FROM PANDEMIC TO GREATER RESILIENCE
ENHANCING DISASTER RISK FINANCING IN THE PEOPLE’S REPUBLIC OF CHINA

Gary Wei, Emma Fan, and Anqian Huang

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From Pandemic to Greater Resilience: Enhancing Disaster Risk Financing in the People’s Republic of China

Gary Wei, Emma Fan, and Anqian Huang

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<td>Asian Development Bank</td>
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<td>CAREC</td>
<td>Central Asia Regional Economic Cooperation</td>
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<td>CAT bond</td>
<td>catastrophe bond</td>
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<td>CCL</td>
<td>contingent credit line</td>
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<td>CCRIF</td>
<td>Caribbean Catastrophe Risk Insurance Facility</td>
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<td>COVID-19</td>
<td>coronavirus disease</td>
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<td>GDP</td>
<td>gross domestic product</td>
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<td>IBRD</td>
<td>International Bank for Reconstruction and Development</td>
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<td>MEM</td>
<td>Ministry of Emergency Management</td>
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<td>PEF</td>
<td>Pandemic Emergency Financing Facility</td>
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<td>PICC</td>
<td>People’s Insurance Company of China</td>
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<td>PRC</td>
<td>People’s Republic of China</td>
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<td>SARS</td>
<td>severe acute respiratory syndrome</td>
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<tr>
<td>SPC</td>
<td>segregated portfolio company</td>
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<td>SPV</td>
<td>special purpose vehicle</td>
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<td>TA</td>
<td>technical assistance</td>
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<td>US</td>
<td>United States</td>
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**EXECUTIVE SUMMARY**

**Significant impacts of disasters.** Many countries around the world are confronted with disaster risks at levels and varieties far greater than their public finances could manage efficiently and effectively. The People’s Republic of China (PRC) is no exception. The outbreak of the coronavirus disease (COVID-19) pandemic has increased the likelihood of severe impacts from risk exposure and vulnerabilities from disasters. A flood in Zhengzhou, Henan Province in July 2021 was described as a once-in-a-thousand-year event. The off-budget fiscal demands of a government’s response to disasters can reduce its financial capacity to fulfill other functions and undermine socioeconomic progress and development. Economic losses from disasters in 2019 amounted to about $47.5 billion.¹ These catastrophes can have a material impact on fiscal and financial stability.

**Traditional insurance is not the answer.** Traditional indemnity insurance contingent products are generally ineffective in covering risks from such events. Government-subsidized insurance has covered only a small portion of the losses created by adverse weather events in the PRC agriculture sector, for instance. Moreover, the aggregate losses from secondary effects set off by the primary catastrophes such as the COVID-19 pandemic, severe earthquakes, and powerful typhoons could significantly amplify the initial negative cost impacts. Mega disasters defy accurate risk assessment from the law of large numbers as they are outliers.² The maximum indemnity under any catastrophe insurance is capped at levels far below the actual losses.

**The differences between indemnity insurance and parametric insurance.** According to the Wharton School of the University of Pennsylvania Risk Management and Decision Processes Center, indemnity insurances reimburse the consumers for the damages they sustain or the costs they incur after a specified incident. In this context, the insurance company must know the exact cost or loss, such as by sending a loss adjuster to assess the damage. In contrast, parametric (sometimes also called index-based) insurance pays out the compensation based on an objective measure of the causal event instead of the damage sustained, such as related to wind speed in a location or the height of a river above flood stage. This is referred to as the “trigger.” Since the payout is not linked to property damages, it is a useful approach for covering a wider range of disaster losses such as business interruption.³

**Improving the disaster risk financing structure.** This report highlights the inadequacy of public finance instruments employed by governments in 2021—fiscal reserves, contingent credit arrangements, and traditional indemnity insurance—to adequately contribute to the management of the contingent liabilities that disasters represent. In addition to these insurance products, there are additional tools—such as parametric insurance—to build public finance capacity in the wake of major disasters, soften budget shocks, and bolster long-term fiscal stability and resilience.

**Research into better tools.** Governments recognize that more effective public finance tools for managing the costs of disaster risks are beneficial to reduce the fiscal impacts after a disaster event.

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² In the insurance business, the law of large number produces its axiom. As the number of exposure units (policyholders) increases, the probability that the actual loss per exposure unit will equal the expected loss per exposure unit becomes higher, so that it is easier to establish the correct premium and thereby reduce risk exposure for the insurer as more policies are issued within a given insurance class. The law of large number enables insurers to calculate expected losses and determine premium rates. Individual uncertainty may disappear in large pool of observations.

In this context, the Asian Development Bank (ADB) East Asia Department has been supporting the Government of the PRC to identify effective fiscal tools for managing the contingent liabilities in the event of major disasters. This involves consultation with policy makers, local government authorities, emergency management officials, financial market players, and research institutions about the technical requirements, market feasibilities, advantages, and drawbacks of available public finance innovations.

**Parametric insurance as an added tool.** Many governments around the world have turned to parametric insurance with closely targeted and carefully crafted coverage to provide contingent capital and cover the contingent public sector liabilities that disaster risks create. Parametric insurance products need to be incorporated into government contingent fiscal liabilities, which is a major resource for financing post-disaster reconstruction and recovery. It offers pre-specified payouts contingent on a trigger of events—such as rainfall level, typhoon speed, temperature, and earthquake intensity—reaching the thresholds within a specified geographic area. Parametric insurance could be purchased with disaster risk cash reserves, for example, and supplement the captive insurance, contingent borrowing, and other instruments to better cushion government fiscal constraint in case of disasters. Each of these tools can be applied separately or in combination. Parametric insurance has several advantages.

**Broader coverage of complex disaster effects.** Traditional indemnity insurance schemes generally cover predetermined losses from specific types of damages arising from narrowly defined events such as fire, flooding, and health issues. However, this structure is not suited for major disasters in which various types of damages occur at once and cover relatively large geographical areas. For example, a building fire could be a secondary result of a gas leak and explosion which, in turn, is a tertiary product of the ground movement during a severe earthquake. At the same time, flooding and personal injuries caused by the same earthquake would likely require different indemnity policy coverages. Parametric insurance, on the other hand, covers the occurrence of the underlying disaster event itself, such as the same earthquake, provided its epicenter is in a predetermined geographical area and above a predetermined intensity. Unlike the payouts under a traditional indemnity insurance structure, the payouts under a parametric insurance structure are not generally tied to actual losses of narrowly specific events. The parametric insurance scheme can be used to finance a government disaster response and complement existing instruments.

**Payout speed and access to capital markets.** The payout by parametric insurance can be available for deployment shortly (e.g., within days) after the trigger event. The assessment of actual losses—and often lengthy loss adjustment process required by indemnity insurance—is much more efficient. For large risks and contingent liabilities that insurers or reinsurers are otherwise unwilling to cover, parametric insurance can provide cover—structured by special purpose vehicles on behalf of governments in the form of catastrophe bonds—to transfer the risks from public finance obligations to capital markets. Catastrophe bonds and similar securities are increasingly used by governments in many parts of the world for disaster risk financing.

**Technical challenges.** To bring about the determination of the premium and the expected payouts when the disaster occurs, the insurance and reinsurance companies require reliable historical data—including data on past losses, locations, and periods of similar past disasters—and sophisticated modeling tools to simulate future events based on various disaster types and the likely losses incurred.

**Quality design for quality coverage.** Parametric insurance has a trigger point, such as a certain magnitude of an earthquake or a particular wind speed during a typhoon. To capture the disaster risk and the likely loss, insurers need to carefully evaluate the trigger parameter, location, or time period. Parametric insurance can also involve a lower basis risk—the risk that payout may not be commensurate with actual loss—because it uses complex formulas and metrics to match the levels of loss and payouts associated with parameters such as the disaster intensity and geographical location. Parametric insurance demands soundness and accuracy in product design. Effective monitoring through technology such as
weather stations and ground-movement detectors is crucial. Skilled brokers are needed to deal with savvy insurers that will use their long experience to seek advantage and greater profits, as are knowledgeable securities advisers to help frame the insurance parameters in cases of catastrophe bonds.

**Developing parametric insurance and other instruments in the People’s Republic of China.** The PRC is particularly well suited to pilot new parametric disaster risk finance strategies and tools. The country is highly vulnerable to a variety of disasters. Central, provincial, and municipal governments need to address the immense fiscal contingent liabilities issues brought by these frequent disasters. A relatively weak insurance market has not been able to transfer a meaningful amount of the risks to the capital market, which offers good opportunities via catastrophe bonds or other securities. Government policy in the PRC favors the exploration and development of financial innovation as outlined in the 14th Five-Year Plan to improve climate resilience and fiscal sustainability.

**Pre- and post-disaster tools.** According to an ADB and World Bank report, there are pre-disaster and post-disaster finance instruments. Pre-disaster instruments include contingency budgets, reserve funds, contingent credit, and sovereign risk transfer solutions. Post-disaster instruments include budget reallocations, tax increases, post-disaster borrowing, and donor presence and assistance (footnote 4).

**Five pilot program options.** The parametric insurance structure and instrument could address the disaster risk finance challenges in the context of providing some level of certainty to the PRC government fiscal contingent finance. There are five parametric insurance pilot programs that the government can consider to enhance public finance capacity for disaster risk responses. Development partners such as ADB are well-placed to support the government in introducing and implementing the programs and creating replicable models for other developing countries.

1. **Adding parametric and securitized insurance to public health disaster risk financing.** To address risks of future COVID-19-like pandemics and other public health disasters, a pandemic index insurance—in which payouts are contingent on a defined outbreak of certain pandemics—could be designed and implemented. The purchase of these insurance products with available fiscal reserves would leverage additional contingent capital for pandemic intervention, medical assistance, financial compensation to businesses and individuals, and government support for the resumption of work and production. As demonstrated by the COVID-19 pandemic, much greater (and less costly) coverage of insurance-linked securities—such as catastrophe bonds—would be important in the event of major disasters, making securitization through CNY-denominated public health disaster risk bonds on the PRC and foreign capital markets. This model will reduce the shortfalls in the capacity of public finance to respond to public health disasters and make securitization of disaster parametric insurance a reality in the PRC.

2. **Embedding parametric insurance in the public financing of Yangtze and Yellow River basin flood disaster relief.** The Government of the PRC could introduce a parametric insurance structure into the public financing framework for managing the frequent flood disaster risks of the Yangtze River and the Yellow River (the two largest river systems in the PRC) regions. The under-resourced, reserves-based regimes in 2021 could be supplemented by ones that combine reserves with contingent finance through the purchase of this insurance product with available fiscal reserve funds to shore up the budget adequacy for disaster responses and relief.

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(iii) **Integrating parametric index insurance into central government agricultural disaster response.** The central government could introduce agricultural weather index insurance into the national budget for agricultural disaster relief. The insurance could be purchased with available reserves, augmented by the insurance payouts triggered by agrometeorological disasters in crop productions, such as drought, excessive rainfall, and other extreme weather conditions. The insurance products can build on lessons from an earlier pilot by various provincial governments in which a set of standards and a verification framework result in greater contingency finance availability for managing agricultural disasters and the integration of innovative financial products into public finance.

(iv) **Parametric disaster insurance by municipal governments.** Due to the prevalence of megacities throughout the world, the scale of disaster risks in urban settings could be excessively high, such as from fire, flooding, earthquake, and other incidents that affect public safety. The response to these disasters can threaten the financial stability of large municipal governments. A fourth pilot could blend parametric insurance products with municipal government budgets to address disasters and emergencies and their economic effects.

(v) **Local government disaster risk financing.** The fifth pilot could use a combination of reserves-based, borrowing-based, and other budgetary responses such as cash reserves and contingent finance. Each tool kit could employ reserves, debt financing, contingent credit, parametric insurance, and/or marketable disaster securities according to the local risk profile. Parametric insurance pilots by the provincial governments—such as in Guangdong—provide a good starting point for the design of such a framework.
I. RESPONDING TO A PANDEMIC’S WAKE-UP CALL

Once-in-a-century event. The coronavirus disease (COVID-19) pandemic is the most devastating global public health disaster since the influenza pandemic in 1918–1919. From its outbreak in 2019 to the time when vaccination began in the first half of 2021, COVID-19 had infected more than 220 million people and killed more than 4.5 million. The pandemic and associated containment measures have resulted in severe economic distress.

