CATASTROPHE BONDS*

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An important element of risk financing is risk transfer. In addition to transferring risk to an insurer or reinsurer, risk can be placed directly in the capital markets through insurance-linked securities (ILS). The ILS market emerged following the devastating damage of Hurricane Andrew, which hit Florida in 1992. Hurricane Andrew was the costliest natural disaster in U.S. history at the time and remained so until it was surpassed by Hurricane Katrina in 2005. Following the storm, there was an insufficient supply of reinsurance to cover coastal catastrophe risk. This led to increased development of tools that use the financial markets for enhancing risk transfer.

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Catastrophe bonds are the most well-known type of ILS to transfer catastrophe risk to capital market investors and the second-largest according to volume.[2] The first catastrophe bonds were issued in the mid-1990s and the market has been steadily growing since that time. This primer explains the general mechanics of catastrophe bonds, provides examples of their use, and outlines future opportunities for the market.

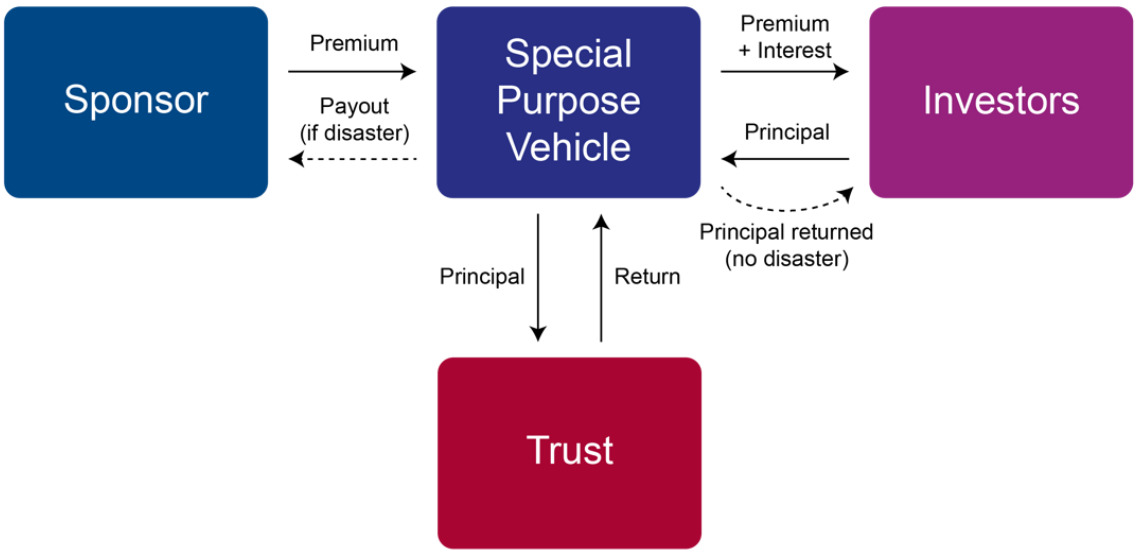
[1] We would like to thank Ruiqi Li for research assistance and Jenna Epstein for assistance with the figures for this primer.
[2] Since 2012, the largest ILS instrument by volume has been collateralized reinsurance. See: Aon Securities LLC (2020). ILS Annual Report 2020—Alternative Capital: Growth Potential and Resilience.

HOW DOES A CATASTROPHE BOND WORK?

The typical structure of a catastrophe bond is shown in Figure 1. The sponsor, or cedent, is the entity that seeks to transfer catastrophic risk off its balance sheet. Usually the sponsor is an insurer or reinsurer. However, there are also cases in which large corporations (e.g., Disney), public authorities (e.g., the New York City Metropolitan Transportation Authority), and even sovereign nations (e.g., the Republic of Chile) have used catastrophe bonds to manage their risk exposure.

