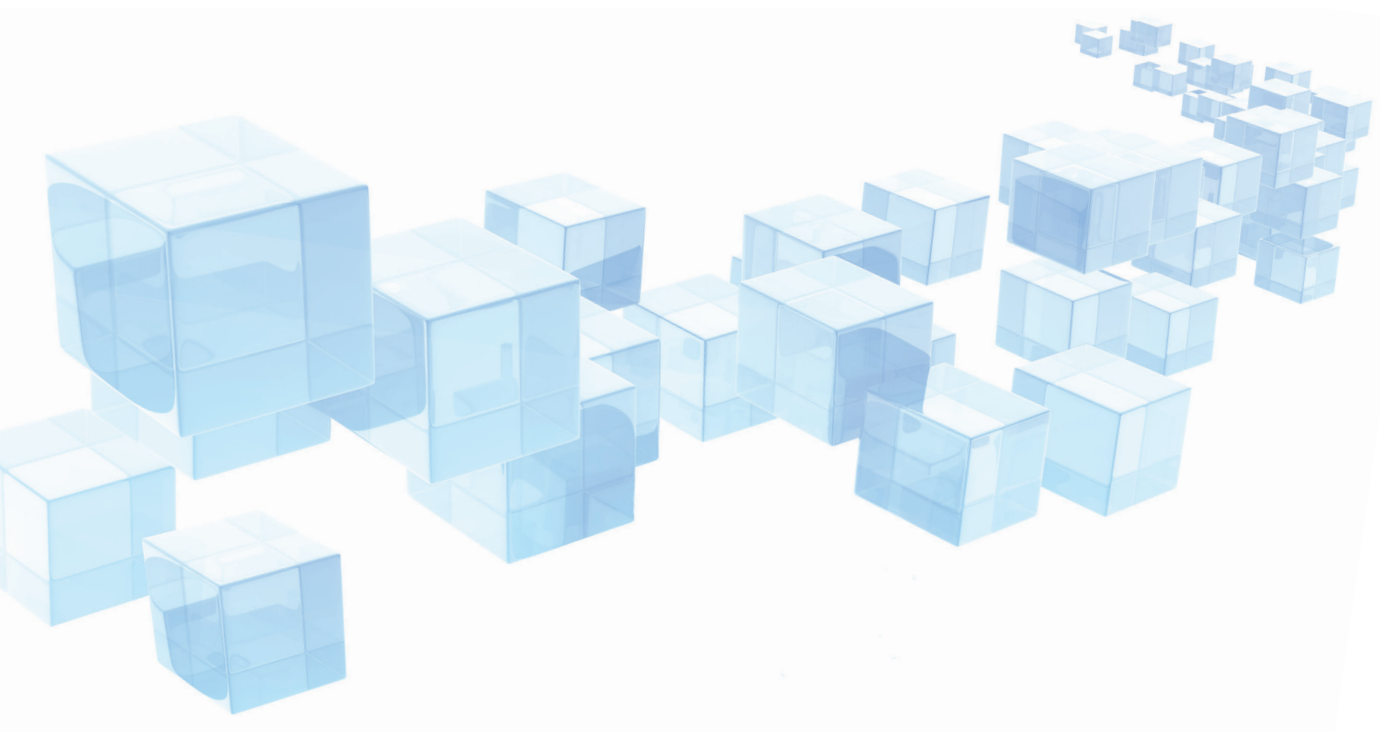


Gauging the Basis Risk of Catastrophe Bonds

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Outline

- A. Market Overview
- B. Assessing Basis Risk

A. Market Overview

A catastrophe bond is a structured debt instrument that transfers risks associated with low-frequency/high-severity events to investors. Catastrophe bonds are employed by the insurance industry as an alternative to traditional reinsurance and retrocession contracts. Depending on the risk appetite of investors, specific layers of risks are bundled together and, through traditional securitization methods, transferred to the capital markets.

