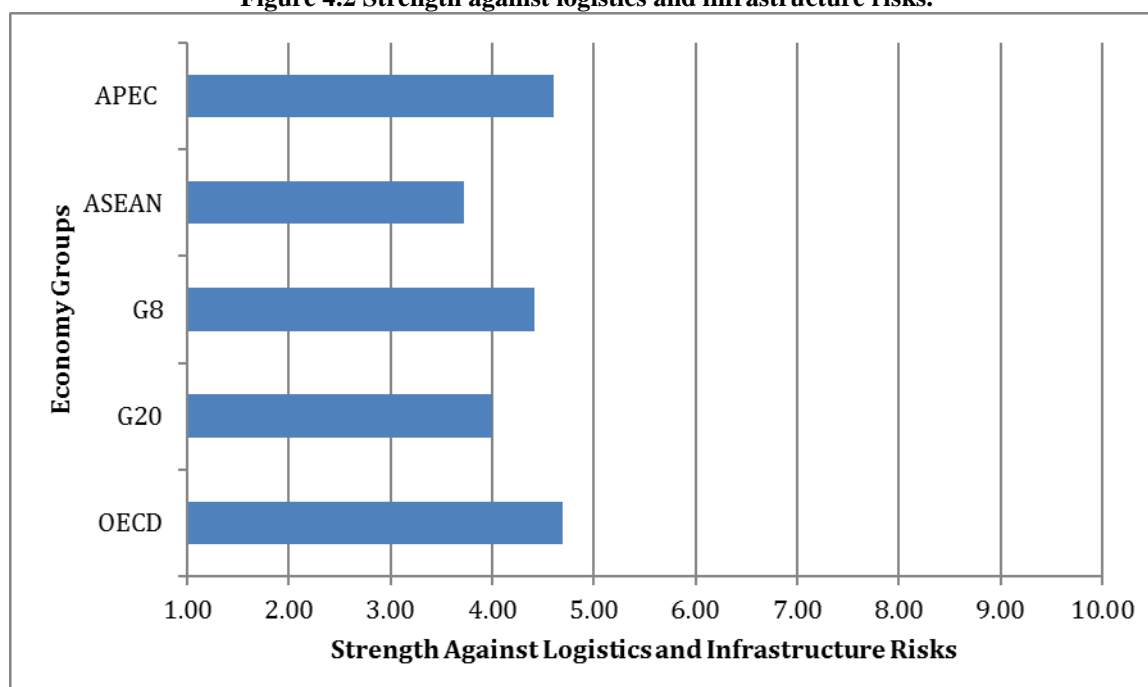
As can be seen from the figure, APEC's performance on strength against natural disaster risks is very encouraging, and comparable to that of the G-20. The only groups that have significantly higher scores are the OECD and the G-8, both of which only contain developed economies. Indeed, developed APEC economies have a very high average score of 8.5, which is the same as that of the G-8. Developing APEC economies have a noticeably lower average score, which indicates that there is still significant room for boosting performance in this area. Nonetheless, APEC's score is significantly higher than that of ASEAN, which indicates better performance in relation to this dimension of Value Chain Strength.

Given the prevalence of natural disaster risks in the Asia-Pacific region, developing strength and resilience in the face of such problems is an important aspect of overall value chain strength. It is also an issue that is discussed further in the context of the case studies presented in Chapter 5. The Phase One report of this project found that some economies in the Asia-Pacific are particularly prone to natural disaster risks, such as earthquakes. However, the findings of this phase suggest that those economies have generally developed strong systems to deal with such risks. As a result, the disruption caused by the occurrence of natural disasters is minimized, and value chains are able to resume operations within a relatively short time period—a feature that is brought out clearly in the case studies in Chapter 5.

## STRENGTH AGAINST LOGISTICS AND INFRASTRUCTURE RISKS

The index for this category of Value Chain Strength is the simple average of the following indicators: the LPI timeliness of delivery indicator; the LPI competence and quality of logistics services indicator; road network length per unit population; rail network length per unit population; air transport freight per unit population; and container port traffic per unit population. Figure 4.2 presents results in comparative perspective.

Figure 4.2 Strength against logistics and infrastructure risks.



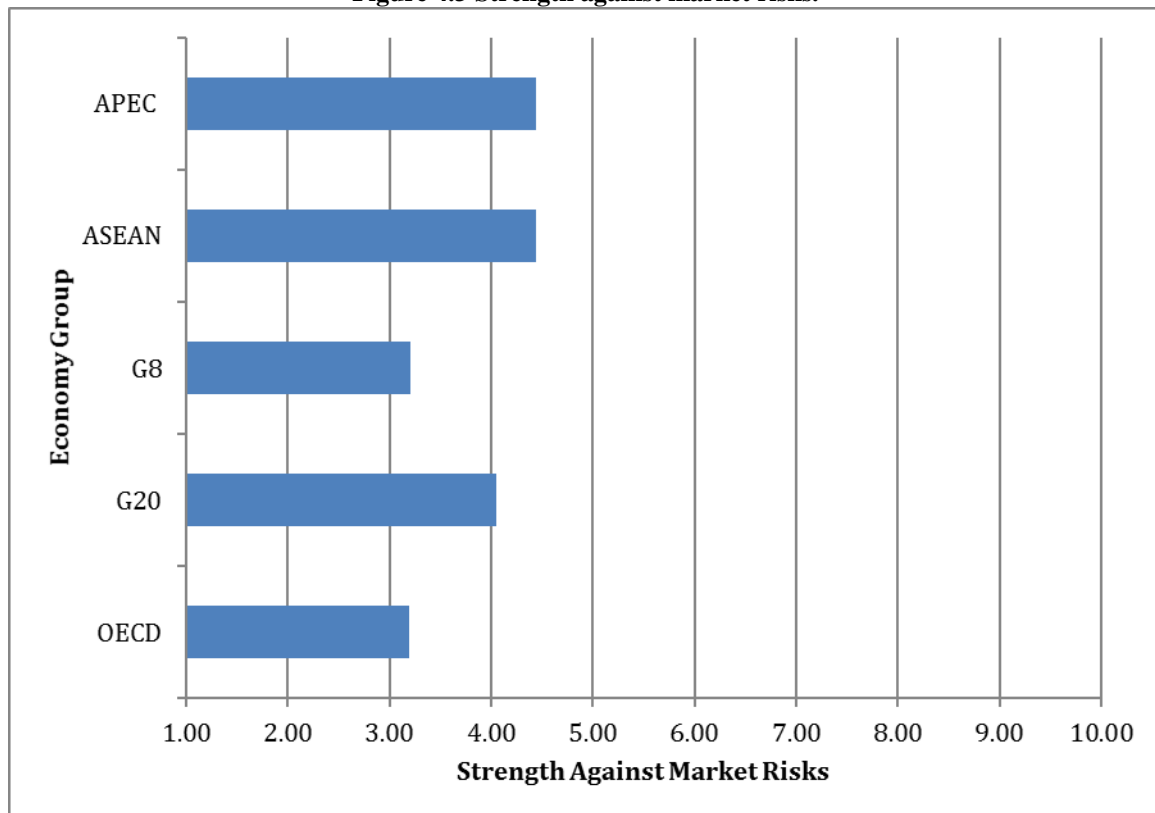
Source: Authors' calculations.

Performance in this area of Value Chain Strength is considerably more uniform across economy groups than strength against natural disaster risks, which displayed a significant level of variation. APEC's performance is, however, very strong despite its heterogeneity in terms of development level within the group of member economies: its score is only slightly below that of the OECD, and is higher than that of the G-8 developed economies. Importantly, both developed and developing APEC economies are strong performers, with a score of 5.1 for the former and 4.5 for the latter. Developing APEC economies exhibit a slightly higher level of value chain strength in this area than the G-8 group of developed economies, which is a remarkable result. The conclusion to be drawn is that logistics processes are particularly well developed in APEC, and they are capable of effectively managing the many risks that arise when moving goods across borders. This high level of performance is very positive in terms of overall value chain strength in the region.

### STRENGTH AGAINST MARKET RISKS

This category of Value Chain Strength is calculated as the simple average of the following proxy indicators: market capitalization of listed companies as a percentage of GDP; bank capital to assets ratio; the cash surplus/deficit as a percentage of GDP; the inverse of central government debt as a percentage of GDP; and total reserves in months of imports. Comparative results are in Figure 4.3.

Figure 4.3 Strength against market risks.



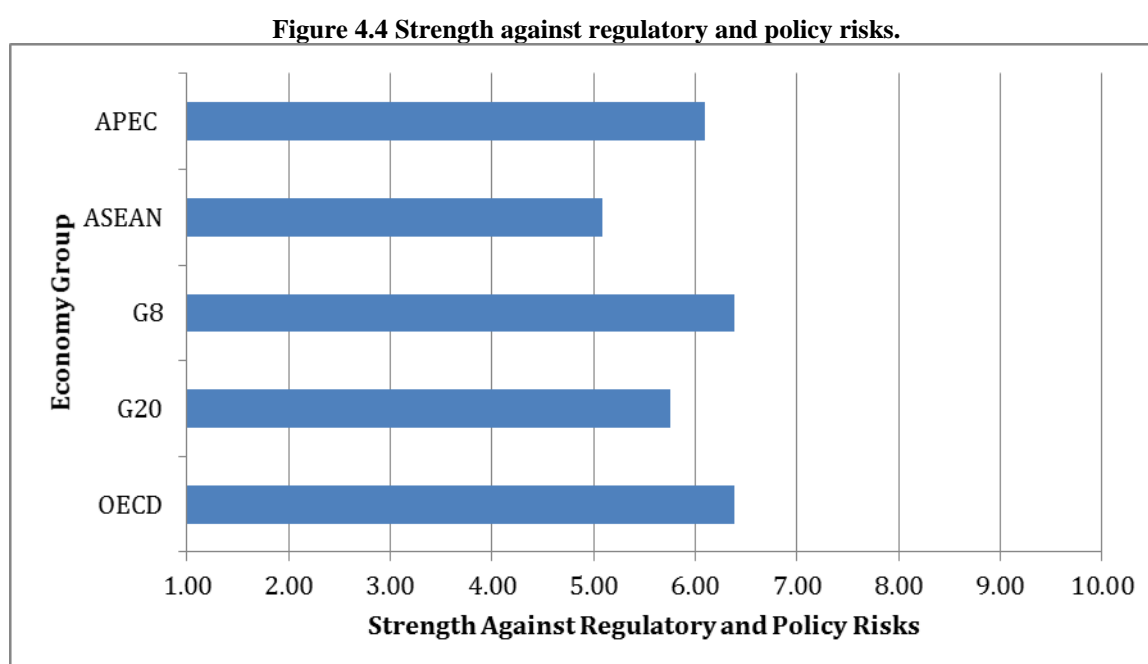
Source: Authors' calculations.

As in the case of strength against logistics and infrastructure risks, APEC's performance in this area of Value Chain Strength is impressive. Indeed, its index number is higher than either the G-8 or the OECD groups of developed economies, as well as that of the G-20, which is a mixed group in terms of development level. Part of the reason for APEC's strong performance is that government finances around the region are in a relatively strong position

despite the Global Financial Crisis of 2008-2009, and subsequent recovery. Conditions have been very challenging in many developed economies, which has led to higher levels of debt and budget deficits. However, government finances in much of the Asia-Pacific have remained strong. In addition, Asia's experience of currency crises in the past has led governments to maintain high levels of reserves, which is another positive factor in terms of strength against market risks.

### **STRENGTH AGAINST REGULATORY AND POLICY RISKS**

Value Chain Strength in relation to regulatory and policy risks is measured as the simple average of the following series: the rule of law index; the index of the efficiency of the legal system in settling disputes; the efficiency of the legal system in challenging regulation; the strength of auditing and accounting standards; and the strength of investor protection. Comparative results are presented in Figure 4.4.



*Source: Authors' calculations.*

Results again indicate the APEC is a strong performer in this dimension of Value Chain Strength. Its score is comparable to, albeit slightly lower than, those of the G-8 and the OECD groups of developed economies. This is a strong result, given that APEC's member economies are much more heterogeneous in terms of their level of development. Indeed, developed APEC economies have the highest score of any group in this area (7.9), and the score of developing member economies (6.0) is still very strong. APEC's overall performance is considerably better than that of ASEAN, and even the G-20 group of major economies. In terms of interpretation, the conclusion is again that Value Chain Strength in the APEC region is well developed, and deals effectively with the various regulatory and policy risks that confront operators on the ground.

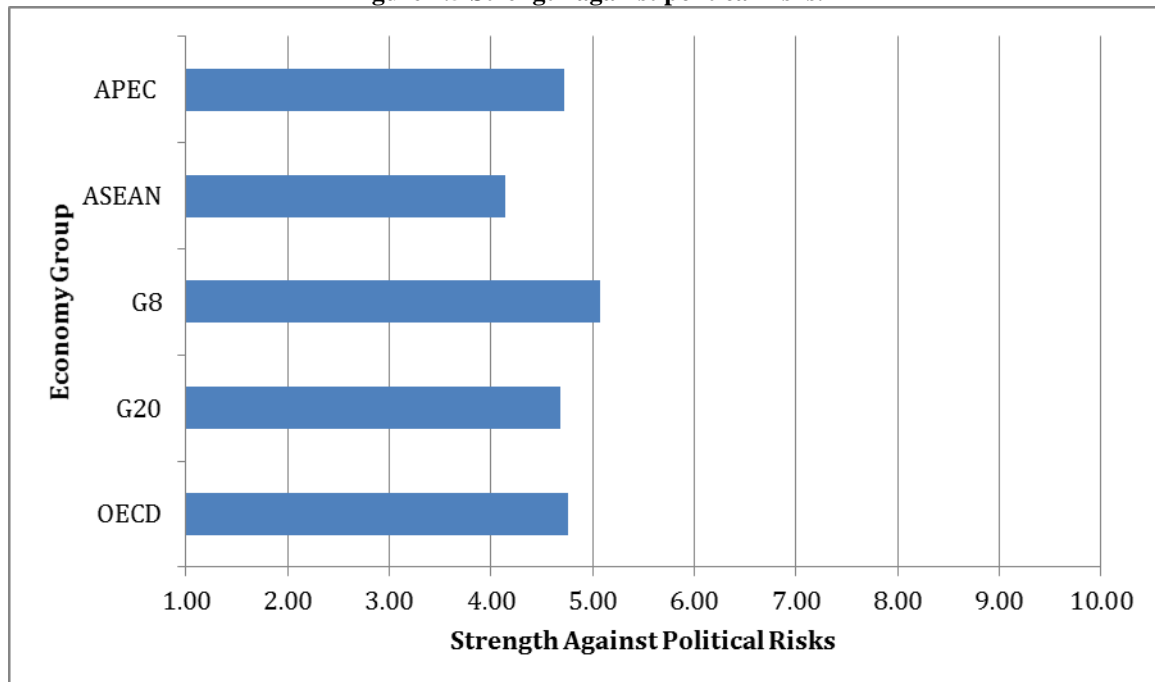
### **STRENGTH AGAINST POLITICAL RISKS**

The fifth and final category of Value Chain Strength is strength against political risks. This index is a simple average of the following indicators: the number of police officers per unit



population; military expenditure as a percentage of GDP; and an index of the reliability of police officers. Comparative results are in Figure 4.5.

**Figure 4.5 Strength against political risks.**

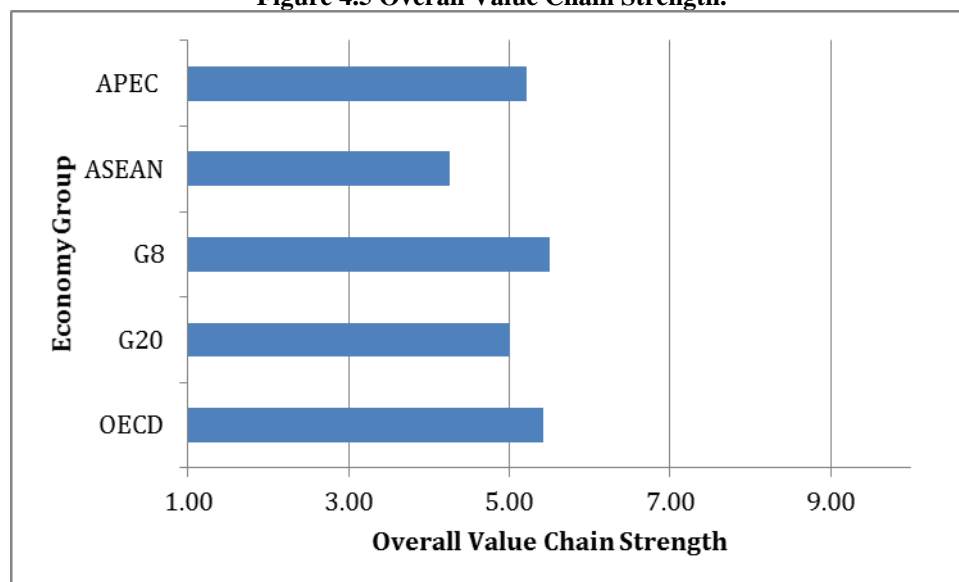


*Source: Authors' calculations.*

Performance in this dimension of Value Chain Strength is again strong in APEC. APEC's average score is comparable to the G-20 and OECD comparator groups, and is only slightly less than that of the G-8. It is noticeably higher than ASEAN's average score. Developed APEC economies have a score (5.0) that is very close to that of the G-8 (5.1), and developing member economies perform only slightly less impressively (4.7).

## **OVERALL VALUE CHAIN STRENGTH**

As set out in the previous chapter, the overall Value Chain Strength index is the simple average of the five categories discussed above. Results are in Figure 5.6, with the same comparator groups as elsewhere in this chapter.

**Figure 4.5 Overall Value Chain Strength.**

Source: Authors' calculations.

In light of the strong results of APEC in each of the Value Chain Strength categories, it is unsurprising that the region's overall index score is also strong: it is higher than the scores of the G-20 and ASEAN, and comparable to the OECD and G-8 developed economy groups. Developed APEC economies have the highest score of any group in these data (5.8), and developing member economies have a score (5.1) that is higher than that of the G-20 and ASEAN.

