The Development Dimension

Fostering Catastrophe Bond Markets in Asia and the Pacific

OECD DEVELOPMENT CENTRE

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Foreword

This publication aims to inform the discussion of disaster risk financing strategies in Asia and the Pacific, in support of the region's efforts towards greater resilience. It explores how catastrophe (CAT) bonds work, the benefits they provide, and recent trends in their market development. Based on case studies of successful CAT bond issuances around the world, the report also reviews the challenges associated with their use, and provides policy recommendations for policy makers in Asia and the Pacific to address them.

An earlier version of this report was presented in various fora in the region, inviting input and feedback from policy makers, academics and other international organisations, as well as the private sector.

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Editorial

Countries in Asia and the Pacific are increasingly exposed to natural catastrophes that claim human lives and cause substantial economic losses: the frequency of disasters in the region has roughly doubled since 1950 and the annual costs have increased nearly sevenfold from the 1980s to the 2010s.

The region must therefore strengthen its risk management strategies in anticipation of rising recovery and reconstruction costs. Catastrophe (CAT) bonds, this report argues, are one important market-based solution which policy makers in Asia and the Pacific could use much more to mobilise new finance against such disaster risks.

Indeed, the global CAT bond market has grown steadily over the last three decades, providing valuable alternatives to private insurance. Benefits include the diversification of coverage, flexible multi-year coverage, full collateralisation, as well as transparency and fast settlement.

In order to help policy makers in Asia and the Pacific make the most of those, the report draws lessons from successful CAT bond issuances in the region and elsewhere, advising them on how to prepare appropriate market conditions, fit for their specific needs and circumstances. This includes formulating grand designs of disaster risk financing strategies, developing catastrophe risk models, investing in measurement infrastructure, establishing trustworthy data, and reinforcing capacity building. Additionally, where issuing bonds independently is infeasible, the report suggests that multi-country CAT bonds represent an alternative, practical way of reducing transaction costs and broadening the investor base.

Providing policy advice to our members – which include China, India, Indonesia, Thailand and Viet Nam – and partners, based on fresh, evidence-based analysis is a core mission of the OECD Development Centre. I hope this publication can feed a constructive dialogue in Asia and the Pacific, as the region strives to strengthen its resilience to climate change and its consequences.

Ragnheiður Elín Árnadóttir

Director, OECD Development Centre

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Executive summary

Faced with increasing exposure to natural catastrophes such as tropical storms, earthquakes, floods and droughts, the countries of Asia and the Pacific are in growing need of risk management strategies. One of the important challenges is financing disaster-related expenses. Traditional methods are not necessarily sufficient, so governments need to broaden their financial options by exploring innovative approaches. This study focuses on the adoption of catastrophe (CAT) bonds as a potentially useful disaster risk financing tool by the countries of the region. CAT bonds allow the transfer of disaster risks to investors in capital markets, lightening the load on governments in the event of a natural catastrophe, among other advantages. However, developing a CAT bond market presents challenges, especially for emerging economies.

This report discusses policy guidelines for countries of the region to consider when developing a CAT bond market. It also explores examples of the use of CAT bonds as a risk transfer mechanism around the world, as well as regional initiatives.

CAT bond markets in Asia and the Pacific have room for development

The global market for catastrophe bonds has grown steadily since it began developing in the 1990s. However, CAT bonds have mainly been issued in Europe, Japan and the United States, and the market in Asia and the Pacific remains underdeveloped. The Philippines is the only country of the Association of Southeast Asian Nations (ASEAN) to have issued a sovereign CAT bond covering property risks to date. Nonetheless, CAT bonds sponsored by the governments of Jamaica, Mexico and the Philippines show that there is market appetite for these instruments when they are deployed by countries that are highly exposed to disasters.

At the same time, protection gaps are a major issue in the region as insurance coverage for disasters is limited. From 2012 to 2018, only a negligible share of losses due to natural disasters was insured in many Asia and Pacific countries. In the absence of sufficiently developed private insurance markets, disaster losses either remain with households and firms or must be absorbed by the public sector.

CAT bonds offer advantages but their deployment may prove challenging

Catastrophe bonds are financial instruments that utilise a process called securitisation to wrap natural disaster risk into a tradable format. In most cases, they provide a fast means of absorbing the impact of natural catastrophes in the short run since bond protection can be put in place immediately. They can be issued anytime and have a typical term of three years, offering flexibility and price stability. CAT bonds are designed to immunise the sponsor against counterparty default risk through full collateralisation with high-quality securities. Furthermore, in the event of a disaster, parametric triggers allow for a quick source of funding, while price signals from the CAT bond market and modern pricing models allow for informed decision making.

However, the development of CAT bond markets presents certain challenges. The use of parametric triggers may lead to basis risk – the gap between the sponsor's actual loss and the composite index of losses that prevents the sponsor from receiving full risk hedging. The use of CAT bonds requires advanced and reliable infrastructure, trustworthy data providers and suitable catastrophe risk models. Moreover, the sovereign sponsor needs to design efficient and fair distribution schemes. The lack of a track record in CAT bond issuance can stifle investor interest. Investors may have concerns about standardisation and illiquidity. Lastly, as CAT bonds are a relatively new financial product in many developing countries, legal and regulatory frameworks remain underdeveloped.

The successful development of CAT bond markets requires policy reforms

To develop bond markets successfully, policy makers should:

- Formulate a *grand design for disaster risk financing*, while recognising the importance of an integrated approach to disaster risk management and the contribution of risk assessment, risk awareness and risk prevention to the financial management of disaster risks.
- Invest in *measurement infrastructure*.
- Improve *quality of data*.
- Develop *tailor-made catastrophe risk models*.
- Enhance *capacity-building*.
- Broaden *investor bases*.
- Minimise *basis risk*.
- Prepare *distribution schemes*.
- Develop the *local currency bond market*.

While the individual issuance of CAT bonds has its merits and allows sponsors to address their unique risk profiles and tailor the instruments to their specific needs, governments can also explore regional initiatives. In addition to reducing transaction costs, joint issuance of CAT bonds allows sponsors to access a broader investor base. A regional approach may represent an alternative for developing countries in Asia and the Pacific, with cost-sharing benefits.

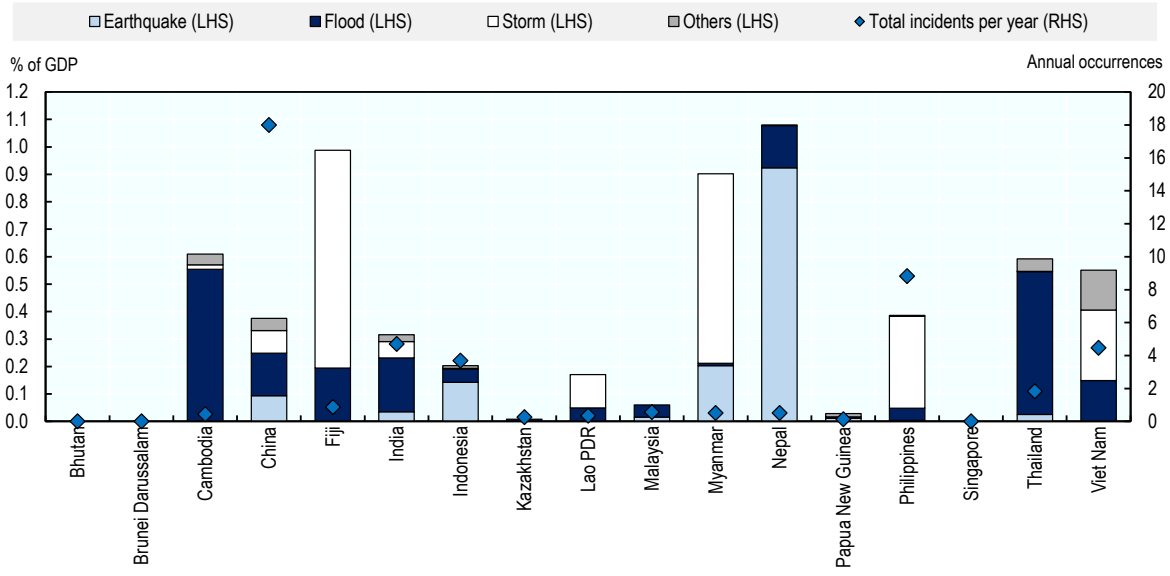
1 Overview

Asian and Pacific countries' exposure to natural hazards is increasing while their fiscal capabilities to respond to large-scale disasters remain limited. With limited coverage of disaster insurance in many countries in the region, alternative financing mechanisms are needed. Catastrophe (CAT) bonds can provide one such alternative by securitising disaster risk, allowing for financing to be sourced directly from capital markets. This chapter provides an overview of the characteristics and benefits of CAT bonds, of the challenges to their implementation, and of policies to tackle those challenges. It concludes with examples of CAT bonds implemented across the globe.

As exposure to natural hazards increases, countries in Asia and the Pacific are in growing need of risk management strategies to lower their economic burdens in the wake of catastrophes. Large-scale natural hazards often leave countries faced with insufficient funds to provide emergency relief to victims and to finance recovery efforts. Countries therefore need to seek to broaden their financing options and adopt alternatives beyond traditional mechanisms. Catastrophe (CAT) bonds are one such alternative. The costs associated with the outcomes of disasters vary significantly depending on the type, size, severity and frequency of disasters faced by a given country. Floods are the major threat in most of the region's countries, but certain countries, such as Fiji, Myanmar, the Philippines and Viet Nam, are more affected by tropical storms, while Nepal and Indonesia are more exposed to earthquakes (Figure 1.1), meaning there is no "one-size-fits-all" approach. In making decisions on disaster risk financing, countries in the region should carefully consider the characteristics and types of disasters to which it is exposed.

Figure 1.1. Cost and frequency of disasters in selected Asia and Pacific countries

Annual average, 2000-22



Note: The figure only includes the types of natural disasters for which data are available.
Source: Authors' elaboration based on data from EM-DAT.

StatLink https://stat.link/pq4m5u

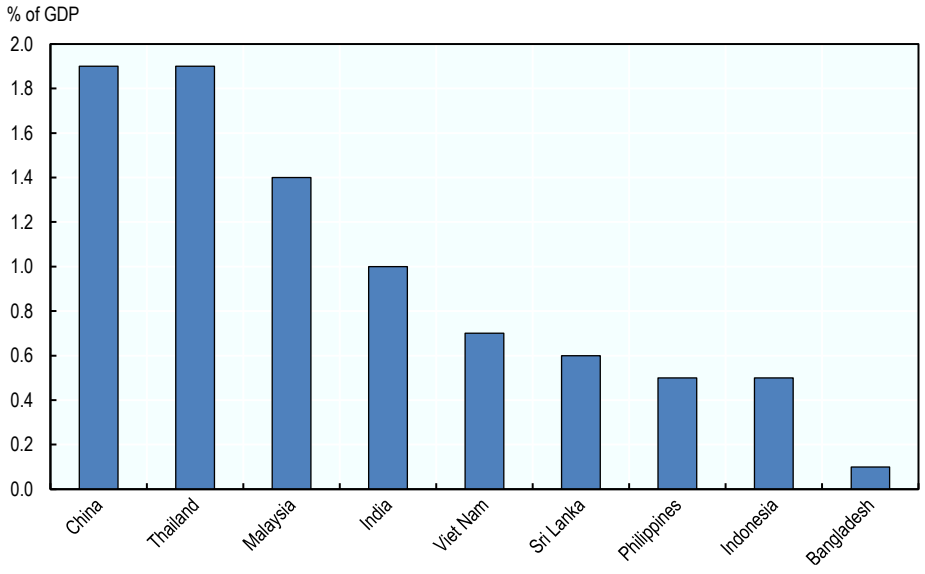
Protection gaps are a major issue

Protection gaps in natural catastrophe insurance are a major issue for both OECD and emerging economies. These gaps are defined as the difference between economic losses and insured losses from natural disasters (Holzheu and Turner, 2017[1]). The worldwide protection gap has now reached a staggering USD 368 billion, with approximately 76% of natural catastrophe exposure remaining uninsured (Evans, 2023[2]). In the United States, protection gaps for hurricanes, floods and wildfires are relatively large. The Federal Emergency Management Agency (FEMA) estimates that fewer than 50% of US homeowners have flood insurance. Insurance coverage for disasters is limited in Emerging Asia. From 2012 to 2018, just 0.3% of overall losses in Viet Nam, 0.5% in Malaysia and 0.8% in Thailand were insured, based on Munich RE's NatCatSERVICE data.

Another way to look at this issue is to consider a country's insurance penetration, which reflects the development of the national insurance sector. It relates the aggregate volume of insurance premiums in

an economy to gross domestic product (GDP). Figure 1.2 compares the insurance penetration rates of selected Asian countries in 2021.

Figure 1.2. Insurance penetration in selected Asian countries, 2021 (premiums in % of GDP)



Source: (Swiss Re, 2022[3]), *World insurance: Inflation risks front and centre*.

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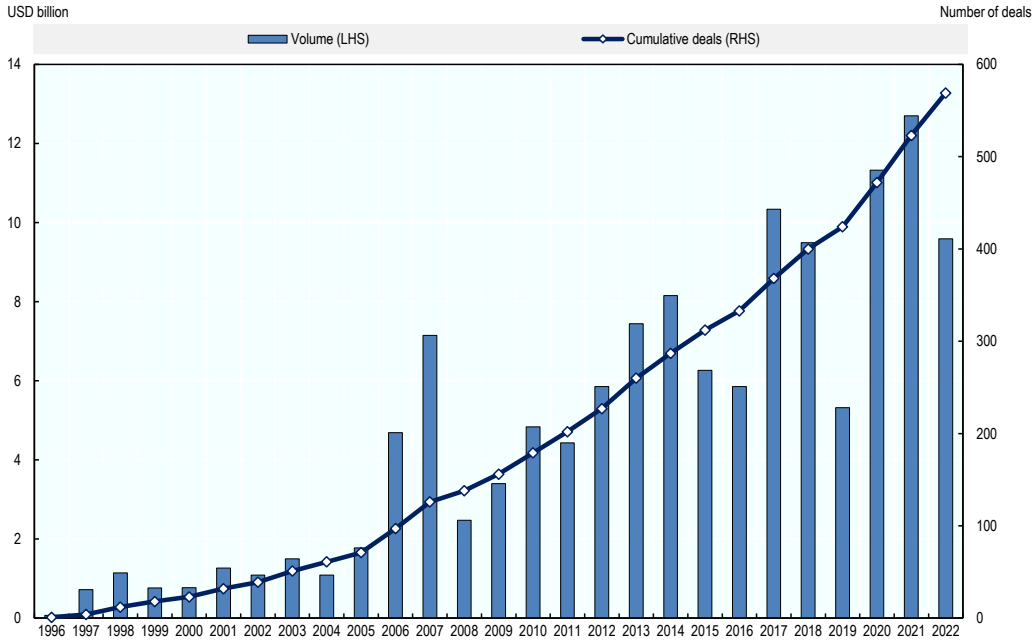
The CAT bond market is growing, but it remains limited in the region

The CAT bond market has grown steadily since it began developing in the 1990s, with the corporate world as the main issuer over the first decade. From a single transaction recorded in 1996, the cumulative issuance of CAT bonds had grown to more than 560 deals in 2022 (Figure 1.3). In terms of volume, CAT bond issuance surpassed USD 12 billion in 2021, the biggest cumulative annual amount over the 1996-2022 period. However, CAT bond markets remain underdeveloped in the countries of Dynamic Asia and the Pacific[1] (Artemis, 2020[4]). CAT bonds have been primarily issued to cover certain named perils in Europe, Japan and the United States, while the coverage for developing countries represents a much smaller share (Figure 1.4). Among countries and regions with emerging economies, the Caribbean and Mexico are covered more frequently than others. To date, the Artemis Deal Directory lists only one CAT bond covering property risks among the member countries of the Association of Southeast Asian Nations (ASEAN). It is a CAT bond issued by the World Bank in November 2019 to provide financial coverage to the Philippines in the event of earthquakes and tropical cyclones (Artemis, n.d.[5]).

Figure 1.3. CAT bond issuance and number of deals worldwide, 1996-2022

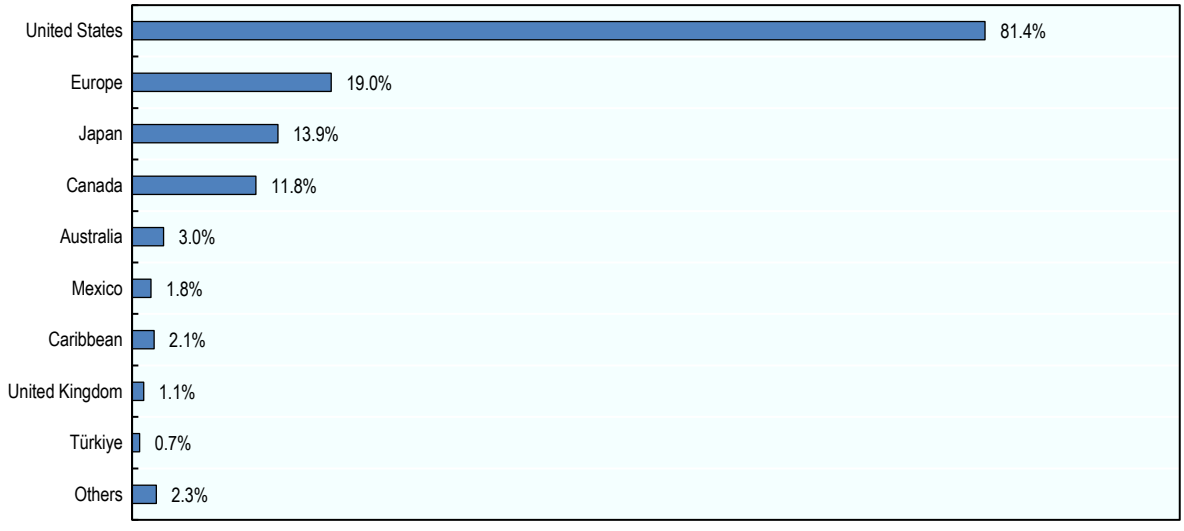


Note: Only 144A CAT bonds or similar are included. 144A CAT bonds are privately placed CAT bonds under Rule 144A of the US Securities Act. LHS = left hand scale. RHS = right hand scale.
Source: Artemis (n.d.), *Catastrophe Bond & Insurance-linked Securities Deal Directory* (database), www.artemis.bm/deal-directory/.

StatLink https://stat.link/fusm92

Figure 1.4. Geographical coverage of CAT bonds issued from 1996-2022

Percentage of total issuance



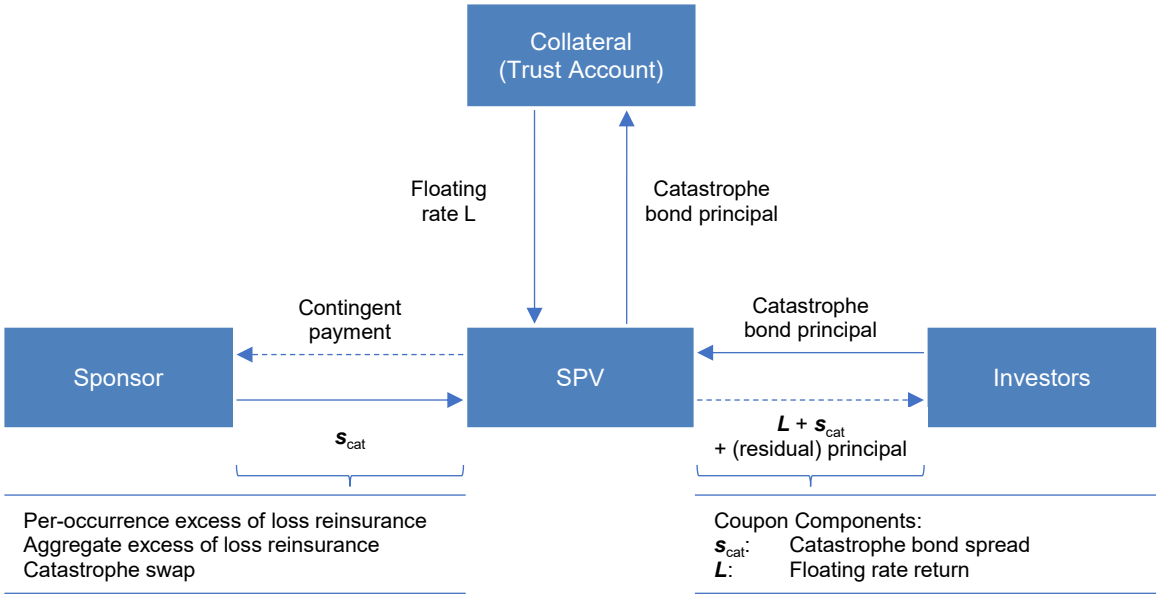
Note: Only 144A CAT bonds or similar issued in 1996-2022 are included. "Others" includes Chile, the People's Republic of China, Cyprus, Colombia, El Salvador, Guatemala, Israel, New Zealand, Peru, the Philippines and Chinese Taipei. Some percentages involve multiple counting; this applies to a CAT bond transaction that covers multiple countries or regions.
Source: Artemis (n.d.), *Catastrophe Bond & Insurance-linked Securities Deal Directory*, www.artemis.bm/deal-directory/.

StatLink https://stat.link/2cyzj7

Characteristics of catastrophe bonds

Catastrophe bonds are financial instruments that utilise a process called securitisation to wrap natural disaster risk into a tradable format. This process is depicted in Figure 1.5. A typical transaction requires the sponsor or cedent (the entity that would like to lay off the risk) to set up a special-purpose vehicle (SPV), which acts as a facilitator to transfer the catastrophe risk from the sponsor to the investors between the two parties. The SPV (also called a special-purpose entity or single-purpose company) is a firm with the solitary goal of enabling the transaction. The SPV grants reinsurance coverage or catastrophe swap protection to the sponsor and collects the required risk capital by issuing the CAT bond to investors. During the term of the reinsurance contract between the sponsor and the SPV, the investor's capital is held in the form of highly liquid and low-risk collateral in a trust account.

Figure 1.5. Typical catastrophe bond structure



Source: Authors' elaboration.

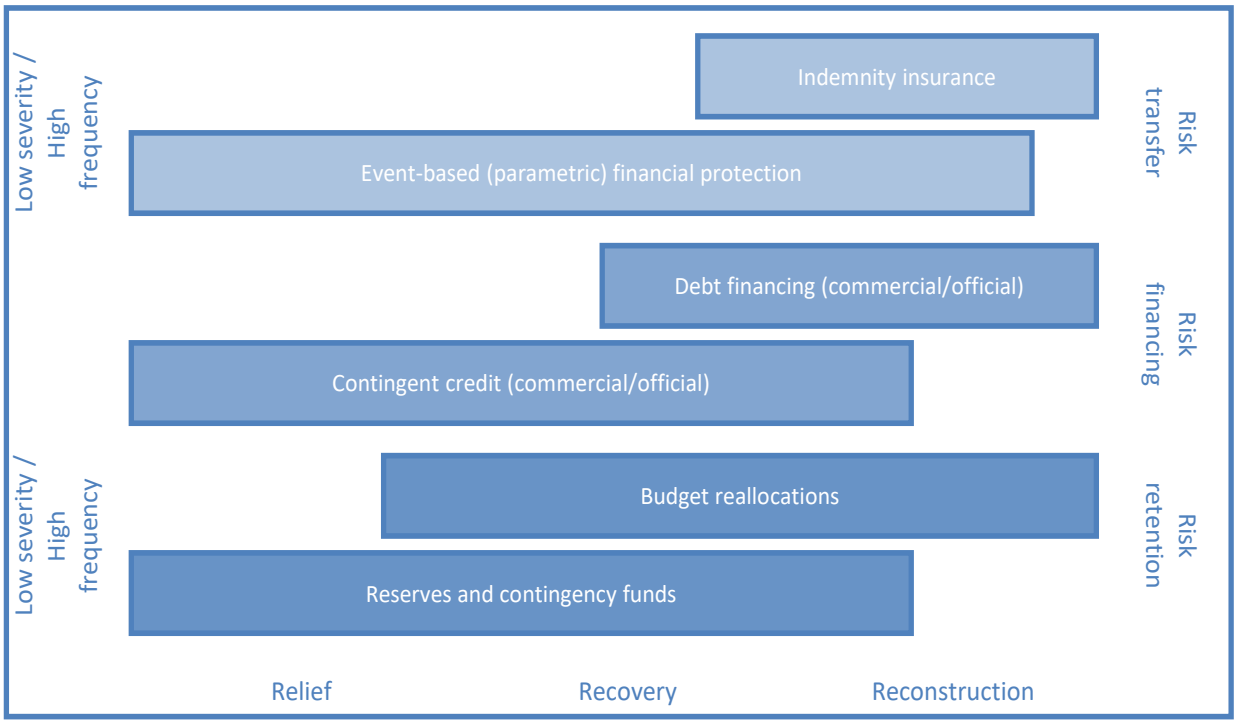
CAT bonds offer a coupon stream consisting of the floating interest rate (term premium) from the collateral securities and a fixed spread (risk premium) that is determined at issuance. The fixed spread represents the Rate on Line (ROL) paid under the reinsurance contract or catastrophe swap. CAT bonds carry minimal interest rate and credit risk due to their floating rate and the high quality of the collateral. Yet investors may lose their principal, because it is paid out to the sponsor if a predefined trigger event occurs during the term of the bond. The payout function can be binary or proportional to an underlying trigger metric.

To determine whether a payout is due under the embedded reinsurance contract or catastrophe swap, CAT bonds use different trigger mechanisms. CAT bond trigger mechanisms vary and provide investors with various levels of transparency and basis risk (the difference between the actual losses experienced and the expected payout). Mechanisms can be broadly classified into indemnity and non-indemnity triggers. Non-indemnity triggers can be further divided into parametric (index) triggers, industry-loss triggers, modelled-loss triggers and hybrid triggers. While the most common CAT bonds are those that feature indemnity triggers, index-triggered CAT bonds, including parametric, industry-loss and modelled-loss, have been favoured by investors due to their simplicity and higher transparency, hence no moral hazard issue. While these types of CAT bonds may pose greater basis risk for sponsors, the payout can be disbursed faster than with indemnity-triggered CAT bonds.

The use of CAT bonds provides various benefits

The countries of Dynamic Asia and the Pacific have a range of options for the financing of natural disaster losses accruing to the assets of households, companies and the public sector. However, applying these instruments in an isolated fashion will usually not be sufficient. Figure 1.6 indicates how sovereign risk transfer can be stacked together with other public sector measures in a risk management strategy.

Figure 1.6. Funding approaches to cover contingent liabilities from disasters



Source: (OECD, 2022[6]), *Building Financial Resilience to Climate Impacts: A Framework for Governments to Manage the Risks of Losses and Damages*.

Catastrophe bonds can, in most cases, provide a fast means of absorbing the impact of natural catastrophes in the short run since bond protection can be put in place immediately. Within a risk financing strategy, CAT bonds are one of the options for ensuring adequate funding for disaster responses, and they are ideal for transferring low-frequency, high-severity risk. Moreover, catastrophe bonds can be issued anytime and have a typical term of three years, therefore offering flexibility and price stability. CAT bonds are designed to immunise the sponsor against counterparty default risk through full collateralisation with high-quality securities. Furthermore, the use of parametric triggers potentially allows for a quick source of funding, while price signals from the CAT bond market and modern pricing models allow for informed decision making. Investors need to diversify their ILS portfolios; thus, they tend to accept a spread discount when risks are shared at a multi-country level.

Constraints and challenges hinder CAT bond development in the region

Although catastrophe bonds present various advantages, the development of CAT bond markets in Dynamic Asia and the Pacific is hindered by constraints and challenges, as set out in the following list:

- *Basis risk*. The use of parametric triggers may lead to basis risk scenarios where a country has been struck by a disaster, yet its sovereign CAT bond does not pay out. Basis risk has been shown to negatively affect the demand for coverage. It is hence crucial that emerging market sovereigns understand the consequences of basis risk and take measures to minimise it where possible.
- *Reliable measurement infrastructure*. Parametric triggers also require reliable measurement infrastructure in the geographic territory covered. Emerging countries that lack measurement infrastructure may need significant public investment before parametric CAT bonds can be used for sovereign risk transfer.
- *Data quality and reliable data providers*. Sovereign CAT bonds are not feasible without trustworthy data providers that are independent and adhere to the highest standards of data processing, storage and submission. In addition, missing track records will be a challenge. Track records are important for investors because they provide valuable information about the past performance of an asset and the trustworthiness of the sponsor.
- *Rapid and target-oriented distribution of the payout*. Once a sovereign sponsor receives a CAT bond payout to fund its post-disaster needs, it requires sufficient personnel and processes to ensure an efficient and targeted distribution of the proceeds.
- *Standardisation and liquidity concerns*. Standardisation of financial instruments is a desirable feature from an investor's perspective as it improves market liquidity and helps investors to manage their portfolios in a more efficient manner. Illiquidity can be a major concern as it reduces the ability to trade out of an unwanted position. Illiquid securities are characterised by low trading volumes and wide bid-ask spreads.
- *Inconsistency in regulatory treatment*. Regulatory issues are another key factor limiting CAT bond market development. CAT bonds are a newer financial product, and legal and regulatory frameworks remain underdeveloped in many developing countries. Information asymmetry and insufficient investor protection are also challenges that need to be addressed. Price transparency is essential for secondary market trading. Concerning the tax treatment of CAT bonds, many countries' tax codes lack comprehensive guidance with regard to the clarity of the structure, the nature of the product and classification for tax purposes. This may hinder investors from engaging in transactions.

Implementing policies for fostering catastrophe bond markets

Based on the benefits of CAT bonds for sovereign risk transfer, as well as the challenges associated with their adoption in emerging markets, major policy recommendations can be drawn. These recommendations may serve as guidelines for government decision making regarding the development of new sovereign disaster risk management programmes or the enhancement of existing ones. Policy recommendations for fostering CAT bond markets include the following:

- *Formulate a grand design for disaster risk financing*. Formulating a grand design from a long-term perspective is important for countries in Dynamic Asia and the Pacific, while recognising the importance of an integrated approach to disaster risk management and the contribution of risk assessment, risk awareness and risk prevention to the financial management of disaster risks (OECD, 2023[7]). However, the manner of building up the disaster risk financing framework will differ among countries. Broadly, there are two main pillars of function that policy makers need to

consider in the grand design, namely risk pooling and risk transfer. Countries in the region need to strengthen both functions in parallel, though the way forward will be different depending on the level of each country's development. While establishing a catastrophe risk insurance programme to broaden insurance coverage, governments need to carefully consider the potential trade-offs inherent in different approaches to programme design, and the differences in the characteristics of the underinsured peril. All of these factors affect the ability of private insurance and reinsurance markets to assume risk. They will also require different approaches to the design of any catastrophe risk insurance programme. If a country formulates a grand design of disaster risk financing strategy, it is important to recognise the level of development of its capital and insurance markets, potential differences in fiscal resources and repayment capacities, and other key factors that may influence financial strategies for disaster risk, such as data availability and technical expertise (OECD, 2022[6]).

- *Invest in measurement infrastructure*. Creating meteorological, hydrological and seismological services and investing in measurement infrastructure are also important. Many emerging countries already have measurement networks in place. These networks should be improved by investing in denser geographical coverage and more reliable and resilient devices, as well as reliable maintenance plans to ensure their functionality in the long run. In addition to existing measurement stations, governments can consider the use of advanced monitoring technologies, such as remote sensing, satellite imagery and permanent drone surveillance. These technologies may deliver real-time data on natural disasters and enable technological leapfrogging compared to classical measurements for certain perils (e.g. floods and drought).
- *Improve quality of data*. Accurate and timely data are critical for effective disaster risk transfer. Data providers must be independent and have reliable processes plus trained personnel, and they need to fulfil high standards of data security. Trustworthy data providers deliver accurate, reliable and up-to-date information that can be used with confidence for decision-making purposes. To this end, they need standard operating procedures and personnel who are highly trained in all matters of data management.
- *Develop catastrophe risk models*. The successful usage of CAT bonds for sovereign risk transfer crucially depends on the availability of reliable catastrophe risk models. Many countries in Asia and the Pacific are exposed to natural perils. Before these risks can be transferred to capital markets, they must be modelled. Without proper risk quantification, pricing and risk transfer are not feasible.
- *Enhance capacity-building*. The adoption of CAT bonds needs to be accompanied by a build-up of expertise and experience. Experience and expertise are also critical factors for adoption on the investor side. At the same time, understanding financial competence in the context of CAT bonds to be something larger than management of personal finances is essential for the capacity-building of policy makers, and increasing the capacity of policy makers to take advantage of CAT bonds requires a whole-of-government approach.
- *Broaden investor bases.* Training is key to broadening investor bases, something that should be a central goal for policy makers seeking to develop CAT bond markets. In addition to the technical aspects of investing, training is also essential for overcoming other barriers such as low personal confidence, and lack of trust in experts.
- *Minimise basis risk*. Minimising basis risk could be accomplished by considering a risk pool with insurance portfolio to enable indemnity triggers, while maximising the correlation to losses if using a parametric trigger. The choice of parameters should be aligned with exposure in the best way possible. This can be achieved by switching from pure parametric to parametric index triggers which allow cedents to apply a weighting to the readings from different measurement stations that best mirrors their actual exposure.
- *Prepare distribution schemes*. To ensure a rapid and targeted distribution of the proceeds from sovereign CAT bonds in the event of a disaster, and to avoid slow political processes, contingency

plans must be put in place ex ante, taking social vulnerabilities into account and prioritising cash over in-kind aid.

- *Develop the local-currency bond market.* Local-currency government bond markets provide the necessary platform and institutional framework for the issuance of catastrophe bonds in the region.

The use of CAT bonds as a risk transfer mechanism in countries around the world

The implementation of sovereign catastrophe bonds by developing countries is still limited, yet examples such as CAT bonds sponsored by the governments of Jamaica, Mexico and the Philippines show that there is market appetite for this sophisticated financial instrument when it is deployed by highly exposed and vulnerable countries.

The implementation of CAT bonds by the Philippines government has been made possible by the continuous improvement of the country's disaster risk financing and insurance (DRFI) strategy, with support from international development partners. The Philippines is present in the CAT bond market indirectly, the bonds having been issued by the World Bank on its behalf. In 2019, the World Bank issued two tranches of CAT bonds to provide the Philippines with a total of USD 225 million in financial coverage against earthquakes and tropical cyclones for three years. The CAT bonds were issued under the Capital at Risk Notes programme of the International Bank for Reconstruction and Development (IBRD). This programme can be used to transfer risks related to natural disasters and other risks of developing countries to capital markets.

A strong legal and institutional framework for disaster risk financing is essential to facilitate the development of risk transfer mechanisms such as CAT bonds. The Philippines provides an example in this regard. The rollout of other disaster risk financing programmes in the Philippines – such as the Parametric Catastrophe Risk Insurance Program, which preceded the CAT bond issuance – provided the country with an enabling environment and valuable lessons for CAT bond adoption. One such lesson was the need to improve the availability and quality of disaster-related data for the development of more sophisticated catastrophe models. There is also a clear need for the country to clarify the post-disaster responsibilities of stakeholders in order to improve the transparency and timeliness of fund disbursement in the aftermath of a disaster event.

In Indonesia, natural disasters often cause significant fiscal pressure. With the launch of the country's DRFI strategy in 2018, the government has sought to overcome the fiscal burden resulting from various natural catastrophe events. Although Indonesia is not yet present in the sovereign CAT bond market, there is a possibility for CAT bonds to be used as a risk transfer mechanism within the country's disaster risk financing strategy. Following a series of deadly catastrophes in 2018, including the earthquake in West Nusa Tenggara, the earthquake, tsunami, and liquefaction in Central Sulawesi, and the volcanic tsunami in Sunda Strait, the government looked into bolstering its financial resilience against disasters through the use of sophisticated financial instruments. The government also considered CAT bonds among the viable options for funding disaster recovery efforts for future catastrophe events that cause damages that exceed the annual disaster-related budget (MoF, 2018[8]). However, challenges may need to be addressed for CAT bonds to be used effectively, including strengthening risk data and analytics; improving the legal framework for risk transfer mechanisms and the regulatory framework for disaster data management; and recalibrating existing models to produce more accurate prediction and reflect local practices.

In the People's Republic of China (hereafter "China"), budgetary instruments are the main financing mechanism for disaster risk used by the government. These include the budget reserve funds that, under the Budget Law, should be allocated by government at all levels. The funds can be used in case of emergencies, disasters and other unforeseen events. Budgetary instruments that are intended solely for disaster relief include the central government's disaster relief funds and the Central Fiscal Fund for Agricultural Production Disaster Relief and Reduction. Government-backed insurance schemes are

available in China, and these have helped the government to reduce the financial burden in the aftermath of disaster events. However, contingency funds and the government-backed insurance schemes are constrained by low awareness, low demand and insufficient and uncertain coverage. The Chinese government and insurance regulator have been promoting the use of the Hong Kong, China ILS regulatory regime to transfer part of the country's catastrophe risks. In 2015, the Chinese state-owned reinsurer, China Re, sponsored its first CAT bond, the first one to place Chinese catastrophe perils in capital markets, through a Bermuda-domiciled special purpose insurer (SPI), issued on behalf of the Chinese government. The second one sponsored by China Re was completed in 2021, using Hong Kong, China as a domicile.

In India, as in many other countries of Asia and the Pacific, underinsurance remains a challenge. Sovereign parametric insurance schemes covering public assets against the risk of natural disasters are non-existent, as are other sovereign risk transfer mechanisms. Because its current financing options are limited, India often relies heavily on ex post financing mechanisms, including natural disaster reserve funds, budget reallocation, external debt and donor assistance. The country could develop adequate risk transfer mechanisms to lessen the burden of meeting post-disaster needs. India has the potential to adopt CAT bonds as one of its financing mechanisms to protect against the most severe disasters, and the government has recently begun to encourage the development of CAT bond markets. However, for CAT bonds to be effective, a comprehensive DRFI strategy needs to be established.

Sovereign CAT bond markets are more developed beyond Dynamic Asia and the Pacific. The governments of Mexico and Jamaica have issued this type of financial instrument in order to strengthen their disaster risk management strategies. Mexico's 2009-12 MultiCat programme was implemented in partnership with the World Bank, with the World Bank Treasury acting as an intermediary between the Mexican government and major investment banks to develop the product and arrange the deal. As the global co-ordinator throughout this process, the World Bank played a vital role in deciding which trigger mechanism to use, based on the needs of the Mexican government, and in proposing a strategy for placing the bonds (Michel-Kerjan et al., 2011[9]). The World Bank also provided capacity building related to sovereign debt markets to a dedicated team within the Mexican government, which allowed the government to stay in control of the process.

Jamaica has sought to increase its financial resilience through the deployment of various financing instruments for post-disaster activities, including a contingency fund, contingent credit and catastrophe insurance from the Caribbean Catastrophe Risk Insurance Facility (CCRIF). Jamaica was among the 16 countries in the CCRIF that benefited from a CAT bond issued in 2014 under the World Bank's Capital at Risk Notes programme. As available budgetary resources were deemed insufficient to bridge the financing gaps resulting from tropical cyclone events, risks were transferred to capital markets, with technical assistance from the World Bank and bilateral financial support from donor countries, including Germany, the United Kingdom and the United States. In 2021, Jamaica became the first Small Island Developing State in the Caribbean region to sponsor a CAT bond independently. The instrument provides the country with financial protection of up to USD 185 million for three years against named tropical cyclone impacts, on a parametric trigger and per occurrence basis. Should an event breach the predefined trigger criterion, payout would be made within weeks of a storm event once the calculation report is available – a quick payout calculation made possible by an innovative reporting feature included in the transaction. The experiences of Mexico and Jamaica demonstrate the importance of engaging with international financial institutions during the pre-issuance and issuance phases of a CAT bond transaction.

In several OECD countries, such as Australia, Japan, New Zealand and the United States, CAT bond markets have been shaped by the active involvement of the private sector, particularly the (re)insurance industry. The first CAT bond covering Australian risks was issued in 2006 by SPV Australis. Swiss Re, a prominent player in the insurance industry, secured USD 100 million in coverage against the perils of earthquakes and tropical cyclones. Australia brought another CAT bond to the market the following year, while Insurance Australia Group (IAG), the largest general insurance company operating in Australia and New Zealand, diversified its reinsurance programmes in 2019 by sponsoring its first CAT bond, issued out

of Singapore. In New Zealand, the Earthquake Commission, the state-owned residential property disaster insurance entity, issued its first CAT bond in 2023 in a strategic move to diversify funding sources beyond traditional annual reinsurance.

In Japan, the first CAT bond transaction dates back to the mid-late 1990s, when Tokyo Marine and Fire sought reinsurance for USD 100 million of earthquake risk over a 10-year period. The transaction paved the way for subsequent CAT bond sponsorships, highlighting the country's strong insurance and reinsurance industry. More recently, Japanese sponsors have engaged in joint issuance of CAT bonds, which involves multiple entities coming together to issue the bonds collectively. Joint issuance allows sponsors to leverage each other's expertise, resources and market reputation, potentially attracting a broader investor base and reducing transaction costs.

The CAT bond market in the United States has experienced notable growth since its establishment in the mid-late 1990s. This growth has been driven by several major events, including Hurricane Katrina in 2005, the 2008 financial crisis and a post-crisis period of low interest rates. The impact of Hurricane Katrina highlighted the importance of CAT bonds in risk diversification. The collapse of Lehman Brothers during the financial crisis caused a significant decline in CAT bond issuances, but alternative collateral solutions restored confidence and enticed investors back into the markets. The catastrophe funds of individual states, such as the California Earthquake Authority (CEA) and the Florida Hurricane Catastrophe Fund (FHCF), have played a vital role in maintaining functional insurance markets by transferring and diversifying their risk profiles through CAT bonds. The CEA entered the CAT bond market in 2001 and has maintained a continuous presence, with new issuances every year since 2014. At the same time, the participation of federal entities such as FEMA in CAT bond markets demonstrates the continued relevance and growth of this risk transfer mechanism. FEMA introduced its initial CAT bond in 2018, providing reinsurance protection to the National Flood Insurance Program against flood losses resulting from named storm events.

Sharing risks among countries

While many countries in Dynamic Asia and the Pacific are prone to natural disasters, they often have limited capacity to respond quickly to disaster events due to their limited fiscal space. At the regional level, several initiatives are in place to address the financial risks arising from natural disasters. For instance, catastrophe risk pools can help countries in the region to access insurance coverage at lower costs. Catastrophe risk sharing facilities transfer a share of the risks of participating countries to international reinsurance or capital markets. In addition to cost sharing in transactions, joint issuance of CAT bonds allows sponsors to access a broader investor base. CAT bonds, which have gained popularity among sovereign entities, may also become a viable solution for reinsuring risks.