A focus on the People’s Republic of China. This report focuses on the People’s Republic of China (PRC), which is prone to disasters such as earthquakes, droughts, floods, typhoons, and storm surges. Within the PRC, areas prone to disasters are home to more than 70% of the cities and over 50% of the population. Coastal areas in southern and eastern PRC—and some inland provinces—are vulnerable to tropical cyclones. Provinces along the Yangtze and Yellow River regions are prone to annual flooding. Serious droughts occur in the northeast, northwest, and northern PRC. Many regions in the PRC have experienced earthquakes of a magnitude 5 or above. About 69% of the territory consists of mountains and plateaus where geological disasters such as landslides, mudslides, and rock avalanches happen frequently due to geological nature. As an upper middle-income country with significant experience in managing disasters, the PRC can offer a wealth of development experiences and lessons in addressing the economic consequences, financial costs, and lessons to address the huge contingent liabilities for public finance due to disasters.

Lessons for disaster policies and planning. This report explores the enhancement of responses to the economic and financial risks posed particularly by mega disasters. It covers the effects of disasters on economies, societies, and global supply chains, particularly within the context of climate change. The report analyzes the weaknesses of the traditional reserves-dominated fiscal budget system and/or post-disaster borrowing—among other mechanisms for contributing to disaster relief—and proposes a new framework and strategies which blend the use of reserves and contingent financing instruments that are in line with the likely frequency and severity of future disasters. The framework aims to leverage existing fiscal funding to narrow public financing gaps for contributing to stronger disaster risk resilience.

Relevance to the government and ADB strategies. This report is aligned with government strategy. Specifically, the 14th Five-Year Plan of the PRC calls for the development of disaster risk insurance instruments to strengthen the emergency management system for various natural and other disasters.1 The report also aligns with the ADB PRC Country Partnership Strategy, 2021–2025 to strengthen disaster resilience and improve climate change adaptation.2 Similarly, the disaster risk finance framework is aligned with the ADB Strategy 2030 as one of its seven operational priorities of “Tackling Climate Change, Building Climate and Disaster Resilience, and Enhancing Environmental Sustainability.”3 The disaster finance work supports global initiatives such as the Sendai Framework for Disaster Risk Reduction (2015–2030) to substantially reduce disaster risk in the economic, physical, social, cultural, and environmental assets of persons, businesses, communities, and countries. Development partners such as ADB are well-placed to support the PRC government in strengthening its disaster risk financing systems. The formulation of a more sophisticated disaster risk financing system would be an important step forward for the PRC and can generate a successful business model for other ADB developing members.

Growing threats and vulnerability. The annual average direct economic loss from the primary impact of disasters increased from $18 billion in the 1980s to about $167 billion globally in 2021.\(^4\) According to the World Meteorological Organization Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019), there were more than 11,000 reported disasters globally, causing over 2 million deaths and $3.64 trillion in losses.\(^5\) The poverty, emotional effects, and other social impacts induced by disasters far exceed the monetary losses. The following sections outline the types of disasters.

A. Public Health Disaster Risks

Public health disasters are events such as outbreaks of infectious diseases and mass illnesses, food sources, or occupational poisoning that seriously endanger the health and lives of people and place a heavy burden on medical systems.

1. Examples of Major Public Health Disasters

**1918–1919 flu pandemic.** The 1918–1919 pandemic caused by a particularly virulent strain of the influenza virus was first identified in the United States (US) and infected one-third of the world’s population in four waves and killed 50 million people worldwide.\(^6\) Although COVID-19 has caused fewer infections and deaths than this public health disaster, the global containment and relief efforts have significantly strained the world economy. These two crises demonstrate the characteristics of catastrophic public health disaster risks.

**The risks posed by viral outbreaks.** Not every pandemic will lead to the scale of economic and social devastation like the 1918–1919 flu or COVID-19, but the frequency of viral outbreaks highlights the significant economic risks that governments are unprepared for. First detected in the PRC in 2003, severe acute respiratory syndrome (SARS) infected more than 8,000 people and killed almost 10% of them, resulting in unexpected economic losses in global trade, travel, tourism, and businesses. The H1N1 virus began spreading in 2009 and grew into the first influenza pandemic of the 21st century. The Middle East respiratory syndrome virus—first identified in Saudi Arabia in 2012—was not easily transmitted but had an estimated fatality rate of 35%.\(^7\) The Ebola virus—first identified near the Ebola River in South Sudan in 1976—reemerged in West Africa in 2014 and killed more than 11,000 people. Ebola cases were detected in six countries on three other continents.\(^8\) The Zika virus—first recorded in 2007 in the Federated States of Micronesia—illustrated the potential for viral spread.\(^9\) Any of these infections and viruses could potentially develop into a major pandemic for which many countries and the world are unprepared.

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\(^6\) Centers for Disease Control and Prevention. 2021. 1918 Pandemic (H1N1 virus). Atlanta.

\(^7\) Centers for Disease Control and Prevention. 2019. Middle East Respiratory Syndrome (MERS). Atlanta.


2. The COVID-19 Pandemic

COVID-19—or coronavirus 2 (SARS-CoV-2)—is a contagious disease that caused more than 249 million confirmed infectious cases and a death toll of 5 million worldwide from March 2020 to November 2021. Even with the global efforts to vaccinate the global population, the continued virus mutations have caused repeated coronavirus surges, with the strongest being the Delta variant during the middle of 2021. The social and economic impact of COVID-19 has been significant. At the beginning of the pandemic in March and April 2020, for example, more than 3.9 billion people in more than 90 countries or territories were asked to stay at home by their governments. ADB predicted that the global economic impact of COVID-19 could reach $8.8 trillion—9.7% of global gross domestic product (GDP)—under a 6-month lockdown scenario. The International Monetary Fund estimated that the loss of global economic output could reach $28 trillion by 2025. In August 2021, McKinsey & Company predicted that the total costs from the COVID-19 pandemic would reach $16 trillion–$35 trillion by 2025. As a result, governments are under tremendous financial and fiscal constraints. In the US, the government passed the $3 trillion HEROES Act in May 2020, the $900 billion relief bill in December 2020, and the $1.9 trillion American Rescue Plan in March 2021 to address the COVID-19 pandemic. The US Federal Reserve increased holdings of Treasury and mortgage-backed securities by about $3 trillion during the first half of 2020. Japan launched a fiscal stimulus worth $2.14 trillion, accounting for 42.2% of its GDP in 2020. The global fiscal support to address the COVID-19 pandemic could reach $30 trillion by 2023. Massive fiscal gaps could substantially reduce future public spending. Moreover, the pandemic is also intensifying the inequalities within and across countries.

B. Disaster Risks

Disasters result from events in the natural environment that adversely impact human lives and activities, and often inflict fatalities, property damage, and social and economic disruption. Disasters are normally categorized into two types: meteorological, such as droughts, floods, typhoons and hurricanes, frost, hail, and snow disasters; and geological, such as earthquakes, tsunamis, debris flows, landslides, and volcanic eruptions. A disaster finance (response) system determines overall disaster risks by assessing the sources of potential disasters, the conditions under which the risks may increase, the exposure and vulnerability of the country to the damage, and public financing required if disasters strike. The risks of some disasters can be elevated by human activity, such as inadequate infrastructure to accommodate the disaster risk levels.

Direct economic losses from disasters. In 2018, the United Nations Office for Disaster Risk Reduction reported that direct economic losses from climate-related disasters had increased by 250% during...
1998–2017. Disasters are related to extreme weather effects such as floods, storms, droughts, and heat waves. The effects of greenhouse gases on the global climate and the incidence of extreme meteorological events are expected to continue to grow. The National Oceanic and Atmospheric Administration estimated that the total direct global losses from disasters have steadily increased from 1980 to 2018, likely caused by increased human activities that led to climate changes (Figure 1). Munich Re—a reinsurance company based in Germany—reported the occurrence of 820 extreme disasters in 2019, with total economic losses reaching $150 billion. These disasters were 7% geological; 45% floods; 38% rainstorms, flash floods, and landslides; and 10% heat waves, frosts, and wildfires. Meteorological disasters occurred in Asia (43%), the Americas and the Caribbean (20%), Africa (15%), Europe (12%), and Oceania (2%). Asia was the hardest hit in terms of direct losses ($75 billion). Typhoons Hagibis and Typhoon Faxai in Japan, and Typhoon Lekima in the PRC accounted for almost half of this amount ($34 billion). The intense weather events categorized typhoons are particularly frequent in Asia. In general, India and the PRC also suffer greatly from massive monsoon floods.

C. The Risks of Disasters Caused by Humans

Examples of disaster risks caused by humans include calamitous fires and explosions not due to natural events; airline crashes; maritime, rail, and mining accidents; or the collapse of buildings or bridges. In these cases, human actions are the trigger. The growing complexity of human activities has made the world an increasingly fertile hotbed for the occurrence of such disasters. The risk levels for these disasters depend on many factors—including social, economic, technological, lifestyle—and the geographical environment in the place where the threat may exist, as well as the disaster risk-related legislative, judicial, regulatory, and governance systems. A more complex global economy and trade could potentially make these types of disaster more frequent and severe, such as in multiple port explosions from concentrated fertilizer shipments and storage.

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19 United Nations Office for Disaster Risk Reduction. 2018. UN 20-year review: earthquakes and tsunamis kill more people while climate change is driving up economic losses. Geneva.
20 Geological disasters refer to earthquakes and any disasters related to forces of geophysics.
Figure 1: Direct Global Losses from Disasters by Type, 1980–2020

Global reported disasters by type, 1970 to 2019
The annual reported number of disasters, categorised by the type. This includes both weather and non-weather related disasters.

Impact
Mass movement (dry)
Volcanic activity
Wildfire
Landslide
Earthquake
Extreme temperature
Drought
Extreme weather
Flood

Sources: EMDAT (2020): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium
OurWorldInData.org/natural-disasters • CC BY
National Oceanic and Atmospheric Administration.
III. DISASTER RISK CHALLENGES IN THE PEOPLE’S REPUBLIC OF CHINA

A. Public Health Disaster Risks

The Chinese Center for Disease Control and Prevention defines public health emergencies as events such as major infectious diseases, mass diseases of unknown causes, foodborne illness outbreaks, and occupational poisoning incidents that occur suddenly and seriously harm human health and life.23

The SARS public health emergency. An infectious disease that struck the PRC southeast province of Guangdong in December 2002 was subsequently identified as SARS and later was detected in other parts of the country. Eventually, it spread to 32 countries and regions, infected more than 8,000 people, and killed more than 800.24

The COVID-19 public health crisis. While there was a significant initial spike in COVID-19 infection and death rates, the PRC largely controlled the pandemic within a few months. By July 2021, COVID-19 had reportedly caused 104,157 infections and 4,848 deaths in the country. The GDP of the PRC contracted by 6.8% in the first quarter of 2020, however, growth resumed in the remaining three quarters of 2020 as the country contained the spread of the disease. The overall GDP growth for 2020 was 2.3%.

Technical challenges. Modeling of disaster risks and pricing of insurance solutions are subject to substantial historical disaster risk data that cover a wide range of subjects including weather patterns, hydrology, and loss incurred. Several institutions in the PRC carry out the necessary data collection and analysis, including the China Meteorological Administration, Yangtze River Commission, and local water resource and hydrology institutes, among others. Insurance and reinsurance companies also use their data banks to carry out modeling work. There are limited open-source modeling platforms. Global modeling firms such as RMS, EQE Consulting, and CAT also provide the services.