These results therefore strongly suggest that APEC is performing well in the area of Value Chain Strength. They are an important complement to the results of Phase One of this project, which showed that significant levels of Value Chain Risk pertain in the region. Despite this risk profile, the region has performed well in meeting the challenge, and putting in place public and private systems to manage such risks effectively, and minimize the negative impacts of their occurrence. The data present consistent evidence that APEC provides a supportive environment for the establishment and development of value chains. Indeed, the Asia-Pacific is well-known as the home of successful value chains, particularly in sectors such as electronic goods and automobiles. The success of these business models owes much to the way in which the private and public sectors have managed the risks inherent in operating a value chain structure.

## 5. CASE STUDIES

The quantitative analysis in the previous chapter provides a general overview of Value Chain Strength in the APEC region in comparison with other economic groupings around the world. It focused primarily on public sector measures, which provide the backdrop for private sector actions that maintain the functioning of value chains in the face of the occurrence of major risks.

This chapter complements the previous one with case studies that use value chain analysis to look at the impact of recent crises that affected either the global economy (case study 1: the global financial crisis of 2008-09) or individual APEC economies (case studies 2 and 3: the Thailand floods and Japan earthquake of 2011). In particular, the case studies look at the factors of resilience and disruption that have shaped the effects and the responses to the crises. Of course, the case studies are selective and do not include all examples of APEC economies responding to significant shocks.

For example, Chile has developed the capacity to respond very rapidly to the occurrence of natural disaster risks, such as earthquakes. After a recent event, port traffic was only interrupted for a very short time, and returned to normal almost immediately. An assessment from the International Monetary Fund team noted that: “Chile’s economy has recovered rapidly from the global financial crisis and the February 2010 earthquake. Its resilience was underpinned by solid policy frameworks (including a fiscal rule, inflation targeting and exchange rate flexibility), a sound banking system and a strong policy response, facilitated by the existence of large fiscal buffers.” (Hong 2014:7).

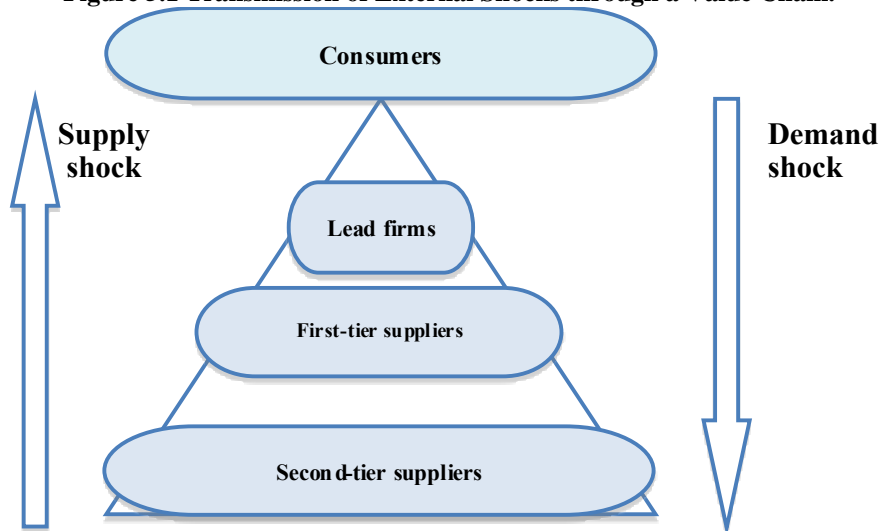
Like the examples used for the case studies, this event is an instance of APEC value chains showing strength in the face of risk, and is a feature of many business models and their public sector supporting structures in the region.

With a view to drawing policy conclusions about value chain resilience, it is important to identify not only the nature of the risk (market risk for case study 1 and natural disaster risk for case studies 2 and 3) but also the segment of the value chain that was affected in the first place. Indeed, the case studies reveal that a number of factors affect the resilience of the value chain to a shock, including:

- Type of governance of the value chain: resilience is enhanced when firms transfer specific resources—financial capital, human capital, or knowledge—to their partners, including related firms within the same overall organization.
- Sector and specificity of the products or services traded: products that are “modular” are more standardized across suppliers, which means that production can be shifted relatively easily from one supplier to another following a disruption. In that sense, product modularity determines value chain modularity.
- Type of lead firms: global buyers shift production faster than global manufacturers.
- Regulatory environment: the higher the level of integration among economies, the less subject they are to protectionist responses to crises. In this sense, the regulatory environment—which includes an ongoing commitment to free and open trade and investment flows—is a key determinant of value chain resilience following disruptions.

Demand shocks should be distinguished from supply shocks, although a shock at a given point of the chain is simultaneously a supply shock for downstream firms and a demand shock for upstream firms (Figure 5.1). Another important distinction relates to the resilience of a value chain versus the resilience of particular firms within it. Modularity is an important characteristic of some value chains, in the sense that component parts are subject to standardization practices that make it possible to acquire them from multiple sources. As a result, a disruption to a value chain can cause a lead firm to shift part of its supply process to another firm that is not subject to the disruption (what economists call an adjustment at the intensive margin) or to shift all of its supply process to an unaffected firm, thus cutting the old firm out of the value chain entirely (an adjustment at the extensive margin). Adjustments following disruptions can also be made through consolidation, i.e. shortening the length of the value chain, in the sense of reducing the number of intermediate links between suppliers and consumers.

**Figure 5.1 Transmission of External Shocks through a Value Chain.**



*Source: Authors.*

## **THE GLOBAL FINANCIAL CRISIS (2008-09): DEMAND SHOCKS AND RESILIENCE TO MARKET RISKS**

### **Description of the Shock**

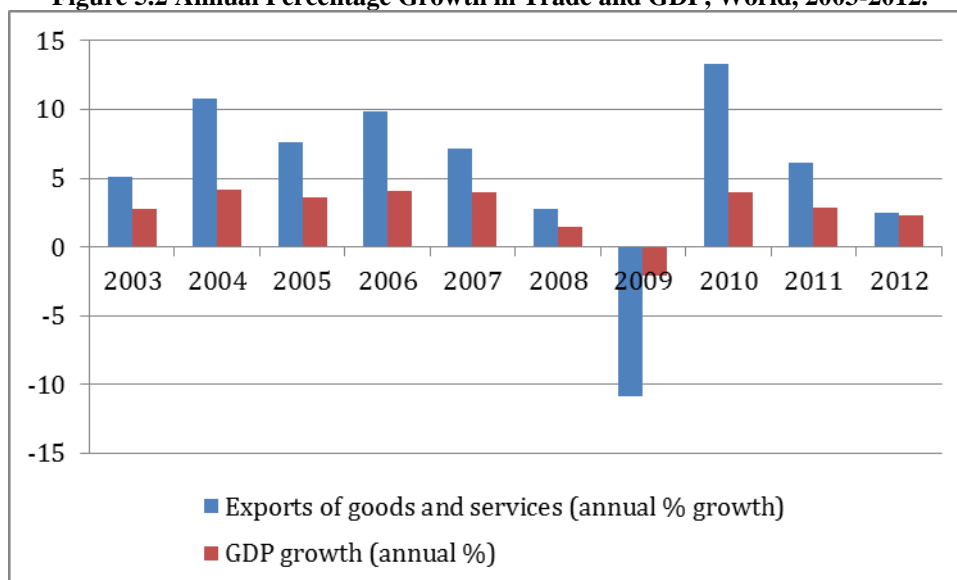
The global financial crisis (GFC) of 2008-09 was the most severe economic crisis in modern history, often compared in seriousness and potential for economic distress to the Great Depression of the 1930s. The economic downturn started with the bursting of the U.S. housing bubble in 2007 that translated into a liquidity crisis, the collapse of large financial institutions, the bailout of banks by national governments, and downturns in stock markets around the world. The financial crisis turned into an economic and social crisis with the failure of key businesses, massive layoffs, and declines in consumer wealth estimated in USD trillions.

According to the World Bank, for the first time since the Great Depression, the world's GDP dropped by 2.2 percent in 2009, with a sharp 3.3 percent decline in developed economies and a deceleration of growth in developing economies from 5.6 percent in 2008 to 1.2 percent in 2009 (World Bank, 2010). Net private capital flows fell by nearly 70 percent from their record high in 2007. Global unemployment increased by more than 30 million in 2009, to reach 200 million unemployed (Jansen and von Uexkull, 2010), and an additional 64 million people lived in extreme poverty at the end of 2009 as a result of the crisis (World Bank, 2010).

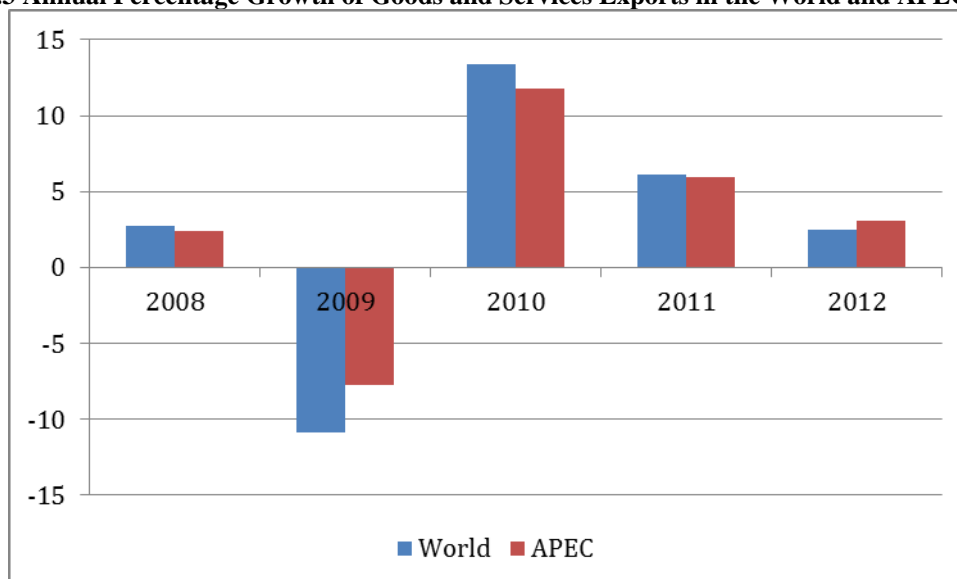
The GFC was a perfect illustration of a large-scale shock associated with a market risk. The GFC was a demand shock: consumption in main markets like the U.S. and Europe dropped as a result of the recession, and lead firms headquartered in those economies reduced their demand to upstream suppliers accordingly. The GFC was also a supply shock: major producers in key value chains (e.g., in the automotive industry) went bankrupt, and liquidity problems impaired trade operations with an estimated trade finance gap that peaked at \$300 billion in late 2008 (Chauffour and Malouche, 2011).

### **Trade Impact of the GFC**

The GFC underscored the importance of value chains in the world economy. International trade was at the same time a casualty and a main transmission channel of the crisis (Cattaneo et al., 2010). The effect of the crisis on trade was even more pronounced than on GDP (Figure 5.2), with sharp 11% and 7.7% declines in trade volumes in 2009 in the world and APEC respectively (Figure 5.3).

**Figure 5.2 Annual Percentage Growth in Trade and GDP, World, 2003-2012.**

Source: World Development Indicators.

**Figure 5.3 Annual Percentage Growth of Goods and Services Exports in the World and APEC, 2008-12.**

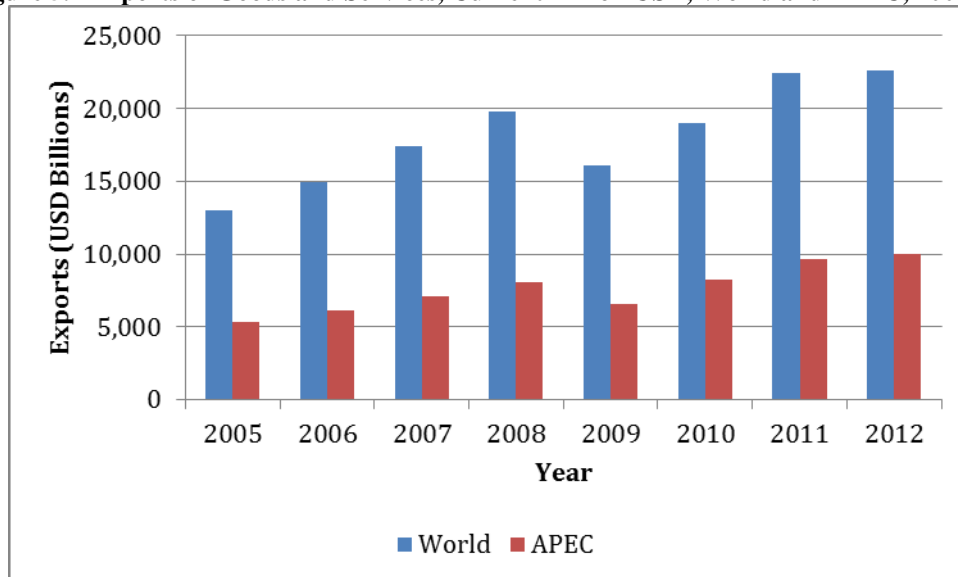
Source: World Development Indicators, and authors' calculations.

The prevalence of value chains in global business operations could partially explain the high level of reactivity of trade to the financial crisis. Because of value chains, adverse shocks affect firms not only through their sales of finished goods (final demand), but also through fluctuations in the supply and demand of intermediate goods via forward and backward linkages in value chains. The so-called “bullwhip effect” characterizes a faster drop of intra-chain trade followed by a faster recovery than arm's length trade that could be attributed to the adjustment of inventories within supply chains (Altomonte et al., 2011). Thus, the elasticity of global trade volumes to real world GDP has increased gradually from around two in the 1960's to above three in recent years, driven by production sharing arrangements in value chains (Escaith et al., 2010; Milberg and Winkler, 2010; and Freund, 2009). The “crisis elasticity” of trade has increased over the years, and trade adjustment is not only larger but also faster than it used to be, because lead firms can immediately adjust their production (down in time of crisis, and up in time of recovery) in response to changes in market demand.

Trade was also a transmission channel of the crisis because an increasing number of economies have relied in recent decades on exports to sustain economic growth and development: exports as a share of low- and middle-income economies' GDP grew from just 10 percent in 1970 to 33 percent in 2007 (Milberg and Winkler, 2010). Exposure to external shocks symmetrically increased, in particular for those economies highly dependent on exports to the U.S. and E.U.—the economies most affected by the crisis.

Trade and value chains were not only transmission channels for the crisis, however. They were also central elements of resilience and recovery. Historically, trade flows are procyclical and follow a more exaggerated cyclical pattern than GDP: the same way trade declined far more than GDP, world trade rebounded faster and higher than world GDP (Figure 5.2). Value chains not only increased the “crisis elasticity” of trade, but also its capacity to recover from shocks: compared to the observed four years needed for trade to pass the pre-downturn level in previous crises (Freund, 2009), it took trade less than a year in APEC and two years in the world to pass its 2008 level (Figure 5.4).

**Figure 5.4 Exports of Goods and Services, Current Billion USD, World and APEC, 2005-12.**



Source: World Development Indicators, and authors' calculations.

Trade patterns and reactions to the crisis were relatively homogeneous in APEC, albeit with some differences in the magnitude of the shock and recovery: for example, while exports dropped by 26% in Japan in 2009, they dropped by only 9% in Viet Nam. Most APEC economies had recovered their 2008 trade level by 2010, with the exceptions of Brunei Darussalam, Canada, Japan, the Russian Federation, and the U.S. In 2012, three APEC economies had a trade level more than 40% higher than their 2008 level, namely Viet Nam (+83%), Peru (+47%), and China (+43%); and eleven economies had a trade level between 20% and 40% higher than their 2008 level. On average, the 2012 trade level in APEC was 26% higher than the pre-crisis level.

A finer analysis of trade flows at the sectoral level shows very similar trade patterns across sectors. The iron and steel sector is the only one that had not recovered its pre-crisis level three years after the downturn, probably due to the drop in price of those commodities (a price rather than volume effect). It appears nonetheless that the demand for “postponable goods” dropped faster during the crisis, because consumers could delay their purchases (e.g.,

electronics, and automobiles); on the contrary, sectors like clothing, pharmaceuticals, and food were less affected by the shock. Services trade, especially of business services, also remained relatively unaffected, due in particular to the non-storability of services, and the fact that a larger part of services demand involves outsourced services (for example book-keeping) that are necessities for producers (Borchert and Mattoo, 2009).

In sum, value chains seem to amplify trade adjustments in times of crisis, and increase longer-term trade resilience to systemic risks. From a policy perspective, participation in value chains has also been an important factor of resilience: by increasing the cost of protectionism, trade in intermediates and value chains have helped avoid a repetition of the “historic mistakes of protectionism of previous eras” (G20 London Declaration of 2009; Gawande et al., 2014). Recovery was neither impaired nor delayed by the diffusion of protectionist measures in economies participating in value chains (Evenett et al., 2009).

### **Factors of Value Chain Disruption**

The drop in consumer wealth resulting from the GFC had two effects: first, a drop in demand, where consumers could postpone their purchases; and second, a search for lower priced goods or services, where consumers could not postpone their purchases (Cattaneo et al., 2010). The substitution effect created new opportunities for producers with lower production costs. This effect could explain, for example, the record sales of Walmart and the vitality of some Chinese exports during the crisis. In the mobile phone sector, the lack of low-end product lines offered by traditional lead firms resulted in a shift in demand towards Chinese handsets (Sturgeon and Kawakami, 2010). In the automotive sector, lead firms in the US increased sourcing in Mexico in the wake of the crisis to cut costs (Van Biesebroek and Sturgeon, 2010). In the apparel industry, low-cost Asian producers (including China, Indonesia, and Vietnam) have increased their market shares at the expense of regional sourcing economies for the U.S. and the E.U. (Gereffi and Frederick, 2010). In the services sector, some firms froze offshore contracts while others outsourced additional services in order to lower their costs and remain competitive (Gereffi and Fernandez-Stark, 2010).

Overall, the GFC revealed that the demand effect was more important than the substitution effect, and value chains proved resilient: demand for high quality goods rebounded (with record profits, for example, in the luxury sector) at the same time as demand for lower priced goods consolidated.

