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Adding the resilience dimension to industrial policy: Lessons from COVID-19

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Adding the resilience dimension to industrial policy: Lessons from COVID-19

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Abstract

This paper discusses the role of industrial policy in strengthening the social and economic resilience of nations, building on guidance offered by the Sendai Framework and reflecting on lessons learned from the COVID-19 pandemic, as well as previous crises. First, the paper briefly discusses the importance of manufacturing industries for building resilience across a number of dimensions: as the provider of goods critical to life and national security; as the source of essential goods needed to tackle emergencies; and as a contributor to economic recovery and growth. Recognizing that the first priority of the Sendai Framework is understanding risk in all its dimensions, this paper discusses the evolving risks associated with modern manufacturing global value chains—across supply, operations and demand—and illustrates how these risks have manifested in practice. This paper then identifies an industrial policy toolkit, with measures and activities to address those risks and strengthen resilience across the "four phases" of emergency management: (i) prevention, (ii) preparedness, (iii) response, and (iv) recovery from the pandemic. Examples of implementation are drawn from international experience. Finally, the paper discusses the implications, with an emphasis on the challenges to effective policy implementation in developing countries. While this study is formulated in the context of a pandemic that is still ongoing, the insights offered can support policymakers' efforts to use post-disaster reviews as opportunities to support learning and inform policy thinking.

Keywords: manufacturing; industrial policy; build back better; disaster risk management; Sendai Framework; resilience; COVID-19; emergency management.

1. Introduction

The COVID-19 pandemic has evidenced the strategic role of manufacturing in national economies. Whether keeping food processing lines running to keep us fed, supplying protective equipment for our hospitals or meeting the needs of critical industries such as energy and transportation, manufacturers have played a crucial role throughout the crisis. The pandemic has also demonstrated that most nations had failed to adequately prepare to prevent the public health crisis that unleashed across the globe despite advance warnings from international and national agencies (CRED and UNDRR, 2020a). What are the lessons policymakers can draw from COVID-19? In particular, how can countries ensure that their industries (and industrial policies) are better prepared for such crises in the future?

The Sendai Framework for Disaster Risk Reduction 2015–2030 provides guidance to integrate disaster risk reduction and the building of resilience into policies, plans, programmes and budgets at all levels (UNDRR, 2015). The Framework outlines globally accepted definitions, lessons learned from previous disasters and priorities for action. It encourages countries to use post-disaster reviews as opportunities to enhance learning and public policy.

This paper seeks to make a contribution by focusing on how resilience considerations can be better integrated into industrial policy, building on the guidance offered by the Sendai Framework and the broader emergency management literature, and reflecting on lessons learnt from this and previous crises. While the resilience dimension is a common guiding principle in a number of policy areas, including emergency management and civil protection, urban planning, infrastructure and defence, it has not been the case in the area of industrial policy (Pike et al., 2013).

As countries began to restrict movement and places of work were closed, the impact of the pandemic could be felt on integrated, complex manufacturing supply chains across the world (Policy Links, 2020a). Some supply chains and networks came to a complete halt. Supplier lead-in times increased dramatically, and freight costs became significantly more expensive (Notteboom et al., 2021). Acute shortages of essential supplies ensued (WHO, 2020b). One year after the declaration of the pandemic, the international debate centred around another critical manufacturing challenge: the global scale-up of vaccine production. Safe and effective vaccines have been developed and approved at record speed, but the vast majority had only been administered in a handful of countries (Ghebreyesus, 2021). These lessons about the role of manufacturing in societies and economies have resulted in increased calls for the resilience dimension to be incorporated into industrial policy thinking (Policy Links, 2020a).

The remainder of this paper is organised as follows. Section 2 discusses the contribution of manufacturing to national social and economic resilience. Section 3 reviews the key risks associated with modern manufacturing global value chains across *supply*, *operations* and *demand*. Section 4 identifies policy measures and activities that, as part of an *industrial policy toolkit*, can help address those risks across the "four phases" of emergency management: (i) *prevention*, (ii) *preparedness*, (iii) *response*, and (iv) *recovery*. Where possible, examples of such measures and activities are drawn from recent international experience. While this study is formulated in the context of a pandemic that is still ongoing, the toolkit is designed to inform policy thinking as countries debate the future scope of industrial policies. Finally, Section 5 discusses the policy implications, particularly those related to implementation in developing countries.

2. The role of manufacturing in social and economic resilience

In formulating future policies to strengthen national social and economic resilience, why should policymakers focus on manufacturing in particular? What is the relevance of manufacturing industries for resilience, particularly during an emergency of global dimensions such as the COVID-19 pandemic?

2.1 The multidimensional nature of resilience

The term 'resilience' has many meanings and is used differently in various disciplines such as ecology, software engineering and emergency management. Its roots go back in history.[1] Recently, resilience has gained attention in countries and regions responding to an increasingly diverse array of external shocks and transitions, including financial crises, climate change, food shortages, energy disruptions, utility network breakdowns, technological shifts, counterterrorism campaigns, natural hazards and extreme weather events.

The Sendai Framework adopts the United Nations Office for Disaster Risk Reduction definition of resilience as the "ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner…" (UNDRR, 2015, p. 9). The main goal of the Sendai Framework is to strengthen resilience through the implementation of measures that "prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery" (UNDRR, 2015, p. 12).

[1] A review of the history of the term *resilience* is provided by Alexander (2013).

Resilience can be analysed at various levels, as proposed by Pike et al. (2013):

1. **Firm level:** resilience can be determined by whether specific business units are able to withstand and respond to disruptive changes such as demand shocks, technological shifts and financial crises.

2. **Industry/sector level:** resilience is determined by the capacity of the aggregate of firms to ride out and adapt to disruptive changes, including recessions, cyclical downturns and radical innovations.

3. **Macro level:** the resilience of national economies and institutions is determined by their ability to withstand or rebound from—or even pre-empt—disruptive changes such as demand shocks, currency collapse and sovereign debt crises.

Resilience in manufacturing needs to also be understood in terms of its interdependencies with other critical sectors and resources. Manufacturing firms and networks interact with energy, water, communications and transportation systems, among others. Therefore, when thinking of manufacturing resilience, it is also necessary to pay attention to sectors providing support services (World Bank, 2020). In this regard, the Sendai Framework highlights the need to increase business resilience and protect productive assets "throughout the supply chains" (UNDRR, 2015, p. 20). It recognizes the multidimensional nature of resilience and aims to guide the management of disaster risk at all levels, as well as within and across all sectors. The focus of this paper is, however, on manufacturing industries because of their critical role in societies, as explained in the following section.

2.2 Why does manufacturing matter for resilience?

As with any other sector of the economy, ensuring the manufacturing sector's continuity and supporting its affected workforce needs to be incorporated into national disaster risk management frameworks. However, extreme events such as the COVID-19 pandemic have drawn attention to manufacturing industries' particular role in social and economic resilience in national economies across three dimensions. The first dimension entails the role of manufacturing industries as providers of essential goods that are *critical to life and national security.* The second concerns the role of manufacturers in supplying goods that are *critical to tackling the emergency* itself. Lastly, the third dimension relates to the manufacturing sector's contribution to the *recovery and growth of national economies*.

Figure 1: Manufacturing plays a critical role in socio-economic resilience

- Manufacturing provides goods that are critical for the sustenance of life – including food, beverages, medicines, clothing, fuel and other basic necessities.
- Manufacturing provides inputs (such as machinery, components, systems and engineering services) to critical national infrastructure (such as transportation, electricity and communication).

- Manufacturing provides strategically important products and assets to address certain types of emergency.
- A shortage of COVID-19-critical items hampered countries' ability to respond to the crisis.
- Different types of goods are required during different emergencies.

- Historically, manufacturing has been dubbed the "flywheel of growth" because of its contribution to productivity, trade, jobs and innovation.
- In a number of countries, manufacturing industries have offered "pockets of resilience" supporting recovery from COVID-19, as well as previous crises.

Industrial policy needs to be part of the national dialogue on "building back better"

Source: Authors.

Critical to life and national security

Manufacturing industries provide goods that are critical to life during "normal" times – including food, beverages, medicines, medical goods, clothing, fuel and other basic necessities. In times of disaster, however, manufacturing supply chains that functioned well previously might experience a significant disruption, turning a disaster into a catastrophe (DHS and FEMA, 2019).

To understand the significance of industrial policy, the impacts of a lack or complete cessation of manufacturing supplies on the sustenance of life and the functioning of the economy must be assessed. For example, concerns about food security in the midst of the global pandemic refocused attention on the global food supply chain industry. The key concerns were logistics disruptions of short shelf-life agricultural products and the closure of food manufacturing plants as a result of worker illness in industries such as meat processing (OECD, 2020a). However, the contribution of manufacturing as an economic activity goes beyond basic necessities. To fully understand the relationship between manufacturing and socio-economic resilience, it is important to consider its

position within a broader set of activities and infrastructure upon which the continued operation of manufacturing industries relies.

Notably, manufacturing provides inputs to *critical infrastructure* such as transportation, electricity, communication and defence – in the form of machinery, components, systems and even engineering services. A major disruption in the sector could thus have a significant national economic impact and cascade across multiple critical infrastructure sectors or regions. Similarly, manufacturing activities rely on technology solutions from information and communications technology (ICT) industries; air, land and maritime transportation services; water supplies; and large amounts of uninterrupted power (DHS and FEMA, 2019).

The definition of critical infrastructure has changed over time and varies across countries (Singh et al., 2014). The UNDRR defines it as "physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society" (UNDRR, 2020a). For example, the United States identifies 16 critical infrastructure sectors, one of which is "critical manufacturing" (The White House, 2013). Industries within critical manufacturing include *primary metals manufacturing* (including iron, steel and aluminium production and processing); *machinery manufacturing* (including power transmission, agricultural and construction machinery); *electrical equipment manufacturing* (including equipment for power generation such as transformers, electric motors and generators and industrial controls); and *transportation equipment manufacturing* (including vehicles and commercial ships manufacturing).

Critical to tackling the emergency

Manufactured goods are critical to tackling emergencies. In March 2020, the World Health Organization (WHO) published a list of COVID-19-critical items facing a global shortage, grouped into three categories (Table 1). Despite efforts by companies to expand their capacity, governments utilizing accumulated stockpiles and people switching to substitutes, there was still a gap between the supply and demand of these essential products, which hampered global responses to the pandemic (López-Gómez et al., 2020).

The COVID-19 pandemic has emphasized the importance of medical supplies. The WHO compiles an online database containing information on essential medicines "that everyone should have access to at all times, and that all governments should ensure are available – and affordable – to their populations" (WHO, 2021).

Table 1: COVID-19-critical items

Category	Critical items identified by the WHO
Personal protective equipment (PPE)	Gloves, examination Gloves, surgical Goggles, protective Gown, protective Face shield Mask, particulate respirator Mask, surgical
Diagnostic equipment	Lab-screening test kit Lab-confirmation test kit RT-PCR kit Extraction kit Cartridges for RT-PCR automatic systems Swab and viral transport medium
Clinical care equipment	Pulse oximeter Concentrator O2, 10L, 230V, 50 Hz + acc. Nasal oxygen cannula, with prongs Ventilator patient, for adult, paediatric CPAP with tubing and patient interfaces for adult and paediatric Suction pump, mechanical High-flow nasal cannula (HFNC)

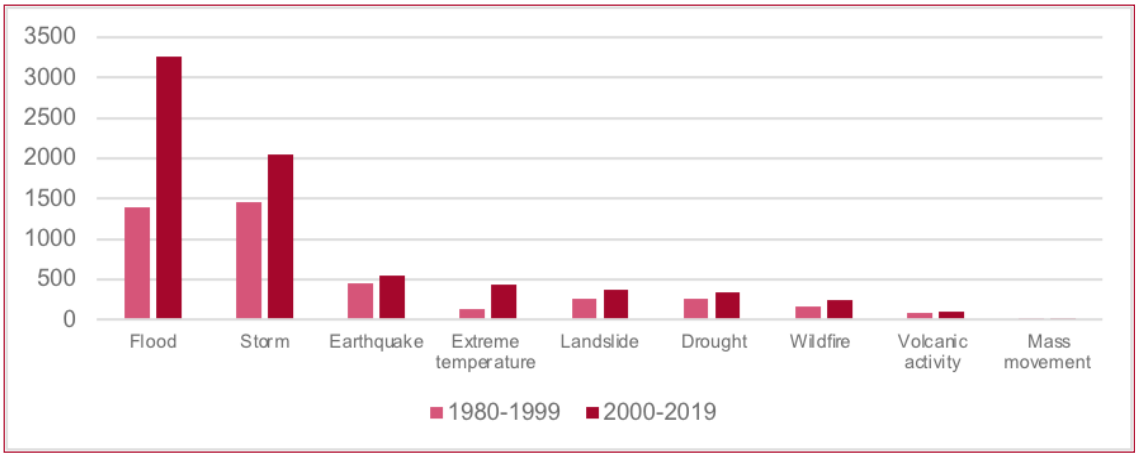
Source: WHO, 2020a.