Without the strong determination of the PRC government to contain the pandemic, the public health disaster could have led to severe macroeconomic contraction and grave social instability. As the world’s largest exporter and the second-largest economy, the PRC could have disrupted global trade and manufacturing supply chains. Because the PRC is a major supplier of semi-finished and finished products for other large economies, the impacts of the pandemic on domestic and global supply chains were among its most harmful secondary effects. One study put the share of companies around the world that experienced delayed delivery of key components from the PRC at 57%.25

B. Disasters

The PRC is highly exposed to disaster risks. It is among the countries hardest and most frequently hit by earthquakes, droughts, floods, typhoons, and storm surges. The areas prone to these disasters include more than 70% of the cities and half of its population. Over two-thirds of its territory is vulnerable to extreme flooding, and the southern and eastern coastal populations and some inland provinces frequently lie in the paths of tropical cyclones. The northeast, northwest, and north occasionally suffer serious drought. All the provinces, autonomous regions, and municipalities directly under the central government have experienced at least one earthquake of magnitude 5 or above since 1949. About 69% of PRC territory consists of mountains and plateaus, where geological disasters such as landslides, mudslides, and rockslides happen.26 The list of disasters in 2019 reported by the PRC Ministry of Emergency Management (MEM) included 130 million affected people, 909 dead or declared missing, and 5.286 million people undergoing emergency evacuation. The disasters destroyed 126,000 houses.

High-risk areas. The three main locales for disaster risks are coastal areas, river basins, and piedmont (foot or base of the mountain) regions. The coastal areas are exposed to typhoons, storm surges, rainstorms, floods, droughts, and saltwater intrusion. Rainstorms, drought, soil erosion, landslides, and mudslides are the main perils in the riverside regions. Drought and flooding are most frequent in the areas abutting the lower areas of a river, least so in its upper reaches, and moderate in between. Severe landslides and mudslides mostly occur along upper river areas. Areas lying at the base of PRC mountain terrains are prone to earthquakes, mudslides, and/or landslides.

1. Meteorological Disaster Risks

Weather as the leading cause of disasters. The PRC is also exposed to meteorological disaster risks. Weather is frequently the cause of most disasters and has historically caused more damage in terms of economic costs and death tolls than that caused by earthquakes. Disastrous weather in the PRC has distinct patterns. Drought is common in the Liaohe and Haihe plains, the Loess Plateau, the Sichuan Basin, and the Yunnan–Guizhou Plateau. The annual increase in the number of days of heavy rain tends to affect the south more than the north. Tropical cyclones affect the coastal regions. In general, dust storms occur in northern PRC.

Examples of weather disasters. The worst flood disaster in the past century was in 1998, which took place in the Nen, Songhua, and Yangtze River basins which encountered the worst flooding in 150 years. Twenty-nine autonomous regions, provinces, and municipalities were inundated to varying degrees. The provinces of Heilongjiang, Hubei, Hunan, and Jiangxi were impacted the most: 223 million people were affected, and 4,150 died. Across the country, 196 million mu (13.1 million hectares) of land were flooded, and 318 million mu (21.2 million hectares) were affected. About 6.85 million houses were destroyed,27 and direct economic losses amounted to $48 billion.28 Record heavy storm rains and flooding in 1975, and the collapse of more than 60 dams around Zhumadian—a prefecture-level city in Henan Province—reportedly killed about 230,000 people.

The PRC experienced losses from flood-related disasters during 2003–2018, with particularly severe losses in 2010, 2013, and 2016 (Figure 2). These are believed to have resulted directly from heavier rainfall due to climate change as well as an increasingly fragile environment and greater risk exposure.

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In July 2021, the PRC province of Henan encountered sudden and extremely heavy rainfall. Zhengzhou—the capital city of Henan Province—experienced 610 millimeters of precipitation within 24 hours, which is the normal annual volume. The flooding caused 302 deaths; 50 people went missing; 30,106 houses collapsed; and there was direct economic damage of $17.68 billion.29

**Agricultural vulnerability.** Agricultural production and yields are exposed to a multitude of weather conditions, including extreme highs and low in temperature; untimely frost; drought; heavy rains, snow, and hailstorms; high winds; and various combinations of these (Figure 3). The weather-related

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agricultural disasters that most affect grain and cash crop production in the PRC are drought, flooding, and freezing temperatures.

![Figure 3: Areas of Agricultural Damages due to Disasters, 2010–2018](image)

2. **Geological Disaster Risks**

**Earthquake risks.** The PRC lies between two of the world’s major seismic belts: the Circum-Pacific Belt and the Alpide Belt. These belts connect highly active fault zones. Earthquakes occur mainly along 23 seismic belts. An earthquake can damage and destroy buildings and other structures; equipment and facilities; communication; transport; and other lifeline infrastructure, especially when many buildings are not designed to withstand severe earthquakes due to the lack of standard building codes. Secondary disasters can take the form of fires, explosions, toxic spills, radioactive contamination, and outbreaks of illness and epidemics. Earthquakes are less frequent than weather disasters and typically last only seconds, but they can cause huge casualties and massive physical damage. The 1976 Tangshan earthquake in the northeastern PRC province of Hebei killed about 242,000 people. In addition to a death toll of more than 69,000 people, the 2008 Wenchuan earthquake in Sichuan Province resulted in CNY845 billion of economic losses, with indirect losses likely several times higher.\(^{30}\)

C. Accidents

The MEM has classified accidents and disasters caused by human factors under the following categories: fire; industry, commerce, and trade; construction; hazardous goods; mines; and others. The Tianjin Port explosions in August 2015 were representative of the kinds of disasters most attributed to human activity. The initial blast occurred in a dangerous goods warehouse and was followed by secondary explosions with an overall explosive power of 450 tons of trinitrotoluene, a chemical compound for explosive materials. The accident killed 165 people, injured 798, and left 8 people missing. Direct economic losses were estimated at more than CNY70 million and resulted in CNY10 billion in insurance payouts.

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32 Government of the People’s Republic of China. 2016. The investigation team of the State Council determined that the “8 12” explosion in Tianjin Port was a particularly serious accident of production safety responsibility. Beijing.
33 Caijing. 2015. August 12 Tianjin Port explosions threaten to cause direct economic losses of CNY70 billion. 31 August.
A. Public Finance Implications of Disaster Risks

A contingent liability all governments inherently face. Government public finance response to a disaster is a major component of post-disaster relief efforts. These include inherent and assigned responsibilities to meet the financial costs of relief, reconstruction, recovery, and post-event social and economic support and assistance when a disaster and associated crises occur. Relief efforts can be regarded as government off-balance sheet contingent fiscal liabilities. In other words, recovery costs associated with a disaster risk could include a contingent debt of a government and is usually one that is far beyond its normal fiscal capacity to cover.

The chain of the financial and fiscal effects of a disaster. The financial losses suffered by individuals, businesses, and governments due to the initial property damage and bodily injuries of a major disaster—such as a typhoon or earthquake—can inflict financial losses through legal, social, and trade relationships (Figure 4). As crisis begets crisis, the waves of effect radiating from the disaster can be even more destructive than the original event itself. The massive and complex ongoing human, social, financial, and economic costs secondary to the public health crisis created by the emergence and spread of COVID-19 have illustrated this fact very clearly.

Figure 4: Causal Model for Disaster Risk Transformation

Source: Asian Development Bank (compiled by authors).
**Government as the last line of defense.** When a disaster strikes and its extremely damaging financial effects spread, the lines of responsibility between individuals, companies, and governments generally blur. As the last line of defense in extraordinary crises, governments and the public sector are left with the duty and often overwhelming financial burden of bearing the brunt of the costs. Eventually, the total cost will be borne by the entire society through tax hikes and monetary expansion that lead to inflationary pressures and other economic malaise.

**B. Disaster Risk Financing Framework**

A comprehensive disaster risk finance framework should embody both pre-disaster and post-disaster tools (Table 1). Allocation of reserve funds and the purchase of insurance products are the primary instruments for pre-disaster risk preparation. While useful, these instruments could also become costly when the funds stay idle and insurance policies are not paid out. Some governments prefer to shift a part of the burden of disaster finance to the time when a disaster happens by reallocating other government funds and issuing debts to fund post-disaster recovery. The ideal strategy is a combination of these finance instruments based on specific conditions. Parametric insurance is an important part of this mix to shift a part of government fiscal contingent liability risks to the markets.

**Table 1: Disaster Risk Finance Framework**

<table>
<thead>
<tr>
<th>Pre-Disaster Financing Instruments</th>
<th>Post-Disaster Financing Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contingency budgets</td>
<td>Budget reallocations</td>
</tr>
<tr>
<td>This is usually a Ministry of Finance budget line to support any disaster-related contingencies.</td>
<td>Following a sudden occurrence of a disaster, the government tends to shift budgets from less critical expenditures to more urgent, post-disaster reconstruction and relief expenditures.</td>
</tr>
<tr>
<td>Reserve funds</td>
<td>Tax increases</td>
</tr>
<tr>
<td>General or disaster-specific reserve funds are used to meet the costs of high-frequency, low-impact disasters. In some countries, they also pay for disaster risk reduction and preparedness.</td>
<td>Tax increases are another way to finance increased expenditure needs after disasters. Their effectiveness depends on various factors, including a national tax base, tax compliance, and tax collection capacity.</td>
</tr>
<tr>
<td>Contingent credit</td>
<td>Post-disaster borrowing</td>
</tr>
<tr>
<td>Some development organizations and private creditors offer a contingent credit line with predetermined terms and conditions for disaster recovery and reconstruction, versus often costlier post-disaster financing. This would facilitate rapid access to financing in times when post-disaster liquidity tends to be constrained.</td>
<td>Governments may also borrow following a disaster to finance post-disaster reconstruction and relief costs, depending on their access to capital markets and their creditworthiness.</td>
</tr>
<tr>
<td>Risk transfer solutions</td>
<td>Donor presence and assistance</td>
</tr>
<tr>
<td>Solutions include products that protect the government budget against fiscal shocks from disasters by transferring the risk to international insurance, reinsurance, and capital markets, for instance, via sovereign risk pools, parametric or index insurance products, or catastrophe bonds.</td>
<td>Development partners may also provide urgent assistance to supplement the government efforts for disaster relief. Examples include the 2020 and 2021 ADB support for vaccine procurement and distribution.</td>
</tr>
</tbody>
</table>

ADB = Asian Development Bank.

C. Disaster Relief System of the Government of the People’s Republic of China

The MEM is responsible for organizing national emergency planning, providing authoritative disaster situation reporting when emergencies occur, and guiding the prevention and response of disasters. It also supervises and administers work safety programs in industry, mining, commercial, trade, and other sectors; plans for and directs emergency rescues; and develops the mechanisms for interdepartmental cooperation on disaster prevention and relief.35

The PRC government budgeting for disaster risks comes in four ways:

(i) Fiscal authorities include budget items for emergency response and disaster relief and rehabilitation. This could come under budgeting for emergency management, agricultural disaster assistance, poverty alleviation, and flood disaster relief, as well as for emergency- and disaster-related functional units.

(ii) Budget reserve funds—which account for an estimated 1%–3% of the fiscal budget in 2021—are to be set aside by governments at all levels under the Budget Law and used in the event of disasters, and other emergencies and unforeseeable events.

(iii) Fiscal budget stabilization funds are allocated under the Interim Measures for the Administration of Budget Stabilization Funds (2018) and come from such sources as fiscal revenue surpluses and fiscal budget reserve funds.

(iv) Some funds are earmarked for disaster relief. These include the central government disaster relief funds, agricultural disaster prevention and relief funds, and agricultural and flood disaster relief funds.

The PRC central government is working toward reforming and enhancing the disaster relief funds. For example, in July 2020, the Ministry of Finance promulgated the Interim Administrative Measures on the Central Fiscal Disaster Relief Fund, allowing the authority of the fund to be shared by both central and local governments.

Adopting a market-based approach. Sovereign risk transfer solutions are limited in the pre-disaster risk finance framework. When a severe or extreme disaster occurs, governments in the PRC typically borrow, shift funds from other budget items, and offer targeted crisis-response low-interest loans and tax incentives. For example, the central government immediately allocated CNY860 million in relief funds after the 2008 Wenchuan earthquake and later added CNY11.73 billion. It also deployed the CNY12.52 billion in donations that came in from abroad, provided CNY20.23 billion in tax cuts for the affected areas, raised CNY70.00 billion for post-disaster recovery and reconstruction funds, and urged central government bodies to set aside 5% of their 2008 budgets for earthquake relief.36 This spending and the tax deductions and exemptions were aimed at the resumption of work and employment, creation of jobs, reduction of tax burdens, reconstruction of basic infrastructure and buildings, and general post-disaster support. The PRC government has made great headway in studying, implementing, and reforming the institutional framework for its public finance response to disaster risks. Using a market-based parametric insurance design, the PRC government could leverage a relatively small amount of insurance premium payments for potentially much larger post-disaster contingency payouts. The PRC government could consider addressing the challenges of a lack of a pre-disaster finance strategy. Success in this effort could significantly reduce the uncertainties concerning the catastrophe risk exposure that confronts the economy and society of the PRC.

