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Insurance-Linked Securities and Catastrophe Bonds

A Public Policy Issue Paper

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Executive Summary

The P/C Extreme Events and Property Lines Committee produced this issue paper on insurance-linked securities and catastrophe bonds to inform and educate key audiences including actuaries, insurance stakeholders, and public policy decision-makers.

Catastrophe bonds (cat bonds)[1] are a subset of insurance-linked securities (ILS), which are debt-like investment instruments providing risk coverage to insurance and reinsurance entities. ILS are principally funded by funds from investors and supplemented by the "insurance premium" paid by the entity obtaining the risk protection (cedant). The insurance or risk premium paid by the cedant works to enhance the yield on these investments.

The capital markets are significantly larger than the (re)insurance market and can more easily accommodate losses from extremely large insured events, benefiting entities seeking risk coverage. At the same time, cat bonds provide investors with potentially higher yield returns on investment generally thought to have little to no correlation with other capital markets.

Cat bonds may be utilized by both insurers and self-insureds, including governments, with the particular needs of the sponsors affecting the structure that the bonds take.

ILS instruments (excluding Mortgage ILS deals) have grown to $14 billion issued during 2021, with $36 billion outstanding. Nearly all (96%) of the $14 billion were cat bonds.

The issue paper describes and explains major components of ILS/cat bonds and concludes with an illustrative example.

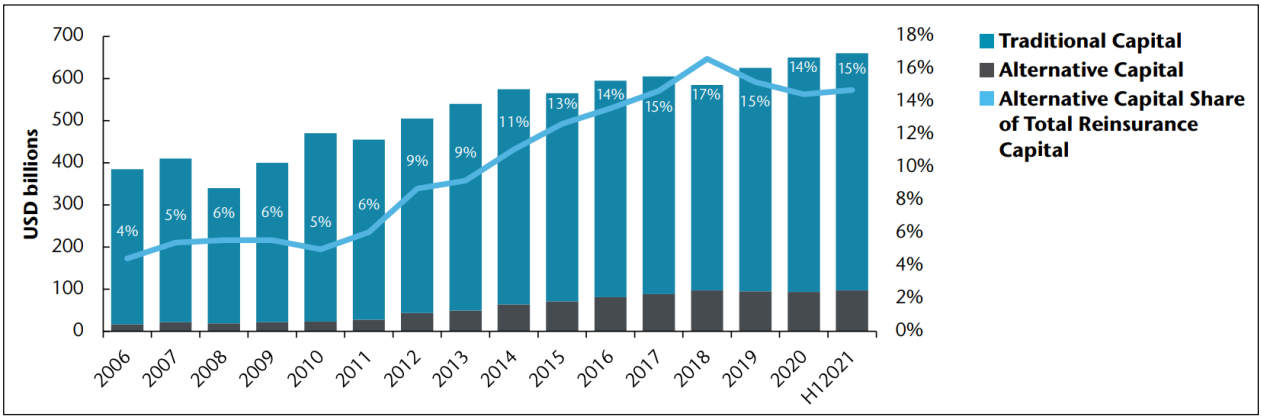
Summary

1 A cat bond is an ILS covering catastrophe risk. Other risks covered by ILS include mortality and mortgage defaults. See "Catastrophe bonds & ILS issued by type and year"; Artemis; 2022.

Introduction

The concept of reinsurance, where an insurance company will itself purchase (re)insurance for its exposures, may be familiar to many readers. "Traditional" reinsurance is the most common concept, where a cedant purchases coverage for a defined set of its exposures from a reinsurer. A growing category of risk transfer is often referred to as alternative risk transfer, meaning an alternative to the more traditional form of reinsurance. As can be seen in Figure 1, alternative capital sources are a significant source of financing.

Figure 1: Alternative Capital as a Share of Total Reinsurance Capital[2]



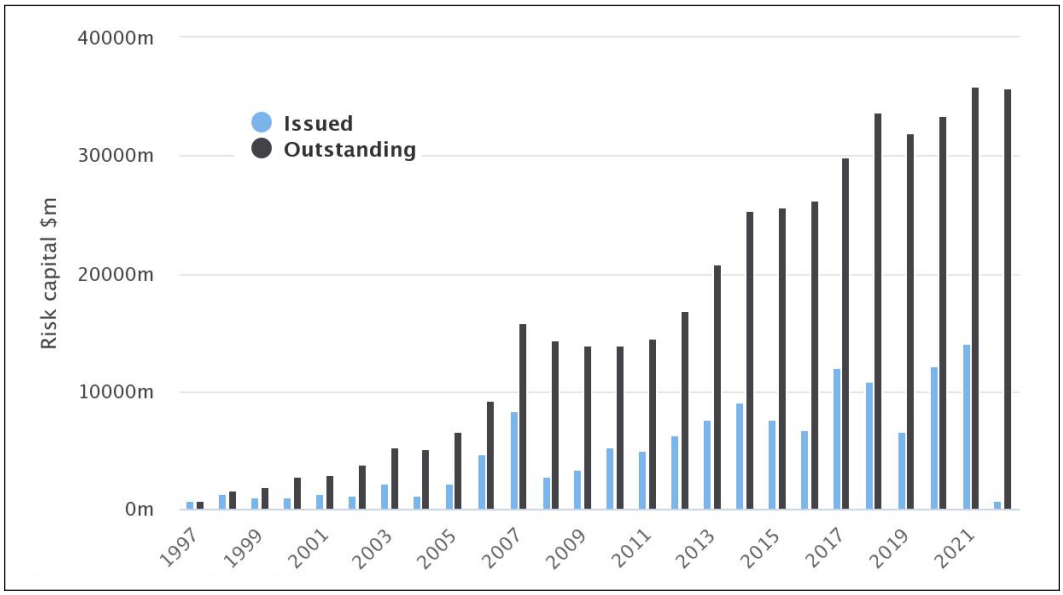
Source: Individual Company Reports, Aon Reinsurance Solutions, Aon Securities LLC

One category of alternative risk transfer is ILS, where the capital accessed for payment to the cedant comes from the capital market rather than the insurance market. With an ILS, a sponsor (the party with the risk to be transferred) arranges for a Special Purpose Vehicle (SPV) to be created as an intermediary between beyond the sponsor and the capital markets. That SPV acts as a reinsurer[3] from the perspective of the sponsor, and as a bond issuer from the perspective of the capital markets. The SPV collects the premium from the sponsor and issues bonds to the capital markets. The SPV uses revenue from the bond sales plus the premium collection to earn investment income. If no triggering event occurs the SPV uses the collected funds plus investment income to pay interest and repay the principle on the issued bonds. If a triggering event occurs the SPV instead uses those funds to pay the sponsor's insurance claim, resulting in a default of the issued bonds.

2 Aon ILS Annual Report 2021—Alternative: Continuing Growth Momentum.
3 Or as an insurer where the sponsor is a self-insured. Self-insurers may also be involved in obtaining risk protection from ILS. See "Owner of Tokyo Disneyland Sells Quake Bonds"; *Los Angeles Times;* May 19, 1999; whereby the owner of Tokyo Disneyland arranged for catastrophe bond protection, a form of ILS.

