



The globalization of local risks through globally interconnected industrial supply chains

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The expansion of industries and the manufacturing of critical industrial components across multiple territories has set the stage for the perpetuation of transboundary climate risks in global supply chains by taking local risks to the global scale.

- Direct climate risks, non-climate drivers and adaptation responses along global industrial supply chains interact with each other and compound, increasing the likelihood of supply chain disruptions.
- Many developing countries are highly vulnerable to climate change and disasters, and this has exposed global production processes, including industrial supply chains, to new risks that are neither fully understood nor addressed.
- There is a lack of transboundary climate risk assessments to analyze natural and climatic hazards on global industrial supply chains, which is a first step towards inclusive multi-stakeholder dialogue for designing risk management and adaptation planning across interconnected components.

Overview

Supply chains are critical for global industrial processes – they connect production centres with resources and consumers around the world and have enabled industrial production to connect national, regional and international economies. They are the backbone of our modern economies, yet supply chains are highly vulnerable to shocks, including the compound impacts triggered by climate change and non-climate shocks such as pandemics. These impacts can span diverse geographic locations and take place over varying timeframes, exacerbating the consequences. Against this backdrop, the transboundary climate risks to the global supply chains of critical industries illustrate the globalization of localized risks. To date, national adaptation planning has focused on risks within borders, overlooking the need to

address the threat of transboundary climate risks to global supply chains. Integrating industrial risk assessments as a part of national and subnational climate change risk assessments and adaptation planning can help to address this systemic risk.

Introduction

Industrial production has evolved over the last century as seen most notably in the shift from locally procured raw materials, human labour and financial capital with a largely local consumer base to outsourcing and globalization. The factors that have expanded industrial production across borders include product specialization, resource scarcity, cost minimization and profit maximization, time and geographical advantages, political and social environment advantages and more. As a result, the various stages of industrial production have changed in terms of their geography and timescales to create highly interconnected and interdependent systems across manufacturing components that link countries across the globe. Boeing, for example, procured more than 1.7 billion parts from 58 countries for manufacturing aircraft in the US, as well as many services in 2019 alone (Boeing, 2020).

Outsourcing and dependency on global supply chains have increased both direct and indirect exposure to climate-related risks (extreme events and slow-onset changes). For example, flood damage to Klang port in Malaysia after heavy rainfall in December 2021 disrupted the semiconductor supply chain (Leslie, 2022; Lim, 2021). The floods damaged semiconductor production facilities and blocked access to the port, disrupting its operations. This event compounded an existing shortage of semiconductors in a sector affected by the Covid-19 pandemic. This demonstrates how non-climate drivers such as pandemics exacerbate risks to supply chains, with cascading consequences downstream that affect, in this case, the manufacturing of consumer electronics and cars.

A number of efforts have been made to understand and address these global supply chain issues, but more

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research is needed to understand the transboundary climate risks through global and regional interconnected supply chains.

Characterization of the transboundary climate risk

Direct climate risks, non-climate drivers and adaptation responses along the world's industrial supply chains interact with and compound each other, increasing the likelihood of supply chain disruptions.

Transboundary climate risks involving global supply chains are characterized by components of supply chain management that are vulnerable to climate risks and adaptation responses (long-term risk reduction and resilience building). Critical components of this management are vulnerable to climate hazards such as extreme events and slow-onset changes in planning, sourcing raw materials, manufacturing, delivery and returns.

Indirect transboundary climate risks are also critical for global supply chains. For example, supply chains are not independent of the manufacturing facilities they serve: they reflect the practices and choices of those manufacturing units. It is, therefore, of paramount importance to understand the production decisions made by manufacturing units that can contribute to supply chain risks, including responses to climate hazards and adaptation planning.

Production processes that are widely distributed enable companies to bring production to the source of the need, and to store and distribute products to different markets – the dominant form of distributed manufacturing. With the expansion of consumer demand and markets outside the areas where industries have operated for a long time and where those industries already understand the local risks, more manufacturers are eager to install production facilities in emerging markets in developing countries.