Nonetheless, joint issuance may present challenges as it involves multiple sovereign entities with different risk appetites and interests. Differences in risk and economic profile may also hamper the establishment of a sovereign disaster risk pool at the regional level. Indeed, the countries of Asia and the Pacific have heterogeneous exposure to natural disaster risks, and they differ in economic size and monetary and fiscal room to manoeuvre. This highlights the need for effective collaboration among participating governments. Moreover, different jurisdictions may have varying regulatory frameworks and compliance requirements, adding complexity to the process. By addressing these challenges, the potential benefits of joint issuance can be fully realised, contributing to the development of CAT bond markets.

The use of CAT bonds by multiple countries has also been observed in regional catastrophe risk pooling facilities, such as the CCRIF in the Caribbean. This approach enables small economies to access capital markets collectively.

In Asia and the Pacific, the Pacific region consists of a number of Small Island Developing States. High exposure to natural disasters and climate hazards makes these countries among the most vulnerable in the world. The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) was launched in 2007. Under the pilot insurance programme, six participating countries – the Marshall Islands, Samoa, the Solomon Islands, Tonga and Vanuatu, as well as the Cook Islands, which joined in the second policy year – were provided with an affordable parametric insurance product against tropical cyclones and earthquakes or tsunamis. The product provided participants with access to rapid liquidity in the wake of major meteorological and seismic events. The initiative benefited from financial support from the government of Japan, the Global Facility for Disaster Reduction and Recovery and the European Union. Technical support was provided by GNS Science (New Zealand), Geoscience Australia and AIR Worldwide.

The ASEAN+3's Southeast Asia Disaster Risk Insurance Facility (SEADRIF) was established in 2018. The facility, an initiative of ASEAN+3 finance ministers and central bank governors, aims to help countries gain access to reliable sources of disaster risk financing through tailored financial products and to enhance their financial resilience through capacity-building services. The establishment of this facility benefited from the financial and political support of Japan and Singapore. SEADRIF's first financial product includes a three-year insurance policy against the risk of floods that was developed in response to a request from Lao PDR. Flood events have caused more damage in the region than other types of natural disasters, making affordable financial protection against floods essential to overcome the financial burden faced by these countries.

Some countries might be reluctant to cross-subsidise the premiums of other members of a given risk sharing arrangement. As such, technical expertise and data that are more current are needed to ensure each country pays an appropriate share of the costs. Administrators of a risk sharing mechanism must also balance the needs and wants of member countries with those of participating countries.

Notes

[1] Dynamic Asia refers to Emerging Asia – the ASEAN-10 countries plus China and India – along with other member countries of the South Asian Association for Regional Co-operation (SAARC), the countries of Central Asia, as well as Mongolia in East Asia.

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2 Catastrophe bonds in Asia and the Pacific: Recent trends and characteristics

The increasing exposure to natural hazards and the widening protection gap in both OECD and Asia and the Pacific countries have led to a growing need for innovative financial solutions to cope with the economic burden of disasters. Catastrophe (CAT) bonds are relatively new disaster risk financing tools for most countries in Asia and the Pacific. This chapter discusses characteristics of CAT bonds, their structure, as well as their advantages and disadvantages. Various trigger mechanisms of CAT bonds such as indemnity and non-indemnity are also discussed. Finally, the chapter presents recent trends in CAT bond markets worldwide, and the development of CAT bond markets in Asia and the Pacific.

Introduction

Asia and the Pacific faces significant exposure to natural hazards. As this exposure increases, countries in the region are in growing need of risk management strategies to lower the economic burdens they face in the wake of disasters. Large-scale natural hazards often leave countries with insufficient funds to provide emergency relief to victims and to finance recovery efforts.

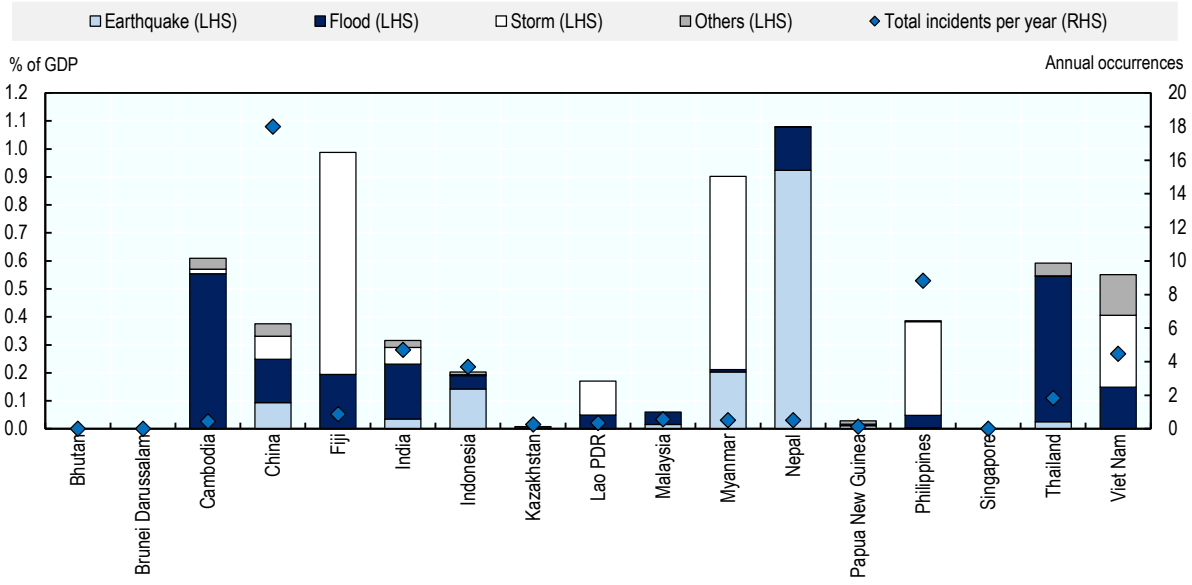
The costs associated with these outcomes of disasters vary significantly depending on the type, size, severity and frequency of disasters faced by a given country. Floods are the major threat in most of the region's countries, but Fiji, Myanmar, the Philippines and Viet Nam, are more affected by tropical storms, while Nepal and Indonesia are more exposed to earthquakes (Figure 2.1), meaning there is no "one-size-fits-all" approach.

In general, countries in the region need to seek to broaden their financial options and to adopt innovative financial solutions to cope with increasing exposure to disasters. Among financing options, catastrophe bonds (CAT bonds) are a relatively new solution for countries in the region.

This chapter begins by discussing the characteristics of CAT bonds, including their structure and the advantages and disadvantages of various features, notably CAT bond trigger mechanisms. It then explores recent trends in CAT bond markets worldwide, before narrowing the focus to the development of CAT bond markets in Asia and the Pacific.

Figure 2.1. Cost and frequency of disasters in selected Asia and Pacific countries

Annual average, 2000-22



Note: The figure only includes the types of natural disasters for which data are available.
Source: Authors' elaboration based on data from EM-DAT.

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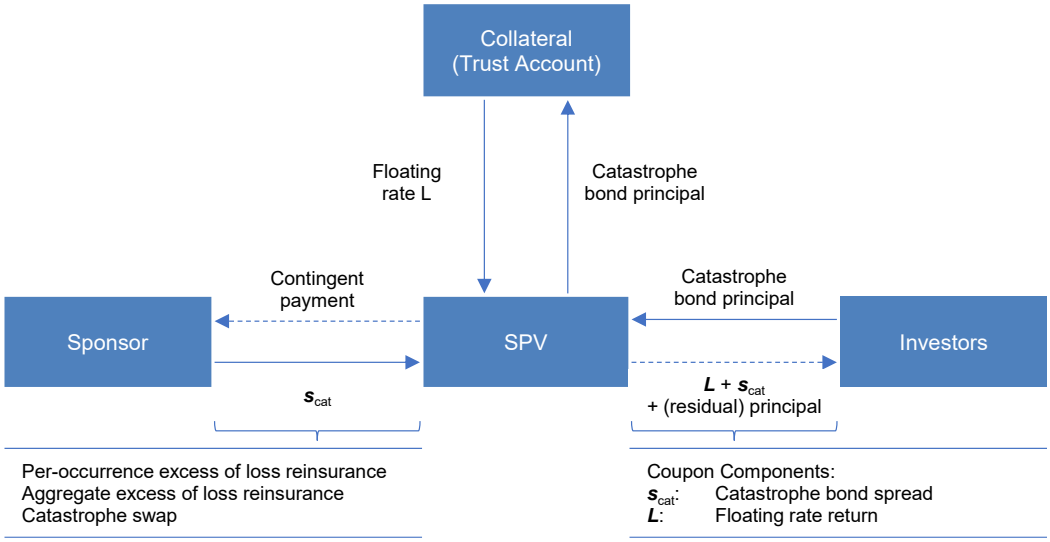
Characteristics of catastrophe bonds

There has been a significant increase in the disparity between the financial losses caused by disasters and the level of insurance coverage deployed to mitigate these losses. This disaster protection gap is widening across both OECD countries and the Dynamic Asia and the Pacific[1] region since exposure is growing faster than the increase in resilience worldwide. There is thus a pressing need for additional capital to support insurance and reinsurance efforts. Addressing the expanding insurance protection gap necessitates the mobilisation of additional risk capital and the implementation of appropriate financial strategies that can bridge the connection between disaster risks and capital markets.

Insurance-linked securities (ILS) emerged at the beginning of the 1990s as a potential solution for easing financial burdens posed by natural disasters. ILS can offer governments some respite in challenging situations by transferring part of the risk stemming from disasters to investors. However, recourse to ILS may entail some challenges. For instance, it may be difficult to establish an adequate premium to be paid for unexpected natural hazards. In parallel, investors may be wary of investing in this asset class given the difficulties inherent in assessing the associated risks (OECD, 2022[1]). Careful assessment of these challenges is necessary to ensure the effective implementation of ILS as a risk transfer mechanism in addressing the expanding insurance protection gap. There are four main types of ILS: collateralised reinsurance, which has the largest share in the ILS market; CAT bonds; industry-loss warranties; and sidecars. CAT bonds offer a solution for financing disaster risks as they provide countries with funds that can be released more rapidly.

Catastrophe bonds are financial instruments that use a process called securitisation to wrap natural disaster risk into a tradable format. This process is depicted in Figure 2.2. A typical transaction requires the sponsor or cedent (the entity that would like to lay off the risk) to set up a special-purpose vehicle, which acts as a facilitator to transfer the catastrophe risk from the sponsor to the investors between the two parties. The SPV (also called a special-purpose entity or single-purpose company) is a firm with the solitary goal of enabling the transaction. It has neither employees nor property and is capitalised through the CAT bonds. The SPV grants reinsurance coverage or catastrophe swap protection to the sponsor and collects the required risk capital by issuing the CAT bond to investors. During the term of the reinsurance contract between the sponsor and the SPV, the investor's capital is held in the form of highly liquid and low-risk collateral in a trust account.

Figure 2.2. Typical catastrophe bond structure



Source: Authors' elaboration.

CAT bonds offer a coupon stream consisting of the floating interest rate (term premium) from the collateral securities and a fixed spread (risk premium) that is determined at issuance. The fixed spread represents the Rate on Line (ROL) paid under the reinsurance contract or catastrophe swap. CAT bonds carry minimal interest rate and credit risk due to their floating rate and the high quality of the collateral, yet investors may lose their principal, because it is paid out to the sponsor if a predefined trigger event occurs during the term of the bond. The payout function can be binary or proportional to an underlying trigger metric.

To determine whether a payout is due under the embedded reinsurance contract or catastrophe swap, CAT bonds utilise different trigger mechanisms. The four primary trigger types – the indemnity trigger, parametric trigger, industry-loss index trigger and modelled-loss trigger – are discussed in detail in the following section.

The simple CAT bond transaction structure depicted in Figure 2.2 could be modified in a variety of ways. A reinsurance company may act as an intermediary between the sponsor and the SPV. Under this arrangement, the reinsurer may absorb basis risk (i.e. the gap between losses to the reinsured portfolio and the recovery amount provided by the CAT bond) before retroceding to the SPV. If a covered catastrophe event occurs, the sponsor would collect reinsurance recoverable amounts based on its own insured losses, while the SPV would pay out on the basis of a particular trigger mechanism (Swiss Re, 2011[2]).

CAT bond trigger mechanisms and choice of trigger

Typically, the default of a CAT bond is measured by a trigger mechanism. CAT bond trigger mechanisms vary and provide investors with different levels of transparency and basis risk (the difference between the actual losses experienced and the expected payout). Trigger mechanisms can be broadly classified into indemnity and non-indemnity. Non-indemnity triggers can be further divided into parametric (index) triggers, industry-loss triggers, modelled-loss triggers and hybrid triggers. Each of these trigger types will be examined in turn.

Indemnity triggers

The most common trigger mechanism is the indemnity trigger, which bases CAT bond payouts on the actual insurance losses experienced by the sponsor. As such, they function similarly to reinsurance. This implies that there is no basis risk for the sponsor; however, investors may face moral hazard due to information asymmetries (Lee and Yu, 2002[3]). For instance, moral hazard may arise when insurers fail to settle catastrophe losses appropriately. Furthermore, the lengthy loss verification process required with indemnity triggers renders rapid settlement impossible. Indeed, given the fact that actual losses must be observed and verified before the bond can be triggered, CAT bonds with indemnity triggers may take two to three years to pay out following a triggering event, compared to three months for CAT bonds with non-indemnity triggers (Polacek, 2018[4]). Furthermore, indemnity CAT bond investors are subject to the operational risk of the ceding company's underwriting and claims function. Rating agencies tend to require additional stress testing due to this operational risk exposure, which may result in a lower rating (Swiss Re, 2011[2]).

Parametric triggers

Parametric triggers use the measured strength of the covered catastrophe, such as wind speed, earthquake magnitude or barometric pressure, to determine payouts. Data for this parameter can be collected at multiple reporting stations in a given geographical area and entered into a predefined formula, resulting in a parametric index trigger. Information about the event parameters is typically available shortly after the occurrence of an event, allowing transactions to be settled more rapidly than when an indemnity

trigger is involved. Furthermore, a parametric trigger can reduce information asymmetry due to the higher level of transparency associated with more objective official measurement. Owing to their higher level of transparency and simplicity of use, parametric triggers have been the preferred type in less-developed countries (Michel-Kerjan et al., 2011[5]). However, imperfect correlation between actual losses and the predefined physical parameters may expose the sponsor to basis risk.

Industry-loss index triggers

Industry-loss index triggers base payouts on the aggregate losses to the entire insurance sector following a large-scale natural disaster. Loss estimates are typically derived by a third-party modeller that can provide an independent estimate of the covered losses, such as Pan-European Risk Insurance Linked Services in Europe and Property Claims Services (PCS) in the United States. With industry-loss indices, payouts are triggered when industry-wide losses from an event reach a specified threshold. If a triggering event occurs, then the CAT bond investors are liable for the percentage of the industry represented by the CAT bond sponsor's share. This subjects the sponsor to basis risk since the claims that the sponsor must pay may not be exactly equal to its share of the industry loss. At the same time, the estimate of the covered losses provided by the third-party modeller may not be exactly equal to total industry losses (Edesess, 2014[6]). A weighted industry index could be used to customise the industry-loss index further and reduce basis risk. By applying weighted calculation factors to various subregions of the covered area, the sponsor can obtain coverage that more closely aligns with its own risk portfolio.

Modelled-loss trigger mechanisms

Modelled-loss trigger mechanisms are based on loss estimation by a modelling firm that compares the physical parameters of events to entries in the firm's database of industry exposures. Alternatively, the CAT bond sponsor may opt for using a representative sample of its own portfolio of exposures instead of the modelling firm's industry database when calculating the modelled losses attributable to a specific catastrophe event (Guy Carpenter and MMC, 2007[7]). The CAT bond is triggered when the modelled losses exceed a specified threshold. This type of trigger is essentially an expansion of the parametric trigger that uses a model instead of an index function. Modelled-loss triggers may be subject to model risk, a condition where the difference between modelled losses and actual losses is large (Cummins, 2008[8]).

Hybrid trigger mechanisms

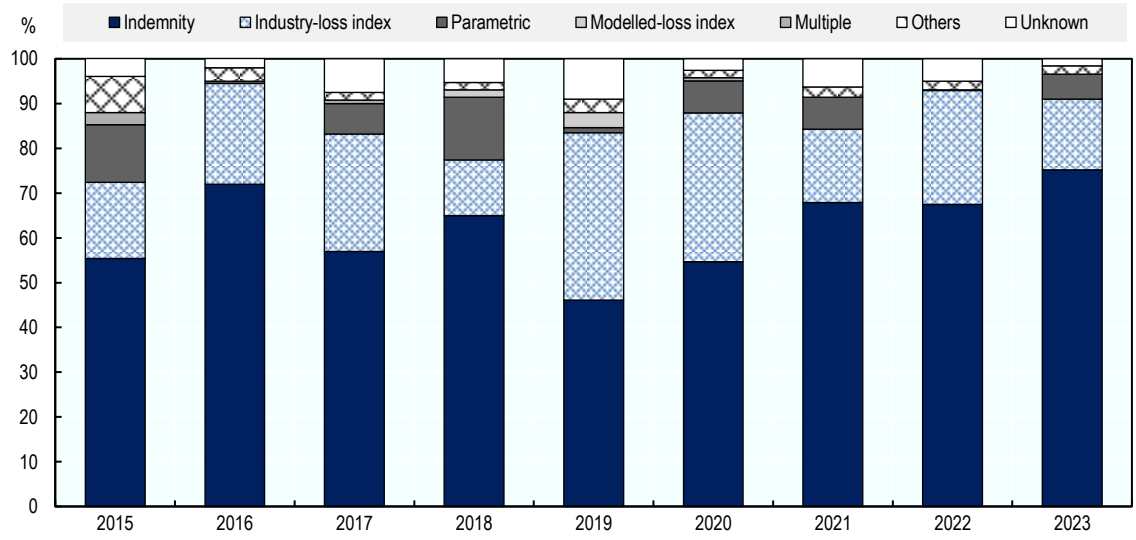
CAT bonds may feature multiple triggers of different types, known as hybrid trigger mechanisms. These hybrid triggers can be further classified into two main categories. The first category uses different trigger types for different perils within a single tranche (e.g. an index trigger could be used to establish losses due to a windstorm and a parametric trigger to establish losses related to an earthquake). The second category of hybrid triggers has a complex nature and applies different trigger types in a sequential fashion when establishing losses from a covered event. Hybrid trigger mechanisms offer greater flexibility for sponsors, allowing them to use different trigger types to address different perils within a single transaction, but investors may find this approach too complex and transactions difficult to understand (Guy Carpenter and MMC, 2007[7]).

Considerations in the choice of a trigger mechanism

Indemnity triggers remain dominant in the current market, accounting for approximately 75% of total CAT bond and ILS issuance in 2023 (Figure 2.3). They remain favoured by sponsors, since they may offer a better way to fit CAT bond coverage within the sponsor's overall reinsurance programme. Issuances in 2020 also featured industry-loss index, parametric and hybrid triggers. According to the Artemis Deal Directory, 2020 was the first year since 2017 when none of the CAT bonds issued featured modelled-loss triggers (Artemis, n.d.[9]).

Figure 2.3. CAT bonds and ILS issuance by trigger type, 2015-23

% of total issuance



Source: (Artemis, n.d.[9]), *Catastrophe Bond & Insurance-linked Securities Deal Directory* (database), www.artemis.bm/deal-directory/.

StatLink https://stat.link/59ga6h

Choosing which trigger mechanism to use involves various elements – a typical one is a trade-off between the costs of moral hazard and potential settlement speeds on the one hand, and the basis risk on the other (see Chapter 3 for a detailed discussion). Moral hazard behaviour occurs when the cost of loss-control efforts by the sponsor (i.e. insurance company) exceeds the benefits from debt forgiveness. The CAT bond's basis risk refers to the gap between the sponsor's actual loss and the composite index of losses that prevents the sponsor from receiving full risk hedging. The basis risk may therefore cause insurers to default on their debt in the case of high individual loss but low index of loss (Lee and Yu, 2002[3]).

Sponsors often prefer indemnity triggers as a means of minimising basis risk, although some theoretical literature suggests that CAT bonds with indemnity triggers should incur higher risk premiums because of moral hazard and information asymmetries. Under this trigger mechanism, investors will likely desire information on the risk exposure of the sponsor's underwriting portfolio, which may be difficult to obtain for complex commercial risks. The need to disclose confidential information on the sponsor's policy portfolio may influence the choice of this trigger mechanism (Cummins, 2008[8]). CAT bonds with indemnity triggers also tend to have higher transaction costs because more documentation is required regarding the sponsor's exposures and underwriting standards. Furthermore, they may take longer to settle following an event because the sponsor's losses must be evaluated (Cummins and Weiss, 2009[10]).

While the potential moral hazard related to the use of CAT bonds with indemnity triggers has been discussed at length in the theoretical literature, empirical evidence on this topic is mixed. Götze and Gürtler (2020[11]) provide some empirical insights by assessing whether the sponsors of CAT bonds with indemnity

triggers are susceptible to moral hazard. The study concludes that ex ante moral hazard is present for insurers who use CAT bonds with indemnity triggers, whereas a CAT bond with an indemnity trigger distressed by a catastrophic event does not seem to cause ex post moral hazard on the insurers' side. Another important conclusion is that vertical loss retention has a positive effect on sponsors' incentives to contain losses.

Non-indemnity or index triggers tend to be favoured by investors, as they minimise moral hazard. CAT bonds with index triggers may also reduce sponsors' basis risk, although empirical evidence is ambiguous in this regard. Early work by Harrington and Niehaus (1999[12]), based on a time-series analysis of the correlation between state-specific loss ratios for a sample of US insurers and the CAT loss index compiled by the PCS, indicates that PCS-index derivatives would have provided effective hedges for many non-life insurers. In a similar vein, Cummins, Lalonde and Phillips (2004[13]) suggest that ILS based on index-linked contracts could be used effectively by sponsors in hedging catastrophe risk. In contrast, Major (1999[14]) finds that Florida-based insurers hedging with a state-wide CAT loss index are subject to substantial basis risk.

While the vast majority of the literature dedicated to the trade-off between moral hazard and basis risk has focused on a particular type of CAT bond trigger, some studies have sought to compare alternative options. A study by MacMinn and Richter (2018[15]) compares an index-triggered security and an indemnity-triggered security similar to a CAT bond within a framework in which a corporation (insurer or reinsurer) is subject to insolvency risk, and this insolvency risk creates an additional incentive problem, known as the judgement proof problem. Under the model, the corporate manager is assumed to act in the interest of shareholders, thus the judgement proof problem leads to a conflict of interest between shareholders and other stakeholders. The study analyses the incentive effects associated with securities having different trigger mechanisms. It finds that the index-triggered security dominates the indemnity-triggered one, as it reduces insolvency risk and provides the corporate manager with greater shareholder values. Conversely, the indemnity-triggered security tends to worsen the risk of insolvency, as it introduces an additional incentive problem.

In another study, Doherty and Mahul (2000[16]) investigate the trade-off between moral hazard and basis risk. They find that, due to their correlation with policyholders' losses, parametric triggers hedge policyholders' losses well enough to provide a reasonable substitute for an indemnity trigger. Hedging with parametric trigger instruments also preserves the incentive of policyholders to invest in loss mitigation, while hedging with indemnity-triggered instruments does not. The study also highlights that the choice among different index triggers depends on the risk preference of the insurer. For instance, a more risk-averse insurer would prefer an index trigger with more moral hazard and less basis risk. Further, the study remarks that efficiency gains may be possible through a combination of hedging tools, namely an index-linked security with an indemnity insurance policy, which can cover the basis risk of an index-triggered instrument.

Empirical evidence remains scarce on how the different instruments should be compared and combined, particularly with regard to disaster risk transfer strategies for sovereigns. A study by Trottier and Lai (2017[17]) compares hedging strategies using CAT bonds and reinsurance to find the optimal disaster reinsurance programme. Their results suggest that a strategy combining CAT bonds and reinsurance, in which small losses are covered by reinsurance and large losses are hedged through issuing CAT bonds, is optimal. The rationale is that the strategy provides higher shareholder value and lower hedging costs, which may include financial distress costs due to insolvency risk (in the case of hedging using reinsurance) and costs associated with compensating investors for their exposure to moral hazard (in the case of issuing CAT bonds).

Decisions on which trigger to use in risk transfer instruments also depend on the country's development level and economic structure. The parametric mechanism is often considered preferable in developing countries (Michel-Kerjan et al., 2011[5]; Clyde & Co, 2018[18]). This is due to its key characteristics of speedy

disbursement, the certainty of payouts and higher transparency. Instruments using the parametric trigger are increasingly offered in low-income countries as an alternative to traditional indemnity insurance. It is also possible to use the parametric mechanism to cover smaller losses where the overhead costs would be too large to make insurance cost-effective using an indemnity mechanism, and to cover non-property related losses like business interruption (Sengupta and Kousky, 2020[19]). The parametric mechanism can also be useful for microinsurance in developing countries, targeted at low-income households or microenterprises.

Further research should explore how different instruments should be implemented in developing countries, where both insurance markets and CAT bond markets are often underdeveloped. Moreover, greater transparency may be afforded by the adoption of new technologies, such as blockchain technology, both by regulators and within the financial sector. Thus, the technology costs of the various instruments should be explored, especially in developing countries.

Drivers of CAT bond premiums

The specialised literature widely discusses the relationship between the pricing of CAT bonds and bond-specific determinants (e.g. choice of trigger mechanism, insured geographical area, peril type or the available credit rating). Empirical findings are inconclusive, however. For instance, using a data set from 2002 to 2012, Gürtler, Hibbeln and Winkelvos (2014[20]) find no significant influence of the applied trigger mechanism on the premiums. Conversely, Cummins and Weiss (2009[10]) argue that indemnity-triggered CAT bonds have higher premiums compared to non-indemnity triggered CAT bonds. The rationale behind these higher premiums is the moral hazard associated with the product plus the higher transaction costs for indemnity-triggered CAT bonds, given that more documentation is needed for indemnity trigger mechanisms than non-indemnity trigger mechanisms. In addition, Galeotti, Gürtler and Winkelvos (2013[21]) assess the trigger mechanisms of CAT bonds issued between 1999 and 2009 and find that the parametric trigger mechanism has less effect over time on pricing compared to the indemnity trigger. As is the case with standard bonds, better credit ratings are found to be associated with lower CAT bond premiums (Gürtler, Hibbeln and Winkelvos, 2014[20]).

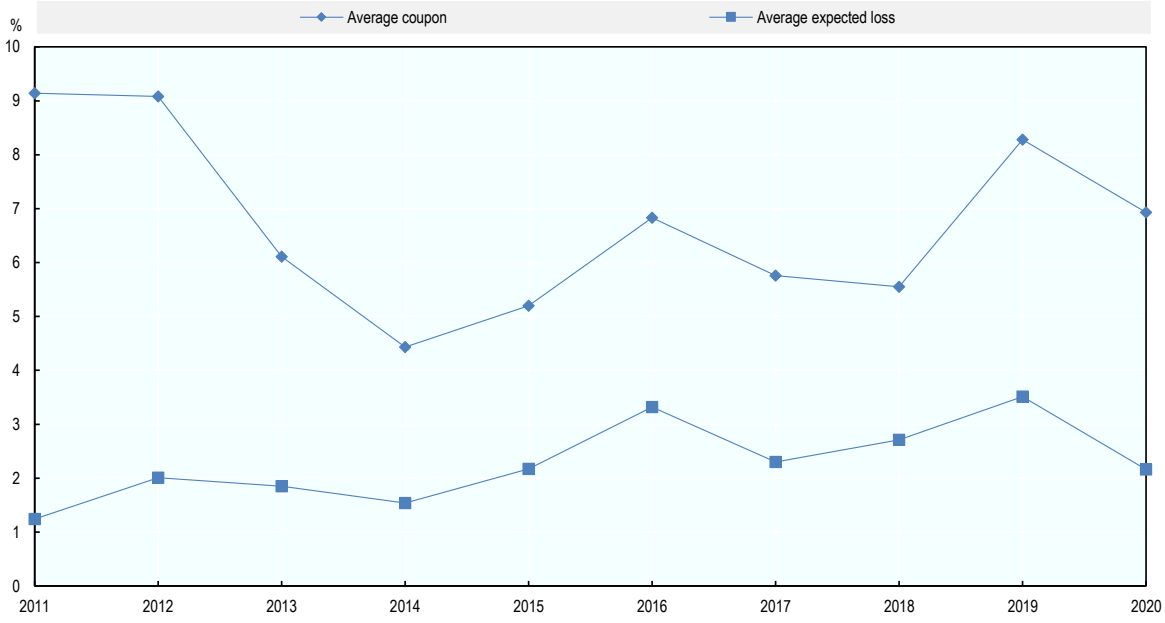
Bond-specific factors, such as the number of perils covered and time to maturity, are additional drivers of CAT bond premiums. CAT bonds can be designed to provide coverage against multiple types of events simultaneously in a single country or in multiple geographic locations. Typically, these multi-peril CAT bonds are not triggered by the first event. For instance, multi-peril CAT bonds provide coverage once a major Japanese earthquake or US windstorm has already occurred during a defined period. Thus, investors are unlikely to lose any principal until at least two major events have occurred. Multi-peril CAT bonds are typically of investment grade and particularly attract institutional investors restricted to purchasing only investment grade bonds (Woo, 2004[22]). From the sponsor's side, multi-peril CAT bonds reduce transaction costs, as they can insure many peril types in a single bond (Guy Carpenter and MMC, 2007[7]). However, empirical evidence shows that higher deal complexity in terms of the number of insured perils tends to inflate the premiums (Gürtler, Hibbeln and Winkelvos, 2014[20]; Galeotti, Gürtler and Winkelvos, 2013[21]). This may imply that an additional risk load is imposed by the market on multi-peril CAT bonds compared to single-peril ones (Galeotti, Gürtler and Winkelvos, 2013[21]). As regards time to maturity, a recent study by Herrmann and Hibbeln (2021[23]) shows that the seasonality in the probability of CAT bonds being triggered causes strong seasonal fluctuations in spreads (e.g. the spread on a hurricane bond is highest at the start of the hurricane season and declines as time goes by without a hurricane).

Other authors have investigated the impact of financial market variables on CAT bond premiums. Since the bulk of CAT bonds are denominated in US dollars, sponsors whose national currency is not the US dollar are exposed to an exchange rate risk. This risk could be covered by introducing a currency hedging cost in the pricing of these bonds, which would therefore increase their overall premiums. An early contribution to this topic is a study by Poncet and Vaugirard (2001[24]), which shows that the currency

exchange risk has a negative effect on the CAT bond price compared to the natural risk. More recently, Lai, Parcollet and Lamond (2014[25]) conclude that CAT bond prices correlate positively with the exchange rate and the foreign interest rate. Conversely, the volatility of the exchange rate and the correlation between the exchange rate and the domestic interest rate have a negative impact on the price.

Prices are also a function of the expected loss. Using a dataset comprising 250 CAT bonds issued on capital markets, Lane and Mahul (2008[26]) find that the market-based catastrophe risk price is estimated to be 2.69 times the expected loss over the long term. The relationship between loss severity and loss frequency has also been discussed quite extensively in the specialised literature. Jaimungal and Chong (2013[27]), assess the role that clustering in activity or severity plays in catastrophe modelling. They propose two marked point processes to account for these features. The first approach assumes that the points are driven by a stochastic hazard rate modulated by a Markov chain, while in the second approach the points are driven by a self-exciting process. These approaches support the hypothesis that the occurrence of a catastrophe event might increase the likelihood of the occurrence of another catastrophe event (Jaimungal and Chong, 2013[27]). Based on available data, the average coupon for CAT bonds issued in 2020 stood at 6.93%, with an average expected loss of 2.16% (Figure 2.4).

Figure 2.4. CAT bond average coupon and average expected loss, 2011-20 (%)



Note: Only 144A CAT bonds or similar are included. 144A CAT bonds refers to privately placed CAT bonds under Rule 144A of the US Securities Act.
Source: (Artemis, n.d.[9]), *Catastrophe Bond & Insurance-linked Securities Deal Directory* (database), www.artemis.bm/deal-directory/.

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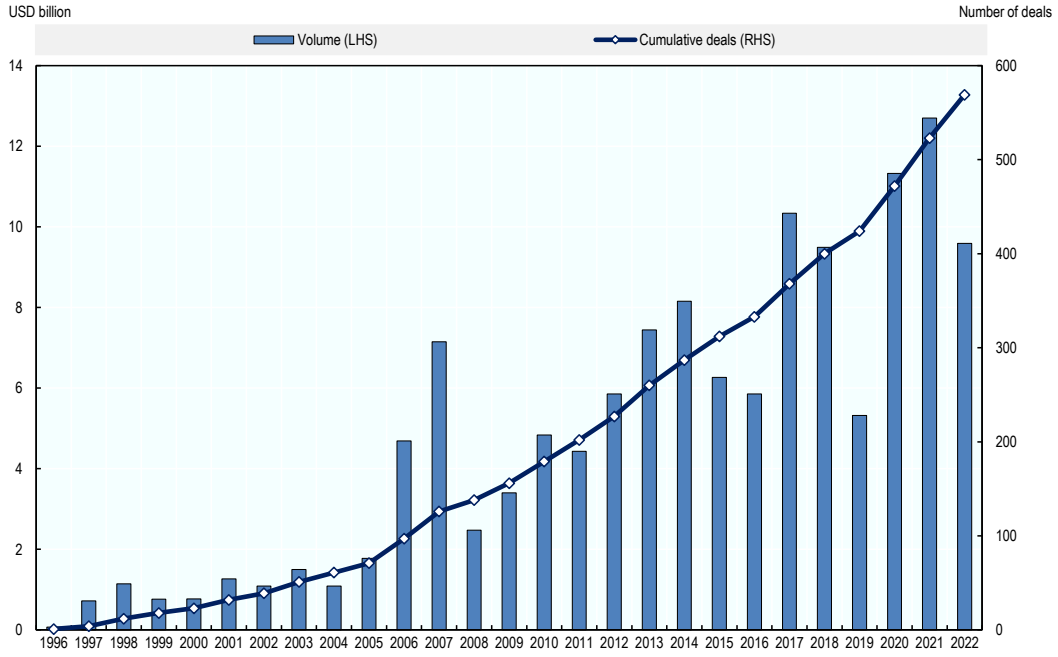
Recent trends in CAT bond markets

The CAT bond market has grown steadily since it began developing in the 1990s, with the corporate world as the main issuer over the first decade (Michel-Kerjan et al., 2011[5]). From a single transaction recorded in 1996, cumulative issuance of CAT bonds amounted to more than 560 deals in 2022 (Figure 2.5). In terms of volume, cumulative CAT bond issuance surpassed USD 12 billion in 2021. More importantly, CAT bonds exhibit little return correlation with other asset classes, making them a great portfolio diversifier (Figure 2.6).

Figure 2.5. CAT bond issuance and number of deals, 1996-2022



Note: Only 144A CAT bonds or similar are included. 144A CAT bonds are privately placed CAT bonds under Rule 144A of the US Securities Act. LHS = left hand scale. RHS = right hand scale.
Source: (Artemis, n.d.[9]), *Catastrophe Bond & Insurance-linked Securities Deal Directory* (database), www.artemis.bm/deal-directory/.

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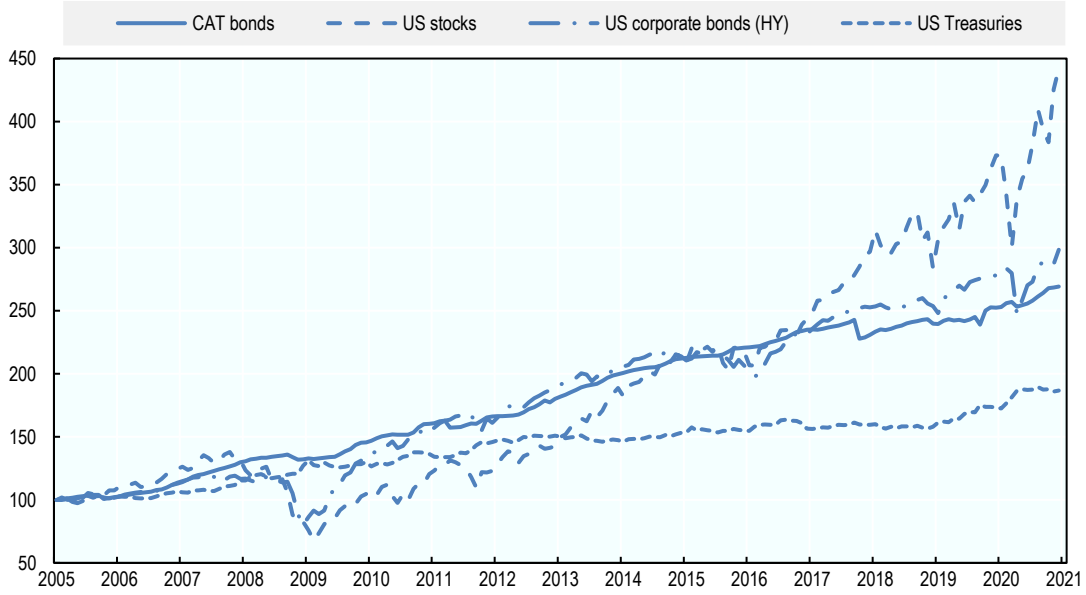
Figure 2.6. Historical catastrophe bond performance



Source: Authors' elaboration, based on data from Bloomberg for the stock markets (S&P 500) and bond markets (Barclays Corporate Bond and Treasury Indices).

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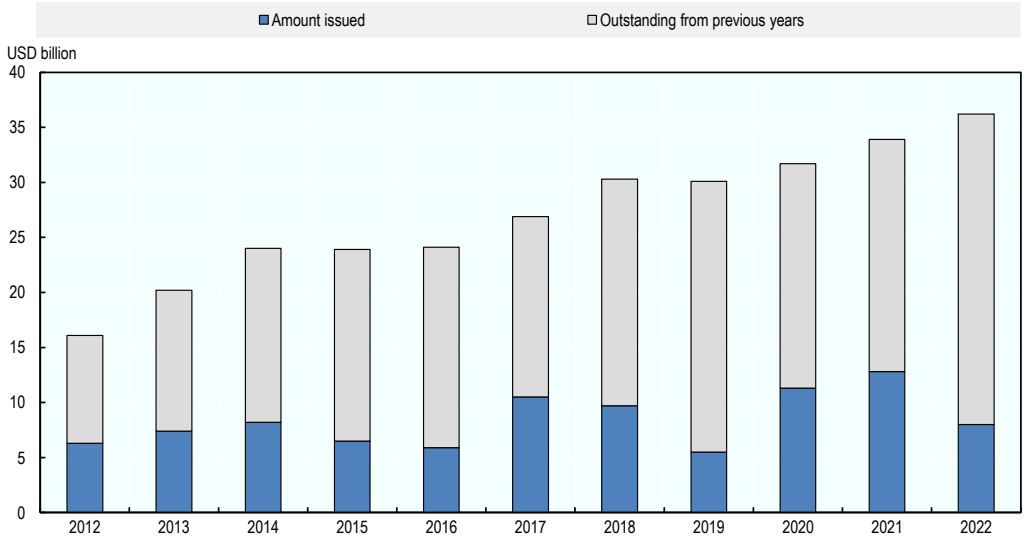
In 2020, as the COVID-19 pandemic unfolded and uncertainty hit financial markets, a secondary market sell-off hit CAT bond markets. The sell-off was largely caused by entities like multi-strategy asset managers seeking opportunities in other markets. As uncertainty related to the COVID-19 pandemic spread in financial markets, the capital position of the CAT bond market came into question frequently.

In 2022, the prevailing conditions included rising inflation, increasing interest rates and notable political and economic uncertainties. CAT bond investors remain concerned about the potential rise in claims and have demanded higher spreads to compensate for the associated risks. Indeed, the spread levels for CAT bonds have soared to heights not witnessed in more than ten years (Swiss Re, 2023[28]). The widening of spreads has had significant repercussions, including severe markdowns on bonds that were completely unaffected by any catastrophe events (Twelve Capital, 2023[29]).

Despite the challenging market conditions, some sponsors were undeterred and proceeded to issue CAT bonds, disregarding the high spread levels. This may have been in the aim of securing capacity, especially considering the extended January renewals season and the scarcity of capital (Swiss Re, 2023[28]). New issuance in the first half of 2022 stood at USD 8 billion, below the 2021 issuance of USD 12.8 billion (Figure 2.7). Nevertheless, even with a substantial amount of new issuance in the first six months of 2022, the CAT bond market measured by notional outstanding has grown by approximately 6.8% since the end of 2021. At the end of the third quarter of 2022, Hurricane Ian contributed to the increase of uncertainty in terms of trapped capital, losses and the possibility to place new issuance.

Figure 2.7. Notional amount of CAT bonds outstanding, 2012-22



Note: 2022 data are as of 30 June.
Source: (Swiss Re, 2022[30]), *Insurance-linked securities market insights*.

StatLink https://stat.link/4drmh6

Some CAT bonds have recently been given additional features, such as links to environmental, social and governance (ESG) concerns. ESG-themed CAT bonds are an extension of the basic CAT bond model that could attract investors interested in climate change mitigation projects. Under an ESG bond framework, the issuer might agree to invest the proceeds in green projects only. An ESG CAT bond issued by the Italian insurance company Generali to cover multiple perils in North America and Europe raised EUR 200 million (Natixis, 2022[31]). The framework governs what types of projects can have green CAT bonds issued for them and how the freed-up capital can be allocated. The framework has two main approaches. The first is to use the freed-up capital benefit for green assets and underwriting. The second

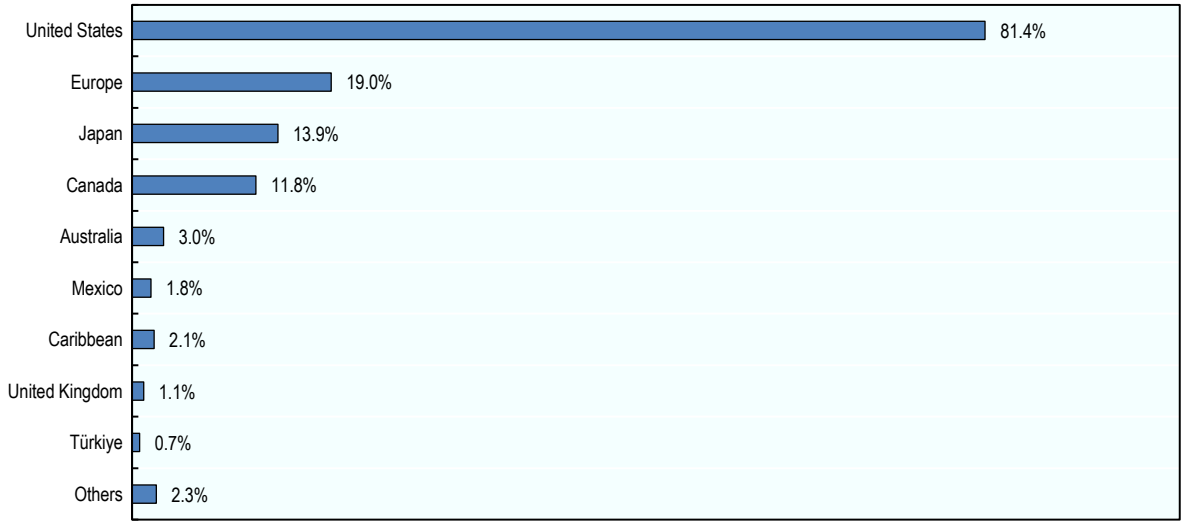
is to invest the proceeds contained in the special-purpose vehicle (SPV) in a portfolio of green investments for growth.