ILS growth is shown in Figure 2, with $14 billion issued in 2021 for a total of $36 billion in insurance coverage ("outstanding") in that year.[4]

Figure 2: Cat Bond and ILS Risk Capital Growth (Excluding Mortgage ILS)

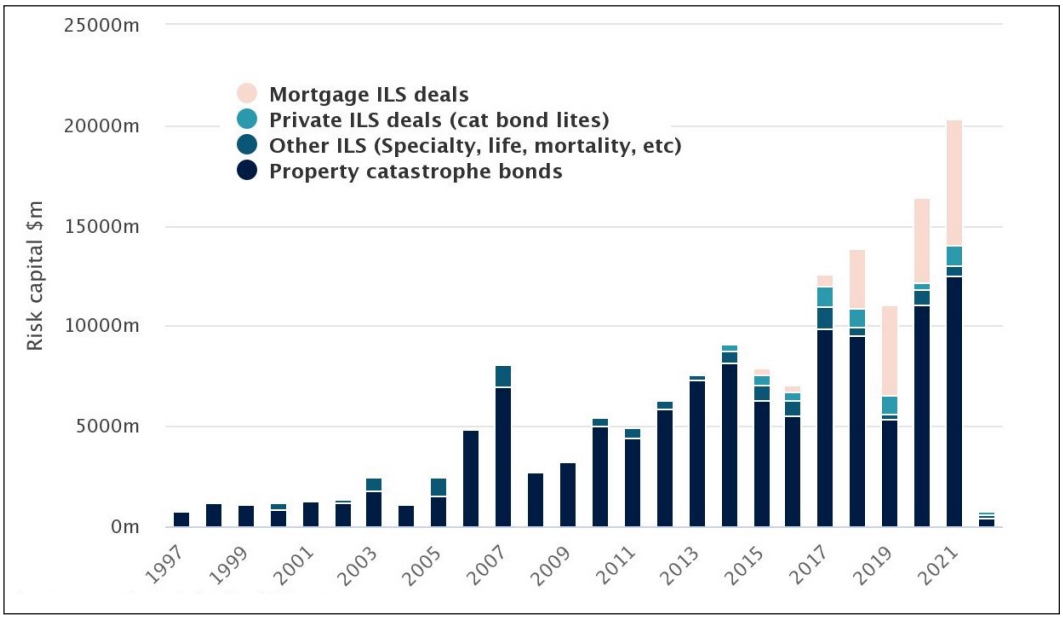


Source: www.Artemis.bm Deal Directory

A subset of ILS is cat bonds, which are arrangements covering insured financial loss from catastrophic events such as hurricanes or earthquakes. As shown in Figure 3, property cat bonds are the most prevalent ILS instrument, with $13.5 billion[5] of the $14 billion ILS issued in 2021.

4 As cat bonds and other ILS instruments are typically multiyear, the total coverage ("outstanding") in a year comes from bonds issued in multiple years.
5 Including both cat bonds and "cat bond lite." "Traditional" cat bonds amount to $12.5 billion of the $13.5 billion total shown here. See definition of "cat bond lite" at www.irmi.com/term/insurance-definitions/cat-bond-lite https://www.artemis.bm/dashboard/catastrophe-bonds-ils-issued-by-type-and-year/.

Figure 3: ILS and Cat Bonds by Type



Source: www.Artemis.bm Deal Directory

While this issue paper focuses on cat bonds, many of its concepts and practices also apply to other forms of ILS. Cat bonds have been primarily used in property lines of insurance but are also used in other lines of business.

ILS represent a convergence of the insurance industry and capital markets. As mentioned above, they are securities whose performance is linked to the possible occurrence of pre-specified events that relate to insurance risks. While usage can vary across the world, much of the paper's discussion will be from the perspective of a private (re)insurer in a developed country where the reinsurance market is well-established.

By using ILS, a ceding company can transfer its risk to capital market investors for risks that may be beyond the capacity that traditional insurers could provide.[6] Governments can also use these to obtain a quick inflow of needed cash given a catastrophic event.[7] Investors can have access to a source of higher-yield fixed income securities with little correlation to other financial markets. Note that ILS transactions do not normally replace other reinsurance arrangements but are used as an additional source of capital for catastrophic events.

6 The largest insurers may have a need for tail risk protection that is beyond the capital capacity of the reinsurance market. That is not a problem for the overall financial markets, as a risk that is a material portion of the global reinsurance market's equity is a much smaller part of the overall financial market capacity. Similarly, the reinsurance market may only be able to provide reinsurance protection for a portion of the catastrophe exposure in a certain part of the world (e.g., Florida hurricane exposure). The total exposure may be excessive when compared to the equity of the global reinsurance market, but not when compared to the global capital markets.
7 Governmental entities can find themselves in need of cash after a major disaster, both due to larger expenses (e.g., infrastructure repair, debris cleanup, overtime for government emergency workers) and lower tax revenues (e.g., devastation to the local economy).

History

Concepts related to insurance-linked securities, particularly cat bonds, existed long before any actual execution of the instruments.

> "*There is some debate about when the Insurance-Linked Securities (ILS) market (a.k.a. Cat Bond market) began. Was it June 1992 with the AIG-sponsored property-cat bond concept promoted by Merrill Lynch? Was it the end of 1992 when the CBOT launched its since-aborted ISO contract? Or was it in 1995-96 with the first successful issuance of an AIG-fronted PXRE property-cat portfolio deal with additional small but successful portfolio deals from Georgetown Re and Reliance National? Perhaps it was later in 1996 when USAA closed the first $500 million single-risk deal.*"[8]

Growth of the ILS market was limited in the early years due to several factors:

- Lack of sophisticated knowledge of both issuers of and investors in these risk transfer instruments.
- Relative immaturity of catastrophe models, which are the basis for the pricing of many cat bonds.
- Length of time to take a deal to market.
- High transactional costs. (ILS are generally structured as multiyear rather than one-year deals so as to minimize the impact of these high costs.)

In 2011, the ILS market began to attract new and nontraditional issuers, such as publicly owned service providers and utilities. Many of these issuers are at least partially self-insured and see ILS as a beneficial addition to their risk management programs. Table 1 provides a few selected transactions.

8 "Trends in the Insurance-Linked Securities Market"; *Lane Financial Trade Notes* newsletter; May 31, 2000.

Table 1: New and Nontraditional Issuers

Year	Issuer	Sponsor	Size	Perils
2011 (August)	Embarcadero Re Ltd.	California Earthquake Authority (CEA)[9]	USD 150M	California earthquake
2011 (August)	Pylon II Capital Ltd.	Electricite De France (EDF) Energy company[10]	EUR 150M	European windstorm
2013 (July)	MetroCat Re Ltd.	New York City Metropolitan Authority[11]	USD 200M	Storm Surge

ILS react to large tail risk events that might create stress for more traditional reinsurance while being less of a stress to the overall capital markets, resulting in more stability than traditional reinsurance in reaction to such events.

As can be seen in Figure 2, following Hurricane Katrina in 2005 there was an increase in ILS/cat bond issuance. This changed abruptly after the 2008 collapse of Lehman Brothers. Investors were concerned that the underlying collateral structures of cat bonds posed too much risk. The collateral up until that time was often structured as total return swaps, with investment banks (such as Lehman Brothers[12]) often being the guarantor. With these arrangements, cat bond investors were exposed to both insurance risk and investment risk. Once more secure underlying collateral structures were developed (currently low-risk stable vehicles such as Treasury money market funds are used), the growth picked up again. Adding to the attractiveness of the instruments were several years of low interest rates following the financial crisis of 2008. Investors were attracted to cat bonds given relatively higher yields of ILS instruments.

ILS and traditional reinsurance markets both increase the supply of capital available to the insurance industry. In the past 20 years, ILS have increased in popularity and had a major influence on market price, terms, and conditions. For example, with cat bonds being multi-year agreements[13], we have seen traditional reinsurance adapt to stay competitive, and many traditional reinsurers have started to offer multi-year capacity for insurers who prefer the stability. During the soft market in the latter half of the 2010s, there was a rise in popularity of aggregate protection from cat bonds and traditional reinsurance as they both cater to insurer or sponsor needs.

9 "A Comprehensive Overview of the Insurance-Linked Securities Market"; NAIC Capital Markets Special Report; NAIC; March 4, 2012.
10 Ibid.
11 "Background on: Captives and other risk-financing options"; Insurance Information Institute; June 20, 2019.
12 Lehman Brothers was the guarantor of total return swaps for four cat bonds at the time of their collapse. See https://www.artemis.bm/news/lehman-brothers-related-cat-bonds-downgraded-by-sp.
13 As mentioned earlier, this is done so as to minimize the per-year high transaction costs associated with their establishment.