Entering new markets is an opportunity to expand market reach to new consumers and target products to their needs and choices while taking advantage of local cheap labour and often lax environmental regulations. The expansion of industries into relatively unknown territories has set the stage for the perpetuation of transboundary climate risks to the global scale.

The expansion of production beyond traditional markets, accompanied by production economics that have pushed industries to “expand or perish” has made it possible to capture emerging markets, supported by the “early bird incentive”. However, this has happened without an understanding of the many local risks in immature emerging markets. Many developing countries are highly vulnerable to climate change and disasters, and this has exposed global production processes, including industrial supply chains, to new risks that are neither fully understood nor addressed.

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Many of these countries do not have fully developed institutional systems to address climate risks and adaptation planning. At the same time, new industries entering these countries are often isolated from the local societies and linkages that are often the forte of locally developed industries. As a result, these new industries miss out on vital social capital and undermine their own prospects for long-term sustainability.

Physical risks

Climate hazards pose a direct risk to industrial supply chains through, for example, the immediate vulnerability and exposure of manufacturing units to such hazards. However, the extent of their exposure is unknown, given the lack of climate risk assessments in many developing countries, until they are surprised by an extreme climate event – an example of the accumulation of hidden vulnerability in many developing countries. As the result of a lack of land-use regulations, combined with poor standards and by-laws that fail to impose construction regulations for flood and typhoon resistance, many manufacturing units are highly vulnerable to such climate hazards. Other physical elements of supply chains – roads, ports, trains and telecommunications, among others – are vulnerable to disruptions triggered by climate change and related hazards. Such infrastructure in many developing countries is not well developed and its strengthening remains a long-standing development gap. Further, much of the infrastructure in many developed countries is not designed to cope with climate change and related climatic disasters. Ports, in particular, are crucial for supply chains, yet they are highly vulnerable to climate risks because of their physical proximity to coastal areas exposed to typhoons and sea-level rises.

Foreign direct investment

Foreign direct investment (FDI) is crucial for global industrial supply chains as a non-climate variable. FDI influences the propagation of transboundary climate risks as it enables external players to invest in new opportunities in emerging markets [Chapter 2.6]. It provides an easy conduit for foreign investors and companies to expand beyond their boundaries and provides a policy framework

Box 5. Case study:
A flood in Bangkok shocks the car industry in Japan

The case of the 2011 floods in Bangkok and its impact on the Japanese car industry demonstrates that climate disasters in vulnerable countries impact not only the multinational manufacturing entities in these countries, but also the source countries of these entities, their societies, institutions and more [Figure 7]. It also shows that the damage to multinational companies has the highest potential to carry risks across borders.

The floods provide a clear example of transboundary climate risks in industrial global supply chains, leading to cascading risks on interdependent industries in Japan and other parts of Asia. The flood itself was caused by strong rainfall events in quick succession as a result of the strong Southern Oscillation Index (SOI) in 2011 (Gale & Saunders, 2013) – the wettest year for more than six decades. Hence, the Chao Phraya River experienced a peak river flow with an estimated return period of 10–20 years.

The estimated economic cost of the flood to the Thai economy was USD 46.5 billion – around 1.1% of national GDP (World Bank, 2012) – with insured losses estimated to be around USD 12 billion (Swiss Re, 2012). Nearly 70% of the total losses were borne by the manufacturing sector because the flood hit industries that were concentrated in the Ayuthaya and Pathum Thani areas. The Navanakorn industrial zone in Pathum Thani alone had 270 manufacturing facilities employing nearly 270 000 workers (Kate, 2011). Many of these industries produced electronic parts and components for automotive manufacturers. While the overall physical damages were fully recovered, losses related to lost production may never be recovered, with the flooding projected to have continued cascading effects in the following years.