Humanity is vulnerable to both human-made and natural hazards – including environmental, technological and biological hazards and risks. Between 2000 and 2019, over 7,000 disaster events were recorded worldwide, claiming approximately 1.23 million lives and leading to approximately USD 2.97 trillion in economic losses (CRED and UNDRR, 2020a). The 10 countries most commonly affected were China, the United States, India, the Philippines, Indonesia, Japan, Viet Nam, Mexico, Bangladesh and Afghanistan (CRED and UNDRR, 2020a).

What is particularly troubling is that the frequency of these globally disruptive events is increasing, due, in particular, to extreme weather events (Figure 2). In fact, it is estimated that the average annual economic loss attributable to weather-related events grew sixfold between 1980 and 2019 (Swiss Re Institute, 2020). The exposure of developing countries to disasters is increasing as their populations are mostly concentrated in urban areas – particularly in low-lying coastal regions that are vulnerable to adverse weather conditions (Swiss Re Institute, 2020).

The increased probability of disasters accentuates the importance of not only protecting manufacturing operations from future disruptive events but also strengthening industrial resilience to ensure that countries are better prepared to respond and recover when emergencies occur. The fact that globally disruptive events are bound to arise will test the ability of countries to tackle emergencies in different ways and ensure the supply of very different types of goods. From earthquakes requiring temporary shelter and housing supplies (Ranghieri and Ishiwatari 2014) to pandemics leading to peak demand for personal protective equipment, the importance of manufacturing to address the aftermath of national emergencies will only increase in the future.

Figure 2: Total disaster events by type: 1980-1999 and 2000-2019



Source: Authors' elaboration using data from the UNDRR and CRE (2020).

Economic recovery and growth

The economic effects of disruptive events have led to discussions about the manufacturing sector's specific contribution to national economic recovery and long-term growth. A number of studies have examined the historic role of manufacturing in economic growth and development. Manufacturing has been dubbed the "flywheel of growth" (Kaldor, 1972) and "the key to prosperity" (UNIDO, 2011). The literature emphasizes the importance of manufacturing across variables such as productivity, trade, jobs and skills, innovation and other spillover effects (Chang, 1994; Szirmai, 2011; UNIDO, 2011; European Commission, 2012; Haraguchi et al., 2016). In the context of global shocks, additional aspects of the manufacturing sector's contribution have been highlighted.

Following the 2008/9 financial crisis, the European Commission declared that a "strong industrial base" is vital to "stimulate economic recovery, provide high-quality jobs and reinforce our global competitiveness" (European Commission, 2012, p. 5). The Commission noted that industrial productivity had risen since the height of the crisis and, remarkably, argued in favour of reversing the declining role of industry in Europe "from its current level of around 16% of GDP to as much as 20% by 2020" (European Commission, 2012, p. 4).

More recently, countries such as the Republic of Korea and Singapore have recognized that manufacturing industries offer "pockets of resilience" that have helped prevent a more pronounced recession and which will be critical to economic recovery following the COVID-19 pandemic. Government analyses in the Republic of Korea explicitly acknowledge that the country's rapid economic rebound has been largely "thanks to manufacturing and ICT" (South Korea Ministry of Economy and Finance, 2020). In Australia, there are calls to rethink the low share of manufacturing in gross domestic product (GDP) to foster long-term economic resilience (Ministry of Industry, Science and Technology, 2020).

Naturally, the relevance of the manufacturing sector in economic recovery will vary from country to country, and further analysis is required to empirically ascertain the relationship between the speed of manufacturing recovery and that of overall economic recovery – in this crisis, as well as in previous ones. However, it is noteworthy that the international political discourse has identified manufacturing as a source of economic recovery since the last two major global crises. Any future assessments of economic vulnerability will need to incorporate analyses of the contribution of different sectors of the economy, including manufacturing, in recovery.

Paradoxically, the crisis may provide new opportunities for diversification and growth in manufacturing as governments invest heavily in the low-carbon economy as part of recovery. There have been growing calls to leverage these investments to accelerate the transition to low-carbon economies, to shift industries to circular business models and achieve net zero emissions by 2050 (Club of Rome, 2020). The challenge for countries will be to exploit emerging opportunities while addressing the socio-economic risks associated with this transition.

3. Risks associated with modern manufacturing global value chains

The Sendai Framework states that policies and practices aimed at strengthening resilience and reducing disaster losses need to be based on understanding disaster risk "in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment" (UNDRR, 2015, p. 14).

Having established the relevance of manufacturing industries for national socio-economic resilience in the previous section, this section shifts the focus to the underlying risks associated with modern manufacturing industries, paying particular attention to the vulnerabilities of global value chains.

With the expansion of international commerce, manufacturing supply chains have grown more complex, interdependent and geographically dispersed. Many sectors' production facilities, suppliers and customers are distributed around the globe. This makes manufacturing global value chains particularly vulnerable to disruptive events (DHS, 2015; European Parliament's Committee on International Trade, 2021). As previous disasters have shown, disruptions to critical manufacturing suppliers can lead to global shortages in industries from automotive and aerospace to electronics (Canis, 2011).

Several underlying characteristics of modern manufacturing systems influence their exposure to risks and disruptions (DHS, 2015):

- Most manufacturing enterprises are integrated into complex, interdependent supply chains.
- Supply chains have been optimized for productivity and efficiency.
- Manufacturers have become highly reliant on global information and communication systems and thus more exposed to cyber-security threats.
- Globalization and outsourcing have linked national manufacturers with foreign suppliers.
- Manufacturers rely heavily on external resource suppliers (e.g. electricity, heat, raw materials).

Naturally, manufacturing activities are not homogenous, and some of these broad characteristics apply more to some industries than others. For example, recent studies have highlighted important differences across sectors (European Parliament's Committee on International Trade, 202):

- Many labour-intensive industries, such as apparel, are particularly exposed to pandemics, heat stress, floods and other risks affecting the workforce.
- Food and beverages and fabricated metals have a lower average exposure to trade-related shocks, because they are among the least traded and most regionally-oriented value chains. However, they might still be susceptible to disruptions from other risks (e.g. droughts and floods can have high impacts on food supply chains).
- Given the high trade intensity of pharmaceuticals and medical devices, exposure relates not only to risks associated with a pandemic but also to trade disputes and demand competition.

The operations management literature identifies a broad set of risks associated with global supply chains – including supply risks, operational risks, demand risks, security risks, macroeconomic risks, policy risks, competitive risks and resource risks (Manuj and Mentzer, 2008). Many of these risks overlap and are interdependent. The literature places particular emphasis on supply, operation and demand risks, which are used for the purposes of this paper to illustrate how risks manifest during disruptive events such as the COVID-19 pandemic (Table 2).

The risks outlined in the upper part of Table 2 ("General risk examples") are general in nature, applicable to various manufacturing disruption events and not exclusive to the coronavirus pandemic. What distinguishes one disruption event from another (e.g. a storm/flood versus a trade dispute) is that each of these events triggers a different and unique combination of risks. Latent supply chain risks combined with disruption events lead to supply-demand imbalances, usually manifested as price volatility and shortages of specific products, services, components or commodities. When this occurs, the different stakeholders along the chain react in accordance with their own interests and capabilities to restore the balance in the system as quickly as possible.

In this regard, observations made since the COVID-19 crisis began suggest that business threats experienced throughout the pandemic have been strongly associated with the speed at which the supply chain was able to respond to specific risks and shocks to the system. The unique characteristic of the COVID-19 crisis in comparison to other events is that, unlike the others, this disruption episode triggered risks across all three categories simultaneously on a global scale: supply, operations and demand.

The lessons gleaned from the COVID-19 pandemic are that simultaneously managing risks across the dimensions of supply, operations and demand requires a profound understanding of the risk sources, the likelihood of these developing into supply-demand imbalances, and the possibilities to increase the readiness of new supply capacity and demand throughout the chain. The following sub-sections highlight some of the key risks that were observed and/or that intensified during the pandemic across the three variables under study to further illustrate the uniqueness of this event for modern manufacturing supply chains (see also Table 2 for specific risk examples from the COVID-19 pandemic).

3.1 Supply risks

Supply risks refer to the "possibility of an event occurrence associated with inbound supply that may cause failures from supplier(s) or the supply market, such that the outcome results in the inability of the focal firm to meet customer demand within anticipated costs, or causes threats to customer life and safety" (Manuj and Mentzer, 2008, p. 138).

Owing to advances in transportation, information technology, and physical and digital infrastructure, modern manufacturing has achieved supply chain efficiencies that enable just-in-time shipments and reduced inventories, but also decrease the ability to absorb disruptions (DHS, 2015). Lean manufacturing approaches help firms eliminate all forms of waste by minimizing work-in-progress, waiting and inventories across the supply chain. While this can create highly efficient and profitable production, it also means that disruptions in the flow of materials and components are quickly felt along the chain.

Many industries had already experienced shortages of essential manufactured inputs even before the crisis – from raw materials to computer chips. The COVID-19 pandemic has exposed the risks of holding too little inventory of critical components or equipment and the consequences of delayed customer deliveries that may follow as a result. According to a survey conducted among 50 ICT firms by the US Cybersecurity and Infrastructure Security Agency (CISA) in August 2020, 16 per cent of respondents had decided to move away from just-in-time production, while 38 per cent planned to do so in the near future (CISA, 2020a).

Supply chains are also exposed to disruptions in infrastructure that provide basic inputs such as electricity and water. During the earthquake and tsunami in Japan in 2011 and Hurricane Maria in Puerto Rico in 2017, it was reported that the sources of supply had remained sufficient to support survivor needs. However, the loss of critical infrastructure, including distribution infrastructure, had affected existing distribution capacity (DHS and FEMA, 2019).

Table 2: Risks associated with modern manufacturing global value chains

	Supply risks	Operational risks	Demand risks
Definition	*Possibility of an event occurrence associated with inbound supply that may cause failures from supplier(s) or the supply market*	*Possibility of an event associated with the focal firm that may affect the firm's internal ability to produce goods and services, quality and timeliness of production*	*Possibility of an event associated with outbound flows that may affect the likelihood of customers placing orders, and/or variance in the volume and assortment desired by the customer*
General risk examples	▪ Disruption of the supply of raw materials, components and technologies ▪ Large inventory fluctuations ▪ Delays in deliveries ▪ Interruption of basic inputs such as electricity and water ▪ Price escalation in high-demand inputs ▪ Increasing cargo transportation fees ▪ Supplier opportunism	▪ Cash flow and liquidity issues; inability to pay salaries and suppliers ▪ Forced closure of production facilities ▪ Restricted workforce mobility ▪ Risks to workforce's health and safety ▪ Reduced processing capability ▪ Restricted access to specialist services to attend machinery breakdowns ▪ Postponed investment due to market uncertainty	▪ Demand variability ▪ Sharp increase in demand for medical equipment ▪ Rise in demand for certain goods (e.g. processed food, IT equipment and computer systems) ▪ Plummeting demand for certain consumer goods ▪ Demand competition between sectors and countries ▪ Failure to meet consumer expectations ▪ Reduced consumer spending power

	Supply risks	Operational risks	Demand risks
Examples from the COVID-19 pandemic	▪ *Bangladesh.* In March 2020, 90% of over 300 garment firms surveyed reported facing delays in shipments of inputs from China, and around 80% reported increases in the prices of inputs ▪ *The Republic of Korea.* Over 50% of SMEs surveyed reported delivery disruptions ▪ *United States*. In late March 2020, 81% of over 500 firms reported increases in the lead times of inputs from China, and 68% reported increases in the lead times of inputs from Europe ▪ *Worldwide*. Fall in cargo capacity in passenger aircraft by 39% in March 2020, with consequent increases in prices ranging from 30% to over 60%	▪ *China*. One-third of SMEs surveyed reported having only enough cash to cover their expenses for a month and another third for only two months (February 2020) ▪ *The Republic of Korea*. In total, 6% of SMEs reported operation disruptions due to employee absence (March 2020) ▪ *Ireland*. SMEs that remained closed until 18 May 2020 (since 24 March 2020) incurred an average cost of EUR 177,000 (~USD 210,000) during the lockdown period ▪ *India*. In April 2020, 61% of over 300 firms surveyed expected to defer expansions for a period of up to 6 or 12 months, while 33% expected to defer plans for more than 12 months ▪ *Worldwide*. Drop of over 50% in the number of greenfield projects in March 2020 in comparison with March 2019	▪ *Bangladesh*. Over half of apparel manufacturers faced cancellations of orders already completed or in process (March 2020) ▪ *China*. Changes in production in Jan–Feb 2020: masks +127.5%, smart watches +119.7%, frozen meat +13.5% and instant noodles +11.4% ▪ *The Republic of Korea*. Exports of ICT goods grew by 1.1% in March 2020 and 8.9% in March 2021 ▪ *Ethiopia*. In total, 95% of over 600 manufacturing firms surveyed reported a drop in sales, with an average decline of 55% in September 2020 compared with September 2019 ▪ *Worldwide*. Temporary iPhone supply shortages that affected sales worldwide (March 2020)

Source: Authors' elaboration based on Anner (2020); Ayele et al. (2021); China National Office of Statistics (2020); CISA (2020a, 2020b); Federation of Indian Chambers of Commerce and Industry (2020); Institute for Supply Management (2020a, 2020b); Korea Ministry of Trade, Industry and Energy (2021, 2020); Manuj and Mentzer (2008); UNCTAD (2020); OECD (2020a, 2020b); WorldACD (2020).