The development of CAT bond markets in Dynamic Asia and the Pacific

CAT bond markets remain underdeveloped in the countries of Dynamic Asia and the Pacific, with advanced economies dominating most issuance (Artemis, 2020[32]). CAT bonds have mainly been issued to cover certain named perils in Europe, Japan and the United States, while the coverage for developing countries represents a much smaller share (Figure 2.8). Among countries and regions with emerging economies, the Caribbean and Mexico are covered more frequently than others. To date, the Artemis Deal Directory lists a CAT bond issued in November 2019 to provide financial coverage to the Philippines in the event of earthquakes and tropical cyclones as the only CAT bond covering property risks among the member countries of the Association of Southeast Asian Nations (ASEAN) (Artemis, n.d.[9]).

Figure 2.8. Geographical coverage of CAT bonds issued from 1996-2022

Percentage of total issuance



Note: Only 144A CAT bonds or similar issued in 1996-2022 are included. "Others" includes Chile, the People's Republic of China, Cyprus, Colombia, El Salvador, Guatemala, Israel, New Zealand, Peru, the Philippines and Chinese Taipei. Some percentages involve multiple counting; this applies to a CAT bond transaction that covers multiple countries or regions.
Source: (Artemis, n.d.[9]), *Catastrophe Bond & Insurance-linked Securities Deal Directory* (database), www.artemis.bm/deal-directory/.

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Singapore is the most active market in ASEAN for CAT bond issuance. During the 12-month period ending on 30 June 2020, four CAT bonds were issued out of Singapore. They were issued using the ILS Grant Scheme launched by the Monetary Authority of Singapore (MAS) in February 2018 to help fund upfront ILS bond issuance costs. Three of these were sponsored by ceding insurers based in the United States to cover losses related to hurricanes there (Aon, 2020[33]).

As of April 2023, the ILS Grant Scheme offered by MAS had provided support for the issuance of 23 CAT bonds in Singapore (PMO, 2023[34]). In an effort to support the development of the market, the initiative has been extended for an additional three years and is now available to qualifying CAT bond and other ILS sponsors until the end of 2025. The extension of the scheme specifically aims to assist in covering the

costs associated with issuing CAT bonds that focus on risks within the Asian region. This may suggest that the scheme's focus is increasingly shifting towards supporting CAT bonds and ILS instruments that transfer regional risks, rather than international risks.

Within the region, Hong Kong, China is gaining momentum as an international hub for risk management. The supportive regulatory environment for ILS in Hong Kong is already benefiting (re)insurers seeking to diversify their risk portfolios. Various initiatives have been implemented, including the simplification of authorisation and regulations for special purpose insurers (SPI), as well as the introduction of a pilot ILS grant that offers up to HKD 12 million (Hong Kong dollars), or about USD 1.5 million, to cover issuance costs.

The first CAT bond domiciled in Hong Kong, China was a USD 30 million transaction sponsored by China Re Group, a state-owned reinsurer, in September 2021. However, this particular transaction did not make use of Hong Kong, China's ILS grant scheme. The scheme was first used by Peak Re, a Hong Kong-based reinsurance company, for its inaugural CAT bond issuance in June 2022. Later in 2022, a Chinese domestic insurer, PICC Property and Casualty Company Limited, sponsored a USD 32.5 million deal to obtain earthquake reinsurance coverage in China, taking advantage of the ILS grant scheme in Hong Kong, China.

The most recent CAT bond based in Hong Kong, China was issued by the World Bank's International Bank for Reconstruction and Development (IBRD) in March 2023. It provides Chile with USD 350 million of parametric earthquake protection. This landmark transaction marks the first-ever CAT bond to be listed on the Hong Kong Stock Exchange (HKEX) (World Bank, 2023[35]).

The development of Singapore as a hub for CAT bonds and the emergence of Hong Kong, China as an international risk management centre underscore the increasing importance of Asia in the global CAT bond landscape and the potential for further growth and innovation in the region. Countries in Dynamic Asia and the Pacific have the opportunity to take advantage of this progress. Singapore, which is a relatively new but increasingly attractive listing location, can be chosen as the domicile for countries in the region that are looking to sponsor CAT bonds. This choice is likely to be well-received, as it aligns with Singapore's aspirations to lead the region in green finance. It is particularly relevant for ASEAN.

CAT bonds also have potential in Central Asia, where disasters have taken a significant toll over the last two decades, resulting in losses exceeding USD 1.5 billion and affecting the lives of more than 2.5 million people (World Bank, 2021[36]). The countries of Central Asia – Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan – are prone to floods, earthquakes and landslides. As the CAT bond market is primarily exposed to risks in the United States, Europe and Japan, diversifying into risks from Central Asia may offer attractive opportunities for investors. Multilateral development banks can serve as intermediaries between the sponsoring countries and investors, allowing a reduction of investors' exposure to credit risk.

The projected economic impact of climate change in South Asia makes CAT bonds relevant there as well. A simulation by the Asian Development Bank (ADB) estimates that economic damage in South Asia due to climate change will average 1.8% of GDP by 2050 and could soar to around 8.8% of GDP by 2100 (ADB, 2014[37]). Without proactive efforts to adapt to and mitigate global climate change, average total economic losses could reach 9.4% for Bangladesh, 6.6% for Bhutan, 8.7% for India, 12.6% for the Maldives, 9.9% for Nepal and 6.5% for Sri Lanka. To address this challenge, (re)insurance and ILS, particularly CAT bonds, offer a robust financial tool for mitigating climate-related risks and protecting the well-being of South Asian communities.

The rise of CAT bond markets also represents an opportunity for Pacific Island countries. Many countries in this region have recently embraced contingent credit, a significant step that can allow countries to become familiar with trigger-based financing mechanisms. This may open the door to exploration of more innovative risk transfer instruments using a trigger-based approach, particularly CAT bonds. Moreover,

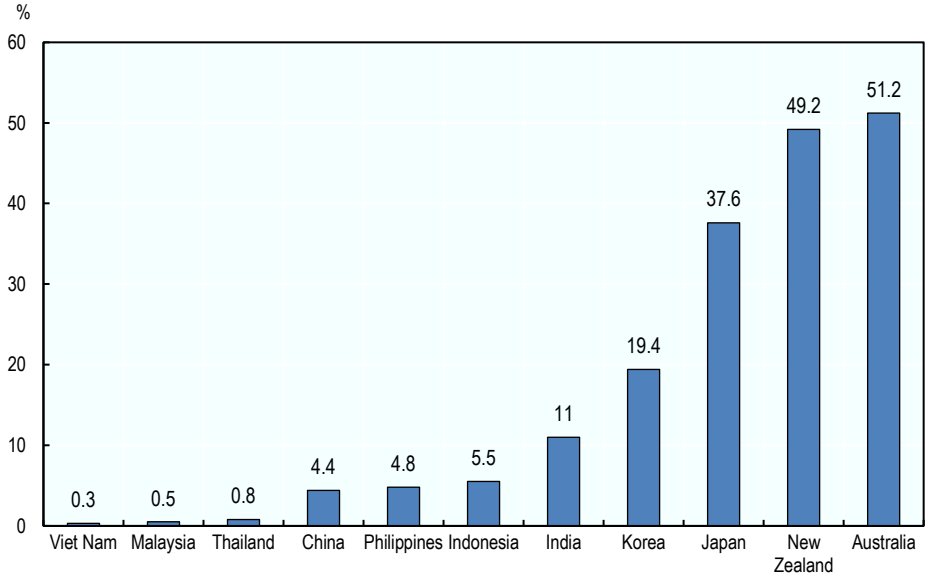
contingent credit arrangements often involve engagement with international financial institutions. As countries navigate these relationships, they establish connections with organisations that are active in global financial markets. This network can be leveraged when considering CAT bonds, which require interaction with a broader range of financial stakeholders. As Pacific Island countries become better prepared for disasters and strengthen their ability to respond, CAT bonds offer them an option for securing financial support in the event of a catastrophe.

Prevalence and consequences of protection gaps

Protection gaps are a major issue for both OECD and emerging economies. The natural catastrophe insurance protection gap is defined as the difference between economic losses and insured losses from natural disasters (Holzheu and Turner, 2017[38]). This gap has now reached a staggering USD 368 billion, with approximately 76% of natural catastrophe exposure remaining uninsured (Evans, 2023[39]). In the United States, protection gaps are relatively high for hurricanes, floods and wildfires. The Federal Emergency Management Agency (FEMA) estimates that fewer than 50% of US homeowners have flood insurance. The situation is far worse for countries with emerging markets. Over the last decade, only 5% of flood losses and 11% of tropical cyclone losses were covered through insurance in these countries, according to estimates by Swiss Re (2022[40]). Figure 2.9 shows that insurance coverage for disasters is limited in Emerging Asia (ASEAN member countries, China, and India). For instance, from 2012 to 2018, just 0.3% of overall losses were insured in Viet Nam, 0.5% in Malaysia and 0.8% in Thailand. In OECD countries the proportion is much higher, for example 51% in Australia and 49% in New Zealand. Emerging Asia exhibits the world's largest protection gaps: 90-100% of storm, flood and earthquake losses in the region are uninsured (Swiss Re, 2018[41]).

Figure 2.9. Insured losses from natural disasters in Asian countries, 2012-18

Percentage of overall losses



Source: Munich RE's NatCatSERVICE (database), https://www.munichre.com/en/solutions/for-industry-clients/natcatservice.html.

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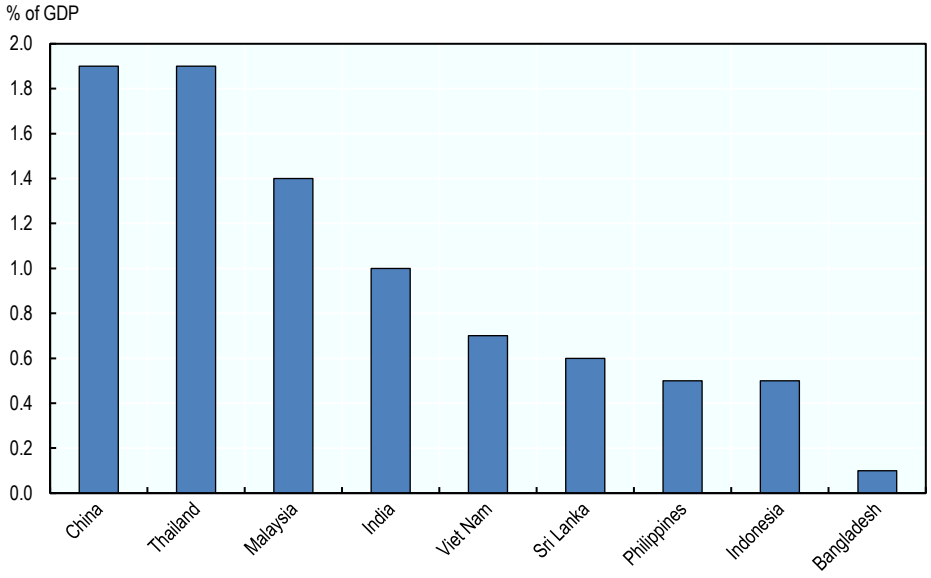
Another way to look at this issue is to consider insurance penetration, which reflects the development of the national insurance sector. It relates the aggregate volume of insurance premiums in an economy to GDP. Figure 2.10 compares the insurance penetration rates of selected Asian countries in 2021.

Figure 2.10. Insurance penetration in selected Asian countries, 2021 (premiums in % of GDP)



Source: (Swiss Re, 2022[40]), *World insurance: Inflation risks front and centre*.

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Conclusion

Dynamic Asia and the Pacific face large exposure to natural hazards, and disasters are increasing in frequency and intensity. As these changes are happening faster than the development of resilience, protection gaps are widening, and the challenge of closing them is growing. While there is no one-size-fits-all approach to disaster risk financing, catastrophe bonds (CAT bonds) are a potentially useful tool that could help sovereigns offload risk onto the private sector, reducing their burden. These instruments offer investors a coupon stream in exchange for taking the risk. The optimal choice of trigger depends on the needs and situations (e.g. speed of payout, basis risk, willingness to pay transaction costs to construct the CAT bond). Factors that affect premiums include the number of perils covered in a CAT bond, time to maturity, the degree of moral hazard in the trigger, the currency in which the bonds are denominated and the expected loss for investors, the estimation of which can be affected by the availability of robust, accurate and current data.

CAT bond markets have developed steadily in advanced economies since 1990s. Financial conditions associated with the COVID-19 pandemic slowed market growth in 2020, but it has since rebounded, and CAT bonds with additional features (such as ESG components) have become more popular. Uptake in countries in Dynamic Asia and the Pacific has been slower but there is significant room to strengthen CAT bond markets in the region.

Notes

1 Dynamic Asia refers to Emerging Asia – the ASEAN-10 countries plus China and India – along with other member countries of the South Asian Association for Regional Co-operation (SAARC), the countries of Central Asia, as well as Mongolia in East Asia.

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3 Benefits and challenges of developing catastrophe bond markets in Asia and the Pacific

This chapter outlines the advantages, challenges and policy directions related to catastrophe (CAT) bonds in Dynamic Asia and the Pacific. CAT bonds can provide a solution to natural disaster exposure as they do not require a pre-existing insurance market, and parametric triggers allow for a fast pay-out mechanism. In addition, CAT bonds minimise counterparty risk through full collateralisation with high-quality securities and allow for efficient price discovery through a decentralised market. Challenges that hinder the development of CAT bond markets include infrastructure prerequisites, funding constraints, and regulatory limitations. Additionally, parametric triggers lead to basis risk. Policy recommendations emphasise a holistic approach to strategic risk transfer planning, knowledge-building, infrastructure investment, data quality enhancement, and broadening investor bases.

Introduction

Natural catastrophes claim human lives and cause substantial economic losses across the globe. The associated costs have grown continuously over the last four decades, from an annual average of USD 30 billion in the 1980s to USD 207 billion between 2010 and 2019 (Swiss Re, 2022[1]).[1] Insurance often covers just a fraction of these costs.

The financial burden resulting from underinsurance, the often referred to as the disaster protection gap, is either shouldered by the public sector or remains with households and companies. The countries of Dynamic Asia and the Pacific usually exhibit larger protection gaps than advanced economies and have less financial flexibility at the government level (see Chapter 2). They thus find it much harder to deliver comprehensive disaster relief and recovery packages as well as a strong fiscal response for reconstruction in the wake of major catastrophe events.

The countries of Dynamic Asia and the Pacific have various options for mitigating this problem. The most straightforward is to promote the maturation of national insurance markets for the coverage of disaster risk. Yet even with rapid advances in technology, it will take time to build up the required organisations and capital bases. Another option is a national disaster fund that underwrites the risk from households and companies. A key challenge in this case is on the distribution side. Alternatively, to secure risk financing directly from capital markets, governments can use insurance-linked securities (ILS). The most popular and tested instrument in this regard is the sovereign-sponsored catastrophe (CAT) bond.

This chapter explores the possibility of disaster-risk transfer through catastrophe bonds in Dynamic Asia and the Pacific. It finds that CAT bonds are a promising means of improving resilience. This is mainly because these bonds can be issued in the absence of a mature insurance market, in most cases they allow for fast settlement. Nevertheless, several countries in Dynamic Asia and the Pacific will need to establish the fundamental preconditions for catastrophe bond issuance, including reliable data providers and measurement stations, suitable risk models and a transparent and robust process for allocating proceeds in case of a trigger event.

This chapter firstly considers the main benefits of CAT bonds for the economies of Dynamic Asia and the Pacific. It then discusses the major challenges that must be overcome to reap these benefits. Finally, the chapter offers policy recommendations and attempts an outlook for disaster-risk financing strategies via catastrophe bonds.

Benefits of catastrophe bonds for Dynamic Asia and the Pacific

Catastrophe bonds, financial instruments that utilise a process called securitisation to wrap natural disaster risk into a tradable format (see Chapter 2), can, in most cases, provide a fast means of absorbing the impact of natural catastrophes in the short run since bond protection can be put in place immediately. Within a risk financing strategy, CAT bonds are one of the options for ensuring adequate funding for disaster responses, and they are ideal for transferring low-frequency, high-severity risk. Moreover, catastrophe bonds can be issued anytime and have a typical term of three years, therefore offering flexibility and price stability. CAT bonds are designed to immunise the sponsor against counterparty default risk through full collateralisation with high-quality securities. Furthermore, the use of parametric triggers potentially allows for a quick source of funding, while price signals from the CAT bond market and modern pricing models allow for informed decision making. Investors need to diversify their ILS portfolios, thus they tend to accept a spread discount by sharing risks at a multi-country level.

The discussion that follows will consider various benefits of the use of catastrophe bonds:

- diversification of coverage
- flexible multi-year coverage

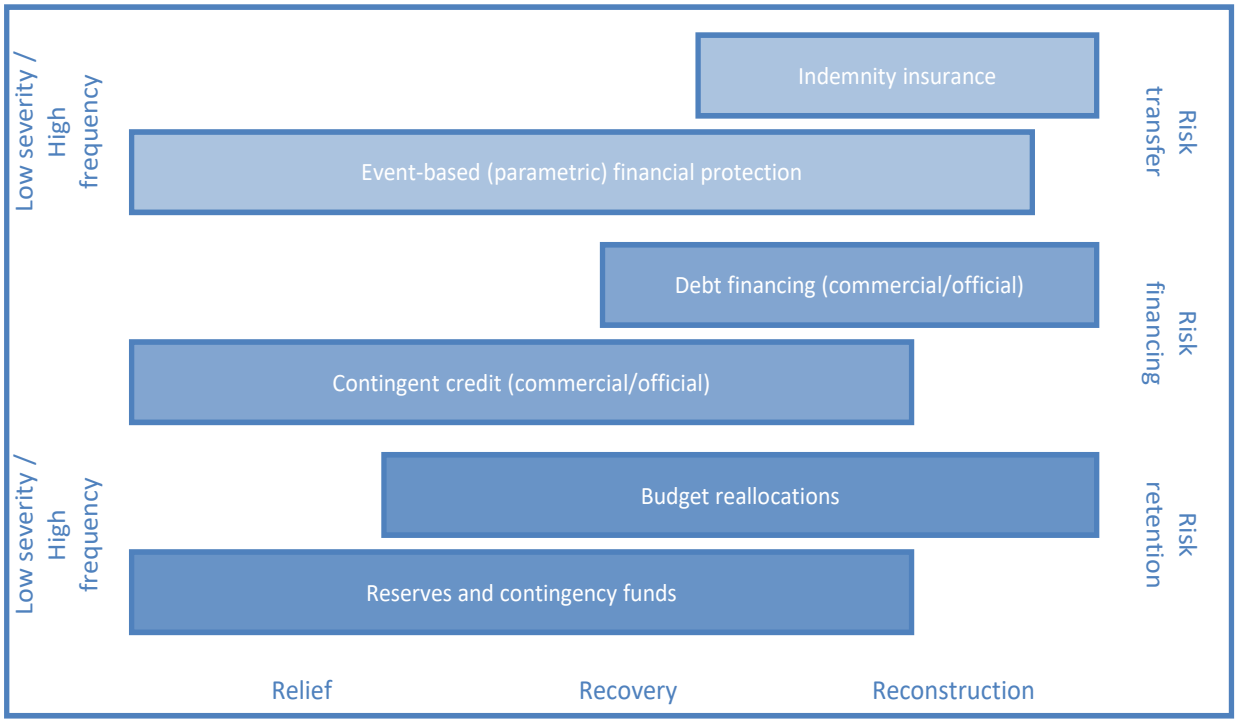
- full collateralisation
- transparency and, in most cases, fast settlement
- efficient price discovery
- multi-country risk sharing

CAT bonds are an important instrument for the diversification of coverage

The countries of Dynamic Asia and the Pacific have various options for financing disaster losses that accrue to the assets of households, companies and the public sector. The extent to which governments can leverage these tools depends on rigidities in the budget as well as competing economic, social and political objectives. Considering these pressures, this section reviews the public financial management practices that governments can use to respond to disaster shocks.

Figure 3.1 shows various financing tools that can be used to cover costs from disasters. Government's optimal post-disaster response is determined by the type of hazard and the magnitude of disruptions to economic activity, among other things (OECD, 2022[2]). Budget reallocations are suitable for absorbing losses caused by disasters that will not overburden a country's fiscal capabilities. When disasters cause emergencies, funds within a budget can be redistributed across programmes, budget lines and ministries thereby allowing a government to restructure expenditures within the range of its approved budget, limiting the fiscal shock. However, depending on the size of the hazards to be covered, budget reallocations can be costly as they put other objectives at risk. Shifting resources from one spending priority to another can cause disruptions in the provision of certain public goods and services.

Figure 3.1. Funding approaches to cover contingent liabilities from disasters



Source: (OECD, 2022[2]), *Building Financial Resilience to Climate Impacts: A Framework for Governments to Manage the Risks of Losses and Damages*.

On the other hand, sovereign CAT bonds and reinsurance coverage secured through a sovereign disaster risk fund pertain to the higher loss layers that will be reached when a rare large-scale disaster strikes. These risk tools ensure that post-disaster funding through financial support from donors, tax increases or the issuance of government bonds comes into play for the residual losses. In many cases, tax hikes and debt financing are not a country's desirable options. Tax increases take time to implement and can have a negative impact on the economy as they reduce disposable income and consumer spending, while debt financing may affect a country's longer-term fiscal flexibility. Although countries can hope for the financial support of donors, it takes time to mobilise international aid, and such aid typically covers only a small fraction of the overall disaster losses (Swiss Re, 2018[3]).

In light of these considerations, CAT bonds are an important instrument for the diversification of coverage in a disaster risk financing framework. Such a framework can be developed based on both theoretical guidelines and best-practice experiences. For example, Clarke et al. (2017[4]) propose a framework that supports sovereigns in evaluating ex ante risk financing instruments and choosing an appropriate combination, taking economic and political constraints into consideration. The size of a CAT bond relative to the weight of the other instruments in the framework should be determined, among other factors, based on the current price of coverage in the CAT bond market relative to the cost of alternative measures, such as traditional reinsurance coverage.

Finally, planning the funding for a disaster budget should take place early. Financing of the spreads (ROLs) for CAT bonds can be challenging for emerging market sovereigns, as they may have limited tax income, restricted access to capital markets and high borrowing costs. Hence, it is of utmost importance to plan early and integrate the costs for the whole disaster risk management programme into fiscal planning on an ongoing basis. Good fiscal planning requires the effective management of public resources. Governments must balance the funds required to pay the premiums during the term of the CAT bond against other public spending needs. However, they should also consider the present value of the expected future cost of relief, recovery and reconstruction, which would need to be funded if no disaster risk coverage is put in place.

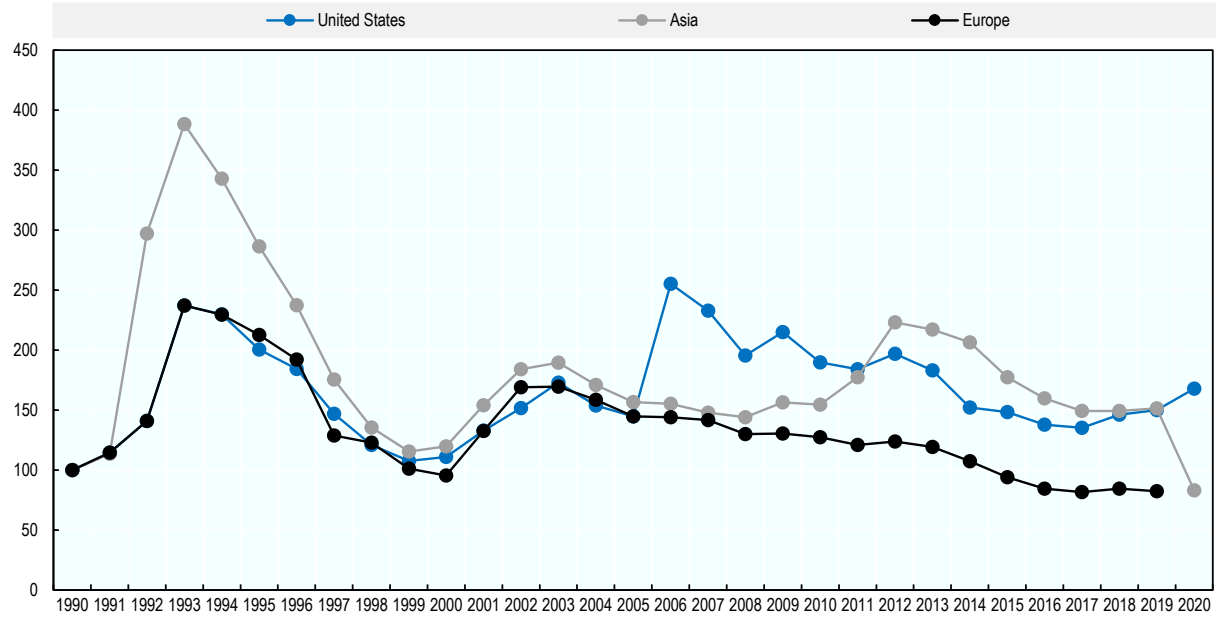
To alleviate the strain of the spread on the country's budget, governments should aim to exploit the non-peak territory and multi-country discounts in the ROL, discussed above. To this end, they could engage in roadshows to educate investors about the diversifying properties of non-peak perils for ILS portfolios that are heavily US-centred. They could also initiate discussions with neighbouring countries that are exposed to the same types of natural disasters. If the opportunity for a supranational risk pool arises, all member countries would be able to benefit considerably from the sharing of the issuance costs and the multi-country spread discount.

Countries have different fiscal capacity, to mobilise their budget, use debt financing and access risk financing and risk transfer markets. Different countries will therefore choose different financing solutions based on the conditions they face.

CAT bonds offer flexible multi-year coverage

CAT bonds can be issued at any time and typically exhibit a term of three to four years. Accordingly, they guarantee emerging countries multi-year coverage for natural catastrophe risk. This is not the case with traditional reinsurance contracts, e.g. those accessed through a sovereign disaster fund, because global reinsurance markets are subject to annual renewal at fixed dates[2] (Gallagher Re, 2022[5]). One-year coverage requires annual renegotiation. This is time consuming and resource intensive for both cedents and risk carriers. Multi-year contracts can reduce this administrative burden. Moreover, multi-year coverage affords cedents better strategic risk management planning. Above all, however, one-year coverage exposes cedents to significant price risk because the rate on line (ROL), or the ratio of premium paid to loss recoverable, is known to fluctuate substantially over time, depending on the amount of risk capital available to the industry, among other factors (Cummins and Trainar, 2009[6]). This phenomenon, known as the reinsurance underwriting cycle, is illustrated by the Guy Carpenter Regional Property Rate-on-Line Index (Figure 3.2).

Figure 3.2. Reinsurance underwriting cycles



Note: The Guy Carpenter Regional Property Rate-on-Line Index, a proprietary index of regional property catastrophe reinsurance ROL levels, has been published since 1990 by Guy Carpenter, a global reinsurance broker. The prices are based on the firm's brokered excess of loss reinsurance contracts.
Source: Guy Carpenter, https://www.artemis.bm/regional-property-cat-rate-on-line-index/.

StatLink https://stat.link/l7zqej

Locking in a multi-year ROL through CAT bonds insulates sovereigns against these large price swings and removes uncertainty from their fiscal planning process. This is particularly valuable after the occurrence of large natural disasters, which tend to drain a substantial amount of capital from the reinsurance industry and subsequently cause a major surge in prices. Figure 3.2 shows the impact on the ROL of two of the costliest natural disasters in history, Hurricane Katrina in the United States (2005) and the Tohoku earthquake in Asia (2011). The consequences of Katrina were severe for cedents, who were abruptly forced to pay much higher premiums to maintain their reinsurance coverage. As insurers passed on costs to their customers, this led to increased rates for policy holders.

Many cedents therefore integrate CAT bonds into their risk management strategy specifically because of the multi-year coverage they offer. In 2022, the French reinsurance company SCOR successfully sponsored Atlas Capital Reinsurance 2022 DAC, a CAT bond that provided it with multi-year coverage of USD 240 million against named storms in the United States, earthquakes in the United States and Canada, and windstorms in Europe. According to Jean-Paul Conoscente, SCOR's chief executive officer, the decision to use a CAT bond was driven by the desire for multi-year coverage (SCOR, 2022[7]).

CAT bonds help to minimise credit risk via full collateralisation

Catastrophe bonds have been designed to minimise credit risk. This is achieved through full collateralisation (Lakdawalla and Zanjani, 2011[8]). The typical CAT bond collateral consists of United States treasury bills and is therefore very safe. Accordingly, both investors and sponsors can avoid the consequences of a counterparty default. For traditional reinsurance, in contrast, some credit risk remains despite the high financial strength ratings of reinsurance companies.[3] The reinsurer selling coverage to a sovereign disaster risk fund may fail to pay out following a major natural catastrophe.

If an insurance product fails to pay out following a major natural catastrophe, the effects can be devastating. In the case of an emerging country seeking coverage for the purpose of funding disaster relief and recovery, and possibly reconstruction as well, such a double default scenario would have dramatic consequences for the well-being of citizens and the financial resilience of firms. Empirical evidence shows how important this "remaining" credit risk is in reinsurance markets. For example, using data from the US property-liability insurance industry from 2002-09, Park Xie, and Rui (2018[9]) examined how sensitive reinsurance demand is to credit risk. They found that reinsurance ceded to a counterparty reinsurer decreases if the reinsurer suffers a rating downgrade. Their results hold at a 1% significance level and show large negative effects of a downgrade, even if the previous reinsurance rating is good. Similarly, Park and Xie (2014[10]) found that both financial ratings and stock prices of ceding insurers react negatively to downgrades by counterparty reinsurers. Hence, full collateralisation is a key benefit of CAT bonds for the cedent, as it notably reduces the uncertainty pertaining to the availability of funds in the case of a trigger event.

CAT bonds have high transparency and permit fast settlement, in most cases

In contrast to other instruments, CAT bonds exhibit high transparency and can deliver rapid payout in the case of a trigger event. This is particularly true if they rely on the parametric trigger mechanism. When a natural disaster has occurred and the respective measurements of the physical parameters have been taken, the transaction can be settled in a matter of days. For instance, only five weeks after a magnitude 8.1 earthquake hit the Chiapas region of Mexico in September 2017, a FONDEN-sponsored CAT bond paid out USD 150 million (Artemis, 2017[11]). In contrast, under an indemnity-based reinsurance contract, all incurred losses must first be verified through the claims management of the reinsurance company. Similarly, raising capital after a disaster by issuing government debt or raising taxes takes a considerable amount of time. A rapid payout can help to avoid additional expenses for cedents and investors.[4]

As delayed payments quickly lead to distrust in the viability of a risk management strategy, they could lead institutions and the general population of emerging countries to withdraw support for the sovereign risk transfer programme with CAT bonds. This would imply a step backwards in terms of the goal of reducing global protection gaps. Payout delays can have a major impact on impoverishment and economic growth, especially for emerging economies (World Bank, 2017[12]). Since their asset base is naturally low, the bridging of payment failures is often disproportionately expensive or impossible. This effect is particularly pronounced for vulnerable populations, such as women and children, and when the insured catastrophe also affects people's labour income.

Parametric triggers, in addition to allowing swift payout, also reduce the risk of legal disputes with investors because the parameter values are usually measured and published by an independent third party. This implies that the payout is based on a highly transparent measure that can be manipulated neither by the seller nor the buyer of protection. It should be mentioned, however, that even a parametric CAT bond does not completely exclude the possibility of disputes over the payout. Specifically, in the case of storms that impacted Mexico in 2014 (Hurricane Odile) and 2015 (Hurricane Patricia), storm chasers delivered atmospheric pressure readings that differed from the figures reported by official sources such as the US National Hurricane Center. This led to a delay of three months in the payout of Mexican CAT bonds (Blackman, Maidenberg and O'Regan, 2018[13]).

CAT bonds allow buyers efficient price discovery

Prices for CAT bonds are less opaque than those for traditional reinsurance. The existence of an over-the-counter secondary market ensures that indicative price sheets by broker dealers are updated on a regular basis. This provides prospective buyers with reliable signals on the current market pricing of natural disaster risk (Beer and Braun, 2022[14]). In contrast, reinsurance markets exhibit an oligopolistic structure. They update their pricing once a year for renewals. The up-to-date pricing information produced by the CAT bond market can be harnessed to calibrate accurate econometric and financial pricing models that have been

developed in recent years (see Annex 3.A.). Moreover, machine-learning approaches for the pricing of risk have become available (Götze and Gürtler, 2020[15]; Makariou, Barrieu and Chen, 2021[16]). The combination of adequate models and frequent market data ensures reliable price tags for risk transfer that enable informed decision making.

However, prospective cedents should be aware that the efficiency of price discovery depends on secondary market liquidity, which varies over time. It should also be noted that CAT bonds are less liquid than corporate bonds (Lane and Beckwick, 2016[17]). Herrmann and Hibbeln (2022[18]) find that a seasonality-implied increase of default risk leads to a substantial reduction of CAT bond trading, even in periods with much new information arriving in the market. The fact that CAT bonds referencing seasonal perils, such as cyclones, are less frequently traded during the risk season implies a higher likelihood of stale prices. This is different from the trading patterns of corporate bonds, where the information effect dominates (Herrmann and Hibbeln, 2022[18]). Issuance activity in the primary market for CAT bonds exhibits the same pattern: it is much lower during the hurricane season from June to November (Braun, 2015[19]). It is therefore advisable to plan the placement of coverage strategically and to avoid periods of low liquidity and inefficient price building.

Multi-country cost sharing offers advantages and a spread discount

A prominent example is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which issued a multi-country CAT bond in 2014, that provided insurance coverage for a group of sovereigns in the Caribbean and Central America against hurricanes, earthquakes and extreme rainfall events. Another example is the parametric Pacific Alliance CAT bond for earthquakes in Chile, Colombia, Mexico and Peru.[5]

Multi-country structures such as the CCRIF or the Pacific Alliance CAT bonds, offer substantial cost advantages (see Chapter 5 for a detailed discussion). Member countries of the pool can share structuring, legal and issuance expenses, which together are a major quantity.[6] Examples are the costs for the offering circular, the catastrophe risk modelling and the placement of the bonds. If the multi-country CAT bond covers adjacent countries, it may be possible to use the same risk model for example, especially when the countries' geological, hydrological and meteorological characteristics are similar. This is particularly useful for small developing nations with geographic similarities. A joint risk management programme with neighbouring nations affected by the same disaster risk can significantly ease the strain on fiscal budgets.

What hinders CAT bond development? Constraints and challenges

This section discusses challenges fostering catastrophe bonds in Dynamic Asia and the Pacific. When parametric triggers are used, it may lead to basis risk scenarios where a country has been struck by a disaster, but its sovereign CAT bond does not pay out. The use of parametric triggers also requires advanced and reliable infrastructure. An example is mesonets, or networks of automated weather stations, that can withstand cyclone wind speeds. Data providers that are independent and adhere to the highest standards of data processing, storage and submission are also needed, together with suitable catastrophe risk models to fill the historical data void. Funding of the CAT bond spreads often poses a challenge as well. When emerging country budgets are too tight to afford the CAT bond spread, sponsors may seek support through development aid. Moreover, the sovereign sponsor needs to design efficient and fair distribution schemes and ensure that social vulnerabilities are considered. The lack of a track record in CAT bond issuance can hamper investor interest. Investors may be concerned about the illiquidity of CAT bonds from Dynamic Asia and the Pacific, and little trading activity may create pricing uncertainty. Lastly, regulatory issues are another key factor limiting CAT bond market development. In many countries in Dynamic Asia and the Pacific, CAT bonds are a relatively new financial product, and legal and regulatory frameworks remain underdeveloped.

The discussion that follows will consider challenges to the use of catastrophe bonds, including:

- basis risk
- measurement infrastructure
- data quality
- rapid and target-oriented distribution of the proceeds
- liquidity and valuation concerns
- inconsistency in regulatory treatment.

Parametric triggers may lead to basis risk scenarios

Policy makers in Dynamic Asia and the Pacific may be reluctant to sponsor CAT bonds, which typically involve relatively high up-front costs and a possible payoff at some point in the future. The one-time costs of issuing CAT bonds tend to be higher than those of other types of debt securities (Michel-Kerjan et al., 2011[20]). CAT bonds are typically structured using offshore special purpose vehicles (SPVs) or special purpose insurers (SPIs).

As discussed in Chapter 2, most CAT bonds issued by insurance and reinsurance companies today exhibit indemnity triggers. Public sector CAT bonds, in contrast, often rely on the parametric trigger. The reason is rather straightforward. Unless a national risk pool acts as the CAT bond sponsor,[7] there is no portfolio of insurance policies that could be referenced by an indemnity trigger. The parametric trigger has further advantages in addition to its employability in the absence of an insurance portfolio, particularly transparency and rapid settlement.

The main drawback of parametric triggers is basis risk for the cedent.[8] Basis risk describes the situation in which a sovereign issuer may face substantial fiscal strain in the aftermath of a catastrophe, but the CAT bond does not pay out because the parameter value measured at the relevant geographic location did not exceed (or fall below) the trigger threshold. This happened, for example, in the case of MultiCat Mexico 2012-1, a sovereign CAT bond issued by FONDEN. Hurricane Odile hit Baja California in September 2014 and caused more than USD 1 billion in economic losses. Despite this substantial damage, the central pressure of the storm simply did not fall below the predefined threshold of 932 millibars (mb) (Artemis, 2014[21]). A similar situation occurred when Hurricane Sandy struck the Caribbean in 2012. Although three CCRIF member countries were impacted severely (Jamaica, Haiti, and the Bahamas), the event did not qualify for a payout from the programme. In two of the three cases, model-based loss estimates were below the trigger threshold, and in the third, the country was located outside of the modelled wind field (Artemis, 2012[22]).

Basis risk has been shown to negatively affect the demand for coverage (Mobarak and Rosenzweig, 2013[23]). It is hence crucial that emerging market sovereigns understand the consequences of basis risk and take measures to minimise it where possible. While the basis risk inherent in parametric triggers can never be fully eliminated, it can be mitigated through parametric indices and proper catastrophe risk modelling. These options will be discussed in greater detail in the context of the policy recommendations that close the chapter.

Parametric triggers require reliable measurement infrastructure

Parametric triggers require reliable measurement infrastructure in the geographic territory covered. In the earlier days of the CAT bond market, parametric triggers for cyclone risk were not possible even in the United States due to the lack of a reliable network of hurricane-hardened weather stations. Standard anemometers, which measure wind speed and direction, needed to be deactivated or failed because of extreme storm gusts. This led to a survival bias, because only those stations that did not experience the most severe wind conditions were able to provide readings (Brookes, 2009[24]). A network of catastrophe-resistant

meteorological or geological measurement stations (ideally with redundancies) is thus crucial for the accurate recording of wind speeds or earthquake strengths for parametric CAT bonds.

The measurement network should also guarantee sufficient density of stations (UN ESCAP, 2015[25]). A report by India's Agricultural Finance Corporation showed that 77% of farmers who used parametric crop insurance were dissatisfied with the location of weather stations (AFC, 2011[26]). The stations had been installed too far from their farms and thus did not adequately reflect their exposure.[9] The World Food Programme, in a joint study with the International Fund for Agricultural Development, estimated in 2010 that for accurate insurance coverage in India, the weather station network would need to be expanded by additional 10 000 to 15 000 units, implying an investment of USD 5-6 million in installation costs and an additional 25% per year in maintenance costs (World Food Programme, 2010[27]). Emerging countries that lack measurement infrastructure may therefore need a significant public investment before parametric CAT bonds can be utilised for sovereign risk transfer.

For other natural perils, such as floods or drought, satellite or drone data could be a cheaper alternative (Matheswaran et al., 2018[28]; Whitehurst et al., 2022[29]). Satellite data is cost efficient and less prone to manipulation than data from conventional weather stations. Yet there are limitations, such as reduced performance in cloudy periods and over mountainous terrain (UN ESCAP, 2015[25]).

Data quality and reliable data providers are also needed

Apart from the measurement infrastructure, sovereign CAT bonds are not feasible without trustworthy data providers. First, the private or public organisation operating the networks of measurement stations in the emerging country, e.g. the national weather service or geological science agency, needs to be independent and adhere to the highest standards of data processing, storage and submission. This will ensure accurate and reliable readings for each catastrophic event that are acceptable as a basis for million-dollar CAT bond transactions.

Second, moral hazard is thought to arise in the context of indemnity-trigger CAT bonds. Since the payout under indemnity triggers is tied to the own losses of the sponsor, the latter has strong economic incentives to relax underwriting and claims handling standards after the coverage has been put in place. Empirical evidence on moral hazard is mixed. Chatoro et al. (2023[30]), and Braun (2015[19]) do not find moral hazard to be priced in the primary market, while Dieckmann (2010[31]), Papachristou (2011[32]), and Götze and Gürtler (2020[15]) claim to find empirical indications for ex ante moral hazard of CAT bond sponsors.

In addition, missing track records will be a challenge. The number of CAT bonds issued to date for sovereign risk transfer in emerging markets remains relatively small. This poses challenges to investor acceptance. While early adopters from the ILS industry have already participated in these transactions, attracting capital on a larger scale may require a longer track record and transaction history. Track records are important for investors because they provide valuable information about the past performance of an asset and the trustworthiness of the sponsor. This is particularly important in the context of exotic securities, such as CAT bonds. This issue may be relevant to pricing as Spry (2012[33]) notes that investors in the CAT bond market closely scrutinise the sponsor of a transaction.

Rapid and target-oriented distribution of the payout must be assured

Once a sovereign sponsor receives a CAT bond payout to fund its post-disaster needs, it requires sufficient personnel and processes to ensure an efficient and targeted distribution of the proceeds. Sovereign CAT bonds can be used to finance immediate relief as well as longer-term recovery and reconstruction. The first decision to be made concerns the allocation of the CAT bond funds across these three domains. This decision must consider further payouts from other components of the country's integrated disaster risk management strategy.

The capital dedicated to relief and recovery then needs to be deployed rapidly. Relief requires temporary shelters, food, medical support, etc., while recovery entails the restoration of critical infrastructure such as electricity, telecommunications and water supply. Time is of the essence for the effectiveness of these measures. Without a high degree of organisational preparedness, it may not be possible to achieve the maximum impact. In contrast, a long-term strategy is required for reconstruction. Countries will first need to prioritise the private and public sector assets needed to rebuild. The available capital will usually not suffice to fund a full reconstruction of all damaged or destroyed assets. Hence, a distribution scheme is needed to select the households or firms most in need of government support.