In order to issue a catastrophe bond, the sponsor must first set up an entity known as a special purpose vehicle (SPV). The SPV has the legal authority to act as an insurer and is bankruptcy remote. As such, the SPV protects both parties to the transaction from each other's credit default risk. The sponsor enters into a re/insurance contract with the SPV, which issues the catastrophe bond to investors. The SPV invests the investors' principal in highly-rated and liquid collateral securities, such as U.S. Treasury Bills or Structured Notes issued by the International Bank for Reconstruction and Development. The collateral is safely held in a trust account and yields a steady stream of variable interest rate payments that are transferred to the investors. Hence, catastrophe bonds are essentially floating rate notes that exhibit minimal interest rate risk. In addition to the floating returns, catastrophe bonds compensate investors for bearing the disaster risk with premium payments from the sponsor. If a pre-defined trigger event occurs during the term of the bond, all or part of the principal is transferred to the sponsor, leading to a full or partial loss for investors. If the bond expires without the trigger event occurring, the principal is returned to the investors.

FIGURE 1. TYPICAL STRUCTURE OF A CATASTROPHE BOND



Issuance of a catastrophe bond typically requires engaging a specialized modeling firm to quantify the catastrophe risk.[3] The risk modeler will estimate the probability that the conditions for the payout would be met over the term of the bond (probability of first loss). The modeling firm also provides an estimate of the expected loss for investors. To this end, it uses its complex scientific models of natural catastrophes in combination with data on insured properties and policy conditions. Such a model-based approach to risk assessment is needed, since historical data on the most extreme natural disasters are typically too scarce for a reliable estimation of the outer tail of the loss distribution.

WHAT TYPES OF NATURAL CATASTROPHES ARE COVERED?

Catastrophe bonds have been designed to provide coverage against the costliest natural disasters in the world. The underlying natural disaster risk is typically described along the two dimensions "peril" and "territory."[4] The peril is the type of hazard insured by the catastrophe bond (for example, windstorms or earthquakes). The reference territory determines where the hazard event has to occur in order to be covered by the bond. In terms of currently outstanding risk capital, the prevailing peril/territory combinations closely mirror the size and importance of primary insurance markets around the world. Transactions referencing windstorm and earthquake risk in the U.S., Japan, and Europe have historically dominated the market. In recent years, however, an increasing number of bonds have been designed to cover natural catastrophe risk in emerging markets such as China (Panda Re 2015-1), Turkey (Bosphorus Re 2015-1), Chile (IBRD CAR 116), Colombia (IBRD CAR 117), Peru (IBRD CART 120), and Mexico (IBRD/FONDEN 2020).

WHAT ARE POSSIBLE CATASTROPHE BOND TRIGGERS?

A catastrophe bond trigger specifies the elements of the event that would cause the release of the principal to the sponsor. Industry experts typically distinguish the following four types of triggers:

- INDEMNITY TRIGGERS are based on actual losses sustained by the sponsor. Just as with a standard insurance or reinsurance policy, an indemnity trigger catastrophe bond is a complete hedge against disaster risk. Accordingly, the sponsor achieves full regulatory capital relief under modern risk-based capital standards (e.g. Solvency II).[5] For investors, indemnity triggers can be relatively opaque, since they do not have direct access to information on the sponsor's insurance portfolio. This raises a moral hazard concern. If the sponsor is an insurance company, it may relax underwriting and claims-handling standards once the catastrophe bond coverage has been put in place. Indemnity triggers typically involve a relatively lengthy payout process, since loss reporting and verification must be accomplished before the release of funds. Nonetheless, the indemnity trigger is by far the most widely used trigger type in today's catastrophe bond market (see Figure 2).