Following the outbreak of COVID-19, *direct* supply disruptions hampering production were initially observed in the world's manufacturing heartland (East Asia). These disruptions spread quickly to other major industrial hubs such as the United States and Europe. Immediate supply disruptions then cascaded down as manufacturing firms in less-affected nations found it more difficult and more expensive to acquire the necessary imported inputs from hard-hit nations, and subsequently from each other (Baldwin and Tomiura, 2020). This was clearly evident in the garment industry in countries such as Bangladesh, Cambodia and Viet Nam, which suffered from supply disruptions and had to interrupt production even before the pandemic hit their countries (Castañeda-Navarrete et al., 2021; UNDP Cambodia, 2020). In March 2020, 90 per cent of over 300 garment firms operating in Bangladesh reported that they were facing delays in shipments of inputs from China, and around 80 per cent reported increases in the prices of inputs (Anner, 2020).

3.2 Operational risks

While economic analyses typically emphasize demand and supply perspectives, operational risks are also relevant when considering individual production units. Even when a firm's supply and demand are uninterrupted, they might be prevented from operating because of other factors, as has been the case due to restrictions to movement imposed during the pandemic. Operations risk is defined as the "possibility of an event associated with the focal firm that may affect the firm's internal ability to produce goods and services, quality and timeliness of production" (Manuj and Mentzer, 2008, p. 139).

The mobility restrictions imposed across countries to contain the spread of the virus hit the agri-food industry particularly hard. Agri-food production is mostly seasonal and highly dependent on domestic and international migrant workers. Hence, mobility restrictions have resulted in reduced capacity and food waste in activities including planting, harvesting and processing of crops and livestock production, which are relatively labour-intensive (FAO, 2020; Stephens et al., 2020).

During emergencies, such as natural hazards, businesses may suffer physical assets losses. For example, in Bangladesh, Cyclone Sidr (2007) damaged approximately 1,800 manufacturing establishments (7 per cent of total operations at that time). The cyclone damaged premises, inventory and equipment, affecting production for several weeks (World Bank, 2020).

Although pandemics threaten the health of workers as opposed to causing damage to firms' physical assets, worker absenteeism could disrupt the efficient flow of critical goods and services. Whereas the impacts of COVID-19 on health-related workplace absenteeism were localized, workers operating in critical sectors were at higher risk of contagion and thus more likely to be absent from their workplace (Groenewold et al., 2020; ILO-OECD, 2020). For instance, outbreaks

were reported in meat processing plants in the United States, where employees often work in close proximity to one another (OECD, 2020a).

Forced closures during the COVID-19 crisis impacted firms' cash flows and caused liquidity constraints. This is particularly true for small and medium enterprises (SMEs). A survey conducted in China in February 2020 found that one-third of SMEs reported having enough cash to cover their expenses for one month only and another third for two months only (OECD, 2020b). The uncertainty created also led to the deferral of investment plans. According to UNCTAD (2020), new greenfield investment project announcements and cross-border mergers and acquisitions fell by more than 50 per cent in March 2020 in comparison with March 2019.

Beyond natural disasters and pandemics, a growing source of risk for modern manufacturing is cyber-security. The convergence of digital and manufacturing systems has led to increasing security risks, including loss of data; intellectual property theft; business interruptions; fraud; reputational damage; cyber extortion; physical asset damage; and others.

3.3 Demand risks

Demand risk is the "possibility of an event associated with outbound flows that may affect the likelihood of customers placing orders with the focal firm, and/or variance in the volume and assortment desired by the customer" (Manuj and Mentzer, 2008, p. 139).

Producers suffer from demand distortion and amplification—the so-called "Bullwhip Effect"—because of distorted information from one end of the supply chain to the other (Lee et al., 1997). The variance of orders may be larger than that of sales as a result of this distorted information, leading to a number of inefficiencies: excessive inventory, inadequate capacity and transformation plans, missed production schedules and poor customer service.

The COVID-19 pandemic increased demand for some manufactured products, such as medicines and their components, PPE, electronic devices and some food products (Table 2). In early March 2020, the WHO estimated that industry had to increase production by 40 per cent to meet the rising global demand for PPE (WHO, 2020b).

One of the more dramatic images in the pandemic's early stages was supermarket shelves emptied of key food and non-food items, including pasta, rice, canned goods, flour, frozen foods, bottled water, hand sanitizer, hand soap and toilet paper (Hobbs, 2020). While panic buying behaviour increased temporarily, the demand for food and other essential products and the closure of restaurants as part of social distancing measures translated into longer-term impacts. Particularly,

the demand for frozen and packaged foods increased as a result of the shift in consumer demand towards food consumed at home (OECD, 2020a).

A negative impact was also observed in the demand for other consumer goods, such as apparel. As the pandemic reached Europe and the United States—the main consumer markets for apparel—drops of around 80 per cent in retail sales of clothing were observed in April 2020 (Castañeda-Navarrete et al., 2021).

3.4 The manufacturing supply chain risk profile post-COVID-19

The COVID-19 pandemic may drive profound changes in the way supply chains operate and have long-lasting effects in the organization of global industries. The recovery process is pushing firms to conduct in-depth reassessments of the structure of supply chains in terms of location, production capacity and the management of material and information flows among stakeholders to identify weaknesses and eventually reconfigure the supply chain structure (Govindan et al., 2020).

Regionalization, reshoring and market diversification are all potential new trends emerging from this crisis. As such, it is to be expected that the risk profile of a similar event in the future would vary, as companies and governments around the world would arguably be better prepared to respond to a similar crisis, and the structure and organization of supply chains might be different by then.

The combination of COVID-19 and trade tensions that had been evolving even before the outbreak of the crisis caused a rethinking of global and regional value chains. A prominent example is the increased interest in the "China Plus One" initiative (that is, locating plants in both China and one other country), first adopted by Japanese firms and later followed by companies from other developed countries. Already set in motion before the pandemic, this strategy involves the diversification of suppliers and the redirection of investments primarily towards Southeast Asian and South Asian countries (Iida, 2015).

Exogenous factors such as climate change might contribute to the further transformation of supply chain risk profiles, particularly in a context of limited understanding of how present and future climate change impacts may affect various industries across geographical regions. As climate change unfolds, new policy and regulatory challenges will demand higher efforts by firms to balance competitiveness and sustainability, as is already the case in various countries where legal carbon emission reduction targets have started to be enforced.

Finally, cyber-attacks are now a growing concern for the manufacturing sector, whether the attacks target safety instrumentation systems, industrial control systems or enterprise systems. A 2018 study by Make UK and AIG found that 48 per cent of manufacturers in the United Kingdom have experienced a cyber-attack, with one quarter of attacks resulting in a financial impact (Make UK and AIG, 2018). In 2017, a candy manufacturer reported a USD187.6 million loss from very infectious malware as a result of damage caused to its hardware and operational software systems, affecting sales, distribution and other financial systems (Rosen, 2018). It lost 1,700 servers and 24,000 laptops because of the malware (McCarthy, 2019).

4. An industrial policy toolkit to support resilience

Having established an overview of the supply, operations and demand risks associated with modern global value chains, this section discusses how industrial policy interventions can contribute to addressing these risks – thereby building resilience against future disasters. Informed by globally accepted disaster management frameworks and guidelines from the Sendai Framework, a "policy toolkit" has been developed that identifies a suite of practical policy measures that can help countries build resilience, accounting for risks that might affect their manufacturing industries (**Table 3**). The section also provides examples of how some of these measures have been implemented in practice based on the review of recent international experience.

The aim of the toolkit presented in Table 3 is to lay the conceptual foundations for the design of national industrial policies that incorporate the resilience dimension by reflecting on lessons from COVID-19 and the manufacturing risks that have become a reality during the pandemic. The paper thereby aims to respond to the Sendai Framework's call to integrate "both disaster risk reduction and the building of resilience into policies, plans, programmes and budgets at all levels" (UNDRR, 2015, p. 9). The toolkit provides a menu of policy options or potential interventions that policymakers could consider informing future industrial policies that incorporate the resilience dimension. Each potential measure has been identified in view of its potential contribution to addressing manufacturing risks across different aspects of emergency management. While efforts have been made to identify a broad suite of relevant interventions, the toolkit is by no means comprehensive, and some measures might be more relevant than others for particular countries.

A number of additional clarifications are pertinent:

- This paper does not seek to assess the extent to which the policy measures are already in place in particular countries, the degree of success of individual measures, or whether the necessary implementation capabilities exist in national governments. The toolkit can inform policy thinking as countries formulate recovery plans and reflect on how their industries (and industrial policies) can be better equipped in the future. Further work should focus on determining what options from the toolkit would be most appropriate for individual countries and for developing implementation strategies.

- Selected examples are presented from a variety of countries with different industrial and economic contexts, which were affected by COVID-19 in different ways. We do not suggest that a specific measure adopted in one country should be adopted by others regardless of context. Given countries' different preconditions, policy responses need to be adapted to the local context, requiring countries to conduct their own experimentation. Nonetheless, the thinking underlying the examples presented illustrate a variety of approaches and thus offers useful lessons for policy design.

- Many policy responses presented as illustrations are repackaged and expanded versions of policies that were already in place before the pandemic. Common enhancements included increased funding allocation, relaxed eligibility criteria and extended programme lifespan. No judgements are made regarding the likelihood of success or timing of implementation by individual countries.

Table 3: An industrial policy toolkit to strengthen resilience: observed measures to address manufacturing risks during the COVID-19 pandemic

GOAL: Increased socio-economic resilience through industrial policy measures					Comments and country examples
Across "four phases" of emergency management		*To address risks in:*			
Phase	**Observed measures**	**Supply**	**Operation**	**Demand**	
1. Prevention	**1.1.** Identifying critical industries and mapping supply chain vulnerabilities	✓	✓	✓	In Chile, the government designated selected manufacturing industries as essential and exempted them from forced closures. Australia's Supply Chain Resilience Initiative aims to address vulnerabilities in domestic and international supply chains.
	1.2. Incentives for building "sovereign capabilities" for critical supplies	✓			The *Self-reliant India* initiative involves tax incentives and loans to strengthen local production capabilities; Nigeria has announced additional funds to boost local manufacturing in critical sectors.
	1.3. Enforcement of regulations to minimize vulnerability of industrial assets		✓		Cyber-security and environmental regulations are likely to become increasingly important for manufacturing firms post-COVID-19.
2. Preparedness	**2.1.** Supply chain task forces to coordinate emergency supply, production and distribution	✓	✓	✓	COVID-19 has evidenced the importance of task forces with specific manufacturing mandates and expertise to support timely production and equitable distribution of critical supplies.
	2.2. Building national strategic stockpiles of critical items	✓			The Nigeria Centre for Disease Control (NCDC) plans to strengthen strategic stockpiles, including the expansion of in-country capacity for the production of reagents and other consumables used for testing.
	2.3. Advisory services for business continuity planning	✓	✓	✓	Examples include services provided by Australia's Department of Industry, Science, Energy and Resources; Enterprise Ireland's Lean Business Continuity Voucher; and Invest India's Business Continuity Planning (BCP) toolkit.

	2.4. Incentives for "rainy-day" savings and expansion of insurance protection			✓	Incentives for "rainy-day" savings have been identified as particularly relevant for SMEs by the UNDRR.
3. Response	**3.1.** Emergency sourcing, import facilitation and logistics support	✓			Bangladesh suspended duties and taxes on imports of medical supplies, including protective equipment and test kits. In the United States, the government covered the cost to fly supplies into the country through the Project Air Bridge.
	3.2. Incentives and technical advice for the rapid scale-up of critical supply production	✓			Japan provided subsidies to repurpose existing manufacturing capabilities for the production of masks. China has provided funding for patent and trademark applications related to technologies used in the prevention and control of the epidemic.
	3.3. Direct involvement of public organizations in production and distribution	✓	✓	✓	In Nigeria, the National Agency for Science and Engineering Infrastructure (NASENI) developed prototypes of a ventilator and disinfection devices to be produced in the country. Viet Nam has been praised for its swift and effective response to the pandemic and the development of affordable test kits.
	3.4. Emergency business support targeting manufacturing		✓		China and the Republic of Korea produced business continuity guidelines covering aspects such as employee health monitoring, ensuring workplace safety, planning for absenteeism, and planning for supply shortages. Cambodia introduced a furlough scheme for garment manufacturing workers, providing a monthly contribution towards employees' salaries.
	3.5. Government procurement guarantees		✓	✓	Given that major procurement institutions sometimes have a limited ability to disburse their funding in a timely manner, procurement guarantees emerged as a mechanism to ensure that numerous suppliers at risk of insolvency could survive the crisis.