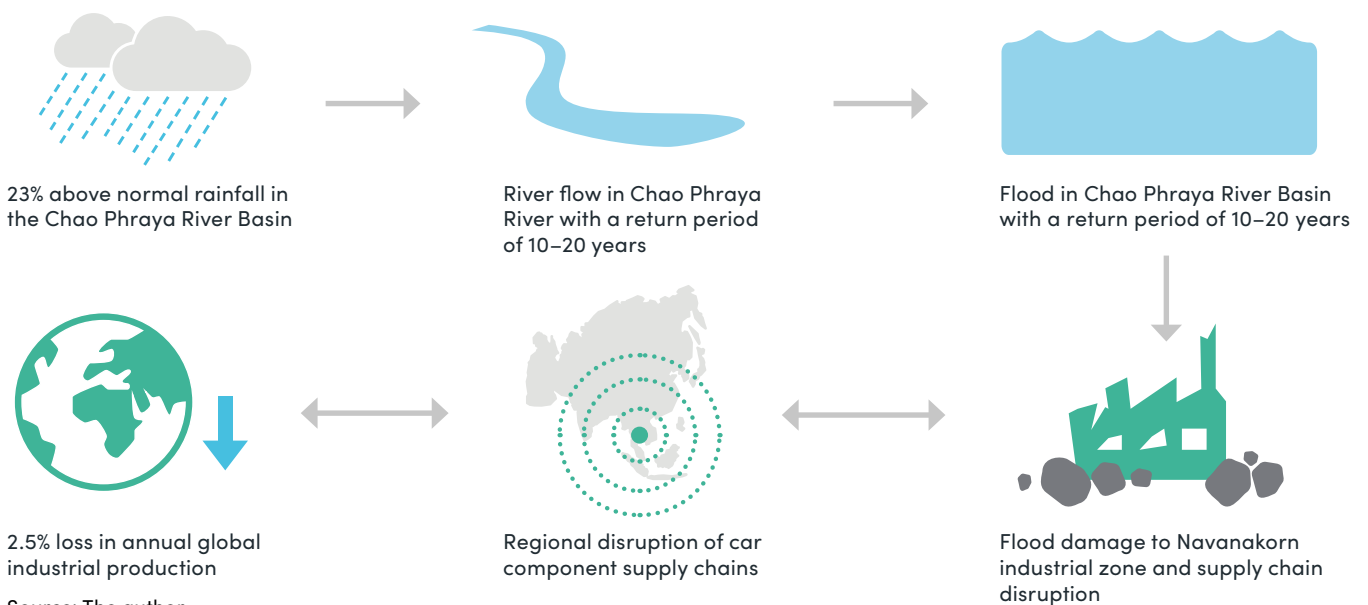
While the flooding itself took place in Thailand, the impact on Japan was significant. More than 550 Japanese affiliate firms were affected, and production facilities such as buildings and machinery were severely affected by floodwaters (Hayakawa et al., 2015). In addition to the direct effects, many Japanese firms engaged in supply chains outside the flooded areas were also affected by these floods: firms that link production facilities in Thailand with other countries in Southeast Asia.

As a result, automobile exports from Japan were severely affected, with falls in their yearly growth rates. This also coincided with the Tohoku earthquake in Japan, which had already disrupted automobile exports in 2011, with a 70% slump in exports in April of that year (Chongvilaivan, 2012). The impact of the Bangkok flood on Japan’s automobile exports led to a 20% downfall in December 2011. Overall, as a result of floods, the insured losses for Japanese firms alone were estimated to be in the range of USD 10–15 billion, with a significant share of these losses borne by Thai insurance companies (Meehan, 2012).

As these firms supply factories in Indonesia, Malaysia, Viet Nam and other parts of the world, the production of these factories was also affected by the shock to the supply chains. Consequently, the floods in Bangkok also had a major impact on global industrial production, with estimates of a 2.5% loss in annual global industrial production (METI, 2012).

Such negative shocks for multinational corporations in developing countries matter if foreign investments in vulnerable and developing countries are to make any tangible difference to their economies. It is important, therefore, that the economic plans and investments by corporations in developing and vulnerable parts of the world are addressed with a multi-pronged approach that takes account of potential transboundary climate risks (Kato & Okubo, 2017).

Figure 7. The impact pathway of industrial supply chain disruption from the 2011 Bangkok floods



for that expansion. However, most FDI policies are oblivious of local risks, and this can contribute to – and even drive – the transboundary climate risks related to industrial supply chains.