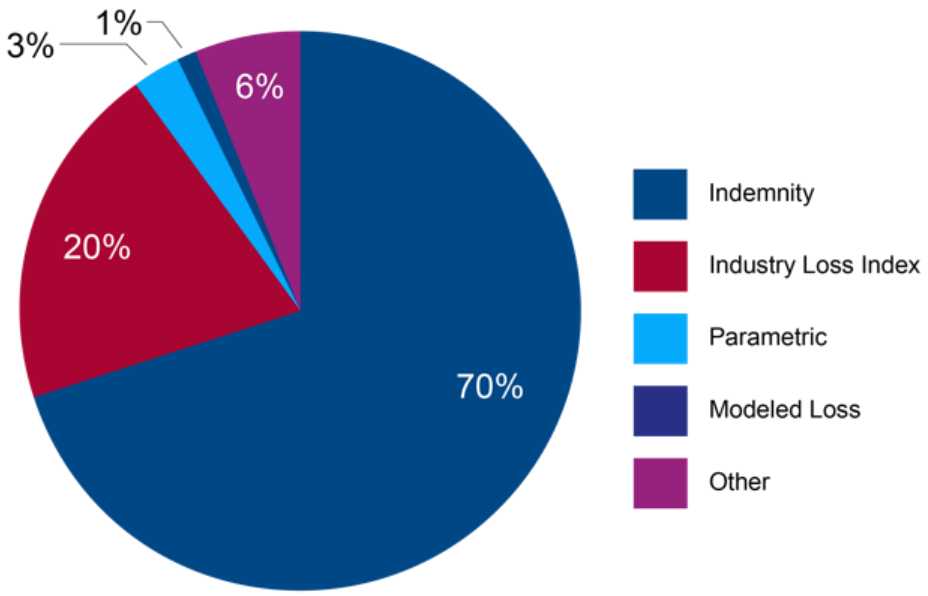
[3] Issuance will also typically require a structuring agent to determine the bond's characteristics and a legal adviser to develop the offering circular with the terms and conditions of the bond.

[4] See, for example: Braun, A. (2016). "Pricing in the Primary Market for Cat Bonds: New Empirical Evidence." Journal of Risk and Insurance 83(4): 811–847.

[5] See, e.g., Braun, A., and J. Weber (2017). "Evolution or Revolution? How Solvency II Will Change the Balance Between Reinsurance and ILS." Journal of Insurance Regulation 36(4): 1–26.

- INDUSTRY LOSS TRIGGERS require aggregate losses experienced by the industry to exceed a predetermined value. The determination that the trigger has been met is usually done by an independent third-party, such as Property Claims Services (PCS), which collects loss reports from insurers and aggregates them into an industry loss index. This solves the moral hazard problem associated with indemnity triggers, since the sponsor can neither influence the industry losses nor the index calculation. At the same time, however, industry loss index triggers introduce basis risk, or the risk that the catastrophe bond might not be triggered in all cases in which the sponsor suffers material losses. Because data collection across the industry is time consuming, a catastrophe risk modeler typically provides an initial estimate of aggregate insured losses directly after the natural disaster has struck. This estimate is then updated over time as new loss information arrives. The industry loss index trigger is the second-most common trigger type according to outstanding volume of risk capital (see Figure 2).
- PARAMETRIC TRIGGERS require a measurable characteristic of the covered catastrophe (such as earthquake magnitude or hurricane wind speed) to exceed a pre-determined value at a predefined set of locations (measurement stations). This trigger allows for a fast payout, since readings of the physical parameter values are available immediately after the catastrophe has occurred. As the underlying physical parameters will not be perfectly correlated with insurance losses, however, this trigger type exhibits a substantial basis risk for sponsors.
- MODELED LOSS TRIGGERS are similar to indemnity triggers, but rely on an independent third-party modeler to estimate the projected losses for the sponsor. This speeds up the payouts, but introduces basis risk. Modeled loss triggers were more common in the initial years of the catastrophe bond market. Today, they have almost fully disappeared (see Figure 2).