4. Recovery	**4.1.** Foreign direct investment (FDI) attraction	✓		✓	Ethiopia introduced measures to improve logistics in export and import processes (e.g. free railway transport of manufacturing goods) and lifted minimum prices for horticulture exports. Many investment promotion agencies (IPAs) have created dedicated and regularly updated COVID-19 sections on their websites with information on government support.
	4.2. Support for market diversification			✓	Various countries have expanded their support for the internationalization of firms, particularly SMEs, through simplification of trade procedures; provision of market information; relaxation of conditions of export credit guarantees; e-commerce technical assistance; organization of virtual meetings with potential buyers; export insurance support; and finance for advertising and overseas expansion.
	4.3. Incentives to strengthen innovation capabilities and support industrial digitalization	✓	✓	✓	Start-Up Chile, a public accelerator, launched a call for proposals as part of its seed funding for solutions to stop the spread of the virus and to address the related disruptions to people's lives. In Brazil, the micro and small business support service provides for access to and information on in-house and partners' digital solutions for business management.
	4.4. Promotion of green industries and products		✓	✓	The Greening Ethiopian Manufacturing Project received additional funding to help micro and small manufacturing firms in light industries to seize green growth opportunities.

Source: Authors.

4.1 The "four phases" of emergency management

The "four phases" of emergency management provide a template against which the role of industrial policy in enhancing national resilience can be analysed. Also known as "aspects", "functional activities" or "components" of emergency management, these phases include:[2] (i) *prevention*; (ii) *preparedness*; (iii) *response*; and (iv) *recovery*. They are defined as follows:

- **Prevention** refers to "activities and measures to avoid existing and new disaster risks" (UNDRR, 2020a). Prevention involves applying intelligence and other information to a range of interventions to prevent an incident from occurring (FEMA, 2008). While certain disaster risks cannot be eliminated, prevention aims to reduce vulnerability and exposure to remove the risk of disasters (UNDRR, 2020a). This includes long-term activities designed to reduce the effects of unavoidable disasters, including land-use management; legislating building safety codes; deterrence operations; heightened inspections and surveillance; and disease prevention among people, domestic animals and wildlife (FEMA, 2008).

- **Preparedness** refers to "the knowledge and capacities…to effectively anticipate, respond to and recover from the impacts of disasters" (UNDRR, 2020a). Preparedness involves the identification of staff, training and equipment needed for a wide range of potential hazards and the development of jurisdiction-specific plans for delivering capabilities as needed during an emergency (FEMA, 2008). Preparedness measures also seek to enhance disaster response operations (for example, by compiling resource inventories, stockpiling critical food and medical supplies and installing warning systems) (FEMA, 2008; NGA, 1979).

- **Response** refers to "actions taken to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected" (UNDRR, 2020a). It involves the execution of emergency plans and begins when an emergency event is imminent or immediately after it has occurred (FEMA, 2008). Response activities focus on the short-term, direct effects of an incident. Response activities also seek to reduce the probability of secondary damage (for example, shutting off contaminated water supply

[2] While the four phases are part of the common language of emergency management literature, a number of adaptations can be found. For example, "mitigation" or "mitigation and prevention" is sometimes used instead of "prevention". Other variations include the use of "planning/preparedness" instead of just "preparedness" and "readiness" instead of "preparedness".

sources) and to speed up recovery operations (for example, conducting damage assessment) (FEMA, 2008; NGA, 1979).

- **Recovery** is defined as the "restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster affected community or society, aligning with the principles of sustainable development and 'build back better,' to avoid or reduce future disaster risk" (UNDRR, 2020a). Recovery includes the identification of lessons learned from an incident and the development of initiatives to mitigate the effects of future events (FEMA, 2008).

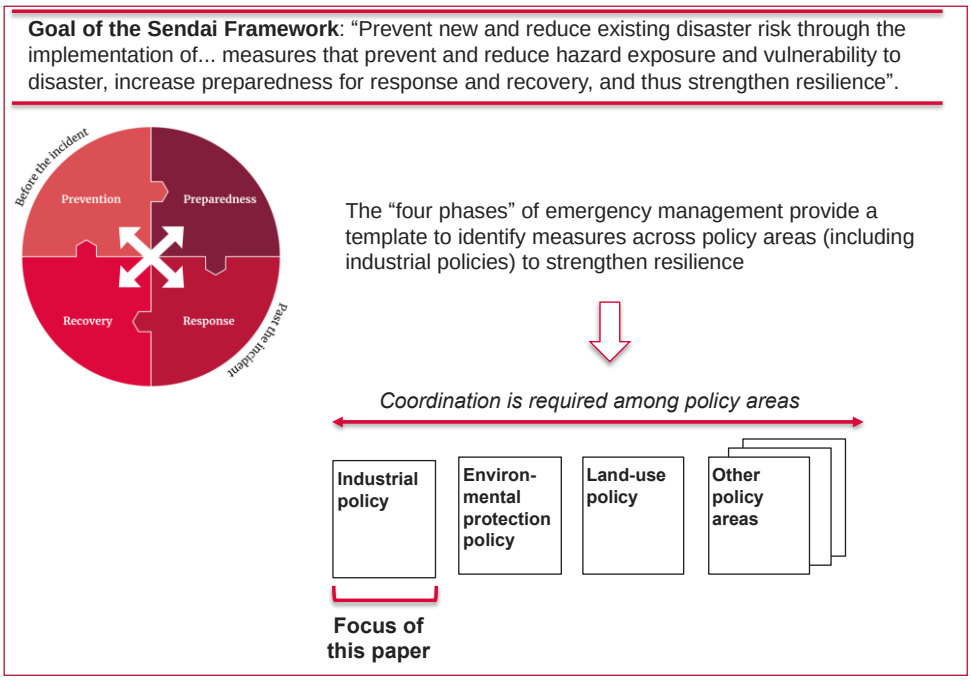
It is important to note that these four phases are related to one another. Actions to improve preparedness will influence the ability to respond and responses' effectiveness. Similarly, recovery efforts can influence a country's level of preparedness by addressing vulnerabilities in view of lessons learned. As such, comprehensive emergency management requires concerted planning and actions across all four phases (UNDRR, 2020a; FEMA, 2008; NGA, 1979).

4.2 Industrial policy measures to strengthen resilience

Based on the analysis presented in previous sections, this sub-section identifies industrial policy measures to enhance resilience across the phases of emergency management. Simply put, the question that we address is: What type of industrial policy actions can be leveraged for risk prevention and for effective disaster preparedness, response and recovery?

The list of measures identified are by no means comprehensive, but helps to illustrate the variety of options that policymakers could consider as part of the efforts to incorporate the resilience dimension into industrial policy. Where available, examples of how these measures have been implemented in different countries are presented, including examples from the COVID-19 crisis. Broader considerations that are likely to become increasingly relevant after the pandemic are also discussed. Naturally, industrial policy responses are only one component, and similar analyses aimed at incorporating resilience considerations are necessary in other policy areas. Indeed, the coordination of actions across policy domains needs to be part of a national dialogue around "building back better", accounting for the weight of different sectors of the economy. The focus of this paper, however, is on the particular contribution of industrial policy (Figure 3).

Figure 3: Identifying industrial policy measures to strengthen resilience



Source: Authors' elaboration based on UNSC, 2017, and UNDRR, 2020a.

4.2.1 Prevention

From an industrial policy perspective, prevention can be framed in terms of measures and activities to reduce the vulnerability of manufacturing industries to the supply, operations and demand risks previously discussed. Three prevention measures are worth highlighting: identifying critical industries and mapping supply chain vulnerabilities; incentives for building "sovereign capabilities", particularly in critical goods; and the enforcement of regulations intended to minimize disaster risk of industrial assets.

Identifying critical industries and mapping supply chain vulnerabilities

A first step in preventing shortages of goods critical to life, such as those experienced during the COVID-19 pandemic, is gaining a better understanding of their supply chains. Among other reasons, visibility of critical supply chains enables policymakers to designate essential industries and exempt them from forced closures (thereby reducing operational risks). In Chile, for example, manufacturing industries that were allowed to continue operations during the COVID-19 outbreak included animal feed; food and beverages; medical products; and paper and carton products (Chile Ministry of Economy and Tourism, 2020).

As industries have become increasingly complex, achieving end-to-end supply chain visibility is ever more crucial to identifying key vulnerabilities and taking preventive actions. This requires emergency managers to examine known and potential hazards plotted along the supply chain, alternate routes, alternate means of transportation, and any known restrictions of storage, handling and/or transportation (DHS, 2019). Country-specific vulnerabilities also need to be taken into consideration. For example, some countries participating in industries that depend on inputs produced in a small number of foreign locations might be more prone to supply risks. This does not need to be limited to medical goods and could involve efforts in other industries that might be vulnerable to supply risks (e.g. electronics that require rare earth materials or semiconductors produced in a small number of countries).

A recent example of efforts in this regard is Australia's *Supply Chain Resilience Initiative* (~USD 82 million, 2020–21 budget), which aims to build a comprehensive understanding of critical supply chains and to identify alternative supply options to address vulnerabilities in domestic and international supply chains (Australia Ministry for Industry, Science and Technology, 2020).

Disaster management agencies can contribute to this task. For example, the US Federal Emergency Management Agency (FEMA) provides toolkits to assess the risks derived from natural hazards and grants for developing hazard mitigation and preparedness strategies. Examples of activities that FEMA funds include facility retrofitting, training, safety inspections, seismic mitigation plans, awareness campaigns and insurance promotion (FEMA, 2020b).

Incentives for building "sovereign capabilities", particularly in critical goods

Another basic action countries can take to reduce supply risk vulnerability is to build "sovereign capabilities", in particular, to produce critical goods. Being able to produce domestically means that disasters that affect other parts of the world do not necessarily need to bring local supply to a halt. Domestic production may entail, for example, investments in research and production capacity, attraction of foreign investment, international collaboration and the establishment of programmes to build domestic production capabilities. Box 1 describes the case of Cuba and how decades of public investment and South-South cooperation led to the development of a successful pharmaceutical sector.

Box 1. Cuba: Building sovereign capabilities in the pharmaceutical industry

As of June 2021, Cuba was en route to becoming the first Latin American country to develop a vaccine against COVID-19, with two vaccines, Soberana II and Abdala, in the last phase of medical trials. This success is the result of a combination of efforts dating back to the 1960s, including public investment in biotech research institutes and state-owned enterprises; South-South cooperation; and support from the United Nations Industrial Development Organization (UNIDO).

In the 1960s, Cuba was highly dependent on vaccines and medicines imports. This became even more difficult after the embargo against the country was imposed by the United States in 1962. The Cuban government responded to these challenges by establishing research institutes, such as the National Centre for Scientific Research (CNIC), established in 1965.

In the late 1970s, UNIDO supported the Cuban government in scaling up the production of pharmaceutical products. The UNIDO project represented an early case of South-South cooperation that led to the establishment of the first chemical synthesis plant for the production of generic pharmaceutical products, the *Empresa Farmacéutica 8 de Marzo*. The plant was equipped with Indian technology, financed by contributions from India and the United Nations Development Programme, and technical support was provided by UNIDO staff.

These initial efforts were followed in the 1980s and 1990s by the establishment of the Centre for Genetic Engineering and Biotechnology (CIGB), public investments and additional UNIDO support to scale up the production of cancer and cardiovascular disease treatments, as well as meningitis and hepatitis vaccines. Today, Cuba has the capacity to produce between 60 per cent to 70 per cent of the medicines it consumes domestically, and exports medicines to over 50 countries.

Source: Swissinfo (2021); UNIDO (2016, 2021); Yaffe (2021).

Understandably, the recent focus has been on strengthening production capabilities in the pharmaceutical sector. For example, Ethiopia launched a 10-year national strategy and plan of action to further develop its pharmaceutical industry even before the COVID-19 pandemic (Federal Democratic Republic of Ethiopia, 2015); meanwhile, Nigeria has announced the allocation of additional funds (~USD 4 billion) over the next three years (2020–23) to boost local manufacturing across critical sectors and support the expansion and technology upgrading of its manufacturing sector (Emefiele, 2020).

Efforts have also been undertaken to build innovation capabilities for the development and adoption of new knowledge and technologies in other sectors producing critical goods. India, for example, launched the *Aatmnirbhar Bharat Abhiyan* or *Self-reliant India* (~USD 307.6 billion), an umbrella initiative involving, among other measures, public-private investments in energy, transport and industrial infrastructure and financial and tax incentives for strengthening India's innovation and production capabilities (Transforming India, 2020). Key sectors targeted include

defence, pharmaceuticals and electronics (India Ministry of Finance, 2020; Transforming India, 2020).