Unfortunately, empirical evidence points to the fact that disaster assistance is often inequitable, both in emerging and developed countries. The reason is that the distribution of public funds for relief and reconstruction commonly focuses on damages, but not vulnerability. This is a major issue, because the most vulnerable populations are least able to cope with the consequences of natural disasters (O'Keefe, Westgate and Wisner, 1976[34]). For example, Emrich, Aksha and Zhou (2022[35]) analysed the proceeds paid to US homeowners by the Individuals and Households Program (IHP) of the Federal Emergency Management Agency (FEMA) between 2010 and 2018. They found that allocations are driven by damages while ignoring social vulnerabilities. Their study also reveals significant imbalances in terms of the ethnic and racial composition of the receiving counties. Similarly, Drakes et al. (2021[36]) investigated the relationship between short-term disaster relief and social vulnerability, based on US data. Their results showed that geographic areas with a high social vulnerability were not sufficiently served by FEMA's IHP programme. Factoring social vulnerability into the distribution scheme for post-disaster assistance would help to combat major societal inequities.

Investors may have standardisation and liquidity concerns

Standardisation of financial instruments is a desirable feature from an investor's perspective as it improves market liquidity and helps investors to manage their portfolios in a more efficient manner. Investors are more likely to invest in CAT bonds if they view them as relatively liquid and standardised assets that are associated with low administration costs and that adhere to transparent pricing rules (Yago and Reiter, 2008[37]; Braun, Müller and Schmeiser, 2013[38]). Although the basic structure of CAT bond follows a standardised approach, most deals are tailor-made transactions. In issuance terms, the CAT bond market is currently almost evenly split between indemnity and non-indemnity structures (Artemis, 2022[39]). This lack of standardisation partly explains the current fragmentation of the CAT bond market and may be a challenge to further growth.

The role of standardisation in CAT bond market development has been discussed in the specialised literature. For example, to explain institutional investors' reluctance to invest in CAT bonds, Bantwal and Kunreuther (2000[40]) employ behavioural economics aspects, such as ambiguity aversion, myopic loss aversion and the fixed costs of education. The authors suggest that sponsors should aim for a larger degree of security standardisation in order to decrease demand and promote market growth. In a similar vein, (Cummins, 2005[41]) describes CAT bonds as a valuable means of portfolio diversification and emphasises that more standardised and transparent transactions, and the development of a public secondary market, would help realise the full potential of this asset class.

Illiquidity can be a major concern of CAT bond investors as it reduces the ability to trade out of an unwanted position. Illiquid securities are characterised by low trading volumes and wide bid-ask spreads. To find a buyer, investors may have to wait longer and accept a lower price. The prices of illiquid securities tend to be more volatile and may be stale. This poses difficulties in valuation and can lead to large losses if investors need to sell quickly.

Less liquid CAT bonds thus carry a higher spread. Using data from the Trade Reporting and Compliance Engine (TRACE), Herrmann and Hibbeln (2022[18]) disentangle the default and liquidity premium of CAT bonds. They find that the liquidity component included in secondary market CAT bond yields amounts to 98 basis points, or 21% of the total risk compensation, and they also document that this effect is more

pronounced for high-risk CAT bonds. Although there is no empirical evidence yet for the link between the structural characteristics of CAT bonds and the illiquidity premium, it may be suspected that the illiquidity premium is even larger for countries for which no sophisticated catastrophe risk models exist. Illiquidity may not only lead to higher risk spreads but may also affect the ability to value CAT bonds in general.

Inconsistency in regulatory treatment can limit CAT bond market development

Regulatory issues are another key factor limiting CAT bond market development. In many developing countries, CAT bonds are a relatively new financial product for transferring disaster risks, and legal and regulatory frameworks consequently remain underdeveloped. Development of appropriate frameworks may allow effective risk transfer and ensure the rights of investors, increasing their confidence and their demand for CAT bonds.

Sponsors may also be deterred by regulatory concerns. For instance, to be able to issue CAT bonds, sponsors need to establish an SPV or SPI. Regulatory frameworks should: enable the establishment of such an entity with appropriate and clear procedures and requirements; provide governing standards related to the management and administration of the SPV or SPI; and define the reporting system. Lack of SPV or SPI regulatory frameworks in developing countries is a major reason why CAT bonds are often issued offshore. Among Dynamic Asian countries, the Philippines and Thailand have issued regulations to govern the functioning of SPVs. However, the scope is limited to very specific transactions, such as the purchase of non-performing assets in the Philippines (BSP, 2002[42]) and securitisation transactions in Thailand (SEC, 1997[43]).

Information asymmetry and insufficient investor protection are also challenges that need to be addressed. Price transparency is essential for secondary market trading. Information asymmetry can deter investors from purchasing CAT bonds and thus hamper market liquidity. Investors may be reluctant to take on risks if the sponsor is assumed to have superior information. Using insights from behavioural economics, Froot (1999[44]) argues that the greater the information asymmetry, the greater the risk of adverse selection of transactions against the investor. This is because investors might be concerned that sponsors who consider the cost of protection low are those whose risk is greater than appreciated. This effect worsens as the cost of securing financial coverage increases. Relatedly, Li et al. (2019[45]) contend that greater disclosure of information means a lower transaction cost, which implies that the respective CAT bonds also display higher liquidity.

Issuers of CAT bonds are not requested to report on a regular basis, unlike issuers of traditional bonds. As a result, many of the investor protection rules common to most traditional registered investments are missing in the case of CAT bonds (FINRA, 2021[46]). Regulatory authorities therefore need to ensure that CAT bond sponsors disclose sufficient information on the state of the collateral securities and offer investors an ongoing view of the catastrophe risk.

Concerning the tax treatment of CAT bonds, the tax codes of many countries lack comprehensive guidance with regard to the clarity of the structure, the nature of the product and classification for tax purposes. This may hinder investors from engaging in transactions. Under International Financial Reporting Standards (IFRS), the accounting treatment of alternative risk transfer mechanisms depends on whether they are classified as reinsurance contracts or financial derivatives. Under IFRS, reinsurance accounting applies only to risk mitigation instruments that have an indemnity-based trigger (IFRS Foundation, 2021[47]).

This classification will determine the applicable tax regime. Due to the lack of specific guidance with respect to the treatment of CAT bonds, their classification for income tax purposes remains uncertain and highly dependent on the particular features of each tranche of each issuance. For instance, if CAT bonds are qualified as a financial instrument, whether they are classified as an asset or liability may affect the tax status of gains or losses. On the other hand, if CAT bonds are treated as a reinsurance contract, then CAT bondholders will be subject to the tax regime applicable to reinsurance products. However, because of their

inability to be bifurcated into an equity and liability component, CAT bonds tend to be closer to a financial instrument than to reinsurance (Kaplan and Lefebvre, 2003[48]).

The 2020 amendments to existing accounting standards will nevertheless allow contracts that limit compensation to the settlement of the policyholder's obligations to be classified as financial instruments under IFRS 9. The significant insurance risk included in the CAT bond contractual cash flows suggests that they would be accounted for at fair value through profit and loss (KPMG, 2020[49]). These developments are likely to bring more clarity to CAT bondholders. Policy makers in Dynamic Asia need to ensure that local accounting standards reflect these developments at the international level.

Policy directions for fostering catastrophe bond markets

Based on the benefits of CAT bonds for sovereign risk transfer, as well as the challenges associated with their adoption in Dynamic Asia and the Pacific, major policy recommendations can be drawn. These recommendations may serve as guidelines for government decision making regarding the development of new sovereign disaster risk management programmes or the enhancement of existing ones.

First, it is crucial to plan a grand design for sovereign risk transfer, focussing on the risk not covered by the private sector. CAT bonds are a key instrument for sovereign risk transfer and the reduction of protection gaps, and they should not be omitted. Building up know-how involves establishing expertise and experience regarding CAT bonds through training sessions and cross hirings and partnering with private firms and business schools. Developing tailor-made catastrophe risk models is important. Creating meteorological, hydrological and seismological services and investing in measurement infrastructure are also important. Moreover, data providers must be independent and have reliable processes plus trained personnel, and they need to fulfil high standards of data security. Minimising basis risk could be accomplished by establishing a risk pool with insurance portfolio to enable indemnity triggers, while maximising the correlation of parameter values and natural disaster losses if using a parametric trigger. Financing the CAT bonds spreads can be challenging for emerging market sovereigns. It is therefore important to plan early and integrate the costs for the whole disaster risk management programme into fiscal budget on an ongoing basis. In addition, it is important to broaden investor bases and capacity building needs to be strengthened further. Finally, developing the local currency bond market is critical.

Policy recommendations for fostering CAT bond markets include the following:

- Formulate a grand design for disaster risk financing
- Invest in measurement infrastructure
- Enhance quality of data
- Develop catastrophe risk models
- Enhance capacity building
- Broaden investor bases
- Minimise basis risk
- Prepare distribution schemes
- Develop the local currency bond market

Formulating a grand design for disaster risk financing is key

Formulating a grand design from a long-term perspective is important for countries in Dynamic Asia and the Pacific, while recognising the importance of an integrated approach to disaster risk management and the contribution of risk assessment, risk awareness and risk prevention to the financial management of disaster

risks. The OECD has recommendations that provides guidance for governments in building financial resilience to disaster risks (OECD, 2023[50]). They include the importance of:

i) promoting comprehensive disaster risks assessments to support the evaluation of potential financial impacts across the economy and population and allow for the identification of financial vulnerabilities and an assessment of the benefits of investments in risk reduction,

ii) supporting financial resilience of households, businesses, non-profit institutions and subnational governments to disaster risks and the availability and use of risk transfer and risk financing tools for disaster risks, which includes supporting initiatives to raise awareness of disaster risks,

iii) assessing and managing the financial impacts of disasters on public finances by evaluating the potential impacts of disasters on government, developing plans to ensure adequate funding, ensuring adequate plans are in place to disburse funds in a timely and equitable manner, building confidence in the government's capacity to manage disaster risk financing, and assessing cost and benefit of risk retention, risk financing, or risk transfer,

iv) and establishing coherent strategies for building financial resilience to disasters that foster an integrated approach to managing the financial impacts of disaster risks across all levels of government, ensure sufficient institutional capacity and expertise for the implementation of these strategies, ensure co-operation and co-ordination across public and private sectors, leverage opportunities for international co-operation and information sharing considering the potential of cross-border impacts of disaster risks, and most importantly, take into account the characteristics, evolution and implications of different hazards.

Nevertheless, the direction of building up the disaster risk financing framework practically will differ by country. Broadly, there are two main pillars of function that policy makers need to consider in the grand design, namely risk pooling and risk transfer. Countries in the region need to strengthen both functions in parallel, though the way forward will be different depending on the level of each country's development.

Pooling risk, typically in the form of insurance, improves resilience. Such pools may act either as an insurance carrier, offering policies for households and firms not available from the private sector, or as a reinsurer that enlarges the risk-bearing capacity of the country's primary insurers. National insurance or reinsurance schemes have been used in OECD countries (Table 3.1) as well as in emerging markets. Examples include essentially public insurance carriers such as the National Flood Insurance Program (NFIP) in the United States and the Turkish Catastrophe Insurance Pool (TCIP) (Yazici, 2006[51]), as well as the French Caisse Centrale de Réassurance (CCR), which acts as a public-sector reinsurer. In parallel, governments should foster private insurance markets, so that private insurance companies could cover the main part of disaster losses suffered by households and firms. However, in Dynamic Asia and the Pacific, insurance products are often too expensive for many consumers, especially for low-income households, and many households lack a necessary knowledge of insurance. Insurers may thus find it hard to build a profitable business in most cases. The OECD (2021[52]) discusses several important points to develop disaster insurance programme. While establishing a catastrophe risk insurance programme to broaden insurance coverage, governments need to carefully consider the potential trade-offs inherent in different approaches to programme design, including:

- Approaches designed to ensure coverage availability do not always result in broad coverage as policyholders may underestimate the risk of losses or have an expectation of government financial support should a large catastrophe occur and therefore not acquire the available insurance coverage.
- Efforts to support affordability through cross-subsidisation between policyholders can blunt incentives for risk reduction and can raise issues of fairness if cross-subsidies benefit wealthier policyholders that could afford to pay higher premiums, although some mutualisation may be necessary for some risks to become insurable.

- Subsidisation of the aggregate cost of programme coverage can put taxpayers at risk and might also raise competition concerns if the coverage provided by catastrophe risk insurance programmes competes directly with coverage provided by private (re)insurers.
- Limiting the scope or amount of coverage provided by a catastrophe risk insurance programme to specific perils or policyholders can reduce public sector exposure although may lead to gaps in coverage and can also reduce the ability of the programme to benefit from diversification.
- Catastrophe risk insurance programmes can play an important role in developing modelling and risk analytics tools – particularly for perils that have not traditionally created significant exposure for private (re)insurers – although limiting private sector involvement in the assumption of risk could hamper the development of private sector models and analytics.
- Catastrophe risk insurance programmes can provide a source of expertise and funding to support risk reduction although their capacity to contribute will depend on the scope of the coverage that they provide (and the amount of premiums that they collect).

Careful consideration should also be given to the differences in the characteristics of the underinsured peril. By nature, some perils are more challenging to quantify or lead to high levels of correlation in losses:

- Quantifying the financial consequences of infectious disease outbreaks, for example, involves uncertainties related to not only the frequency and severity of outbreaks, but also to the response of public authorities and individuals as well as the capacity of public health systems to manage the health impacts.
- A number of perils (e.g. cyber risk, infectious disease outbreaks) can materialise as both low- and high-severity events with not all occurrences of the peril leading to catastrophic losses.
- Perils also differ in terms of the level of correlation across countries and the diversification benefits that can be achieved in a global portfolio. Cyber risks and pandemics, for example, cannot necessarily be diversified by assuming risk in different countries.

All of these factors affect the ability of private insurance and reinsurance markets to assume risk. They will also require different approaches to the design of any catastrophe risk insurance programme.

To increase the financial preparedness of countries and thus improve their disaster risk resilience, another strategy is risk transfer, typically through market-based solutions such as insurance linked securities or catastrophe bonds. They should be an integral pillar of any integrated grand design of disaster risk management strategy. CAT bonds should be part of any diversified sovereign risk management strategy for emerging countries with major natural disaster exposure. As discussed above, sovereign risk transfer through CAT bonds has various advantages, such as a fully collateralised, flexible and immediate alternative for classical insurance coverage, and additionally guarantees multi-year coverage and price stability.

If a country formulates a grand design of disaster risk financing strategy, it is important to recognise development of capital and insurance market, potential differences in fiscal resources and repayment capacities, and other key factors that may influence financial strategies for disaster risk, such as data availability and technical expertise (OECD, 2022[2]).

Table 3.1. Catastrophe risk insurance programmes in selected OECD countries

	Programmer	Type of insurance offered	Type of perils covered	Types of policyholders covered	Importance as coverage provider	Premium pricing	Public sector involvement
France	Caisse centrale de réassurance (CCR)	Reinsurance	Flood, earthquake, tsunami, landslide, mudslide, avalanche, subsidence and high winds; terrorism	Residential (household) Commercial	Significant provider of coverage (reinsurance)	Fixed cost (sum insured) (uniform additional premium rate)	CCR is a government entity backed by an unlimited government guarantee
	Gestion de l'Assurance et de la Réassurance des risques Attentats et actes de Terrorisme (GAREAT)	Co-insurance/ Reinsurance (pool)	Terrorism	Commercial	Sole provider of coverage for large risks (co-insurance)	Fixed cost (sum insured)	GAREAT's reinsurance coverage is provided by private reinsurers and CCR (government entity)
Japan	Japan Earthquake Reinsurance (JER)	Reinsurance	Earthquake, volcanic eruptions, tsunami	Residential (household)	Significant provider of basic coverage (reinsurance)	Simplified premium structure (hazard zone and type of construction)	Losses above certain thresholds are shared by the government and industry up to a pre-determined amount
New Zealand	Earthquake Commission (EQC)	Direct insurance	Earthquake, volcanic eruptions, tsunami, landslides, storm/flood (for land only)	Residential (household)	Significant provider of basic coverage (direct insurance)	Fixed cost (sum insured)	EQC is a government entity backed by an unlimited government guarantee
Switzerland	Kantonale Gebäudeversicherungen (19 cantons) (e.g. Grisons)[1]	Direct insurance	Flood, storm, hail, avalanche, landslide, snow pressure (as well as fire)	Residential (household) Commercial	Sole provider of coverage (direct insurance) (some cantons)	Simplified premium structure (type of construction)	Established by legislation as independent self-financed entities with their own capital and reserves
	Interkantonale Rückversicherungsverband (IRV)	Reinsurance for public insurers for real estate	Flood, storm, hail, avalanche, landslide, snow pressure (as well as fire)	Residential (household) Commercial	Sole provider of coverage (reinsurance) (some cantons)	Risk-based pricing	Established by legislation as independent self-financed entity with its own capital and reserves
	Schweizerische Pool für Erdbebendeckung (SPE)	Direct insurance (compensation)	Earthquake	Residential (household) Commercial	Sole provider of coverage (compensation)	Fixed cost (sum insured)	None
	Schweizerischer Elementarschadenpool (SVV) of the private insurance sector	Co-insurance	Flood, storm, hail, avalanche, landslide	Residential (household) Commercial	Main provider of coverage (coinsurance) (some cantons)	Fixed cost (sum insured)	None
	Terrorism Reinsurance Facility	Reinsurance	Terrorism	Commercial (large)	Main provider of coverage (reinsurance)		None
United States	National Flood Insurance Program (NFIP)	Direct insurance and risk management programme	Flood	Residential (household) Commercial	Significant provider of basic coverage (direct insurance)	Simplified premium structure (hazard zone and elevation with exceptions,	NFIP is administered by the Federal Emergency Management Agency (a government agency). The NFIP

						although a new rating model is set to be implemented from October 2021)	collects premiums and has the authority to borrow from the US Treasury. NFIP has transferred part of its risk to private reinsurance companies and capital market investors
	Terrorism Risk Insurance Program (TRIP)	Co-insurance	Terrorism	Commercial	Main provider of coverage (co-insurance)	No up-front premium. Post-event assessments are applied through surcharges imposed upon commercial policyholders	Limited federal government backstop through co-insurance for losses above a defined threshold
	California Earthquake Authority	Direct insurance	Earthquake	Residential (household)	Significant provider of coverage (direct insurance)	Risk-based pricing	Established by state legislation
	Fair Access to Insurance Requirements (FAIR) Plans and Beach and Windstorm Plans (e.g. Citizens Property Insurance Corporation (Florida))2	Direct insurance	Wind (as well as other property insurance perils such as fire and theft in some cases)	Residential (household) Commercial	Residual provider of coverage (direct insurance)	Risk-based pricing	Some residual plans are operated as public insurers (e.g. Citizens (Florida) is a state government entity)
	Florida Hurricane Catastrophe Fund (FHCF)	Reinsurance	Wind	Residential (household) Commercial	Significant provider of basic coverage (reinsurance)	Risk-based pricing	Established by state legislation and administered by a government agency

Note: 1. There are public insurers for real estate in 19 Swiss cantons. The information provided in the table is for Gebäudeversicherung Graubündenin the canton of Grisons (as an illustrative example).
2. There are residual insurance arrangements that offer coverage for all or some property risks in many US states. Similar to Citizens in Florida, these programmes are aimed at making insurance coverage available to households that are unable to secure coverage in the private market.
Source: Authors' adaptation of Table 2.1 from *Enhancing Financial Protection Against Catastrophe Risks: The Role of Catastrophe Risk Insurance Programmes* (OECD, 2021) (including table notes).

Investing in measurement infrastructure is important for data collection

The creation of national meteorological, hydrological, and seismological services akin to the US National Oceanic and Atmospheric Association (NOAA) and the United States Geological Survey (USGS) is important. These are government agencies responsible for collecting and analysing data on specific natural events such as cyclones, floods, wildfires or earthquakes. Such services play a critical role in understanding and managing the natural disaster risk that emerging countries in Asia and the Pacific may want to transfer to capital markets via sovereign CAT bonds.

Beyond this organisational prerequisite, governments need to stress test their existing data measurement, data transmission and data storage infrastructure. Many emerging countries already have measurement networks in place, such as meteorological and hydrological monitoring systems. These networks should be improved by investing in denser geographical coverage and more reliable and resilient devices. They also need reliable maintenance plans to ensure their functionality in the long run. If capital market investors doubt the accuracy and reliability of the measurement infrastructure, they will demand substantial spread markups or refrain from purchasing the sovereign CAT bonds altogether.

In addition to existing measurement stations, governments can consider the use of advanced monitoring technologies, such as remote sensing, satellite imagery and permanent drone surveillance. These may deliver real-time data on natural disasters and enable technological leapfrogging compared to classical measurements for certain perils (e.g. floods and drought). Satellite imagery in particular can be a powerful means of assessing losses, including the number of buildings affected and the severity of the damage. Apart from determining the CAT bond payout, this information can also be used by governments to allocate resources for relief and recovery.

The improvement of data measurement infrastructure for natural disaster risk will clearly be associated with substantial public investments in technology and people. It may therefore also require international partnerships or development aid. Governments of emerging countries that want to engage in sovereign risk transfer via CAT bonds should hence foster such partnerships with other countries and international organisations to access the required technical expertise and funding. There are several precedents that document how such partnerships can be fruitful. In 2008, for example, the Chinese central government got involved in a pilot for parametric insurance in Anhui province along with local insurance companies and international organisations (UN ESCAP, 2015[25]).

Enhancing quality of data is crucial

Accurate and timely data is critical for effective disaster risk transfer. As discussed above, emerging countries must improve the availability of data on natural disasters by investing in their data measurement and processing infrastructure. Policy makers in Dynamic Asia and the Pacific should develop databases at the national or regional level to track parametric data on the characteristics of various types of natural hazards. Enhanced parametric data on a wide range of catastrophe events will support the modelling of additional types of perils that are not covered by existing approaches. However, it will be just as important to establish trustworthy data providers. Trustworthy data providers deliver accurate, reliable and up-to-date information that can be used with confidence for decision-making purposes. To this end, they need standard operating procedures and personnel who are highly trained in all matters of data management. The data providers should also be transparent about their sources, methodologies and any limitations or caveats associated with the data.

In addition to these key aspects, the data providers should have appropriate measures in place to protect the data from unauthorised access or breaches. Data security is of critical importance in today's interconnected world, where personal, financial and business information is shared and stored digitally. The increasing reliance on digital information has led to gigantic amounts of data being created and processed, which increases the danger of cyberattacks and unauthorised access.

Finally, the independence of the data provider that acts as the CAT bond cedent is of importance. For example, AIR Worldwide has already begun to expand its Southeast Asia earthquake and typhoon models to smaller countries such as Guam, Macau and the island of Saipan (Verisk, 2016[53]). When the IBRD CAR 123-124 CAT bond was threatened by Typhoon Noru and the Philippine government requested an event calculation process and AIR Worldwide modelled the loss and announced that the cyclone did not qualify as a trigger event (Artemis, 2022[54]; Evans, 2022[55]).

Developing catastrophe risk models is necessary for success

Owing to the infrequent nature of large-scale natural disasters, historical event data does not convey a complete picture of the parameter or loss distributions for CAT bonds (Brookes, 2009[24]). There are simply not enough observations to support the tail. Catastrophe risk models fill this data void by simulating a myriad of artificial events. Today, both advanced science and computing power are available to maintain accurate catastrophe risk models. Different modelling approaches for catastrophe risk pricing are discussed in Annex 3.A. Lane (2022[56]) compares the catastrophe loss experience between 2001 and 2020 to the expected loss estimates generated by catastrophe risk models and concludes that analysis provided by catastrophe modelling firms "gives an accurate characterisation of the risks embedded in the ILS they are considering acquiring". The CAT bond market has come to accept these models a basis for pricing and risk management.

However, just as the main part of the CAT bond market mirrors the largest primary insurance markets around the world (see Chapter 2), so do the most accurate models maintained by catastrophe modelling firms. After all, these firms are for-profit organisations with commercial interests. Thus, the catastrophe risk modelling know-how and capacity available for emerging countries is smaller than for developed economies. Particularly for meteorological disasters, such as cyclones and droughts, the modelling capabilities in developing countries are less pronounced (White et al., 2022[57]). Regarding earthquakes, models for most middle- and high-income developing countries tend to be available, but often lack sufficient data on buildings and infrastructure, which impedes a proper estimation of economic losses (Mahul and Cummins, 2009[58]), which is particularly relevant for certain types of triggers such as modelled loss, industry loss index or indemnity.

The situation in Dynamic Asia and the Pacific is heterogeneous. Several private companies and organisations, such as RMS and AIR Worldwide, have developed catastrophe risk models for Asian countries (Mahul and Cummins, 2009[58]). To estimate the likelihood and potential impact of future catastrophes, these models use a combination of data on historical events, scientific understanding of the hazard, and information on the exposed assets and populations. For example, AIR Worldwide maintains typhoon, earthquake and crop risk models for China. However, the natural disaster risk in other parts of Asia is not yet sufficiently captured by catastrophe risk models, which often suffer from limited availability and quality of data and lack a proper regional specification (White et al., 2022[57]).

While catastrophe risk models have proved a valuable tool for risk assessment, pricing and management of CAT bonds, the application of these models in the Asian context is fraught with challenges. To address these issues, there is a pressing need for concerted efforts from both public and private entities to improve data availability and quality, refine modelling techniques and keep pace with the evolving risk landscape in Asia. This would help to enhance the reliability of catastrophe risk models, facilitating the use of CAT bonds as a tool for sovereign risk transfer in the region.

The successful usage of CAT bonds for sovereign risk transfer crucially depends on the availability of reliable catastrophe risk models. Many countries in Dynamic Asia and the Pacific are exposed to natural perils such as floods, cyclones and earthquakes (Swiss Re, 2022[1]). Before these risks can be transferred to capital markets, they must be modelled. Without proper risk quantification, pricing and risk transfer are not feasible. However, due to the low-frequency, high-severity character of the risks, historical data is not sufficient for risk quantification (Brookes, 2009[24]). Catastrophe models could fill the gap but existing ones are mainly available for established insurance markets, such as the United States or Europe.

Opening access to the CAT bond market to a broader range of investors would require public disclosure of prices, offerings and any other information necessary for investors to assess the risks associated with investing in this asset class. The increasing availability of data and computing power implies that data-driven models of risk pricing will be increasingly sought. Applications from machine learning have the potential to improve the performance of these models.

Sovereigns will also need to establish open data and research policies for the development of catastrophe risk models, making these inputs publicly available (e.g. through public repositories or online platforms) and ensuring that they can be accessed by researchers. Without the sharing of data and information on the underlying risk, such as historical weather and seismological data, risk modelling will be an ill-fated task. After all, catastrophe risk models must be capable of estimating the tail of the loss distribution, while also matching empirically observed loss experience (Moody's RMS, 2023[59]). This point is closely interlinked with the next two policy recommendations discussed below: investing in data measurement infrastructure and reliable data providers. In most emerging countries, the quality and detail of scientific data are not on the same standards as in the United States and Europe. Yet better data is a key condition for better models. Governments should therefore also engage in an ongoing effort to increase the amount and improve the precision of data on the natural perils to which their countries are exposed.

Enhancing capacity-building

The adoption of CAT bonds needs to be accompanied by a build-up of expertise and experience. CAT bonds are complex financial instruments that require cedents to understand both reinsurance and financial markets (Ben Ammar, Braun and Eling, 2015[60]). Experience and expertise are also critical factors for adoption on the investor side Emerging countries aiming to deploy CAT bonds therefore need to establish a dedicated unit or task force inside their public administration bodies.

At the same time, understanding financial competence in the context of CAT bonds to be something larger than management of personal finances is essential for the capacity-building of policy makers. Governments of OECD countries, Dynamic Asia and the Pacific offer financial training to their staff, but the training focuses on management of personal finances rather than skills necessary for policy makers in their official functions. Among the specific topics necessary to examine, policy makers need to understand not just the benefits of CAT bonds, but also their practical implications. A clear regulatory framework, especially regarding taxation, is essential both for policy makers and investors.

Increasing the capacity of policy makers to take advantage of CAT bonds requires a whole-of-government approach. Officials in ministries of economy, finance, and disaster management would benefit from such training depending on the governance and budgeting structures of a given country. Tying career advancement to upskilling would provide an incentive for employees to participate. Policy makers and tertiary educational institutions in Dynamic Asia and the Pacific should collaborate to inform each other of needs and trends, keeping the training current. Post-secondary institutions could also develop relevant courses for students to create a human capital pipeline.

One example of an existing training course on CAT bonds is “The Fundamentals of Insurance-Linked Securities (ILS)”, offered by a UK reinsurer specialising in catastrophe reinsurance (Phoenix CRetro, n.d.[61]). The online course lasts seven weeks and covers an explanation of why risk transfer is important; an introduction to ILS (of which CAT bonds are one type); pricing and legal considerations (that may also have utility for policy makers); advantages and disadvantages; case studies; and in-depth discussion of how ILS can provide disaster risk financing and meet environmental, social and governance (ESG) goals. The course is open to a wide variety of participants including advanced students and finance professionals or policy makers looking to upskill. Recognising the barriers faced by course participants from developing countries and the importance of the subject matter to their prosperity, the course offers tuition reduction for participants from developing countries (Phoenix CRetro, n.d.[61]).

Broadening investor bases

Training is key to broadening investor bases, something that should be a central goal for policy makers seeking to develop CAT bond markets. The collection of data on financial capability disaggregated over many demographics will be required for authorities to gain a fuller picture of who is currently excluded from capital market participation. In some countries, data collection will need to be conducted in multiple languages and the results aggregated where appropriate. Producing training material in multiple languages will necessarily require a certain amount of duplicated effort. While working from a common base, policy makers may consider the implementation of targeted training programmes that emphasise different concepts depending on the needs of each demographic.

In addition to training in the technical aspects of investing, training for overcoming other barriers such as low personal confidence, and lack of trust in experts is also essential. For instance, if investor bases are to be expanded to include more women, then women must receive training suited to their needs. Some women may have a lower risk appetite than many men and less confidence in their abilities due to factors largely beyond their control. Becoming a professional investor does not change this, so training programmes targeted to women should seek to boost their confidence. In addition, self-confidence must align with an individual's level of financial ability and knowledge. For this alignment to take place, it is important that potential investors receive advice from trustworthy and knowledgeable sources. Unfortunately, in their quest for trustworthiness, people often turn to others who may also have low expertise, such as friends or family, which risks perpetuating financial mistakes (van Rooij, Lusardi and Alessie, 2011[62]). For both institutional and retail investors, authorities must foster trust in credentialed experts as superior sources of financial advice.

Minimising basis risk may require several steps

Basis risk means the possibility that the payout of a CAT bond will not perfectly match the actual catastrophe losses suffered by the cedent. It is a concern if the CAT bond relies on non-indemnity triggers. To tackle basis risk in CAT bonds, governments in the countries of Dynamic Asia and the Pacific may take several steps, the simplest of which would be to avoid non-indemnity triggers. However, this requires an insurance portfolio that can be referenced by the CAT bond transaction. In this regard, governments would additionally need to establish a national risk pool that underwrites a policy portfolio from households and businesses. A major challenge here is the distribution of insurance policies to households and firms. In developed countries, national risk pools can tap into the distribution networks of the private insurance sector. An example is the NFIP, which sells policies through insurance agents and brokers. This will be difficult in some countries of Dynamic Asia and the Pacific, such as Viet Nam, because traditional insurance distribution channels are less established (KPMG, 2022[63]). However, digital-direct sales and bancassurance constitute viable alternatives (Gonulal, Goulder and Lester, 2012[64]).

When parametric triggers are chosen or deemed necessary, the minimisation of basis risk is clearly dependent on the development and testing of sophisticated catastrophe risk models and the availability of a reliable measurement infrastructure. The policy recommendations discussed above are thus fundamental prerequisites for the minimisation of basis risk, too. Given the output of a proper catastrophe risk model, it will be possible to quantify basis risk (Brookes, 2009[24]). Subsequently, the key characteristics of the CAT bond (e.g. the geography and layer) can be modified to maximise the stochastic dependence of the physical trigger parameter (e.g. wind speed) with the disaster losses that are expected under any given catastrophe scenario. In doing so, sponsors can minimise the expected shortfall of the payout across all trigger scenarios.

Finally, the choice of parameters should be aligned with exposure in the best possible way. This can be achieved by switching from pure parametric to parametric index triggers. The latter allow cedents to apply a weighting to the readings from different measurement stations that best mirrors their actual exposure (ADB, 2009[65]). The weighted sum of parameter values then constitutes the parametric index. To build a parametric index that is most correlated with losses, accurate historical data and, again, advanced modelling capabilities are imperative.

Preparing distribution schemes ex ante will help to avoid delays in relief and recovery

To ensure rapid and targeted distribution of the proceeds from sovereign CAT bonds in the event of a disaster, contingency plans (protocols and guidelines for disaster responses) must be put in place ex ante. Slow political processes may otherwise substantially reduce the effectiveness of CAT bonds for immediate relief and a timely recovery of essential public infrastructure. In emerging countries with a weak healthcare system and disconnected rural areas that quickly run out of supplies, every hour of delay adds to the suffering of the affected population.

Emrich, Aksha and Zhou (2022[35]) recommend that social vulnerabilities be considered for the allocation of disaster assistance across local governments, households and businesses. Hence, the distribution of the CAT bond proceeds in a contingency plan should be tied to a detailed needs assessment that reflects both the extent of the damage and the financial resilience of the affected communities.

Moreover, the contingency plans should determine how the CAT bond proceeds will be used. This includes transparent accounting and monitoring mechanisms. Establishing appropriate rules ex ante ensures that those in charge of the distribution cannot easily misappropriate funds. Immediate relief can take different forms, such as cash, vouchers or in-kind assistance. Direct cash transfers enable households and businesses to decide for themselves how they would like to achieve the best possible improvement of their situation. Cash is considered to be more effective in disasters than in-kind support through medical supplies, potable water, food, etc.

Developing the local-currency bond market

Local-currency government bond markets provide the necessary platform and institutional framework for the issuance of catastrophe bonds in the region. The trust both local and international investors have in local-currency-denominated government bonds fosters confidence in catastrophe bonds. This is expected to lead to increased local and foreign investor participation.

Several other studies have been conducted to determine the key factors for the development of local-currency bond markets (LCBM). Claessens et al. (2007[66]) find that measures to expand investor bases matter, such that economies with larger domestic financial systems in terms of bank deposits and stock market capitalisation have deeper local currency bond markets. Essers et al. (2015[67]) conclude that lower fiscal balances and inflation, along with higher institutional quality, are associated with larger LCBM capitalisation. Berensmann, Dafe and Volz (2015[68]) highlight the importance of foreign investor participation in LCBM and state that it enhances market size by broadening the investor base. Eichengreen and Luengnaruemitchai (2004[69]) show that major factors contributing to the development of national bond markets are the size of an economy, strong institutional structure and more stable exchange rates. Bhattacharyay (2013[70]) finds that, while the size of the economy associates positively with bond market deepening in both sectors, the size of the banking sector correlates positively with government bond market capitalisation but negatively with corporate-sector bond market depth. Molnar-Tanaka and Imisiker (2023[71]) show that elements affecting LCBM depth include macroeconomic factors such as GDP, inflation and fiscal balance, as well as the exchange-rate regime, capital account openness, and creditor rights. They find that depth of financial markets and institutions, and access to them, have significantly positive relationships with LCBM development.

Overall, a solid macroeconomic framework, as well as a solid institutional framework have been well-established as the key components of the foundation for a robust LCBM. Development of local currency-denominated catastrophe bonds in Asia and the Pacific should occur in conjunction with the development of local currency government bond markets more broadly, though there is no universal approach.

Conclusion

This chapter has discussed catastrophe bonds as a potential sovereign risk transfer tool for Dynamic Asia and the Pacific. It has highlighted both the benefits of CAT bonds for sovereign risk transfer in countries in the region and the major challenges that need to be overcome to realise these benefits. Finally, the chapter has offered policy recommendations for fostering CAT bond markets in the region.

The benefits of using CAT bonds include: their role as an alternative to private insurance; diversification of coverage; flexible multi-year coverage; full collateralisation; transparency and fast settlement; efficient price discovery; the non-peak territory discount; and multi-country cost-sharing and spread discount. Policy recommendations for developing CAT bond markets include preparing a grand design for disaster risk financing; enhancing capacity building; broadening investor bases; developing catastrophe risk models; investing in measurement infrastructure; establishing trustworthy data; minimising basis risk; preparing distribution schemes and; developing local-currency bond markets.

Notes

[1] Inflation-adjusted estimates. Most of this increase is attributable to economic growth, population growth and urbanisation, which lead to a higher concentration of assets in areas exposed to natural disasters.

[2] The most important reinsurance renewal dates are 1 January (Europe), 1 April (Japan) and 1 July (United States).

[3] For example, Swiss Re and Munich Re, the two largest reinsurers in the world, both exhibit financial strength ratings of AA- by Standard & Poor's.

[4] For example, a 2011 report by the National Association of Insurance Commissioners on classical insurance markets found that delayed indemnification can result in additional legal fees, interest charges and other expenses.

[5] This bond relies on a parametric trigger, referencing data from the US Geological Survey.

[6] The ILS markets recently witnessed the advent of CAT bonds lite, highlighting the fact that structuring and issuance costs are a major quantity. A cat bond lite structure relinquishes cost-intensive steps in the issuance process, such as a full prospectus and catastrophe model report. In addition, it is privately placed so that distribution costs are lower than for standard CAT bond structures. For further information, see: https://www.artemis.bm/news/cat-bond-lites-are-growing-in-number-and-importance/.

[7] Prominent examples are the FloodSmart Re transactions by the US National Flood Insurance Program. For more information see: www.artemis.bm/deal-directory/.

[8] Basis risk is also a disadvantage of modelled-loss triggers. These are quite rare in today's market. Under a modelled-loss trigger, the payout of a CAT bond is determined by the output of a catastrophe risk model. Such models are usually provided by one of the large model vendors (AIR Worldwide, RMS and CoreLogic). Post event, the model is fed the key parameters of the disaster, which it then maps into an estimate of the corresponding losses.

[9] Recent statistics on parametric insurance programmes in India show that the penetration of coverage is still low: 65% of the crop area remains uninsured (Agriculture Times, 2021[97]). One driver of this persisting protection gap is likely to be insufficient density of the measurement infrastructure.

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Annex 3.A. Modelling approaches and challenges for catastrophe risk pricing

Overview of CAT bond modelling approaches

The theoretical framework of CAT bond pricing was developed in particular after 1990 and is defined according to several parameters, notably location, period of coverage and disaster types (i.e. have defined triggers). For instance, if a qualifying disaster does not occur over the life of the bond, bondholders receive the face value at maturity. Conversely, if a qualifying disaster does occur, insurance companies are paid out of what bondholders would have otherwise received, and thus bondholders receive the face value less an amount determined by the payoff function of the bond. Payouts to insurance companies may be triggered by indemnity (i.e. the value of the sponsoring insurer's actual losses), an index of industry-wide losses, measurable disaster parameters, such as earthquake magnitudes or wind speeds, modelled losses, or a hybrid of these. In any case, the relevant criteria must exceed defined thresholds for the payout to take place.

Stochastic models with discrete time

The literature on the valuation of CAT bonds is relatively sparse. In the specialised literature on CAT bond pricing, several authors apply stochastic models. Among these models, two advanced approaches that rely on stochastic processes with discrete time are those proposed by Cox and Pedersen (2000[72]) and Reshetar (2008[73]). The approach by Cox and Pedersen (2000[72]) uses the framework of the representative agent equilibrium, while Reshetar (2008[73]) assumes that the payout functions depend on catastrophic property losses and catastrophic mortality.

In the framework proposed by Cox and Pedersen (2000[72]), the CAT bond has a face value of 1, scheduled coupon payments *c* at the end of each period, and a final principal repayment of 1 at the end of the last period (T), if the catastrophe does not occur. Investors make an initial principal investment of 1. If the triggering event occurs, the payoff is a fraction of coupon and face value, which is *f(1+c)*, denoting fraction with *f*. The payment is made in the end of the period during which the event occurs, and the bond is terminated. The general formula for the price at time 0 of the cash flow stream is as follows:

$$V(0) = c\sum_{k=1}^{T} P(k)Q(\tau > k) + P(T)Q(\tau > T) + f(c+1)\sum P(k)Q(\tau = k)$$

Where $P(k)$ is the discount factor, price at time 0 of a zero-coupon bond maturing at time *k*, with face value 1. $Q(\tau > k)$ is the probability under risk-neutral measure that the catastrophe does not occur within the first *k* periods.

Next, the binomial term-structure model and binomial catastrophe risk structure are combined. $Q(\tau > k)$ is modelled as the catastrophe risk, and interest rate along with risk neutral probabilities of being in such state, which reflects in zero-coupon bonds $P(k)$. In the first period, there are four possible states:

i. interest rate goes up, catastrophe occurs, or
ii. interest rate goes up, catastrophe does not occur, or
iii. interest rate goes down, catastrophe occurs, or
iv. interest rate goes down, catastrophe does not occur.

The states are similar for the next periods. Once given the binomial model structure of rates along with risk neutral probabilities, and risk structure, meaning the catastrophe occurs or not, $P(k), Q(\tau > k), Q(\tau = k)$ can be computed in each state. The above cash flow pricing formula is applied to determine the value of the CAT bond.

The framework proposed by Reshetar (2008[73]) implements theoretical pricing of a multiple-event CAT bond in an incomplete market setting using a representative agent pricing model. This model assumes that the belief of the representative agent corresponds to the weighted average of agents' beliefs, while the dispersion in agents' beliefs is incorporated into the discount rate of the representative agent.

Stochastic models with continuous time

The literature on stochastic models with continuous time for CAT bond pricing is comparatively broader than the one addressing stochastic models with discrete time. In an early attempt, Baryshnikov, Mayo and Taylor (1998[74]) use compound Poisson models to incorporate various characteristics of the CAT bond process. However, no analytical formula is derived in this approach. Burnecki and Kukla (2003[75]) correct the method proposed by Baryshnikov, Mayo and Taylor (1998[74]) to calculate non-arbitrage prices of a zero-coupon and coupon CAT bond.

Burnecki and Kukla (2003[75]) consider a bond with the payment of a certain amount *Z* at maturity time *T* contingent on threshold time $\tau > T$, which is in fact a zero-coupon CAT bond (hereafter "ZCCB"). The condition required is that the payout process is a predictable process, which can be interpreted to mean that the payment at maturity is not directly linked to the occurrence and timing of the threshold. The amount *Z* can be, for instance, the principal plus interest, which is usually defined as a fixed percentage over the London Interbank Offered Rate (LIBOR).