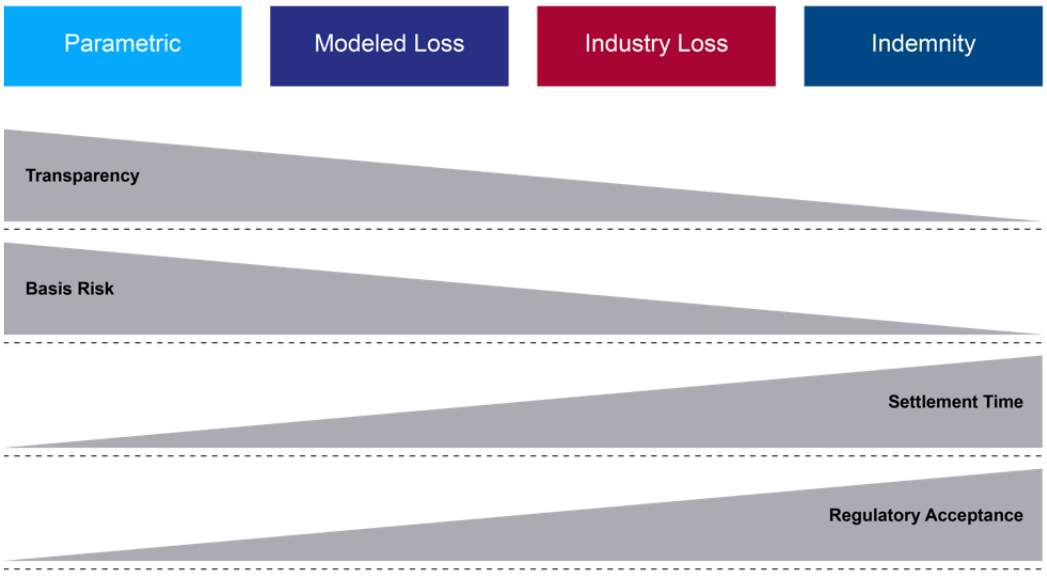
FIGURE 2. TRIGGER TYPES IN THE CATASTROPHE BOND MARKET



Source: Artemis.bm, based on outstanding capital in March 2021.

Figure 3 compares the four main trigger types across different criteria: transparency to investors, basis risk for the sponsor, settlement time, and regulatory acceptance. As shown in the figure, the parametric trigger is the most transparent, but also has the most basis risk. It is also the quickest to settle, but has a low degree of regulatory acceptance. Indemnity triggers are the opposite, with the modeled loss and industry loss triggers ranking in the middle according to the four criteria.

FIGURE 3. CATASTROPHE BOND TRIGGERS IN COMPARISON



Source: Adapted from Hagedorn, D., et al. (2009). Choice of Triggers. In: Barrieu P. and Albertini L. (Eds.), The Handbook of Insurance-Linked Securities (p. 37–48), John Wiley & Sons.

Most catastrophe bonds rely on a single trigger. In some cases, however, multiple triggers are used. In addition, catastrophe bonds are often separated into two tranches that exhibit different risk-return profiles or vary in terms of trigger, reference peril, and covered territory. For instance, with a parametric trigger, 50% of the principal might be paid for a category 3 storm in a certain location and 100% if the storm is a category 4 or higher. Catastrophe bonds are highly customizable and the trigger design can be tailored to the particular risk transfer needs of the sponsor.

WHAT OTHER DESIGN CHARACTERISTICS ARE IMPORTANT?

Catastrophe bonds exhibit an average maturity of three years.[6] Longer maturities up to five years exist, but are not common. There are two main forms of coverage, determined by the type of reinsurance contract embedded in the catastrophe bond: per-occurrence and annual aggregate. In the former case, the catastrophe bond contains an excess-of-loss per event (XL/E) reinsurance contract, meaning it will only trigger if losses caused by a single catastrophe event exceed a given threshold (the so-called attachment point). In the latter

[6] See, for example: Beer, S., and A. Braun (2021). "Market-Consistent Valuation of Natural Catastrophe Risk." Working Paper, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3406577.