Closely related to the substitution effect is the shift in markets to the South: with the drop in demand in the most developed economies affected by the crisis, large developing economies became prime targets for both exporters in the North and the South. For example, in the apparel sector, leading suppliers like China, as well as other economies, concerned about a demand slowdown caused by the GFC, have begun to focus more on sales on their domestic markets or alternative export markets, such as the Russian Federation (Gereffi and Frederick, 2010). As a result, South-South trade increased significantly to represent 50% of world intermediate goods trade in 2009, compared to about 25% in 2000 (Milberg and Winkler, 2010). Lead firms in the North also re-oriented their expansion strategies: for example, in the apparel sector, the Spanish leader Inditex (Zara) improved its performance in 2009 amidst the crisis by opening new retail outlets in economies like China, the Republic of Korea, and Russia – the share of Asia in the group’s sales doubled between 2008 and 2012, with 40% of new store openings.



The shift in the center of gravity of global demand could have important disruption effects in value chains. First, lead firms could move to emerging markets, threatening the survival of old value chains. For example, in the automobile sector, the GFC has accelerated a historic shift within the industry, and some predict a permanent decline in mature markets and the emergence China and other developing economies as market leaders (Sturgeon and Van Biesebroek, 2010). Second, the characteristics of products in demand in those emerging markets are different (consumer preferences): for example, product differentiation based on variety and quality matters less, and some economies like China have a preference for relatively unprocessed products. Suppliers that had upgraded to meet the highest standards and perform higher value-added tasks could lose their position in value chains. For example, a transformation industry in Thailand (cassava) has been wiped out by the shift in demand from the U.S./E.U. to China (Kaplinsky et al., 2010).

Consolidation of value chains is the last disruptive effect that prolonged the shift in end markets and production center of gravity. Consolidation refers to the movement of simplification of value chains that has been underway since the 1990s in many industries, and which was accelerated by the GFC (by contrast with the movement towards dispersion and increasing complexity of value chains that had characterized previous decades). Prior to the GFC, consolidation had started in the handbag, apparel, and footwear industries; the crisis prompted further consolidation in textiles, iron and steel, machinery, and transportation equipment (Milberg and Winkler, 2010).

Consolidation not only takes place at the geographical level, but also at the firm level. There is a tendency on the part of lead firms to prefer larger, more capable, globally operating, first-tier suppliers. This can be observed in the apparel, automobile, and electronics sectors. The GFC prompted lead firms to consolidate their supply bases further and focus on big, well-established companies with whom they have ongoing strategic relationships, causing the elimination and shutdown of marginal suppliers, and asymmetric buying patterns after recovery. This also corresponds to “task bundling” in value chains (Lanz et al., 2011). For example, in the apparel industry, lead firms now require full-package services (from design to distribution), putting economies providing only assembly services (cut, make, and trim) at a severe disadvantage for future participation in value chains (Gereffi and Frederick 2010).

### **Factors of Value Chain Resilience**

Although trade volumes rebounded relatively symmetrically across sectors, with differences in magnitude mainly explained by the nature of the goods and services and the possibility for the consumers to postpone (or not) their purchases, the impact on the shape of value chains varied from sector to sector: value chain consolidation took place in specific sectors, and so did substitution effects. The update of the OECD/WTO Trade in Value-Added (TiVA) database should help determine more precisely which sectoral value chains have most changed shape as a result of the crisis (e.g., by looking at the length of the value chains and the number of domestic and international production stages before and after the crisis).

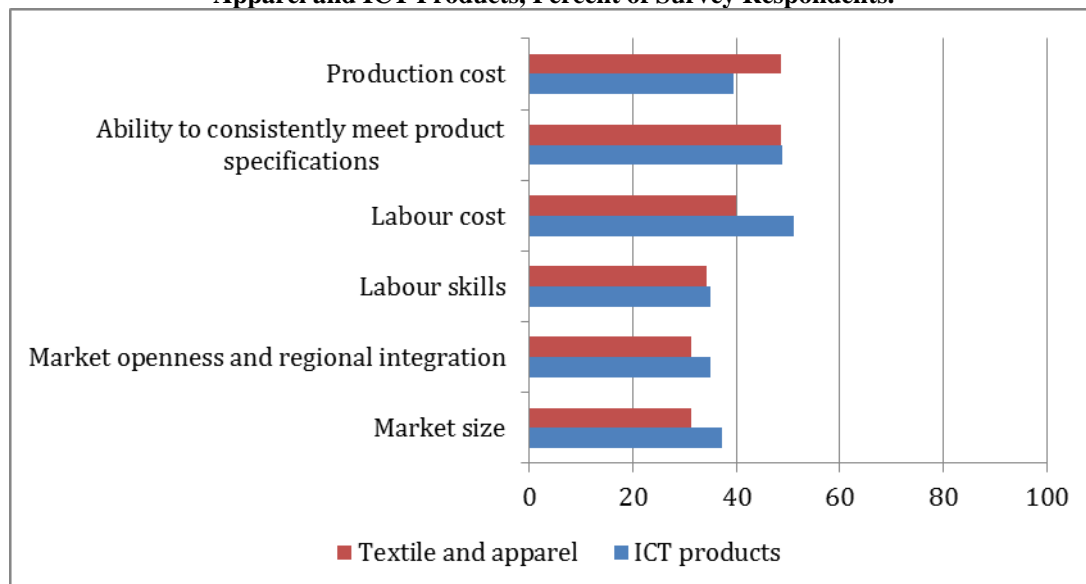
In the meantime, some explanations have been put forward to explain the different structural effects of the GFC. For example, the modularity of products could explain the greater resilience or fragility of certain value chains: where products are easily substitutable, value chain disruptions (i.e., shifts in production from one economy to another) are more likely to happen. This is the case in the electronics industry where high “product modularity” translated into high “value chain modularity”, in which multiple firms can contribute to the

realization of specific products, and where component producers and other firms in the value chain can be substituted without a need for thoroughgoing engineering changes (Sturgeon and Kawakami, 2010).

In addition to product specificity, different economies experienced different effects because of their own specific characteristics. Not all economies are equally exposed to value chain disruption risks. The same way products are more or less substitutable, economies are more or less substitutable in value chains. Factors of strength and weakness include:

- *Value added and innovation.* The strategic position or value added by the economy in the chain is an important factor in explaining the effects of a shock. For example, in the electronics sector, Sturgeon and Kawakami (2010) identified “pinch points” in the value chain with three principal actors: lead firms, contract manufacturers, and platform leaders; shocks affecting those pinch points and key actors are more likely to have a disruptive effect than shocks affecting other actors. They also note that an economy’s capacity to innovate remains an important guarantee of “survival” in value chains: the higher the skills or expertise of the supplier, the less substitutable it is. Moreover, a number of factors explain a lead firm’s decision to invest in an economy and have it join its value chain (Figure 5.5); depending on the comparative advantage of the supplier, a shock affecting one or the other of those factors might not affect the general attractiveness of the economy.

**Figure 5.5. Factors Most Positively Affecting Lead Firms’ Decision to Invest in an Economy, Textiles and Apparel and ICT Products, Percent of Survey Respondents.**

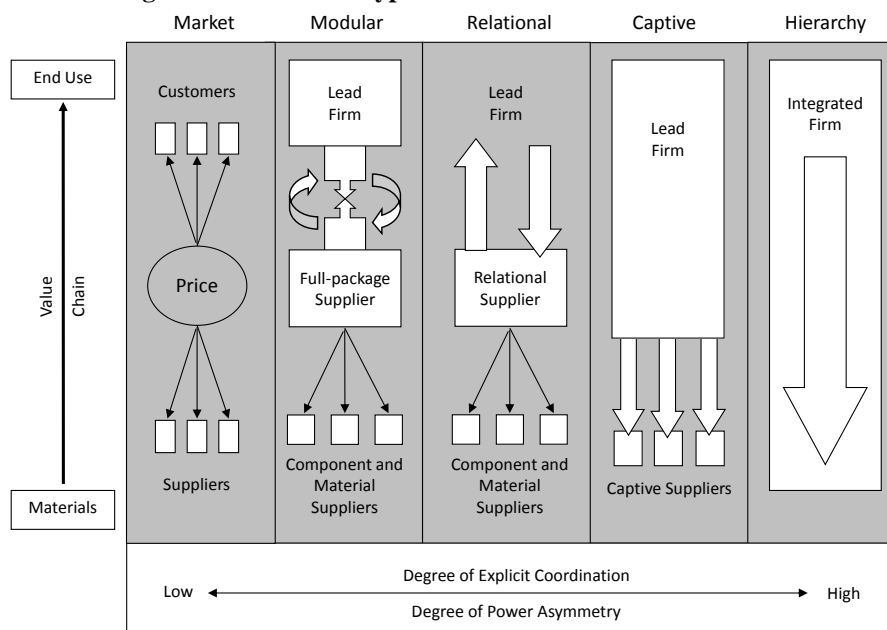


Source: WTO-OECD (2013).

- *Domestic market size.* As illustrated by Figure 5.5, the size of the domestic market is often a critical factor in the investment decision for lead firms. An economy with a large domestic market is therefore less exposed to lead firms’ decisions to shift production (as a result of a substitution or consolidation process) after a shock. On the contrary, in the case of the GFC, the role of large emerging economies in value chains has increased as a result of the shock due to the combined effect of lead firms focusing on emerging markets, and local firms lessening their dependence on traditional exporting markets and focusing on sales in their domestic markets.

Beyond factors that are specific to each economy and sector, including modularity as discussed above, the governance of the value chain is in itself a key determinant of its resilience. Gereffi distinguishes five types of value chain governance on the basis of their level of integration and the nature of relationships among the participants in the chain (Figure 5.6). Analysis suggests that the resilience of value chains to the GFC increased with their level of integration (Altomonte et al., 2012). Resilience has also been greater in value chains where the lead firm was a global manufacturer as opposed to a global buyer (Cattaneo et al., 2010). Resilience could be proportional to the level of transfers effectuated within the chain: these could include seed capital (and infrastructure), technology, knowledge/skills, knowhow, etc. Evidence suggests that value chains are a channel of socio-economic upgrading in developing economies (Staritz et al., 2011): a company that invested in training, standards upgrading, or technology appropriation is less likely to shift production as fast as a company trading at arm's length.

**Figure 5.6. Different Types of Governance in Value Chains.**



Source: Gereffi and Starck-Fernandez (2011).

The GFC has also provided examples of solidarity within value chains that could increase resilience to a shock, but also differ according to the lead firm's strategy. For example, support from some lead firms and large intermediaries in some cases helped remedy trade finance shortages and to mitigate liquidity shortages. This was the case in the apparel sector: during the GFC, 41 percent of Kohl's suppliers benefited from its Supply Chain Finance program; Walmart offered about 1,000 suppliers an alternative to their traditional way of financing and launched a Supplier Alliance Program for expediting payments; Li & Fung became a lender of last resort to factories and small importers whose credit was cut off during the crisis.

### Policy Implications of the Value Chain Effects of the GFC

The APEC economies have all been affected by the GFC, with fluctuations of trade flows greater than GDP. However, APEC proved more resilient, on average, than the rest of the world, due to the fact that some of its members benefited from substitution effects, shifts in end markets, and the consolidation of value chains that have been primarily driven by

differences in production costs. APEC also recovered faster, on average, than the rest of the world, with a level of trade on average 30% higher in 2012 compared to 2008.

With a view to increasing resilience to shocks, the case study suggests that an economy needs to increase the differentiation or specificity of its production, and foster intra-chain solidarity and transfers. The main question is whether a shock is likely to affect an economy's attractiveness for lead firms' sourcing and investment. At the economy level, increasing value chain resilience means reinforcing such attractiveness. Looking at the factors most positively and negatively affecting lead firms' sourcing and investment decisions in value chains, it appears that some are exogenous and can hardly be influenced by policy. Other factors, however, could be positively influenced by the right policy decisions and actions. Those factors are set out in detail in Chapter 4, but the most important ones that emerge from this case study include those related to:

- Trade policy: e.g., customs delays and procedures, market access, market openness, restrictions on investment, regional integration, and uncertainty in the trade regime.
- Infrastructure and transport/logistics: e.g., power supply, local utilities, technological base, and transport costs.
- Business environment: e.g., regulatory uncertainty, governance, access to finance and trade finance, conformity with standards, labor skills/laws and practices/costs, investment and tax incentives.

The case study suggests that connecting to GVCs is just a first step. For many economies already involved in global trade in intermediates, the challenge is to remain competitive and maintain their participation in value chains despite rising labor costs and other exogenous factors such as business strategy changes and consolidation of value chains, whether caused by external shocks or not. Increasing resilience to shocks implies increasing an economy's attractiveness for lead firms. This approach could also be supplemented by policies aimed at reinforcing intra-chain solidarity.

## **THAILAND FLOODS (2011): SUPPLY SHOCKS AND RESILIENCE TO NATURAL DISASTER RISKS**

### **Description of the Shock**

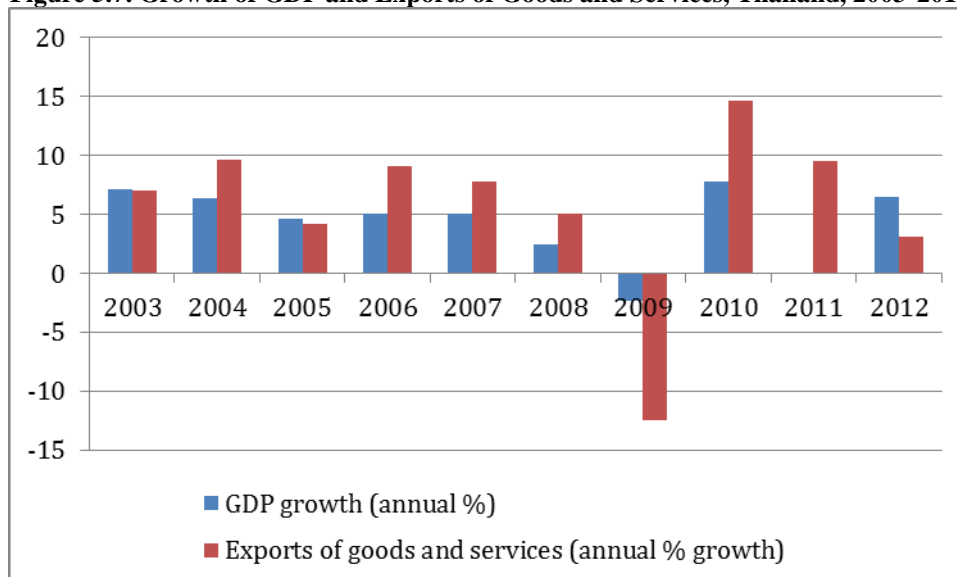
The Thailand floods were the world's fourth costliest natural disaster as of 2011, surpassed only by the 2011 earthquake and tsunami in Japan, the 1995 Kobe earthquake, and Hurricane Katrina in 2005. From July through December 2011, Thailand suffered its worst floods in more than half a century. Caused by excessive and continuous rainfall from successive, powerful monsoons and subsequent, numerous dam breaches, the floods inundated more than 6 million hectares of land and 66 of the economy's 77 provinces, and affected more than 13 million people. The floods resulted in a total of over 800 deaths, along with damage and losses estimated at approximately U.S.\$46.5 billion, with losses accounting for 56% of the total. Rehabilitation and reconstruction needs were estimated at U.S.\$50 billion (World Bank, 2012).

The manufacturing sector bore roughly 70% of the total damage and losses due to the flooding of six industrial estates in Ayuthaya (where a number of Japanese firms are located) and Pathum Thani, from mid-October to November 2011. Severe disruptions to manufacturing value chains affected in particular regional automobile production and the global supply of electronics parts (hard disk drives).

### **Impact of the Thai Floods on Trade**

As a result of the floods, Thailand's GDP growth fell from 7.8% in 2010 to 0.1% in 2011 (Figure 5.7). Compared to the same quarter of the previous year, seasonally adjusted GDP declined by 36.7% in October-December 2011. However, reconstruction boosted GDP, with 6.5% growth in 2012 (World Bank, World Development Indicators).

An analysis by GDP component reveals that net exports (-37.8% compared to the same period the year before) were the largest contributor on the demand side to the negative growth of the October-December 2011 quarter (negative contribution of 6.2%), and the negative growth of the manufacturing sector (-21.6% compared to the same period the year before) was the largest contributor on the supply side (negative contribution of 8.6%). In other words, the disruption of value chains in the manufacturing sector could largely explain the stagnant growth of the economy in 2011 (METI, 2012).

**Figure 5.7. Growth of GDP and Exports of Goods and Services, Thailand, 2003-2012**

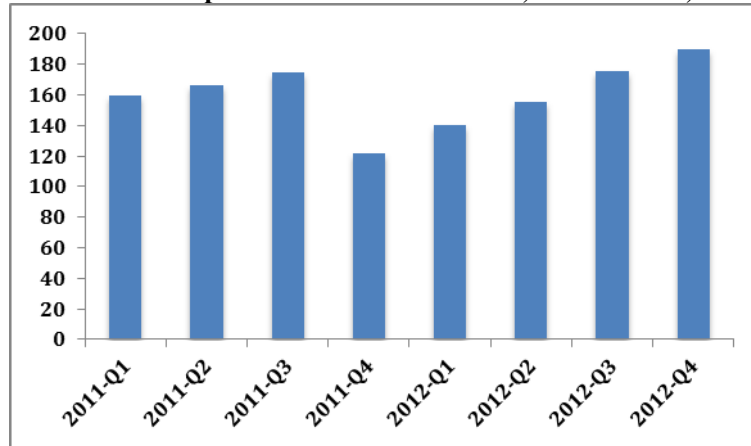
Source: World Development Indicators.

As early as February 2012, Thailand's export growth turned positive again (+0.9% in comparison to the same month the year before). However, due to carry-over effects, goods exports grew by a mere 3% in 2012, i.e. approximately by half the average growth rate for the period 2003-08. Moreover, the current account balance turned negative (U.S.\$-1.4 billion), due to recovery and reconstruction demand that boosted imports.