Catastrophe Reinsurance Basics

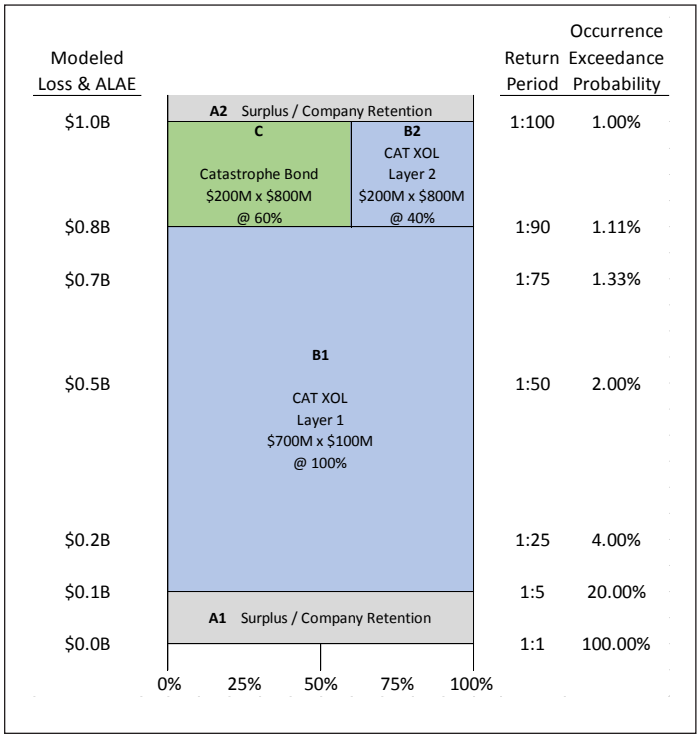
Reinsurance is a form of an insurance coverage for insurance companies whereby the reinsurer assumes risk from an insurer (cedant) in exchange for a premium amount. Primary insurers use reinsurance to write more business, achieve earnings stability, and protect themselves from excessive loss. Most insurance companies establish a set strategy regarding the types of reinsurance protection purchased, with part of that strategy being the structure of their catastrophe reinsurance protection.

Catastrophe reinsurance is focused on catastrophic events affecting multiple policyholders or structures at the same time. The coverage is based on aggregate losses from the event, rather than the loss from a particular policy or building (in the case of a self-insured). The coverage is also typically on an excess of loss (XOL) basis rather than covering the first dollar of loss from the event. These reinsurance contracts can be structured to cover a wide variety of causes of loss (perils), amounts, layers, and other necessary items. Layers are used to define the range of losses that will be considered under the reinsurance contract. Common perils covered by catastrophe reinsurance programs include hurricanes and earthquakes.

Figure 4 in the example below[14] provides an example of how an insurer's catastrophe reinsurance protection might be structured. The structure shown has four layers of aggregate losses: Rectangle A1, Rectangle B1, Rectangles C (the piece covered by a cat bond) and B2, and Rectangle A2. The upper and lower bounds of the rectangle are defined by amounts of loss. The lower bounds of rectangles show the attachment point—e.g., the amount where that particular reinsurance contract would start paying—and the upper bounds show where that contract would exhaust. Reinsurance can be on an occurrence (one event) or aggregate (all events in a time period, usually a year) basis. Many catastrophe reinsurance contracts (especially those on an occurrence basis) have reinstatement terms, whereby the contract can be reinstated for a specified amount if the contract limit is fully used during the coverage term.

14 This example is also repeated later in this report as Figure 9.

Figure 4: CHIC XOL Reinsurance Tower



Insurers generally base their decisions of how much catastrophe reinsurance to purchase on a combination of quantitative analysis and preference. Ceding company philosophies vary with regard to how much risk and what kind of risk to retain. Insurers typically factor in expected loss and variability in each layer, past experience, and market and economic cycles (affecting both risk tolerances and the price of the reinsurance).

The availability of traditional reinsurance and its cost are influenced by global financial and economic conditions, reinsurers' preferences for certain layers, perils, and geographic regions. In addition, reinsurers also seek a diversified portfolio of risks.

The above is focused on the insurance industry and their catastrophe reinsurance portfolios. Governmental entities may choose instead to self-insure catastrophe losses, along with reliance (for state and local governments) on disaster-relief funds from higher levels of government. In addition, while some may purchase traditional reinsurance for certain real property such as buildings, governments may face the cost of debris cleanup that is generally less amenable to insurance coverage.[15]

15 "How States Pay for Natural Disasters in an Era of Rising Costs"; Pew Charitable Trusts; May 12, 2020.

Comparing Cat Bonds and Traditional Catastrophe Excess of Loss

Catastrophe excess of loss (XOL) reinsurance tends to differ from cat bond reinsurance in several different ways, including the layers of loss typically covered, the way it is priced, and coverage terms.

Layers Covered

Cat XOL treaties and cat bonds are used in the upper layers, while the lower layers are generally covered only by cat XOL treaties. Figure 4 above illustrates this concept. Areas B1 and B2 are covered by one or more cat XOL treaties, and Area C is a cat bond, which could pay for 60% of loss and allocated loss adjustment expense (ALAE) greater than $8 million up to $1 billion, while 40% of this layer would be considered for reimbursement under the B2 cat XOL treaty.

Pricing

Catastrophe reinsurance pricing is subject to reinsurance market influences, availability, exposure characteristics and several other factors. Quantitative information for pricing historically had been based upon many years of past data (in recognition of the infrequent nature of catastrophes), but for several years now this has been supplemented and/or replaced by the use of cat models, especially for the higher layers of coverage. The use of catastrophe models has increased significantly over time and has expanded to many more perils. Initially, the only catastrophe models that existed were for hurricanes or earthquakes. Catastrophe models have now been built for most major catastrophe perils, including severe storms, floods, and wildfires.

Cat bond pricing is subject to the same influences mentioned earlier for catastrophe reinsurance, but with a few critical differences. These include credit spreads in the non-investment-grade portion of the bond market and the overall expense required to establish a cat bond.

The bond is generally structured to mirror the default probabilities of high-yield debt (e.g., BB rated bonds). For example, if a bond with a certain rating had a default probability of 4%, then the cat bond would be set up such that the triggering event has a 4% probability of default. If the credit spread of such bonds were currently 100 basis points over risk-free, then the reinsurance premium for the cat bond protection would be set at the same level (i.e., 100 basis points or 1% of the amount insured), assuming that the collateral was invested in risk-free government bonds. The calculation of the default probability generally requires the use of a cat model for the covered peril.

As noted previously, the transaction costs associated with setting up the cat bond (including the SPV, filing requirements for issuing the cat bonds, performing the model runs, presentations, and issuing the prospectus) can be expensive. To mitigate the impact of these expenses, cat bonds are normally set up to cover multiyear periods, thus reducing their per-year cost.

Coverage and Terms of Coverage

As noted above, cat bonds are typically multiyear agreements due to expense considerations, while most traditional reinsurance treaties are placed annually. Traditional cat XOL reinsurance also typically offers one reinstatement, where if the layer limit is exhausted by an event, it will be automatically reinstated to protect the insurer against future events in the contract year. Cedants would typically pay a reinstatement premium proportional to the amount of limit exhausted and the time remaining in the contract. This feature was useful in years such as 2004 and 2005 when multiple hurricanes made landfall on the coast of the U.S.

Cat bonds usually offer single shot protection, or no reinstatements. Cat bonds' multiyear coverage can extend known coverage at a known price. At the end of each risk period or year, cedants might be required to reset the parameters of the deal within certain ranges, depending upon the contract provisions.[16] However, this is not the same protection as offered by reinstatements as it does not address the risk of multiple events during the coverage period.

16 For example, this may be required in order to maintain the same estimated probability of "default" for the bond. If the cedant's book of business subject to the cat bond is growing over time, then the attachment point would need to be increase each year to maintain the same default probability.