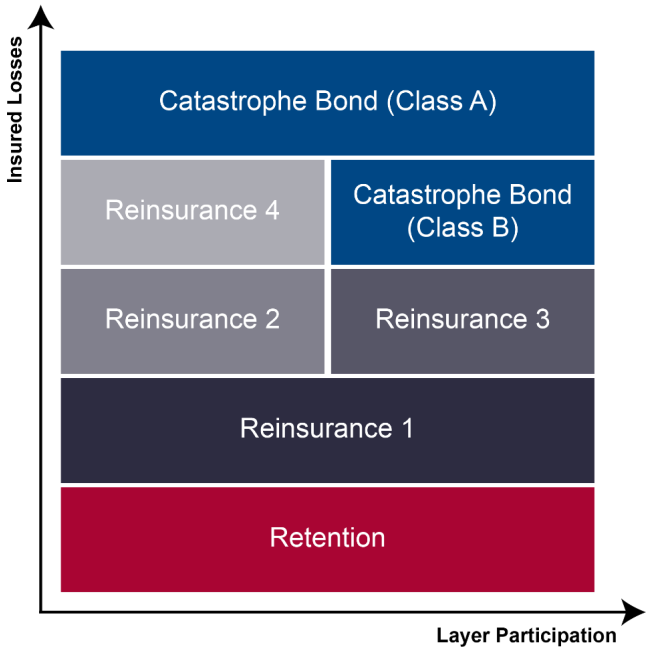
case, the catastrophe bond contains a stop-loss reinsurance contract, allowing for an aggregation of the insured losses caused by all catastrophe events in one year. At the time of writing, the outstanding market volume was almost evenly split between per-occurrence (47.1%) and annual-aggregate (52.9%) catastrophe bonds.[7]

Catastrophe bonds are also flexible in terms of payout design. The common forms are proportional payouts and binary payouts. Under a proportional payout, the percentage loss of principal suffered by investors rises with the amount by which the underlying insurance losses exceed the attachment point of the catastrophe bond. A full loss for investors is reached once the underlying insurance losses hit the exhaustion point of the catastrophe bond. Under a binary payout, in contrast, a predefined amount of principal (usually 100%) is transferred to the sponsor as soon as the underlying insurance losses reach the attachment point.

WHAT ARE THE BENEFITS TO THE SPONSOR?

Catastrophe bonds provide many benefits to the sponsor. As they typically exhibit a term of several years, they provide multi-year price stability for transferring a layer of catastrophe risk. They are also fully collateralized. The sponsor can, therefore, be highly confident that it will receive the necessary payment should a disaster occur; default risk is effectively minimized. Catastrophe bonds can be used as both a complement and a substitute to classical reinsurance. They are typically used for the highest loss layers—that is, those with a low probability but possibly substantial impact. For these layers, the diversification advantage of classical reinsurers becomes negligible and they have to back one dollar of exposure with one dollar of risk capital. Given that the cost of equity for reinsurers often exceeds the risk premiums paid on catastrophe bonds, it can be attractive to securitize the risk instead of backing it with capital or attaining a classical retrocession cover. Moreover, catastrophe bonds allow the sponsor to diversify its sources of capital for catastrophe risk. (See Figure 4 for an exemplary risk transfer tower.)