Catastrophe Bond Triggers

Catastrophe bonds can be defined by the types of triggers underlying the bond structure. Indemnity catastrophe bonds contain trigger mechanisms where reimbursements are based upon the actual incurred losses of the sponsor. The reimbursement and trigger mechanisms of non-indemnity catastrophe bonds are not based upon the losses of the sponsor. Non-indemnity triggers include the following:

- Pure parametric trigger: Payouts are triggered by actual reported physical events, such as wind speed of hurricane, magnitude of earthquake, location of earthquake, etc.
- Industry loss index trigger: Payouts are triggered by an estimate of industry losses by a third party entity.
- Modeled loss trigger: Payouts are determined by inputting events' parameters into a predetermined and fixed model to calculate losses.

Non-indemnity catastrophe bonds come with “basis risk,” which in the context of catastrophe bonds, generally reflects the possibility that a catastrophe bond may not be fully triggered (or triggered at all) for covered perils even when the sponsor of the catastrophe bond has suffered a loss. This criteria procedure discusses the factors that AM Best considers in estimating how much basis risk is inherent in non-indemnity catastrophe bonds and discusses how AM Best determines the amount of reinsurance credit given to the insurance/reinsurance companies that sponsor non-indemnity catastrophe bonds.

B. Assessing Basis Risk

Key Considerations

AM Best's assessment of basis risk in catastrophe bonds relies primarily on data and information obtained from transaction sponsors, their representatives or experts, and independent peril modelers. AM Best accepts modeled losses from the peril modelers that reflect the most conservative trends in



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peril activities. The items reviewed, evaluated, or monitored to gauge the basis risk of a catastrophe bond may include, but are not limited to, the following:

- The amount of objective analysis performed by independent peril modeling organizations
- The documents provided by the transaction’s sponsor and service providers
- The specific peril included in the transactions
- The derivation of share factors to scale the industry losses to the losses of the sponsor
- The specific parameters/models used in the index
- The probability of the index or model losses falling short of company losses for a wide range of scenarios
- The composition of the book of business being reinsured
- Any adjustment of the index share factors for changes in modeled risk or industry exposure

For multiyear catastrophe bonds AM Best may conduct a yearly evaluation of the basis risk, since the composition of the book of business may change over time.

Sources of Basis Risk

There are several levels of basis risk in non-indemnity catastrophe bonds, and not all of them can be modeled with absolute precision. In the discussion below, three general sources of basis risk are illustrated by a catastrophe bond with an industry loss-based trigger, along with the factors that may make them difficult to model:

- 1. The Discrepancy between the Reported Industry Loss and Actual Industry Loss**
For this example, the industry loss index would probably be approximated by total industry losses as modeled by the peril modelers. However, there is no assurance that modeled industry losses would equal the reported industry loss figures, so from the outset, there is basis risk that cannot be captured by the peril modelers.
- 2. The Discrepancy between the Modeled Index Loss and Modeled Company Loss**
This is the basis risk that can be measured readily by the peril modelers. Index share factors typically are designed to minimize this risk, though this risk may subsequently grow as a result of portfolio changes.
- 3. The Discrepancies between Modeled Company Loss and Actual Company Loss, as well as Modeled Industry Loss and Actual Industry Loss**
If the company’s loss is a derivative of the reported industry loss and if the index share factors used to scale the industry loss to the company loss are wrong, another level of basis risk (sometimes called “secondary uncertainty”) may not be captured by peril modelers.

Steps in Estimating Basis Risk

AM Best’s objective in estimating basis risk is to determine how much reinsurance credit should be given to non-indemnity catastrophe bonds in the BCAR analysis, a component of an insurer’s balance

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sheet strength assessment. One way to accomplish this objective is to assign a score to a list of quantitative and qualitative variables that can affect the level of basis risk inherent in such catastrophe bonds. This approach tends to reveal some of the hidden drivers of basis risk. Another approach is to observe the direct impact of the non-indemnity catastrophe bond on an insurer's probable maximum loss (PML) and give reinsurance credit based on the resulting "net" PML.