As mentioned earlier, cat bonds and cat XOL treaties are typically placed at relatively high layers to cover less-frequent, higher-severity events. In addition, cat bonds may not be appropriate for lower layers due to the lack of reinstatement protection combined with the fact that lower layers have a higher probability of being exhausted than higher layers. The focus of cat bonds on the far tail risk is also consistent with the lack of reinstatements, as the probability of two far tail events in the same period is highly unlikely.

Cat Bond Triggers

While traditional reinsurance pays claims on indemnity basis, cat bonds may use different payout triggers. The sponsor of a cat bond chooses how recoveries from the principal will be triggered when setting up the cat bond offering. Sponsors select triggers based on many factors, including basis risk (the payout might not fully cover the losses incurred or could pay more than the actual loss), transparency (so the investor can assess the risks assumed), length of time between an event and the claim settlement, and accounting implications. Most cat bonds can be categorized into one of four trigger types: indemnity, industry loss index, modeled loss, or parametric. Each type has its pros and cons. Hybrids of the above are also possible (e.g., dual indemnity and parametric triggers).

Indemnity triggers

The sponsor's actual losses trigger the bond[17], so the sponsor is indemnified as if they had purchased traditional catastrophe reinsurance. As shown in the earlier example (Figure 4), the layer specified in the cat bond is $200 million excess of $800 million, so if the total loss and ALAE is more than $800 million, the bond is triggered. Indemnity triggers have the least amount of basis risk for the sponsor because there is perfect alignment between sponsors' losses and recoveries.

One side effect of an indemnity trigger is a required public disclosure of the sponsor's catastrophe losses, which might not otherwise be made public.[18] Despite the disclosure of a sponsor's losses, indemnity triggers have the least transparency for investors. Because payouts depend on sponsor losses, investors (or at least a lead investor[19]) need a good understanding of the sponsor's underwriting, operations, and claims handling in order

17 i.e., triggers the payout to the sponsor and a default to the bond buyer.
18 This can be avoided by placing the cat bond in the private market rather than having the bonds be part of a public placement. Regardless, public disclosure of an insurer's losses due to a catastrophe has become much more common for publicly held companies, whether or not a cat bond is involved.
19 Not all the investors need to have this understanding, as they may rely on the expertise of a lead investor.

to properly value the cat bond investment . Because these details vary among cedants, comparing cat bonds issued by different sponsors can be difficult and time-consuming. Indemnity triggers rely on claim verification, which can also be time-consuming.

Compared to other triggers, indemnity triggers usually require the longest time to settle the payout, which is a drawback for both sponsors and investors. As a result, cat bonds with indemnity triggers typically have mandated commutation provisions. These commutation provisions are necessary for cat bonds to be attractive to bond investors[20]. These mandated commutations take place at the end of the final risk period if covered events have occurred, even if open claims and reserves remain from the triggering event. As a result, adverse loss development beyond the extension may not be recoverable for the cedant.

Indemnity triggers allow the sponsor to use insurance accounting to account for both the premium payment and contingent loss recovery[21]. Otherwise, the cedant would have to use derivative accounting for the transaction.

Indemnity triggers are the most commonly used trigger type by insurer sponsors because of their low basis risk, favorable accounting treatment, and growing acceptance by investors as their understanding has increased over the years.

Industry Loss Index triggers

The cat bond is triggered when the insurance industry loss from a covered event reaches a specified threshold, for example $25 billion. The cat bond will specify the source of the industry loss estimate or amount. In the U.S., the use of a recognized agency like Property Claim Services (PCS) is common. Modified index-linked securities customize the index to a company's own book of business. Unlike indemnity triggers, industry loss index triggers do not require sponsors to disclose any information about their portfolios. On the other hand, sponsors carry more basis risk because there are potential disconnects between their own portfolio's incurred losses and the industry loss. Industry Loss Index triggers are most commonly used by reinsurer sponsors who are more likely to accept the basis risk (although the use of such a trigger requires the cedant to use derivative accounting for the transaction and not reinsurance accounting). Because reinsurers' portfolios are typically quite diversified, they are not as likely to have pockets of exposure concentrations where their own incurred losses are disproportional to their industry market share.

20 This is because bonds as an investment class have a well-defined maturity date. Without a commutation clause, a cat bond would not have a well-defined maturity date, unlike the rest of the investment class.
21 This is true for U.S. GAAP and statutory accounting statements, as well as for IFRS accounting statements.

Modeled Loss

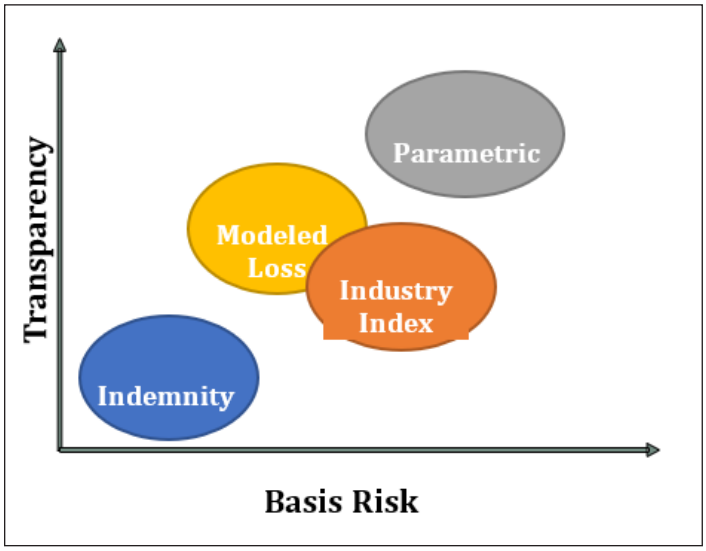
The sponsor constructs an exposure portfolio for use with specified catastrophe modeling software, and when there is a catastrophe event, the event parameters are run against the exposure database in the cat model. If the modeled losses are above a specified threshold, the cat bond is triggered. Modeled losses may not perfectly align with incurred losses, so the basis risk for sponsors is higher than for indemnity triggers. Modeled loss triggers have the advantage of not being dependent on claims settlement, thus reducing the time needed to determine recoveries. While transparency for investors is contingent upon understanding of the cat model, investors can at least avoid having to rely on loss information that is privy only to the sponsor.

Parametric

The trigger uses specified parameter(s) of a natural hazard, for example, windspeed for hurricane or magnitude for earthquake. Data for this parameter are often collected at multiple reporting stations as inputs into an index formula. If the result exceeds a predefined threshold in a predefined geographical region, then the cat bond is triggered. Many sponsors are uncomfortable with pure parametric bonds due to potentially low correlation with actual loss. Among the four types of triggers, parametric triggers generate the most basis risk for sponsors. To mitigate the basis risk of pure parametric covers, sponsors can use models to obtain an approximation of loss as a function of the speed at differing locations, which then can be used to determine a payout function for the bond. These functions are hybrid parametric and modeled loss bonds and can still offer sufficient transparency for investors. Key advantages of parametric triggers are transparency and shorter payout settlement after an event.

Parametric triggers are most commonly used by the public sector (e.g., government entities). Government entities may find this type of trigger the easiest to understand because they are not direct players in the insurance industry and are not likely to be as familiar with the detailed insurance exposures and losses involved. Unlike private companies, government entities are not bound by accounting rules that may cause parametric triggers to be less favorable. They also may prefer this kind of trigger over the other options as they have the least access to relevant modeling of their losses. Government entity losses include many items not typically included in vendor catastrophe models as many of their disaster-related costs are not related to damaged buildings. Examples of such costs not included in vendor catastrophe models include infrastructure repair costs, increased payroll costs (e.g., overtime costs from police, fire, public works, and building inspector employees), and reduced tax revenue due to reduced economic activity immediately after the event.

