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Best's
Methodology and Criteria

Gauging the Basis Risk of Catastrophe Bonds

Emmanuel Modu
908 882 2128
Emmanuel.Modu@ambest.com

Thomas Mount
908 882 2192
Thomas.Mount@ambest.com

Myles Gould
+44 207 397 0304
Myles.Gould@ambest.com

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Outline

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.

(Re)insurers issuing non-indemnity catastrophe bonds may be exposed to "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 due to those perils. 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 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 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**
   The industry loss index would normally 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 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 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 may be used to incorporate 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 separate Basis Risk score for each of the VaR (Value at Risk) levels used in BCAR based on the metrics shown in **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

<table>
<tr><th>Metric</th><th>Scale</th><th>Description</th><th>Weight</th></tr>
<tr><td>Shortfall</td><td>1 to 5</td><td>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 from the following table:
<table>
<tr><th>50% Shortfall</th><th>Score</th></tr>
<tr><td><=10%</td><td>1</td></tr>
<tr><td>>10% & <=15%</td><td>2</td></tr>
<tr><td>>15% & <=20%</td><td>3</td></tr>
<tr><td>>20% & <=25%</td><td>4</td></tr>
<tr><td>>25%</td><td>5</td></tr>
</table>
The score for the Shortfall metric will be the same for each VaR level.</td><td>35%</td></tr>
<tr><td>Exhaustion Probability</td><td>1 to 5</td><td>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:
<table>
<tr><th>Exhaustion Probability</th><th>VaR 95 Score</th><th>VaR 99 Score</th><th>VaR 99.5 Score</th><th>VaR 99.6 Score</th><th>VaR 99.8 Score</th></tr>
<tr><td>>= 20%</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>>= 10% & < 20%</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>>= 5% & < 10%</td><td>3</td><td>2</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>>= 1% & < 5%</td><td>4</td><td>3</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td>>= 0.5% & < 1%</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>>= 0.4% & < 0.5%</td><td>5</td><td>5</td><td>4</td><td>3</td><td>2</td></tr>
<tr><td>>= 0.2% & < 0.4%</td><td>5</td><td>5</td><td>5</td><td>4</td><td>3</td></tr>
<tr><td>>= 0.1% & < 0.2%</td><td>5</td><td>5</td><td>5</td><td>5</td><td>4</td></tr>
<tr><td>< 0.1%</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td></tr>
</table>
The score for the Exhaustion Probability metric can vary by VaR level.</td><td>25%</td></tr>
</table>

Metric	Scale	Description	Weight
Peril	**1 to 5**	Perils differ in terms of how much data is available for modeling probabilities of occurrence. For example, there is more data available for hurricanes than for severe earthquakes. The peril ranking is as follows: **Score** **1** Florida wind **2** US wind, Europe windstorm, Japan typhoon **3** California earthquake, Pacific Northwest earthquake, Japan earthquake **4** New Madrid earthquake, US wildfire, US flood, European flood **5** Earthquakes in other regions not traditionally known for having seismic activity and other perils that have not traditionally been modeled, such as cyber The score for the Peril metric will be the same for each VaR level.	**10%**
Independent Peril Modelers' Involvement in Basis Risk Analysis	**1 to 5**	**Score** **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. Scores 2 to 4 will be used to reflect intermediate positions in this category as determined by AM Best. The score for the Independent Modelers' Involvement metric will be the same for each VaR level.	**10%**
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. The score for the Data Quality metric will be the same for each VaR level.	**10%**

Metric	Scale	Description	Weight
Certainty of Business Composition	**1 to 5**	**Score** **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 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 be used to reflect intermediate positions in this category as determined by AM Best. The score for the Certainty of Business Composition metric will be the same for each VaR level.	**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 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:

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

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 score on a scale of 1 to 5, where 5 is the riskiest measure, at each VaR level
- Multiply each of the numbers by the factor weight in **Exhibit B.1**
- Sum all the products of the scores and their corresponding weights to get a total score at each VaR level
- Correlate the total score at each VaR level to the Scoring-Based Reinsurance Credit Scale (**Exhibit B.3**). Credit for non-integers cores are obtained by interpolation.

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.