AM Best has devised the following four-step process that incorporates both approaches, as well as additional considerations that cannot be quantified easily:

1. Calculate a score for the non-indemnity catastrophe bond based on AM Best's Basis Risk Scoring Table and correlate that score to a reinsurance credit table
2. Calculate a ratio based on the PML impact that directly ties to reinsurance credit
3. Take the lesser of the results from steps 1 and 2
4. Other considerations

Step 1

Basis Risk Scoring Table

In Step 1, AM Best calculates a score based on **Exhibit B.1**. This exhibit describes AM Best's scoring system for gauging basis risk. Each of the items in the exhibit is scored from 1 to 5 with 1 representing the least amount of basis risk. Although it is not possible to capture all aspects of basis risk using this approach, AM Best believes this table is useful as a relative measure of basis risk from transaction to transaction.

Exhibit B.1: AM Best's Basis Risk Scoring Table

Metric	Scale	Description	Weight		
Shortfall	1 to 5	Shortfall is defined as the amount by which the modeled index loss falls short of the modeled company loss, and it is expressed as a percentage of the total principal amount of the catastrophe bond. This probability may vary from transaction to transaction depending on the structure of the bond. Based on the parametric catastrophe bond's "%" shortfall, AM Best will assign the appropriate score on the following table:	35%		
				50% Shortfall	Score
				10%	1
				15%	2
				20%	3
				25%	4
>=30%	5				

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Metric	Scale	Description	Weight																								
Exhaustion Probability	1 to 5	<p>AM Best considers the exhaustion point in determining whether the catastrophe bond should merit any capital relief. Imagine a situation in which the attachment probability is 5% and the exhaustion probability is nearly 0%. In this case, the full value of the bond should not be given credit, since the probability of recovering the full balance is nearly 0%, although the probability of recovering some portion of the balance is relatively high. For this reason, AM Best ranks the exhaustion probability in the following manner:</p> <table border="1"> <thead> <tr> <th>Wind Probability of Exhaustion</th> <th>Score</th> <th>Earthquake Probability of Exhaustion</th> <th>Score</th> </tr> </thead> <tbody> <tr> <td>>= 2.0%</td> <td>1</td> <td>>=0.60%</td> <td>1</td> </tr> <tr> <td>1.50%</td> <td>2</td> <td>0.50%</td> <td>2</td> </tr> <tr> <td>1.00%</td> <td>3</td> <td>0.40%</td> <td>3</td> </tr> <tr> <td>0.50%</td> <td>4</td> <td>0.30%</td> <td>4</td> </tr> <tr> <td><=0.25%</td> <td>5</td> <td><=0.20%</td> <td>5</td> </tr> </tbody> </table>	Wind Probability of Exhaustion	Score	Earthquake Probability of Exhaustion	Score	>= 2.0%	1	>=0.60%	1	1.50%	2	0.50%	2	1.00%	3	0.40%	3	0.50%	4	0.30%	4	<=0.25%	5	<=0.20%	5	25%
Wind Probability of Exhaustion	Score	Earthquake Probability of Exhaustion	Score																								
>= 2.0%	1	>=0.60%	1																								
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<=0.25%	5	<=0.20%	5																								
Peril	1 to 5	<p>Perils differ in terms of how much data are available for modeling probabilities of occurrence. In general, there are more data available for hurricanes than for earthquakes (at least of late), although scientists are constantly reviewing geological samples to detect earthquakes that occurred long ago to increase the statistical accuracy of their calculations. The peril ranking is as follows:</p> <ol style="list-style-type: none"> 1) Florida wind 2) US wind, Europe windstorm, Japan typhoon 3) California earthquake, Pacific Northwest earthquake, Japan earthquake 4) New Madrid earthquake 5) Earthquakes in other regions not traditionally known for having seismic activity and other perils that have not traditionally been modeled 	10%																								
Independent Peril Modelers' Involvement in Basis Risk Analysis	1 to 5	<ol style="list-style-type: none"> 1) If the independent peril modeler is fully engaged to model the index and tabulate loss shortfalls and is involved in the verification of the model inputs to maintain data consistency. 5) If basis risk analysis is done wholly by the sponsor with no input from an independent peril modeler. <p>Scores 2 to 4 will depend on the finer shades of distinction in this category as determined by AM Best.</p>	10%																								