D. Existing Disaster Insurance Solutions

The government has adopted insurance solutions—as a pre-disaster instrument—to help reduce the financial burden of government from pre-disaster risks, for example, by subsidizing the premium of agricultural insurances for farmers.

1. Government-Subsidized Agricultural Insurance Program

The Ministry of Finance has piloted central government subsidization of agricultural insurance premiums since 2007. Policy-oriented agricultural insurance is government-backed, market-oriented indemnity insurance for crop and aquaculture industries covering losses from defined agricultural disasters. Such insurance is aimed at providing farmers with the least amount of funds to resume farming, as sums insured are small relative to expected crop yields. Subsidies from three levels of government—central, provincial or municipal, and county—cover up to 80% of agricultural insurance premiums, while the remaining 20% is borne by individual farmers. The crops, livestock, or aquaculture products covered are determined annually based on local conditions and requirements. The geographical coverage and subsidy levels of the program are determined each year based on the strength of the financial situation and fiscal capabilities of a county. The premiums for this insurance increased 10 times in the 11 years after the program started during 2007–2018. The main underwriter has been the partly state-owned People's Insurance Company of China (PICC), which accounts for nearly 50% of the market share. PICC is followed by China Insurance and China Pacific Insurance. Policy-oriented agricultural insurance premiums and payouts fall far below actual losses in the PRC from drought and flood each year, which makes the program less relevant than originally expected (Figure 5).

The heavily subsidized policy-oriented agricultural insurance program does not adequately lessen the great need for disaster risk financing in the PRC. There are a few reasons for the limited coverage of costs. For example, policy-oriented agricultural insurance products are designed to only cover the costs of materials needed to resume production after a disaster—including the costs of seeds and chemical fertilizers—but they do not cover land rental for agricultural production costs and farmworkers. This means payouts are—as a rule—far lower than full losses. In addition, the program is designed for individual farmers (not agricultural production collectives), large farm households, and agribusinesses working on transferred land, which are exposed to far greater financial risks than what the program may cover.

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2. The Earthquake Insurance Pool for Urban and Rural Residential Housing

In 2015, the China Insurance Regulatory Commission and the Ministry of Finance formed a consortium of 45 insurance companies to provide earthquake indemnity insurance coverage for urban and rural residential properties against material losses from earthquakes and secondary disasters such as tsunamis, fires, explosions, and landslides. Coverage for urban residential housing ranges from CNY50,000 to CNY1 million, and for rural residential housing from CNY20,000 to CNY1 million, of which payouts are subject to an assessment of property damage levels. PICC acts as the executive unit and chief coinsurer for the pool. Premiums are paid by individual property owners, although local governments subsidize parts of—or even the whole—premiums in some earthquake-prone areas. Considering the aggregate exposure associated with earthquakes, the consortium has a five-tiered insurance system involving insurance, coinsurance, reinsurance, earmarked funds, and reserve funds.

Despite the development of this innovative product, the awareness, demand, and coverage are still low except in such provinces as Hebei and Yunnan where the earthquake risks are particularly high. Like policy-oriented agricultural insurance, earthquake insurance faces the same issue of insufficient and uncertain coverage. This and other problems underline the need for the earthquake insurance consortium to redesign its operating mechanism, products, marketing approaches, and institutional framework in line with budgeting and financing strategies.

3. Pilots on Disaster Parametric Insurances

Some PRC provinces have started to pilot weather index insurance (WII) as a part of disaster-related fiscal budgeting reform. One of these is Guangdong Province, which used WII to address sudden-onset disasters such as typhoons and heavy rainfall. An increasing number of provinces and municipalities are following suit.

The subtropical Guangdong Province in the PRC is perennially threatened by typhoon and flood disasters, which affect the economy, livelihoods, and local government finances. Guangdong Province had several pre-disaster budget allocations and reserve funds, and post-disaster budget transfer mechanisms to
address the potential disaster risk. However, there is no market-based risk hedging mechanism that links the existing budget allocation and reserve funds to the contingency risk. The WII was designed to increase the adequacy of rainy-day funds when disasters strike and to safeguard the reliability of fiscal budgeting while still setting aside a reasonable amount for disaster relief. The provincial departments of finance, civil affairs, and water conservancy, and the Guangdong Office of the China Bank and Insurance Regulatory Commission, began a WII disaster insurance pilot in 2016. The purpose is to ensure that municipalities have sufficient funds for disaster relief, restoration and reconstruction of public facilities, and restoration of production and life in the event of typhoon disasters and heavy rainfall disasters.

The insurers were to pay the amount stipulated in the insurance policies to the affected cities based on such triggers as wind speed and/or precipitation level. The insurance payout was to be earmarked by local government finance units for emergency response, disaster relief, and reconstruction. The project involved 10 prefecture-level cities in the province, which were to pay an annual premium of CNY30 million each.\(^38\) One-quarter of this premium was borne by the city and three-quarters by the provincial government.

Based on its location, risk exposure, and disaster relief funding needs, each city chose one or both of the index perils and negotiated the payout structure, thresholds, calculation cycle, and weighted sums insured attached to each of the weather stations with the insurers. The total coverage in 2016 was about CNY2 billion, and total premiums were CNY300 million. With technical supervision and support from the Guangdong Climate Center, the threshold structure was revised in 2017. This led to an expansion of the project across the province. Guangdong planned to pilot the insurance against flash flooding in 2021.

The Guangdong Climate Center realized that the initial insurance payouts had been designed to be confined to a percentage of the premium and requested that this structure be adjusted in 2017, aiming to ensure that the insurance product could become effective in cases of disasters. Since then, the program has been revised and improved and has been able to perform as intended, with payouts more aligned with the scale of disaster events.

E. Obstacles and Misconceptions for Disaster Risk Financing

Inadequate financial technical capacity of individuals, companies, and governments affects the effectiveness of adopting parametric disaster insurance. The reasons are as follows:

\[(i)\] Many people are unaware of the potential contingent liabilities from the disaster risks, which are rare occurrences.

\[(ii)\] There is a misperception that the government is capable of paying all the costs of post-disaster recovery.

\[(iii)\] There are usually huge gaps between the fiscal reserves for disaster response (e.g., pre-disaster instruments) and the actual contingent liabilities (e.g., post-disaster effects) associated with disasters.

\[(iv)\] Existing insurance products are often designed as having confined payouts for insurance companies’ risks, but do not function as intended insurance products to provide relief when disasters strike.

\[(v)\] Existing indemnity insurance products largely cover property damage and bodily injuries, rather than being commensurate with the contingent liabilities in association with disaster risks.

\(^{38}\) The cities include Heyuan, Maoming, Meizhou, Qingyuan, Shantou, Shanwei, Shaoguan, Yangjiang, Yunfu, and Zhanjiang.
A. Strategy for Public Finance Responses

**New multilayer risk frameworks.** Scientifically integrating contingency reserves, contingent financing instruments, and risk transfer tools to address disaster risks has become a mainstream public finance strategy for better financial readiness when a disaster occurs. The traditional approach—which combines pre-disaster fiscal contingency budget reserves beforehand with post-event budget adjustments and outsized borrowing—did not ascertain an adequate level of fiscal contingency finance. A new framework for disaster-related budgeting and financing preparation includes pre-disaster contingency reserves (e.g., disaster-related budget items, specific disaster relief funds, fiscal budget reserve fund, and fiscal budget stability funds), and risk transfer tools such as traditional insurance, parametric insurance, and insurance-linked securities. These could be combined with post-disaster contingent financing instruments (e.g., budget reallocations, tax increases, post-disaster borrowing, and donor presence and assistance) to significantly elevate the effectiveness of disaster risk finance.

**Different tools for different intensities.** Low frequency and high severity disasters—such as earthquakes—can be reliably modeled for risk pricing, and catastrophe bonds (CAT bonds) could serve as the main source of capital for the insurance industry, as CAT bond investors would play dual roles of investors and insurers and may forego parts or the whole of the bond principle if earthquakes strike above specified intensities. Contingent credit is a preapproved loan to be released on certain conditions and may be placed to deal with those disaster risks of scale, frequency, and severity being in the midrange, such as explosions and floods. The risk transfer instruments are mainly indemnity insurance, parametric insurance, and insurance-linked securities, which are used for catastrophic disaster risks of low frequency and high severity. Parametric insurance can be used to replace traditional contingency budget reserves and contingent loans for enhanced capital management.

**Two instrument types.** International research and practice show that disaster-related budgeting and financing instruments can be divided into two categories: (i) risk retention instruments (which means setting up a self-insurance reserve fund to pay for losses as they occur rather than shifting the risk to an insurer or using hedging instruments) and (ii) risk transfer instruments (which transfer the risks to the insurer or use hedging instruments). The risk retention instruments are partly suited for high-frequency, low-intensity disaster risks, such as disaster-related budget items and reserve funds; post-disaster budget adjustments; lines of credit; post-disaster borrowings (e.g., bond issues); and post-disaster tax increases. Risk transfer instruments include parametric insurances and their linked securities, catastrophe swaps, and public property insurance. These suit low-frequency and high-intensity disaster risks. The overall framework is provided in Figure 6. Some of these risk transfer instruments have already been used in PRC public finance and commercial markets such as the typhoon and rainfall parametric insurance program of Guangdong Province in 2016.

B. FONDEN Fund of Mexico

**Multitask disaster funding.** FONDEN—the Mexican fund for disasters—was established in the late 1990s as a mechanism to support the rapid rehabilitation of federal and state infrastructure affected by adverse natural events. It was first created as a budget line in the Federal Expenditure of Budget 1996 and became operational in 1999. It could be used for the rehabilitation and reconstruction of (i) public infrastructure at the three levels of government (federal, state, and municipal); (ii) low-income housing;
and (iii) certain components of the natural environment (e.g., forestry, protected natural areas, rivers, and lagoons). FONDEN is composed of two accounts: the primary budget account is for post-disaster reconstruction, and the other account is set up to support disaster prevention by funding activities related to risk assessment, risk reduction, and capacity building on disaster prevention.39

Layered instruments. The federal government empowered FONDEN to develop a layered catastrophe risk financing strategy in 2005 that combined risk retention and risk transfer instruments. The Mexico Federal Budget (and Fiscal Responsibility) Law requires the Ministry of Finance to commit no less than 0.4% of the total federal budget to FONDEN, and Article 19 allows exceptional budget allocations to the fund (Figure 7). The World Bank issued a CAT bond in 2006 to support the FONDEN disaster risk response. This increased the budget line by allowing securities investors to underwrite catastrophe index insurances for the fund.

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Expansion in catastrophe bonds. The huge sums of funds required to respond to the Mexico earthquake and hurricane easily exceeded the resources the original FONDEN layered structure could provide. As a result, a pre-disaster parametric insurance scheme that addresses those relatively low-frequency and high-intensity events could elevate the level of financial certainty of post-disaster responses in Mexico (Figure 8).40

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**Catastrophe bonds triggered.** CAT bonds—starting with one that the World Bank issued in 2006 to scale up disaster-related financing coverage—are parametric insurance-linked securities. The World Bank later issued earthquake and hurricane parametric insurance-linked bonds for FONDEN in 2009, 2012, 2017, 2018, and 2020 (Figure 9). The process is as follows: Mexico pays an insurance premium for the coverage, which the World Bank transfers to the CAT bond investors, who as a whole will earn the premium plus a fixed rate of bond return. If an earthquake or hurricane triggers a payout during the life of a bond, Mexico will issue a notice to an independent calculation agent to determine the insurance payout. Real losses need not be assessed. The World Bank will transfer the payout to Mexico as soon as a calculation report is available—within about 1 month for an earthquake and 5 months for a hurricane—and the CAT bond investors will lose their principal. The CAT bonds attracted 38 investors, including dedicated CAT bond funds, asset management companies, pension funds, hedge funds, and reinsurance companies (Figure 10).\(^{41}\) Hurricane Patricia triggered the 2012 CAT bond in 2015, resulting in a $50 million payout to FONDEN. An earthquake in 2017 triggered the 2017 CAT bond which resulted in a $150 million payout.\(^{42}\) While still in a relatively limited amount compared to the total cost of the disaster recovery efforts, the CAT bonds payouts have provided an additional layer of certainty to the overall post-disaster financial response.