The same approach is used in Burnecki, Kukla and Taylor (2005[76]). The underlying assumption in this model is that there is a Poisson point process of potentially catastrophe events. However, these events may or may not result in economic losses. The authors also assume that the economic losses associated with each of the potentially catastrophic events are independent and have a certain common probability distribution. Within this model, the threshold time can be seen as a point of a Poisson point process with a stochastic intensity depending on the instantaneous index position.

In a different approach, Vaugirard (2003[77]) develops an arbitrage method for pricing CAT bonds, which accounts for catastrophe events, interest rate randomness and non-traded underlying state variables. In the model, the bondholder expects to lose interest or a fraction of the principal if a natural risk index, whose value at date *t* is denoted I_t, hits a pre-specified threshold *K*. More specifically, if the index does not reach the threshold during a risk-exposure period *T*, the bondholder is paid the face value *F*. Otherwise, he receives the face value minus a write-down coefficient in percentage *w*. The author allows bond maturity *T'* to be longer than the risk-exposure period *T* to account for possible lags in the risk-index assessment at expiration. $IB_{(t)}$ is the price of a ZCCB at time *t*, and $T_{I,K}$ is the first passage time of *I* through *K*.

Another approach is proposed by Jarrow (2010[78]), who obtains an analytically-closed CAT bond valuation formula, considering the LIBOR term structure of interest rates. The characteristics of the CAT bond value are as follows: the CAT bond receives floating payments based on the Δ-year LIBOR rate L_t, paid in arrears, plus a spread $c \geq 0$. The face value of the bond, denoted *A*, is due at the bond's maturity date, time *T*, unless there is a catastrophe event.

The CAT bond value is seen to be equal to:

i. The value of the next coupon payment, which equals the discounted value of the next coupon payment multiplied by the probability of no event

ii. If an event occurs before the next coupon payment at time $t + k$, the recovery on the LIBOR floating rate note, which equals the discounted recovery of principal multiplied by the probability of the loss occurring at time *s*, summed across all times

iii. The value of a LIBOR floating rate note received at the next payment date $t + k$, which equals the value of a LIBOR floating rate note *A* discounted to the present, multiplied by the probability of no event

iv. Less the expected loss after the next coupon payment, which is the discounted loss at time *s*, multiplied by the probability of the loss occurring at time *s*, summed across all times

v. Plus, the expected fixed payments after the next coupon payment.

Hardle and Lopez Cabrera (2010[79]) evaluate the calibration of a real parametric CAT bond sponsored by the Mexican government to secure coverage against earthquake events and derive the price of a hypothetical modelled-index CAT bond for Mexican earthquakes. Annex Box 3.A.1 illustrates the main steps in the pricing of this hypothetical CAT bond.

Annex Box 3.A.1. Example of pricing approach for a hypothetical modelled-index CAT bond for Mexican earthquakes

Hardle and Lopez Cabrera (2010[79]) evaluate the pricing of a catastrophe (CAT) bond for earthquakes in Mexico with a modelled-index loss trigger mechanism. The authors apply the CAT bond pricing methodology of Burnecki and Kukla (2003[75]) and Baryshnikov, Mayo and Taylor (1998[74]) to the loss data obtained from the National Institute of Seismology in Mexico. The loss data contain information about 192 earthquakes with a magnitude above 6.5 on the Richter scale that have occurred in Mexico between 1900 and 2003. The historical losses were adjusted to the population growth, the inflation rate and the exchange rate (MXN [Mexican peso]/USD [United States dollar]) converted to USD in 1990. The losses are modelled by means of linear regression methods, using as explanatory variables the earthquake magnitude, the depth of the earthquake and the impact of the earthquake on Mexico City.

The authors then model earthquake arrival frequency through various methods and conclude that the process can be correctly modelled with a Homogeneous Poisson process. Next, Hardle and Lopez Cabrera (2010[79]) assume a zero-coupon CAT bond (ZCCB) that pays a principal amount *P* at time to maturity *T*, conditional on the threshold time $\tau > T$. *P* is a predictable process, which implies that the payment at maturity is independent of the occurrence and timing of the threshold *D*. The principal *P* is fully lost in case of occurrence of a trigger event.

The non-arbitrage price of the ZCCB is associated with the threshold *D*, the earthquake flow process N_s with intensity rate λ_s and a loss distribution function *F(x)*.

Following these pricing assumptions, the authors obtain the values of a ZCCB with principal *P* = 160 million at *t* = 0 with respect to the threshold level *D* and expiration time $t \in (0, 3)$ years. The threshold *D* is defined as $D \in [100, 135]$ million, which corresponds to the 0.7 and 0.8 quantiles of the three yearly accumulated losses (i.e. approximately three payoffs are anticipated to occur in 100 years). The authors further assume a continuously compounded discount interest rate $r = \log(1.054139)$ to be constant and equal to the London Interbank Offered Rate (LIBOR) in May 2006 and an earthquake intensity rate λ_s=1.8504. When *D* = 135 million and *T* = 1 year, the ZCCB price is equal to 151.78 million.

Source: Hardle and Lopez Cabrera (2010[79]), "Calibrating CAT Bonds for Mexican Earthquakes", *The Journal of Risk and Insurance*, https://doi.org/10.1111/j.1539-6975.2010.01355.x.

In a more recent paper, Nowak and Romaniuk (2016[80]) use the martingale method for pricing CAT bonds. More precisely, the authors price the CAT bonds by means of a generalised payoff structure, which assumes that the bondholder's payoff depends on an underlying asset driven by a stochastic jump-diffusion process (i.e. a model that includes both stochastic volatility and jumps). Simultaneously, the risk-free spot interest rate also has a stochastic form and is described by the Cox, Ingersoll and Ross (1985[81]) model. Furthermore, Nowak and Romaniuk (2016[80]) assume the possibility of correlation between the Brownian part of the underlying asset and the components of the interest rate model.

Empirical approaches

Empirical approaches have emerged since the first CAT bond issues. They have the advantage of being more pragmatic than theoretical approaches and are better understood by investors. In addition, linear regression models are shown to perform relatively well in the out-of-sample forecast of CAT bond premiums (Trottier and Lai, 2017[82]). One of the main empirical approaches is proposed by Lane (2000[83]) and continuously improved. This approach only focuses on the risk load and establishes that the premium over the expected loss is a Cobb-Douglas-type function of probability and expected loss in the event of default. More precisely, Lane (2000) posits that the CAT bond premium can be derived according to the following formula:

$$\begin{aligned} Full\ premium &= (PFL) \times (CEL) + \gamma (PFL)^{\alpha} \times (CEL)^{\beta} = PFL\left[CEL + \gamma (PFL)^{\alpha-1} \times (CEL)^{\beta-1}\right] \\ &= EL\left[1 + \gamma (PFL)^{\alpha-1} \times (CEL)^{\beta-1}\right] \end{aligned}$$

Where *PFL* is the probability of first loss, *CEL* is the conditional expected loss, and *EL* is the expected loss. *PFL* and *CEL* take values between 0 and 1.

Instead, Lane and Mahul (2008[84]) accomplish a multivariate linear regression analysis in order to identify factors explaining the risk loads of CAT bonds in addition to the expected loss. They suggest a multiple linear relation between the premium, the underlying peril, the expected loss, the wider capital market cycle and the risk profile of the transaction. The simple linear model has the following form:

$$Premium\ spread = a + b \times (Expected\ loss)$$

The authors then adjust the simple model to account for the cycle by using two approaches, namely add another coefficient to the regression or divide the actual spread by the index deflator. This results in the following two specifications:

$$(Premium\ spread)_t = a + b \times (Expected\ loss) + c \times (Cycle\ level)_t$$

Or equivalently:

$$[(Premium\ spread)_t / (Cycle\ level)_t] = a + b \times (Expected\ loss)$$

Last, Lane and Mahul (2008[84]) also amend the simple model to allow for peril exposure as follows:

$$Premium\ spread = a + \sum_p \left[b_p \times (Expected\ loss)_p\right]$$

Where parameter b_p is the coefficient associated with peril *p*, and $(Expected\ loss)_p$ is the expected loss from peril *p*.

Other approaches consider further factors that could drive the CAT bond premium, in addition to those outlined in the approaches above. Braun (2015[19]), for example, proposes a linear model that includes a dummy variable for exposure to peak territory, a dummy variable for being sponsored by Swiss Re and a dummy variable for being rated investment grade. The model contains no intercept to reflect the fact that the explanatory variables proxy CAT bond risk. All variables equalling zero would correspond to the risk-free rate. The multilinear model can be written as follows:

$$Spread_i = \beta_1 EL_i + \beta_2 Peak_i + \beta_3 Swiss\_Re_i + \beta_4 Inv\_grade_i + \beta_5 Lane\_index_i + \beta_6 BB\_spread_I + \varepsilon_i$$

Some authors have departed from the linear model, opting instead for a log-linear specification. Papachristou (2011[32]), for instance, fits a Generalised Additive Model to market data, considering various explanatory variables for CAT bond prices. One variable is the expected loss that reflects, to some extent, the volatility of losses. Another variable is the type of peril and territories covered, mainly reflecting correlation with investor portfolios. In addition, the author includes the reinsurance cycle, reflecting loss experience, changes in risk perception over time and the availability of capital. Last, the type of trigger is also included, to reflect the amount of basis risk. The selected model has the following form:

$$Log(RL_i) = f_1\big(log(EL_i)\big) + f_2(time_i) + Peril/Territory_i + Trigger_i + \varepsilon_i$$

Where RL_i is the risk load, EL_i is the expected loss, *f*s are smoothing functions, $Peril/Territory_i$ and $Trigger_i$ are factor variables, and ε_i are independent and identically distributed random variables.

A log-linear approach is also outlined in Mevorach (2018[85]). The author develops a multivariate log-linear model that includes cyclical as well as CAT bond-specific variables that have been established in the literature and are highly statistically significant. The model has the following form:

$$\ln(Spread_i) = \alpha + \beta_1 ln(EL_i) + \beta_2 ln(Lane\_index_i) + \beta_3 US\_Exposure_i + \beta_4 Hurr_i + \beta_5 JPN\_EQ_i + \varepsilon_i$$

Where *EL* is the expected loss, $Lane\_index_i$ is the Lane Financial synthetic insurance-linked securities rate-on-line index, $US\_Exposure_i$ is a dummy variable for exposure to US perils, $Hurr_i$ is a dummy variable for exposure to hurricanes, JPN_EQ_i is a dummy variable for exposure to Japanese earthquakes, and ε_i are independent and identically distributed random variables.

Challenges of existing CAT bond modelling approaches

Examples of limitations of CAT bond pricing models

Modelling the valuation of CAT bonds is an area for continued research and development. Since the CAT bond market is incomplete (Galeotti, Gürtler and Winkelvos, 2012[86]), the deployment of an appropriate pricing model is of outmost importance. Current modelling approaches have various limitations. More specific and theory-based models are necessary, as most models used by practitioners are primarily descriptive rather than grounded in theory. In addition, the very existence of the risk premium is modelled on an ad hoc basis, with no economic explanation for its existence. In particular, the models do not consider the systematic nature of the risk associated with CAT bonds. Furthermore, since the global financial crisis, CAT bond spreads have become correlated with those of corporate bonds, suggesting the emergence of a significant systematic component in CAT bond prices. CAT bond investors are also more sensitive to catastrophe events that trigger a reassessment of risk (Carayannopoulos and Perez, 2014[87]).

Another thing to note is that the current models can be very sensitive to the parameters used, in the sense that a slight change in parameters can lead to significant losses. This issue could be addressed by establishing a maximum threshold of acceptable risk. An example are the floods that affected the United Kingdom in 2000. The floods caused severe damage, and insurance companies agreed to cover the losses. However, in return, the UK government took action to increase annual expenditure to enhance flood preparedness (Kelman, 2001[88]). Relatedly, the use of historical data for the estimation of future losses is rather problematic, as many variables affecting the size of these insurance losses have changed materially (Canabarro et al., 2000[89]). For instance, demographic changes and mitigating factors (e.g. improvements in construction standards and risk management strategies) mean that historical data may be of little relevance for forecasting future losses caused by catastrophe events.

Model calibration has significant practical importance. The appropriate calibration of a CAT bond model requires specifying a probability distribution for the underlying variables in such a manner that the model is able to reproduce the current market prices of a set of benchmark financial instruments. It is well known, however, that sometimes there can be multiple solutions, and sometimes there is no solution at all. This

means that prices may not be consistent with any risk-neutral probability (i.e. an arbitrage exists) or that there exist several risk-neutral probabilities consistent with the benchmark prices due to market incompleteness. In an incomplete market, not all states of nature can be spanned, and as a result, parties are not able to move funds freely across time and space, nor to manage risk (Heaton and Lucas, 1996[90]). As the CAT bond market is incomplete (Galeotti, Gürtler and Winkelvos, 2012[86]), any calibration procedure involves making subjective choices.

Existing models may not be suitable for capturing natural hazards that are very common in Emerging Asian countries. For example, floods are one of the regular hazards in the region. In addition, countries also often struggle with slow-onset hazards, such as drought. However, the existing models are focused on either earthquakes or tropical cyclone events. In the case of drought, no probabilistic drought risk model for Emerging Asia currently exists (UN ESCAP, 2019[91]). Thus, an additional key step is adapting the models to the geographic area of interest.

Machine learning could improve the performance of CAT bond pricing models

A robust CAT bond pricing model should be based on both statistically and economically significant price determinants and avoid overfitting issues. Furthermore, a good forecasting framework must correctly specify the functional relationship between the dependent and explanatory variables and provide a suitable choice of the underlying conditions of the prediction (Gu, Kelly and Xiu, 2020[92]). The development of an appropriate forecasting model is therefore a complex undertaking, and existing theoretical and empirical models may not always provide a good solution in this regard. Artificial intelligence could considerably improve pricing models' forecasting performance by allowing a rich set of possible model specifications compared to conventional methods (Gu, Kelly and Xiu, 2020[92]; Mullainathan and Spiess, 2017[93]). More recently, several studies have emerged, ranking the performance of various machine learning techniques in asset pricing models (Annex Table 3.A.1).

Annex Table 3.A.1. Examples of machine learning methods with the highest forecasting performance in asset pricing models

Methods compared	Methods with the highest forecasting performance	Reference
Linear regression; penalised linear models; random forests; and neural networks	Random forests	Götze, Gürtler and Witowski (2020[15])
Linear regression; penalised linear models; principal components regression; partial least squares; boosted regression trees; random forests; and neural networks	Boosted regression trees; random forests; and neural networks	Gu, Kelly and Xiu (2020[92])
Linear regression and random forest	Random forests have at least as good a prediction performance as the benchmark linear regression in the temporal context and superior prediction performance in the non-temporal one; random forests perform better than the benchmark model when multiple predictors are excluded.	Makariou, Barrieu and Chen (2021[16])

Source: Authors' compilation, based on cited references.

Some authors evaluate the performance of these techniques in relation to CAT bond pricing. Makariou, Barrieu and Chen (2021[16]), for instance, apply the random forest method to predict spreads in the full spectrum of the primary non-life catastrophe bond market. They find that random forests have at least as good a prediction performance as the benchmark linear regression in the temporal context and superior prediction performance in the non-temporal one. The authors also conclude that the random forest approach performs better than the benchmark model when multiple predictors are excluded in accordance with the importance rankings or at random. This result suggests that the random forest method extracts information from existing predictors more effectively and captures interactions better without the need to specify them.

Likewise, Götze, Gürtler and Witowski (2020[15]) assess the forecasting performance of linear regression models versus machine learning techniques in the CAT bond market. The authors use linear regression with variable selection, penalisation methods, random forests and neural networks in order to forecast CAT bond premiums, concluding that random forests exhibit the highest forecasting performance. Additionally, random forests display a smaller variance in forecasting performance over time compared to the linear regression model. This result is important in a context where uncertainty is high and performance stability becomes highly relevant. On the other hand, Götze, Gürtler and Witowski (2020[15]) suggest that the performance of the neural network approach depends on the applied test specification and lags both the linear regression models and the random forests.

The literature on the performance of machine learning methods for asset pricing models in general is broader than that narrowly focused on the CAT bond market. These studies could nevertheless provide useful insights on machine learning methods that could also be applied to the pricing of CAT bonds. A number of authors use machine learning techniques to deal with the high-dimensionality challenge. Rapach, Strauss and Zhou (2013[94]) apply the lasso method to select a few predictors from a large set of candidates, while Stambaugh and Yuan (2016[95]) use covariance cluster analysis to identify two groups of related anomalies and then build factors based on stocks' average within-cluster characteristics rank. Kelly, Pruitt and Su (2019[96]) perform dimensionality reduction of the characteristics space by extending the projected principal-component analysis to allow for time-varying factor loadings. In a comparative study of several machine learning methods for measuring asset risk premiums, Gu, Kelly and Xiu (2020[92]) conclude that boosted regression trees, random forests and neural networks are the best-performing methods.

4 Country case studies of catastrophe bonds

The global catastrophe (CAT) bond market has grown steadily since the 1990s. However, the implementation of sovereign CAT bonds is still limited in Asia and the Pacific. This chapter provides some examples of the implementation of CAT bonds in various countries, including selected OECD countries such as Australia, Japan, New Zealand and the United States, as well as those sponsored by the governments of Jamaica, Mexico and the Philippines. Case studies of Indonesia, China and India also provide insight on the current situation of disaster risk financing in those countries, as well as the challenges they face in developing CAT bond markets.

Introduction

This chapter first addresses how countries in Dynamic Asia and the Pacific can overcome the practical challenges of adding CAT bonds to their disaster risk financing menu. Firstly, it provides an overview of the Philippines' CAT bonds and the supporting factors that facilitated their adoption and discusses further challenges related to the implementation that may need to be addressed. Second, the chapter addresses the current state of play of disaster risk financing in Indonesia and how it can adopt CAT bonds to tackle pressure on the government budget after natural catastrophes. It also discusses further challenges related to Indonesia's capacity in managing disaster-related data as one of the prerequisites of CAT bond development. Next, the chapter discuss challenges related to financing for post-disaster recovery in the People's Republic of China (hereafter "China") and presents examples of the transfer of disaster risk to capital markets by the Chinese reinsurance sector. It then provides an overview of disaster risk financing mechanisms adopted by India. The adoption of CAT bonds and issuance mechanisms by Mexico and Jamaica will also be discussed. Finally, it presents the development of CAT bond markets in selected OECD countries, namely Australia, Japan, New Zealand, and the United States (US).

The case of the Philippines

The Philippines is one of the most disaster-prone countries in the world. It holds the top position as the country with the highest disaster risk according to the 2023 World Risk Index (Bündnis Entwicklung Hilft/IFHV, 2023[1]). Every year, the Philippines experiences many forms of natural disasters, such as earthquakes, typhoons, floods, volcanic eruptions, droughts and landslides. Recently, Typhoon Rai (known as Super Typhoon Odette locally), hit in December 2021. As of early February 2022, over nine million people had been affected (NDRRMC, 2022[2]). In November 2020, Super Typhoon Rolly (Typhoon Goni) battered large parts of the country, affecting over two million people residing in nearly half the country (NDRRMC, 2020[3]). Issuing sovereign CAT bonds is a feasible risk transfer solution that could be emulated by other highly exposed countries. Furthermore, several enabling factors could facilitate more widespread sovereign CAT bond issuance in the Philippines (Table 4.1).

The Philippines is already present in the CAT bond market, albeit indirectly, as the bonds have been issued by the World Bank on the country's behalf. In 2019, the World Bank issued two tranches of CAT bonds to provide the Philippines with a total of USD 225 million financial coverage against earthquakes and tropical cyclones for three years. The CAT bonds were issued under the IBRD's Capital-At-Risk Notes programme, which can be used to transfer risks related to natural disasters and other risks of developing countries to capital markets.

Table 4.1. Enabling factors for and challenges to the widespread issuance of sovereign CAT bonds in the Philippines

Enabling factors	Challenges
• Presence on the CAT bond market through the World Bank issuance • Strong legal and institutional frameworks for disaster risk management, including provisions on risk transfer mechanisms • Availability of models for several types of catastrophe events	• High transaction costs • Narrow investor base • Short-term coverage • Need to recalibrate existing models to reflect local practices • Lack of data and statistics on the probability and severity of a catastrophe event

Source: Authors' compilation.

Of the total USD 225 million insurance coverage, the first tranche, featuring USD 75 million of Class A notes, covered risks of earthquake, while the second tranche, featuring USD 150 million of Class B notes, was exposed to tropical cyclone risks. Both tranches covered the entirety of the Philippines. The Philippines paid an insurance premium for the coverage, which was fixed during the tenure of the bond. The World Bank had a swap agreement with the Philippines, which allowed the former to transfer the collected insurance premium to the CAT bond investors. Investors received monthly coupon payments based on the prevalent three-month USD London Inter-Bank Offered Rate (LIBOR) interest rate plus funding and risk margins (Table 4.2). On a modelled-index loss trigger basis, the World Bank used the swap arrangement to transfer the payout proceeds to the Philippines in the case an earthquake or a tropical cyclone occurring and meeting the predefined criteria under the bond terms.

Table 4.2. Selected terms and conditions of the CAT bonds issued by the World Bank on behalf of the Philippines

Parameters	Class A bond	Class B bond
Aggregate nominal amount	USD 75 million	USD 150 million
Perils covered	Earthquake	Tropical cyclone
Trigger type	Modelled loss	Modelled loss
Issue date	15 November 2019	15 November 2019
Maturity date	22 December 2022	2 December 2022
Bond coupon (per annum)	Three-month USD LIBOR + funding margin + risk margin (subject to a minimum rate of interest equal to the risk margin)	Three-month USD LIBOR + funding margin + risk margin (subject to a minimum rate of interest equal to the risk margin)
Funding margin	-0.12% per annum	-0.12% per annum
Risk margin	5.50% per annum	5.65% per annum
Coupon payment dates	Monthly	Monthly
Redemption amount	The aggregate nominal amount reduced by any principal reductions, partial payments or partial redemptions	The aggregate nominal amount reduced by any principal reductions, partial payments or partial redemptions
Principal reductions	Depending on the calculated earthquake modelled loss following any earthquake event, the outstanding nominal amount may be reduced by 0%, 35%, 70% or 100%.	Depending on the calculated tropical cyclone modelled loss following any tropical cyclone event, the outstanding nominal amount may be reduced by 0%, 35%, 70% or 100%.

Note: LIBOR = London Inter-Bank Offered Rate.
Source: (World Bank, 2019[4]), "World Bank Catastrophe Bond Transaction Insures the Republic of Philippines against Natural Disaster-related Losses Up to US$225 million", www.worldbank.org/en/news/press-release/2019/11/25/world-bank-catastrophe-bond-transaction-insures-the-republic-of-philippines-against-natural-disaster-related-losses-up-to-usd225-million.

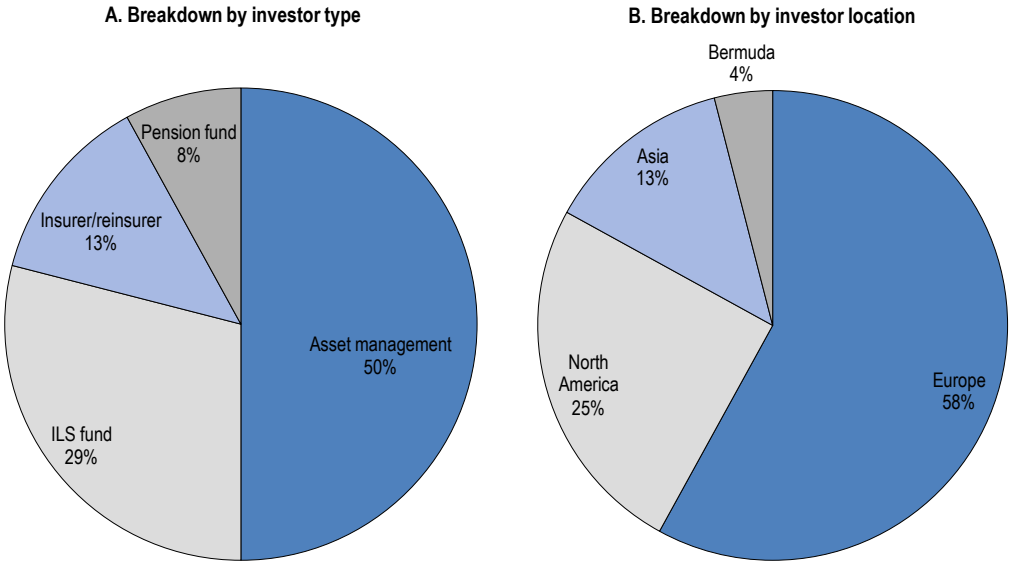
Depending on the calculated modelled loss amount following any earthquake or tropical cyclone event, the outstanding principal of either tranche could have been reduced by 0%, 35%, 70% or 100% (Table 4.2). More precisely, the Philippines government would have received payouts amounting to 0%, 35%, 70% or 100% of the principal, depending on the severity of an earthquake or a tropical cyclone event that occurred during the coverage period. If a qualifying event had occurred, the payout process would have taken approximately one month for an earthquake and five months for a tropical cyclone (World Bank, 2019[5]). The process would not have required assessment of the real losses incurred by the country.

The Philippines CAT bond transaction marked an important milestone in the country's long collaboration with the World Bank. Its development involved a number of specialised actors, for instance GC Securities and Swiss Re as the joint structuring agents, bookrunners and managers; Munich Re as a joint structuring agent, placement agent and manager; and AIR Worldwide as a risk modeller and calculation agent. In addition, the issue benefited from the Monetary Authority of Singapore's insurance-linked securities (ILS) Grant Scheme, which reduced the issuance cost by SGD 2 million (Singapore dollar) (DFA, 2019[6]). This

instrument was the first CAT bond sponsored by an Asian sovereign and listed on an Asian exchange (the Singapore Exchange).

The listing of the Philippines CAT bond on a recognised international exchange may enhance their secondary market liquidity, improve transparency for ILS transactions and increase the securities' attractiveness for some investors, particularly those required to hold listed and tradable securities in their portfolios. The Philippines CAT bonds were subscribed by 24 investors globally, ranging from asset management companies, dedicated CAT bond funds, pension funds and (re)insurance companies (Figure 4.1): asset management companies (Panel A) and Europe-based investors (Panel B) are the largest holders.

Figure 4.1. The Philippines CAT bond investor distribution by type and location



Note: ILS = insurance-linked securities.
Source: World Bank (World Bank, 2019[4]), "World Bank Catastrophe Bond Transaction Insures the Republic of Philippines against Natural Disaster-related Losses Up to US$225 million", www.worldbank.org/en/news/press-release/2019/11/25/world-bank-catastrophe-bond-transaction-insures-the-republic-of-philippines-against-natural-disaster-related-losses-up-to-usd225-million.

StatLink https://stat.link/3xlrtu

The Philippines' regulatory and institutional environment for CAT bond adoption

A strong legal and institutional framework for disaster risk financing is essential to facilitate the development of risk transfer mechanisms such as CAT bonds. The Philippines provides an example of good practice in this regard. The Philippine Disaster Risk Reduction and Management Act of 2010 (DRRM Act or the Republic Act [RA] No. 10121) contains detailed provisions on risk reduction budgets at various levels (Amach, 2021[7]). The Philippine Development Plan 2017-2022 also outlines several DRR strategies, among which was the development of facilities for adaptation, including risk transfer mechanisms (NDRRMC, 2020[8]).

The National Disaster Risk Reduction and Management Plan has been updated. Among other provisions, the updated plan is intended to strengthen disaster and climate risk governance by clarifying the roles, accountabilities, strategies and activities of DRR and management stakeholders at all levels. For instance, in adherence to the RA No. 10121, the Department of Science and Technology is the overall lead for disaster prevention and mitigation activities. One of the main objectives stipulates the institutionalisation

of risk financing mechanisms for both ex ante and ex post actions. This scope of activity emphasises the complementarity of resources to help strengthen financial resilience at all levels, with the Department of Finance (DoF) as the lead agency (NDRRMC, 2020[8]).

The updated National Disaster Risk Reduction and Management Plan 2020-30 also outlines several key focus areas within disaster prevention and mitigation pillar. For instance, under the leadership of the DoF, to ensure accessible disaster risk financing strategies efforts will include research and development of new mechanisms on risk financing; creation of an enabling environment for private-sector participation in the development of financing options; an information, education and communication campaign to encourage hazard insurance coverage at all levels; promotion and development of insurance schemes across sectors; and directory update of available financing windows for local government units (LGUs).

The Philippine government's adoption of a national Disaster Risk Financing and Insurance (DRFI) strategy in 2015 marked a key milestone in the country's financial planning for disasters. The DoF, supported by the World Bank, developed the national DRFI strategy with the aims of maintaining the sound fiscal health of the national government and of developing sustainable financing mechanisms for LGUs, among others. With the DoF and the Bureau of the Treasury (BTr) leading the implementation, the DRFI has allowed the government to expand its portfolio of disaster risk financing instruments.

The various instruments implemented by the government complement each other within the risk layering approach. This approach allows the government to efficiently use different financial instruments against events of differing frequency and severity. For instance, the government can rely on the resources annually allocated to the national or local DRR and management funds (NDRRM Fund and LDRRM Fund) to address funding needs after the occurrence of a high-frequency, low-severity event. Within each of these funds, 30% is allocated as a Quick Response Fund (QRF) to ensure swift availability of resources for immediate response efforts when disasters strike.

Additional solutions include contingent lending by international partners, such as the Asian Development Bank (ADB), the Japan International Cooperation Agency and the World Bank. The government also implemented the national parametric insurance programme pilot from 2017 to 2019. With over PHP 3 billion (Philippine peso) in premiums from the budget, the programme was intended to protect national government agencies (NGAs) and LGUs from risks of earthquakes and typhoons (World Bank, 2020[9]). The CAT bonds issued in 2019 were an example of instruments belonging to the top layer of the strategy. These instruments are deployed to provide rapid liquidity when rare but high-severity events occurred.

As an additional instrument to strengthen financial resilience, the National Indemnity Insurance Programme (NIIP) is currently being prepared. Led by the BTr, in tandem with the Government Service Insurance System (GSIS), the programme will cover economically important government assets, such as school buildings, bridges and roads in the national capital region and the eastern seaboard against various perils, including typhoons, floods, storm surges, earthquakes and volcanic eruptions. The implementation of the NIIP is supported by the recently issued Joint Memorandum Circular (JMC) No. 2020-001 or the Philippine Government Asset Management Policy (DoF/DBM/NEDA, 2020[10]).

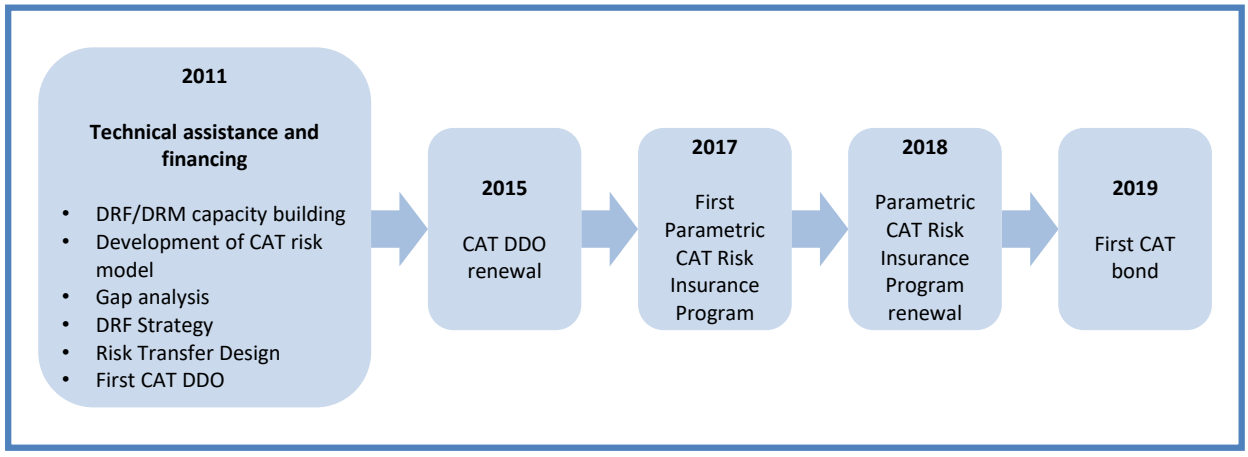
The JMC serves as a guide to government agencies and government-owned and government-controlled corporations on adopting the country's asset management system, which requires them to submit data related to their non-financial assets to the National Asset Registry System (NARS). Data within this information technology-based registry maintained by the BTr contain geographical, legal and financial data, asset attributes, risk mitigation features and insurance information. This also allows the government to enhance asset management, including prioritisation of assets for insurance coverage and disaster risk modelling (DoF/DBM/NEDA, 2020[10]). Currently, the government, with help from development partners, is enhancing the NARS to make it a web-based portal with more functionalities.

Additionally, the government completed the first nationwide catastrophe risk assessment in 2014 with assistance from development partners (World Bank, 2020[11]). It provided estimates of potential disaster losses of both public and private assets, which in turn allowed the government to analyse the costs and benefits of various risk financing instruments. Additionally, the risk assessment facilitated the evaluation of efficiency gains from combining various instruments to address various risks. For instance, based on the experience of implementing the catastrophe risk insurance programme in 2018, the government opted to use CAT bonds instead of renewing the insurance programme to reflect better the country's needs during disaster aftermath.

The Parametric Catastrophe Risk Insurance Program as a key facilitator of the Philippines CAT bonds

The development of disaster risk financing programmes began in 2012 and culminated with the issuance of CAT bonds (DFA, 2019). This instrument is the latest step of the World Bank's programme to support the country's disaster risk management (Figure 4.2). The national Parametric Catastrophe Risk Insurance Program, piloted from 2017 to 2019 with help from the World Bank, allowed the government to enhance its disaster risk management strategically and led to the application of a more suitable instrument that fits the government's needs (i.e. CAT bonds). Additionally, this pilot CAT risk insurance programme provided the country with technical expertise and lessons learned from its implementation that are useful for the preparation and placement of the CAT bonds (World Bank, 2020[11]).

Figure 4.2. Timeline of selected disaster risk financing programmes in the Philippines



Note: DRF = disaster risk financing. DRM = disaster risk management. DDO = deferred drawdown option.
Source: (World Bank, 2019[5]) "The Philippines: Transferring the Cost of Severe Natural Disasters to Capital Markets", https://thedocs.worldbank.org/en/doc/752771575392782540-0340022019/original/casestudyPhilippinesCATbondfinal12.3.2019.pdf.

Three underlying contracts exist within the Parametric CAT Risk Insurance Program. The first involves the BTr and the GSIS whereby the BTr acts as the policyholder, and the GSIS acts as the primary insurer. In fact, the structure of the programme initially had the LGUs as the policyholders. However, limitations regarding the LGUs' capacity to pay the premium and their lack of familiarity with the instrument led the national government to pay the premium on their behalf (World Bank, 2020[11]). The second contract involves the GSIS and the World Bank whereby typhoon and earthquake risks insured by the GSIS were reinsured by the World Bank Treasury. The third contract is between the World Bank and a panel of reinsurers, allowing the World Bank to transfer the aforementioned risks to the international reinsurance market in local currency. The private sector has shown significant interest in the transaction, with various counterparties being attracted, including non-traditional parties, such as pension funds. In the second year

of the policy, the number of counterparties doubled. With such strong demand, the achieved price of the insurance programme was comparable to other parametric programmes in the international market (World Bank, 2020[11]).

During the first year of the programme, the insurance policy provided financial protection of USD 206 million. This doubled to USD 406 million in the second year, providing coverage against both perils for NGAs and coverage against major typhoons for 25 selected LGUs (Table 4.3). The proceeds of the insurance coverage were intended solely for recovery and rehabilitation activities related to government infrastructure and facilities that are essential for the reinstatement of operations and the delivery of basic services.

Under the General Appropriations Acts of 2017 and 2018, premium payments were financed through the NDRRM Fund. These amounted to USD 19.84 million (PHP 1 billion) in the first year and increased to USD 39.68 million (PHP 2 billion) in the second year. The premiums are divided into two categories: disaster specific and province specific. For instance, during the first year of the policy, PHP 500 million was allocated on a disaster-specific basis, with 79.2% for typhoon and 20.8% for earthquake. The remaining PHP 500 million was province-specific and split equally among 25 provinces, with each province contributing PHP 20 million. Nonetheless, the way in which premiums were allocated among provinces changed in the second year of the policy (Table 4.3). Previously allocated equally among 25 LGUs, the premium payment of the programme renewal was split among participating LGUs according to the risk level, namely high, medium and low.

Table 4.3. Key facts of the Philippines Parametric Catastrophe Risk Insurance Program

Parameters	Year 1	Year 2
Total coverage	USD 206 million	USD 406 million
Perils covered	Typhoon, earthquake	Typhoon, earthquake
Trigger type	Modelled loss	Modelled loss
Policyholder	Bureau of the Treasury	Bureau of the Treasury
Intended beneficiaries	50% for NGAs, 50% for 25 LGUs	50% for NGAs, 50% for 25 LGUs
Premium	USD 19.8 million	USD 39.7 million
Premium allocation	Equal allocation among 25 LGUs	Premium allocation based on category of risks
Payout structure	Predefined partial payout with 10% probability of occurrence; predefined full payout with 3.3% probability of occurrence	Predefined partial payout with 10% probability of occurrence; predefined full payout with 3.3% probability of occurrence
Number of payouts	1 typhoon	1 typhoon and 1 earthquake
Number of calculation requests	2 typhoons	2 typhoons and 9 earthquakes
Total value of payouts	USD 1.7 million	USD 26.6 million
Policy term	July 2017-July 2018	December 2018-December 2019

Note: NGA = national government agency. LGU = local government unit.
Source: Authors' compilation.

There are, however, a few limitations during the first year of the policy. For instance, as the coverage, hence premium payment, was allocated equally across 25 participating LGUs, this implies that should the predefined trigger be met, all 25 provinces would receive identical payout amount. This mechanism did not consider the fact that each province has different level of risks. With such a mechanism, a province that suffers limited actual losses may receive a large, fixed payout relative to the modelled damages.

As the country's catastrophe risk model was developed on a modelled-loss basis, the Parametric CAT Risk Insurance Program used modelled loss as a trigger mechanism. The first national catastrophe risk model was released in 2014, and a commercial catastrophe risk model, which includes the subnational level, has

been available since 2016 (World Bank, 2020[11]). In the Philippines' case, AIR developed the new commercial catastrophe risk model used for the programme. The model was benchmarked and validated against previous versions of the country's catastrophe risk model.

Nonetheless, the experience of the Philippines reveals the complexity of using modelled losses. Indeed, this trigger mechanism has proven hard to understand and explain to potential counterparties. Risk analysis, which is performed using the probabilistic catastrophe risk model, is required for the international reinsurance or capital market, as it forms the basis of the technical price. To participate in this market, market participants require a good understanding of the modelling process, input data, assumptions used for the model and the uncertainties in outputs from the model when deployed for real-time loss estimation.

The complexity of a modelled-index loss trigger was also among the factors that led to the significantly increased number of calculation requests during the second year of the programme, as the government preferred to avoid the risk of missing a potential payout (World Bank, 2020[11]). Indeed, the BTr and the GSIS may request a calculation notice in the event of a disaster. Throughout the first and second policy terms, a total of 13 calculation requests were made. Out of these, the policies paid out for three events, namely typhoons Tembin and Tisoy and the Zambales earthquake.

Through the Parametric CAT Risk Insurance Program, the government could improve its knowledge related to parametric insurance. As the Philippines had no prior experience working with parametric insurance, there was little institutional knowledge about it within the government in general and within the GSIS (the insurer) specifically. This lack of experience working with parametric insurance posed a regulatory challenge for the first implementation in 2017.

For instance, because of the lack of prior experience with parametric insurance policy, the GSIS was unable to retain any of the risks associated with the parametric programme, while legislation stipulates that any insurance provided to the government should be provided by the GSIS. This implies that the GSIS had to seek 100% reinsurance for the programme. However, the country's standard procurement guidelines, which serve as a reference for laws that govern the GSIS procurement of international reinsurance, are not well suited for the purchase of (re)insurance cover (World Bank, 2020[11]). As a result, it was difficult for international financial markets to provide direct reinsurance coverage to the GSIS.

To overcome this issue, the Insurance Commission registered the World Bank as a reinsurer, thus allowing the GSIS to transfer risk to the World Bank. Amendments to or clarification of the Commission on Audit rules were also implemented, to allow LGUs to use funds from the LDRRM Fund to finance premium payments. This experience in addressing institutional and regulatory challenges created an enabling environment from which future transactions, including CAT bonds, may benefit.

Challenges remain, particularly concerning budget allocation. The NDRRM Fund still lacks the capacity to leverage efficiently its budget allocation through financial instruments, such as insurance and other risk transfer mechanisms. Moreover, budget allocations are still based on the previous year's allocation or on the known reconstruction costs (IBRD/World Bank, 2020[12]). This has resulted frequently in insufficient funding and often delayed immediate response activities.

Furthermore, the Philippines should give additional attention to the institutional and legal structure so that the NDRRM Fund can play a role as a financial vehicle that can efficiently leverage the national budget allocation. Initiatives may include setting up a special purpose fund with the capacity to channel additional financial instruments in a transparent and efficient way, including contingent financing, insurance, and CAT bonds. This may also help support the Fund during severe disaster years by allowing it to accumulate across fiscal years as a self-insurance mechanism. However, the Republic Act 10121, which governs the NDRRM Fund, primarily focuses on allocating resources for DRR, response, and recovery efforts. For the NDRRM Fund to function as a financial vehicle, potential amendments might be necessary within the legislation to explicitly allow such uses. It would need to incorporate provisions that allow the Fund to engage in financial mechanisms beyond direct disaster response and recovery. A mechanism that

balances years with higher and lower disaster costs would enable the government to smooth out unexpected expenditures. It is worth noting that, for the Fund to perform this function, the government may need to work on its governance and operational arrangements to guarantee implementation capacity, appropriate supervision and transparency.

Improving the quality and availability of exposure data is essential for more sophisticated catastrophe models

Regardless of the type of trigger, CAT bonds need to rely on a catastrophe model to assess the average expected loss and the possibility of partial or full loss in order to establish the bond premium. In the Philippines, earthquake and typhoon models have been used in the insurance market for several years and have been continuously improved. Data are indeed fundamental for loss estimation and model development. For instance, developing an earthquake model requires historical data on earthquakes, which can be obtained from local and regional historical earthquake catalogues. For tropical cyclones, sources of information include historical data in the form of barograph traces from land stations and ships, actual wind records from weather service stations, aircraft reconnaissance flight data, and precipitation data, among others.