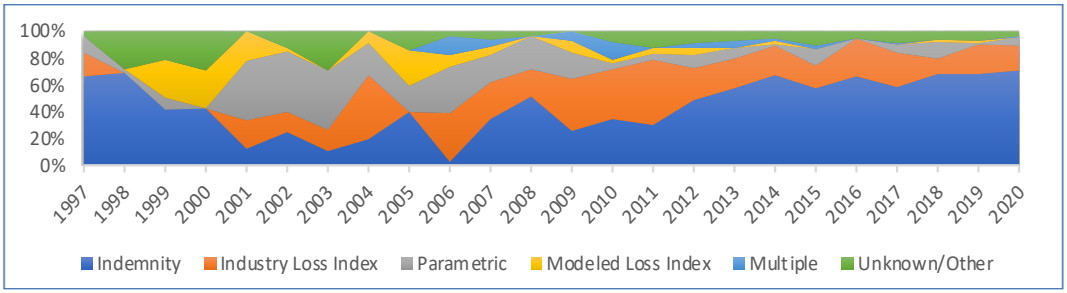
Figure 5: Trigger Types Basis Risk and Transparency



Source: Risk Management Solutions

In the early 2000s, parametric and industry loss indexes were popular because they were easier to understand by investors who did not at that time have as much familiarity with insurance and catastrophe modeling. As ILS and cat bonds' popularity grew over the past two decades, indemnity triggers became more widely accepted and are now the most common type of trigger.[22] Triggers can be on a per occurrence or aggregate basis. A decade ago, the majority of cat bonds were on a per occurrence basis, but the market has shifted toward aggregate triggers. The relative popularity of trigger types is shown in Figure 6.

Figure 6: Types of Triggers Over Time



Source: www.Artemis.bm

22 "Catastrophe bonds and ILS issuance by trigger and by year"; Artemis.

Sponsor Perspective

There are two facets of cat bonds that dictate the sponsor's perspective. The first is the structure of cat bonds whereby they mimic the default rates of corporate bonds (typically high-yield corporate bonds). That restricts the risk protection from cat bonds to the tail of the distribution and away from working layers[23] of coverage. The second is the high transaction cost. The cost factor restricts the use of cat bonds to large amounts of coverage, and generally to multiyear agreements. Therefore, a sponsor is more likely to investigate the use of cat bonds for coverage of tail risks (e.g., 1-in-50- to 1-in-100-year events) and where the limits of protection needed are relatively large. For example, the average cat bond limit for bonds issued in 2020 was over $230 million, with a range of limits from $50 million for the smallest to $775 million for the largest.[24] Sponsors also consider the potential greater stability of the pricing for tail risks via the cat bond markets as opposed to traditional reinsurance markets. Typically, cat bond prices respond more to financial market trends, whereas traditional reinsurance prices respond more to recent catastrophe activity. Events that are likely to drive up the cost of traditional reinsurance may not impact the cost of cat bonds. For example, after hurricanes Harvey, Irma, and Maria in 2017, traditional reinsurers quoted significant price increases, whereas cat bond issuance prices were less reactive because the broader capital market was stable. In contrast, in 2019–2020, the broader capital market drove up the price of cat bonds. While cat bond pricing was lower than traditional reinsurance in prior years, there was a reversal of this pricing relationship between cat bonds and traditional reinsurance in 2020.

The relative cost of cat bonds versus traditional reinsurance is another consideration for potential cat bond sponsors. This relative cost can vary over time, but in general the cost of cat bond protection has come down over time as capital markets have become more familiar with the concept, catastrophe models have matured and expanded to additional perils, and as the concept has been tested by observed cat bond defaults.

The high of cost of setting up an SPV for a cat bond could be a barrier to entry for a first-time sponsor. Among other things, the process involves many third-party service providers. In addition, cat bonds require a copious amount of documentation and potential disclosure of company-specific information.[25] On the other hand, most sponsors already have familiarity with the placement of traditional reinsurance, and the process is shorter and less complex. Traditional reinsurance placement can be handled through a reinsurance broker,

23 IRMI defines "working layer" as "a dollar range in which an insured or, in the case of an insurer's book of business, a group of insureds is expected to experience a fairly high level of loss frequency."
24 Based on data on cat bonds found on Artemis' website.
25 "First time sponsors discuss catastrophe bond pros and cons"; Artemis; Sept. 16, 2014.

and brokerage fees are typically netted from the reinsurance premium. Because relationships with reinsurers tend to be long term, the communications and processes involved in traditional reinsurance are more likely already in place and have been tested.

From a governmental entity perspective, cat bonds can potentially provide a cash infusion when needed the most. They also allow implicit reimbursement for costs that might not be amenable to insurance and may not be easily modeled (e.g., lost tax revenue, higher employee costs).

The coverage terms in a typical cat bond versus traditional reinsurance can differ, as discussed above, which can affect a sponsor's decision regarding sponsoring a cat bond. First, most traditional reinsurance is offered on an annual basis, allowing for regular customization of the coverage, while cat bonds are often issued over multiple years, so the coverage and price are locked in during that time period. The lack of reinstatements can also affect a sponsor's view of cat bonds, although the focus on tail events that are unlikely to have multiple occurrences in the same year mitigates this to some extent. However, sponsors can mitigate this risk of multiple tail events in the same year by setting cat bond triggers on an aggregate basis.

Finally, cat bonds have an advantage over most traditional reinsurance with regard to credit risk. Counterparty credit risk exists for traditional reinsurance and varies based on the strength of the reinsurer. Even for the most highly rated traditional reinsurer, there is still some amount of credit risk. Cat bonds have minimal to no credit risk because they are 100% collateralized.

In summary, from the sponsor perspective, cat bonds provide price stability over multiyear periods, which may be especially desirable during a hard reinsurance market. They also provide coverage for layers and amounts that may not be available or fully available from the traditional market, and with minimal credit risk. Offsetting these benefits, the upfront costs can be expensive, terms are generally locked-in for the full period (making it difficult or impossible to adjust mid-term), and basis risk can exist depending on the selected trigger(s).

Investor Perspective

Cat bonds are investment vehicles. ILS investors include asset managers, hedge funds, pension funds, mutual funds, banks, (re)insurers, endowments, and other sophisticated entities seeking diversification and potentially high returns. This issue paper's introduction illustrates the continued growth of invested capital in these instruments. Important factors supporting that growth include innovation of ILS products and investors' growing sophistication with respect to insurance.

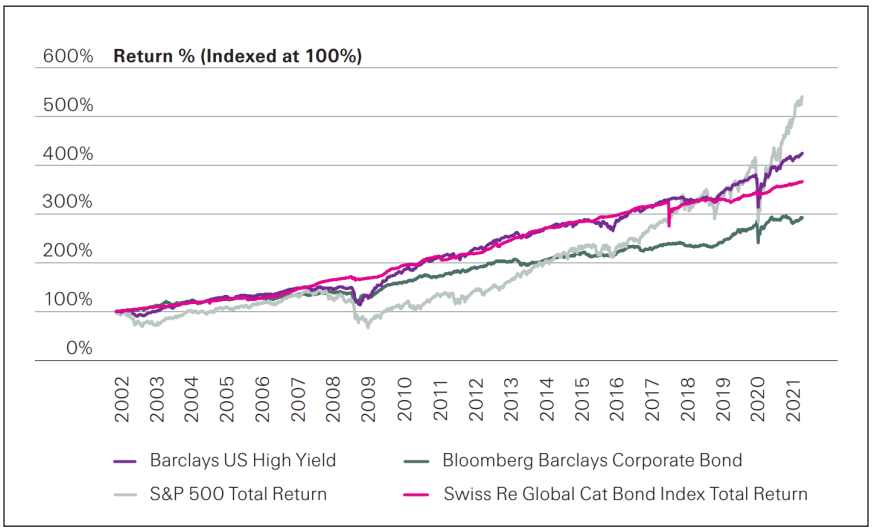
Evaluation of cat bonds by investors is similar in many ways to reinsurance underwriting. For example, cat bond risk analysis could involve assessing sponsors' operations and exposure portfolios, or judging whether modeling results are conservative or aggressive, and then using the analysis to determine an appropriate price for the cat bond. Investors[26] may also compare the return of cat bonds to returns from other fixed income (i.e., bond) investments, or the price of cat bonds to corresponding traditional reinsurance layers to evaluate the risk-return trade-off.