FIGURE 4. EXEMPLARY RISK TRANSFER TOWER



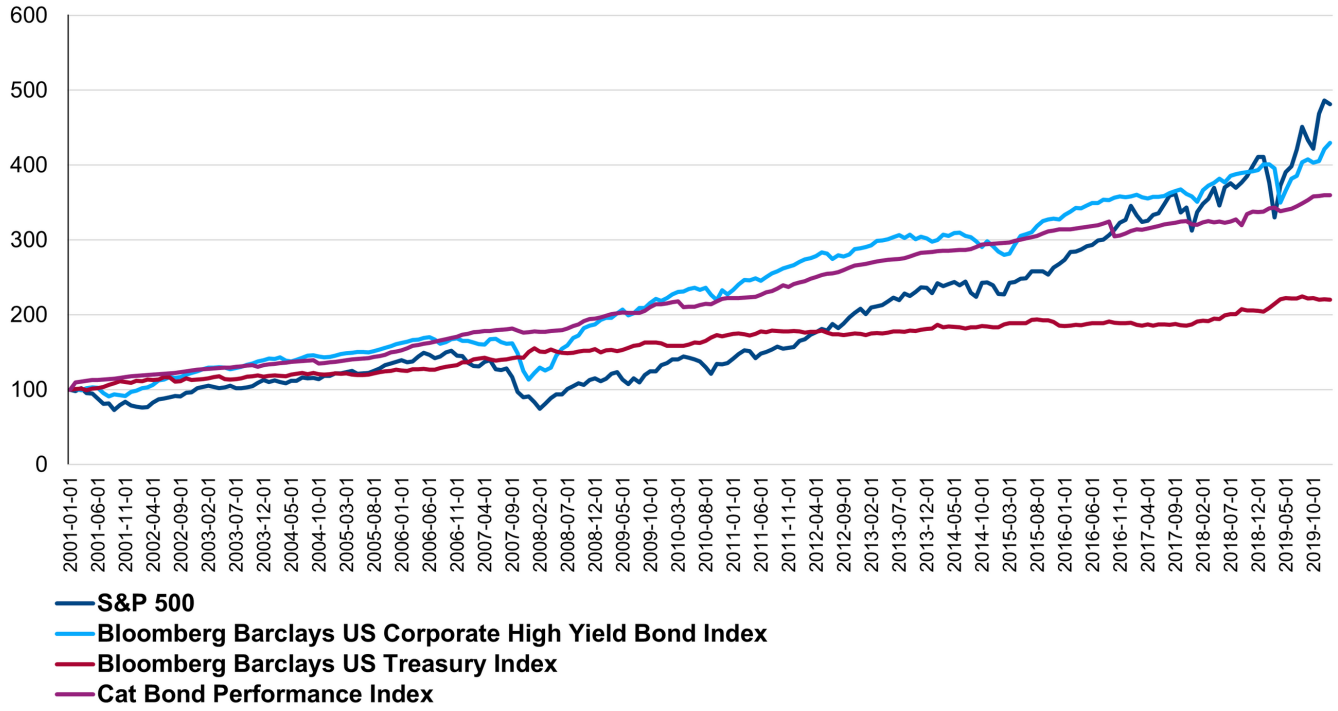
[7] See the Artemis.bm ILS Dashboard.

WHAT DRIVES INVESTOR INTEREST IN CATASTROPHE BONDS?

Interest in catastrophe bonds as an alternative investment has grown substantially throughout the last decade. The attractiveness of catastrophe bonds to investors is often based on high single-digit returns that exhibit a low volatility and are largely uncorrelated with those of other asset classes.

Directly investing in catastrophe bonds, however, requires a high level of expertise. Catastrophe bonds are difficult to handle for investors not versed in extreme event risk. A catastrophe bond portfolio can steadily grow in value over a prolonged period of time, exhibiting a very low return volatility. If a major catastrophe loss year such as 2017 occurs, however, the investment will suddenly suffer a major drawdown (see Figure 5). In addition, some of the structures are quite complex, exhibiting multiple perils, territories and triggers.

FIGURE 5. HISTORICAL PERFORMANCE OF THE CATASTROPHE BOND MARKET



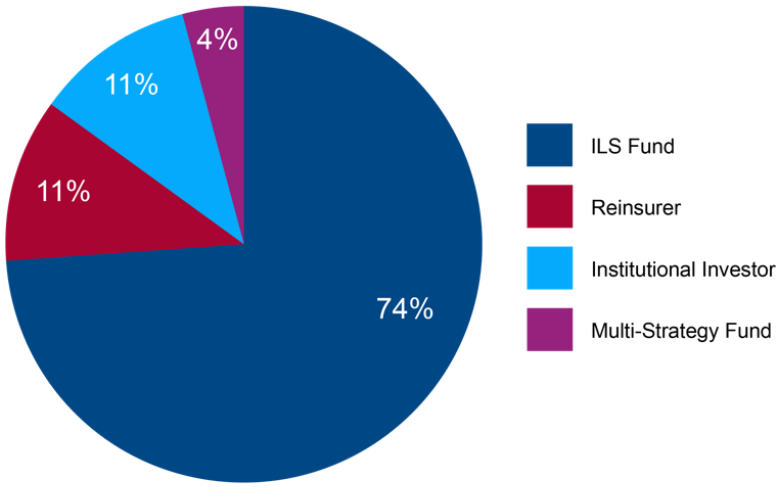
Source: Bloomberg for the S&P500 and Barclays Bond Indices. Braun, A. et al. (2021). "Common Risk Factors in the Cross Section of Catastrophe Bond Returns" (Working Paper) for the catastrophe bond index.