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**Figure 10: Structure of the 2020 FONDEN Catastrophe Bond as a Mexico–World Bank Collaboration**

<table>
<thead>
<tr>
<th>Currency</th>
<th>US dollar ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td></td>
</tr>
<tr>
<td>Class A</td>
<td>Earthquake low frequency</td>
</tr>
<tr>
<td>Class B</td>
<td>Earthquake high frequency</td>
</tr>
<tr>
<td>Class C</td>
<td>Atlantic Hurricane</td>
</tr>
<tr>
<td>Class D</td>
<td>Pacific Hurricane</td>
</tr>
</tbody>
</table>
| Notional (Max Payout) | Total cover: $485 million  
• Class A: $175 million  
• Class B: $60 million  
• Class C: $125 million  
• Class D: $125 million |
| Tenor (Term) | 4 years |
| Payout Structure | Piecewise linear payout function |
| Trigger Basis | Parametric, per occurrence |
| Trigger Type | Earthquake: CAT-in-a-grid  
Hurricane: CAT-in-a-grid (gates) |
| Expected Loss/Attachment Probability | Earthquake low frequency: 0.90%/1.17%  
Earthquake high frequency: 5.78%/8.30%  
Atlantic Hurricane: 5.79%/8.29%  
Pacific Hurricane: 4.06%/6.23% |
| Pricing/Premium Multiple | Earthquake low frequency: 3.5%/3.89  
Earthquake high frequency: 9.0%/1.56  
Atlantic Hurricane: 10.0%/1.73  
Pacific Hurricane: 6.5%/1.60 |

* Simplified structure shown here for information purposes only  
** Plus World Bank funding margin

CAT bond = catastrophe bond.  
Source: Authors’ compilation from Case Study. Insuring Mexico against Disasters. World Bank, 2020.
A model worthy of emulation. The CAT parametric insurance-linked bonds have enhanced FONDEN financial capacity for post disaster reconstruction to supplement the fund reserves from the federal expenditure budget. FONDEN stands as an example of what countries and regions highly exposed to disasters and catastrophes could do to build a more comprehensive and certain disaster risk management system by combining international capital and innovative market-based products. It has also applied innovative information technology to continually upgrade the quality and transparency of damage assessment and emergency reconstruction by systematically institutionalizing the flows of disaster information, funds for relief and rehabilitation, and the process of reconstruction.

C. Caribbean Catastrophe Risk Insurance Facility

A multinational approach. The Caribbean Catastrophe Risk Insurance Facility (CCRIF) was a pioneer in two ways when it was founded in 2007: (i) it was the first multicountry risk pool in the world and (ii) it was the first insurance instrument to successfully develop parametric policies backed by both traditional insurance and capital markets. In 2014, the facility was restructured into a segregated portfolio company (SPC) to facilitate offering new products and expansion into new geographic areas. It is now named CCRIF SPC. It is owned, operated, and registered in the Caribbean. CCRIF SPC limits the financial impact of natural hazard events to the Caribbean and Central American governments by quickly providing short-term liquidity support when a policy is triggered. CCRIF SPC offers parametric insurance policies for tropical cyclones, earthquakes, excess rainfall, and the fishery sector. As of 2021, the CCRIF SPC had 23 members: 19 Caribbean governments, 3 Central American governments, and 1 electric utility member. CCRIF SPC was developed with the World Bank and a grant from the Government of Japan. It was initially capitalized through contributions to a multi-donor trust fund by the governments of Canada, France, Ireland, the United Kingdom, the European Union, and Bermuda; the Caribbean Development Bank and the World Bank; as well as through membership fees paid by participating governments. A large number of sponsors have since opted in.

Program structure. CCRIF SPC can be seen as a captive insurance company, cofounded by member countries that are highly exposed to disasters. It is guided by the principle of financial sustainability and retains those risks it can financially manage while transferring those beyond its capacity to the reinsurance market. Most of the large multinational asset-heavy companies have their captive insurance companies against operational risks. Such a captive insurance approach can be considered for public finance in the PRC and other countries.

Stable post-disaster liquidity source. The core CCRIF SPC business principle is to remain financially sustainable. For the 2019−2020 policy year, all CCRIF SPC members renewed their parametric insurance coverage. Members purchased 59 policies: 21 tropical cyclone policies, 15 earthquake policies, 21 excess rainfall policies, and 2 fishery policies, an increase of 4 policies compared with the previous year. The total coverage limit for the Caribbean and Central American members was $972.9 million, an increase of almost 30% over the policy year 2018−2019.

Prompt payouts. CCRIF SPC has made 48 payouts in an aggregate amount of $194 million on its policies since its inception in 2007 and delivered these funds to the 14 member governments all within 14 days of the triggering event. The largest was $20.4 million paid out to the Government of Haiti following Hurricane Matthew in 2016. Member governments provide reports on how they use the paid-out funds (Figure 11).

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44 CCRIF SPC. 2014. CCRIF Members to Benefit from World Bank’s First Ever CAT Bond Issuance. 8 July.
Most go toward immediate recovery and repair activities; aiding the people affected; stabilizing critical facilities such as water treatment plants; repairing crucial infrastructure (e.g., roads, drains, and bridges); investing in risk mitigation to build greater resilience to future disasters; and paying first responders, healthcare workers, and other key government employees. In the 2019 and 2020 policy years, CCRIF SPC payout capacity fell within its guidelines for financial security to supplement the overall post-disaster financial relief (footnote 45).

![Figure 11: Use of Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company Payouts, 2007–2019](image)

**D. Pandemic Emergency Financing Facility**

**Pre-COVID-19 insurance against pandemic risks.** The Pandemic Emergency Financing Facility (PEF) was set up by the International Bank for Reconstruction and Development (IBRD) and the International Development Association in July 2017, along with the World Health Organization and other stakeholders. The PEF aimed at providing relief funds for large outbreaks and the cross-border spread of viral diseases for the 77 International Development Association-eligible countries that represent the poorest parts of the world. The funds were to be granted through a $425 million insurance window and a $50 million cash window. Among the viruses covered by the PEF were those most likely to cause a pandemic, including influenza, SARS, the Middle East respiratory syndrome virus, Ebola, Marburg, Crimean Congo hemorrhagic fever, Rift Valley fever, and Lassa fever. The spread of COVID-19 also subsequently met the PEF triggering conditions.46

**Insurance window via bonds, swaps, and cash.** The World Bank designed the PEF insurance window, which provided coverage of up to $425 million. The pandemic parametric insurance was obtained in July 2017 in two classes of assets of bond and swap. Class A was composed of $225 million in bonds and $50 million in swaps, and Class B was composed of $95 million in bonds and $55 million in swaps. The IBRD Global Debt Issuance Facility issued the bonds. Germany and Japan donated $107.2 million.47

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The $225 million in class A bonds covered the flu virus and the coronaviruses, and the $95 million in Class B bonds targeted the others. The bond issues were oversubscribed by 200% and purchased by 26 institutional investors.48 The World Bank also added $105 million of pandemic parametric insurance-linked swaps with several insurers. Germany donated €50 million and Austria $7 million for the initial cash window in 2018. The cash window provided fast financial support to countries fighting disease outbreaks, as funds could be transferred within days after approval by the steering body (Figure 12).

**Program performance.** The World Health Organization declared the COVID-19 outbreak a public health emergency of international concern on 12 March 2020, and a pandemic on 23 March 2020. A payout of nearly $196 million had been expected, made up of 16.67% of the $225 million of Class A pandemic CAT bond notes and $50 million of Class A swaps ($37.5 million and $8.34 million), as well as the 100% of the $95 million Class B pandemic CAT bonds and $55 million Class B swaps.49 The World Bank announced the allocation of nearly $196 million in payouts to 64 of the world’s poorest countries on 27 April 2020 after AIR Worldwide—the PEF third-party calculation agent—determined the bond and swap trigger conditions had been met as of 31 March 2020.50 Previously, the PEF paid out $61.4 million from its cash window to fight the ninth and 10th Ebola outbreaks in the Democratic Republic of the Congo in 2018 and 2019.51

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50 Footnote 50; World Bank. 2020. PEF Allocates US$195 million to more than 60 low income countries to fight COVID-19. Press release. 27 April.


Source: Authors’ compilation from the World Bank Pandemic Emergency Financing Facility and associated World Bank webpages and sources.
VI. DISASTER RISK FINANCING INSTRUMENTS

A. Reform Framework

Proposed approach. The Government of the PRC needs to comprehensively identify pre-disaster and post-disaster funding mechanisms—including fiscal contingent liabilities—for comprehensively hedging major disaster risks. The proposed approach—adopting a parametric insurance approach—will focus on pre-disaster risks and the use of parametric insurance mechanisms based on the prevailing international models and tailored to conditions and systems in the PRC. The framework aims to match the choice of financing instruments to the relevant frequency and severity of disaster risks associated with the post-disaster fiscal contingent liabilities costs to improve certainties of the fiscal budget balance. Fiscal contingent liabilities associated with the disaster risks of low frequency and high severity could be relatively large considering their volatility. The framework matches financing instruments with the relevant disaster risks of various frequencies and severities (Figure 13). This is aligned with the general framework of international best practice as outlined in Figure 6.

B. Financing Instruments of Risk Transfer—Disaster Parametric Insurance and Its Applications

1. The Concept

Use of general insurance products in public finance. Insurance is off-balance-sheet capital contingent on specified conditions being met. It is widely used to offset the off-balance-sheet contingent liabilities related to risks of individuals, businesses, and the government. As a public financing instrument, insurance can effectively reduce the uncertainties in fiscal contingent liabilities that arise from the responsibility of a government to provide relief and support reconstruction in the event of disasters.

Advantages. Parametric insurance supplements other pre-disaster and post-disaster financing instruments such as fiscal budget reserves, budget stabilization funds, disaster-related budgets of government departments, and special fiscal funds and reserves. In particular:

(i) As a fund contingent on an outbreak of specified risks, it can fill the gap of existing fiscal reserves in response to the contingent liability of the government for relief and rehabilitation costs associated with disaster risks of low frequency and high severity at least cost to public finance.

(ii) It can be incorporated into government emergency and disaster-related budgets without the need for additional funding. It can boost the capacity of budget reserves, special funds for disaster relief, emergency and disaster-related budgets, and other funds and allow the government to maximize fiscal budget credibility and certainty in case of disasters.

(iii) The parameter threshold can be aligned with a disaster intensity that will require the government to respond with concerted flows of information and data of disaster risks, relief funds, and responses to relief and rehabilitation. It can provide highly leveraged financial support at an acceptable cost.
Selection of reserves or contingent financing tools should be in alignment with relevant frequency and severity of the disaster risks identified in the risk profile of the public finance framework.

CAT = catastrophe.
Source: Asian Development Bank (compiled by authors).
Parametric insurance pays out more quickly than traditional insurance, which often indemnifies for actual losses after adjustment well after the disaster event. Predetermined parametric insurance payouts are made when the predefined thresholds of event parameters are reached or exceeded, such as when a scale 12 typhoon strikes a particular place. Payment generally takes place within days or weeks, compared to months or years in cases of indemnity insurance.

Experiences in the PRC. The necessity and feasibility of adaptation of parametric insurance solutions in public finance response to disaster risks in the PRC have been discussed, such as the pilot program operating since 2016 in Guangdong Province. The provincial government has integrated disaster parametric insurance with earmarked budgets to increase the financial capacity and certainty. Such pilots provide lessons for the future design of parametric insurance products.