Cat bonds are a source of diversification for investors. Historically, cat bonds have shown less volatility and lower correlation with the general capital market than other asset classes. As demonstrated in Figure 7 below, the S&P 500 Total Return and Barclays US High Yield Total Return indices were significantly impacted by the financial crisis of 2008–2009, while the Swiss Re Global Cat Bond Index Total Return (which consists of price and coupon components) was much less affected. Catastrophe events are usually regionalized and do not have as much correlation with the global financial market as do non-insurance events. Despite Hurricane Ike in 2008, U.S. tornados and the Japan earthquake in 2011, and Hurricane Sandy in 2012, the overall cat bond returns remained stable.

For much of the past decade, cat bonds generated higher returns than similarly risky fixed income assets. Overall, investors earned sizable returns from investing in cat bonds as there were not many disruptive events. Until early 2017, the Swiss Re Global Cat Bond Total Return index outperformed the S&P 500 Total Return and Barclays High Yield Corporate Bond Total Return index. In the first half of 2017, the coupon returns decreased, reflecting the attractive pricing that sponsors were able to achieve with new cat bond issuances. Price return was the bigger driver of the index performance due to back-to-back years of cat activity. In Q3 2017, the market reacted to hurricanes Harvey, Irma, and Maria, and in 2018, returns were positive until Q4 due to hurricanes Florence and Michael.[27]

26 Note that this may not be true of all investors, as some may rely on a few lead investors for a particular cat bond.
27 Swiss Re ILS Market Updates, 2018-2019.

Figure 7: Swiss Re Global Cat Bond Total Return Index vs. Other Relative Benchmarks



Source: Swiss Re Capital Markets and Bloomberg LP, as of June 30, 2021.

As mentioned earlier in this issue paper, current cat bond collateral structures usually involve investing in stable, conservative, short-term instruments, such as Treasury money market funds. As a result, financial market risk has been virtually eliminated and cat bonds have become safer investments, leading to a broader pool of investors.

Cat bond investors also have the ability to diversify their exposure to catastrophe risks by peril and geography. For example, rather than investing in cat bonds with only Florida hurricane triggers, they can achieve greater catastrophe risk diversification by also investing in cat bonds with earthquake triggers or with Pacific typhoon triggers.

Actuarial Expertise

Actuaries perform the same roles for a sponsor (cedant considering or purchasing an ILS) as for traditional reinsurance. If both instruments are used, it is critical for them to be coordinated to provide the best protection. There are also functions that require accredited actuarial participation and signatures, and many where the expertise is not required but adds value.

Investors are focused on the capital market, and may have little knowledge of the (re) insurance market. Actuarial oversight and participation can augment the knowledge and skills of those capital market experts.

Additionally, actuaries can contribute to estimating ultimate loss and ALAE for commutations, catastrophe modeling analyses, and selection and pricing considerations and decisions. It is critically important to understand the role of experts in the various fields involved and to understand the data and assumptions used by each of them.

Appendices

Appendix 1: Catastrophe Modeling

Catastrophe model results are used in ILS, including cat bonds, as well as in traditional reinsurance and primary insurance. The details of catastrophe models are documented elsewhere. A basic overview (*Uses of Catastrophe Model Output, July 2018) can be found on the American Academy of Actuaries' website*.

For this issue paper, there are two areas of catastrophe models of focus—the exposure input and the financial module.

The sponsor's exposure input data, which contains information about insured property, is most often controlled by the sponsor, either directly or through a broker or other third party. Industry or aggregate input is available from the entities that collect or control that data, with such data possibly embedded in the models themselves (rather than requiring separate input). Cedant/sponsor data tends to be more detailed than industry data and contain some important characteristics. For example, the cedant/sponsor data may be available at a very granular geographic level and may have a detailed range of building and occupancy characteristics and coverage terms. Industry or aggregate data currently is often not available at any geographic level below postal code or county level. Building and contents information may be limited to a few major categories. This is partially due to the lack of consistency from sponsor to sponsor (which creates aggregation difficulties), and because the usefulness of such data tends to decrease with as the variety of sources increases (for example, if some sponsors have three categories of high-rise height and some have five that do not map to the three, it might be better to not collect the number of stories at all.)

The financial modules of catastrophe models are also useful. This is where the coverage terms in the contract are quantified. Various coverage terms being considered or included in the contract can be modeled and both the results and changes in results from one scenario to another can be reviewed and analyzed. These terms can include items such as attachment and exhaustion points, occurrence vs aggregate coverages, reinstatement and reset information, consideration of demand surge, secondary perils (such as fire following earthquake and/or sprinkler damage), inuring order, and many others. Inclusion of exclusion of identified groups of exposures can also be analyzed, both for the groups themselves and their potential impact on a portfolio. Note that similar to the exposure data, coverage data at an industry level may be quite general, with detailed information on coverage terms not directly available.

For each model analysis, there are a few key metrics used in ILS analysis. These are:

Probabilities (sometimes stated as Return Periods)

- *The attachment probability*, which is the probability that the cat bond will experience some losses during a given period, typically one year. In our example, this probability is 1.11%, the probability that the sponsor's losses exceed $800 million from an event covered by the cat bond.[28]
- *The exhaustion probability*, which is the probability that the cat bond will experience a total loss during a given period, typically one year. In this example, there is a 1%, or 100-year Return Period chance that the sponsor's losses exceed $1 billion ($200 million excess of $800 million) from an event covered by the cat bond.

Average Annual Loss (AAL)

- *Expected annual loss*. The expected annual loss is determined by weighting all the expected annual losses by the probability of those losses for all return periods. AALs are produced for the totality of the exposure and for each layer of interest. Unsurprisingly, AALs tend to decrease as the layer probabilities decrease. In Figure 10 in the example in the appendix, upper layers have smaller AALs, when expressed as loss per $1,000 of coverage. Model output does not include any loss adjustment costs.

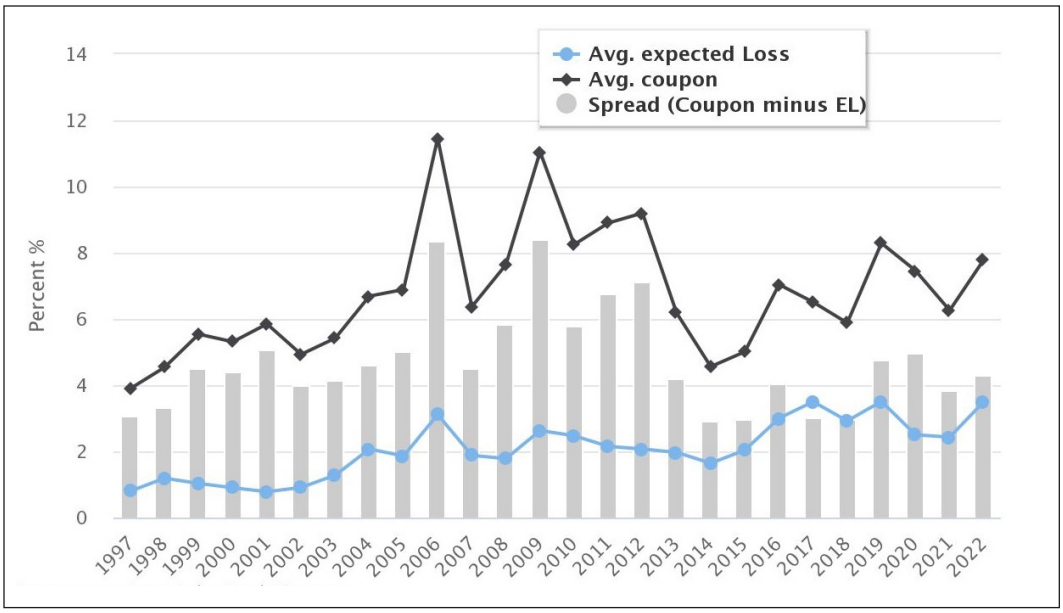
Variability or Uncertainty

- Catastrophe models were created to assist in planning for the financial cost of extreme events as well as to management total concentration exposure. Extreme events are typically both infrequent and severe. While vast amounts of data have been collected, analyzed, and used in the development of these models, these data are limited in how well they represent real-world phenomena. Model results contain uncertainty, or variability, and the more that is known, the more robust the planning can be. Sources of uncertainty as well as various measures are examined. These are represented by calculated measures, which can be reviewed by layer. As the events become more costly, and less frequent, the uncertainty increases since there are fewer actual events available for analysis. The various measures of uncertainty (and other metrics) and how they are used in cat bonds are beyond the scope of this paper