With regard to the industry exposure databases (IED), much of the information is obtained from government statistical agencies and private firms specialising in this type of information. It includes data ranging from low-tier administrative areas, such as municipalities, to location-level data. According to AIR, the risk modeller and calculation agent for the Philippines' CAT bonds, the late 2015 edition is the country's IED, while as of late 2013, it is the exposure database of national government assets. The national government assets database also relies on data from various government agencies, including the Department of Education, the Department of Public Works and Highways, and the GSIS. This database comprises information about state-owned enterprises and specific infrastructure assets, including their location, structural and non-structural characteristics, and replacement cost. Roads, bridges, light rail, airports, seaports, schools, hospitals, prisons and other public administration buildings are among the assets modelled.

Risk modelling can, however, present several challenges, especially when there is a lack of historical loss data that can be useful for projecting future losses. Moreover, the available loss data are often inadequate due to the continued establishment of properties in hazard-prone areas and the constantly changing landscape of insured properties. This includes changing property values and costs of repair and replacement, as well as new building materials, design and structure that may be more or less vulnerable to catastrophe events. As a result, the limited available loss data are not suitable for directly estimating future losses.

The Philippines has put in place a number of initiatives to improve asset information, for instance through the adoption of the Philippines Government Asset Management Policy and the establishment of the NARS. In addition, the government is currently trying to track disaster-related expenditures in a systematic way through the development of a Disaster Risk Reduction Expenditure (DRRE) in the System of National Accounts. The framework encompasses various DRRE activities, including transfer from central to local government; inflow and outflow of international transfers (official development assistance); total disaster-related expenditures by category, by government and by non-government, as well as beneficiaries of total expenditures; and the total transfers received. However, such practices remain challenging due to, among other factors, the lack of standard concepts, definitions, classifications and methodologies; the limited capacity of regular reporting; and data gaps and time lags (Ilarina, 2021[13]). The creation of the Philippine City Disaster Insurance Pool, a risk pool designed to cover municipalities against the risk of typhoons and earthquakes, also enhanced the capacity to strengthen data collection processes and needs assessment (Box 4.1).

Box 4.1. Characteristics of the PCDIP

Cities in the Philippines face particularly high disaster risk. The Philippine City Disaster Insurance Pool (PCDIP) was established to address the need for rapid access to early recovery financing. Ten cities participated in the design of the pool. Their selection was based on an array of factors, including exposure to disaster risk, demographic and economic size, geographic location, data availability and disaster risk management governance. An additional element considered was the relative scale of government and public facilities, as an indication of post-disaster levels of expenditure. To support the optimal design of the PCDIP, the cities took part in a number of activities, including exposure data collection, needs assessment and capacity building.

The PCDIP is intended to provide rapid post-disaster financing for early recovery in a cost-efficient manner. A parametric insurance pool whereby payouts are determined based on the physical features of a catastrophe event (e.g. wind speed, earthquake intensity) rather than on actual losses suffered by the policyholder was identified as the best solution. The PCDIP offered parametric insurance coverage against typhoons and earthquakes in its first phase, with flood coverage added at a later stage. PCDIP payouts are made within 15 business days of the occurrence of an event.

Participating cities can purchase insurance coverage based on the types of hazards they want to insure against, the frequency and scale of payouts they would like to receive, and the funding available for premium payments. The premiums paid by each city are based on the level of risk the respective city brings to the pool. The PCDIP was structured to ensure that: i) municipalities can afford the premiums (e.g. via flexibility in choosing their coverage); ii) the pool is able to honour payouts in a timely manner; and iii) the pool is financially sustainable over the long term. Payouts are funded by a combination of pool capital and reinsurance protection purchased from domestic and international markets. The initial pool capital was provided by the government and will be supplemented by retained profits in years characterised by low disaster-related losses.

Source: (ADB, 2018[14]), *Philippine City Disaster Insurance Pool: Rationale and Design,* www.adb.org/sites/default/files/publication/479966/philippine-city-disaster-insurance-pool-rationale-design.pdf.

The aforementioned initiatives notwithstanding, data on public assets, particularly assets owned by NGAs, and data on disaster-related damage in the Philippines, remain incomplete (IBRD/World Bank, 2020[12]). Moreover, data on the use of different disaster-related funding sources are fragmented. For instance, detailed information with regard to disaster-related expenditures are often not included in government agencies' reports. At the local level, it is often difficult to obtain data on LGU expenditures for past disasters or the expected share of expenditures between LGUs and the national government for future disaster scenarios (World Bank, 2020[11]). Additionally, the government lacks access to complete data on all assets owned by NGAs, including information related to the location, condition, maintenance and valuation of assets. This may create challenges for authorities to establish financial and risk management plans, and for stakeholders involved in CAT bond transactions (e.g. the modelling agent) to obtain better model estimates.

There is room to improve implementation of the Philippine Government Asset Management Policy in ways that would facilitate nationwide roll-out. This can be done, for instance, by requiring all government agencies to submit data to the NARS. Capacity building would also be necessary for the government to improve its capacity to assess, record and report damage and loss resulting from natural disasters. The collection and reporting of data should include all details on asset loss, in addition to registering aggregate data. By including granular data, the government could have a better understanding of post-disaster needs, which may in turn help implement the most cost-efficient risk transfer mechanism available.

Clarifying post-disaster responsibilities is crucial for the timely disbursement of funds

The implementation of the Parametric CAT Risk Insurance Program paved the way for the issuance of CAT bonds. While CAT bonds can provide quick liquidity following the triggering events, efficient disaster response and recovery may be hindered if there is a lack of clarity on risk ownership between national and local governments, lack of monitoring of post-disaster spending and lack of predefined fund flow mechanisms and beneficiaries. For instance, following the occurrence of Typhoon Rai (known as Super Typhoon Odette locally) that struck the Philippines in late 2021, the government issued notice to the calculation agent to see whether the event was severe enough to trigger the USD 150 million CAT bonds that cover typhoon losses.

The Typhoon Rai has, indeed, breeched the CAT bond trigger, resulting a partial payout of USD 52.5 million (35% of the principal) for the government. Although details on the use of funds originating from CAT bond payout was unavailable at the time of writing, lessons can be taken from the implementation of the Parametric CAT Risk Insurance Program, as both instruments share characteristics. Both the Philippines' CAT risk insurance programme and CAT bonds provide coverage against risks of earthquake and tropical cyclone, use the same trigger mechanism, are reinsured and issued by the same institution (the World Bank), transfer risks to international markets, and require loss calculation by the same calculation agent (AIR) for payout procedures, among other aspects. Lessons learned from the Parametric CAT Risk insurance Program, particularly those related to payouts or fund disbursement, may therefore also be relevant for CAT bonds.

As discussed, the Parametric CAT Risk Insurance Program generated a total of three payouts from the first and second policy terms. These payouts were efficiently transferred from the international reinsurance market to the reinsurer (World Bank), then to the insurer (GSIS), and further to the policyholder (BTr). All payouts were completed as planned and in a timely manner. For instance, policy payments to the BTr were made six weeks after Typhoon Tembin hit the country in late 2017, eight weeks after the earthquake struck off Zambales and five weeks after Typhoon Tisoy hit in late 2019 (Table 4.4).

Table 4.4. Payout timeline of the three events that triggered the Philippines Parametric Catastrophe Risk Insurance Program

Detail	Typhoon Tembin	Zambales earthquake	Typhoon Tisoy
Event date	21 December 2017	22 April 2019	2 December 2019
Calculation notice date	27 December 2017 *6 days after event*	8 May 2019 *16 days after event*	5 December 2019 *3 days after event*
Calculation reporting date	11 January 2018 *3 weeks after event*	17 May 2019 *25 days after event*	11 December 2019 *9 days after event*
Reinsurance payment date	24 January 2018 *5 weeks after event*	3 June 2019 *6 weeks after event*	23 December 2019 *3 weeks after event*
Policy payment date	1 February 2018 *6 weeks after event*	17 June 2019 *8 weeks after event*	7 January 2020 *5 weeks +1 day after event*

Source: (World Bank, 2020[11]) *Lessons Learned: The Philippines Parametric Catastrophe Risk Insurance Program Pilot,* https://openknowledge.worldbank.org/bitstream/handle/10986/36013/The-Philippines-Parametric-Catastrophe-Risk-Insurance-Program-Pilot-Lessons-Learned.pdf?sequence=1&isAllowed=y.

While payout transfers from the international reinsurance market to the BTr were done successfully according to the plan, fund disbursement from the BTr to the intended beneficiaries had several issues due to the lack of clarity in the rules governing fund disbursement. For instance, during the first policy term, the mismatch between payouts and losses from Typhoon Tembin resulted in misunderstandings and led to difficulties in allocating the funds (World Bank, 2020[11]). In fact, payouts related to Typhoon Tembin

were subject to positive basis risk, meaning the payout amount based on modelled losses, was higher than the actual losses observed in the province that triggered the payout.

Given the positive basis risk, there was disagreement among authorities on how the funds would be distributed. Arguments included, among others: i) funds should be transferred to LGUs or NGAs, as the national government had paid the premiums; ii) funds should be given to the triggering province to demonstrate the usefulness of the insurance product; iii) funds should be distributed to the neighbouring provinces most in need; and iv) funds should be retained by the government to support future premium payments. As part of the fund disbursement procedure, the JMC outlines that the Department of Budget and Management requires an allocation report to trigger the Notice of Cash Allocation (NCA). This NCA would further allow the BTr to release the funds. However, due to disagreements among authorities on how to allocate the funds, as well as the lack of clarity in the JMC, an allocation report was not produced, and the NCA was never submitted. As a result, the funds have remained with the BTr (World Bank, 2020[11]).

Learning from the experience of the first policy term, significant changes were made to the JMC to manage payouts better during the second policy term. With the new JMC, payouts would not automatically go to the triggering LGUs. Instead, payouts would be made in accordance with the allocation report produced by the authorities. This could include payouts to affected LGUs, regardless of their inclusion in the programme.

The revision of the JMC also outlines the responsibilities of the Office of Civil Defense (OCD) in conducting post-disaster assessments. From previously being responsible for producing the rapid damage and needs assessments report, the revised JMC mandates the OCD to produce a simpler situational report. Such changes were made to improve the timeliness of fund disbursement. This is due to the production of the rapid damage and needs assessments report, which took a long time to produce during the previous policy term, hence slowing down the production of the allocation report and the disbursement of the funds to the LGUs.

Despite the JMC being revised, an issue remains that hinders smooth fund disbursements from the national government to the intended beneficiaries. The JMC states that the BTr requires the receipt of an NCA to release the funds. However, as of July 2020, the NCA was not prepared or received for either event that triggered payouts during the second policy term (the Zambales earthquake in mid-2019 and Typhoon Tisoy in late-2019) (World Bank, 2020[11]). Therefore, the funds have remained in the BTr account and have reached neither the LGUs nor the NGAs.

The pilot CAT risk insurance programme demonstrates the complexity of allocating funds, including payouts, in the most efficient and fair way during the post-disaster period. From the issues presented above, it follows that the Philippines may need a more efficient procedure of payout from the national government to beneficiaries. This would ensure that the country could really benefit from the rapid payouts offered by risk transfer instruments, including the currently implemented CAT bonds. From a regulatory perspective, the country may need to set clear public financial management rules that ensure the efficient and transparent flow of funds in the aftermath of natural disaster events. More can be done, for instance by establishing clear fund-flow arrangements and by providing clear guidance with regard to the delays or time needed to accomplish each step of the procedure.

In addition, cost sharing between the national government and the local governments may need to be clarified. Indeed, the national government currently covers most of the disaster response costs, including premiums. Through clear and credible rules on how these costs are shared between national and local governments, risk ownership could be more explicit, thereby improving financial planning for disaster response at all levels. Clear risk ownership would also create incentives to strengthen risk management and financial preparedness, especially at the local level, where disaster-related resources are available, but their utilisation is often inconsistent with the intended purpose (COA, 2021[15]).

The case of Indonesia

The Indonesian archipelago lies along the Pacific Ring of Fire. Due to its geographical location, the country is often exposed to many disasters, including earthquakes, tsunamis, floods, landslides and volcanic eruptions. According to the World Risk Report 2023, Indonesia's risk index ranked second in the world, with exposure to natural hazards falling into the "very high" category (Bündnis Entwicklung Hilft/IFHV, 2023[1]). Nonetheless, the Indonesian Disaster Risk Index (IRBI), which is a measure to calculate and monitor disaster risks in Indonesia based on three factors, namely exposure, vulnerability, and capacity, shows a declining trend. The decline in IRBI in recent years is a positive development, as it indicates that Indonesia is making progress in reducing its risks of disasters. However, the decline in the budget for DRR is a concern as it could lead to a decrease in the effectiveness of DRR programs.

Between 2000 and 2022, the annual damages resulting from disasters amounted to around USD 1.4 billion (CRED, n.d.[16]). With such significant losses relative to the USD 214 million annual disaster-related budget (MoF, 2018[17]), the country seeks to improve its financial resilience through risk transfer mechanisms by minimising fiscal risks due to disasters.

Although not by means of a sovereign-sponsored CAT bond, the risk of volcanic eruptions in Indonesia has recently been transferred to capital markets through the world's first volcanic risk CAT bond, issued on behalf of the Danish Red Cross (Box 4.2).

Box 4.2. Characteristics of the first volcano CAT bond

The world's first volcano catastrophe (CAT) bond provides a three-year coverage against risks associated with ten volcanoes across parts of Africa, Asia, Central America, North America and South America. The privately placed CAT bond, worth USD 3 million, was issued on behalf of the sponsoring organisation, the Danish Red Cross. The capital is set to be used to support humanitarian relief efforts in the aftermath of a volcanic eruption. The CAT bond features a parametric trigger based on plume heights and prevailing wind direction, meaning varying amounts of payout would be triggered if a volcanic ash plume reaches a certain height within the three plume height thresholds, and the prevailing wind directs the resulting ash fallout towards vulnerable communities.

The ten volcanoes covered by the CAT bond were selected based on the significant humanitarian risks they pose. All have at least 700 000 individuals living within the radius of 100 km, a distance wherein the ash fallout is expected to have greatest impact. The volcanoes are well monitored and studied; hence the CAT bond trigger can be assessed. They include three volcanoes in Ecuador, one in Chile, one in Colombia, one in Guatemala, one in Mexico, one in Cameroon and two in Indonesia (Merapi and Raung).

The typical privately placed CAT bond issuance providing international coverage often features multiple perils from various geographic locations around the world, such as earthquakes in Australia, windstorms in Europe and named storms in the United States. The volcano CAT bond, however, provides coverage against a single type of peril but in multiple locations, making it the first of its kind in the CAT bond market.

This volcano CAT bond has been considered a strong model for CAT bond design due to its innovative features, including the modelled risks that use parametric triggers with a hybrid nature (i.e. the occurrence of an eruption measured by ash plume height and wind direction). With such a model, the trajectory of the ash cloud can be used to estimate the impact better. In addition, the model helps anticipate where funds will be needed, improving the efficiency and effectiveness of humanitarian relief. Another innovative feature is its placement, which is made through a unique blockchain-based ILS platform. This offers a cost-effective way to settle the transaction for both issuers and investors. It reduces issuers' transaction costs by around USD 200 000 to USD 400 000 per issue compared to the traditional settlement system, and it enables investors to hold their securities on their own computer

servers rather than use a custodian bank. This could save a further five to ten basis points per annum on the value of the securities held by investors.

Source: (Evans, 2021[18]), "First volcanic eruption CAT bond issued for the Danish Red Cross", www.artemis.bm/news/first-volcanic-eruption-cat-bond-issued-for-the-danish-red-cross/.

With regard to sovereign CAT bonds, however, Indonesia is not yet present in the CAT bond market. Nevertheless, there is a possibility for CAT bonds to be used as a risk transfer mechanism within the country's disaster risk financing strategy. Following a series of deadly catastrophes in 2018 (Box 4.3), including the earthquake in West Nusa Tenggara, the earthquake, tsunami, and liquefaction in Central Sulawesi and the volcanic tsunami in Sunda Strait, the government aims to strengthen its financial resilience against disasters through the use of sophisticated financial instruments (World Bank, 2018[19]). The government also considered CAT bonds among the viable options to fund disaster recovery efforts for future catastrophe events that cause damage beyond the annual disaster-related budget (MoF, 2018[17]). However, several challenges may need to be addressed in order to use CAT bonds effectively (Table 4.5).

Table 4.5. Enabling factors for and challenges to the implementation of sovereign CAT bonds in Indonesia

Enabling factors	Challenges
• Establishment of a Pooling Fund for Disasters with the capacity to leverage budget through market-based instruments • Strong legal and institutional framework for disaster risk management • Support for risk management infrastructure, including development of Indonesia One Disaster Data • Availability of models for several types of catastrophe events	• High transaction costs • Narrow investor base • Insufficient legal framework for risk transfer mechanisms • Lack of regulatory framework for disaster data management • Need to strengthen risk data and analytics to facilitate risk modelling and instrument design • Need to recalibrate existing models to produce accurate prediction and to reflect local practices

Source: Authors' compilation.

Box 4.3. Indonesia's three major catastrophes in 2018

In 2018, Indonesia experienced significant losses resulting from three major catastrophes. The first occurred in July and August 2018, when the province of West Nusa Tenggara was struck by a series of earthquakes. The strongest (magnitude 7.0 on the Richter scale) took place on 5 August 2018. According to the updated report released on 20 January 2019 by the national disaster management agency, Badan Nasional Penanggulangan Bencana (BNPB), the event claimed 564 lives, injured 1 886 people and displaced around 472 000 people (BNPB, 2019[20]). Moreover, the earthquake caused severe damage to property, infrastructure and livelihoods, including to almost 72 000 houses, 671 schools, 52 health facilities, 6 bridges and many roads (BNPB, 2018[21]). Based on the BNPB's initial assessment using basis data as of 13 August 2018, damage and loss amounted to approximately IDR 7.45 trillion (USD 514 million) (BNPB, 2018[21]).

On 28 September 2018, a magnitude 7.4 earthquake hit the province of Central Sulawesi and led to a tsunami that struck the coastal areas of the Palu Bay. The event caused landslides and liquefaction of soil in several densely populated areas, including the city of Palu and three other regencies, making relief and recovery efforts complicated. As of February 2019, more than 4 000 people have been

reported either dead or missing, and approximately 172 000 people have been displaced (BNPB, 2019[22]). Damage to buildings and infrastructure was extensive, including to 68 451 houses, 265 schools, 78 offices and 7 bridges, with an overall cost of IDR 18.5 trillion (USD 1.3 billion) (BNPB, 2019[22]).

On 22 December 2018, a volcanic tsunami affected five regencies in the provinces of Banten and Lampung, located along the Sunda Strait. The event was caused by the eruption and subsequent partial collapse of the Anak Krakatau volcano under the sea. The impact of the tsunami hit the coast around the Sunda Strait, causing damage and loss of life in residential and tourist areas. As of 14 January 2019, the event had caused 437 fatalities and displaced 16 198 people (BNPB, 2019[23]).

The economic and social costs resulting from these disasters led to significant fiscal pressure. Costs are estimated to exceed IDR 40 trillion (USD 2.8 billion) (ADB, 2018[24]), representing around 0.27% of the country's GDP in 2018. For instance, rehabilitation and reconstruction activities for Central Sulawesi require IDR 22 trillion (Central Sulawesi Provincial Government, 2018[25]), an amount expected to increase due to the need to relocate residents outside of the disaster-prone zone set by the government and to rebuild the settlements of residents who survived the tsunami and liquefaction.

Financing for post-disaster activities often comes from the national government, complemented by sources from regional governments, the private sector and international assistance. Responding to and meeting the needs of disaster recovery therefore require fiscal adjustments at both the national and local levels. To meet the 2018 post-disaster needs, the government also requested support from development partners mainly to address the urgent need for financial and technical assistance. In addition, a number of key agencies and line ministries were instructed to reallocate existing resources under the 2018 budget to provide priority support to affected areas (ADB, 2018[24]). This further highlights the need for additional financing resources to meet emergency needs and, most importantly, to avoid budget reallocations at the expense of government investment projects in other parts of the country.

Indonesia's legal and institutional arrangements for CAT bond adoption

The overall aspects of disaster risk management in Indonesia are co-ordinated by the national disaster management agency, Badan Nasional Penanggulangan Bencana (BNPB), and its subnational counterparts. The country's legal framework for disaster risk management, including the financing aspects of it, is outlined in Law No. 24/2007. The law provides guidelines on funding mechanisms for different post-disaster phases and outlines the financial responsibilities of national and subnational governments. It mandates the government to allocate an adequate amount of the state budget for disaster management and for the On-call Fund or *Dana Siap Pakai* (DSP), which can be released during emergencies.

To support the implementation of Law No. 24/2007, the government issued Regulation No. 22/2008, which states that both the National State Budget (APBN) and Subnational Government Budget (APBD) are obliged to provide funds for three phases of disaster risk management (i.e. before, during and after disasters) (MoF, 2018[17]). Concerning the financial distribution between the national and regional governments, Law No. 33/2004 stipulates that National State Budget emergency funds should be allocated to a region experiencing a catastrophe declared a national disaster for which the region's Subnational Government Budget faces a shortfall due to the magnitude of its impact.

In emergency funding, DSP serves as readily available funds, while Belanja Tidak Terduga (BTT) or unexpected expenditure is budget expenditure at the expense of the APBD for emergency needs. BTT is used to budget expenditures for emergencies, covering urgent needs that could not be predicted beforehand and refunds of excess payments on regional revenues in previous years as well as for social assistance that cannot be planned. BTT can be employed in various emergency situations, including

natural disasters, non-natural disasters, social disasters, and/or extraordinary events. Both DSP and BTT mechanisms play crucial roles in ensuring swift financial response to emergencies, offering flexibility to address immediate needs and unexpected costs during disaster situations. These funds contribute to effective disaster management by facilitating quick and adaptive financial measures.

As disasters keep putting pressure on the state budget by widening the financing gap, and as the financing mechanism focused heavily on post-disaster funding and international assistance, the government sought to fix the shortfalls by adopting a DRFI strategy. The strategy was formally launched in 2018 under the leadership of the Minister of Finance and the Vice President. Improving the governance and funding of disaster management at the local level, as well as developing alternative funding schemes for disaster management, has been set as a national priority and is included in the 2020-24 Medium-Term Development Plan. The recently issued Presidential Regulation No. 87/2020 on the Master Plan for Disaster Management 2020-2044 also outlines innovative funding schemes, including risk transfer as a strategy to strengthen investment in disaster risk management (BPK RI, 2020[26]).

Under the country's DRFI strategy, the government assigns priority to protecting the state budget through the establishment of a dedicated budgetary mechanism by relying on five main principles. These include: i) synergy and/or collaboration among national and local governments, the private sector and communities; ii) a risk layering strategy; iii) timeliness and adequacy of funds; iv) a well-targeted, transparent and effective fund disbursement mechanism; and v) accurate data and information. Table 4.6 details the implementation of Indonesia's DRFI strategy, including the government's targets and priorities in the short and medium terms.

In terms of disaster financing mechanism tailored for specific groups of population, such as farmers, Law No. 19 of 2013 on the Protection and Empowerment of Farmers led to the introduction of agricultural insurance. Following the regulations set by Minister of Agriculture Regulation No. 40 of 2015, which further governs the implementation of agricultural insurance in Indonesia, the program commenced in 2015. The Directorate General of Infrastructure and Agricultural Facilities of the Ministries of Agriculture plays a primary role in this insurance initiative, and the Ministry has partnered with PT Jasa Asuransi Indonesia as the underwriter for the insurance program.

Table 4.6. Indonesia's DRFI strategy

Short term (2018-19)	Medium term (2020-23)
1. Strengthen the policy framework	1. Prepare and establish a pooling fund
2. Implement the Public Asset Insurance programme	2. Explore new financing schemes
3. Strengthen and scale up existing risk transfer schemes	3. Increase subnational governments' role (cost-sharing) in disaster risk financing
4. Run a feasibility study on a pooling fund	4. Explore prearranged disbursement channels
5. Explore appropriate international instruments	5. Improve fiscal and budget management
6. Provide DRFI education (to law enforcement, parliament, line ministries, and subnational governments)	6. Enhance international co-operation (knowledge exchange) and initiatives

Source: (MoF, 2020[27]), *Terms of Reference Environmental and Social Management System (EMS) Development and Environmental and Social Management for Indonesia Disaster Risk Finance Pooling Fund Project (IndoRisk Project)*, https://fiskal.kemenkeu.go.id/files/lain-lain/file/ToR-Environmental-and-Social-Management-System(ESMS).pdf.

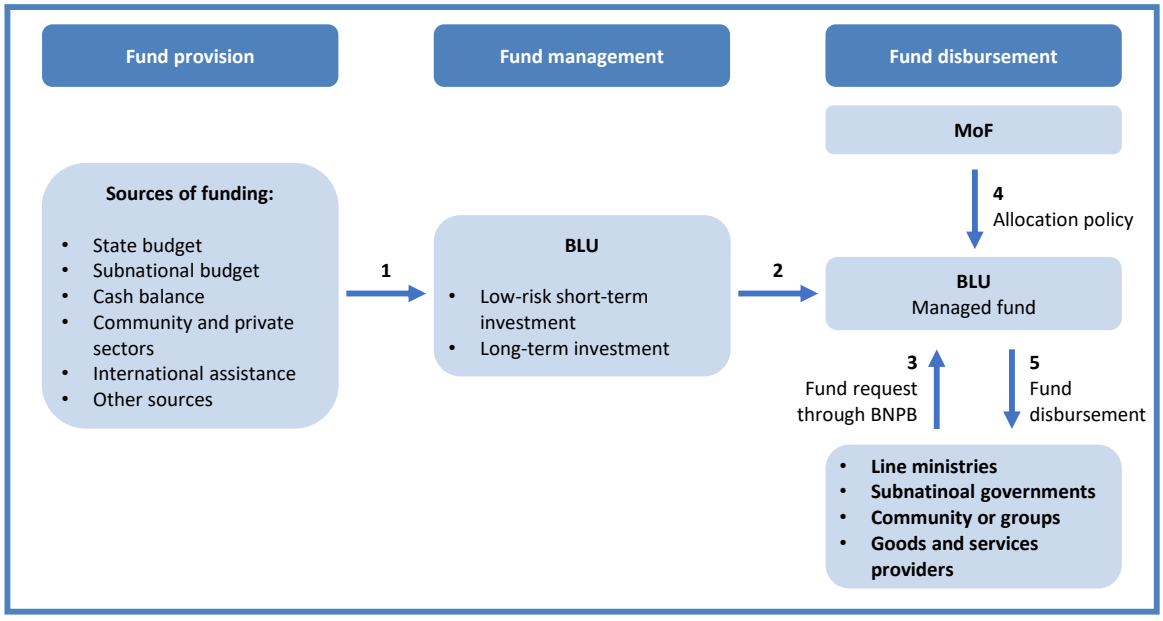
The government launched the Disaster Pooling Fund, or the *Dana Bersama Penanggulangan Bencana*, also known as *Dana Bersama* or Pooling Fund Bencana (PFB), by issuing Presidential Regulation No. 75/2021 on 13 August 2021. To complement this presidential regulation, on 3 January 2024, BNPB issued the BNPB Regulation No. 1/2024 on the Review, Verification, and Evaluation of the Distribution of the Disaster Pooling Fund as one of its derivative legal instruments. Article 2 stipulates that it covers distribution for pre-disaster, during emergency response, post disaster (particularly on recovery activities), and risk transfer funding. The PFB is the core component of Indonesia's DRFI strategy. It marks an

important milestone for the country's disaster risk management, as it has the potential to: i) increase disaster financing capacity by enabling the government to accumulate unspent budget allocations for disaster response, which can be used to build reserves to spend when disaster occurs in future years; ii) improve the efficiency of using funds originating from the state budget through improved upfront planning and budgeting; iii) leverage additional financial instruments by linking them directly to the PFB with clear operating procedures agreed upon in advance; iv) connect the PFB to clear, prearranged disbursement channels and rules, thereby increasing the speed and transparency of post-disaster spending and providing predictability to implementing agencies on the availability of funds; and v) increase the ability to link risk financing to incentives and activities for all phases of disaster risk management (MoF, 2020[27]).

The PFB is managed by a public service agency, the Badan Layanan Umum (BLU), under the supervision of the Ministry of Finance. By using the BLU as a structure to manage the pooling fund, the PFB has some flexibility in financial management, such as the possibility of accumulating budget surpluses over multiple fiscal years. At its launch, the PFB is set to manage initial capital of IDR 7.3 trillion (over USD 500 million) (MoF, 2021[28]). The flexibility gained by using the BLU model can be applied to managing the non-financial aspects of the PFB. For instance, it allows the PFB to design and implement its own governance structure to ensure that the fund is managed appropriately and according to international standards. The PFB may also recruit staff and experts to meet the fund's varying and complex needs. Most importantly, the PFB may procure services and perform tasks required to fulfil its needs. Examples include purchasing insurance or reinsurance protection for the fund using the managed funds and receiving payouts directly from the insurance companies.

The PFB is designed to serve as a self-insurance mechanism for the government. It will receive budget funding; accumulate and leverage funds received from national and local governments, the private sector, communities and development partners; develop a risk financing strategy; and work with implementing agencies to establish different post-disaster compensation schemes through which funding will be disbursed. The PFB scheme allows the streamlining of some administrative processes, ensuring that disbursement of funds or distribution of insurance payouts is timely, transparent and accountable (Figure 4.3).

Figure 4.3. Characteristics of the PFB scheme



Source: Adapted from (MoF, n.d.[29]), "Pooling Fund Bencana", https://fiskal.kemenkeu.go.id/strategi-drfi/pooling.

The PFB model builds on international best practices of self-insurance funds, such as Australia's Comcover (Box 4.4). As such, the adopted model of the PFB operates differently from existing regional risk pools. The latter typically serve as insurance companies that offer specific parametric insurance products, such as the Southeast Asia Disaster Risk Insurance Facility, the CCRIF and the Pacific Catastrophe Risk Insurance Company (MoF, 2020[27]).

Box 4.4. The Australian government's self-managed insurance fund: Comcover

Comcover was established in 1998 to provide insurance and risk management services to Australian government entities classified as belonging to the General Government Sector (Fund Members). It serves to protect the Commonwealth Budget by ensuring that all Fund Members have comprehensive financial protection from major threats that can arise from claims associated with insurable risks. It is not structured as an insurance company. Instead, it is a self-managed fund that operates by collecting premiums from participating Fund Members, accumulating reserves and meeting future losses from those reserves. Under Comcover's Statement of Cover, Fund Members receive cover for all general insurable risks, including liability, property, motor vehicle, and personal accident and travel. As of 2015, Comcover insured more than 160 Fund Members with various responsibilities and functions.

Comcover also facilitates a comprehensive and consistent approach to protecting Fund Members by building risk management capability through effective data collection and claims management. Under its risk management programmes, Comcover aids Fund Members in building their risk management capability and ensuring the successful implementation of risk management within their organisations. This is done through education and training programmes that target Australian public service officials at the foundation, practitioner and senior executive levels.

Additionally, as the key part of Comcover's risk management services, the Risk Management Benchmarking Programme allows Fund Members to self-asses their risk management capability and measure the maturity of their risk management frameworks. Through this mechanism, Fund Members are provided with the ability to track their risk management performance against that of their peers. Comcover's risk management programmes also include an annual award, giving recognition and rewards to Fund Members who demonstrate excellence in risk management.

Source: (DoF, 2015[30]), "An Introduction to Comcover", www.finance.gov.au/sites/default/files/2019-11/introduction-to-comcover.pdf.

With the newly established PFB, there is enormous potential for Indonesia to tap into capital markets and adopt an alternative risk transfer mechanism, such as CAT bonds, as part of a broader risk financing strategy. This would allow the country to have greater certainty in terms of budget planning, to diversify its funding sources to cope with the impact of natural catastrophes, and to have guaranteed access to financing sources for timely recovery. However, the adoption of such an instrument will depend on the government's commitment and capacity to overcome challenges associated with the implementation of CAT bonds, including the high transaction costs, the insufficient legal framework for risk transfer mechanisms and the lack of a regulatory framework for disaster data management (BNPB/BPS, 2020[31]).

Transferring the risk of Indonesia's severe earthquakes through CAT bonds is an option

Indonesia's current DRFI strategy consists of various financing options set under a risk layering approach to tackle financing challenges resulting from events of varying frequency and severity. Financing arrangements for risk retention include, among other, the allocation of national and subnational budgets, and the contingency credit. In late 2020, Indonesia was provided with a USD 500 million loan from the ADB (ADB, 2020[32]). This policy-based loan, which can be accessed following disaster declarations, also supports the government in reforming disaster risk management in three areas: i) strengthening policies and action plans

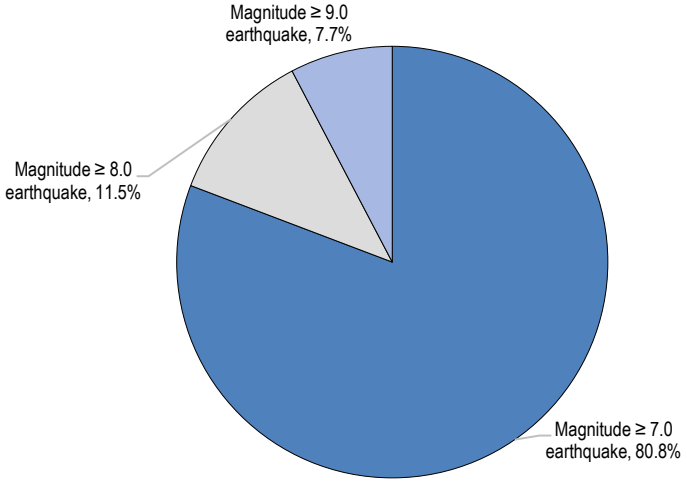
for disaster response and health-related emergencies; ii) increasing public infrastructure resilience against disaster and climate risks; and iii) improving financing for disaster risk and pandemic response.

Indonesia has been implementing the government-supported insurance programme as a risk transfer strategy. It targets low-income households, particularly small farmers and fish cultivators. In 2019, the country added the Public Asset Insurance programme to its disaster risk financing menu. Previously, the implementation of programme, including the planning process, budgeting, procurement, claims and repairs fell under the responsibility of participating ministries and institutions. However, with Presidential Decree No. 75/2021, all processes will be conducted by the BLU, the agency that manages the PFB. The new scheme will streamline procurement and claims processes for the insurance industry as the industry will now serve only the BLU rather than all ministries and institutions.

Throughout 2020, the Public Asset Insurance programme covered government losses of IDR 1.14 billion (around USD 78 000), which is the value of claims related to 18 public assets affected by disasters (Retnowati, 2021[33]). Although the claims have been paid, there is a lack of detailed information with regard to the claims process, making it challenging to evaluate the programme and to benchmark it against international best practices. As of mid-2021, the government has insured more than 4 300 public assets of 51 ministries and institutions, with a total premium of IDR 49.13 billion (USD 3.4 million) and a total insured value of IDR 32.41 trillion (USD 2.3 billion) (MoF, 2021[34]). These figures illustrate a promising trend. In 2019, the programme only covered Ministry of Finance assets; in 2020, it evolved to cover 2 112 assets of 13 ministries and institutions (Subekti, 2020[35]). Claims from the Public Asset Insurance programme contribute to the non-tax state revenues, allowing the government to reconstruct damaged state assets while minimising the use other resources within the APBN.

Despite strong efforts, there remains clear opportunities to enhance Indonesia's post-disaster financing capacity. The current DRFI strategy lacks a mechanism to cover losses from the most severe disasters. At the local level, rehabilitation and reconstruction activities are usually financed through funds allocated within the APBD. However, in the case of large-scale disasters, the APBD may become insufficient, prompting the central government to provide financing using social assistance funds in the forms of grants sourced from the APBN. Looking at the historical data, Indonesia has suffered a number of extreme disasters, in particular strong seismic activities and tsunamis. Between 2000 and 2023, there were 21 earthquakes of magnitude 7.0 or greater; three (11.5%) were magnitude 8.0, and two (7.7%) were magnitude 9.0 (Figure 4.4).

Figure 4.4. Major earthquakes in Indonesia, 2000-23



Source: (CRED, n.d.[16]), *Emergency Events Database (EM-DAT)* (database), https://public.emdat.be/.

StatLink https://stat.link/qy58a4

Most of the parametric CAT bonds available in the market that provide coverage against earthquakes were typically triggered by a magnitude 8.0 or greater earthquake event, whether they were sponsored by sovereigns or the private sector. These include Mexico's CAT bond issued in 2017, in which the magnitude 8.1 Chiapas earthquake fell within the parametric box and triggered a 100% payout (USD 150 million) on the Class A notes. Another example is Peru's CAT bond issued in 2018 as part of the World Bank's IBRD multi-country CAT bond. A 30% payout (USD 60 million) was triggered following the magnitude 8.0 earthquake that struck within the parametric zone defined under the terms of the CAT bond.

As suggested by these examples, there is potential for the use of CAT bonds as an additional instrument to protect Indonesia's state budget against losses from severe earthquakes and to complement other financing mechanisms arranged under the country's DRFI strategy. However, capacity building and in-depth analysis would be required to ensure that CAT bonds could meet the country's needs and efficiently bridge the financing gap not covered by the current financing instruments.

Budgetary resources would need to be allocated to the CAT bond transaction should the government decide to transfer part of its exposure to capital markets. Given the allocated budget, the government should take the best possible decision with regard to the coverage, including which trigger mechanism to use and which parts of the country to cover – a critical consideration – as the higher the likelihood of being covered, the higher the price. The choice of trigger mechanism also determines CAT bond price. Typically, a simple trigger mechanism, such as a parametric trigger, generates better CAT bond pricing for the government and provides greater clarity for investors (Michel-Kerjan et al., 2011[36]). To make the best possible decision requires a good understanding of disaster risk exposure. Good-quality data therefore play a vital role in the structuring of CAT bonds, as they may help obtain better probability estimates.

Strengthening risk data and analytics could be achieved, for instance, through investment in cutting-edge technologies to facilitate the development of catastrophe risk modelling and instrument design. Risk assessment and hazard analysis would require a more comprehensive list of the country's public assets – across the country or in highly vulnerable areas – their construction type and their value. This could be done by optimising the use of the government's state asset database system. Linking it with the Public Asset Insurance pilot project could be a good start to developing an integrated damage assessment system. Additionally, based on the experiences of the Philippines, strong and continuous co-operation with international development partners may help overcome barriers, especially in terms of strengthening technical capacity to adopt CAT bonds.

Data management and budget tracking can facilitate financial decision making

Risk data and analytics are among the key components of risk-informed decisions and could further help develop high-quality hazard models, inform effective disaster risk prevention, improve financial decision making and help design appropriate financial instruments. In Indonesia, the availability of emergency response data has helped the country meet its needs for disaster-related data. For instance, a georeferenced map, InaRISK, which is integrated with the implementation of DRR activities, serves as a monitoring tool for reducing the disaster risk index. Launched in 2016, InaRISK describes the scope of the hazard-prone area, affected population, potential physical and economic loss and potential environmental damage. This tool, however, may need to be simplified. In addition, data on risks, occurrences, impacts and financing related to disasters and disaster management vary in terms of concept and definitions (BNPB/BPS, 2020[31]), highlighting the need to manage data in a more standardised way.

To address the issue, the country recently launched Indonesia One Disaster Data, a synthesis of existing international guidelines on disaster-related statistics. The initiative was guided by Presidential Regulation No. 39 of 2019 on Indonesia One Data policy and by BNPB Regulation No. 1/2023 on One Disaster Data, issued on 4 January 2023. It was jointly developed by the BNPB and the national statistics agency, Badan Pusat Statistik (BPS), wherein the BNPB acted as disaster data custodian by formulating and setting the

policies to manage and facilitate data co-ordination among sectoral data producers, including line ministries and agencies. All actors converged in a Disaster Data Forum. Implementation support was provided by BPS as basic data advisor and by the Indonesia Geospatial Agency as geospatial data advisor.

Indonesia One Disaster Data aims to improve the coverage and consistency in compiled data based on primary disaster-related data and basic statistics for all types of disasters. With such a mechanism, the initiative can create better comparability such that data from one locality or time and period can be matched with data from another based on the actual values of the relevant data. Moreover, data collection and analysis use a standard methodology, metadata and master references, allowing for greater coherence in disaster documentation and data interoperability, regardless of the forms and sources of data, including national and local governments, and national and international development partners.

The scope of Indonesia One Disaster Data covers pre-disaster data, which is information obtained when there is no disaster occurring and/or when there is the potential for a disaster to happen; emergency response data, which refers to temporary data collected to meet needs during emergency disaster situations; post-disaster data, which is data obtained from rehabilitation and reconstruction activities; and disaster management financing data, which includes data on financing and/or investment in the implementation of disaster management. It includes data related to, first, disaster risk, such as data on hazards, vulnerabilities, exposures, the ability or capacity gap in facing potential disaster events, and data on disaster risk reduction programs and activities. Second, it includes data related to disaster events, such as the characteristics of the event, place and time of the beginning and end of the event, status of the event and an identifier or a unique registration code to facilitate recording, reference and tracking. Third, it contains data on both the direct and the indirect impacts of a disaster. The former include data on affected populations, damage to key infrastructure, material and economic losses, disruptions to basic services and impacts on the environment and cultural heritage. The latter (i.e. data on the indirect impacts of a disaster) cover displacement, loss of employment and poverty, among others. Fourth, the disaster management financing data consists of information on prevention, risk reduction, mitigation, and preparedness costs; emergency response costs; recovery costs; and general government, education, research and development-related expenses associated with disaster management. As of 2023, the Indonesia One Data portal is accessible to the public, comprising nearly 300 000 datasets, of which roughly 3 600 are disaster-related data, encompassing information down to the sub-district level.

The majority of financing for preparedness, emergency response and recovery activities still comes from public funding, particularly through transfers from the national government budget to the local government. Statistics within this scope of activities can help ensure transparency, track financing trends and identify beneficiaries and potential funding gaps and opportunities for interventions. For instance, they would allow the government to obtain more information on disaster-related spending by line ministries and which programmes or activities are receiving funds. It would also provide more information on the nature of disaster-related expenditures, such as goods and services, capital expenditure and subsidies. Tracking such spending may provide support for either the public budget or the functionality of the PFB.

However, precision in tracking the financing of disaster management activities remains challenging, as it is implicitly recorded as part of a broader classification of national aggregate transactions within the National Account System (BNPB/BPS, 2020[31]). As a result, tracking is done by monitoring the type of transfers and other activities having specific objectives for disaster management within the balance of payments and national account statistics.

To date, exercises in expenditure tracking through a national accounting system have been very few, with most countries in Asia-Pacific not tracking disaster-related investments and expenditures (Amach, 2021[7]). Although it is challenging to collect the fragmented information on disaster risk management financing, improving capacity in budget tagging or in public expenditure tracking on a regular or systematic basis may help provide a clearer picture of the flow of financial resources, ensure effectiveness of public funding and strengthen risk financing capacities through access to new revenue streams.