Among developed countries, examples of efforts to strengthen local capabilities were identified in countries including Australia and Germany. In Australia, policy discussions have addressed the need to develop advanced design and (flexible) production capability in sectors including critical minerals processing; food and beverage manufacturing; pharmaceuticals and medical technologies; and energy technology (Australia's Ministry for Industry, Science and Technology, 2020; Parliament of the Commonwealth of Australia, 2020). Meanwhile, the German government has provided support to increase the production capacity of personal protective equipment and active medical substances as part of the EUR 50 billion (~USD 60 billion) *Future Package* (Germany's Federal Ministry of Finance, 2020).

Other efforts to tackle supply risks and reduce foreign dependency, observed in developed countries, in particular, include encouraging the reshoring and diversification of production bases. Incentives provided to promote the reconfiguration of supply chains may include subsidies to relocate production sites, tax breaks proportional to the percentage of reduced output at overseas sites and subsidies conditional on linkages with domestic SMEs (Policy Links, 2020b).

A potential reconfiguration of global value chains is relevant for developing countries, as some of these initiatives aim to diversify regional supply chains. For example, a major reshoring initiative in Japan targets India and Bangladesh, in addition to ASEAN countries,[3] as locations for nearshoring. One motivation behind Japan's nearshoring efforts is to reduce supply risk by diversifying production bases under the so-called "China Plus One" model – that is, locating plants to both China and one other country (Iida, 2015). As part of its *COVID Relief Fund*, Japan allocated JPY 220 billion (~USD 2.1 billion) to support companies' reshoring to Japan, assisting 57 companies in its first round of applications, including major face mask producers (European Union, 2021). While these types of measures were in place even before the outbreak of the pandemic in response to escalating tensions in international trade, some countries have since intensified their use. For example, the Korea Trade-Investment Promotion Agency (KOTRA) has been running a support programme for "U-turn" firms since 2013. However, in April 2020, the Agency announced a new target to help 100 firms to reshore to the Republic of Korea by 2022 with an investment of over KRW 6 trillion (~USD 5 billion) (Korea Trade-Investment Promotion Agency, 2020).

[3] Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Viet Nam.

Enforcement of regulations to minimize the vulnerability of industrial assets to disaster risk

Disaster risk management relies on national and local frameworks of safety-enhancing guidelines, standards, laws and regulations – including land use and urban planning, building codes, environmental and resource management and health and safety standards (IFRC and UNDP, 2014). To ensure effective disaster risk management, countries need to enforce compliance with such frameworks and update them where needed (UNDRR, 2015). While the overall responsibility for such regulations might fall under national disaster management agencies or civil defence offices, industrial policy has an important role to play in ensuring that regulations are fit for their purpose and achieve high levels of compliance in manufacturing industries, particularly to minimize operational risks in critical industrial assets. For example, the enforcement of seismic engineering design regulations can help ensure the survival and operation of critical industrial assets in any likely earthquake.

As digitalization becomes more pervasive in manufacturing, firms are increasingly exposed to disruptions caused by the failure of IT systems and cyber-attacks. Such phenomena can lead to operational disruptions and damage of industrial facilities, endangering the safety of workers. However, most cyber-security standards and regulations are still not tailored to the needs of the manufacturing sector (Leal-Ayala et al., 2019). New regulations for cyber-security have emerged in recent years, addressing issues related to the security of IT systems and data privacy. Examples are the Budapest Convention on Cybercrime, the EU General Data Protection Regulation (GDPR), as well as a host of cyber security acts around the world. However, these norms tend to pay little attention to the security of physical assets (e.g. production technologies) which manufacturing industries hinge upon.

Furthermore, environmental regulations are likely to become increasingly important in the years to come as countries around the world commit to emission-reduction targets. For manufacturing industries, the challenge will be to comply with such regulations in the short term while maintaining competitiveness in the long term. As one of the largest contributors to carbon emissions, the implementation of environmental regulations in manufacturing has a critical role to play in reducing the risk of future climate-related disasters.

4.2.2 Preparedness

From an industrial policy perspective, the preparedness phase involves the development of emergency plans for delivering manufacturing goods and capabilities as required in the event of disasters. Industrial policy measures for preparedness include the establishment of supply chain task forces to coordinate emergency supply, production and distribution; building national strategic stockpiles of critical items; the provision of advisory services for business continuity planning; and incentives for "rainy-day" savings and expansion of insurance protection.

Supply chain task forces to coordinate emergency supply, production and distribution

During an emergency, common information failures between producers, vendors and buyers become even more acute. International experience suggests that task forces with specific manufacturing mandates and expertise can play a key role in coordinating emergency supply, production and distribution of critical goods. While emergency management agencies are usually in charge of establishing protocols to respond to emergency situations at the national level, COVID-19 has clearly evidenced the risks of failing to establish purpose-designed mechanisms focused on ensuring the timely production and equitable distribution of life-saving goods.

A notable example is the *COVID-19 Supply Chain Task Force*, organized by FEMA and the Department of Health and Human Services, which was in charge of monitoring and relieving the shortage of PPE across the United States (FEMA, 2020a). Efforts focused on rapidly increasing supply in the short term while expanding domestic production of critical resources to increase long-term supply (FEMA, 2021). The crucial role played by FEMA in the United States during the pandemic was only made possible by leveraging existing disaster management structures and by unifying government and private industry prioritization recommendations. This role, however, contrasts with that of similar agencies in developing countries, which may not have such ample mandates or sufficient resources to build on.

Relevant efforts in other countries are also worth noting. In Chile, the participation of the National Office for Emergency (ONEMI) was mainly focused on the diffusion of information to the public (ONEMI, 2020). In Nigeria, the National Emergency Management Agency (NEMA) was involved in the coordination of a slightly wider range of actions, including the logistics of the delivery of health services and of social protection support. NEMA's efforts were deployed under the oversight of the Presidential Task Force, a focal point of the government's efforts to address the pandemic (Government of Nigeria, 2020). At regional level, the Africa Centres for Disease Control and Prevention (Africa CDC), a specialized technical institution of the African Union, played a key role in the coordination of COVID-19 policy responses. Through the *Africa Medical*

Supplies Platform (AMSP), Africa CDC has established a one-stop online marketplace for the procurement of COVID-19-related diagnostics, medicines and medical equipment; enabled volume aggregation and equitable distribution; and provided payment facilitation and logistics support (Africa CDC, 2020).

An important function that could fall under the remit of supply chain task forces is the monitoring, quantification and fluctuations and shortages of critical goods during an emergency. This is a complex task that requires the integration and continuous review of data from the healthcare sector, the scientific community, manufacturing industries and public authorities. During the pandemic, the WHO has developed a suite of "surge calculators" to support this task. This includes the *WHO COVID-19 Essential Supplies Forecasting Tool* (ESFT), which is designed to help governments and other stakeholders estimate potential requirements for essential supplies, including PPE, diagnostic equipment, biomedical equipment, essential drugs for supportive care and consumable medical supplies (WHO, 2020c).

Another critical task that requires manufacturing expertise is the mapping of domestic production capabilities that could be deployed or repurposed to address shortages. Efforts in this area can leverage expertise in both the public and private sectors. Australia's Advanced Manufacturing Growth Centre and India's Council of Scientific and Industrial Research, for example, have developed online platforms to map and coordinate the efforts of manufacturers, suppliers and buyers of critical medical supplies (AarogyaPath, 2021; AMGC, 2020). Meanwhile, Ireland's Chartered Institute of Logistics and Transport has developed a database on spare logistics capacity with the participation of government and industry representatives. The database contains the contact details of the companies, availability and a brief description of the services provided (CILT, 2020). International and regional organizations, such as the Asian Development Bank (ADB), have also undertaken efforts to map key supply chains during the pandemic. In May 2020, the ADB launched the online *Supply Chain Maps for Pandemic-Fighting Products*. The mapping tool includes the entire supply chains of critical medical goods, including ventilators, N95 masks and other PPE (ADB, 2020).

Building national strategic stockpiles of critical items

Global and national strategic stockpiles of medical products have helped address this and previous emergencies (Yen et al., 2015). Severe shortages of critical items were reported in many countries during the COVID-19 pandemic, evidencing the need for increased preparedness in this area.

However, the need for strategic stockpiles of manufactured goods goes beyond medicines. For example, national strategic stockpiles in Australia and the United States also cover PPE for staff in front-line health services (Australia Department of Health, 2020; US Department of Health and Human Services, 2021). As of April 2021, the US Strategic National Stockpile (SNS) had deployed the following resources in response to the pandemic: over 180 private industry partners engaged in medical supply and delivery; over 600 flights and 4,000 trucks transporting supplies; over 16,000 cargo shipped; and over 200 staff to serve in the stockpile operation centre (US Department of Health and Human Services, 2021).

As the COVID-19 pandemic has exposed the vulnerabilities in the global medical supply chain, the US SNS has expanded its breadth and depth. Key enhancements include increasing the amount of PPE in the stockpile, adding new medication and equipment, predictive analytics, improved technology to provide real-time visibility of supply chains (in 5 PPE categories and 38 pharmaceutical goods) and working with other federal agency partners to expand the domestic production of critical supplies (US Department of Health and Human Services, 2021).

Nigeria's response has also involved maintaining and expanding stockpiles of PPE and food products. The Mid-Action Review of the Nigeria Centre for Disease Control (NCDC) defines strategic directions to improve preparedness in this area (Box 2).

Advisory services for business continuity planning

Business continuity planning (BCP) emphasizes the value in ensuring that in the event of a disruptive incident, operations and vital functions can continue without a severe drop in services (CISA, 2020b). BCP development commonly includes four steps: (1) conducting a business impact analysis to identify critical business functions and processes and the resources that support them; (2) developing plans to recover critical business functions and processes; (3) organizing a business continuity team and compiling a business continuity plan; and (4) conducting tests and exercises to evaluate recovery strategies and the plan (CISA, 2020b). International experience suggests that business advisory services—including guidelines, manuals and resources—can help firms raise awareness of the importance of BCP to mitigate losses (World Bank, 2020).

For example, Australia's Department of Industry, Science, Energy and Resources has provided guidance and advice for business continuity during the pandemic. Services include online guides and templates to create and update a business continuity plan; information on digital tools for business management; export advice; marketing guides, tutorials and templates; information on occupational health and safety; and guidance on customer relations (Australian Government, 2020a).

Box 2. Enhancing Nigeria's national strategic stockpiles of medical supplies

National strategic stockpiles are repositories of medical supplies and equipment to ensure that front-line health services have the materials needed to provide essential services during health emergencies. Stockpiles function as short-term buffers when the immediate supply of medical goods may not be available or sufficient to address an unexpected surge in demand.

During the COVID-19 pandemic, the Presidential Task Force on COVID-19 played a key role in addressing demand for PPE, medicines and food in Nigeria. Its responsibilities included the assessment of demand and logistics and increasing stock where needed. However, the need to strengthen their national and sub-national strategic stockpiles soon became apparent, as reflected in the Mid-Action Review of the Nigeria Centre for Disease Control (NCDC). The review defines strategic directions to improve preparedness, including:

- Conducting warehouse capacity assessment at national and sub-national levels;
- Renting or building a national strategic stockpile warehouse to store supplies;
- Hiring surge staff to support warehouse operations;
- Developing and disseminating data collection tools to warehouses across the country; and
- Supporting the expansion of in-country capacity on the production of reagents and other consumables used for testing through collaboration with the private sector, research institutions and the United Nations.

As shown by the experience of the US Strategic National Stockpile's response and the related *Sustainable Public Health Supply Chain* Executive Order, additional actions that can contribute to enhancing strategic stockpiles include:

- Assessing public health supply chains and agencies' capacity to respond;
- Revisiting national stockpile and distribution strategies and governance structures;
- Leveraging digital technologies to improve the visibility of critical supply chains;
- Expanding the breadth and depth of strategic stockpiles; and
- Providing training on good practices for storing and distributing stockpiles and monitoring demand.

Source: Government of Nigeria (2020); NCDC (2020); US Department of Health and Human Services

Enterprise Ireland, the Irish innovation agency, has provided subsidized advisory support to firms for developing resilience plans. Through the *Lean Business Continuity Voucher*, created in response to the pandemic, companies can access up to EUR 2,500 (~USD 3,000) in training or advisory services support (from an approved service provider) related to the continued operation of their businesses. Advisory services covered in this initiative include crisis response, process re-engineering and planning for resilience post-crisis (Enterprise Ireland, 2020). From April to August 2020, this programme supported 11,857 applications, spending EUR 25.7 million (~USD 31 million) (Department of Business, Enterprise and Innovation, 2020).

Invest India, in partnership with business advisory firms, has also provided subsidized advisory services to help firms strengthen their resilience. Through the *Business Continuity Planning Toolkit*, companies can access customer engagement solutions, using a software-as-a-service (SaaS) model to improve decision-making (Box 3). While these services are constrained by local public capacity to deliver business advisory services, the cases of Australia, Ireland and India illustrate how governments can leverage private sector capabilities.