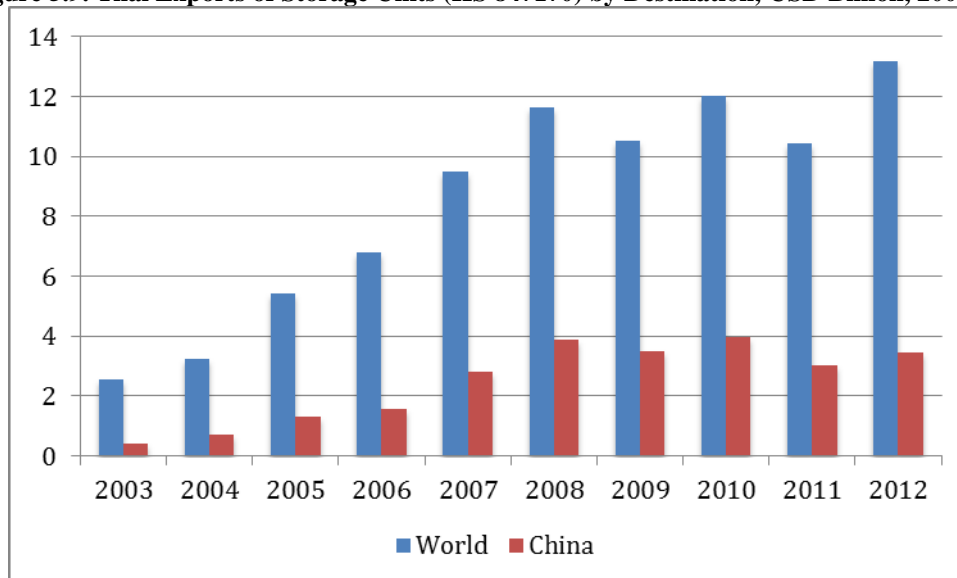
The four main items that experienced a serious downturn due to the shock were: transportation machinery (automotive sector, with a drop in production by 84% in November 2011 compared to the same month a year before), office/electrical equipment (hard disk drives, -77%), information and communication equipment (radios, televisions, -73%), and electric products (air conditioners, refrigerators, -59%). They also happened to be major export items and segments of regional or global value chains.

Through trade and supply chains, damages were not confined to Thailand but spread throughout the region, and in particular to Japan, which had massively invested in some of the affected provinces, and led Thailand's advances in the industry. Half of the companies located in the flooded industrial estates near Ayuthaya were Japanese. Thus, to the direct effects, it is important to add the indirect effects. For example, in the automotive industry, Japanese manufacturers represented 91% of automotive production in Thailand: since Thailand acted as a hub of the parts supply network in the region, the disruption of its production depressed the car manufacturing industry in Japan (METI, 2012). Similarly, the whole computer industry was affected by the shortage and price surge of hard disk drives (reduction of margins on computer producers, and/or rise in consumer prices).

At the time of the shock, Thailand represented 40% of global production of hard disk drives. As a result of the shock, world shipments dropped by 30% during the fourth quarter of 2011 (Figure 5.8). Prices nearly tripled in November 2011 (METI 2012). The floods had a deeper impact on Thai exports of hard disk drives than the 2008-2009 GFC (Figure 5.9).

**Figure 5.8. World Shipments of Hard Disk Drives, Million Units, 2011-2012**

Source: METI (2012) and Fuji Chimera Research Institute (2012).

**Figure 5.9. Thai Exports of Storage Units (HS 847170) by Destination, USD Billion, 2003-12.**

Source: WITS.

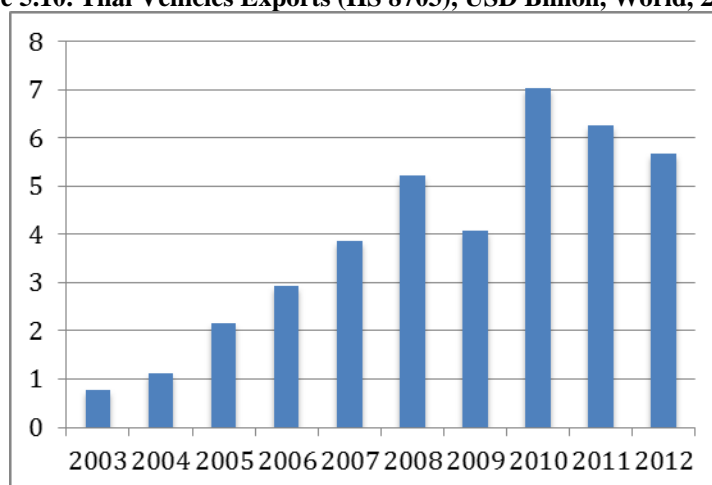
World shipments of hard disk drives recovered their pre-crisis level about a year later, and Thai exports of storage units resumed their growth trend, with a 10 percent increase compared to the 2010 level. The impact on prices was more persistent, however, and by mid-2012, the price of hard disks was still 1.6 times higher than before the shock (METI, 2012).

In addition to electrical equipment like hard disk drives, the automotive sector also strongly felt the effects of the floods. In 2010, Thailand was ranked first in terms of exports (and fourth in terms of production, with about 7% of the world market) of pickup trucks. It also has strong ties with Indonesia, Malaysia, Vietnam, and the Philippines that belong to the same value chains and have intensive exchanges of intermediate goods. For example, Malaysia and Indonesia represented each about 26% of Thailand's exports of intermediate goods in transportation machinery, Vietnam and the Philippines 20% and 14% respectively; Thailand also represented about 42% of the Philippines' exports of intermediate goods in the transportation machinery sector, and 20% for Malaysia (METI, 2012).

The Thai automotive industry faced two shocks in 2011 that were channeled through value chains: a demand shock in the second quarter of year due to the Great Tohoku Earthquake,

and a supply shock in the last quarter of the year due to the floods. The production of vehicles in Thailand dropped dramatically as a result of the floods: in October and November 2011, production fell by, respectively, 68% and 85% compared to the same months the year before. The number of units produced fell in November to the lowest level since 2000 (METI 2012). Figure 5.10 shows that the effect of the shock was still felt in 2012.

**Figure 5.10. Thai Vehicles Exports (HS 8703), USD Billion, World, 2003-12.**

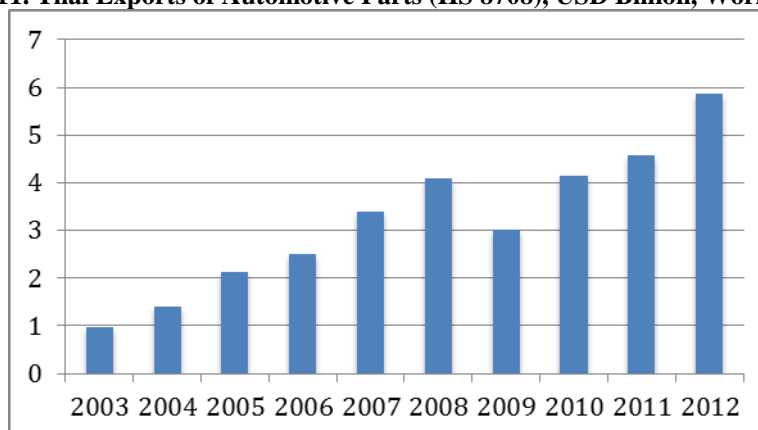


Source: WITS

Looking at the automotive parts industry (automotive parts, engine parts, and integrated circuits – processors, controllers), it appears that both shocks had a similar impact on Thailand's exports. Interestingly, whether the shock was demand or supply-driven, it spread similarly to all the economies in the region (METI, 2012).

Figure 5.11 shows that the floods had a more limited impact on Thai exports of automotive parts than the 2008-2009 GFC. The main effect of the shock was to delay full recovery from the GFC by a year, which goes to show the strong resilience of the value chain. A shift in final demand could also explain these relatively good results, since exports to China increased by over 120% in the quarter following the Great Tohoku Earthquake.

**Figure 5.11. Thai Exports of Automotive Parts (HS 8708), USD Billion, World, 2003-12.**



Source: WITS

The automotive industry rebounded rapidly, with the production of vehicles in Thailand attaining its highest recorded level in March 2012. However, overall, in 2012, gross exports of the industry remained lower than before the shock (but higher than before the 2009 shock).



Recovery from the Great Tohoku Earthquake was immediate for Thai exports of automotive parts. The effects of the floods lasted longer, however, and negative export growth was still observed at the beginning of 2012. Nonetheless, the industry quickly rebounded thereafter with, for example, a 125% increase of integrated circuit exports in March 2012 (METI, 2012). The year 2012 concluded with 28% growth of automotive parts exports from Thailand compared to 2011, and a 41% increase compared to the pre-crisis level.

### Factors of Value Chain Resilience and Disruption

The Thailand case clearly illustrates the variation of value chain resilience on the basis of the level of integration and the type of management of the chain: substitution effects mainly took place in value chains where transactions were made at arm's length (hard disk exports to China), and more integrated chains (automotive industry trade with Japan) better resisted the shock, although the cost of alternative production prompted a number of economies and companies to review their sourcing and risk management strategies.

Across value chains, a number of adjustment mechanisms have come into play after the shock:

- *Market adjustments.* The shortage of supply of certain items like hard disks resulted in a sudden increase in price, and either a reduction in margins for firms down the value chain, or an increase in final sale prices. Delays for order delivery were also increased.
- *Stocks.* The disruption of production led to the rapid depletion of inventory in the affected industries: in the last quarter of 2011, the inventory level dropped by up to 82% for televisions, 90% for integrated circuits, 98% for transistors, 84% for trucks, and 75% for passenger cars (METI, 2012).
- *Alternative production.* Other temporary adjustment mechanisms operated in the most integrated value chains affected by the Thai floods. In response to the disruption in production in Thailand, Japanese firms resorted to temporary alternative production in Japan, third economies, or alternative sites in Thailand. With a view to maintaining the level of production and know-how, a number of Thai employees from the flooded Japanese factories were sent to Japan as temporary workers.

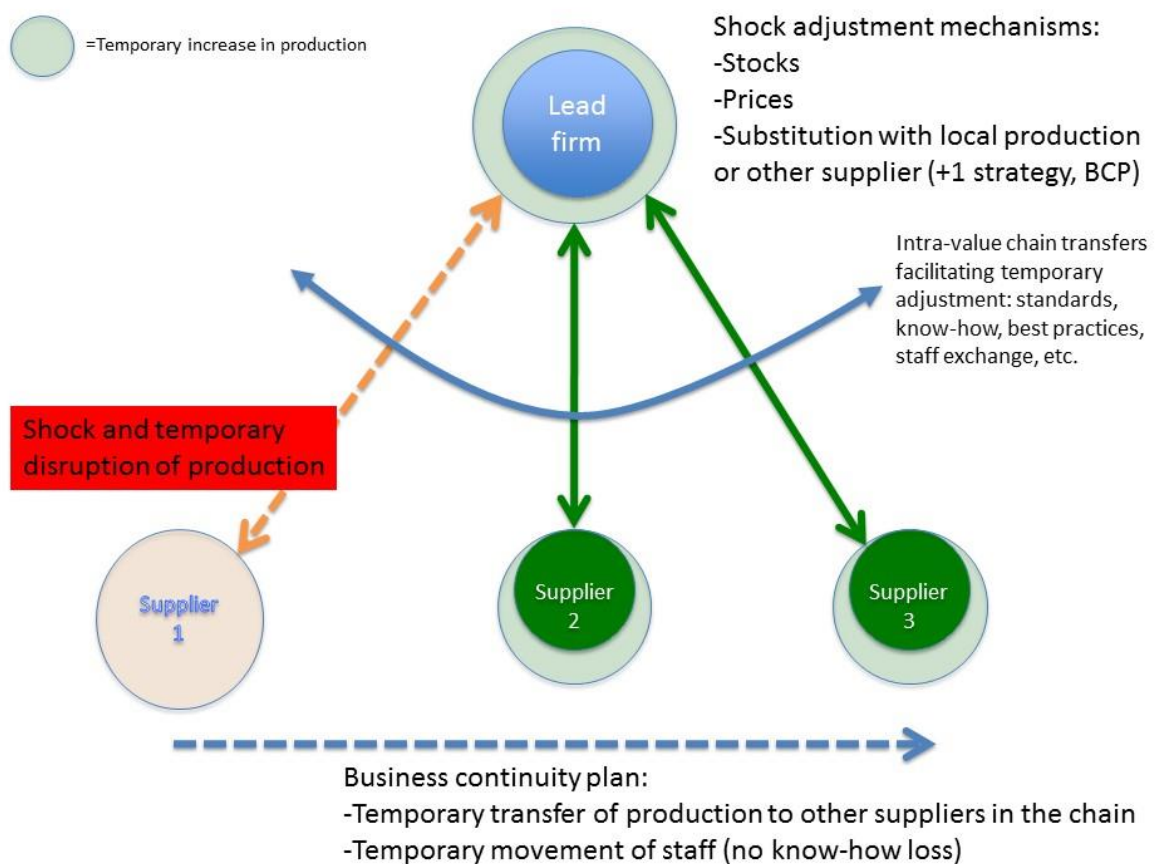
The capacity of a lead firm to develop temporary alternative production schemes depends on the management type of the firm and, in particular, the type of intra-chain transfers that took place (Figure 5.12). One possible role of a host government is to facilitate those transfers with a view to not only increasing the economy's attractiveness for investors and lead firms, but also to increasing the resilience of the economy's participation in value chains. Possible measures include the facilitation of the movement of key personnel, the removal of unnecessary barriers to trade (and non-tariff measures in particular), the harmonization of standards, and other measures (Cattaneo et al., 2013). These outcomes could be achieved through unilateral reforms, as well as through concerted regional action.

Value chains in the electronics sector resisted less than in the automotive industry following the floods. While Thai exports quickly rebounded, a more detailed analysis suggests that some substitution effects took place, reducing Thailand's share in key markets such as China. In spite of the collapse of world hard disk shipments in November 2011, China continued to increase its imports, thereby increasing the share of other economies in the region, such as the Republic of Korea, the Philippines, and Malaysia. In 2012, the level of Thailand's exports of storage units to China was still significantly lower than before the crisis.

The question is whether those substitution effects are temporary or permanent. Here again, the answer depends on a combination of factors pertaining to the specificity of the value chain, the economy, and the sector/products, as was the case for the case study 1 on the GFC:

- *Sector/product specificity.* Substitution effects and value chain disruptions mainly took place in the electronics industry where the modularity of products is highest. The risk of permanently losing market share as a result of a shock is therefore higher.
- *Value chain specificity.* Although Japanese-led value chains in the automotive sector proved resistant to the shock and found temporary alternative production methods, arm's length trade of electronics (in the case of Hard Drive) with China proved less resistant. Resilience of the value chain proved proportional to the governance of the chain and the amount/quality of transfers (investment, training, upgrading, etc.) that took place between the lead firm and the suppliers prior to the shock.
- *Economy specificity.* Thailand has become an important production base for Japanese manufacturing companies, and the floods did not profoundly affect the economy's attractiveness as an investment destination of choice (METI, 2012). Indeed, the economy's attractiveness is based on a number of factors, including its market growth potential, its labor supply, its institutional infrastructure, its supply base, and security aspects that remained largely untouched; only the physical infrastructure was damaged. This finding is confirmed by a number of surveys that demonstrate the continuous appeal of Thailand for foreign investors and lead firms (METI, 2012).

**Figure 5.12. Value Chain Resilience during the Thai Floods.**



Source: Authors.

### **Policy Implications of the Value Chain Effects of the Thai Floods**

The longer-term effects of the 2011 shock cannot be fully appreciated yet. In spite of a very positive conclusion about the resilience of some value chains, lead firms affected by the shock realized that they spent considerable time and money in alternative production: business continuity plans and other programs to increase supply chain resilience to external shocks have become the center of attention of global business and governments alike. The World Economic Forum in association with Accenture (2013), and Deloitte (2014), among others, have developed strategies to build resilience in value chains.

This development means that, while Thailand's attractiveness is not at stake, risk diversification might incite lead firms to maintain alternative production sites. After the 2011 floods, Japanese firms have pursued a "Thailand-Plus-One" strategy. Some Japanese automobile parts producers, electronic parts makers, and consumer goods manufacturers operating in Thailand have begun to relocate their labor-intensive production just across the Thai border. The objective of this strategy is to consolidate Thailand as a regional hub of manufacturing, controlling smaller-scale production bases outside the economy (Chachavalpongpun, 2014). This could be a win-win since the development of within value chain alternative production solutions is the best remedy to permanent substitution effects.

In sum, the Thailand case shows that value chain resilience could have different and somewhat conflicting meanings depending on whether one looks at the strength of the value chain itself or the continued participation of each individual economy in the chain. Higher value chain resilience could coincide with higher economy exposure to substitution effects. In terms of policy, this finding means that economies need to put in place measures that encourage lead firms to remain present in their value chains even after severe disruptions. Those factors have already been identified, and include most notably the facilitation of specific investments that make it less beneficial to change to an alternative supplier in another economy. Openness to investment, and a strong business climate, are both crucial to fostering such transactions. Table 5.1 provides a more complete overview of the risks value chains face, and the measures economies can put in place to mitigate them, i.e. to foster Value Chain Strength and Resilience. Many of these issues are reflected in the quantitative indices prepared in Phase One of this project, as well as in the present report.

**Table 5.1. Value Chain Strength: Matrix of Risks.**

Value chain / product or sector / economy specificity	Adjustment type	Disruption risk	Policy measures to prevent/mitigate risks
Low integration and limited transfers High product modularity Limited economy specificity (e.g., small domestic market, low-skilled activities)	Extensive margin - Out of network substitution	- High value chain modularity hence resilience - High economy exposure to production shifts	- Trade facilitation and removal of barriers to trade
High integration and important transfers (e.g., technology transfers, training, infrastructure) Limited product modularity or high product specificity High economy specificity (e.g., large domestic market, availability of skilled labor, geographical location, industrial clusters, infrastructure)	Intensive margin - Within value chain alternative production - Within value chain movement of personnel - Financial support facility	- Higher adjustment costs and longer recovery period - Lower economy exposure to production shifts	- Facilitation of intra-firm transfers (e.g., movement of personnel, IP protection for technology transfers, investment protection) - Reinforcement of economy specificity/attractiveness (business and investment climate, education, innovation, infrastructure) - National strategy for value chain resilience

Source: Authors.