Despite this limitation, FDI policies have become “go-to” economic policies for developing countries wanting to attract foreign investments in manufacturing and technology (Kimura & Obashi, 2011). As a result, FDI flows doubled between 1990 and 2016, with Asia attracting the most FDI for its manufacturing, infrastructure, energy and transport sectors (Prabhakar & Shaw, 2020). This was a win-win situation for developing countries as they introduced new technologies and provided new labour markets.

Yet many FDI policies do not specify the climatic risks or inform the investors about these risks or the precautions needed – a situation often compounded by lax environmental regulations in many of these developing countries. Poor risk communication between recipient countries and investors is a key factor in the exposure of global supply chains to climate change risks. In the context of rapidly growing global investments in Asia, countries that attract global investments for manufacturing and service industries are also seen as highly vulnerable to climatic disasters and related losses (World Bank, 2012).

Regional integration processes

Regional integration processes also contribute to the globalization of local risks, such as the processes happening in Southeast Asia to promote free trade and labour market mobility. Enhanced trade and investments have been significant for regional integration in Asia and other parts of the world in recent decades (Asian Development Bank, 2017). Asia has become a producer of goods and services for the rest of the world and, as a result, investments in the region have grown significantly (World Bank, 2018). While such regional integration processes benefit countries by enabling them to tap into economic growth potential, they also lead to the expansion of growth in climate-vulnerable locations, including coastal areas that are vulnerable to flooding and sea-level rises.

Governance

The legal aspects of supply chain governance merit attention to understand their vulnerability to climate change risks. Unlike manufacturing establishments that are governed by the law of the land, other parts of the supply chains are not governed by any single entity or institution. Instead, their legal governance is often spread across several countries, laws and regulations depending on the specific element of the supply chain. This makes it challenging to manage the risk coherently. While supply chain management is largely left to individual manufacturing units, the ability of these units to fully manage supply chains is limited.

Planning is an integral part of supply chain management, with simulation and scenario-based planning helping to envisage some potential shocks. Yet, most planning focuses on production disruptions caused by machinery failure, for example, rather than the prospect of large-scale catastrophic disruptions that seem unlikely, or high-impact climate events that affect manufacturing and supply chains. Most businesses now focus on lean manufacturing processes, and while these can increase efficiency, there is little incorporation of risk management or the identification of risk elements across the full supply chain. However, businesses are increasingly aware of the risks to their supply chains, as shown in the case study.

Critical reflections on existing policy tools and their limitations

The multi-pronged approach needed to address transboundary climate risks via supply chains can be informed by existing solutions or those that are being debated. Many of these have been derived from the efforts made through the corporate disaster risk reduction initiatives by various countries and industries; climate change adaptation interventions; and the debates and experiences emerging from the Covid-19 pandemic, which caused serious disruptions to global supply chains.