2. How to Design Disaster Parametric Insurance

Determine and quantify disaster response needs. Disaster parametric insurance should be designed as an integral part of the overall pre-disaster and post-disaster financing framework and reflect the correlation between disaster risks and funding needs for disaster responses. The government should consult disaster risk finance experts and professional insurance brokerage services to structure and design a suitable parametric insurance product. This would be done by identifying, categorizing, quantifying, and analyzing the extent of various funding availability under disaster frequency and severity scenarios to meet its emergency response, disaster relief, public facility repair and reconstruction, social assistance, and other responsibilities and needs.

Determine the amount and types of parametric insurance coverage. The gaps to be filled by parametric insurance can be determined by subtracting known emergency budgets, special funds, and budget reserves designated for disaster relief during a particular period from the total fiscal fund requirements based on the carefully estimated disaster finance obligations. The government can identify the need for—and structure of—parametric insurance coverage in amounts, and for the triggering events and parameter thresholds that best fit the identified disaster risks and contingent liability gaps as well as the appropriate periods, geographical locations, and effective calculation methods.

Data critical to sound design. The effective use and design of parametric insurance requires data from reliable institutions that have monitored and recorded disaster events for long periods. In practice, these disasters could be meteorological—such as typhoons and floods, earthquakes, pandemics—or major accidents due to human error. Table 2 outlines the factors in the design of parametric insurance and the fundamental steps in researching and validating parametric insurance products.

Table 2: Factors in the Design of Parametric Disaster Insurance

<table>
<thead>
<tr>
<th>No.</th>
<th>Factors</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analysis of risk exposure gaps</td>
<td>Holistic analysis of the disaster perils, hazards, and exposure based on historical data and information on disasters and related losses to understand the development, pattern, and trend of disaster risks and gaps in response capacity</td>
</tr>
<tr>
<td>2</td>
<td>Analysis of gaps in disaster risk finance governance</td>
<td>Analysis of public policies, systems, resources, budgets, and both pre-disaster and post-disaster financing instruments</td>
</tr>
<tr>
<td>3</td>
<td>Factors of insurance structure</td>
<td>Analysis and understanding of the following factors:</td>
</tr>
<tr>
<td></td>
<td>Disaster events</td>
<td>Disaster events of which the intensity can be parameterized, such as pandemics, earthquakes, floods, typhoons, heavy rainfalls, temperatures, droughts, low temperature, explosions, and fire</td>
</tr>
</tbody>
</table>
Table 2 continued

<table>
<thead>
<tr>
<th>No.</th>
<th>Factors</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>−</td>
<td>Insurance parameters</td>
<td>Parameters that reliably measure the frequency and severity of disaster events objectively by credible institutions with historical records of sufficient duration</td>
</tr>
<tr>
<td>−</td>
<td>Insurable interests</td>
<td>Economic losses arising from property damage and bodily injuries caused by disaster events, as well as the liability of the government for disaster relief and post-disaster reconstruction</td>
</tr>
<tr>
<td>−</td>
<td>Sums Insured</td>
<td>Amount of coverage to be commensurate with the insurable interests</td>
</tr>
<tr>
<td>−</td>
<td>Trigger threshold</td>
<td>The threshold upon which an insurance claim payout can be triggered for an insurer to pay the relevant sum insured according to policy conditions</td>
</tr>
<tr>
<td>−</td>
<td>Underwriting</td>
<td>Process of accepting risks by insurers, reinsurers, and bond investors</td>
</tr>
<tr>
<td>−</td>
<td>Modeling and pricing</td>
<td>Profession and value of Insurance brokers, insurers, third-party risk modeling services</td>
</tr>
</tbody>
</table>
| −   | Solution design           | • Analysis of the perils, hazards, and exposure which may significantly impact public finances in the geographies concerned.  
• Analysis of the correlations between disaster events and insured interests.  
• Analysis and selection of relevant peril index, trigger thresholds, calculation cycles, and sums insured which may reliably reflect the insured interests.  
• Discussion and negotiation with the insurance market for reliable placement. |
| −   | Claims                   | A third-party independent institution engaged to monitor, report, and calculate the trigger of insurance claims |
| −   | Validation of insurance structure | To calculate and compare the ratios of annual payout to the annual sum insured based on historical peril index data, to determine how much of the sum insured would have been used in each of those years |
| −   | Verification standard     | The ratio of annual claim to the annual sum insured in the years of well-known disasters should not be less than 50% and should reach nearly 100% in the year of a catastrophic disaster |

Source: Asian Development Bank (compiled by authors).

3. Pandemic Index Insurance

Changing context. Pandemic parametric insurance has been increasingly simplified, particularly in terms of trigger conditions. However, the insurance industry has now recognized a pandemic is no longer a disaster event of low frequency and high severity, but a disaster of relatively high frequency and very high severity given the renewed waves of pandemic, particularly the outbreak of COVID-19. This has led to a diminished capacity for such products in the insurance and reinsurance market. More powerful insurance tools are needed to manage the immense contingent liabilities of such disaster risks. The complex nature of risks posed by disaster events defies reliable projection and costing through the law of large numbers that traditional insurers depend on, and these insurers would have to pursue capacity from the capital market. This makes the issuance of pandemic parametric insurance-linked bonds and derivatives to provide insurance coverage against pandemics a necessary and practical next step, not only in the improvement of disaster risk financing but also in financial markets development by converging insurance, securities, and banking.

4. Agricultural Weather Index Insurance

Insuring against bad weather. Parametric index insurance in agriculture is generally tied to the weather. Agricultural weather index insurance qualifies as disaster risk insurance when losses due to unfavorable weather patterns reach certain trigger levels. It can cover a particular crop variety and feature triggering events, crop cycles, insurable interests, parameter thresholds, payment limits, and other elements.
**How it works in theory.** The insurance incorporates the amount of rainfall and the temperatures required by a particular crop variety at the different growth cycles and sets parameter thresholds based on these indicators. Agricultural experts may provide these parameters. The thresholds of either insufficient or excessive rainfall during the cycle that would result in production losses would be established accordingly. This allows the modeling of drought and flood parametric insurance solutions for a single crop in a specific area. For instance, drought parametric insurance could be designed to make payouts each time when there is no rain for 5 days or more during a particular cycle within the 120-day certain crop period.

**Practical requirement 1: Effective rainfall monitoring.** Designing such insurance to work well in practice requires the best precipitation monitoring services. Options in the PRC include local China Meteorological Administration ground precipitation monitoring stations, a satellite and/or radar-enabled grid precipitation monitoring network, and private professional companies that offer grid precipitation monitoring services. The efficacy of weather index insurance depends greatly on the accuracy of rainfall distribution and precipitation monitoring data. If, for example, a 50-square-kilometer county has only one ground precipitation monitoring station, the projection on the precipitation and its distribution across the county cannot be reliable. To make index insurance effective, the monitoring services must not only have the capacity to measure rainfall across entire insured areas but also have sufficient historical precipitation data for long enough periods for proper insurance coverage design and price assessment modeling.

**Practical requirement 2: Solid payout formulas.** The insurer program quote normally comes with an annual premium and an overall annual payout limit that can appear sufficient to help relieve disaster-level agriculture losses. However, the payout formula may be complex, such as based on the data from weather stations and different calculation cycles of growth stages, and insurance purchasers could potentially never receive the full payout limit amount. A very low threshold may be set as a first trigger, which would allow payout to be easily obtained in certainty. A second threshold may be paid out at a potentially unlikely but possible trigger event. The third threshold may be set extremely high and be unattainable. Therefore, it is important not to look at the maximum payouts but the likelihood to receive the full payouts when a major disaster hits.

5. **Earthquake Index Insurance**

**Index example: Event magnitude, regional relative importance.** The parameters used in the earthquake index insurance include the magnitude of an earthquake—as measured by seismographs—and the resulting intensity: the degree of the shaking within specified geographies. The payout triggers for earthquakes would be based on a magnitude index. A disaster in the earthquake epicenter would result in a maximum payout, but the payouts would be downscaled even for the same magnitude earthquake but in less populated and economically active areas.

**Technical challenges with intensity indexes.** Ground-motion attenuation underpins seismic hazard analysis because it can help estimate and identify the field and degrees of damages from ground motion at various locations. Although the China Earthquake Administration has published forecasting equations, the insurer and the insured need to agree on how to calibrate the relationship between ground motion attenuation and losses. After an earthquake occurs, government agencies need to calculate the earthquake intensity based on the specified observation points of earthquake intensity monitoring stations and detailed data analysis of the relationship between ground motion attenuation and losses.

6. **Typhoon Index Insurance**

**How it works.** Typhoon speed index insurance is an effective financing tool for hedging economic losses arising out of typhoon disasters. The common model is the “typhoon inbox,” which sets a range of geographies exposed to typhoon disasters in the form of a circle or frame delineated by latitude and
longitude. For example, the insured and insurer may study and agree on a range of insurance payout indexes based on a laddered typhoon speed scale from scale 12 to 17, lasting at least 2 minutes within the “box.” The insurer makes payout to the insured if a typhoon enters the box with a wind speed of scale 12 to 17 lasting for at least 2 minutes.

**Province-wide pilot test.** The prefectures and cities in Guangdong Province in the PRC are now piloting parametric typhoon index insurance to offset the economic and fiscal damage to public finance created by intense windstorms. The policyholder and the insurer need to agree on the proposed windspeed parameters of the policyholder, as well as on the prices and conditions of the insurance coverage. An independent third party will make the calculations based on whether payments have been triggered when a typhoon enters a delimited area based on the agreed parameters.

**Simple and user-friendly.** The Guangdong pilot program sets its parameter triggers against an index of wind speeds sustained for more than 2 minutes in certain geographies. More specifically, the payout is triggered when a typhoon sustains a wind speed of no less than 50 meters per second (wind force 12) for 2 minutes or more within a specified area. Payouts are calibrated from 50% of the overall agreed payout limit for a scale 12 typhoon to 100% for a scale 17 event. This structure has the advantages of simplicity, ease of use, and prompt payout mechanism.

### 7. Disaster Parametric Insurance Market

**Coverage against multiple well-researched risks.** Disaster parametric insurance is a type of mature insurance product that is composed of insurance brokerages, insurers and reinsurers, and investment institutions through risk bonds, as well as technical service vendors such as modeling agencies, data service providers, and calculation agencies. The parametric insurance can be designed to cover most of the main disaster risks including (i) disaster risks (by using such parameters as precipitation amounts, wind speeds, temperatures, radiation levels, earthquake magnitude, earthquake intensity, and fire-burn and flood areas); and (ii) other disasters such as industrial disasters and public health disasters (based on confirmed cases, death toll, and other related indexes). For policyholders, parametric insurance needs to be built on carefully determined triggering parameters that reliably reflect the underlying risks by using a comprehensive set of historical data on disaster parameters and corresponding losses recorded by a credible institution.

**How governments design effective disaster coverage.** Based on the existing pre-disaster and post-disaster financing framework, a central or local government body—as a parametric insurance buyer—needs to appoint a professional insurance broker licensed by the regulatory authorities to conduct a detailed analysis on the specific disaster. Based on the purpose and objectives of the insurance solution, the broker will calculate the probability distribution of the frequency and intensity of the disaster and determine a payout limit related to the disaster risk. After testing the insurance structure, payout limits, and amounts for soundness and applicability against data on past disasters and the related losses and financing demands, the broker can help make a proposal to insurers and reinsurers and assist the government in negotiating the terms and conditions that will be acceptable to the government.

**A good broker is essential.** A skilled and trusted insurance broker is crucial to the successful negotiation of parametric disaster insurance coverage that benefits both parties equally. In general, governments possess less knowledge and expertise in the areas of insurance pricing and terms than insurers and reinsurers. Insurers and reinsurers often resort to extremely complicated triggering mechanisms to secure their profits. This underlines how important it is for the broker appointed by the government to design the insurance scheme.
C. Insurance-Linked Catastrophe Bonds

**Sound insurance for governments through capital markets.** CAT bonds are one of the insurance-linked securities that insurers and reinsurers and the governments may use to transfer risks to capital market investors, which will be in a better position to manage and absorb the underlying risks. The CAT bond sponsor is usually a government or other entity—including certain insurance and reinsurance companies—to hedge their risk exposure. The CAT bond issuer is a special purpose vehicle (SPV) set up by the sponsor (or its agent) to issue the bond. The investor is usually an investment institution, such as a fund. CAT bond investors have dual roles as insurers and investors. Issuing CAT bonds involves multiple service vendors, including structuring agents, reporting agents, calculation agents, bookrunners, trust managers, and lawyers. CAT bonds are structured to have bonds issued to investors for the bond principal to be placed as collateral for a disaster parametric insurance policy. If a trigger event and losses do not occur before the bond matures, the investors will receive a refund of the bond principal as well as an insurance premium and regular fixed-rate interest payments. If an event triggers a payout, the investor will lose the principal and any outstanding interest in part or in full to the bond sponsor. CAT bonds are a good choice for insuring against the risks related to low-frequency, high-severity events, particularly earthquakes, typhoons, floods, and disease outbreaks on the scale of the COVID-19 pandemic. However, due to the uniqueness of the instrument, the CAT bond market is still limited in size. A typical structure of insurance-linked securities is provided in Figure 14.