Box 3. Business Continuity Planning Toolkit: Invest India toolkit

Business continuity planning (BCP) helps organizations identify the potential effects of a disruptive incident and to develop the capability to continue operations following the incident. Support for BCP activities can contribute to reducing supply and operations disruptions and facilitate a swift recovery after a crisis.

Invest India, the National Investment Promotion and Facilitation Agency, developed the *Business Continuity Planning Toolkit* aimed at minimizing disruptions amid the COVID-19 pandemic and building enterprise resilience. The toolkit is available for organizations of all sizes and from every sector, but it is particularly focused on micro, small and medium-sized enterprises (MSMEs) and start-ups.

Invest India has partnered with start-ups to provide pro bono services to businesses, including sales CRM software, customer support software, marketing automation software, project management tools and online training.

Based on the BCP programmes delivered by the Australian and Irish governments, additional support could also include online guides and templates, and specific management advice for: conducting risk assessments, implementing process re-engineering and developing occupational safety practices. The design of the support programme as a voucher may also offer additional flexibility to involve private-sector partners in the programme.

*Source***:** Australian Government (2020a); Haraguchi et al. (2016); Enterprise Ireland (2020); Invest India (2020); and World Bank (2020).

Incentives for "rainy-day" savings and the expansion of insurance protection

Two common ways firms can seek to protect themselves against the risk of disruptions are through reserve (or "rainy-day") funds and insurance.

On the one hand, the pandemic has once again put in question the "financialization" of corporations (Lazonick, 2014), which pushes for buy-backs and debt-fuelled expansion while overlooking innovation investment and "rainy-day" preparations. This is particularly important if firms are to strengthen their ability to withstand fluctuations in demand caused by emergency events. Incentives for "rainy-day" savings have been identified as particularly relevant for SMEs in recent applications of the Sendai Framework (UNDRR, 2020b).

On the other hand, the pandemic has also revealed limitations in the insurance market. Recent studies have suggested that the impossibility of modelling and pricing large-scale disaster risks (such as the risk of a pandemic of the magnitude of COVID-19) is the most significant obstacle to securitizing and insuring pandemic risk (Schanz, 2021). Governments can help address the gap by developing and implementing standards and practices to encourage the expansion of insurance protection. As "insurers of last resort", governments can support risk transfer over time through taxation and borrowing. Public sector involvement in risk protection schemes may include (a) mandatory or voluntary direct insurance offered by the government; (b) government reinsurance backstopping mandatory or voluntary private sector coverage; and (3) mandatory social insurance (Schanz, 2021).

On a related aspect, recent studies have suggested that opportunities exist for insurance to more actively address the cyber-security risks that are increasingly affecting manufacturing industries (Copic and Leverett, 2019). While only a few companies offer specific products focused on industrial systems, this market is growing. Innovative application processes by insurers can help evaluate the cyber-risk profile of a corporation and to continuously monitor risk exposure, encouraging security risk mitigation and driving an improvement culture within corporations.

4.2.3 Response

From an industrial policy perspective, the goal of response activities can be framed in terms of ensuring the continuous operation of the manufacturing sector when an emergency event is imminent or immediately after it occurs. Short-term response actions aim to maintain adequate provision of critical manufactured goods during an emergency, as well as to speed up industrial recovery soon thereafter. Key manufacturing assets, systems and networks operate in close integration with other critical sector services and resources, such as energy, water, communications and transportation systems. As a result of these interdependencies, disruptions

to one sector may affect operations in others, and local events can cascade to multiple geographical regions and sectors (DHS, 2015).

As the COVID-19 outbreak spread globally, national governments deployed policy measures to cope with the immediate, direct effects on health and safety, firms and livelihoods. Several types of response activities and measures were introduced, including emergency sourcing, import facilitation and logistics support; incentives and technical advice for increasing production capacity of critical supplies; direct involvement of public organizations in production and distribution; support for business continuation (including job retention schemes); and government procurement guarantees.

Emergency sourcing, import facilitation and logistics support

As the effects of disasters, including lockdowns, are felt in global transportation capacity and infrastructure, the ability to source parts and components can be severely hampered. In some countries, emergency measures, such as the relaxation of import regulations, have been used to address shortages of PPE and pharmaceutical products during the COVID-19 pandemic. For example, Japan loosened its import regulations of critical medical supplies, and the Republic of Korea simplified its procedures for the import and production of a list of 44 priority chemicals.

Similar measures were introduced in a number of developing countries (IMF, 2021a). In Brazil, import levies on essential medical supplies were lowered. The National Board of Revenue in Bangladesh suspended duties and taxes on imports of medical supplies, including protective equipment and test kits. Nigeria introduced import duty waivers for pharmaceutical firms, while Viet Nam enacted tax exemptions for medical equipment. China went further than most countries: it not only exempted imported supplies used for COVID-19 prevention and control from import duties, but also extended the exemptions to value added tax and consumption tax (PRC State Administration of Taxation, 2020).

Other examples of emergency sourcing include the use of public funds to accelerate the transportation of essential goods. For example, in the United States, the FEMA supply chain task force established the *Project Air Bridge* through which the government covered the cost to fly supplies into the United States, thereby expediting the shipment of supplies from major distributors. As a result, the time taken to ship PPE from overseas factories went from weeks to days (FEMA, 2020c).

Incentives and technical advice for rapid scale-up of critical supply production

Production capacity is the maximum amount a manufacturing operation can produce. Increasing capacity usually requires detailed planning, significant capital investment and an expansion of the workforce to meet an immediate or future increase in customer demand. Strategies to increase manufacturing capacity include adding shifts to use existing equipment for longer periods; outsourcing and/or repurposing equipment; making more efficient use of existing equipment (higher productivity); or purchasing new equipment (Vorne, 2021).

To meet the surge in demand for PPE during the COVID-19 pandemic, national governments delivered financial and fiscal support to help manufacturers increase their existing capacity and repurpose production lines. For example, Japan provided subsidies to repurpose existing manufacturing capabilities for the production of masks; and China provided corporate and value added tax deductions to firms producing critical medical supplies (PRC State Administration of Taxation, 2020). China has also provided loans to firms producing critical supplies such as masks, medical clothing, disinfection machines, disinfectant solutions and infrared thermometers.

To increase manufacturing capability, China provided funding for patent and trademark applications related to technologies used in the prevention and control of the epidemic, and set up an information platform for high-tech companies developing these types of technology (JD Supra, 2020). Meanwhile, in Brazil, the national service for industrial training (SENAI) helped 600 Brazilian manufacturers comply with technical specifications and norms in the production of PPE (Agencia Brasil, 2020).

Direct involvement of public organizations in production and distribution

Under normal market conditions, the manufacturing sector aims to maintain a stable supply of critical goods in balance with foreseeable demand patterns. As it became clear that the private sector alone would struggle to respond to the shortages of critical medical supplies during the COVID-19 emergency, governments around the world leveraged their distinct institutional frameworks and modes of economic governance to respond to this situation. While most countries favoured mechanisms such as financial and fiscal incentives and voluntary business consortia, others, such as China and the United Stated, pursued more active participation in the production and distribution of these supplies. China’s State-owned Assets Supervision and Administration Commission of the State Council (SASAC) required state-owned firms to address the shortage of anti-epidemic medical protection materials. Meanwhile, the United States invoked the Defense Production Act, which gives the government powers to require businesses to accept and prioritize government contracts (US Congressional Research Service, 2020).

Public research and technology organizations (RTOs) have played a key role in addressing supply shortages by coordinating firm consortia, simplifying and supporting certification procedures and providing technical advice. In Province of China, Taiwan, the Industrial Technology Research Institute (ITRI), the Metal Industries Research and Development Center (MIRDC) and the Precision Machinery Research and Development Center (PMC) are key actors of "Team Taiwan". Together with 30 machine and medical device producers, Team Taiwan managed to triple the national production of masks within 6 weeks (Taiwan Ministry of Economic Affairs, 2020).

In Germany, the Fraunhofer-Gesellschaft, an applied research organization that operates 75 technology and research institutions, played an essential role in the fight against the pandemic. Their actions included assisting PPE manufacturers, developing new drugs and innovative diagnostic techniques, as well as developing track and tracing apps (Fraunhofer, 2020).

While public research and innovation infrastructure and capabilities may be more developed in industrialized economies, developing countries also managed to leverage their innovation assets to respond to the pandemic. In Nigeria, the National Agency for Science and Engineering Infrastructure (NASENI) developed prototypes of a ventilator and disinfection devices to be produced in the country (NASENI, 2021). Meanwhile, Viet Nam has been praised for its swift and effective response to the pandemic and the development of affordable test kits (later exported to Europe). As in the case of Province of China, Taiwan and Germany, public research organizations were involved in the development of test kits, including the Viet Nam Academy of Science and Technology, the Institute of Military Medicine and the University of Technology, Hanoi (Klingler-Vidra et al., 2021) (Box 4).

Emergency business support targeting manufacturing

The coronavirus crisis and the subsequent restrictions imposed by governments have exposed numerous businesses to considerable financial stress, with many forced to close either temporarily or permanently. In response, national governments have implemented a range of policies to support firms to continue their operations during the pandemic. Common support measures observed as part of national strategies have included delivering liquidity support in the form of loans at preferential rates and payment deferrals; publishing business continuity guidelines; ensuring energy supply; organizing supply chain dialogues; providing business advisory services; and job retention schemes.

Liquidity support measures were aimed at helping businesses from many sectors survive the initial shock of the pandemic and preventing a liquidity crisis that could translate into full insolvency and business failure. Tax cuts, tax deferrals, business grants and small business loans were common across many industrialized nations, including the United Kingdom, France, Canada, Germany, Japan, Ireland and Singapore, among others (Tetlow and Dalton, 2020).

China and the Republic of Korea produced business continuity guidelines covering aspects such as employee health monitoring, ensuring workplace safety, planning for absenteeism and for supply shortage. The Australian government also contributed to business continuity through the provision of infection control training and guidelines, with an emphasis on workers' safety. Training was conducted in partnership with all state and territory governments for customer-facing businesses, including transport and logistics (Australia Department of Education, Skills and Employment, 2020). To ensure continued supply of energy, the Australian Energy Regulator published a *Statement of Expectations of Energy Businesses* to encourage energy suppliers to assist customers facing financial stress (AER, 2020), while China reduced electricity fees (Xinhua, 2020).

China was among the first countries to reopen its economy. However, as activities resumed, different challenges emerged. For example, the government realized that SMEs were struggling more than larger firms to resume operations. The Ministry of Industry and Information Technology coordinated efforts and established a special working group to restore the automotive supply chain involving Guangzhou Automobile Group Co. and over 400 key suppliers. Within weeks of the initial disruptions, the capacity utilization rates reported by firms increased from 16 per cent to 80 per cent (PRC Ministry of Industry and Information Technology, 2020).

Japan and China also provided financial support to the development of new technologies and business models that reduce the risk of infection among manufacturing workers (e.g. contactless delivery using drones, increased use of cloud computing and teleworking) (Japan Ministry of Economy, Trade and Industry, 2020; PRC Ministry of Science and Technology, 2020).

Box 4. Learning, coordination and collaboration: Viet Nam's agile and effective response

Viet Nam's effective response to the COVID-19 pandemic demonstrates the importance of institutional learning from previous crises, the key role of the State as a coordinator of emergency response and the relevance of having a domestic manufacturing base.

During the severe acute respiratory syndrome (SARS) outbreak in 2003–4, Viet Nam faced a significant death toll among healthcare workers. Since then, the country has improved its health infrastructure by investing in organizational systems, building physical facilities and buying equipment and supplies. During the COVID-19 outbreak, testing capacity and the use of a tracking system, deployed in Viet Nam since 2016, helped the State contain the spread of the virus.

The Vietnamese government formulated a shared mission, aligning the efforts of different ministries, research organizations and civil society. The government's coordination role facilitated agile and effective collaboration to develop test kits. For example, in January 2020, Viet Nam's Ministry of Science and Technology organized a meeting on COVID-19 with virologists around the country, where the Institute of Military Medicine (IMM) was commissioned to develop test kits within two weeks.

Collaboration between public and private actors was key for scaling up the production of both test kits and PPE. Viet Nam has an export-based economy dominated by manufacturing. These domestic production capabilities facilitated the production and export of affordable test kits. IMM's kit was commercialized by a private company, Viet A, and exported to Malaysia, Iran, Finland and Ukraine, among other countries. Meanwhile, the kit developed by Hanoi University of Science and Technology (HUST) benefited from collaboration with the companies Innogenex and Sunstar, which offered funding, access to clinical validation and production capacity.

Vietnamese efforts were also supported by international collaboration, which provided access to state-of-the-art approaches to testing for SARS-CoV-2. Two of the test kits referenced and adapted were the WHO and the US Centers for Disease Control and Prevention (CDC) test kits.