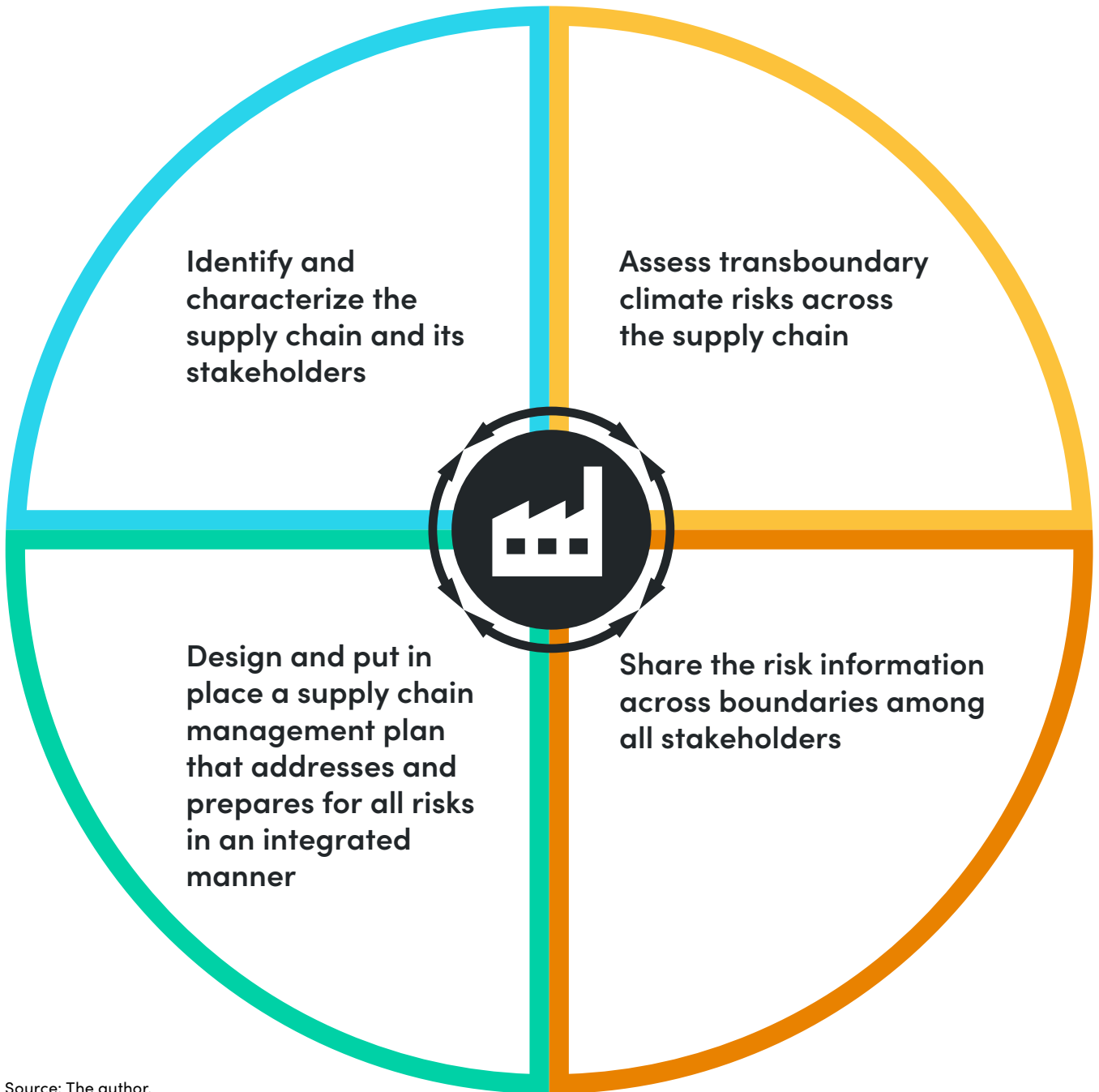
Key solutions to reduce the globalization of local risks in the face of a changing climate and non-climate drivers are:

- the identification and characterization of the supply chain and its stakeholders
- mandatory and transboundary risk assessments that go beyond financial and market risks to analyse natural and climatic hazards
- the open and transparent sharing of risk information by countries, within the supply chain across boundaries, and with potential investors, and
- the strengthening of risk management and adaptation planning across supply chains [Figure 8].

The rest of this chapter discusses aspects of these four categories of solutions for making supply chains resilient to transboundary climate risks.

First, firms often may not fully understand transboundary climate risks in their own supply chains to the extent needed. They need to understand not only the quality of products and services offered by the supply chain, but also the risks and underlying vulnerabilities for the various stakeholders within those supply chains. Building a supply chain that is resilient to transboundary climate risks starts with a deep understanding of the supply chain from the point of view of their risks and the capacities of their component actors.

Figure 8. Management and adaptation planning across supply chain



Source: The author.

Second, effective, transboundary risk assessments are crucial. Supply chain risk assessments are not new, yet most current industry risk assessments focus on the potential for mechanical failures, labour shortages, market risks, financial risks, resource production and supply and, to some extent, political risks. Natural hazards including climate changes and social risks are given less attention. However, this is changing slowly. A recent study using a localized climate change variability/vulnerability index revealed that nearly 49% of manufacturing facilities are exposed to climate variability and rapid temperature and precipitation changes in China, Taiwan and the US

(Boyson et al., 2022). This analysis looks at how facilities can be affected by floods, storms, heatwaves, water scarcity and fires in a changing climate. Such assessments would help industries move away from disaster management that focuses on event-based planning towards a more long-term and integrated adaptation perspective to address climate change risks.