**Figure 14: Typical Structure of Insurance-Linked Securities**

- **Purpose:** Pilot of 1st RMB pandemic parametric insurance-linked bond domiciled in the PRC
- **Sponsor:** Government agencies as insured of pandemic insurance and bond sponsor
- **SPV:** Debt issuance facility acting as SPV to issue bond and insurance policy
- **Insurance:** Financing tool imbedded in public finance framework in response to the pandemic
- **Bond:** Capacity for the pandemic insurance issued by SPV, and to be publicly traded
- **Insurance:** Domestic and international capital market, to act as investors and insurers

**vendors:** structuring agent, reporting agent, calculation agent, bookrunner, trust manager, lawyers

**Sponsor (government)**

- **index (re)insurance policy**
- **(re)insurance claims**

**SPV**

- **collateral trust**
- **risk spread and interest**
- **remaining principal**

**Investors**

- **investment**
- **fixed interest to be subject to claim and redemption liquidity**
- **reliable fixed interest**
- **trading notes at risks**

**risk modeling**

- **risk spread, triggers**

**regulations:** special purpose vehicle, (re)insurance policy, bond issuance, bond trading, trust account investment

ADB = Asian Development Bank, RMB = renminbi, SPV = special purpose vehicle.
Source: Asian Development Bank (compiled by authors).
**Designed to address catastrophic loss.** CAT bonds were invented in the 1990s after major disasters in the US demonstrated the inability of traditional insurers and reinsurers to adequately cover catastrophic losses. CAT bonds were an attractive investment vehicle following the 2008 global financial crisis—as a unique asset class—due to their low correlation to the traditional financial market performance. The World Bank issued a series of pandemic index insurance-linked securities in 2017 to cover countries receiving relief funds in the event of a pandemic outbreak.

**Slightly adjustable short-term securities.** CAT bonds typically mature in 3–5 years and sponsors can make reasonable realignments (once a year) to their coverage portfolio to match changing exposure to catastrophe risks. Because the frequency and severity of a particular type of disaster can vary between geographical areas, it is important that the data collection and analysis and catastrophe modeling be conducted expertly so that the pricing and parametric triggers of CAT bonds reliably reflect the risks.

**Well-designed triggers a key factor.** The triggering mechanism is the defining factor in categorizing and determining the marketability of CAT bonds. The most common triggers are based on indemnity amounts, modeled losses, industrial losses, pure parametric measures, and more refined parametric index formulas. Most have their strengths and weaknesses:

1. **Indemnity.** An indemnity trigger is easy to administer and is based on the losses incurred to the insured. However, this risk is less transparent to potential investors. They will require higher risk spreads and more detailed information from the sponsor. Issuers of these CAT bonds must also wait longer for their payouts until the losses are determined and verified.

2. **Modeled loss.** A modeled loss trigger is based on the calculation of modeled losses with a specified formula. Because it is more transparent than an indemnity trigger, it can lower investor expectations for spreads.

3. **Industrial loss.** An industrial loss trigger is based on the indexed claim of a particular line of insurance businesses in a particular market. It is less transparent and introduces more basis risks than the modeled loss trigger.

4. **Pure parametric.** The pure parametric trigger sets a single threshold on some parametric dimension of a disaster event. It is the most transparent trigger method and ensures a swift payout once the parametric threshold is reached. Because it is not directly related to actual disaster losses, however, it involves large basis risks.

5. **Formulated index.** A formulated index is based on a calculation of multiple parameters using complex formulas and detailed metrics. The outcome can be more reliably accurate but may not be realistic in some cases as historical data may not be easily available for such calculation.

**Fundamentals in place in the PRC.** The PRC capital market—now the world’s second largest—is much more able to absorb PRC disaster risk financing needs than its insurance and reinsurance industry. However, CAT bonds have never been established and traded in the PRC, although CAT bonds have been widely traded in insurance and capital market elsewhere since 2000. This is mainly because in the PRC the regulatory authorities for insurance and securities are still separate and would not be able to establish a single set of regulations for governing insurance-linked securities in a concerted capacity, even though the basic technical capability and market capacity for insurance-linked securities are already mature. A reasonable reform of the financial market policy and regulation for the PRC-domiciled and CNY-denominated insurance-linked securities may lead to a significant development of both markets.
D. Debt Financing Instruments

Preparation on a smaller scale. Contingent credit hedges the risk from outbreaks of specified disasters. Unlike the risk and disaster response financing tools needed to deal with infrequent and highly severe disasters and catastrophes, this instrument is better suited for risks of less-severe events that occur more often. Contingent credit can be drawn only when a disaster that meets predetermined metrics or other agreed conditions takes place. As of 2021, it is available from such multilateral financial institutions like ADB, the World Bank, and the International Monetary Fund, as well as from the China Development Bank and PRC commercial banking. Commercial banks make wide use of contingent credit lines (CCLs), and they play an important role in the functioning of short-term capital markets.

How the credit line contracts work. A typical credit line contract has several characteristics. It specifies a maximum amount that a financial institution is committed to lending a client over a given period, called the “commitment.” Typically, the client has the right to draw any amount up to the maximum committed. The contract specifies an interest rate that will apply either to the amount committed or to the amount drawn down. It also specifies the various fees the lender will charge: an upfront commitment fee, an annual fee levied on the total amount committed, and/or a usage fee levied annually on any undrawn portion. CCL contracts contain a material adverse change clause, essentially an escape clause that allows the bank to deny credit if the financial condition of the client changes in a substantive way, such as if its credit standing is downgraded.52

Useful for transferring risks and prompt post-disaster payouts. Governments and other institutions have several reasons to use lines of credit to transfer some disaster finance risks and bolster public finance resilience. Credit lines can secure lending at an acceptable cost that might not be available after a major disaster event due to the tighter liquidity and rising interest rates, or credit downgrades as capital market conditions change. The unused relatively low-cost credit provided by these arrangements can represent insurance against the worst financial effects should public finance contingent liabilities be triggered by a disaster. This in turn can strengthen the disaster risk resilience of governments and other institutions. CCL also pays out more quickly than other disaster risk transfer instruments.

E. Regional Cooperation and Knowledge Sharing

Innovative disaster risk finance instruments and structures are critical to channel the unhedged fiscal risks (or contingent liabilities) to markets and complement public sector financial management solutions. This will support the advancement of disaster risk financing instruments and the development of comprehensive public finance frameworks for disaster resilience. The knowledge and experience gained will propel financial innovations and benefit governments well beyond the pilot areas in the PRC.

As disasters are often not confined within national borders, a concerted regional and global effort is required to promote disaster risk finance development across Asia and the Pacific. ADB could provide technical backstopping on developing a comprehensive public financial framework for disaster risk management, integrating public sector solutions with market-based instruments such as catastrophe bonds and parametric insurance and reinsurance. Alternatively, ADB could support the in-depth analysis and design and implementation of innovative financing instruments. For example, the ADB Technical Assistance (TA) project 9878-REG: Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation (CAREC) Region directly supports the identification and design of

disaster risk finance mechanisms in the CAREC countries. The compound risk analysis and disaster risk modeling under the TA will provide added disaster risk technical underpinning. The conceptualization and analysis of the protection gap in the TA—which illustrates the level of financial risks (or the level of contingent liabilities) that a government would not be able to shoulder—address the level of insurance and other market-based solutions required. The global and regional networks of ADB with other development agencies, international insurers, reinsurers, brokers, and financial institutions will help mobilize and integrate diverse expertise for designing and structuring innovative disaster risk finance solutions.

Overall, ADB can play a catalytic role to (i) develop comprehensive public finance frameworks for disaster risk management, (ii) introduce advanced and innovative financial solutions that will create successful business models, and (iii) replicate them among its members. Knowledge development and sharing through regional and international platforms in which ADB is actively involved—such as the CAREC and the Greater Mekong Subregion Program—will play a key role in advancing the disaster risk management and financing instruments and enabling mutually beneficial regional solutions.

ADB. 2019. Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation Region. Manila.
VII. FIVE SUGGESTED PILOT PROGRAMS TO STRENGTHEN DISASTER RISK PUBLIC FINANCE IN THE PEOPLE’S REPUBLIC OF CHINA

Building on the innovations in disaster risk financing and experience in the PRC and elsewhere, this report proposes five parametric insurance pilot programs for the government to consider. These are described below in no order of importance. These programs can build on the findings covered in this report. Implementation of these or related programs could contribute to the establishment of a comprehensive disaster-resilient public finance framework, reduce post-disaster finance uncertainties, expand insurance markets, and develop capital markets in the PRC. Bankable and replicable business models for other ADB developing members could be created.

A. Pilot to Blend Pandemic Parametric Insurance-Linked Securities in Public Finance to Address Public Health Disaster Risks

Preparing for another epidemic or pandemic. As a part of the pre-disaster finance mechanisms, governments could complement the standard use of reserves with well-structured and risk-based parametric insurance products and securities. The use of parametric solutions could help expand government financial capacity to, for example, respond to public health emergencies and adequately perform the duties in the public interest in times of crisis.

How the pilot would work. A pilot program could be sponsored by central or local governments—as beneficiaries—of pandemic index insurance with a maximum payout limit commensurate with the government fiscal risk exposure. An SPV established in the PRC would issue CNY-denominated bonds to institutional investors to cover potential losses of the sponsor up to the required limit. The bond principal collected from purchasers would be deposited by the SPV into a collateral account to guarantee the ability of the sponsor to pay under the insurance policy. The SPV would then issue pandemic index insurance to the government for future pandemic emergencies.

B. Pilot to Integrate Parametric Insurance into the Public Financing Response to Flood Disaster Risks in the Yangtze

Parametric insurance as a key tool in overall flood management. The Yangtze River basin is subject to flooding disasters that have sometimes reached catastrophic levels. For instance, the Yangtze River floods due to a prolonged period of heavy rain affected more than 40 million people in 2020. In addition to other risk mitigating measures—such as designated budget allocations and reserve funds—parametric insurance could provide an important addition to the overall effort to prevent, control, mitigate, and recover from the damage of flooding in an effectively managed and fiscally sustainable way.

Dynamics of Yangtze River flooding. Melting snow and glaciers provide a small portion of the baseflow of the Yangtze River but it also absorbs a significant amount of runoff each year. The seismic sea waves that occasionally occur around the estuary affect the river basin only slightly, but storm surges and tides can move upriver from the coast and cause major floods, especially when they are associated with low-pressure weather systems. In 1998, the Yangtze River basin suffered its worst and

most widespread flooding. The losses to flood infrastructure and agricultural lands were extensive and about 223 million people were affected.\footnote{Baike Baidu. 2021. The 1998 Yangtze River Floods (in Chinese language).} Flooding of the river’s middle reaches on the Hanjiang River caused CNY93.9 billion in direct economic damage in the city of Wuhan in 2017.\footnote{Xinhua News Agency. 2018. Yangtze River floods caused direct economic losses of over CNY90 billion last year. 10 January.} The 2020 floods affected a large number of provinces such as Anhui, Guangxi, Hubei, Jiangxi, Sichuan, and Zhejiang, a major part of the southeast PRC.