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Metric	Scale	Description	Weight
Data Quality	1 to 5	AM Best will ask each peril modeler for some generic indication on the different gradations of data quality used in modeling losses. For example, AM Best expects the extent to which the latitude and longitude of property locations are supplied to the model to be an indication of the level of data quality. Other indicators of data quality could be the extent to which the model has been supplied information about construction type, roof type, occupancy type, contents information, square footage, etc. Excessive use of default values in the models for primary and secondary characteristics of property is an indication of poor quality data. Information supplied by the peril modelers will be used to rank data quality from 1 to 5.	10%
Certainty of Business Competition	1 to 5	1) If historical data show the type of business that is likely to be presented to the sponsor and the sponsor has a long track record. Sponsor credibility is critical to this scoring category. 5) If the sponsor has no track record (such as if it is a brand new reinsurer) and is uncertain about the type of business that is likely to be presented to it. Scores 2 to 4 will depend on the finer shades of distinction in this category as determined by AM Best.	10%

Shortfall

As shown in **Exhibit B.1**, the shortfall of the bond is one of the scoring factors. A shortfall is defined as the amount by which the payout on the catastrophe bond “falls short” of the sponsor’s loss, i.e., the modeled company loss. **Exhibit B.2** shows sample probabilities of shortfalls, expressed as a percentage of the total principal amount of the catastrophe bond. AM Best requests an exhibit similar to **Exhibit B.2** for all parametric catastrophe bonds.

Exhibit B.2: Shortfall Table Example

Shortfall (% of Limit)	Conditional Probability of Exceedance (%)
>0	70
>10	50
>20	45
>30	40
>40	30
>50	20
>60	15
>70	12
>80	8
>90	5

As an example of how a shortfall is calculated for one scenario, consider one path of a hurricane that causes a certain level of industry loss. Assuming that the index is a loss index, the peril modeler can calculate a modeled index loss by applying various scaling factors to the modeled industry loss. In

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In addition, the peril modeler can calculate the modeled company loss based on the company's book of business (as is supplied to the peril modeler by the sponsoring insurance company). If the modeled index loss is less than the modeled company loss, then the shortfall is calculated as follows:

$$\text{Shortfall} = \frac{(\text{Modeled Company Loss} - \text{Modeled Index Loss})}{\text{Bond Principal Balance}}$$

This shortfall can be tabulated for thousands of scenarios of hurricane paths (in some cases for hundreds of thousands of paths) to generate a distribution of shortfalls. From that distribution, confidence intervals of shortfalls can be determined. For example, **Exhibit B.2** shows that the probability of having a shortfall of greater than 50% of the principal amount of the bond (on the left column of the exhibit) is 20% (as shown on the right column of the exhibit).

Scoring Procedures

The scoring mechanics for determining reinsurance credit are as follows:

- For each of the items in **Exhibit B.1**, assign a number on a scale of 1 to 5, where 5 is the riskiest measure
- Multiply each of the numbers by the factor weight in **Exhibit B.1**
- Sum all the products of the scales and their corresponding weights to get a total score
- Correlate the total score to the Scoring-Based Reinsurance Credit Table (**Exhibit B.3**)

Scoring-Based Reinsurance Credit Scale

Exhibit B.3, the Scoring-Based Reinsurance Credit Scale, is the reinsurance credit table. AM Best adjusts for some of the modeling uncertainties that are associated with basis risk by imposing a maximum reinsurance credit of 90% (as shown in **Exhibit B.3**).

Exhibit B.3: Scoring-Based Reinsurance Credit Scale

Summed Basis Risk Score	Credit
1	90%
2	75%
3	50%
4	30%
5	10%

Exhibit B.4 is an example of how the scoring procedures would be applied for a catastrophe bond covering California earthquake.

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Exhibit B.4: Scoring-Based Calculation Example (California Earthquake)

Metrics	Score	Weight	Weight Multiplied by Score
Shortfall	2	35%	0.70
Exhaustion Probability	1	25%	0.25
Data Quality	2	10%	0.20
Peril Type	3	10%	0.30
Peril Modeler Involvement	1	10%	0.10
Certainty of Business Composition	2	10%	0.20
	Total		1.75

The total score translates to approximately 79% of the scoring-based reinsurance credit scale (**Exhibit B.3**).