Other manufacturing firms also leveraged their capacity and capabilities to respond to the emerging challenges. Viet Nam's biggest conglomerate, Vingroup, started to produce ventilators and thermometers for the first time. As a result, Viet Nam was able to send medical aid to China, Cambodia and Laos and supplied the United States and European markets with protective equipment.

Source: Klingler-Vidra et al. (2021); Our World in Data (2021); Taiwan Trade (2020); VoA, (2020).

Job retention schemes, such as furlough programmes, were widely delivered during the pandemic to mitigate increases in unemployment and ease financial pressures on employers (OECD, 2020c). Effective practices have included flexible schemes that allowed employees to work reduced hours instead of laying them off, such as the German *Kurzarbeit*, and retention schemes targeting apprentices and trainees, for example, the Australian *JobTrainer skills package* (Australian Government, 2020b; IMF, 2020). In response to the pandemic, Germany simplified access to *Kurzarbeit* and expanded its coverage to protect agency workers (OECD, 2020c). The Australian

government also expanded the number of apprenticeships, providing preferential support to women (Australian Government, 2020b).

While job retention schemes tended to be extended to all sectors, in some developing countries, such as Cambodia, these were targeted at the most affected industries. The Royal Government of Cambodia introduced a furlough scheme for garment manufacturing workers, providing a monthly contribution of up to USD 40 towards employees' salaries, depending on the number of days the worker was suspended from work in a month (MoLVT, 2020). In addition, some of these schemes were accompanied by cash transfer programmes targeted at the most vulnerable households.

Government procurement guarantees

The procurement of goods, services and works on behalf of government departments and agencies accounts for a considerable part of national economies, where public authorities are seen as key drivers of demand. From construction services to manufacturing goods, facilities and management services, education, passenger transport and social community care supplies and services, government procurement equalled roughly 12 per cent of global GDP in 2018 (Bosio and Djankov, 2020; Davies, Chan and Cheung, 2018).

It is therefore not surprising that guaranteeing payment to suppliers to ensure service continuity during and after the coronavirus crisis ranked highly among government priorities. Given that major procurement institutions have legal or technical requirements that sometimes limit their ability to disburse their funding in a timely manner, procurement guarantees emerged as a mechanism to ensure that numerous suppliers at risk of insolvency could not only survive the crisis, but also be ready to resume normal contract delivery once the emergency is over (MedAccess, 2021; Cabinet Office, 2020).

Under these schemes, suppliers at risk continue to be paid as usual, even if service delivery is disrupted or suspended, through various payment measures that can include forward ordering, payment in advance/pre-payment, interim payments and payment on order (without receipt). In case contracts include payment by results, procurement guarantees established payments based on previous invoices (Cabinet Office, 2020).

Procurement guarantees ensured the flow of cash across the supply chain at a critical point during the crisis, which allowed firms to continue paying employees and maintain the flow of funding to subcontractors. Together with other key measures discussed before, government procurement guarantees helped prevent a crisis of solvency that would have led to widespread and permanent business failures in many national economies.

4.2.4 Recovery

There is broad recognition of the critical role that manufacturing firms and related engineering capabilities can play in long-term economic resilience. Manufacturing industries, for example, have offered "pockets of resilience" in various countries throughout the COVID-19 pandemic, which have helped prevent more pronounced recessions and could be critical to long-term recovery. From an industrial policy angle, the goal of recovery activities could be defined as not only the execution of restoration plans for disaster-affected industrial sectors but also the identification and use of lessons learned as input for future industrial strategy.

In this regard, governments around the world have attempted to seize the COVID-19 crisis as an opportunity to modernize, improve sustainability and strengthen the resilience of their manufacturing industries through recovery initiatives that account for the heterogeneous impacts and needs of different industries and regions. Beyond immediate responses, national governments have launched and reinforced policies with longer-term consequences and impacts, paving the way to sustainable recovery. Some of the key types of recovery-oriented policy observed in the immediate aftermath of the pandemic include:

- Foreign direct investment (FDI) attraction;
- Support for market diversification;
- Incentives to strengthen production and innovation capabilities, including support for industrial digitalization; and
- Promotion of inclusive green growth.

Foreign direct investment (FDI) attraction

Although the spread of COVID-19 has had a negative effect on global FDI flows as a result of demand shocks and supply chain disruptions, FDI could play an important role in supporting economies after the crisis, as it represents a channel through which foreign companies may provide financial support to their local affiliates and domestic suppliers.

In the aftermath of the COVID-19 crisis, governments have actively adapted their approaches to encourage the recovery of FDI flows. For example, to support FDI in the country, the Ethiopian

government introduced measures to improve operational facilitation of logistics in export and import processes (such as free railway transport of manufacturing goods between Ethiopia and Djibouti), and lifted the minimum prices set for horticulture exports (IMF, 2021a). Similarly, many investment promotion agencies (IPAs) have created dedicated and regularly updated COVID-19 sections on their websites with information on government support and applicable restrictions. In addition to dedicated sections on COVID-19 available on their websites, IPAs are reaching out to their clients via a number of digital tools and have developed comprehensive information brochures. The Korea Trade-Investment Promotion Agency (KOTRA), Germany Trade and Invest and ABA Invest in Austria, among others, provide daily updates, news and continued information on the evolution of the COVID-19 situation for investors (OECDd, 2020).

Support for market diversification

As the effect of the collapse in global demand for certain products is felt across countries and recovery prospects remain uncertain, governments are treating market diversification as a strategy to support future growth. Many countries have expanded their support for the internationalization of firms, particularly SMEs, through the simplification of trade procedures; provision of market information; relaxation of conditions of export credit guarantees; e-commerce technical assistance; organization of virtual meetings with potential buyers; export insurance support; and finance for advertising and overseas expansion (Policy Links, 2020a).

In Singapore, eligible firms were also given a 200 per cent tax deduction until the end of 2025 on expenses incurred for international market expansion and investment activities, such as the search for talent and potential partners. Singapore has also introduced or strengthened measures targeting SMEs (Singapore Ministry of Trade and Industry, 2020). For instance, the SG Together Enhancing Enterprise Resilience (STEER), managed by Enterprise Singapore (a statutory agency that supports SME development), provides a match of USD1 for every USD 2 (previously USD 4) raised by industry-led initiatives that position business for continued growth through and beyond the crisis, including marketing, market diversification and branding activities (Enterprise Singapore, 2020).

An international advisory centre known as GlobalConnect@SBF was launched by the Ministry of Trade and Industry in collaboration with the Singapore Business Federation to provide dedicated market access support, with a focus on Southeast Asia, Africa, the Middle East and Central Asia. The government also compiled information on the business support measures in overseas markets offered by respective governments, for the reference of Singaporean businesses with an international footprint. Market Readiness Assistance, an existing scheme supporting

SMEs to expand overseas, was extended for three additional years with higher funding caps and a broader scope of eligible activities to include overseas business development efforts such as free trade agreement consultancy services and deployment of staff abroad (Enterprise Singapore, 2020).

Incentives to strengthen innovation capabilities and support industrial digitalization

Firms with stronger innovation capabilities are better equipped to respond to emergencies and therefore tend to be more resilient in the long term. For example, an industrial survey of UK-based manufacturers carried out during the peak of the COVID-19 pandemic found that 46 per cent of respondents agree that past investments in industrial digitalization capabilities have helped them survive the COVID-19 crisis, whereas 71 per cent were planning to increase their investment in industrial digitalization over the next two years in response to the crisis (Make UK, 2020). Recognizing this, governments around the world have deployed policy instruments to help technology companies retain talent; accelerate manufacturing modernization and technology adoption; stimulate the development of new technologies and related capabilities; and support the commercialization of new COVID-related products and business (Policy Links, 2020a).

Expanded innovation support for existing and new start-ups has been established in a number of countries, including the relaxation and increase of research and development (R&D) support schemes. In India, the Indo-US Science and Technology Forum (IUSSTF) introduced support for joint applied R&D to generate public goods through the commercialization of technology developed in partnerships between American and Indian researchers and entrepreneurs (United States-India Science and Technology Endowment Fund, 2020). Three pharmaceutical parks were set up through grant-in-aid schemes to produce bulk drugs and reduce imports of basic raw materials for the Indian pharmaceutical industry, already the third largest in the world by production volume (India CSR Network, 2021).

Demand-side innovation policy instruments, such as public procurement and innovation prices, were also delivered to address the emerging challenges and at the same time support the future development of innovative firms. For example, *Start-Up Chil*e, a public accelerator, launched a call for proposals, as part of its seed funding, for solutions to stop the spread of the virus and to address the related disruptions to people's lives. It was not limited to Chilean companies and the award involved funding of CLP 25 million (~USD 35,500) and advisory services such as: mentorship, workshops, networking and legal advice (Start-Up Chile, 2020).

Innóvate Perú, the Peruvian innovation agency, launched a series of hackathons aimed at encouraging the development of solutions that address COVID-19-related challenges. The innovation agency also launched *Innovar para Reactivar* (Innovate to Reactivate), an umbrella initiative that builds on existing programmes to support the recovery of both MSMEs and large companies in the short term, and their innovative capabilities and resilience in the long term. Activities supported include prototype scale-up, digital technology adoption, open innovation, certification processes and technology management training. While most of these programmes are open to firms across all sectors, some target the industries most affected during the pandemic, such as hospitality, creative industries and textiles and garments (Innóvate Perú, 2020).

In the past decade, industrial digitalization has largely been motivated by the desire to boost productivity and growth in an increasingly competitive manufacturing landscape. The pandemic is expected to accelerate the adoption and application of industrial digital technologies of various levels of complexity due to increased demand for supply chain predictability and flexibility, remote working and workspace reconfiguration. Recognizing the growth potential of industrial digital technologies, countries have reaffirmed their previous commitments to Industry 4.0 technologies, as well as creating new funding programmes and initiatives. The common policy responses included digital infrastructure investment, consumption incentives and digital skills development programmes (Policy Links, 2020c).

In the Republic of Korea, the Office for Government Policy Coordination and the Ministry of Economy and Finance launched the Korean New Deal to upgrade the economic structure. Under the "Digital New Deal", massive investment in the digital infrastructure and ecosystem is planned, from telecommunications networks and public transportation systems to early-warning systems for disasters. In addition, approximately 600 SMEs were provided with vouchers for artificial intelligence (AI) solutions (South Korea Ministry of Economy and Finance, 2020).

In Singapore, Enterprise Singapore and the Infocomm Media Development Authority have increased grant amounts and expanded the scope of business solutions and learning resources for businesses keen on adopting digitalization under various existing schemes such as Productivity Solutions Grants and Advanced Digital Solutions Funding Support. "Go Digital", a programme that has been in place since 2017, widened its scope to include remote working and visitor management solutions. It was repositioned as part of the solutions to overcome the challenges posed by the pandemic (*Korea JoongAng Daily*, 2020). "Go Digital" has also included support for the adoption of more advanced digital technologies for those firms ready to deepen their digital capabilities (IMDA, 2021).

In Latin America, countries including Brazil and Chile are leveraging online platforms that were already in place before the pandemic, to ease access to digital technologies. In Brazil, Sebrae, the Brazilian micro and small business support service, provides access and information on in-house and partners' digital solutions for business management (Sebrae, 2021). In Chile the Ministry of Economy and Tourism established a three-phased programme, *Digitaliza tu Pyme* (Digitalise your SME), which includes support to: (i) increase awareness of digital technologies, (ii) develop digital skills, and (iii) adopt technology solutions (*Digitaliza tu Pyme*, 2020). The programme is delivered in partnership with the Inter-American Development Bank (IDB) and Fundación País Digital, a network of private actors, universities and government (IDB, 2020) (Box 5).

Box 5. Chile's SMEs go digital

The Chilean government is supporting small and medium-sized enterprises in taking the digital leap to make them more productive and competitive through the *Digitaliza tu Pyme* (Digitalise your SME) initiative. Over 25,000 SMEs are expected to benefit from the digitization strategy that was first launched in January 2019. Public-private partnerships are in place with firms such as Facebook, Google, Amazon and Intel.

SME digitalization has accelerated in response to the COVID-19 crisis, and the Chilean government has responded to this trend with a reinforced scheme. The aim is to digitalize 250,000 SMEs by 2022 through access to a package of digital tools and learning materials that can help firms increase their sales, lower their operating costs and improve their relationships with customers and suppliers.

The offer of *Digitaliza tu Pyme* includes an online self-assessment, which takes approximately 25 minutes and provides SMEs with a report of their digital readiness and recommendations to progress in their digital transformation (*Chequeo digital*). The assessment covers eight business areas: technology and digital skills; leadership; organization; communication; data analytics; processes; products and innovation; and strategy and digital transformation.

After conducting a self-assessment, SMEs can participate in online training courses to help them in their digitalization journey (*Ruta Digital*). Other support provided through *Digitaliza tu Pyme* includes: an e-commerce platform (*Compra Pyme*) to facilitate the participation of SMEs in digital commerce; e-commerce training (*Pymes en Línea*); and awareness campaigns across the country on the benefits of digital technologies (*Atrévete Digital*).