## **THE GREAT TOHOKU EARTHQUAKE (2011): THE SHIFT IN RISK PERCEPTION AND VALUE CHAIN RESILIENCE STRATEGIES**

### **Description of the Shock**

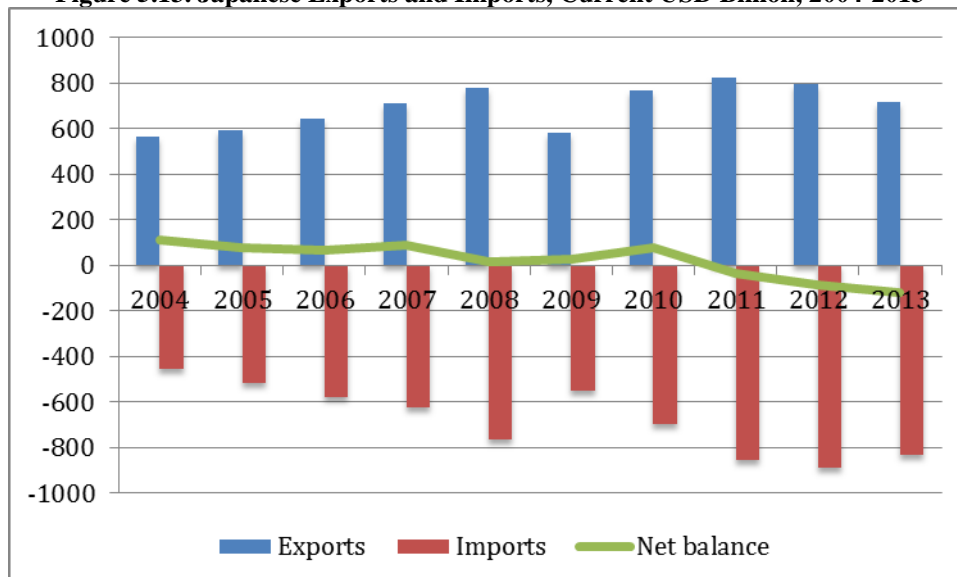
On 11 March 2011, an earthquake of magnitude 9.0 hit the Northeastern coast of Japan and triggered tsunami waves that reached heights of up to 40 meters and travelled up to 10 km inland. In turn, the tsunami caused nuclear incidents. Casualties included more than 18,000 deaths or missing people across twenty prefectures in Japan. The World Bank estimated the economic cost at over U.S.\$200 billion, or 3.8% of Japanese GDP, making the Great Tohoku Earthquake the costliest natural disaster in world history. More than 45,000 buildings were destroyed and 144,000 damaged by the earthquake and tsunami; 10% of the fishing ports of the economy were damaged; about 4.4 million households were left without electricity; transport and telecommunications suffered major disruptions in the affected areas. Japanese mining and manufacturing production dropped by 15.5% in March 2011 – its biggest drop in history. Automobile and electric machinery were the most affected industries, with respective falls in production of 48% and 8% (ESCAP, 2013).

### **Impact of the Earthquake on Trade**

For the first time since 1980, Japan had a trade deficit in 2011 (Figure 5.13). This could be attributed to the earthquake, but not solely: a combination of factors could explain this performance (METI, 2012). They include the earthquake, the Thai floods (October 2011), and a severe external environment (including the appreciation of the yen and soaring energy prices). Simultaneously, exports declined by 2.7% (earthquake damage) and imports surged by 12.1% (reconstruction needs), resulting in a 2.56 trillion yen deficit.

Exports started to decline in March 2011, the month of the earthquake, and continued to decrease for five consecutive months until July 2011, while bottoming out in April 2011 (-12.4% from the previous year). Exports then remained weak until the Thailand floods hit the Japanese firms established there. Exports dropped again after October for five consecutive months until January 2012, reaching a bottom in January 2012 (-9.2% (METI, 2012).

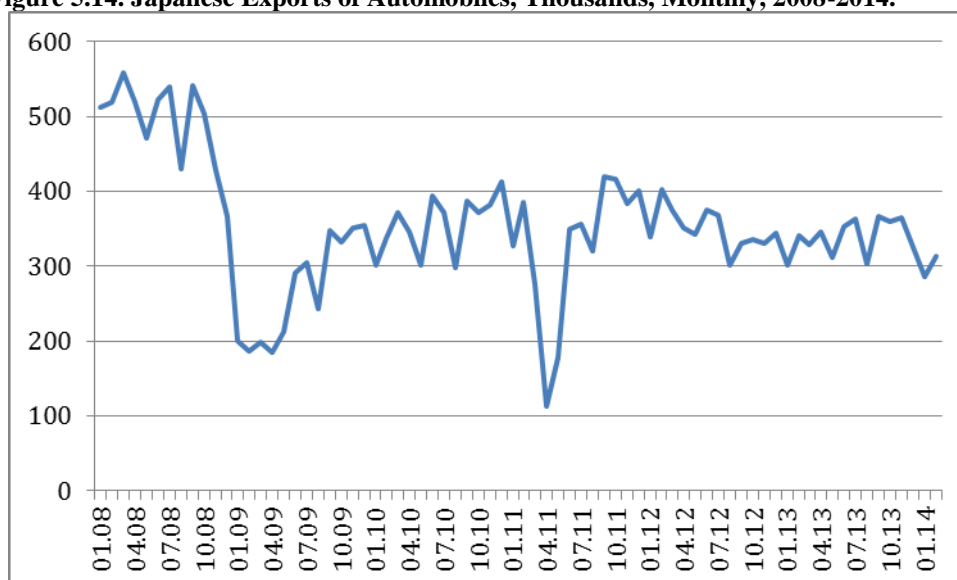
Transportation and electrical equipment were the main items affected by the shock, with respective declines of 1.8 and 1.6 percentage points in contribution; the increase in imports of mineral-related fuels (7.3 percentage points in contribution) was the main contributor to the 12.1% increase in total Japanese imports in 2011 (METI, 2012).

**Figure 5.13. Japanese Exports and Imports, Current USD Billion, 2004-2013**

Source: WTO Trade statistics database

There has been a constant decline in the Japanese trade balance since 2011. These long-term effects could not be solely attributed to the 2011 natural disasters (Japan earthquake and Thailand floods). Demand for exports declined, and it is essential to consider structural factors as operative causes of the overall pattern observed, in addition to the shocks examined in this chapter.

This conclusion is supported by a more precise analysis of Japanese exports and the recovery of production levels in individual industries after the earthquake. For example, the transport equipment industry demonstrated strong resilience to the shock, and the level of exports returned to its pre-earthquake level less than six months after the shock; however, exports have continuously declined since September 2011, due to sluggish demand in Europe and the U.S. in particular (Figure 5.14).

**Figure 5.14. Japanese Exports of Automobiles, Thousands, Monthly, 2008-2014.**

Source: Japan Automobile Manufacturers Association database

In the electrical equipment industry, recovery has been slower due to the higher impact of the Thailand floods on value chains, with Thailand producing 40% of all hard disk drives in the world – see Case Study 2 above. Year-to-year monthly growth rates turned positive again in March 2012 only; thereafter, exports have continued to decline due to a lesser demand in China in particular (METI, 2012).

The disruptive effect of the earthquake was particularly prominent in Southeast Asia due to the high dependency of the region's economies on Japanese intermediates, especially in electronics and transport equipment. Thailand, for example, has import dependency ratios of above 70% with Japan in several electronic product categories; other Asian economies have ratios of 20%-30% in these industries (OECD, 2013).

The automobile sector was the most affected of all by the earthquake. A typical motor vehicle has over 15,000 parts, and the lack of an essential component may halt the completion of vehicles and cause a slowdown or stoppage of assembly lines. Considering that Japan is the second-largest vehicle-producing nation (after China), and that many of the world's vehicles and vehicle parts originate there, the Great Tohoku Earthquake had major disruptive effects for the global motor vehicle supply chain (Canis, 2011).

As a result of the earthquake, the plants that make 17 out of the top 20 models of Japanese vehicles sold in the U.S. temporarily closed (i.e., half of Toyota's plants in Japan, all of Suzuki's facilities, and several Honda and Mitsubishi vehicle plants). Beyond Japanese makes, many foreign vehicle manufacturers were affected by the disruption of the global vehicle industry value chain. For example, General Motors (U.S.) had to temporarily halt production of certain vehicles; Ford closed assembly plants in Chinese Taipei, the Philippines, and China for two weeks to conserve parts in short supply. Automakers in the U.S. had to cut their second-quarter production in 2011 by 350,000 to 400,000 units. It was estimated that over four million units of vehicle production were lost because of the disasters in Japan, with 90% of them from Japanese automakers (Canis, 2011, and ESCAP, 2013).

The earthquake also affected the production of Japanese electronics suppliers like Renesas, Panasonic, Toshiba, and Hitachi. Japan produces 60% of world's silicon wafers for semiconductors. The earthquake caused the temporary closure of two factories that represented 25 percent of wafer shipments (ESCAP, 2013).

For example, Renesas Electronic Corporation, the world's largest maker of microcontrollers for cars (representing 40% of the global market, and 60% of microcontrollers for cars produced by Toyota, Nissan, and Honda, and 20% for GM) had to close eight of its plants and operate at about 10% capacity for several months. The shutdown of a single factory in the Ibaraki Prefecture caused the world supply of microcontrollers to drop by 10%. Due to the high specificity of the products, the transfer of production to Renesas plants in Singapore and Northern Japan took several months, and it took more than four months before production could again meet demand. As a result, GM temporarily halted production at a pick-up truck factory in the U.S., and Toyota, Honda, Nissan and Mazda shut down 22 plants. Losses from the earthquake totaled U.S.\$615 million for Renesas (ESCAP, 2013, and Canis, 2011).

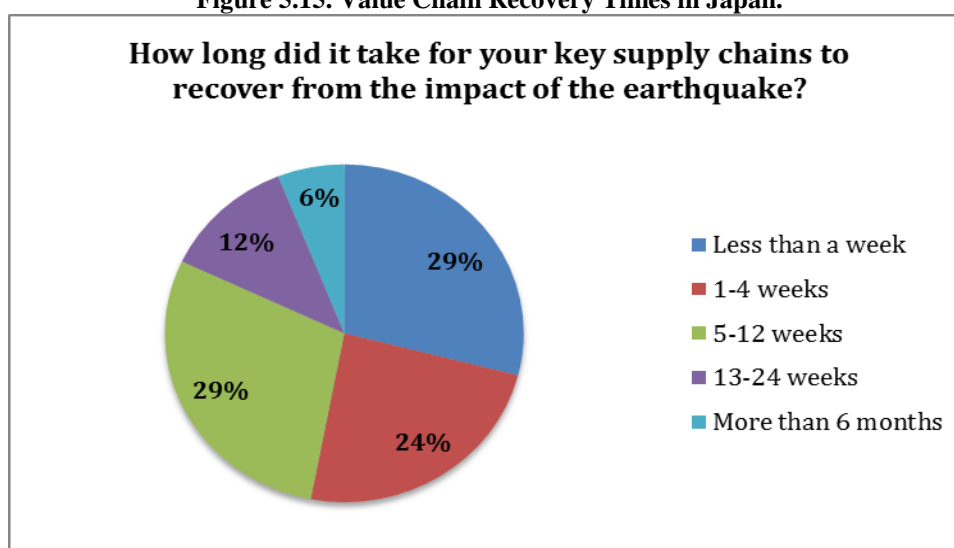
Here again, the high degree of product specificity or differentiation could explain the magnitude of the short-term value chain disruption and long-term resilience. For example, automotive microcontrollers are generally designed in close cooperation with other

automotive parts suppliers, and each requires a special production line. Thus, in the absence of industry standardization, the disruption of production in just one or two custom-made components can cause a value chain to break, even if they account for a very small amount of the final product's value (ESCAP, 2013).

### Factors of Value Chain Resilience and Disruption

Japanese industry's efforts to reconstruct value chains after the earthquake have contributed to strong resilience, and a quick recovery of production. A survey by the Japan Bank for International Cooperation showed that about 80% of the companies that were damaged by the earthquake had restored their facilities by July 2011 (JBIC, 2012). Figure 5.15 confirms this quick recovery time, with only 6% of the firms surveyed needing more than six months to recover from the earthquake. Interestingly also, the strenuous restoration efforts made by business and people in the disaster-affected areas, from right after the earthquake until now, led to a strong improvement in the industrial production index of those areas that have surpassed the least affected regions (METI, 2012).

**Figure 5.15. Value Chain Recovery Times in Japan.**



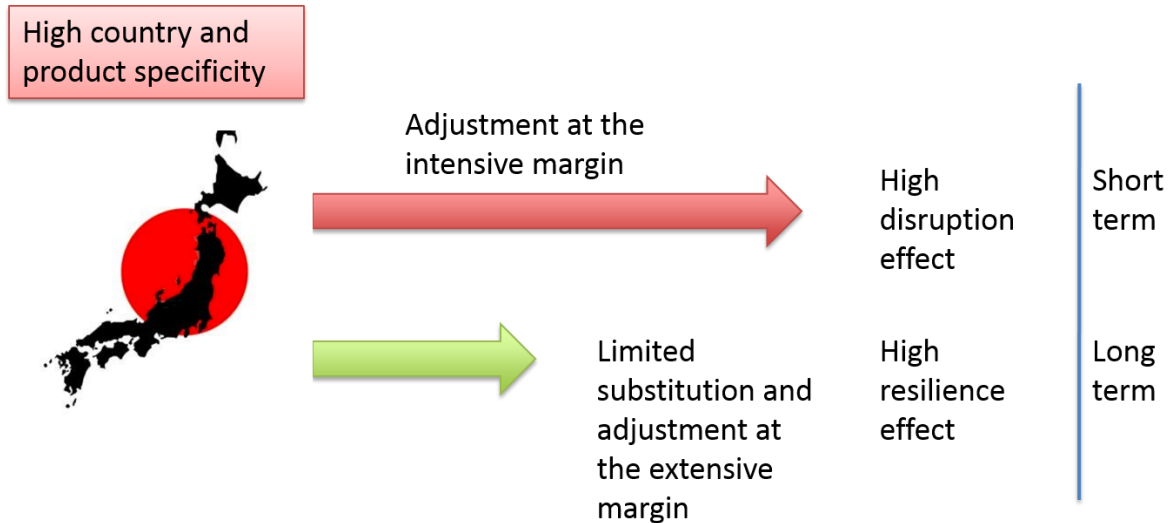
Source: Business Continuity Institute (2012).

With regard to substitution, the survey by the Japan Bank for International Cooperation (JBIC, 2012) revealed that 70% of firms had their procurement of materials and components affected by the earthquake. Among those firms that were affected, about half did not change suppliers; other substituted their suppliers with other Japanese producers (45%) and/or foreign producers (22.5%). China has been the main benefactor of these substitution effects, capturing a quarter of the new contracts, closely followed by South Korea and Europe/the U.S. In total, permanent or long-term substitution effects with foreign suppliers should represent about 5% of total production among the surveyed companies (JBIC, 2012).

The Great Tohoku Earthquake has revealed the high resilience and quick recovery capacity of value chains in which Japan participates, as well as the potential global impact of value chain disruptions. The Japanese case is a perfect illustration of the trade-off between resilience at the extensive and intensive margins presented in Table 5.1 of Case Study 2 (Thailand): the high specificity of Japanese production resulted in a low substitution capacity, a higher disruptive effect in the short term and higher value chain resilience in the long term (Figure 5.16).



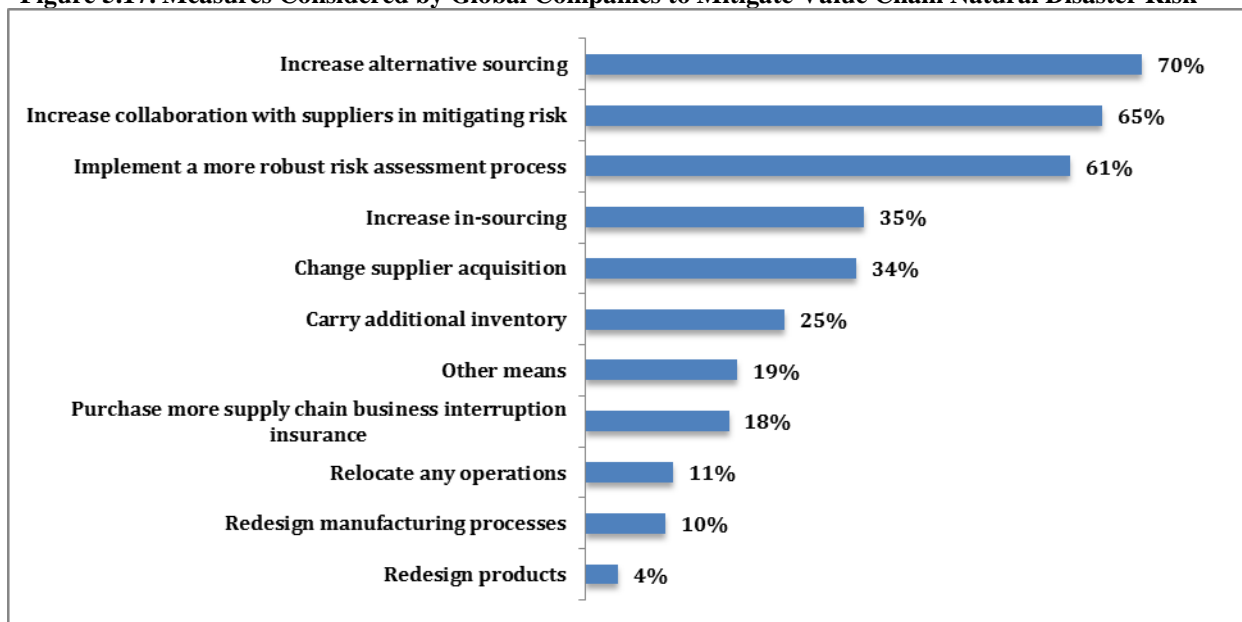
Figure 5.16. Japan Specificity and Value Chain Resilience.



Source: Authors.