Figure 9 shows coupon, (modeled) expected loss, and spread, illustrating the price of uncertainty for ILS issues.

28 In catastrophe models, probabilities are often expressed in Return Period (years.) This labeling convention developed from the belief that describing events as a "1-in-a-100-year event" would be easier to understand than statistical terms like probability. The probability and the Return Period years can be calculated from each other. The attachment probability of 1.11% can also be expressed as a 1 in 90-year chance. (1/90 = 0.0111)

Figure 8: Coupon, Expected Loss and Spread



Source: www.Artemis.bm Deal Directory

Catastrophe Model Use in Cat Bond Transactions

Selection of Coverage Terms

The impact of various cat bond coverage terms, both singly and in combination, upon the cedant's potential net loss can be analyzed using a catastrophe model. The cedant's financial position can be compared among various possible scenarios to determine the optimal mix of attachment points, exhaustion points and other coverage terms. For example, a cedant may have a goal of retaining potential losses up to the 1-in-100-year event, but not any more than that. The cedant can model its potential loss without any risk transfer, and with various risk transfer arrangements to determine which is the best option for its portfolio.

Trigger

As described in the trigger section above, model results using either industry or cedant exposures (or a combination of the two) are used in several of the types of triggers. Parametric triggers can be evaluated based on the model's treatment of the event characteristics.

Pricing

As mentioned above, the expected loss (AAL) for the cat bond layers is most likely rather small. It is the uncertainty of the event that tends to be more of an influence on the cost. There is no standard formula for using cat model uncertainty measures in the pricing of the bonds; rather those metrics provide insight into the relative uncertainty among layers, coverages, etc. Both the occurrence/non-occurrence (frequency) and costliness of events if they do occur (severity) have uncertainty associated with them.

End of Contract Term

As described above and as shown in the example in appendix 2, there are several things that can happen during and at the end of the contract period. Modeling results can be useful in these.

Commutation. If losses that have not been fully paid still exist at the end of the contract period, an additional time can be designated to allow the loss to develop more thoroughly. It is in the interest of both parties to have a closing time for the contract. Model results may be used to determine the final loss, and/or to determine an appropriate payout period.

Resets. Cat bonds do not have reinstatements. However, a new contract can follow expiration of the initial period of time. Model results are often used as the basis for "reset" options for the cedant, allowing or requiring it to reposition the ILS-backed reinsurance each year to a range of potential attachment probabilities as its annual reinsurance programs are placed, until the expiration of the multiyear ILS deal.

Appendix 2: Catastrophe Bond Example

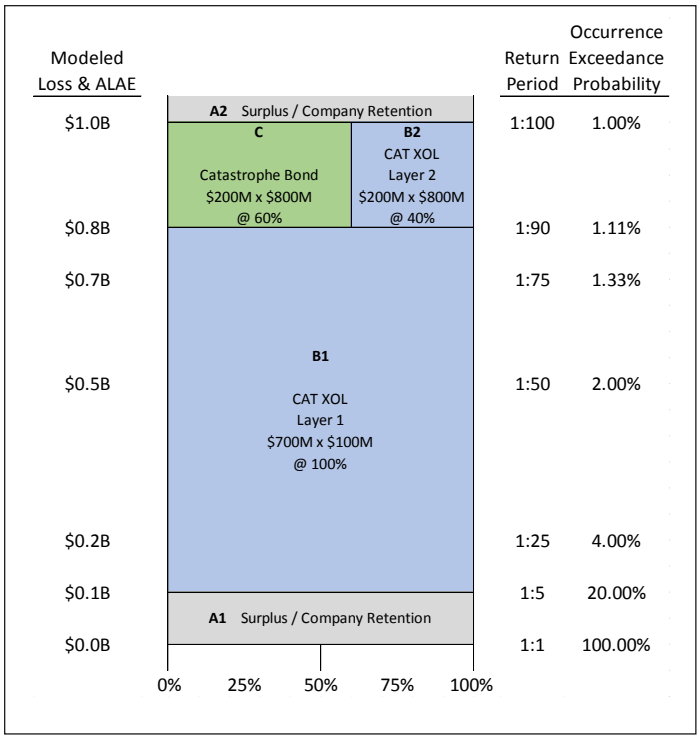
The following illustrative example details how a primary insurance company could use an ILS (here, a catastrophe bond) in its risk management program. We explain how the cat bond is used within a reinsurance placement to protect against a large loss event, and detail three scenarios—no loss, full loss, and partial loss to the cat bond.

Coastal Homeowners Insurance Company (CHIC, a hypothetical company) primarily provides homeowners' insurance in hurricane-prone areas and is interested in protecting against large accumulations of losses during a hurricane. The diagram provides an example of how a catastrophe bond fits into CHIC's first event catastrophe excess of loss reinsurance tower.

Reinsurance towers are used to visualize how the layers of a reinsurance program fit together to ensure appropriate coverage. The vertical axis identifies the amount of per occurrence cumulative loss & ALAE at which each reinsurance contract attaches, as well as exhausts. The horizontal axis identifies the percentage placement for each contract. Like many insurance companies, CHIC uses catastrophe models to estimate the company's aggregate loss and ALAE per event by simulating storms against a dataset of its portfolio of insured properties at a point in time. Model output does not normally include any ALAE costs, but because coverage for those expenses is usually included in contracts, it is part of the evaluation.[29] Selected modeled return periods and associated occurrence exceedance probabilities are shown along the right side of the reinsurance tower. Note that catastrophe models provide additional metrics to quantify the uncertainty of these point estimates, which are also typically considered. The topic of catastrophe model uncertainty is outside the scope of this issue paper, and as such we have excluded these uncertainty metrics for simplicity.

29 ALAE is an example here of a "non-modeled" loss. Other examples may include outbuildings such as sheds on a homeowner's property. Non-modeled losses may be included as a percentage load on the modeled losses.

Figure 9: CHIC XOL Reinsurance Tower



The cat bond (C) is accounting for 60.0% of the layer $200 million excess of $800 million per occurrence, with the remaining 40% of the layer covered by traditional reinsurance, as represented by CAT XOL Layer 2 (B2). Therefore, the cat bond represents $120 million (= $200 million x 60.0%) of collateralized protection. A hurricane causing at least $800 million of loss and ALAE on CHIC's portfolio is estimated by the catastrophe model to have a probability of occurrence of 1.11%, or 1 in 90, in any given year. Investors in the cat bond required an expected risk margin30 in addition to their annualized expected loss on the bond, so the interest rate (i.e., the coupon) on the bond was set at 5.0%.31 The SPV for this cat bond pays this interest periodically, according to the terms of the cat bond, from the premium paid to it by CHIC and the earnings from the invested collateral.