Alternatively, an investor may gain exposure to catastrophe bonds through open-end funds. Although the latter are sometimes grouped together with mutual funds or hedge funds in the fixed-income space, the returns from funds that hold catastrophe bonds exhibit a fairly unique behavior, characterized by low volatilities and correlations to the broader capital markets.[8]

[8] Classical factor models such as the Capital Asset Pricing Model (CAPM) or the Fama-French model, therefore, cannot explain the return variation of ILS funds. See Braun, A. et al. (2019). "Asset Pricing and Extreme Event Risk: Common Factors in ILS Fund Returns." Journal of Banking and Finance 102: 59–78.

In 2020, the investor base for catastrophe bonds was highly concentrated on dedicated ILS fund managers, which absorb almost three-quarters of the outstanding volume. These specialists typically have a long-standing experience in reinsurance risk. They are, therefore, well-equipped to compose and manage diversified catastrophe bond portfolios for other institutional investors such as pension funds. The remainder of the catastrophe bond investor base is made up of multi-strategy funds (4%), reinsurers (11%), and other institutional investors (11%).[9] This is shown in Figure 6.

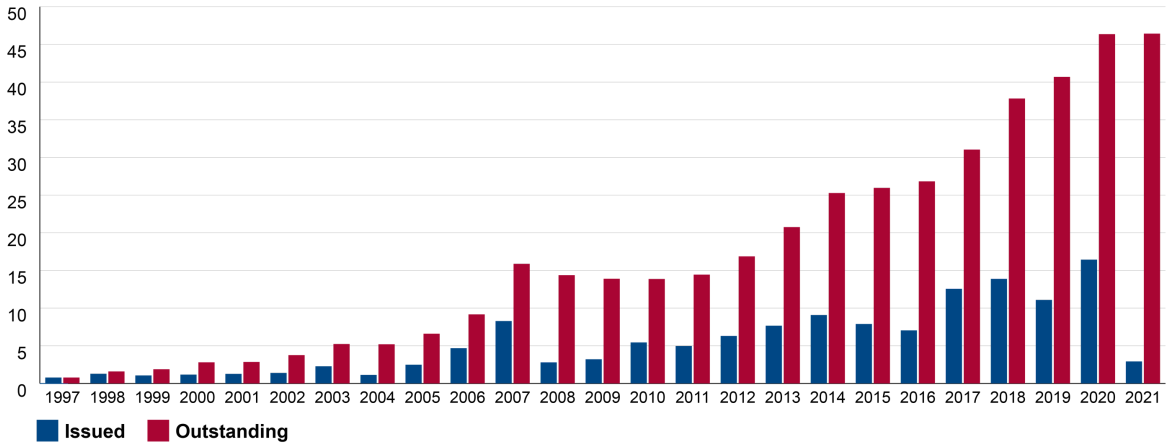
FIGURE 6. CATASTROPHE BOND INVESTORS



CURRENT MARKET SIZE AND EXEMPLARY TRANSACTIONS

The growing investor interest in catastrophe bonds is apparent when looking at new insurances by year, as shown in Figure 7. After a decline during the economic downturn in 2008, issuances began to grow again. While there was a slowdown in the market at the beginning of the COVID-19 pandemic, the market has now stabilized. The first months in 2021 have been very active and point to a potential new record year in terms of issuance volume.[10]

FIGURE 7. CATASTROPHE BOND ISSUANCE AND RISK CAPITAL OUTSTANDING (1997–2020)



Source: Artemis.bm.

[9] See AON (2020). ILS Annual Report 2020 – Alternative Capital: Growth Potential and Resilience.
[10] See Artemis.bm.

We briefly describe a few exemplary transactions that give an indication of how catastrophe bonds are being used and the wide range of possible applications.