Although substitution effects remained marginal due to the specificity and differentiation of Japanese products, the cost of adjustment for business permanently affected the business perception of value chain disruption risks and management. A recent survey of 600 global companies (Deloitte, 2014) revealed that 48% of the surveyed executives reported an increase in the frequency of value chain risk events that had negative outcomes in the last three years. Not only are such risks becoming more frequent, they are also becoming more costly, according to 53% of survey respondents, affecting margins, effective management, and the flow of physical products (Deloitte, 2014). The Great Tohoku Earthquake has played a major role in this evolving perception: according to a survey of the Business Continuity Institute (2012), 92 of the respondents stated that their supply chain strategy had been reviewed as a result of the earthquake.

In spite of this, only 30%-40% of the companies that consider value chain risks as an important part of strategic decision-making had effectively implemented analytics and data visualization tools within their value chain risk management programs. According to FM Global (2011), the earthquake was "a close call and a call to action" for many global companies with value chains in Asia. Figure 5.17 presents some of the firm-level measures considered to increase value chain resilience after the Japan earthquake.

**Figure 5.17. Measures Considered by Global Companies to Mitigate Value Chain Natural Disaster Risk**

Source: FM Global 2011

### Policy Implications of the Value Chain Effects of the Great Tohoku Earthquake

As observed by the OECD (2013), the role of government in managing value chain risks appears somewhat limited, as decisions regarding the length of the chain and the number of alternative suppliers are entirely company matters. However, governments increasingly need to understand, support company risk management strategies, and in some cases themselves manage factors that create risk in global value chains, as they now constitute the backbone of the global economy.

Two types of policy responses to the shock can be analyzed: first, measures taken in Japan to resume production and the normal functioning of value chains (curative); and second, measures taken by other governments to increase the resilience of value chains (preventive).

On the curative front, the Japanese government targeted its assistance at restoring normal business functions in general. Measures included (ESCAP, 2013):

- *Assistance in financing:* The government helped the facilitation of credit and the mitigation of cash flow deterioration for SMEs (longer repayment period or repayment grace, special grants, soft loans, etc.).
- *Employment support:* The government introduced an employment subsidy and employment benefits for enterprises affected by the disaster.
- *Assistance in taxation:* The government introduced special tax deductions for post-disaster reconstruction and tax incentives for investment in earthquake mitigation.
- *Rehabilitation support:* The government supported the establishment of temporary plants and stores and helped with radioactivity inspections.

These measures were supplemented by local government support, and many companies received support from the lead firms (global manufacturers) they were supplying. Thus, within value chain (private-private) solidarity supplemented government (public) assistance to restore normal business functions.

On the prevention front, the U.S. National Strategy for Global Supply Chain Security (2012) provides a good example of public policy efforts aimed at fostering a economy's ability to absorb shocks and reduce the overall impact of global value chain disruptions. The U.S. government assigned itself the objectives of:

- Mitigating systemic vulnerability to a supply chain disruption prior to a potential event by using risk management principles to identify and protect key assets, infrastructure, and support systems; and promoting the implementation of sustainable operational processes and appropriate redundancy for those assets.
- Promoting trade resumption policies and practices that will provide for a coordinated restoration of the movement of goods following a potential disruption by developing and implementing national and global guidelines, standards, policies, and programs.

At the multilateral level, the OECD is preparing Principles on Economy-wide Risk Management that aim to frame the international policy dialogue and support economies' efforts to prepare for and respond to global risks (OECD 2013).

## 6. CONCLUSION AND POLICY IMPLICATIONS

Phase One of this project concluded that APEC economies overall faced a moderate level of Value Chain Risk, but that particular action was required to deal with some of those risks where levels were higher relative to comparator regions. This Phase Two, focusing on Value Chain Strength, has shown that APEC economies have indeed been active in this area. They have put in place supporting environments that enable their firms to effectively manage Value Chain Risk. The policy environment is supportive of a combined public-private approach to risk management, which makes it possible to conclude that the overall risk-strength balance in APEC is positively turned towards the greater establishment and development of value chains. The conclusion to be drawn from the first two phases of this project is that although some risks are significant in the Asia-Pacific region due often to circumstances outside governments' control, the response has been a robust one, which results in a climate in which overall Value Chain Resilience appears to be strong relative to comparator regions. Indeed, APEC's performance appears to be on a par with some developed economy groupings, and is significantly better than that of regional partners made up primarily of developing economies.

Results from the quantitative and qualitative analyses go very much in the same direction. The case studies focus on particular examples of the occurrence of major risks to which APEC governments and companies have had to respond. Overall, the evidence suggests that value chains rebound rapidly even from such major crises as the GFC, the Thai floods, and the Great Tohoku Earthquake. The strongly positive recovery from these extreme events suggests that more common occurrences of value chain risk are also managed effectively by value chain participants, thanks in part to the supportive environment established by the public sector.

In terms of policy implications, there are three main findings from this study. This first is that managing the occurrence of value chain risk is typically an activity that involves more than one economy. The nature of cross-border value chains is that shocks to economic activity in one economy are rapidly transmitted to related sectors and producers in other economies. As a result, a regional approach in which governments and firms coordinate their responses to the occurrence of risks is often appropriate. APEC and other regional fora may provide appropriate frameworks for this type of cross-economy collaboration.

Second, although risk management is primarily a private sector activity, there is much that the public sector can do to put in place an environment that is conducive to reinforcing Value Chain Strength and promoting resilience. Developing infrastructure, and repairing it rapidly in case of major impairment, is one important area. Effective government action to bring relieve to affected communities and businesses is another. Facilitating access to bridging finance in situations of supply-side shocks that cause private firms to require capital is another area in which active government involvement can help sustain value chains through a challenging period, and ensure that they rebound rapidly from an unexpected event.

Finally, although APEC's results on Value Chain Strength are generally very strong by world standards—and this is reflected in the rapidity with which its private operators resume and expand activity following negative events—it is necessary to ensure continuous improvement. Value chains operate in a highly competitive environment. Although the

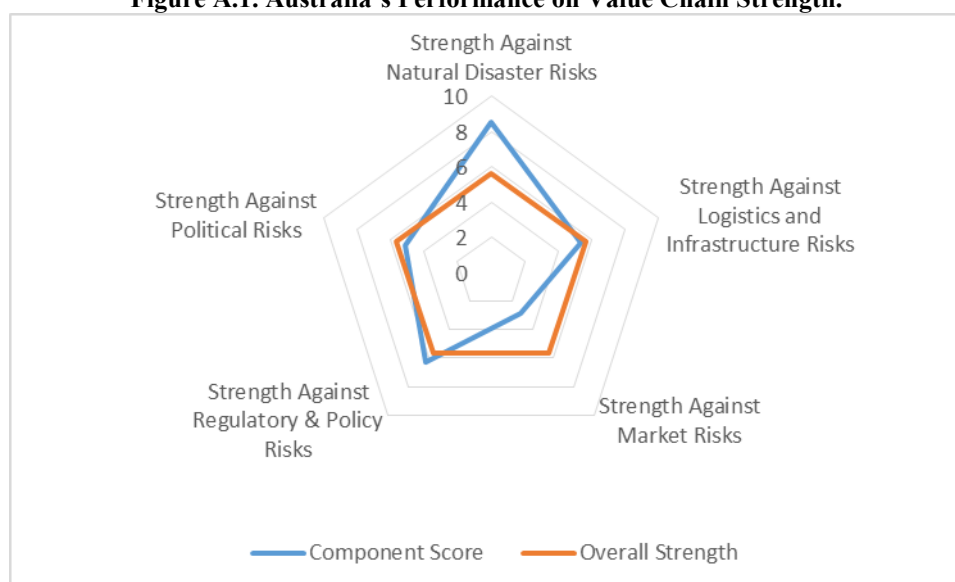
emergence of the business model is typically localized in the Asia-Pacific, it has now spread to other regions of the world, and sectors not traditionally associated with value chains in the Asia-Pacific. As a result, APEC governments and firms need to work together to ensure that Value Chain Strength remains high, and increases over time. Some aspects of Value Chain Risk, such as natural disaster risk, are beyond government control. All that can be done is to put in place policies and systems to respond to the occurrence of such risks. It will be vital to ensure continuous improvement in those systems, in order for APEC to maintain its position near the global best practice frontier in some areas. In those areas where practice can be improved relative to comparator regions, it will be important to undertake upgrading. Given the generally strong level of performance in the region, APEC economies are well placed to take on such activities, and they fit well with broader APEC work on trade and investment, such as improving economic connectivity.

## APPENDIX 1: INDIVIDUAL ECONOMY RESULTS

### AUSTRALIA

Australia's overall Value Chain Strength index score is 5.6. Figure A.1 shows how that score breaks down by component part. As is clear from the figure, strength against natural disaster risk is an area in which this economy performs particularly well, significantly in excess of its average (overall) score. By contrast, the opposite can be said of strength against market risks, where Australia performs lower than its overall score. These findings suggest that increasing strength against market risks could be a useful policy priority for Australia going forward.

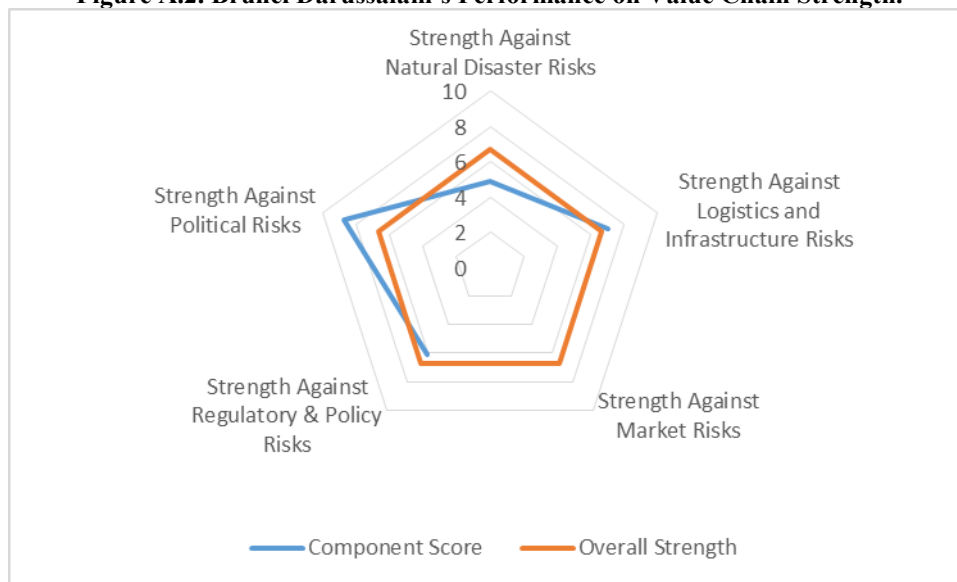
**Figure A.1. Australia's Performance on Value Chain Strength.**



*Source: Authors' calculations.*

### BRUNEI DARUSSALAM

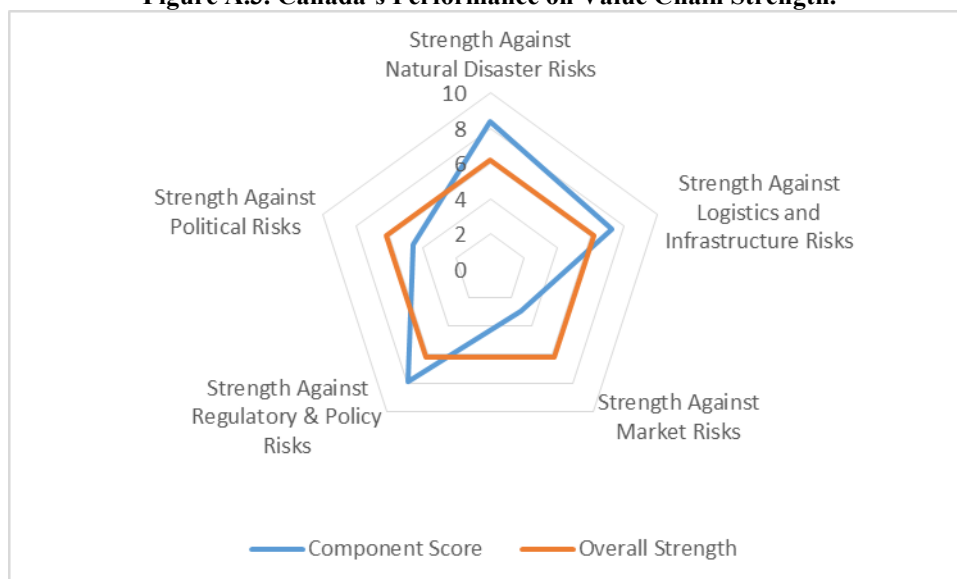
Brunei Darussalam's overall Value Chain Strength score is 6.7, but it does not include a component on strength against market risks due to lack of data availability. In terms of the available components, strength against political risks stands out as an area of strong performance relative to the economy's overall benchmark level. By contrast, strength against natural disaster risks has a score that is lower than the economy's overall (average) score, which suggests that it might be a useful area of concentration for policymakers in the future.

**Figure A.2. Brunei Darussalam's Performance on Value Chain Strength.**

Source: Authors' calculations.

## CANADA

Canada has an overall Value Chain Strength score of 6.2. Three areas stand out as having higher scores than the overall (average measure): strength against natural disaster risks, strength against infrastructure and logistics risks, and strength against regulatory and policy risks. By contrast, strength against political risks has a lower score than the economy's average. One interpretation is that that might indicate a need for greater policy attention in the future, but it could also be a reflection of limited geopolitical threats and a climate of strong law and order, both of which tend to reduce the need for the types of spending that this measure captures.

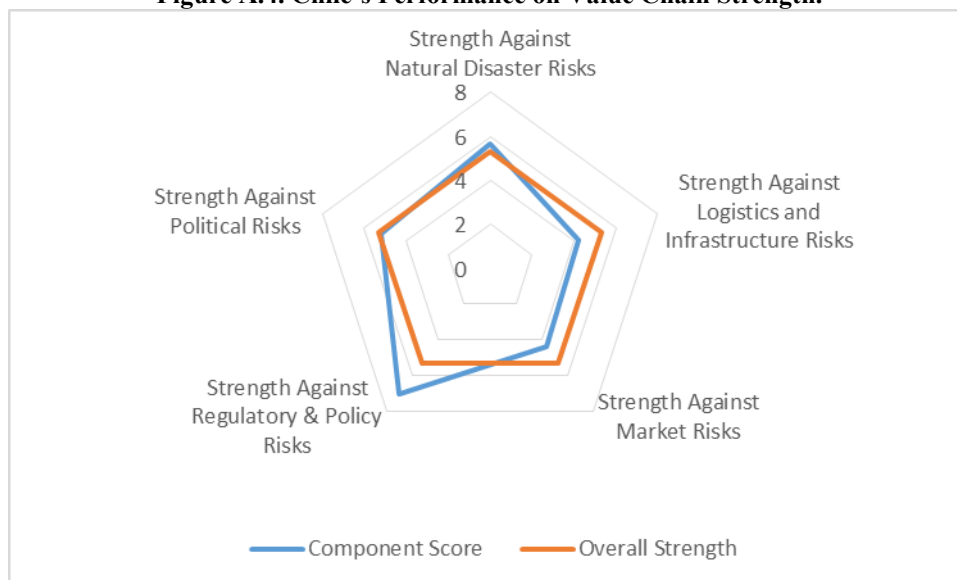
**Figure A.3. Canada's Performance on Value Chain Strength.**

Source: Authors' calculations.

**CHILE**

Chile's overall Value Chain Strength score is 5.3. Its performance is well above its average score in the area of strength against regulatory and policy risks. On the other hand, performance is slightly below the level of its overall score in relation to strength against logistics and infrastructure risks, and strength against market risks. Importantly, given the findings on natural disaster risk in the Phase One report, Chile's performance on strength in that area is strong. It has clearly developed public and private systems to deal effectively with such risks, and limit the human and economic toll inflicted by them.

**Figure A.4. Chile's Performance on Value Chain Strength.**

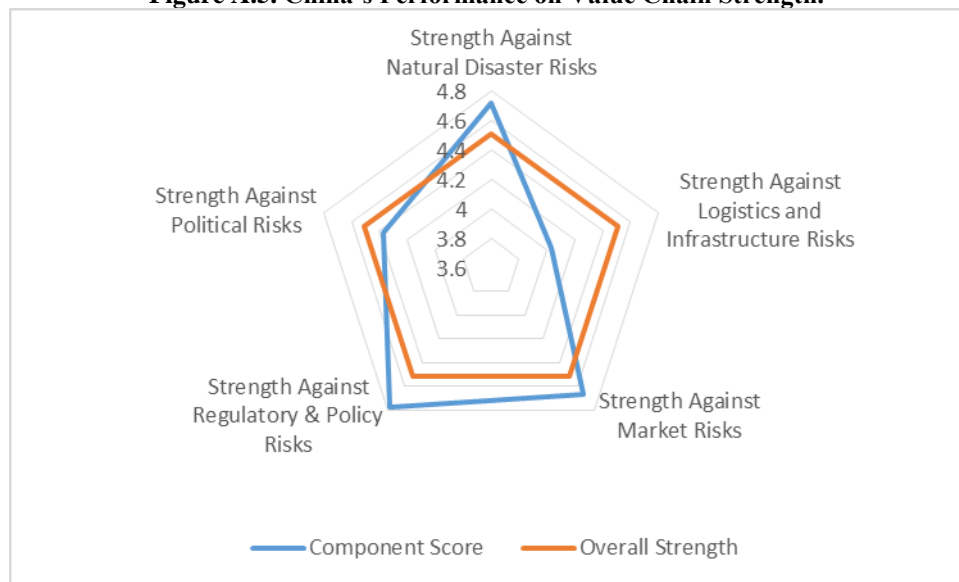


Source: Authors' calculations.

**CHINA**

China's overall Value Chain Strength score is 4.5. Figure A.5 shows that performance in particular component dimensions is above the overall score (average) in three cases: strength against natural disaster risks, strength against market risks, and strength against regulatory and policy risks. Strength against political risks is, by contrast, slightly below the economy's average score. An area in need of greater attention, however, is strength against logistics and infrastructure risks: the score is well below China's average, which suggests that it should be a priority for policymakers going forward.