30 This risk margin plus annualized expected loss, or "spread," would be compared to the spread for corporate bonds with similar risks of default.
31 As mentioned previously, this was set based on the spreads (over the risk-free rate) of bonds with similar expected rates of default.

CHIC chose to place this catastrophe bond due to limited reinsurer capacity for CAT XOL Layer 2. Additionally, CHIC found the pricing on the cat bond to be favorable to that of traditional reinsurance and placed this cat bond on a three-year basis, both to reduce the per-year transaction costs and to reduce uncertainty regarding the cost of this slice of reinsurance protection for the next few years. A summary of key criteria for this cat bond follows:

Table 2: CHIC Cat Bond Terms

Bond Criteria	Value
Effective Period	June 1, 20X0 to May 31, 20X3
Occurrence or Aggregate	Occurrence
Attachment Point	$800M
Limit	$200M
Placement Percentage	60.0%
Interest Rate	5.0%
Commutation/Final Payment Date	May 31, 20X5
Trigger	Indemnity

These criteria are typical but may vary by individual contract. For example, the coupon on the bond may be a fixed 5% guaranteed by the sponsor, with 3% expected to come from investment returns on the collateral and 2% from the projected premium paid by the cedant. In that situation, if the investments in the collateral account earn less than the expected 3% return, then the sponsor must make up the difference, increasing the cedant's premium from the original projection.

Note that the commutation/final payment date is May 31, 20X5, while the effective period runs from June 1, 20X0, to May 31, 20X3. Catastrophe bonds often include such dates to ensure payments can be finalized and collateral can be released, instead of being tied up until all loss and ALAE associated with an event are fully paid, which can take many years. The commutation date, imposed before the total actual losses are known, can create a source of risk for CHIC,[32] as is demonstrated in an example that follows.

32 A commutation date can also provide some benefit to the sponsor in that the sponsor may receive the cat bond payout before the sponsor has paid all the underlying losses. This assists the sponsor in managing its cash needs as a result of a catastrophe.

Let's investigate three potential scenarios for the cash flows on this security. For simplicity, let's assume that CHIC provides a proof of loss at each 12-month period ending on May 31, that interest is paid on the balance of the collateral at the beginning of each year of the contract (years beginning June 1), and that the loss and ALAE payout pattern in the case of an event impacting the company is as follows:

Table 3: CHIC Assumed Payout Pattern

Event Maturity (Years)	Payout Percentage
1	50%
2	30%
3	10%
4	10%

Scenario 1: No Loss

In this scenario, there is no event during the three-year effective period of the cat bond. CHIC pays interest payments annually and does not make any recoveries under the contract. Annual interest payments are $6.0 million (= $200 million x 60.0% x 5.0%), and cash flows are as follows:

Table 4: CHIC Scenario 1—No Loss

Year	Interest Payment	Loss & ALAE Recovery	Available Collateral (beginning of year)
1	$6.0M	-	$120.0M
2	$6.0M	-	$120.0M
3	$6.0M	-	$120.0M
4	-	-	-
5	-	-	-

At the end of year 3, CHIC informs the cat bond sponsor that there have been no occurrences during the effective period, and the full $120 million of collateral is released back to investors as a return of their principal.

Table 4: CHIC Scenario 2: Year 1 Loss Exceeding Limit

In this scenario, a hurricane impacting CHIC's insured property portfolio results in an estimated ultimate loss and ALAE of $1.5 billion during year 1, which is in excess of CHIC's coverage under the cat bond. Annual cash flows are as follows:

Table 5: CHIC Year 1 Loss Exceeding Limit

Year	Interest Payment	Event Maturity (Years)	CHIC Cumulative Paid Loss & ALAE	Loss & ALAE Recovery	Available Collateral (beginning of year)
1	$6.0M	1	$ 750.0M	-	$120.0M
2	$6.0M	2	$1,200.0M	$120.0M	$120.0M
3	-	3	$1,350.0M	-	-
4	-	4	$1,500.0M	-	-
5	-	5	$1,500.0M	-	-

In year 1, CHIC pays loss and ALAE totaling $750 million (= $1.5 billion x 50% year 1 payout) to its policyholders, which is below the attachment point of the catastrophe bond. CHIC reports these payments, as well as loss and ALAE case reserves, to the catastrophe bond sponsor. CHIC may report estimated IBNR as well.

In year 2, CHIC pays an additional $450 million (= $1.5 billion x 30% year 2 payout) of loss and ALAE, for a cumulative $1.2 billion loss and ALAE paid to date. This amount exceeds the combined limit and attachment point for the catastrophe bond of $1 billion (= $200 million limit + $800 million attachment point), and the entire $120 million of collateral is released to CHIC on May 31, 20X2. Catastrophe bond investors lose their entire principal and only receive interest payments for two years, as no principal remains beyond that point. Remaining paid loss and ALAE in excess of available recoveries from the cat bond and traditional reinsurance are funded by CHIC.

Note that upon the occurrence of this hurricane, CHIC may desire to place additional reinsurance for future events, as the company does not expect any collateral on this cat bond to be available for subsequent catastrophes.

Scenario 3: Year 3 Loss Within Limit

In this scenario, a hurricane impacting CHIC's insured property portfolio results in an estimated ultimate loss and ALAE of $900 million during year 3, which is between the attachment and exhaustion points for the cat bond. Annual cash flows are as follows:

Table 6: CHIC Scenario 3—Year 3 Loss Within Limit

Year	Interest Payment	Event Maturity (Years)	CHIC Cumulative Paid Loss & ALAE	Loss & ALAE Recovery	Available Collateral (beginning of year)
1	$6.0M			-	$120.0M
2	$6.0M			-	$120.0M
3	$6.0M	1	$450.0M	-	$120.0M
4	$6.0M	2	$720.0M	-	$120.0M
5	$6.0M	3	$810.0M	$60.0M	$120.0M

Interest payments of $6.0 million proceed as normal for years 1 through 3. During year 3, CHIC pays loss and ALAE totaling $450 million (= $900 million x 50% year 1 payout), which is below the attachment point of the cat bond. CHIC reports these payments, as well as loss and ALAE case reserves, to the cat bond sponsor. CHIC may also report estimated IBNR.

In year 4, CHIC pays an additional $270 million (= $900 million x 30% year 2 payout) of loss and ALAE, for a cumulative $720 million loss & ALAE paid to date. This remains below the attachment point of the cat bond, and the collateral remains available for another year. Note that interest payments continue in year 4 to compensate cat bond investors for their trapped collateral. The terms of other cat bonds may vary with respect to this scenario.

In year 5, CHIC pays an additional $90 million (= $900 million x 10% year 3 payout) of loss and ALAE, for a cumulative $810 million loss and ALAE paid to date. Normally, CHIC would recover $6.0 million (= 60% x ($810 million – $800 million attachment point)) in this scenario; however, the commutation/final payment date has been reached. The cat bond contract details the requirements of the commutation, which involves a third-party actuarial firm auditing CHIC's actuarial workpapers and certifying an ultimate loss and ALAE to be used for the final commutation. Here, the $900 million ultimate loss and ALAE is certified, resulting in a recovery of $60 million (= 60% x ($900 million – $800 million attachment point)) to CHIC. The remaining $60 million of collateral is released to investors for a partial recovery of their principal.

This example shows a few downsides to CHIC for the issuance of the cat bond. Interest payments continue past the effective dates of coverage due to the exposed collateral, which means CHIC may be paying for this coverage on a past event in addition to reinsurance for similar sized events that may occur in years 4 and 5. Individual contracts vary on this provision, and some include reduced rates of interest in a loss scenario (a benefit to CHIC, but a negative to the catastrophe bond investors). Additionally, with the fixed commutation/final payment date, considerable uncertainty may remain as to the true estimate of ultimate loss and ALAE for an occurrence—particularly for events that occur closer to the commutation date. Like any commutation, this presents basis risk to CHIC if loss and ALAE develops adversely (and to the catastrophe bond investors, if loss and ALAE develops favorably).

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