Third, it is vital to share information. Governments need to facilitate a mechanism where the local climate change risks are transparently communicated to investors. Likewise, the industry should communicate the supply chain risks

that may adversely affect the national interests and security. Many climate risks to supply chains originate outside the industrial establishments, i.e. through damage to roads, ports and telecommunications, and many of these are under the purview of governments. Governments also play a key role in incentivizing FDI and the proliferation of industrial agglomerations and other policy instruments. Climate hazards also affect the communities that provide industries with their labour force, generating cascading effects on livelihoods and household welfare.

For all of these reasons, effective climate risk communication is critical across governments, the private sector, civil society organizations, science and technology institutions and communities for the governance of transboundary climate risks and global supply chains, alongside multi-stakeholder engagement and participation. The risk communication between national governments and investing entities should be strengthened such that the hidden risks are clearly recognized and efforts are made to reduce them. International investing entities, in particular, should be able to show that their investments don't bring global risks to the local level and that they don't act as conduits that carry local risks to the global level.

Finally, manufacturing countries need to put in place measures to adapt to the climate risks for industry in general and for their international investments. Measures include building climate-proof infrastructure, information communication and constructing a risk insurance facility for industry. National and subnational adaptation plans should focus on industry-specific risk assessments and identify where government policies can have an impact by changing the behaviour of stakeholders. Governments can, for example, make it mandatory for all industrial units to conduct their own climate change risk assessments to examine the effects on employees and societies that depend on their goods and services. A similar requirement could be imposed by the industry-originating countries on how foreign investments by domestic multinational corporations affect national stability and sustainability through feedback shocks through financial markets etc. Past experience indicates that industry can adopt stringent measures for its competitiveness and overall sustainability (e.g., environmental standards).

Continual engagement with input suppliers and original equipment manufacturers is an important and emerging area that can enable industries to address the quality of services they provide, but these engagements could also focus on understanding and addressing transboundary climate risks. Traditionally, companies have provided designs and asked the original equipment manufacturers to provide components that are subsequently tested and certified by the procuring entity. However, this is changing. More manufacturers now engage with their suppliers on a long-term basis, training them so that the original equipment manufacturers can test the components even

before they arrive at the assembly line. This has advantages including avoiding last-minute surprises, reducing delays, managing demand and, importantly, improving trust with parts providers.

Such engagements have the potential to build resilient supply chains and avoid supply chain disruptions. For example, Boeing, through its quality integration strategies, has helped suppliers to design and test parts, and by closely monitoring the process, has been able to reduce delays in input supplies and reduce costs. Some companies such as Mitsubishi are going further to advise their parts manufacturers to insure against known risks including climatic disasters, thereby reducing their overall risk exposure. Supply chain insurance products are now being offered but they have very high premium costs as they are often custom-made and the market is small. As more multinational corporations encourage supply chain insurance, there is the potential for a reduction in premium prices in the near term.

Redundancy in supply chains has also received much attention in relation to supply chain management and transboundary climate risks. Redundancy refers to the identification and contracting of back-up manufacturing facilities and multiple-input procurement sources and channels, finding alternative transportation routes, and constant engagement with alternative options to understand the lurking risks. One related aspect is the need to balance procurement in terms of geographical spread. More industries are focusing on local procurement rather than depending on distant suppliers – following their experiences during the Covid-19 pandemic. This can have implications for costs and for the availability of suppliers that can meet quality and quantity requirements. Corporations can, however, address these issues by weighing the costs and benefits of building the capacity of local suppliers against the risks involved in procuring from distant locations.

In conclusion, there is a wealth of experience across various industries and the strengthening of supply chains is higher on their agendas than it has ever been. It is time for them to take a long-term perspective to address climate change risks and engage with a wider range of stakeholders than they have in the past. ●

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