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

							Weight Multiplied By				
Metrics	VaR 95 Score	VaR 99 Score	VaR 99.5 Score	VaR 99.6 Score	VaR 99.8 Score	Weight	VaR 95 Score	VaR 99 Score	VaR 99.5 Score	VaR 99.6 Score	VaR 99.8 Score
Shortfall	2	2	2	2	2	35%	0.70	0.70	0.70	0.70	0.70
Exhaustion Probability	5	4	3	2	1	25%	1.25	1.00	0.75	0.50	0.25
Data Quality	2	2	2	2	2	10%	0.20	0.20	0.20	0.20	0.20
Peril Type	3	3	3	3	3	10%	0.30	0.30	0.30	0.30	0.30
Peril Modeler Involvement	1	1	1	1	1	10%	0.10	0.10	0.10	0.10	0.10
Certainty of Business Composition	2	2	2	2	2	10%	0.20	0.20	0.20	0.20	0.20
Total						100%	2.75	2.50	2.25	2.00	1.75
Scoring-Based Reinsurance Credit							56%	63%	69%	75%	79%

As shown in Exhibit B.4, the total score and the corresponding scoring-based reinsurance credit can vary across the different VaR levels. In this example, the improving total score and increasing reinsurance credit is due to the improvement in the scores associated with the Exhaustion Probability metric, as the scores for the other metrics do not change across the various VaR levels. This improvement can occur if the losses are modeled at a point further into the tail of the modeled loss distribution that is beyond the exhaustion probability. This implies it is more likely that the catastrophe bond limit has been used up and, therefore, the bond should receive more reinsurance credit.

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, AM 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:

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

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, each of which 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:

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

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:

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

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:

$$Absolute\ Reinsurance\ Credit = ACER$$

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*

Confidence Level	PML Before Bond ($Millions)	PML After Bond* ($Millions)	Principal Balance of Bond ($Millions)	Capital Effectiveness Ratio (CER)	Credit Derived from Scoring Table	Absolute Reinsurance Credit (ACER)
95	200	200	150	0%	56%	0%
99	300	300	150	0%	63%	0%
99.5	400	280	150	72%	69%	69%
99.6	450	300	150	90%	75%	75%
99.8	600	450	150	90%	79%	79%

*PMLs modeled giving benefit to a hypothetical catastrophe bond that is triggered at 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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METHODOLOGY AND CRITERIA

A.M. Best Rating Services, Inc.
Oldwick, NJ
PRESIDENT & CEO **Matthew C. Mosher**
EXECUTIVE VICE PRESIDENT & COO **James Gillard**
EXECUTIVE VICE PRESIDENT & CSO **Andrea Keenan**
SENIOR MANAGING DIRECTORS **Edward H. Easop, Stefan W. Holzberger, James F. Snee**

AMERICAS
WORLD HEADQUARTERS
A.M. Best Company, Inc.
A.M. Best Rating Services, Inc.
1 Ambest Road, Oldwick, NJ 08858
Phone: +1 908 439 2200

MEXICO CITY
A.M. Best América Latina, S.A. de C.V.
Av. Paseo de la Reforma 412, Piso 23,
Col. Juárez, Alcadía Cuauhtémoc, C.P. 06600, México, D.F.
Phone: +52 55 1102 2720

EUROPE, MIDDLE EAST & AFRICA (EMEA)
LONDON
A.M. Best Europe - Information Services Ltd.
A.M. Best Europe - Rating Services Ltd.
12 Arthur Street, 8th Floor, London, UK EC4R 9AB
Phone: +44 20 7626 6264

AMSTERDAM
A.M. Best (EU) Rating Services B.V.
NoMA House, Gustav Mahlerlaan 1212, 1081 LA Amsterdam, Netherlands
Phone: +31 20 308 5420

DUBAI*
A.M. Best Europe - Rating Services Ltd. - DIFC Branch*
Office 102, Tower 2, Currency House, DIFC
P.O. Box 506617, Dubai, UAE
Phone: +971 4375 2780
*Regulated by the DFSA as a Credit Rating Agency

ASIA-PACIFIC
HONG KONG
A.M. Best Asia-Pacific Ltd
Unit 4004 Central Plaza, 18 Harbour Road, Wanchai, Hong Kong
Phone: +852 2827 3400

SINGAPORE
A.M. Best Asia-Pacific (Singapore) Pte. Ltd
6 Battery Road, #39-04, Singapore
Phone: +65 6303 5000

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