SWISS RE'S MATTERHORN RE (SERIES 2020-5)

Matterhorn Re is a prime example of how the insurance and reinsurance industry utilizes catastrophe bonds to secure retrocessional coverage against major disaster risk exposures in their underwriting portfolios. Swiss Re started their Matterhorn Re program in summer 2019. With Matterhorn series 2020-5, launched in December 2020, Swiss Re sought at least $150 million of fully collateralized coverage against U.S. named storm losses on a per-occurrence basis. The catastrophe bond issuance comprised two tranches (Class A and Class B notes) with a two-year maturity that differed slightly in terms of covered territory. Both tranches use industry loss index triggers. Due to very strong investor demand for this catastrophe bond, Swiss Re was able to double the initial volume from $150 to $300 million.[11]

NEW YORK CITY'S MTA

After sustaining billions of costly damages to its infrastructure from Hurricane Sandy (2012), the New York City Metropolitan Transportation Authority (NYC MTA) found it difficult to acquire insurance after the storm. As a result, it looked for alternative solutions and in 2013 turned to a $200 million catastrophe bond. The MTA's captive insurance company, First Mutual Transportation Assurance Co., established a special purpose vehicle under the name MetroCat Re Ltd. to enable the MTA to issue its catastrophe bond.

The MTA designed their first catastrophe bond to specifically target potential damages to the MTA's aging infrastructure from storm surges. The MTA catastrophe bond used a parametric trigger based on the water height at selected tidal gauges chosen to have a high correlation with flooding of the New York City subway. MTA renewed their catastrophe bond in 2017 and again in 2020, adding earthquake coverage, as well.

MEXICO'S FONDEN

As a country that is highly exposed to natural disasters, Mexico has dealt with a range of storms, earthquakes, and volcanic eruptions. Since disaster insurance take-up rates in the country are low, Mexico formed FONDEN (Fondo de Desastres Naturales/Natural Disaster Fund) to help improve the financial recovery from disasters. FONDEN has worked with the World Bank, which acts as the intermediary between FONDEN and capital market investors, to issue six catastrophe bonds since 2006.

The first of these issuances marked the world's first government-sponsored catastrophe bond. The latest, issued in 2020, provides Mexico $485 million of protection against earthquakes and hurricanes for four years. It is the first hybrid catastrophe-and-sustainable development bond, structured such that the investor funds can be put towards financing sustainable development projects managed by the World Bank.[12]

[11] Information on Matterhorn Re has been obtained from the Artemis.bm Deal Directory.

[12] Read more about this in a Q and A with the World Bank team that assisted with the bond online here: https://riskcenter.wharton.upenn.edu/lab-notes/uniting-disaster-risk-transfer-with-sustainable-development/

OUTLOOK FOR THE CATASTROPHE BOND MARKET

Over the decades since catastrophe bonds emerged, they have expanded and broadened in their design and use. Several trends suggest this expansion will continue. First, there is continued focus on helping bring risk transfer solutions to underserved populations. In countries with poorly developed insurance markets, ILS and catastrophe bonds can be a part of the solution. The World Bank, in particular, has been making wider use of catastrophe bonds for developing and emerging markets. There should continue to be investor interest in a broader range of perils and geographies being brought to the market. Second, a larger variety of firms and public sector entities are exploring the use of catastrophe bonds in their risk management strategies. Finally, as countries and organizations work to achieve the United Nations Sustainable Development goals, there will be greater investments in critical infrastructure, such as water plants, energy systems, schools, and transportation networks—all of which could benefit from financial protection against increasing disaster risk.

The rapid evolution of technology and data access will also impact the catastrophe bond market. Blockchain and tokenization could lower the issuance costs of catastrophe bonds, with smart contracts automating payouts. Satellite and sensor data are both evolving and could be used in more parametric trigger designs going forward. Harnessing mobile money platforms and new apps could also facilitate the creation of micro catastrophe bonds to complement microinsurance models. In short, there should be no shortage of innovation in the catastrophe bond market in the coming years.