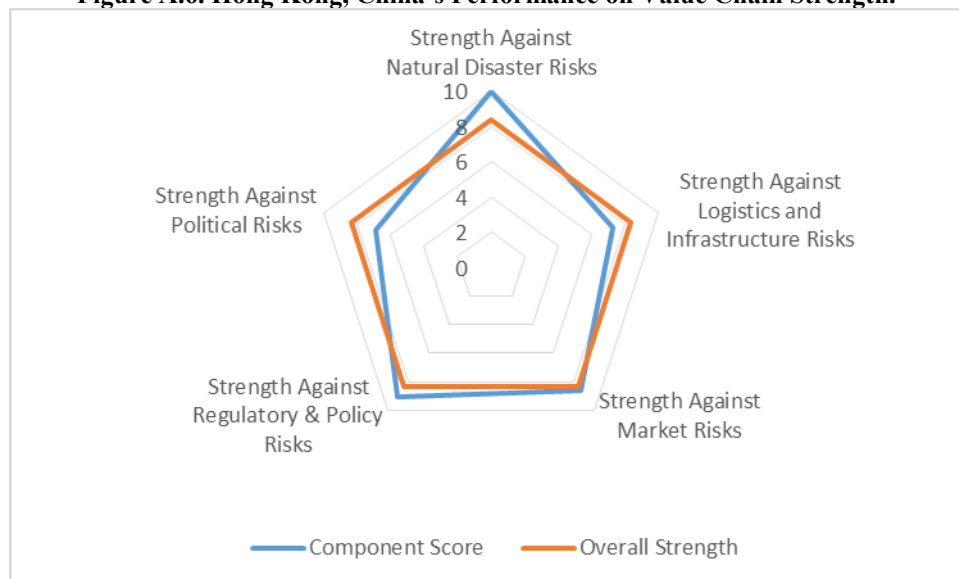


**Figure A.5. China's Performance on Value Chain Strength.**

Source: Authors' calculations.

## HONG KONG, CHINA

Hong Kong, China has an overall Value Chain Strength score of 8.4. Its performance on strength against natural disaster risks stands out as being above the economy's overall average. The same is true, but to a lesser degree, for strength against regulatory and policy risks. By contrast, strength against political risks, and strength against logistics and infrastructure risks are a little lower than the economy's overall score, which indicates that there may be room for improving these dimensions even further in the future.

**Figure A.6. Hong Kong, China's Performance on Value Chain Strength.**

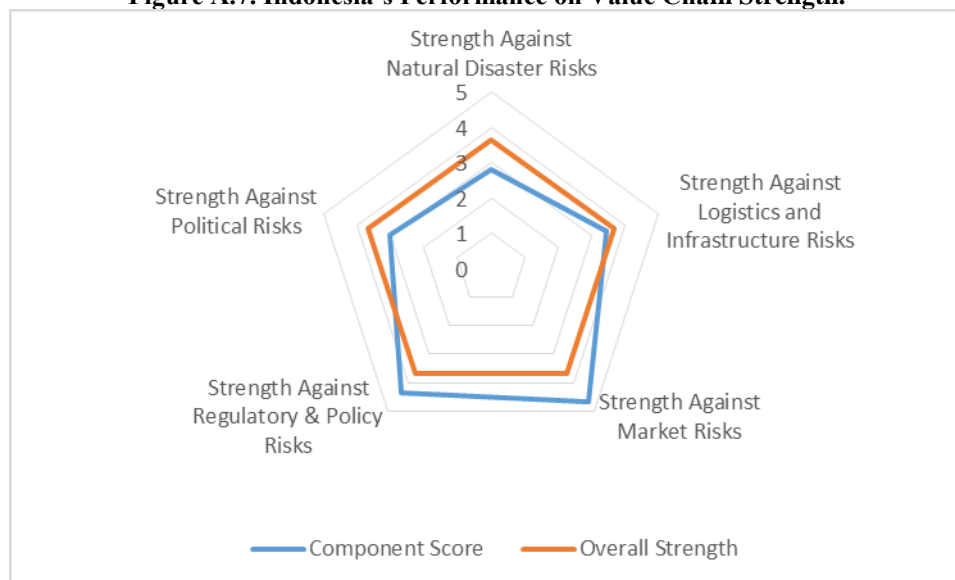
Source: Authors' calculations.

## INDONESIA

Indonesia's overall Value Chain Strength score is 3.7. Strength against market risks, and strength against regulatory and policy risks stand out as two areas in which component index

scores are higher than the overall average. By contrast, strength against natural disaster risks and strength against political risks are noticeably lower than the economy's average. These areas may be ones that policymakers wish to give increased attention going forward, in order to boost overall performance.

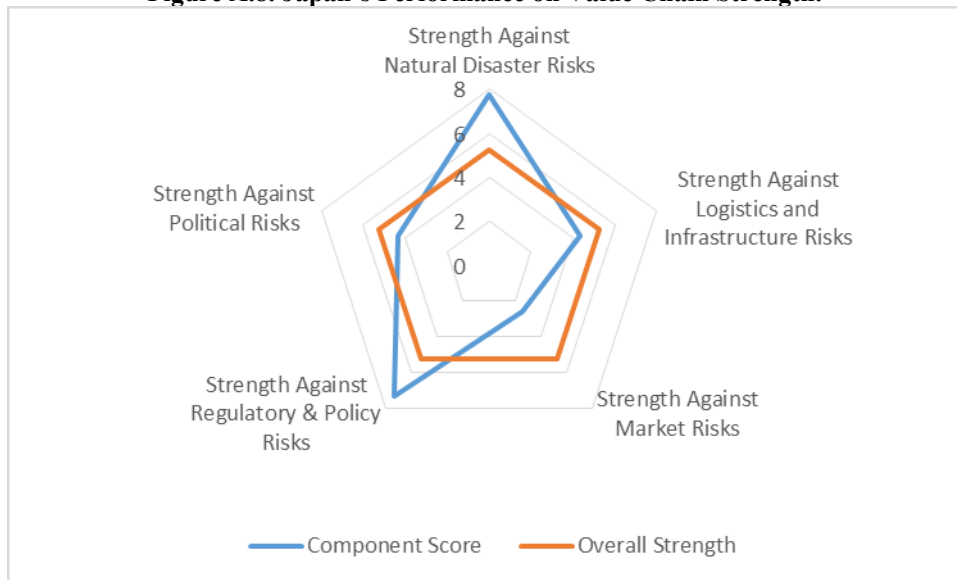
**Figure A.7. Indonesia's Performance on Value Chain Strength.**



*Source: Authors' calculations.*

## **JAPAN**

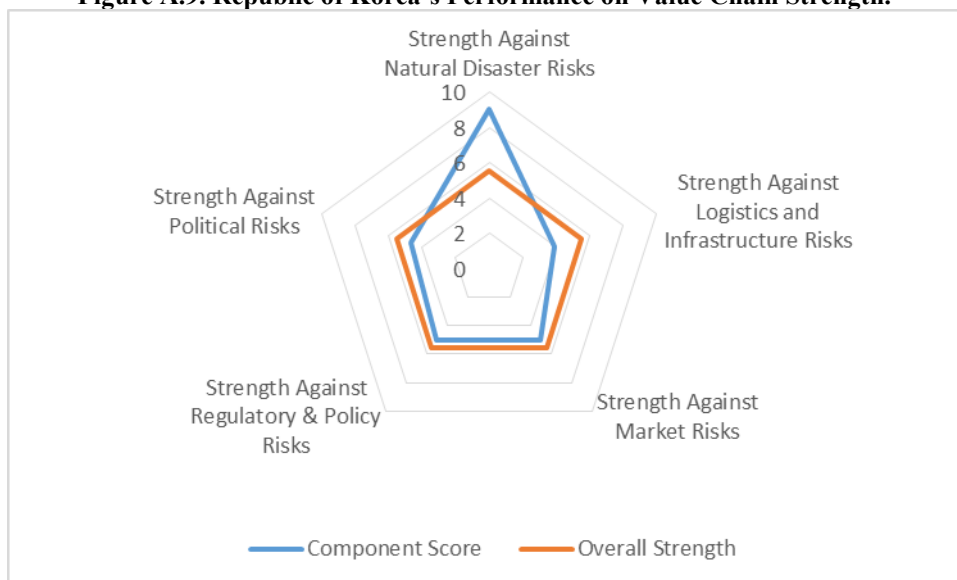
Japan's overall Value Chain Strength score is 5.3. It performs particularly strongly in the areas of strength against natural disaster risk, and strength against regulatory and policy risks. However, performance in the area of strength against market risks may require further attention from policymakers, as it is significantly below the economy's overall average score. This performance undoubtedly reflects the economic problems Japan has been confronted with over recent years, and it is to be hoped that current policies will restore confidence and growth, and thereby assist in raising the economy's score in this dimension of Value Chain Strength.

**Figure A.8. Japan's Performance on Value Chain Strength.**

Source: Authors' calculations.

## REPUBLIC OF KOREA

The Republic of Korea has an overall Value Chain Strength score of 5.5. The standout area is strength against natural disaster risks, where its score is well above the economy's overall score (average). Most other component scores are close to the average, with the exception of strength against logistics and infrastructure risks. This could be an area that policymakers may wish to redouble their efforts on in the future, in order to boost overall performance.

**Figure A.9. Republic of Korea's Performance on Value Chain Strength.**

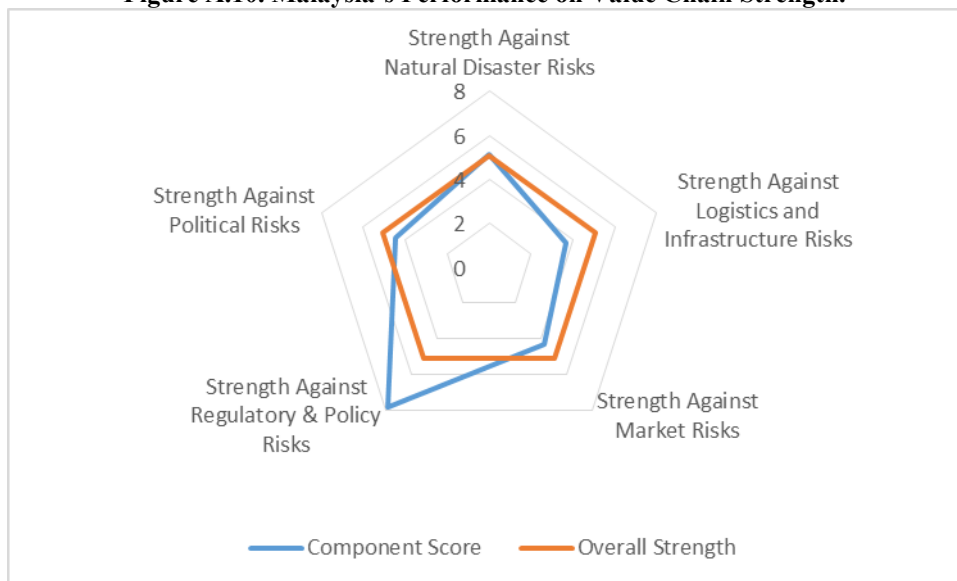
Source: Authors' calculations.

## MALAYSIA

Malaysia's overall Value Chain Strength Score is 5.1. Strength against regulatory and policy risks stands out as an area in which performance is much stronger than the economy's average across all components. By contrast, strength against logistics and infrastructure risks

is an area in which Malaysia’s score is noticeably lower than its overall average. The remaining three areas have scores that are quite close to the overall average.

**Figure A.10. Malaysia’s Performance on Value Chain Strength.**

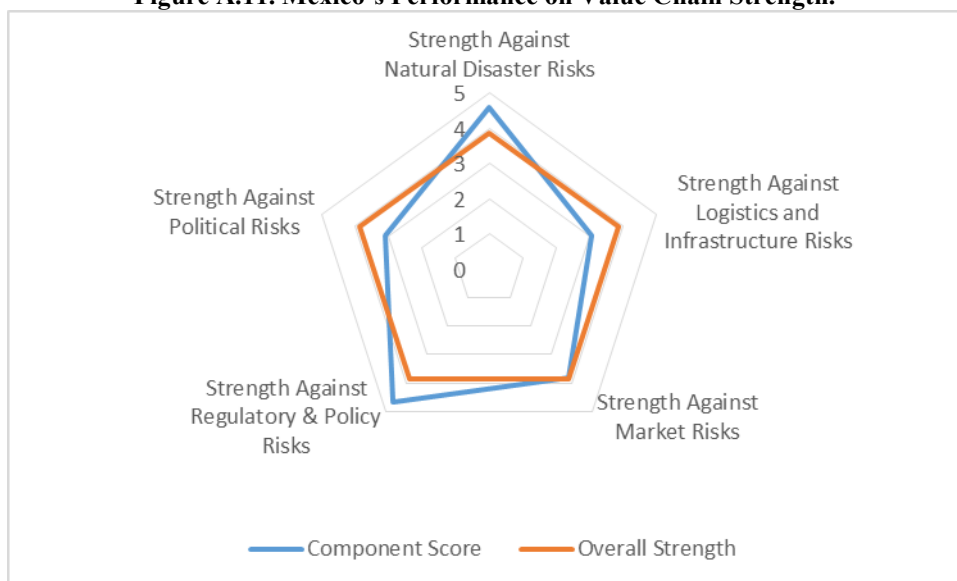


Source: Authors’ calculations.

## MEXICO

Mexico has an overall Value Chain Strength score of 3.8. Its performance on strength against natural disaster risks and strength against regulatory and policy risks is above the economy average. However, performance in two other dimensions of Value Chain strength—strength against logistics and infrastructure risks and strength against political risks—is substantially lower than the economy’s overall score. These could be priority areas for policymakers going forward.

**Figure A.11. Mexico’s Performance on Value Chain Strength.**

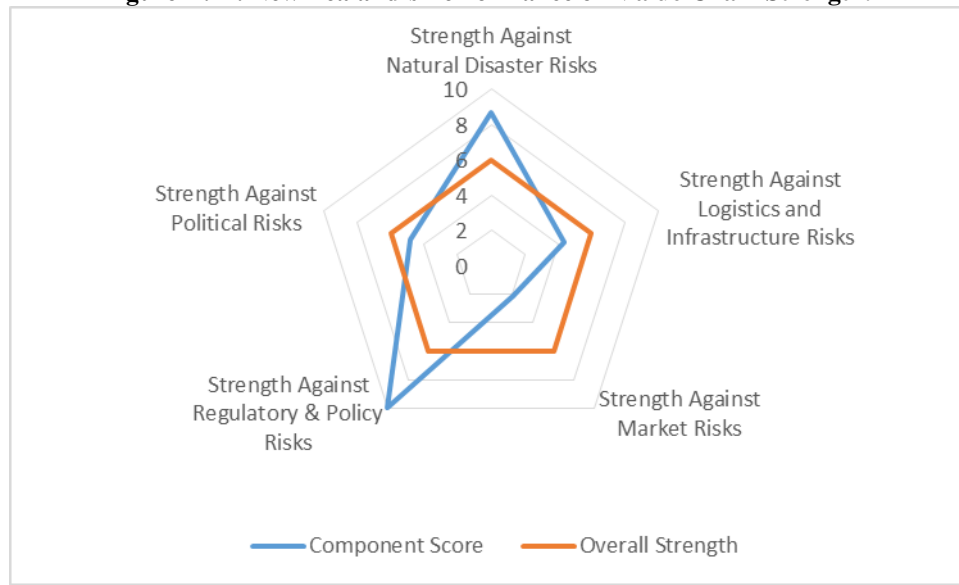


Source: Authors’ calculations.

## NEW ZEALAND

New Zealand's overall score on the Value Chain Strength index is 6.0. Its performance in two areas is well above its overall average score: strength against natural disaster risks, and strength against regulatory and policy risks. Strength in the other three dimensions is lower than the economy's average score. The effect is particularly noticeable in the case of strength against market risks, which indicates that that area might be one that could benefit from further attention from policymakers in the future.

**Figure A.12. New Zealand's Performance on Value Chain Strength.**

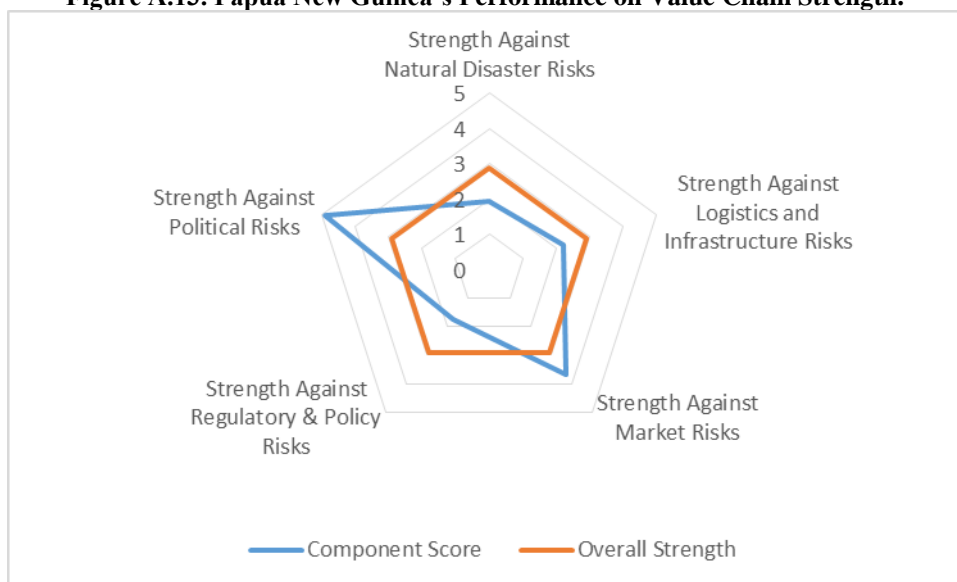


Source: Authors' calculations.

## PAPUA NEW GUINEA

Papua New Guinea's overall score on the Value Chain Strength Index is 2.9. Its performance is above its economy average score in the areas of strength against political risks, and strength against market risks. The other areas—particular strength against regulatory and policy risks, and strength against natural disasters—have scores that are significantly lower than the economy's overall average score.