From Singapore's SMEs Go Digital programme, other useful support for SME digitalization includes:

- Industry-specific transformation maps (e.g. Food Manufacturing Industry Digital Plan);
- Subsidies to adopt pre-approved digital solutions;
- Chief technology officer-as-a-service for SMEs that need more in-depth digital advisory; and
- Funding support for the adoption of advanced digital solutions for those firms ready to deepen their digital capabilities.

Source: Digitaliza tu Pyme (2020); IMDA (2021); OECD (2021a, 2021b).

Promotion of green industries and products

As climate change becomes a more prominent issue in the global policy agenda, industries around the world are facing the serious challenge of balancing their competitiveness while reducing the carbon footprint of their operations, products and services. In this context, governments have attempted to seize the COVID-19 crisis as an opportunity to push the sustainability agenda and accelerate a "green" manufacturing future. As was the case before the pandemic, there is an emphasis on reducing the carbon emissions of industrial operations to contribute to "net zero" targets. In addition, there is increased interest in gaining a competitive edge on "green" products expected to underpin future sources of demand to support a post-COVID-19 recovery (Policy Links, 2020b).

In the Republic of Korea, under the "Green New Deal", funding was channelled to R&D projects on renewable energy and start-ups that introduce innovative use of IT in water management, waste management and pollution monitoring. Considering that workers in many industries lost incomes and jobs to the pandemic, these green growth projects were infused with job-creation objectives. Government of the Republic of Korea expects the Green New Deal to create 659,000 jobs by 2025 (Government of the Republic of Korea, 2020).

In Ethiopia, the Greening Ethiopian Manufacturing Project received additional funding to help Ethiopian micro and small-scale manufacturing firms in light industries (textiles and apparel, leather and footwear, handicrafts) adopt sustainable production practices and seize green growth opportunities. The project is expected to benefit hundreds of micro and small-scale firms through training and technical support in design for sustainability, improved resource usage and waste management (*The Ethiopian Herald*, 2020). The project is funded by the European Union and is being implemented by the Ethiopian Chamber of Commerce and Sectoral Associations (ECCSA) with the support of consulting firms (ECCSA, 2021).

The impact of COVID-19, while significant, has been uneven across industries and households. To support an inclusive green recovery, different countries have prioritized access to economic stimulus packages for the most impacted industries, regions and households. For example, consumer incentives to purchase energy-efficient goods were provided to low-income households in the Republic of Korea (South Korea Ministry of Economy and Finance, 2020). There was also a focus on strengthening worker protection. In China, a number of government and affiliated bodies aligned support measures ranging from safety nets and job searches to tax deductions for vulnerable workers, especially those with disabilities (China Ministry of Human Resources and Social Security, 2020).

5. Implications for future industrial policy incorporating a resilience dimension

While addressing the immediate need to fight COVID-19 is the current priority, the pandemic threatens the gains achieved towards the Sustainable Development Goals (SDGs) (UN, 2020). Countries around the world therefore face a dual challenge: swiftly delivering the required emergency responses today while enabling a more resilient future. Policy actions, including industrial policies, have a critical role to play in tackling these challenges. This section discusses the implications for future industrial policymaking, with a particular emphasis on developing countries.

Figure 4: Policy implications

Source: Authors.

Manufacturing matters to national socio-economic resilience: Future industrial policies need to incorporate the resilience dimension while identifying interfaces with other policy areas

Extreme events such as the COVID-19 pandemic have drawn attention to the role of manufacturing industries in societies and economies as the provider of goods that are critical to life and national security; as the source of essential goods needed to tackle emergencies; and as a contributor to economic recovery and growth. The critical role of manufacturing was recognized in previous crises but the attention given to the sector by some governments eventually faded away.

The Sendai Framework encourages countries to use post-disaster reviews as opportunities to enhance learning and public policy. Enhancing understanding of the role of manufacturing in national socio-economic resilience is one such opportunity. In particular, COVID-19 has brought forward key questions about the significance of manufacturing that need to be addressed to inform future industrial policies, for example: The incapacitation or destruction of which manufacturing assets would have a debilitating effect on the sustenance of life and functioning of the economy? Is the country able to produce and distribute critical items required to tackle disasters? And how well do we understand the contribution of manufacturing to recovery and long-term economic growth of individual countries?

Naturally, industrial policy needs to be understood in the context of broader objectives such as productivity, sustainability and inclusiveness (Santiago and Laplane, 2021). As such, the industrial policy measures identified to support resilience should be seen as complementary to broader industrial policy agendas. Moreover, for resilience to be improved, the interfaces between industrial policy and other policy areas need to be explicitly laid out. For example, civil protection agencies are commonly in charge of developing and enforcing regulations (e.g. safety inspections and seismic building codes) intended to minimize disaster risk at the national level. Industrial policy can contribute to these efforts by focusing on ensuring high levels of compliance with such regulations on industrial firms and assets, particularly those in critical industries. The identification of such interfaces between industrial policy and other policy areas should be part of a national dialogue around "building back better" in which countries reflect on the multidimensional nature of resilience, identify any potential trade-offs between societal actor perspectives and account for the importance of different sectors.

Building state capabilities, particularly in developing countries, should be guided by an understanding of the close links between prevention, preparedness, response and recovery

The pandemic has laid bare deep divisions and inequalities between countries – in terms of resource availability, institutional capabilities and policy space. Critically, the fiscal capacity of developing countries has been tightly constrained and pales in comparison to that of developed countries (IMF, 2021b).

However, the need to build state capabilities in developing countries goes beyond fiscal and monetary policy space. A large body of literature acknowledges the necessity to build government capabilities in developing countries across the entire government (Christopher, 2018; Mazzucato et al., 2021; Royal Academy of Engineering, 2021; World Bank, 2020).

As forcefully shown by the COVID-19 experience, when disaster strikes, it is already too late to put together a system of response. Understandably, the focus in many countries is, at this point in time, on *response* efforts. But the State's primary responsibility to "prevent and reduce disaster risk" and to "build back better" (UNDRR, 2015) points to the need to coordinate public and private programmes based on understanding the close links between all four phases of comprehensive emergency management.

Immediate *response* and long-term *recovery* measures to assist and support businesses and people experiencing economic hardship could be particularly costly, and their scope and coverage may be largely determined by governments' ability to spend. However, if managed in the context of overall development planning, these can contribute materially to resilience. In particular, lessons learned from response and recovery activities should be used to *prevent* the consequences of future disasters and develop institutional mechanisms to improve *preparedness*. From an industrial policy perspective, *prevention* and *preparedness* could be enhanced by capturing lessons on the supply, operational and demand risks experienced during the pandemic.

Going forward, the relevant knowledge, capabilities and capacity for industrial policy delivery include capabilities to assess risks and vulnerabilities across supply chains, particularly those of critical goods; foresight and data analytics capabilities, particularly applied to the understanding of industrial and technology trends; governance structures to leverage research, design and engineering and re-engineering domestic capabilities (e.g. supply chain task forces); technical and financial capacity to deliver business advisory services; and governance structures and communication channels to leverage collaboration and resources from different actors, including local and foreign private-sector and international organizations (Christopher, 2018; Mazzucato et al., 2021; Royal Academy of Engineering, 2021; World Bank, 2020).

The next crisis is not going to be the same: Lessons from COVID-19 should help us rethink the role of domestic manufacturing capabilities

Less developed countries had already been suffering from shortages of essential goods, but the pandemic has exacerbated those shortages. While developed nations were able to quickly acquire PPE, medical equipment and, more recently, vaccines, developing countries without the affluence to purchase these critical goods found their ability to respond to the pandemic severely limited. While the current focus is rightly on COVID-19-related products, the task will not be over once these products are obtained.

It is crucial that countries recognize that future crises are likely to require different types of manufactured goods. The frequency of globally disruptive events is increasing, and developing countries are particularly vulnerable to disasters, as their populations are concentrated in urban and low-lying coastal regions. Globally disruptive events will test the ability of countries to tackle emergencies in different ways and ensure the supply of very different types of goods. For example, temporary housing supplies are more important in the event of an earthquake.

Two implications are worth emphasizing. The first is the importance of identifying critical manufacturing products and understanding vulnerabilities in their supply chains. There is therefore a need to continuously review the type of critical items required for crises of a distinct nature, and to understand the country's ability to produce or source them. Section 3 discussed the underlying risks associated with modern manufacturing industries, emphasizing that as global manufacturing evolves, so do the risks associated with it. For example, we highlighted the increasing risk of cyber-security attacks and noted that the exposure of developing countries to weather-related events is increasing. Thus, the "risk profile" of manufacturing industries needs to be periodically assessed and information disseminated among stakeholders as an integral part of industrial policymaking.

The second implication is the need to build domestic manufacturing capabilities. It is critical that countries keep adequate stocks and domestic production capacity of life-saving products. However, it is simply not feasible to stockpile all types of products, regardless of demand fluctuations. Therefore, a certain level of "sovereign manufacturing capabilities", particularly for critical goods, might be required. This further highlights the importance for developing countries to press on with an industrialization agenda, developing institutional frameworks and expanding the focus of FDI attraction. Such measures have, of course, been part of the industrial policy agenda for some time, but disasters such as COVID-19 further emphasize their urgency. Efforts in this area in countries including Ethiopia and Nigeria, as discussed in Section 4, are encouraging.

The policy toolkit presented in this paper is just the first step in the process; implementation needs to be stepped up

The Sendai Framework identifies the need for focused action within and across sectors by states at local, national, regional and global levels in four priority areas: (1) understanding disaster risk; (2) strengthening disaster risk governance to manage disaster risk; (3) investing in disaster risk reduction for resilience; and (4) enhancing disaster preparedness for effective response and "building back better" in recovery, rehabilitation and reconstruction. Similarly, the Sendai Framework outlines seven global targets to guide, and against which to assess, progress, including: reducing direct disaster economic loss in relation to GDP by 2030; substantially increasing the number of countries with national and local disaster risk-reduction strategies by 2020; and substantially increasing the availability of, and access to, multi-hazard early-warning systems and disaster risk information and assessments to people by 2030. UN member states self-report to the UNDRR progress data towards the seven global targets (UNDRR, 2021).

Although some progress has been achieved in the implementation of the Sendai Framework, many countries are still lagging behind. As of April 2020, 85 countries out of 195 had reported having national disaster risk-reduction strategies in place. From these, the average self-reported score of alignment with the Sendai Framework, an indicator of the quality of implementation, was 0.67 on a scale of 0 to 1 (United Nations, 2020). In 2020, only around one-fifth of countries had submitted reports—or were in the process of submitting them—on the economic losses attributed to disasters, and less than one-fourth had reported having a multi-hazard early-warning system (UNDRR, 2021).

Against this background, it is important to note that the toolkit presented here is only a first step in the process of developing future industrial policies incorporating the resilience dimension. The toolkit lays the conceptual foundations to inform national industrial policies, whose development and implementation are at different stages in different countries. Future work will be required to discuss in more detail the extent to which the policy options presented here are already in place in individual countries or whether the required institutional framework for their implementation exists locally.

Regardless of their starting point, the COVID-19 pandemic has demonstrated that strengthening manufacturing know-how is required to inform strategies that account for differentiated impacts, needs and long-term prospects of different industries, countries and regions. Such understanding is critical at the highest levels of government but also for civil servants in key departments in agencies in charge of coordinating national efforts in areas ranging from the establishment of

national task forces to the emergency repurposing of production lines to increase the supply of life-saving goods.

A final area worth exploring relates to opportunities to increase the policy space in developing countries. Beyond fiscal and financial policy space, the pandemic has shown that governments' authority to strike agreements with private industry matters. Developed countries were able to deploy and use instruments, such as the US *Defense Production Act*, which gives countries significant emergency authority to tackle hoarding and price speculation, limit exports of medical goods and increase the production of critical supplies. The potential of such instruments in developing countries should be explored.

National efforts are necessary but not sufficient – global value chains make international cooperation essential

The Sendai Framework recognizes the important role of regional and international organizations in providing support to developing countries. It calls for the support from developed countries and partners to developing countries to be tailored according to identified needs and priorities (UNDRR, 2015). COVID-19 has evidenced the interconnectedness of the world and the need for internationally coordinated responses for the production and distribution of medical equipment and vaccines. In addition, vast interconnected systems often shared among countries are a critical infrastructure.

The impact of the pandemic is still unfolding. Governments, particularly in developing countries, might not be able to maintain the level of support achieved during the pandemic for much longer. Considering this, the OECD believes that support from member states to developing countries should be unprecedented in terms of resources mobilised, scope and ambition (OECD, 2020c).

International cooperation is crucial to ensure the equitable distribution of critical goods such as vaccines. An aspect that has received less attention, however, is that cooperation among countries participating in critical supply chains is required to ensure the efficient operation and scaling-up of critical goods production. Regional collaboration, exemplified by the *Africa Medical Supplies Platform* and the *Supply Chain Maps for Pandemic-Fighting Products*, needs to be encouraged and expanded.

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