The case of China

China is prone to earthquakes, droughts, floods and storms. Each province has experienced earthquakes of magnitude 5.0 or greater while tropical cyclones often strike the eastern and southern coastal regions and some inland provinces (World Bank, 2020[37]). Among the most recent and deadliest natural disasters, the magnitude 8.0 Wenchuan earthquake in 2008 caused direct economic losses of USD 159 billion (2018 value) or more than 1% of China's 2018 GDP (IBRD/World Bank, 2020[38]).

Budgetary instruments are the main financing mechanism for disaster risk used by the Chinese government. These include the budget reserve funds, which, under the Budget Law, should be allocated by government at all levels. The funds can be used in case of emergencies, disasters and other unforeseen events. Budgetary instruments which are intended solely for disaster relief include the central government disaster relief funds and the Central Fiscal Fund for Agricultural Production Disaster Relief and Reduction.

Government-backed insurance schemes are available in China, and these have helped the government to reduce the financial burden in the aftermath of disaster events. The government-subsidised agricultural insurance programme is one example. This initiative provides coverage for individual farmers against a number of agricultural disasters, allowing them to resume farming after a disaster. Eighty percent of the premiums are subsidised by central, provincial or municipal, and county governments. Nonetheless, this heavily subsidised programme is deemed inadequate to meet farmers' needs during post-disaster periods as payouts are far lower than total losses (Wei, Fan and Huang, 2022[39]) as the insurance product only covers the cost of materials needed to resume farming, such as costs of seeds and chemical fertilisers, but not land rental. An earthquake insurance pool for urban and rural residential housing, whereby local governments partially or entirely subsidise premiums in several earthquake-prone areas is another major initiative, but this indemnity insurance scheme faces several issues, including low awareness and demand, as well as insufficient and uncertain coverage.

With limited coverage from the existing risk transfer solutions, governments often have to rely more heavily on traditional funding sources to respond to severe disasters. This has led the central government to reform the institutional framework for its disaster risk financing. The introduction of a market-base parametric insurance scheme, called the weather index insurance (WII), is an effort taken to address limited financial capacity. Piloted in 2016, the initiative provides cities with coverage against risks of typhoons and heavy rainfall. Premium payments were split into two, with the municipality bearing 25% of the total premium and the provincial government the remainder (Wei, Fan and Huang, 2022[39]). The WII has undergone many structural improvements, allowing the scheme to generate payouts better aligned with the scale of natural disaster events. The scheme can also provide lessons for the future development of alternative financing instruments, including CAT bonds with parametric triggers.

Most recently, the Chinese government and insurance regulator have been promoting the use of the Hong Kong, China ILS regulatory regime to transfer part of the country's catastrophe risks. This illustrates the close co-operation between the mainland China government and the Special Administrative Region in supporting the growing Chinese (re)insurance market by giving mainland Chinese insurers access to capital markets for risk transfer purposes. The Hong Kong, China ILS regulatory regime, along with its adequate licensing and supervision infrastructure allow for the establishment of SPV or SPI with sound protection mechanism for the ceding insurance companies. This initiative has enabled China Re (a state-owned reinsurer) to sponsor CAT bond issuance using Hong Kong as an ILS domicile. This issuance marks the second CAT bond sponsored by China Re (Box 4.5). Example set by China Re could further enhance Chinese insurance industry's expertise in risk management. For instance, the Chinese insurer PICC Property and Casualty Company Limited (PICC P&C) has also had recourse to CAT bonds to secure reinsurance protection against losses from earthquake. This Great Wall Re CAT bond, issued through the Hong Kong market, is eligible for Hong Kong's Pilot ILS Grant Scheme, providing support of up to HKD 12 million (Hong Kong Dollar) for the transaction's issuance costs.

Box 4.5. Examples of CAT bonds covering Chinese perils sponsored by the reinsurance sector

In 2015, the Chinese state-owned reinsurer, China Re, sponsored its first catastrophe (CAT) bond through a Bermuda-domiciled special purpose insurer (SPI), issued on behalf of the Chinese government. It was the first CAT bond to place Chinese catastrophe perils in capital markets. The USD 50 million Panda Re Series 2015-1 CAT bond provided earthquake coverage across the People's Republic of China (China), excluding Hong Kong (China) and Macau (Artemis, 2015[40]). The transaction, listed on the Bermuda Stock Exchange, had a three-year term and used an indemnity trigger to pay out on a per-occurrence basis (Table 4.7).

The second CAT bond issuance sponsored by China Re was completed in September 2021. Using an indemnity trigger, the USD 30 million CAT bond provides a year of retro reinsurance protection against losses resulting from typhoons (Table 4.7). The Greater Bay Re CAT bond was the first to be issued using Hong Kong, China as a domicile, incentivised by the introduction of Hong Kong (China)'s regulatory regime for insurance-linked securities (ILS) in early 2021. The bond was issued as a zero-coupon deal priced at 96.96% of par and benefited from Hong Kong, China's Pilot ILS Grant Scheme.

The two-year Pilot ILS Grant Scheme is an initiative of the government of Hong Kong, China that aims to attract sponsors to the jurisdiction for their CAT bonds and other ILS issuances. The initiative incentivises CAT bond issuance by allowing eligible onshore and offshore issuers and sponsors that choose Hong Kong, China as an issuance domicile to have reduced upfront costs depending on the maturity of the instrument. For instance, the grant covers 100% of the total upfront costs if the maturity of the CAT bond is three or more years (IA, 2021[41]). For a CAT bond with a tenure of one to three years, the grant scheme covers 50% of the total upfront costs.

Table 4.7. Summary of CAT bonds sponsored by China Re

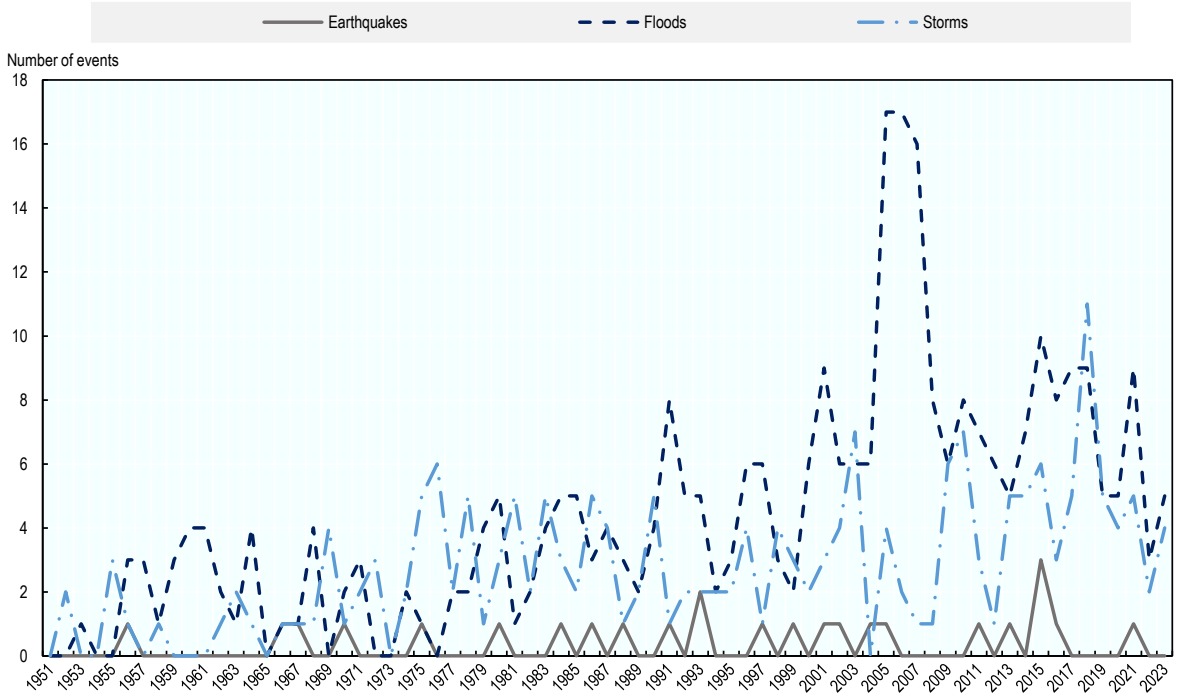
Parameters	Panda Re CAT bond	Greater Bay Re CAT bond
Aggregate nominal amount	USD 50 million	USD 30 million
Perils covered	Earthquake	Typhoon
Trigger type	Indemnity	Indemnity
Issue date	July 2015	September 2021
Maturity date	July 2018	October 2022
Issuer domicile	Bermuda	Hong Kong (China)

Source: Authors' compilation.

The case of India

India is exposed to a variety of natural disasters with varying intensity, including floods, tropical cyclones, and other storms and storm effects. These disasters have become more frequent in India over the past seventy-two years (Figure 4.5). Of 319 total floods in India from 1951 through 2023, 59% of them occurred in 2001 or later, as did 47% of total storms in this period. According to the 2023 World Risk Index, India ranks 3rd as a country with the highest disaster risk. Moreover, the country's vulnerability to the effects of natural hazards falls into "very high" category (Bündnis Entwicklung Hilft/IFHV, 2023[1]). The high population density and intense development within high-risk zones are among factors making this country vulnerable to natural disasters.

Figure 4.5. Recorded occurrences of natural disasters in India, 1951-2023



Note: Data as of 7 November 2023.
Source: (CRED, n.d.[16]), *Emergency Events Database (EM-DAT)* (database), https://public.emdat.be/.

StatLink https://stat.link/erf5gb

Almost 76% of the 7 516 km Indian coastline is prone to cyclones and tsunamis (Bindal et al., 2021[42]). The most recent extremely severe tropical cyclone was Cyclone Fani in 2019, affecting three states (Odisha, Andra Pradesh, and West Bengal). The event severely affected livelihoods and various economic sectors, including housing, electricity, telecommunications, agriculture, fisheries and livestock. The total damages resulting from the event were estimated at USD 2.4 billion and USD 1.1 billion, respectively (ADB/GoO/UNDP/World Bank, 2019[43]).

In addition to India being highly exposed and vulnerable to natural disasters, it is often faced with inadequate resources for disaster recovery, in large part due to a lack of appropriate financing mechanisms. After several major disasters between 1999 and 2008, long-term recovery was difficult to attain due to absence of adequate resources (Bindal et al., 2021[42]). Recovery efforts were heavily supported by international institutions, including the Asian Development Bank (ADB) and the World Bank.

As in many other Dynamic Asian and Pacific countries, underinsurance remains a challenge in India. Sovereign parametric insurance schemes covering public assets against risk of natural disasters, as well as other sovereign risk transfer mechanisms, are non-existent. Among its neighbouring countries in South Asia, Sri Lanka is the only country with a public insurance programme providing coverage against risk of natural disasters implemented at national level (Box 4.6). In addition to the national insurance scheme, Sri Lanka adopted contingent credit lines (e.g. CAT DDO from the World Bank) to help cope with disaster aftermath. This type of instrument is also deployed by other South Asian countries, such as Bhutan, Maldives and Nepal. In contrast, India often relies heavily on ex post financing mechanisms, including the natural disaster reserve funds, budget reallocation, external debt and donor assistance in the aftermath of a disaster due to its current financing options being limited. The initiative set by Sri Lanka may serve as both example and lesson for India to implement a nationwide insurance scheme as a means of providing additional financing sources to face disaster risks.

Box 4.6. The National Natural Disaster Insurance Scheme of Sri Lanka

The National Natural Disaster Insurance Scheme (NNDIS) provides free protection of lives and properties to all households regardless of income level and to any small business establishments with annual turnover not exceeding SLR 10 million (Sri Lankan rupee). Introduced in 2016, the programme covers disasters triggered by certain perils, including tropical cyclones, storms, floods, landslides and earthquakes. With the National Insurance Trust Fund (NITF) as the insurer, NNDIS covers damage worth up to SLR 2.5 million per household or business establishment.

Despite the benefit offered by the scheme, the budgetary allotment for purchasing insurance was made on an ad hoc basis, depending on funding availability (ADB, 2019[44]). For the 2016/17 policy year, premium paid by the government (the insured) amounted SLR 300 million. To provide financial protection to its capital, the NITF purchased reinsurance protection from the international reinsurance market, amounting to SLR 420 million for the same policy year (ADB, 2019[44]). Following the flooding in 2016 and 2017, NNDIS faced an estimated net loss of about SLR 2 billion (Nozaki and Cook, 2018[45]). For the 2016 floods, NITF paid SLR 500 million, the amount of claim covered by its reinsurance programme. The reinsurance costs for the following policy year amounted to SLR 800 million, an amount that could not be met as the government had only made available SLR 500 million through the policy premium. As a result, NITF was not reinsured and claims from the 2017 floods were met directly by NITF (ADB, 2019[44]).

Several steps can be taken to help improve the risk management of NITF and ensure the sustainability of NNDIS. For instance, reinsurance costs can be reduced by carefully choosing which risk layers to cover. Assessments of risk exposure may also need to be more thorough and based on asset values and average payouts to households. Policies should focus more on poor households, while richer households should be encouraged to buy insurance from private insurers. As the scheme alone might be insufficient to protect the uninsured population, and it does not provide protection for the public sector, the government may need to consider developing a comprehensive disaster risk financing strategy with innovative risk transfer instruments, including parametric insurance and CAT bonds.

India introduced its first National Disaster Management Plan in 2016. It outlines financial arrangements for disaster management, which include the provision of fund allocated by the government for the National Disaster Response Fund, State Disaster Response Fund and other budgetary instruments to finance disaster prevention, mitigation and preparedness. The Plan was revised in 2019, however, it still lacks guidance with regard to risk transfer solutions. Despite the funds allocated to boosting recovery efforts, there remains a significant gap between economic losses and available state funds (Bindal et al., 2021[42]).

Most of government-backed insurance schemes in India offer protection for poor people. Nonetheless, they do not provide protection against losses of assets and lives resulting from natural disasters. Owing to the limited options to cope with disaster effects, the government is seeking innovative ways of financing for disaster risks. Most recently, a working group was established to address the issue. The group receives support from the National Disaster Management Authority that provides guidance to the working group and from the Insurance Regulation Development Authority that contributes recommendations.

Among a range of recommendations proposed during the 2020 National Workshop on Disaster Risk Financing, Insurance, and Risk Transfer, parametric insurance is considered as a solution to help protect the low-income group against a number of perils, such as earthquakes, tropical cyclones, extreme precipitation and river floods. In order to reach the targeted segment of population, should the proposed parametric solution be implemented, it can be fully supported by the government at the first phase, whereby the government buys the policy and receives the claim payment (Bindal et al., 2021[42]). In the second

phase, the scheme can be partially subsidised, with the beneficiary receiving the claim payment directly from the insurer.

Such a parametric insurance scheme has already been piloted in Nagaland in 2020 where the state government proactively engages with (re)insurance companies to design parametric coverage against excess rainfall (InsuResilience, 2022[46]). This state-level initiative could serve as a model and provide lessons for the future design of parametric insurance products that can be implemented nationwide to provide cost-efficient protection. For this to happen, clear strategy with regard to disaster risk financing using a layering approach should be established and integrated into the national disaster risk management plan. As such, alternative risk transfer mechanisms may have a place within the national strategy. Indeed, India has the potential to adopt CAT bonds as one of its financing mechanisms to protect against the most severe disasters as the government has begun to encourage the development of CAT bond markets recently. The country's International Financial Services Centres Authority (IFSCA) has constituted a committee with aim of building a globally competitive environment and thereby making India's International Services Centre a global (re)insurance hub.

Mirroring the example set by Singapore, whereby the country's monetary authority is actively engaged with industry and academic institutions to develop the markets, the IFSCA is also advised to promote the involvement of academic institutions in producing accurate and fair assessments of risk, industry exposure and weather reporting (IFSCA Insurance Committee, 2021[47]). While the enabling environment for CAT bond issuance is under development and such initiatives may attract global issuance, particular focus should be given to facilitating the domestic adoption of CAT bonds as part of the country's disaster risk financing strategy.

The cases of Mexico and Jamaica

Following the four case studies from Asia, this section looks at the experience of other countries with the issuance of CAT bonds. Two prominent examples are considered, namely the issuance of CAT bonds by the governments of Mexico and Jamaica.

Mexico's 2009-12 MultiCat programme, implemented in partnership between the government of Mexico and the World Bank, provides a good example. The World Bank Treasury, as one of the main bond issuers in the international capital markets, acted as an intermediary between the Mexican government and major investment banks to develop the product and arrange the deal. The World Bank acted as the global co-ordinator throughout the process, working with the modelling firm and investment bank and playing a vital role in deciding which trigger mechanism to use based on the needs of the Mexican government and in proposing a strategy for placing the bonds (Michel-Kerjan et al., 2011[36]). This bond placement considers market appetite, market trends, implementation costs and a timeline, which considers a seasonality risk of an event (e.g. hurricane season) to execute a transaction. The 2009 and 2012 bonds were significantly oversubscribed, showing that investors continue to exhibit interest for non-peak risks (World Bank, 2013[48]). The CAT bond recently sponsored by the government of Jamaica provides another example of the World Bank's role in supporting CAT bond transactions (Box 4.7).

Box 4.7. Jamaica's first sovereign CAT bond

High exposure to natural disasters, such as hurricanes and earthquakes, has cost Jamaica significant resources, putting considerable strain on the country's public finances. When Hurricane Ivan struck in 2004, damage and loss exceeded USD 350 million, equivalent to approximately 3.4% of Jamaica's GDP in 2004. It is estimated that, between 2001 and 2010, the country bore USD 1.2 billion in losses resulting from natural disasters. With such significant economic consequences, Jamaica sought to

increase its financial resilience through the deployment of various financing instruments for post-disaster activities, including a contingency fund, contingent credit and catastrophe insurance from the Caribbean Catastrophe Risk Insurance Facility (CCRIF). Jamaica was among the 16 countries in the CCRIF that benefited from the catastrophe (CAT) bond issued in 2014 under the World Bank's new Capital at Risk Notes programme.

As available budgetary resources were deemed insufficient to bridge the financing gaps resulting from tropical cyclone events, risks of losses from several storm events were transferred to capital markets, with technical assistance from the World Bank and bilateral financial support from donor countries, including Germany, the United Kingdom and the United States. Jamaica became the first Small Island Developing State in the Caribbean region to sponsor a CAT bond independently. The instrument provides the country with financial protection of up to USD 185 million for three years against named tropical cyclone impacts on a parametric trigger and per occurrence basis (Table 4.8). The CAT bond is the first to feature an innovative cat-in-a-grid parametric trigger design for tropical cyclone risk. Should an event breach the predefined trigger criterion, payout would be made within weeks of a storm event once the calculation report is available – a quick payout calculation made possible by the innovative reporting feature included in the transaction. The CAT bond attracted investors from around the world, with insurance-linked securities funds and Europe-based investors being the largest bondholders.

Table 4.8. Selected features of CAT bonds issued by the World Bank on behalf of Jamaica

Parameters	Details
Aggregate nominal amount	USD 185 million
Perils covered	Named storm
Trigger type	Parametric, per occurrence
Trade date	19 July 2021
Settlement date	23 July 2021
Scheduled maturity date	29 December 2023
Issue price	100%
Bond coupon (per annum)	Compounded SOFR + funding margin + risk margin
Funding margin	0.05% per annum
Risk margin	4.40% per annum
Coupon payment dates	Monthly
Redemption amount	Outstanding nominal amount less any principal reductions or partial repayments

Note: SOFR = Secured Overnight Financing Rate.
Source: (World Bank, 2021[49]), "World Bank Catastrophe Bond Provides Jamaica $185 Million in Storm Protection", www.worldbank.org/en/news/press-release/2021/07/19/world-bank-catastrophe-bond-provides-jamaica-185-million-in-storm-protection.

Jamaica's CAT bond is a result of a continued engagement on disaster risk financing between the government of Jamaica and the World Bank. Prior to the CAT bond transaction, the country received both financial and technical support from the World Bank in understanding the financial impact of natural disaster events, particularly from tropical storms and earthquakes, and the cost-benefit analysis of using various disaster risk financing instruments. Throughout the implementation, support from the World Bank included managing the preparation, structuring and executing the CAT bond transaction, and procuring the external service providers, such as the risk modeller, event calculation agent and listing agent. The World Bank also secured bilateral financial support in the form of grants from donor countries to finance CAT bond premium and transaction costs related to the design, structure and placement of the CAT bond.

Source: (World Bank, 2021[50]), "World Bank Catastrophe Bond Provides Jamaica with Financial Protection against Tropical Cyclones", www.financialprotectionforum.org/sites/default/files/Jamaica%20Cat%20Bond%20Case%20Study.pdf.

In addition to being highly involved in the transaction process in Mexico, the World Bank provided capacity-building related to sovereign debt markets to a particular team within the Mexican government, which allowed the government to stay in control of the process. In 2012, Mexico issued another multi-peril CAT bond with a larger coverage area and more sophisticated structure than the 2009 transaction. Mexico has continued to sponsor CAT bonds, with additional issuances in 2017, 2018 and 2020. Table 4.9 summarises Mexico's CAT bonds. Among the six issued, two (the MultiCat Mexico Series 2012-1 and the International Bank for Reconstruction and Development [IBRD] Capital-At-Risk [CAR] Series 113) faced principal loss, meaning the government received a payout from these CAT bonds after the calculation agent confirmed that the predefined parametric triggers had been breached. The corresponding payouts were channelled through FONDEN, the country's natural disaster fund, to support the reconstruction and rehabilitation of public building infrastructure (e.g. schools, hospitals, highways) and housing damaged by the event (Artemis, 2017[51]).

Table 4.9. Selected features of CAT bonds sponsored by Mexico, 2006-20

Parameters	2006	2009	2012	2017	2018	2020
Deal name	CAT-Mex	MultiCat Mexico 2009	MultiCat Mexico (Series 2012-1)	IBRD CAR 113-114-115	IBRD CAR 118-119	IBRD/FONDEN 2020
Issue size (USD)	160 million	290 million	315 million	360 million	260 million	485 million
Perils covered	Earthquake	Earthquake, hurricane	Earthquake, Atlantic hurricane, Pacific hurricane	Earthquake, Atlantic and Pacific named storms	Earthquake	Earthquake, Atlantic and Pacific named storms
Trigger type	Parametric	Parametric	Parametric	Parametric	Parametric	Parametric
Issue date	May 2006	October 2009	October 2012	August 2017	February 2018	March 2020
Maturity date	2009	October 2012	December 2015	Class A: August 2020 Class B and Class C: December 2020	February 2020	2024
Pricing			Class A: 8.00% Class B: 7.75% Class C: 7.50%	Class A: 4.50% Class B: 9.30% Class C: 5.90%	Class A: 2.50% Class B: 8.25%	Class A: 3.50% Class B: 9.00% Class C: 10.00% Class D: 6.50%
Principal reductions			Class A and Class B: principal reductions by 100% if any qualifying event occurs. Class C: depending on the minimum central pressure of a hurricane that passes through the hurricane zone, the outstanding nominal amount may be reduced by 50% or 100%.	Class A: principal reductions by 25%, 50%, 75% or 100%, depending on a qualifying earthquake's characteristics. Class B and Class C: principal reductions by 25%, 50% or 100%, depending on a qualifying named storm's characteristics	Class A and Class B: Principal reduction by 50% or 100%, depending on various parameters associated with an earthquake event	Class A and Class B: principal reductions by 25%, 50%, 75% or 100%, depending on the parameters associated with an earthquake event. Class C and Class D: principal reductions by 25%, 50% or 100%, depending on the parameters associated with the named storm event
Payouts			50% payout of the Class C tranche (USD 50 million) following the occurrence of hurricane Patricia in October 2015	100% payout of the Class A tranche (USD 150 million) following the occurrence of magnitude 8.1 Chiapas earthquake in September 2017		
Time to payment			4 months	5 weeks		

Source: Authors' compilation.

The cases of selected OECD countries

The CAT bond markets have witnessed significant growth and progress in various developed countries. In advanced economies, CAT bond markets have been shaped significantly by the active participation of the private sector, particularly the (re)insurance industry. This highlights the importance of certain prerequisites for the establishment of CAT bond markets, including a robust (re)insurance industry, regulatory frameworks that support risk transfer instruments, and the occurrence of significant catastrophic events that underscore the need for risks diversification. For instance, the existence of a robust (re)insurance industry means that (re)insurance companies can serve as reliable counterparties in CAT bond transactions. Their financial stability and creditworthiness are crucial factors that investors consider when evaluating the risks associated with purchasing CAT bonds, thus inspires confidence in the markets. Moreover, the active participation of the (re)insurance industry in CAT bond markets facilitates collaboration and knowledge sharing between (re)insurers and capital markets, which helps drive innovation in risk transfer mechanisms, enhances risk modelling capabilities, and promotes the development of new products and structures that cater to the specific needs of the markets. This section provides an overview of CAT bond markets development in selected OECD countries, namely Australia, New Zealand, Japan, and the US.

Australia and New Zealand

The introduction of the first-ever CAT bond covering Australian risks occurred in 2006, with an issuance by an SPV Australis. Swiss Re, a prominent player in the insurance industry, secured USD 100 million in coverage against the perils of earthquakes and tropical cyclones. The duration of this insurance protection spanned three years, and the bond was structured with a parametric trigger basis, which allowed for efficient and swift claims settlement based on predefined conditions. Building on the success of this venture, Australis brought another CAT bond to the market the following year. This subsequent issuance, also tailored to cater Australian perils, provided Swiss Re with an additional USD 50 million in coverage.

The Australian insurance industry experienced a significant change in perception towards CAT bonds in 2019, as the remarkable growth of this emerging market segment played a crucial role. Encouraged by the positive trend, the Insurance Australia Group (IAG), the largest general insurance company operating in Australia and New Zealand, seized the opportunity to diversify its reinsurance programs by sponsoring its very first CAT bond. This strategic decision underscored the company's commitment to enhancing risk management capabilities.

Through the deal, IAG secured AUD 75 million (Australian dollars) in annual aggregate reinsurance protection against catastrophe risk prevalent in Australia and New Zealand. The three-year duration of this coverage helped to ensure a sustainable level of financial security for the company, allowing for effective planning and management of potential catastrophe-related losses. Notably, this marked the first CAT bond being issued through a Singapore domiciled special purpose reinsurance vehicle (SPRV). IAG took advantage of the Singaporean ILS grant scheme, initiated by the Monetary Authority of Singapore in 2018. This not only provided cost saving in terms of issuance expenses on behalf of the sponsor, but also solidified the global reputation of the Singaporean financial market as a hub for insurance-linked securities in the region.

The Earthquake Commission (EQC), also known as Toka Tū Ake EQC, a New Zealand's state-owned residential property disaster insurance entity, has recently made its debut in the market by issuing CAT bonds in 2023. This strategic move allows EQC to diversify its funding sources beyond traditional annual reinsurance. In fact, the reinsurance coverage only comes into effect if the EQC scheme surpasses NZD 2 billion (New Zealand dollars) in claims. Prior to reaching that threshold, any claims are funded through the Natural Disaster Fund (NDF) and the Crown Guarantee, which become accessible to Toka Tū Ake EQC once the NDF is exhausted (Toka Tū Ake EQC, 2023[52]).

The CAT bond, issued through a Singapore-domiciled SPRV, plays a vital role in fortifying the resilience of the New Zealand insurance market. Amounting to NZD 225 million in size, the bond provides coverage against losses from an array of potential perils that may arise within the country, including earthquakes, tsunamis, landslides, volcanic eruptions, hydrothermal events, storms, and floods. By encompassing such broad spectrum of risks, it offers a robust layer of financial security for both insurers and policyholders alike.

The bond is structured with an indemnity and per-occurrence basis with a coverage period spanning for four years. By offering such long-term security, it affords stability to the Toka Tū Ake EQC, enabling a more effective response in the event of any catastrophic event. This approach exemplifies the commitment of the entity to fulfil its mandate of safeguarding the interest of the New Zealand population and ensuring the continuity of critical insurance services. Moreover, the favourable spread of 8.75% offered to investors further enhances the attractiveness of this CAT bond. The Toka Tū Ake EQC's participation in the CAT bond markets provides an example of bolstering the New Zealand insurance market's ability to withstand the challenges posed by natural perils.

In summary, the introduction of the first-ever CAT bond covering Australian risks in 2006, followed by a subsequent offering in 2007, marked a pivotal moment in the insurance industry. This development created new opportunities for insurers and investors alike. The recent entry of the IAG into the CAT bond markets further underscores the industry's recognition of the significant potential and value that this instrument offers in diversifying reinsurance programmes. As the CAT bond markets continue to flourish, it has the potential to reshape the risk transfer landscape, presenting an effective mechanism to reduce the consequences of devastating events in Australia and New Zealand.

Japan

Located in a seismically active region, Japan has encountered a number of catastrophic events throughout its history, including earthquakes, typhoons, and tsunamis. The country's vulnerability to these disasters has underscored the need for innovative risk management strategies. CAT bonds have played a crucial role in diversifying risk transfer mechanisms and bolstering financial resilience in the face of such perils. One of major factors contributing to the development of CAT bond market in Japan has been the country's robust (re)insurance industry. Indeed, Japan's insurance market has a notable record of leveraging CAT bonds as a means to access a wide range of reinsurance capacity from the capital markets.

The first CAT bond transaction dates back to the mid-to-late 1990s, when Tokyo Marine and Fire, one of the major players in the Japanese insurance industry, sought reinsurance for USD 100 million of earthquake risk over a 10-year duration. The arrangement involved the establishment of Parametric Re, a special purpose reinsurer based in the Cayman Islands, which provide the reinsurance agreement pertaining to the earthquake coverage. The payout mechanism was determined based on a sliding scale, which depended on the severity of an event taking place within the specified area around Tokyo and surpassing the magnitude 7.1 trigger point. For instance, in the event of an earthquake with magnitude of 7.1, 7.2, and 7.3 occurring within the inner grid, the corresponding outcome would entail 25%, 40%, and 55% of the principal amount being exposed to the risk of loss, respectively (Brink and Teste, 2001[53]). If an earthquake surpassing magnitude 7.6 within the inner grid, the entire principal would be at risk of loss.

The deal consisted of two tranches of notes, whereby the first comprised a higher-risk tranche, amounting to USD 90 million. Investors in this tranche received a floating rate of 430 basis points over LIBOR. A smaller USD 10 million tranche offered investors a return of 206 basis points over LIBOR. The initial offering generated substantial investor interest, resulting in oversubscription. The deal attracted participation from 32 institutional investors, with mutuals and banks represented a significant majority of 50%, while the remaining portion consisted of life insurers, hedge funds, reinsurance, and other non-life insurers (Brink and Teste, 2001[53]).

Since then, there have been recurring instances of Japanese CAT bond sponsors entering the market, with notable examples including Zenkyoren. This Japan's national mutual aid system of agricultural cooperatives has actively participated in the CAT bond market since 2003. In 2008, Zenkyoren sponsored a parametric CAT bond transaction that was issued through Muteki Ltd., a Cayman Islands domiciled vehicle. Following the Tohoku earthquake in 2011, this transaction resulted in a full payout, which was subsequently utilised to provide payments to insured farmers.

More recently, Japanese CAT bonds sponsors have recourse to joint issuance of CAT bonds, which involves multiple entities coming together to issue the bonds collectively. Joint issuance of CAT bonds offers several advantages. For instance, it allows sponsors to leverage the expertise, resources, and market reputation of each other, thereby potentially attracting a broader investor base and reducing transaction costs. While joint issuance offers risk diversification and shared resources, it also presents challenges in terms of co-ordinating multiple sponsors with potentially divergent interests, risk appetites, and underwriting requirements.

The Tomoni Re 2022 represents a recent example of a CAT bond jointly sponsored by two Japanese insurance companies, namely Mitsui Sumitomo and Aioi Nissay Dowa. The issuance was done through a Singapore-based SPV. With a total value of USD 220 million, the CAT bond was structured with an indemnity trigger mechanism and divided into two series of notes. The first tranche of notes provides Mitsui Sumitomo USD 100 million of per-occurrence reinsurance coverage for a period of approximately four years against losses stemming from Japanese typhoons and flood risks. The second tranche of notes offers Aioi Nissay Dowa USD 120 million of reinsurance protection against Japanese typhoons and floods.

United States

The emergence of CAT bond markets was sparked by the occurrence of Hurricane Andrew in 1992. Since the mid-to-late 1990s, the market has experienced notable growth driven by several major events in the US, including Hurricane Katrina in 2005, the 2008 financial crisis, and the subsequent period of low interest rates following the crisis. In particular, the impact of Hurricane Katrina in 2005 played a crucial role in elevating the popularity of CAT bonds as a means of diversifying risks. Following the event, the substantial insured losses, amounting to approximately USD 62 billion, depleted reinsurance capital and led to a surge in reinsurance prices (Polacek, 2018[54]). This sharp increase in reinsurance prices attracted a significant influx of capital to the CAT bond markets.

Nonetheless, the issuance of CAT bonds experienced a significant decline during the financial crisis that ensued after the collapse of Lehman Brothers in 2008. The failure of Lehman Brothers had a profound impact on the CAT bond markets, creating significant market turmoil and leading to a complete cessation of new issuances until early 2009. This was primarily due to Lehman's involvement as a counterparty in various CAT bond transactions, causing concerns about credit risk. In the aftermath of Lehman's failure, issuers sought alternative collateral solutions to mitigate such risk and shifted towards more cautious options such as government-backed collateral and money market funds (Hills, 2010[55]). This shift became the prevailing norm and successfully enticed investors back into the CAT bond markets.

In the years following the financial crisis, the CAT bond market has experienced robust expansion. This growth has been fuelled by the extended period of low interest rates, which has attracted non-insurance industry capital to the CAT bond markets. Institutional investors, in particular, have been drawn to the market due to the higher yields offered by CAT bonds than those available through traditional instruments. This appeal has been particularly pronounced as long-term Treasury bond yields reached historically low levels and corporate bond spreads tightened, making CAT bond a more attractive investment option (Polacek, 2018[54]).

CAT bonds sponsors can typically be distinguished into three types of institutions, namely insurance companies, reinsurers, and state catastrophe funds. Notable among these state funds in the US are the

California Earthquake Authority (CEA) and the Florida Hurricane Catastrophe Fund (FHCF), each of which play a crucial role in maintaining a functional catastrophe insurance market for the residents of their respective states. The establishment of these public entities can be traced back to the unprecedented disasters that struck California and Florida. The Hurricane Andrew that devastated Florida in 1992 caused over USD 15 billion in losses and severely impacted the state's insurance market (OPPAGA, n.d.[56]). The Northridge earthquake in 1994 also left a severe impact on insurance market as the event caused insured losses totalling USD 12.5 billion, an amount that exceeded the cumulative earthquake insurance premium collected in California over the previous 80 years (Polacek, 2018[54]).

Prior to these catastrophic events, private insurers in both states were under legal obligation to offer coverage for losses arising from such disasters as a requirement to provide any type of property insurance. However, the perceived increase in risk and insufficient compensation led many private insurers to reduce their coverage or completely withdraw from the states. To attract private insurers back into their respective states, the CEA and FHCF took on the catastrophe risks that were previously shouldered by these insurers.

For instance, the CEA directly offers earthquake insurance policies to homeowners, relieving private insurers of this obligation. On the other hand, the FHCF established a facility similar to reinsurance to reimburse private insurers for losses stemming from hurricane events. Nonetheless, as the state funds took on the responsibility of insuring against disaster events on behalf of multiple private insurers, they acquired insurance portfolios burdened with substantial tail risks associated with disasters. To mitigate their exposure to such risks, the state funds resorted to employing CAT bonds as a strategy to transfer and diversify their risk profiles.

The CEA entered into the CAT bond market in 2001 and has maintained a continuous presence with new issuances every year since 2014. Some US federal agencies also have a presence in the CAT bond market. In 2018, the Federal Emergency Management Agency (FEMA) introduced its initial CAT bond, providing reinsurance protection to the National Flood Insurance Program (NFIP) against flood losses resulting from named storm events. FEMA's active involvement in the market is evident through annual issuances. Both the CEA and FEMA employ indemnity triggers as a mechanism to align the risk coverage obtained from CAT bonds with the losses incurred in their portfolios.

Conclusion

Albeit limited, implementation of sovereign CAT bonds by developing countries, such as the ones sponsored by the Jamaican and Mexican governments and the recently issued Philippine CAT bonds, demonstrates that there is market appetite for this sophisticated financial instrument when it is deployed by highly exposed and vulnerable countries. Further examination of efforts to develop CAT bond markets in China and India demonstrate further challenges common to many developing countries during this process, while a review of CAT bond markets in OECD countries reveals the benefits of having a CAT bond market.

The case of the Philippines provides evidence that such instruments can be useful in Dynamic Asia and the Pacific, though model refinements are necessary. The case of the Philippines also highlights the need to clarify the roles and responsibilities of CAT bond stakeholders. The case of Indonesia reveals the necessity of robust legal frameworks to support risk transfer. China and India face low awareness of and demand for insurance and the lack of comprehensive DRFI strategies. Countries such as Jamaica and several from within the OECD have overcome these barriers to develop robust CAT bond markets, providing evidence that working to overcome these barriers is worthwhile.

The case studies presented in this chapter offer a practical overview of the successes and challenges of CAT bond market development which receive more analytical treatment elsewhere in the publication.

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5 Sharing disaster risk among countries: Regional case studies

This chapter explores the utilisation of catastrophe (CAT) bonds in regional risk-sharing initiatives. Three regional initiatives from the Caribbean, Southeast Asia, and the Pacific are used as examples. Advantages of such jointly issued CAT bonds lie in cost savings on legal and other fees, and in the increased regional diversity of a multi-country issuer. Challenges arise from the need to accommodate the divergent interests of involved countries, most importantly through detailed risk assessments of each participating country to allow for individual pricing.

Introduction

Many countries in Asia and Pacific are prone to natural disasters and often have limited capacity to respond quickly to these events due to narrow fiscal space. In recent years, a number of financial solutions to strengthen financial resilience of these countries have become the focus of the regional community. Access to CAT bond markets through a joint issuance could be more feasible than countries seeking access individually. This regional approach may represent an alternative for developing countries in Asia and the Pacific while enjoying cost-sharing benefits (Box 5.1). In addition to cost sharing in transactions, joint issuance of CAT bonds allows sponsors to access a broader investor base.

Nonetheless, challenges may arise when it comes to joint issuance as it involves multiple sovereign entities having different risk appetites and interests. This emphasises the importance of effective collaboration among participating governments. Moreover, different jurisdictions may have varying regulatory frameworks and compliance requirements, adding complexity to the process. By overcoming these challenges, the potential benefits of joint issuance can be fully realised, contributing to the growth and development of the CAT bond markets.

This chapter first discusses how regional initiatives should accommodate the diverse risks and economic profiles of countries in a region. An example of CAT bonds that are structured as a joint issuance to cover multi-country risks is also presented. It then discusses the CAT bond issued on behalf of the Caribbean Catastrophe Risk Insurance Facility (CCRIF). Next, it addresses challenges faced by other regional risk-sharing facilities, including the Southeast Asia Disaster Risk Insurance Facility (SEADRIF) in ASEAN+3 region and the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) Facility. The last section provides challenges to enhance the functioning of risk sharing.

Box 5.1. Cost sharing through the joint issuance of CAT bonds

The Pacific Alliance CAT bonds for earthquake risk from Chile, Colombia, Mexico and Peru, which are united under a regional Pacific Alliance initiative for economic integration. The Pacific Alliance countries are located along the seismically active area of the Pacific Rim, making them prone to natural hazards, especially earthquakes.

The CAT bonds provide insurance coverage against earthquake risk in Pacific Alliance countries. Amounting to USD 1.36 billion, the CAT bonds mark the largest sovereign risk insurance transaction and the largest CAT bond issuance the World Bank has ever facilitated. It allows several sovereign nations to be present in the CAT bond markets without any risk pooling facility. For Chile, Colombia and Peru, this transaction represents a means to access capital markets with a view to sourcing disaster risk insurance for the first time.

The transaction was split into five classes of bonds: one class each for Chile, Colombia and Peru and two classes totalling USD 260 million for Mexico (Table 5.1). Although all notes were designed to cover earthquake risks on a parametric trigger basis, the terms of the CAT bonds differ for each class. For instance, the CAT bonds provided three years of insurance protection for Chile, Colombia and Peru with a February 2021 maturity date, while Mexico benefited from two years of coverage with a February 2020 maturity date.

Table 5.1. Summary of the Pacific Alliance CAT bonds transaction

Parameters	Chile	Colombia	Mexico	Peru
Issue size	USD 500 million	USD 400 million	USD 260 million	USD 200 million
Perils covered	Earthquake	Earthquake	Earthquake	Earthquake
Trigger type	Parametric	Parametric	Parametric	Parametric
Issue date	February 2018	February 2018	February 2018	February 2018
Maturity date	February 2021	February 2021	February 2020	February 2021
Pricing	2.50%	3.00%	Class A: 2.50% Class B: 8.25%	6.00%
Principal reductions	Principal reduction by 30%, 70% or 100%, depending on the parameters associated with an earthquake event	Principal reduction by 25%, 50% or 100%, depending on the parameters associated with an earthquake event	Class A and Class B: Principal reduction by 50% or 100%, depending on the parameters associated with an earthquake event	Principal reduction by 30%, 70% or 100%, depending on the parameters associated with an earthquake event
Payouts	x	x	x	30% payout or USD 60 million following the occurrence of a magnitude 8.0 earthquake in Peru on 26 May 2019. The payout went straight to Peru's disaster fund with the use of funds determined by the Technical Secretariat of FONDES.
Time to payment	x	x	x	Payout determination was made within 25 days.

Note: 'x' means not applicable.
Source: Authors' compilation.

As a facilitator, the World Bank provided end-to-end support for the complex process of CAT bond issuance, including specialised technical assistance and the execution of capital market transactions. Each government was supported in structuring its legal and regulatory framework and in customising its agreement documentation with the World Bank (World Bank, 2019[1]). Given that the CAT bonds were structured as a joint transaction, all four countries benefited from cost savings on legal and other fees incurred in a capital market transaction.

Additionally, the joint issuance offered investors a new risk diversification tool covering four different geographies. The timing of the issuance in early 2018 corresponds to the high demand for new risks, especially for the January renewals. Indeed, the transaction received very strong demand, attracting orders for almost double the size, or around USD 2.5 billion, from more than 45 investors globally (World Bank, 2019[1]). The strong investor demand put downward pressure on prices, resulting in lower premium rates for sponsoring countries.