**Figure A.13. Papua New Guinea’s Performance on Value Chain Strength.**

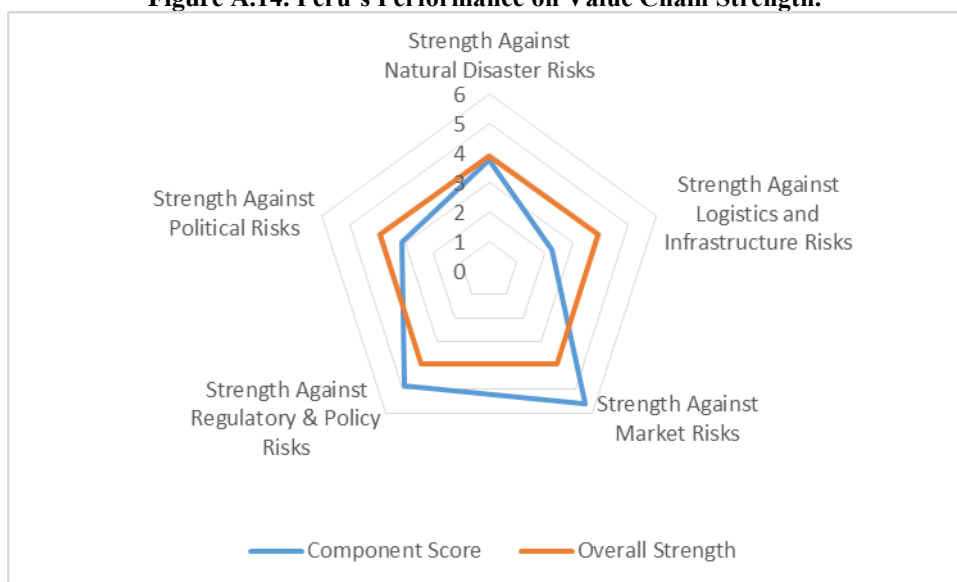


Source: Authors’ calculations.

**PERU**

Peru’s overall Value Chain Strength score is 3.9. Its performance in terms of strength against market risks and strength against regulatory and policy risk is above its economy average level. However, its scores for strength against logistics and infrastructure risks and strength against political risks are below its economy average. This finding suggests that these areas may benefit from further policy attention in the future.

**Figure A.14. Peru’s Performance on Value Chain Strength.**



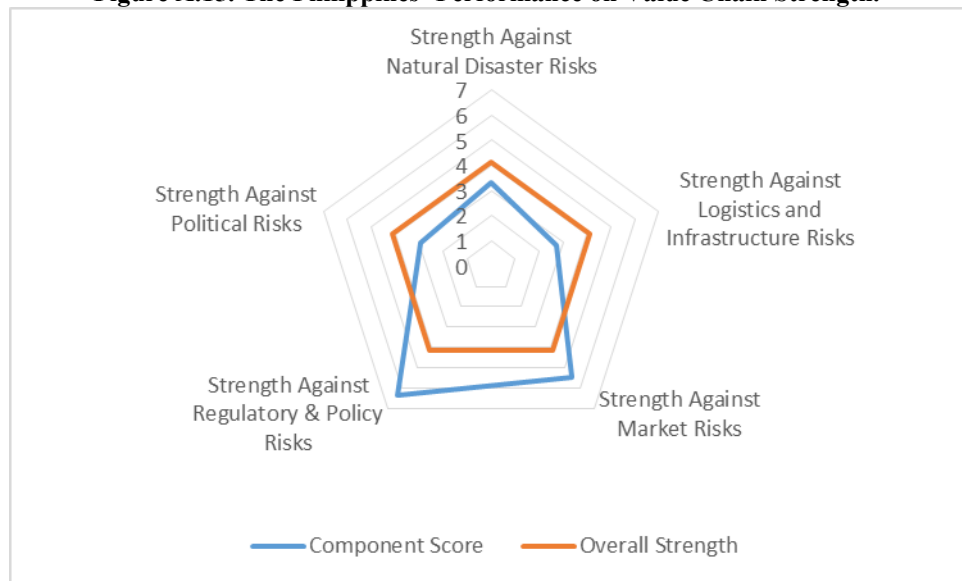
Source: Authors’ calculations.

**THE PHILIPPINES**

The Philippines has an overall Value Chain Strength index score of 4.1. Two areas that stand out as having superior performance compared with this economy’s average level are strength against regulatory and policy risks, and strength against market risks. The other three

dimensions of Value Chain Strength have scores that are significantly below the economy average, which indicates that policymakers could usefully redouble efforts in these areas in the future.

**Figure A.15. The Philippines' Performance on Value Chain Strength.**

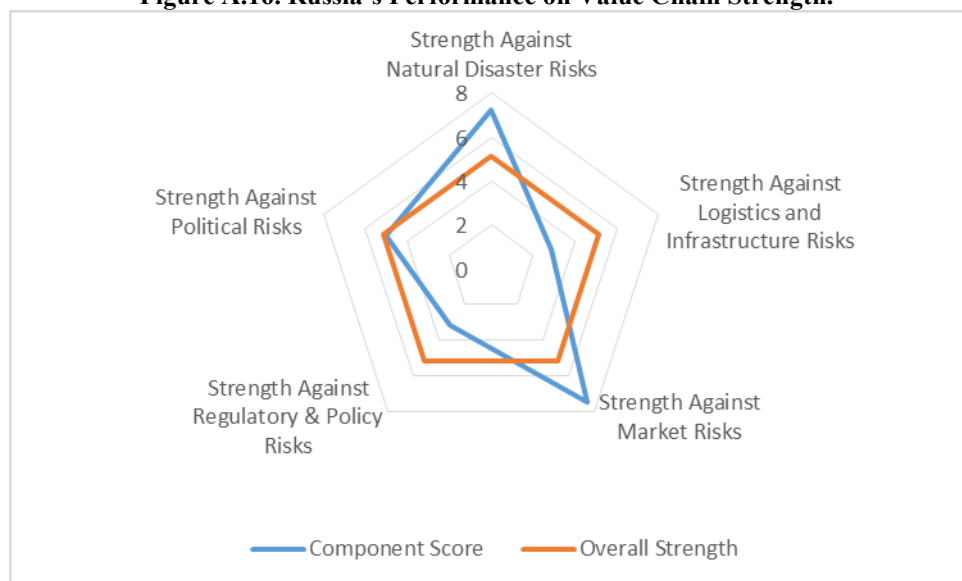


Source: Authors' calculations.

## RUSSIA

Russia's overall level of Value Chain Strength as measured by this report's index is 5.1. Performance is above the economy average level in two areas: strength against natural disaster risks, and strength against market risks. Of the remaining three areas, two exhibit performance levels that are substantially below Russia's overall score: strength against logistics and infrastructure risks, and strength against regulatory and policy risks.

**Figure A.16. Russia's Performance on Value Chain Strength.**

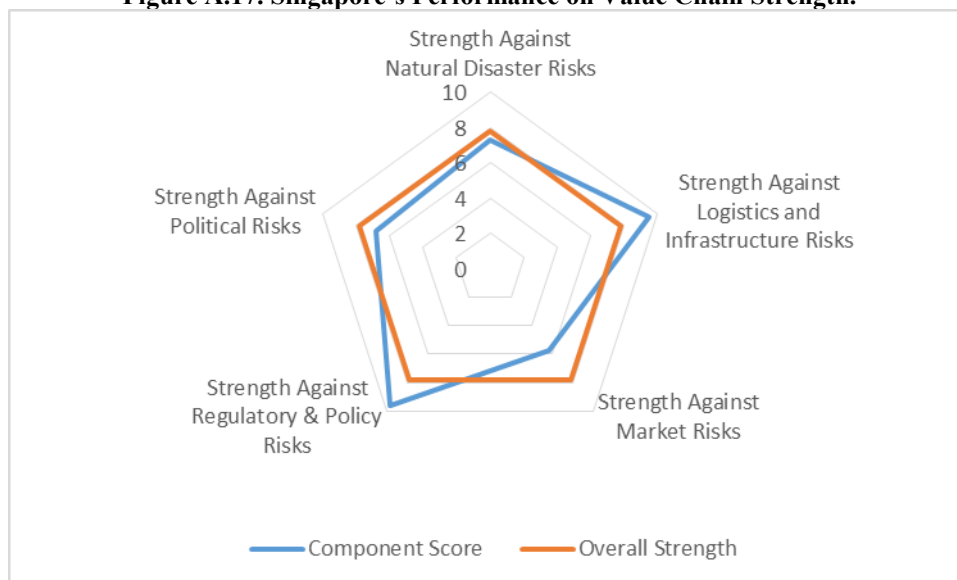


Source: Authors' calculations.

## SINGAPORE

Singapore's overall score on Value Chain Strength is 7.8. Its performance in the areas of strength against logistics and infrastructure risks and strength against regulatory and policy risks is above the economy average level. Of the remaining dimensions of Value Chain Strength, only strength against market risks is at a level that suggests that it may benefit from increased policy attention in the future: it is noticeably below the economy average level.

**Figure A.17. Singapore's Performance on Value Chain Strength.**

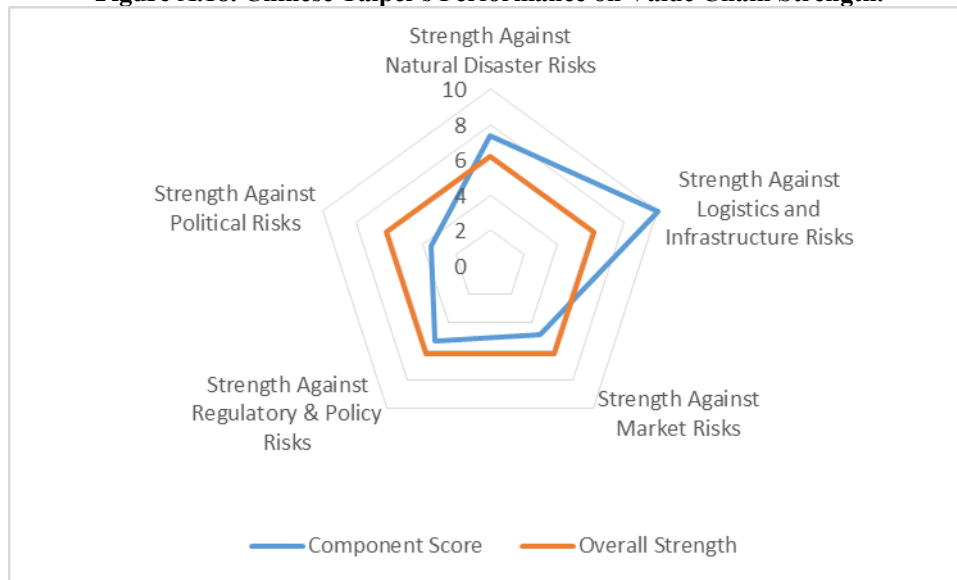


*Source: Authors' calculations.*

## CHINESE TAIPEI

Chinese Taipei's average score for Value Chain Strength is 6.2. Of the component indices, strength against natural disaster risk and strength against logistics and infrastructure risk stand out as areas in which performance is well above the economy average level. By contrast, strength against political risks is below the economy average, as is strength against market risks. These areas could benefit from increased attention from policymakers in the future, in order to improve overall performance.

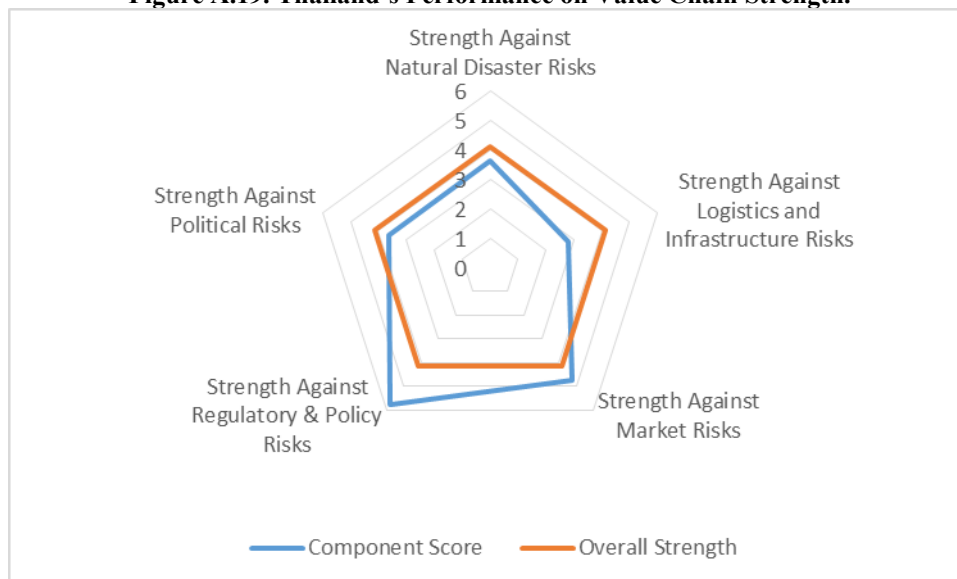


**Figure A.18. Chinese Taipei's Performance on Value Chain Strength.**

Source: Authors' calculations.

## THAILAND

In terms of overall Value Chain Strength performance, Thailand has an index score of 4.1. Strength against regulatory and policy risks, as well as strength against market risks, stand out as areas of stronger than average performance. By contrast, strength against logistics and infrastructure risks has a substantially lower index score than the economy average. This area could be one that would benefit from policymakers' attention going forward, in the interests of increasing the overall level of Value Chain Strength performance.

**Figure A.19. Thailand's Performance on Value Chain Strength.**

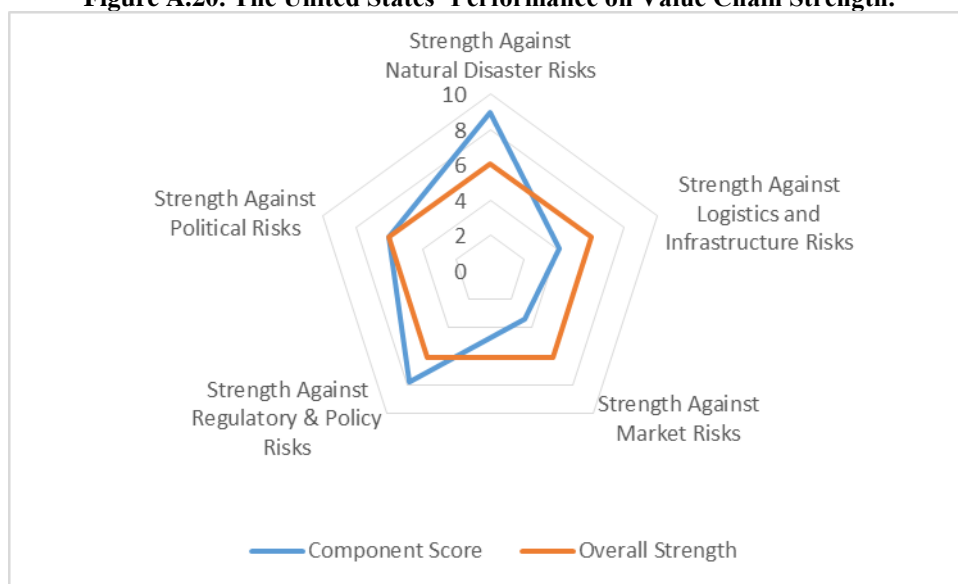
Source: Authors' calculations.

## UNITED STATES

The United States has an overall Value Chain Strength score of 6.1. Strength against natural disaster risks, as well as strength against regulatory and policy risks, stand out as areas in

which performance is significantly above the overall score. On the other hand, strength against logistics and infrastructure risks and strength against market risks have scores that are lower than the economy average. These areas are the subject of ongoing attention from policymakers, and it is to be hoped that these efforts are fruitful in boosting overall Value Chain Strength performance.

**Figure A.20. The United States’ Performance on Value Chain Strength.**

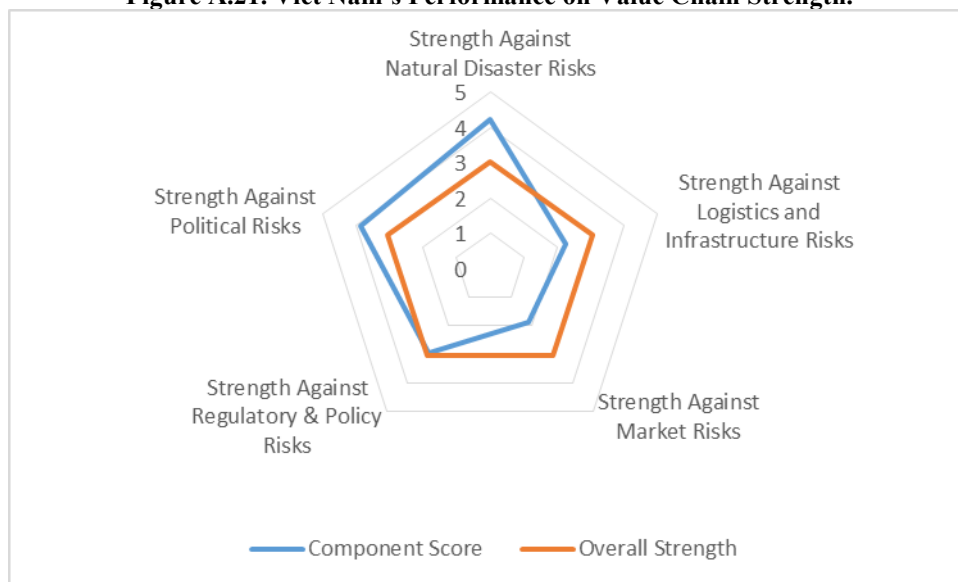


Source: Authors' calculations.

### VIET NAM

Viet Nam's overall Value Chain Strength index performance is 3.0. In terms of dimensions that are above the economy average, strength against natural disaster risks and strength against political risks stand out. By contrast, strength against logistics and infrastructure risks and strength against market risks have scores that are substantially lower than the economy average. These areas could benefit from a redoubling of efforts going forward, so as to lift overall performance.

**Figure A.21. Viet Nam's Performance on Value Chain Strength.**



Source: Authors' calculations.

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