Step 2

Calculating the Capital Effectiveness Ratio

In Step 2, AM Best calculates a Capital Effectiveness Ratio (CER) and the Aggregate CER (ACER) the components of which are supplied by the sponsor of the non-indemnity catastrophe bond and its peril modeling agency. Ultimately, AM Best is interested in the extent to which the non-indemnity catastrophe bond being contemplated is effective in providing reinsurance protection to the sponsor. To this end, A.M Best needs the following aggregate exceedance curves for the company:

1. The base aggregate exceedance curve before adding the effect of the non-indemnity catastrophe bond; and
2. The base aggregate exceedance curve after adding the non-indemnity catastrophe bond.

Depending on the return period being targeted, AM Best will compare the PML based on the aggregate exceedance curve after adding the non-indemnity catastrophe bond with the PML based on the aggregate exceedance curve before adding the bond. At a specific confidence level, AM Best will calculate the CER for each catastrophe bond tranche as follows:

$$CER = 90\% \left(\frac{PML \text{ Before Adding Bond} - PML \text{ After Adding Bond}}{Bond \text{ Principal Balance}} \right)$$

The 90% factor in the CER above is an adjustment factor for the various sources of basis risk that are difficult to model, as discussed earlier.

Calculating the Aggregate Capital Effectiveness Ratio

The diversification effect of issuing multiple tranches of catastrophe bonds that cover the same peril (such as earthquakes and hurricanes) can be positive for basis risk. At its discretion, AM Best will ask for additional aggregate exceedance curves that are based on combining two or more tranches of catastrophe bonds that provide protection for the same peril. Based on these aggregate exceedance curves and the aggregate PML (APML) derived for each peril, AM Best will calculate ACERs for the cumulative balance of the catastrophe bonds for each peril as follows:



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$$ACER = 90\% \left(\frac{APML \text{ Before Adding Bonds} - APML \text{ After Adding Bonds}}{\text{Total Principal Balance of Bonds}} \right)$$

Step 3

Calculating the Absolute Reinsurance Credit

In Step 3, AM Best calculates the Absolute Reinsurance Credit, which is the maximum reinsurance credit to ascribe to the non-indemnity catastrophe bond. The formula for the reinsurance credit of each individual catastrophe bond is as follows:

$$\text{Absolute Reinsurance Credit} = \text{Minimum}(\text{CER}, \text{Credit Derived from Scoring Table})$$

If the issuer has issued or intends to issue two or more catastrophe bonds covering a particular peril, the Absolute Reinsurance Credit for the catastrophe bonds covering the peril may be calculated (at AM Best's discretion) as follows:

$$\text{Absolute Reinsurance Credit} = ACER$$

Exhibit B.5 contains an example of the calculation of reinsurance credit for a single non-indemnity catastrophe bond covering earthquakes.

Exhibit B.5: Sample Calculation of Reinsurance Credit*¹

Confidence Level	PML Before Bond	PML After Bond	Principal Balance of Bond	CER	Credit Derived from Scoring Table	Absolute Reinsurance Credit
95	200	200	150	0%	79%	0%
99	300	300	150	0%	79%	0%
99.5	400	280	150	72%	79%	72%
99.6	450	300	150	90%	79%	79%

*Amounts in USD.

¹The modeled benefit to this hypothetical company's PML from the bond is triggered at the 99.5 confidence level.

Step 4

Other Considerations

Since an insurer's or reinsurer's book of business changes from year to year, the basis risk associated with the multiyear non-indemnity catastrophe bond it sponsors also changes. AM Best may discuss with the catastrophe bond sponsor how it intends to measure basis risk changes as its business portfolio changes. AM Best may also consider how the index share factors are derived by the sponsor of the catastrophe bond, as well as how the index share factors may change at extreme ends of catastrophic losses when gauging basis risk.

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