Transferring regional risk to the capital markets

CAT bonds have also been used as part of regional catastrophe risk sharing mechanisms, similar to the approach adopted by the Caribbean Catastrophe Risk Insurance Facility (CCRIF). This facility has recognised the value of CAT bonds as a means of transferring and managing disaster risks. The CCRIF has implemented the use of CAT bonds to enhance its capacity to respond to catastrophic events in the Caribbean region. Examples of other catastrophe risk sharing mechanisms, include the ASEAN+3's

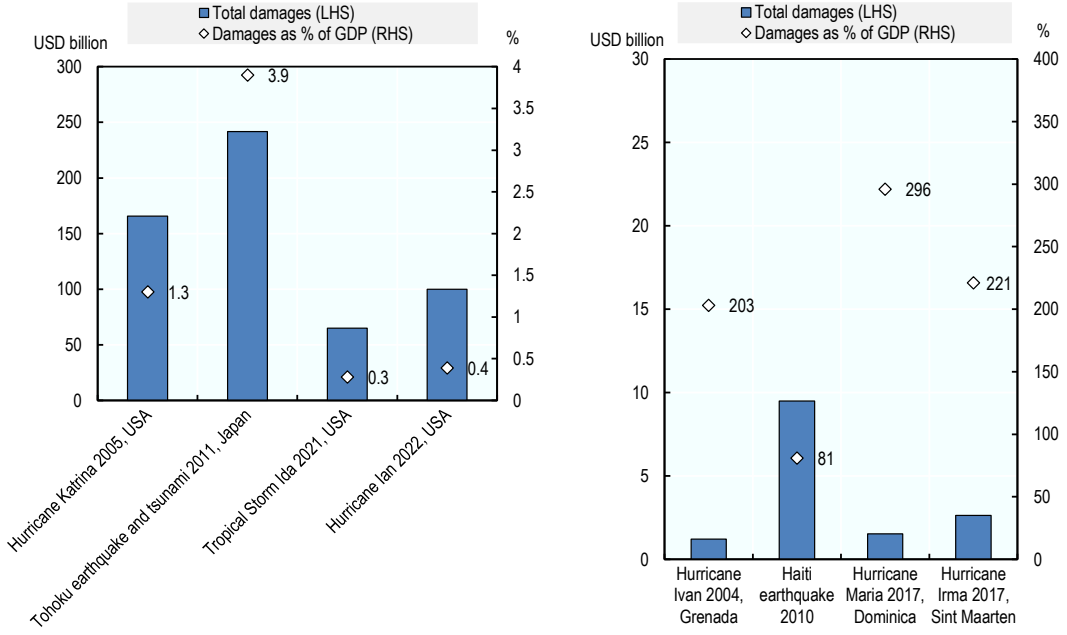
Southeast Asia Disaster Risk Insurance Facility (SEADRIF) and the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) Facility. Case studies about challenges faced by each regional risk sharing mechanism will be further detailed below.

The case of CCRIF

The Caribbean region is highly exposed to natural disasters that are frequent and costly, including hurricanes, intense rains and earthquakes. The Caribbean experienced two-thirds of the 511 natural disasters that have hit Small Island Developing States globally since 1950 (UN, 2020[2]). Over the last 20 years, direct damages resulting from meteorological and geological hazards averaged USD 1.6 billion (United States dollar) per year for the region, leading to the risk of sovereign debt accumulation and narrowing of fiscal space (World Bank, 2018[3]).

When a major disaster strikes a large economy, the damage is typically equal to a small share of its gross domestic product (GDP). For instance, damages from the Tohoku earthquake and tsunami that struck Japan in 2011 amounted to USD 241.6 billion or 3.9% of the country's GDP that year (Figure 5.1). Total damages from hurricane Ian in the United States in 2022 amounted to only 0.4% of the country's GDP that year.

Figure 5.1. Damages from major disasters in selected economies, 2000-23



Note: LHS = left hand scale. RHS = right hand scale.
Source: (CRED, n.d.[4]), *Emergency Events Database (EM-DAT)* (database), https://public.emdat.be/; (World Bank, n.d.[5]), *World Development Indicators* (database), https://databank.worldbank.org/source/world-development-indicators.

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Conversely, damages from a major catastrophe can constitute a multiple of GDP for smaller economies. Small Island Developing States in the Caribbean region, such as Grenada and Sint Maarten, suffered extreme damages amounting to over 200% of their GDP as a result of Hurricane Ivan in 2004 and Hurricane Irma in 2017, respectively (Figure 5.1). When Dominica was struck by Hurricane Maria in 2017, total damages reached 296% of GDP or almost three times the country's GDP that year.

The vulnerability of the Caribbean region may predominantly be associated with the prevalence of Small Island Developing States (SIDS). The characteristics of small states limit Caribbean countries' individual capacity to absorb the financial impact of natural disasters. For instance, the small geographic size of each state prevents diversification of risk. Establishing reserves to meet post-disaster needs might be challenging due to limited fiscal revenues. Additionally, transferring risks can be expensive due to high transaction costs, as there is a limited volume of business to be transferred to international (re)insurance markets.

Risk sharing is among the mechanisms that can help SIDS reduce the financial impact of disasters through insurance instruments, as high costs can be shared among pool members. These insurance instruments can help member countries gain access to quick financial liquidity following a disaster event. The CCRIF is an example of a regional catastrophe risk pooling facility that offers financial protection against natural disasters to Caribbean governments. It is financed through both traditional reinsurance and capital market-based instruments.

The CCRIF was developed under the technical leadership of the World Bank and benefited from a grant provided by the government of Japan. The capitalisation came from the Multi-Donor Trust Fund (MDTF), consisting of contributions from the governments of Bermuda, Canada, France, Ireland and the United Kingdom, the Caribbean Development Bank, the European Union and the World Bank.

The capital injection from donor countries and international partners amounted to nearly USD 71 million, enabling the CCRIF to increase its risk-bearing capacity by reimbursing operating costs, including policy payouts and reinsurance premiums (World Bank, 2012[6]). Given that donor support covers payouts and reinsurance premiums, other sources of capitalisation (e.g. premiums and membership fees paid by participating governments) could allow the CCRIF to build the risk-bearing capacity a lot faster than in the absence of donor support and ensure its financial sustainability.

The CCRIF is present in the CAT bond market with a USD 30 million CAT bond directly issued by the World Bank in 2014 under its newly established Capital at Risk Notes programme. This transaction marked an important milestone in the partnership between the CCRIF and the World Bank. In fact, since 2007, the World Bank has been helping the CCRIF to transfer its risks to the international reinsurance markets by intermediating catastrophe swaps between the pool and the markets for the riskiest layer of its portfolio.

The CAT bond provides three years of reinsurance protection against tropical cyclones and earthquakes for the 16 CCRIF member countries. The World Bank acts as an intermediary, standing between the CCRIF and CAT bond investors in capital markets. The World Bank entered into a catastrophe swap with the CCRIF, mirroring the terms of the CAT bond. This allows the World Bank to transfer insurance premiums collected from the CCRIF to investors. Investors receive quarterly coupon payments based on the prevalent six-month London Inter-Bank Offered (LIBOR) interest rate plus 6.3% with a floor of 6.5% (Table 5.2). The notes are transferable in the secondary market and are listed on the Luxembourg Stock Exchange. This means that the CAT bond is highly liquid, and investors holding the notes are able to sell them on the secondary market through broking desks.

The proceeds of the CAT bond are kept on the World Bank's balance sheet, and the outstanding principal (full or reduced) will be transferred to the CCRIF through the swap arrangement if a predefined disaster meets the triggering criteria specified under the bond terms. If no qualified event occurs during the CAT bond coverage period, investors will receive the principal back following the maturity of the bond.

The CAT bond uses a parametric modelled loss triggering mechanism, by which parameters of an event are applied to member government exposure information to determine loss estimates. This is the same trigger as deployed for the CCRIF's parametric insurance scheme. With such a trigger, there is no need to assess the damages and losses afterwards, which can be time consuming and contentious, to determine payout. This trigger can therefore ensure transparency and rapidity of payments.

Table 5.2. Selected features of the CAT bond issued on behalf of the CCRIF

Parameters	Details
Aggregate nominal amount	USD 30 million
Perils covered	Caribbean tropical cyclone and earthquake
Trigger type	Parametric modelled loss
Issue date	30 June 2014
Maturity date	7 June 2017
Bond coupon	Six-month USD LIBOR + 6.30%, floored at 6.50%
Coupon payment dates	Quarterly
Listing	Luxembourg Stock Exchange
Redemption amount	The nominal amount reduced by all principal reductions as a result of applicable Caribbean tropical cyclone or earthquake events as defined in the terms of the CAT bond
Beneficiaries	16 Caribbean countries: Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, the Cayman Islands, Dominica, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, and the Turks and Caicos Islands.

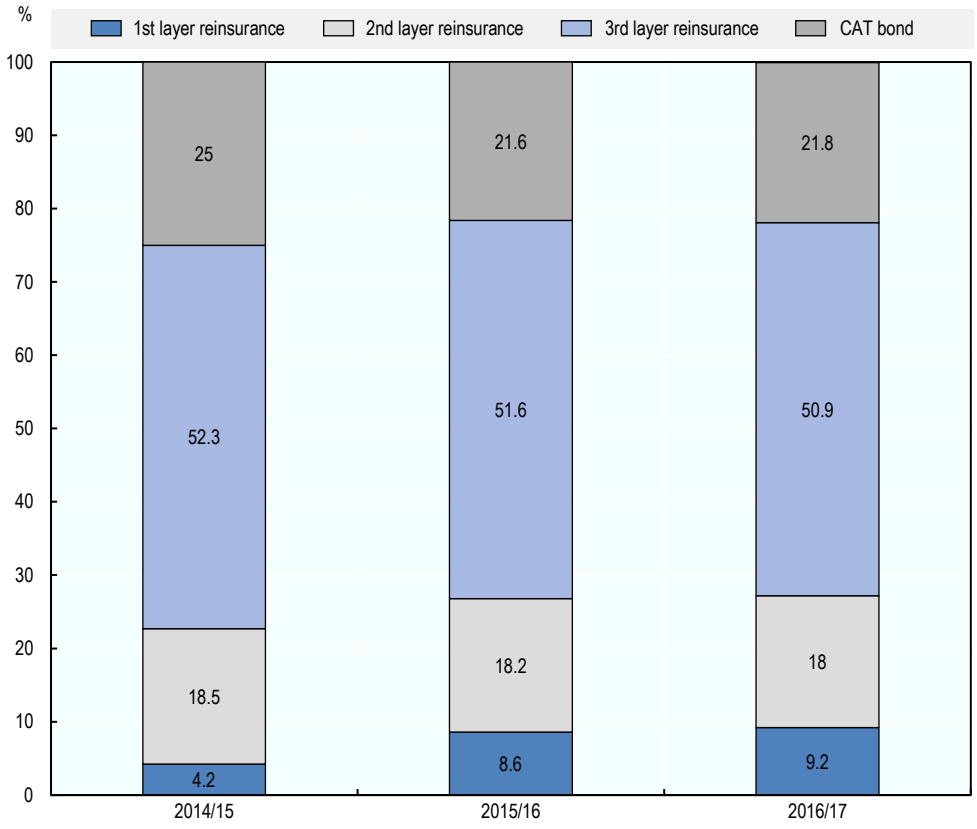
Source: (World Bank, 2015[7]), "Facilitating Catastrophe Risk Transfer", https://documents1.worldbank.org/curated/en/463201468015629255/pdf/93909-CCRIF-CatBond-2015.pdf; (World Bank, 2014[8]), "World Bank Issues its First Ever Catastrophe Bond Linked to Natural Hazard Risks in Sixteen Caribbean Countries", www.worldbank.org/en/news/press-release/2014/06/30/world-bank-issues-its-first-ever-catastrophe-bond-linked-to-natural-hazard-risks-in-sixteen-caribbean-countries.

As the CAT bond was issued under the World Bank's Global Debt Issuance Facility, no special purpose insurer (SPI) was needed to complete the transaction. This helped streamline the issuance process in terms of time and costs, making the transfer of risk to capital markets efficient and highly cost competitive. Additionally, with the World Bank's experience as a capital markets issuer, the pool could gain support in the outreach activities and investor engagement required for the CAT bond transaction (World Bank, 2015[7]).

Using CAT bonds, the CCRIF was able to diversify its reinsurance capital sources and secure multi-year access to insurance at a fixed price. This allows the pool to achieve greater stability for its risk transfer programme, as it may reduce the impact of price volatility in the reinsurance market. Indeed, price volatility on reinsurance premiums may account for a significant share of the cost borne by the pooling facility. Deploying CAT bonds in addition to reinsurance, for instance within a layering approach, allowed the CCRIF to achieve greater risk diversification.

Over the three-year CAT bond term, this market-based instrument was deployed in parallel with the second and the third layers of the CCRIF's traditional reinsurance programme. For the 2014/15 policy year, CAT bonds account for around 25% of the CCRIF's total annual risk transfer. It then represents 21.6% and 21.8% of the pool's total annual risk transfer for the policy year 2015/16 and 2016/17, respectively (Figure 5.2). Following its maturity, the CAT bond programme was not renewed, as reinsurance prices remained sufficiently low over the succeeding years as to make the cost gains from the CAT bond marginal (Martinez-Diaz, Sidner and McClamrock, 2019[9]). Although it was not renewed, the experience of the CCRIF might provide a good example of participation in the CAT bond markets for other regional risk pooling facilities, including SEADRIF and the Pacific Catastrophe Risk Insurance Company (PCRIC).

Figure 5.2. Breakdown of CCRIF's risk transfer programme, 2014-17



Note: Years refer to fiscal years from 1 June to 31 May.
Source: Authors' elaboration based on (CCRIF, 2017[10]), *Annual Report 2016-17*, www.ccrif.org/sites/default/files/publications/annualreports/CCRIFSPC_Annual_Report_2016_2017.pdf; (CCRIF, 2016[11]), *Annual Report 2015-2016*, www.ccrif.org/sites/default/files/publications/annualreports/CCRIF_Annual_Report_2015-2016.pdf; (CCRIF, 2015[12]), *Annual Report 2014-2015*, www.ccrif.org/sites/default/files/publications/annualreports/CCRIFSPC_Annual_Report_2014_2015.pdf.

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The institutional arrangement of the CCRIF

The legal structure of the CCRIF has evolved. The structure was originally established as a captive insurer owned by a purpose trust domiciled in the Cayman Islands.

In 2014, the CCRIF was restructured into a segregated portfolio company (now named the CCRIF SPC). This implies that the facility has no physical office or staff of its own. Moreover, significant parts of its operations, including (re)insurance management, asset management, communication, and research and development, are outsourced to third-party providers. With such design features, the CCRIF has been able to control its fixed costs and keep operating costs low. This helps further lower the costs borne by participating countries.

The restructuring has enabled the facility to expand its activity with new products and to increase the geographic areas of coverage, including coverage of Central American countries under the Council of Ministers of Finance of Central America, Panama and the Dominican Republic. From covering 16 Caribbean countries in its inception year, as of 2020, the CCRIF had 23 members, consisting of 19 Caribbean countries, 3 Central American countries and 1 electric utility company (CCRIF, 2020[13]). As of the same reference year, its products include parametric insurance for tropical cyclones, earthquakes,

excess rainfall, fisheries and electric utilities. While greater diversification in terms of geographic coverage and perils can lower reinsurance costs, hence the insurance premiums paid by countries, the CCRIF opted to separate risk pools for the Caribbean and Central America. This was done to address member concerns that the impact of disasters in the latter would deplete the former's capital base (Martinez-Diaz, Sidner and McClamrock, 2019[9]).

Prior to taking up the insurance coverage, member countries are provided with individualised risk profiles. These include country-specific hazard and exposure mapping, information on historic losses and estimated losses to exposed assets for events of differing frequency. Furthermore, the risk profiles allow participating governments to support their insurance-buying decisions, tailoring policies to suit their risk profile and unique circumstances.

The flexibility and responsiveness to members' needs offered by the CCRIF may partially explain the strong insurance uptake by participating governments and the consistent renewal of its products, ensuring stable premium revenue over time. Additionally, the cost of coverage is based on the amount of risk that member countries choose to transfer. As each member pays for what it wishes to cover, there is no cross-subsidisation between members transferring a low amount of risk and those transferring a high amount.

Given its structure as a risk pooling facility with great risk diversification and backed with steady capital since its inception, the CCRIF is able to offer insurance to its member countries at the lowest possible prices. At the time of appraisal, the estimated cost of CCRIF insurance for participating governments would be up to 50% lower than the cost of coverage if members insured themselves individually through traditional insurance markets (World Bank, 2012[6]).

The facility has continuously developed its product offer, reducing member countries' membership fees and premiums. For example, participating countries with three continuous years of coverage could receive a reduction in their participation fee from 100% of premium to 50% (World Bank, 2012[6]). Moreover, a premium discount of 25% is offered in years following years of no claims. These cost-reduction programmes have enabled participating countries to increase their level of coverage over time, in turn increasing the pool's capital.

An increase in a regional pool's capital would help scale up risk transfer mechanisms through various channels while maintaining costs that would be passed on to member states through premiums at a lower cost. These channels could include CAT bonds whose transaction costs may be slightly higher than traditional reinsurance due to their more complex and sophisticated nature. As pools need to transfer their risks to reinsurance markets at a cost, CAT bonds could become an alternative or additional instrument to transfer these risks in case the reinsurance market hardens.

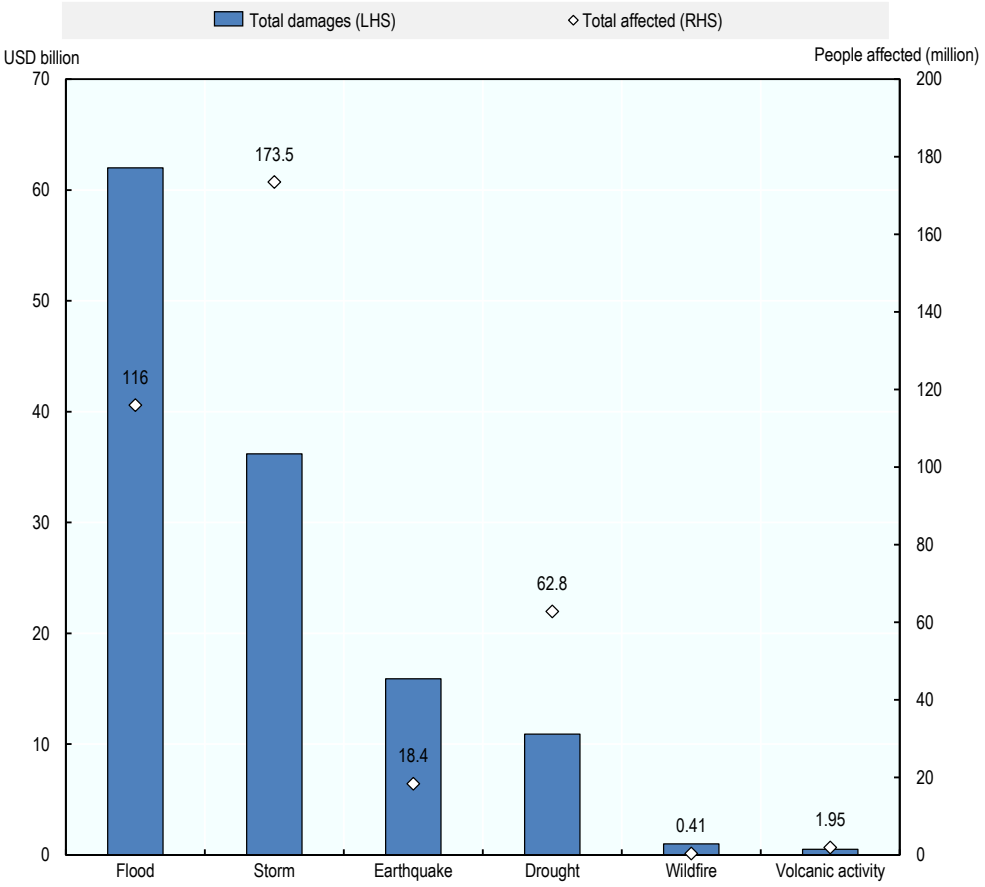
The parametric nature of the CCRIF products enables rapid payouts (i.e. within two weeks or less), providing immediate liquidity for recovery and maintaining basic government functions in the aftermath of natural disaster events. Between 2007 and 2020, the CCRIF made a total of 48 payouts to 14 governments totalling USD 194 million (CCRIF, 2020[13]). Around 69% of this amount concerned tropical cyclone-related policies, approximately 5% concerned earthquake-related policies, and 26% concerned excess rainfall policies.

The CCRIF has deployed sophisticated modelling processes since its inception, which is fundamental for the accurate pricing of the CCRIF's policies and its financial sustainability. The pool has consistently improved and updated its models through investment in research and development. For instance, the new risk model, SPHERA, which was developed using the latest scientific findings and the most updated hazard datasets, was implemented for the 2019/20 tropical cyclone and earthquake policies, replacing the model that had been the basis since 2011 (CCRIF, 2020[13]). The 2019/20 excess rainfall policies also benefited from an upgrade of the model used since 2018. The new model includes features that reduce basis risk, such as the inclusion of soil saturation in loss estimates and the incorporation of assimilated observed data into the meteorological model (CCRIF, 2020[13]).

The case of the SEADRIF in ASEAN +3

Countries in the ASEAN+3 region are prone to various types of natural disasters, including floods, storms, earthquakes and tsunamis, drought, wildfires and volcanic activity. The frequency and intensity of these events are increasing due to climate change, leading the ASEAN region, home to almost 680 million people as of 2022 and with a combined GDP of around USD 3.6 trillion), to be highly vulnerable to natural disasters and climate hazards. Over the last two decades, natural disasters have affected more than 370 million lives in ASEAN countries. Almost half of the fatalities were the result of storm events (Figure 5.3). Total damages resulting from natural disasters occurring between 2000 and 2023 has reached USD 126.5 billion. Damages from flood events accounted for almost 50% of the total (Figure 5.3).

Figure 5.3. The impact of natural disasters in ASEAN countries by peril type, 2000-23



Note: Data as of 7 November 2023. LHS = left hand scale. RHS = right hand scale. Countries include Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Thailand and Viet Nam.
Source: (CRED, n.d.[4]), *Emergency Events Database (EM-DAT)* (database), https://public.emdat.be/.

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Larger ASEAN economies are relatively more capable of raising liquidity to finance their post-disaster needs due to their higher level of insurance and debt-market development. However, it may still be challenging for these economies to obtain adequate liquidity. For instance, although insurance is deployed to cover disaster losses in larger ASEAN countries, including Indonesia, the Philippines and Viet Nam, coverage may be inadequate due to the limited capacity of local insurance markets for catastrophe risks.

The capacity of smaller economies, such as those of Cambodia, Lao PDR and Myanmar, to finance disaster risk is even more constrained due to limited borrowing capacity, underdeveloped local debt and insurance markets, and limited access to international (re)insurance and capital markets.

To help countries gain access to additional and reliable sources of disaster risk financing through tailored financial products and enhance their financial resilience through capacity-building services, a regional risk financing facility was established as an initiative of ASEAN+3 finance ministers and central bank governors. The initial capitalisation of the SEADRIF came from grants funded by Japan and Singapore (SEADRIF, 2023[14]). Administrative support is provided by the ASEAN Secretariat and the World Bank also gave capitalisation support. This capital provision allows the facility to retain part of its risk, thus lowering the reinsurance premiums. Similar to the CCRIF, part of the company's operations, including (re)insurance management, asset management and payout calculations, is outsourced to third-party service providers. This allows the company to lower its operational costs. Owing to the reduced capital requirement, along with the lower transaction and operating costs, participating countries can benefit from premium savings. It has been estimated that, at the appraisal stage, premiums could be more than 20% lower as a result of catastrophe risk pooling, risk retention through joint reserves and economies of scale, compared to the premiums countries would pay if they accessed international reinsurance markets individually (World Bank, 2020). Besides insurance solutions, the most recent 2023-25 Action Plan of the ASEAN+3 Disaster Risk Financing Initiative outlines joint contingent financing as well as joint CAT bonds as its priority areas. Combining these financial instruments will enhance resilience at both the national and regional levels.

The SEADRIF's first financial product includes a three-year insurance policy against the risk of flood. It consists of two components covered by a single premium. The parametric component features a stepped payout structure, allowing participating members to receive payouts amounting to 40% of the policy limit within ten business days in the event of a medium-severity disaster (1-in-8-year flood event) and 100% in the event of a severe disaster (1-in-20-year flood event) (SEADRIF, 2023[14]). The finite risk component is designed to address basis risk, providing participating countries with protection against smaller shocks, regardless of whether they are related to a flood event. Under this component, insured members can be provided with liquidity within five business days in the case an event does not trigger a payout under the parametric component.

This product was developed in response to a request from Lao PDR. Flood events have caused more damages in the region than other types of natural disasters (Figure 5.3), meaning that affordable financial protection against floods is essential to overcome the financial burden these countries face. The flood insurance product design takes several factors into consideration, including product simplicity, pool sustainability, appetite of international reinsurance markets and, most importantly, affordability such that participating countries are able to pay the premium. Under this product, each country determines its premium, and the SEADRIF calculates the coverage it can offer.

The current financial solution offered by the SEADRIF involves a reinsurance-backed catastrophe risk pool for Lao PDR and Myanmar, in which both countries pay an upfront premium and receive a payout when an eligible disaster occurs. Cambodia was expected to join the pool; however, its participation is pending further feasibility studies (World Bank, 2020[15]). By pooling risks and jointly purchasing insurance under the SEADRIF, the capital requirement and transaction costs can be reduced. As of August 2023, the Government of the Lao PDR received two payouts totalling USD 1.5 million within one business day following the submission of the notice of loss due to flooding. Both of these payouts fall under the finite risk component of the insurance policy.

Retaining a higher share of the risk in SEADRIF can lower premium costs for participating countries, incentivising the active involvement of the current participants and attracting more member countries to join. As the SEADRIF's coverage is currently limited to flood insurance, the facility may need to develop other products for other types of disasters. The SEADRIF could strengthen monitoring process, including

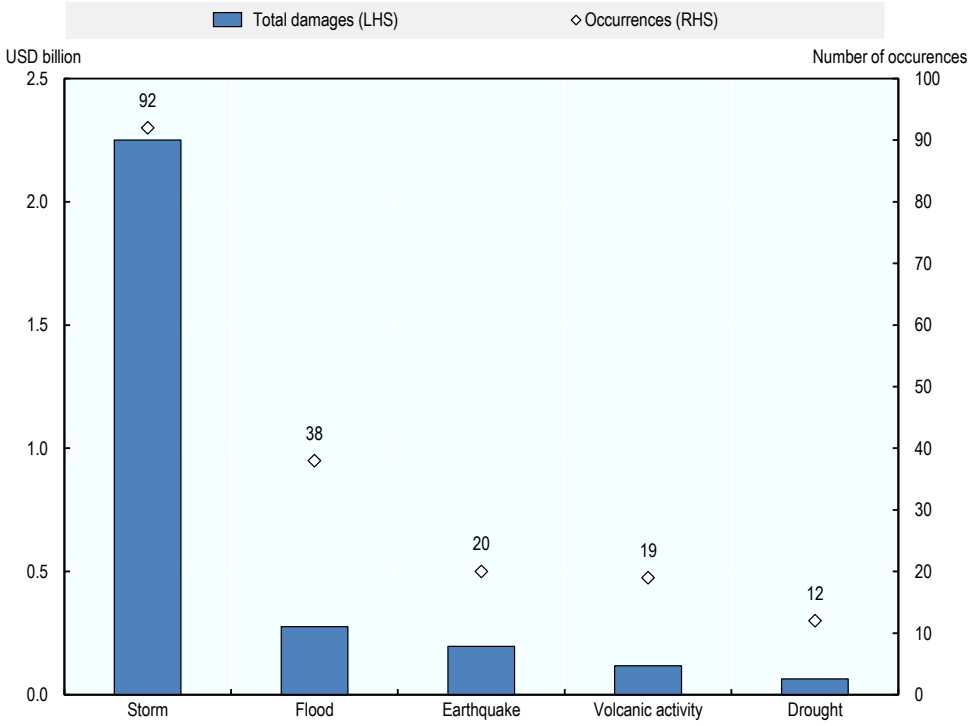
model design, legal arrangement, rating analysis and access to institutional investors in the international capital markets.

In addition, there are other initiatives in Asia, such as APEC's emergency preparedness work. First established in 2005, the APEC Emergency Preparedness Working Group (EPWG) aims to enhance the region's capacity, enabling APEC member economies to prevent, prepare for and recover from the increasing risks of disasters more effectively. In 2016, the EPWG was tasked to lead the formulation of the APEC Disaster Risk Reduction Plan. Sharing of information related to Disaster Risk Financing initiatives, promoting private disaster insurance schemes, deepening their penetration, as well as developing risk transfer mechanisms based on robust data and analysis are among key areas of collaboration outlined within this plan.

The case of the PCRAFI Facility

The Pacific region consists of a number of Small Island Developing States. High exposure to natural disasters and climate hazards has made these countries some of the most vulnerable in the world. Storm events are among the most frequent natural disasters since 2000, generating total damages of USD 2.25 billion (Figure 5.4). Among the most severe storm events, Severe Tropical Cyclone Pam, which struck Vanuatu in 2015, affected 69% of the population and caused total damages amounting to almost USD 450 million or 61.5% of GDP in 2015 (CRED, n.d.[4]). The following year, category 5 Severe Tropical Cyclone Winston made landfall in Fiji, affecting 62% of the population and generating total damages of USD 600 million or over 12% of GDP in 2016 (CRED, n.d.[4]).

Figure 5.4. Disaster occurrences and damages in the Pacific region, 2000-23



Note: LHS = left hand scale. RHS = right hand scale. Data cover 20 countries in the Pacific region: American Samoa, the Cook Islands, Fiji, French Polynesia, Guam, Kiribati, the Marshall Islands, Micronesia, New Caledonia, Niue, the Northern Mariana Islands, Palau, Papua New Guinea, Samoa, the Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna.
Source: (CRED, n.d.[4]), *Emergency Events Database (EM-DAT)* (database), https://public.emdat.be/.

StatLink https://stat.link/pa8s3i

As with other Small Island Developing States, the Pacific Island Countries (PICs) often confront limited access to short-term immediate liquidity in the aftermath of a disaster event. The limited options in raising quick liquidity are a result of PICs' small size, limited borrowing capacity and limited access to international insurance markets. Their small size tends to rule out any risk diversification options, meaning that a risk pool involving the subsidisation of affected regions using revenues from unaffected ones is practically impossible (World Bank, 2015[16]). High transaction costs, small domestic economies and the inability to spread risk over a large territory are among the factors limiting insurance penetration in the region. As a result, governments and households often bear a large proportion of the economic losses from natural disasters.

Against this backdrop, a catastrophe risk insurance programme was piloted from 2013 to 2015 as part of the initial phase of the PCRAFI. Launched in 2007, the PCRAFI is a joint initiative of the World Bank, the Secretariat of the Pacific Community and the Asian Development Bank. The initiative benefitted from financial support from the Government of Japan, the Global Facility for Disaster Reduction and Recovery and the European Union. Technical support was provided by GNS Science (New Zealand), Geoscience Australia and AIR Worldwide. Under the pilot insurance programme, six participating countries (the Marshall Islands, Samoa, the Solomon Islands, Tonga and Vanuatu, as well as the Cook Islands, which joined in the second policy year) were provided with an affordable parametric insurance product against tropical cyclones and earthquakes or tsunamis. The product provided participants with access to rapid liquidity in the wake of major meteorological and seismic events.

As of 2023, a total of four payouts, exceeding USD 11 million in aggregate, have been disbursed. Two countries benefited from rapid payouts during the three-year pilot of PCRAFI while other two payouts amounting USD 3.5 million and USD 4.5 million were made by PCRIC to the Government of Tonga following the Tropical Cyclone Gita in 2018 and the Tropical Cyclone Harold in 2020, respectively. During the pilot programme, the first payout of USD 1.3 million in 2014 provided Tonga with rapid liquidity to respond to the impact of Severe Tropical Cyclone Ian. The payout was made within ten days following the event (World Bank, 2015[16]). The nominal amount can be considered quite significant relative to the country's 2013 contingency budget. Additionally, it accounted for more than half of the reserves of the Tonga National Reserve Fund (World Bank, 2017[17]). Vanuatu received the second payout of USD 1.9 million in 2015, following Severe Tropical Cyclone Pam. Payment was made within seven days following the event (World Bank, 2015[16]). Although the nominal payout amount was equivalent to eight times the country's emergency provision (World Bank, 2017[17]), it was lower than anticipated, reflecting the low level of coverage purchased.

In 2015, the finance ministers of the PICs decided to establish a sovereign regional catastrophe risk pool – the PCRAFI Facility. This marked the end of the PCRAFI pilot and the beginning of Phase II of the PCRAFI. In fact, Phase II has two core components: i) the PCRAFI Facility; and ii) the Technical Assistance Programme to support capacity building for disaster risk financing. To finance these, the PCRAFI MDTF was established, consisting of donor countries Germany, Japan, the United Kingdom and the United States. Donor contributions totalled USD 40 million, a share of which will particularly be used for the establishment and operations of the PCRAFI Facility, as well as to support the initial capitalisation, monitoring and evaluation, and the development of disaster risk insurance products.

The structure of the PCRAFI Facility consists of two entities: the Pacific Catastrophe Risk Insurance Foundation (PCRIF), which is a collective ownership structure for participating countries to govern the risk pooling facility; and the PCRIC, owned and governed by the PCRIF. The PCRIC serves as a captive insurer with a mandate to provide member countries with cost-efficient disaster risk insurance.

Addressing data challenges and client retention issues

The current perils covered by the PCRIC products remain the same as the perils covered during the 2013 pilot insurance programme. PCRIC products still consist of parametric insurance policies covering tropical cyclones, earthquakes and tsunamis whose triggers are based on modelled losses. Under the tropical

cyclone policies, modelled loss are calculated using information on storm position and wind speed. Modelled loss under the earthquake policies is based on parameters that include the location, epicentre and depth of the earthquake. Should the earthquake lead to a tsunami, losses incurred from that event will be accounted for in adjusting the modelled loss.

PCRIC products and the insurance model are developed based on the Pacific Risk Information System (PacRIS), the key output of the PCRAFI. This tool uses the probabilistic assessment results for 15 countries in the region and a regional database on exposures, making it the largest database of its kind in the Pacific region. Data on exposure cover infrastructure, crops, and public and private buildings. Information related to construction features and current condition is collected using remote sensing analyses, country-specific datasets and field visits.

In addition to country-specific exposure, PacRIS includes a catalogue of historical earthquakes, tropical cyclones and loss data, and hazard models that simulate tropical cyclones, earthquakes and tsunamis for each country. The risk profiles are further deployed to estimate direct losses from each type of natural disaster event, providing support in determining appropriate disaster risk financing and insurance solutions, including policy premiums for participating countries. Results from risk assessments, including the geographic distribution of potential losses, can be visualised and are easily accessible via an open-source web-based platform.

In addition, PacRIS was designed to support broader aspects of disaster risk management, including rapid disaster-impact estimation, professional and institutional capacity development, urban planning and infrastructure design, and macroeconomic planning, among others. Notwithstanding the tool being open source, the use of PacRIS can be improved, as it is still limited to supporting the development of financial solutions (i.e. insurance) in practice, and some data gathered under this tool are currently outdated (Martinez-Diaz, Sidner and McClamrock, 2019[9]).

Given that risk assessment relies heavily on data, it is critical for the PCRAFI to keep its database current. Although some asset exposure data are already updated in 2023 as a result of PCRAFI Program Phase II, however, the latest update of complete country risk profiles date back to 2015 (World Bank, 2017[17]). By updating country's risk profiles and information, the facility can ensure the accuracy of its estimates and catastrophe risk models. This can in turn provide participating countries with refined insurance products whose payouts closely reflect the reality on the ground. Improvements in data and thus in risk modelling may also facilitate the pool's risk transfer through CAT bond markets. However, there seems to be other critical challenges the facility needs to overcome in order to transfer part of its risk to capital markets.

Client retention is another issue affecting the functioning of the PCRAFI Facility. Since it was legally established in 2016, the PCRIC has been offering insurance policies to six countries. However, for Season 9, which began in November 2020, policyholders consisted of only three countries (the Cook Islands, Samoa and Tonga) (World Bank, 2021[18]). Other countries, such as the Solomon Islands and Vanuatu, opted out. This may indicate that the PCRIC currently faces challenges, particularly a client retention issue. The small number of participants and resulting lack of risk diversification may lead to higher premiums as transferring risk to reinsurance or capital markets becomes costly. Considering that CAT bonds may involve higher transaction costs than traditional reinsurance, the cost to participating countries could be even higher.

Affordability of premiums is one of the most important factors that determines insurance pool participation. The tight budget of many Small Island Developing States, for instance due to a small population and narrow government revenue base, appears to be the main barrier to purchasing insurance coverage. Almost all countries that have purchased insurance policies, excluding the Cook Islands, relied on premium subsidies from the government of Japan during the PCRAFI pilot programme.

For instance, the grants fully covered premiums during the first pilot season. In the next two seasons, participating countries contributed 5% and 16% of the total, respectively (World Bank, 2015[16]). This growing contribution may indicate participating countries' commitment to the programme; however, the

country consultation report on the insurance pilot programme points out that participating countries would not have the capacity to purchase coverage and that countries would evaluate their ongoing participation if premiums ceased to be subsidised (SPC, 2015[19]). This further demonstrates the importance of premium affordability with regard to participation.

After the establishment of the PCRIC, participating countries benefited from concessional premium financing. The Marshall Islands, Samoa, Tonga and Vanuatu have relied on IDA resources, combined with own contributions, to finance their premiums for the 2015/16 policy year (Season 4) onwards (Martinez-Diaz, Sidner and McClamrock, 2019[9]). IDA grants have been the partial source of premium payments for the Marshall Islands and Samoa, while Vanuatu relied more on IDA credit. Tonga also used IDA credit, in addition to the small grant received. Some other countries in the Pacific are eligible to purchase insurance coverage from the PCRIC but are not eligible to access IDA funding. The limited sources to finance premiums might become a serious impediment to expanding participation.

Another key factor that may affect participation is payout expectation. The decision to drop coverage or to withdraw from the pool might be the result of unmet payout expectations, as with the Solomon Islands, which dropped out after the second season of the insurance pilot (2013/14 policy year). Vanuatu halted coverage after the sixth season (2017/18 policy year). The magnitude 8.0 earthquake and tsunami in 2013 that generated losses in the Santa Cruz Islands did not trigger a payout, as the degree of physical damage was relatively low. The following year, a tropical depression led to extensive flooding, with estimated damages and losses equivalent to 9.2% of the Solomon Islands' GDP in 2014 (World Bank, 2015[20]). Notwithstanding the severity of damages and losses, the event did not trigger a payout, as a tropical depression was not an eligible event under the insurance policy (World Bank, 2016[21]).

Challenges of enhancing regional co-operation

Despite the presence of a political platform that accommodates regional collaboration in financing disaster risks, countries may be reluctant to cross-subsidise premiums for other pool participants (World Bank, 2017[22]). The premium for each country should therefore be based on the level of risk the country brings to the regional risk pool (OECD, 2022[23]). Appropriate calculation methods would need to be developed to ensure that each participating country pays a premium that is both commensurate with its risk exposure and economically viable.

In general, regional catastrophe risk pools employ risk-based pricing whereby policies are priced individually depending on the underlying risks: countries could choose the type, frequency and severity of disasters to cover, which would be reflected in their premium. Individual pricing can prevent cross-subsidisation from countries facing lower risk to those facing higher risk. This could be achieved through the pools' capacity to develop a more detailed risk assessment for each participating country. Granular data and statistical modelling should be able to predict the likelihood and impact of a disaster event for individual locations rather than for a wide area.

In addition to country-specific risk profiles, tailoring appropriate insurance premiums for member countries requires several factors, in particular, a sovereign risk pooling mechanism must accommodate the divergent interests of the parties involved (i.e. participating countries, the catastrophe risk pool itself and donor countries that contributed to the pools' establishment and development).

For instance, when the CCRIF was first established, following participating countries' decisions on their coverage, the model was used to calculate the average annual loss (AAL). A range of other factors were taken into consideration to determine the pricing of CCRIF policies. For example, to respond to its need for growing reserves to reduce the chance of insolvency, and to cover its operating expenses, professional fees, and the cost of reinsurance, the long-term aggregate premium from participating countries should be higher than the AAL of the aggregate CCRIF portfolio (World Bank, 2010[24]). The premium is therefore set

as a function of the AAL, the expense load (e.g. administrative costs) and the cost associated with capital provision, as the risk pool needs to secure a large amount of capital through reserves or reinsurance to ensure its capacity for claims payments. This implies a premium equivalent to a multiple of the AAL. As the reserves increase, the CCRIF could lower the premium rate by 10% from the first to the second season (World Bank, 2010[24]).

The pricing method can be refined as the catastrophe risk model evolves (see Chapter 3). For instance, while using only participating countries' AAL in the function of insurance pricing offers simplicity, including countries' probable maximum loss would better capture the impact of each country's policy on the risk exposure of the pool's aggregate portfolio. Using such a function, a country with a lower AAL but higher loss volatility would contribute more to the pool (World Bank, 2010[24]). As of 2021, CCRIF insurance policy pricing is based on the country's risk profile, presenting losses at various probabilities of occurrence, often referred to as probabilities of exceedance (CCRIF, n.d.[25]).

Conclusion

For countries where issuing CAT bonds independently is infeasible, multi-country CAT bonds represent a possible solution. In such an arrangement, multiple countries share resources to gain the benefits of CAT bonds at a regional level. Multi-country CAT bonds can reduce transaction costs as seen in the example of the Pacific Alliance CAT bonds. Multi-country CAT bonds can also broaden the investor base for the instruments. Indeed, the high demand for the Pacific Alliance CAT bond reduced the necessary premium rates for participating countries.

CAT bonds can also be used as part of regional catastrophe risk sharing mechanisms, as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) has done. The CCRIF was able to diversify its reinsurance capital sources and secure multi-year access to insurance at a fixed price using CAT bonds, stabilising its risk-sharing programme, though CCRIF and other similar programmes still face challenges. High premiums can dissuade countries from joining regional programmes, and the facilities themselves need significant amounts modelling, technical, legal and financial expertise, all of which may be costly in their own right. Furthermore, if the needs of member countries are not met, such as if certain disaster types are not covered or triggers are deemed too restrictive, there is a risk of client attrition.

Finally, some countries might be reluctant to cross-subsidise the premiums of other members of a given risk sharing arrangement. As such, more current technical expertise and data are needed to ensure each country pays an appropriate share of the costs. Administrators of a risk sharing mechanism must also balance the needs and wants of member countries with those of participating countries.

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The Development Dimension

Fostering Catastrophe Bond Markets in Asia and the Pacific

As climate change increases exposure to natural disasters, countries need new solutions to mitigate risks of natural hazards. For many in Asia and the Pacific, mobilising existing resources is not enough: they need to consider a grand design of disaster risk financing strategies. Catastrophe bonds (CAT bonds) can be an effective, market-based financing tool for the region. While the global CAT bond market has grown steadily since the 1990s, it remains weakly developed in Asia and the Pacific. Its successful development there requires robust purpose-built legal frameworks; developed general bond markets, especially in local currency; appropriate capacity building; and data-driven pricing models. This report explores each of these conditions along with policy suggestions for fostering them, and discusses the development of multi-country CAT bonds in Asia and the Pacific.

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