**Changjiang (Yangtze) Water Resources Commission.** Under the guidance and supervision of the Ministry of Water Resources, the Changjiang Water Resources Commission is responsible for organizing, coordinating, and supervising the prevention and control of floods and drought in the basin. This includes the regulation of water inflows and outflows through major hydraulic projects as needed when flooding, drought, or other emergencies arise. It also organizes discussions on flood management measures, leads flood control planning and oversees plan implementation, directs the management of flood detention areas and compensation measures, and arranges or coordinates water resource emergency management.\footnote{Government of the People’s Republic of China, Ministry of Water Resources. 2020. The main responsibilities of the Changjiang Water Resources Commission. Beijing.} The ability of the commission to fulfill its Yangtze River basin functions and prevent and respond to flooding and drought largely depends on its fiscal capacity, which in turn relies in great part on its public finance strategies and models.

**How parametric insurance would work for the Yangtze River basin.** Using parametric insurance as a financing instrument against the risks of river basin flooding would help the government improve fiscal fund certainty. The parameters of such insurance could reflect some of the multiple factors and environmental triggers that might determine a flood event such as rainfall, ice, frost, runoff, and sediment. The design would be built on advanced technological knowledge; data support; and a sound framework that considers the underwriting capacity of traditional insurers, reinsurers, and the bond market. Flood parametric insurance can be integrated into a river basin emergency response system to ensure concerted flows of information and data on disaster risk, relief funds, and response to rehabilitation. The financing structure would combine budget reserves with the contingent funds from the parametric insurance. When a major flood occurs, the flood parametric insurance payout—as a part of the earmarked fiscal budget—would be converted into fiscal funds for disaster relief, post-disaster reconstruction, and ongoing governance. This would be a major step forward in the reform and innovation of public policies on disaster-related fiscal budgeting and emergency response.

**C. Pilot to Combine Agricultural Disaster Parametric Insurance with Central Government Fiscal Funds for Agricultural Disaster Risk Reduction and Relief**

**Closing gaps in agro-disaster funding and relief.** This pilot program would deploy a weather index parametric insurance solution to address structural and fiscal contingent liabilities in agricultural risk public finance. The problems could be approached by the central government by blending parametric insurance into the Central Fiscal Fund for Agricultural Production Disaster Relief and Reduction. The aim would be to reduce gaps in the budget framework with added certainties to extend the relief and recovery funding responding to severe weather-related agriculture disasters to which the country is particularly susceptible in major grain production regions.
**Current gaps.** Severe sector risks and the likelihood that the disasters would affect farmer livelihoods have already prompted the government to subsidize the premiums of agriculture insurance policies. However, these government policies are inadequate. Among other things, by targeting mainly small-scale, low-productivity farmers, they have been unable to support the main agriculture sector of the PRC, which is now dominated by large and specialized producers. As a result, necessary payouts to the entire agriculture sector have not exceeded the premiums to make a meaningful impact. This has repeatedly forced the central government to breach its budget with huge sums of agricultural disaster relief.

**The parametric insurance response.** Embedding parametric insurance into the central government agriculture disaster relief program will liquidate a small part of the reserves to secure a greater amount of contingent fund coverage for use when an extreme agrometeorological event takes place. As the parametric insurance pays out once an event trigger is reached, the budget line goes up for securing agricultural production and the livelihoods of rural people.

**Learning from previous pilots.** Piloting this model regionally has already provided valuable experience and lessons. A set of standards and a verification framework that will help minimize design errors has been designed. The Ministry of Agriculture and Rural Affairs agreed that the incorporation of a well-designed parametric insurance program into the central government budget for agricultural disaster relief would enable the government to access incremental capital when an agricultural disaster takes place and expand the levels of relief funding.

**D. Pilot to Embed Public Safety Parametric Insurance in Fiscal Budgets for Urban Emergencies**

**Significant risks and the need for matching funds.** At times of major disasters, standard fiscal reserves would quickly run out, particularly in densely populated metropolises, where the economic costs are especially high. This calls for the use of parametric public safety insurance on the risks of fire, explosion, flooding, or some other similar event or accident in their jurisdictions.

**E. Pilot to Include Contingent Financing Instruments Reform of Local Government Emergency Management Budgets**

The provincial government of Guangdong used part of the fiscal reserve funds to pay premiums on disaster parametric insurances against typhoon disaster with wind speed and rainfall triggers. Local government fiscal packages that combine reserves, debt and contingency financing, parametric insurances, and CAT bonds can be applied in a variety of disaster risk scenarios. These can be high frequency and low severity, or low frequency and high severity, and can include mainstream floods, agricultural disasters, and concurrent disasters caused by typhoon winds, heavy rainfall, upstream flooding, and downstream storm surges.
How to proceed on these five key pilots. ADB, the PRC, and other stakeholders could work together to move this process forward (Table 3).

**Table 3: Cooperative Development of the Five Pilot Programs to Improve Public Finance Readiness for Disaster Response**

<table>
<thead>
<tr>
<th>No.</th>
<th>Stakeholder</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ADB</td>
<td>ADB could further study the need and feasibility of the innovative models jointly with PRC government policy makers central and local authorities, and other entities, and take part in the pilot program design.</td>
</tr>
<tr>
<td>2</td>
<td>Pilot entities</td>
<td>The pilot program should involve line ministries including the Ministry of Emergency Management, the Ministry of Agriculture and Rural Affairs, the Ministry of Water Resources, the Ministry of Finance, and local governments.</td>
</tr>
<tr>
<td>3</td>
<td>Policy makers and government authorities</td>
<td>The pilot program should lead to policy changes by conducting consultations with such entities as the National Development and Reform Commission, the Ministry of Finance, the China Banking and Insurance Regulatory Commission, the China Securities Regulatory Commission, the Ministry of Emergency Management, the Ministry of Agriculture and Rural Affairs, the Ministry of Water Resources, and local governments.</td>
</tr>
<tr>
<td>4</td>
<td>Research institutions</td>
<td>Think tanks, universities, and research institutes can contribute to the design and implementation of the pilots, for example, the Chinese Academy of Fiscal Sciences, the Chinese Academy of Agricultural Sciences, the China Institute of Water Resources and Hydropower Research, and the Bureau of Disease Prevention and Control.</td>
</tr>
</tbody>
</table>
| 5   | Design and implementation steps | - Further need studies  
  - Feasibility studies  
  - Establishment of public policies and authorization of regulatory permits  
  - Design, discussion, and approval of pilot projects  
  - Implementation of pilot programs |

Source: ADB (compiled by authors).
Public disaster risk finance outmatched by events. The PRC faces disaster risks far greater than its public finance framework can manage or hedge. The worsening climate change will only mean that financing pressure on governments and public finance will grow as extreme weather events happen more frequently and severely.

Augmenting current tools with new ones. This report has detailed some major disaster risks and the limitation of public finance instruments to adequately address the contingent liabilities. Traditionally, there are pre-disaster and post-disaster finance instruments. Pre-disaster instruments include contingency budgets, reserve funds, contingent credit, and sovereign risk transfer solutions. Post-disaster instruments include budget reallocations, tax increases, post-disaster borrowing, and donor presence and assistance. Improved contingency finance with parametric insurance instruments could significantly enhance the public finance framework and budget certainties in post-disaster financial support.

Costs of the status quo. The gaps in the public finance system for disaster risk management are sizeable and could far exceed the original budget allocation. For instance, payouts from the PRC standard government-subsidized insurance programs and the use of disaster reserves have fallen well short of what is needed to offset weather-related agricultural losses. Therefore, the cost of not incorporating a parametric insurance instrument could be significant particularly in case of a low-frequency, major disaster in an urban center.

Accumulation and surges in demand on public finance. The economic losses of the PRC from disasters in 2019—considered a comparatively benign year by the PRC Ministry of Emergency Management—still amounted to an estimated $47.5 billion. The central government, line ministries, and local governments have responded in various ways to the multiple deaths, injuries, and displacements among the 130 million people affected and the widespread physical and economic damage due to the usual occurrence of floods, typhoons, drought, earthquakes, geological disasters, forest and grassland fires, hailstorms, extreme low temperatures, and avalanches. If properly structured, some of these unforeseen risks could have been better managed and absorbed by the capital markets.

Government as the last line of defense. The government and associated public finance are considered the last resort for financial and economic support in the event of any major disasters. Public finance often has the ultimate responsibility to ensure adequate post-disaster responses. For instance, the COVID-19 pandemic has forced many countries to resort to extreme fiscal and monetary measures to provide massive livelihood relief, business bailouts, and monetary stimulus spending; the cost of providing billions of vaccines jabs has also been shouldered by the government in many countries and the PRC.

Advantages in broader coverage of complex disaster effects. Parametric insurance covers the occurrence of qualified disaster events. Unlike traditional indemnity insurance, parametric insurance has a payout structure that is not generally tied to specific losses of a narrow nature and can be used to finance a government disaster response in multiple ways.

Advantages in payout speed. The payout by parametric insurance can be very quick, such as in weeks—if not days—after the trigger event. For indemnity insurance, the assessment of actual losses is often lengthy, and the loss adjustment process required a much longer wait.

VIII. CONCLUSIONS
Ideal conditions for developing parametric insurance. The PRC is particularly well-suited to pilot new parametric disaster risk finance strategies and tools. The capital markets in the PRC—while still relatively small compared to the size of the national economy—are mature and well-developed. It is in a good position to manage and absorb some of the government fiscal contingent liability risks. Furthermore, the assets managed by the insurance companies could be invested in environmental-, social-, and governance-compliant assets. The PRC insurance and reinsurance industries are also developed.

Advantages in access to capital markets. For certain risks that insurers or reinsurers are otherwise unwilling to undertake, insurance-linked securities—such as CAT bonds or other securities—can be structured to transfer the underlying public finance risks from the government to the capital markets. These can be based on the use of the market credit rating agencies which are in a better position to manage these specific risks.

Added care needed to deal with the technical challenges. The design of the parametric insurance products must be based on an in-depth understanding of the government public finance framework to address the contingent liabilities from unforeseen disasters. This requires sophisticated modeling work and analysis of sufficient historical data such as incurred losses at different locations and periods, as well as expert advice. Trigger events—which are linked to the payouts—should have defined parameters, locations, or periods. They also need to be accurately captured to maximize effectiveness and benefits to both the insurers and the insured. Overly complex formulas to affect reasonable payouts should be avoided. Effective monitoring through technologies such as weather stations and ground-movement detectors is crucial. Knowledgeable advice from skilled brokers and/or insurance experts is also important to determine a reasonable set of parameters.

Need to strengthen public finance tools for disaster risk financing in the PRC. A limitation of the PRC government disaster risk financing framework in 2021 is the inability to tap into the reserve funds to, for example, purchase the needed insurance products to reduce post-disaster uncertainties. The scale of the problem requires the government to continuously improve the available public finance systems for disaster risk management and introduce new instruments to complement existing tools.

Five pilot program options. This report proposes five parametric insurance pilot programs for the government to consider. These programs can build on the findings covered in this report. Implementation of these or related programs can enhance public finance resilience for disasters, improve insurance markets, and enrich capital markets in the PRC. It can also generate useful models for other ADB developing members.

Regional cooperation and knowledge sharing. The disaster risk management experiences to sustain local government public finance gained in the PRC will benefit government entities well beyond the pilot areas. The associated knowledge development and dissemination through regional cooperation and integration platforms in which ADB is actively involved will yield significant value to other ADB members. As a leading international development partner, ADB also has extensive networks with other international development agencies, governments, major international insurers, reinsurers, and financial institutions. ADB can bring its conveying capacity as an honest broker. ADB can help governments design and structure innovative financial solutions which are based on international best practices. These will benefit ADB developing members and meaningfully contribute to their disaster risk resilience.
From Pandemic to Greater Resilience
Enhancing Disaster Risk Financing in the People’s Republic of China

This report explores innovative solutions to enhance responses to economic and financial risks posed by mega disasters in the People’s Republic of China (PRC). It proposes five market-based, parametric insurance pilot schemes to enhance the PRC’s public finance capacity for disaster risk responses, soften budget shocks, and bolster long-term fiscal stability and resilience. The report highlights the inadequacy of public finance instruments—such as fiscal reserves, contingent credit arrangements, and traditional indemnity insurance—to manage contingent liabilities that disasters represent. It also discusses the effects of disasters on economies, societies, and global supply chains, particularly within the context of climate change.

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