

Gauging the Basis Risk of Catastrophe Bonds

A catastrophe bond is a structured debt instrument that transfers risks associated with low-frequency/high-severity events to investors. The insurance industry increasingly is employing catastrophe bonds 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. Since their first appearance in the capital markets in 1997, the annual issue volume for publicly disclosed catastrophe bonds with ratings has increased from \$543 million in 1997 to about \$2 billion in 2005. It is anticipated that the first loss accruing to a publicly disclosed catastrophe bond will occur as a result of 2005's Hurricane Katrina – one of the worst natural catastrophes in U.S. history.

Katrina and other recent catastrophic events have made investors more cautious about the types of triggers they will accept in catastrophe bonds. Investors have been shying away from indemnity catastrophe bonds and gravitating toward index-based, parametric catastrophe bonds. (For the purposes of this document, A.M. Best considers non-indemnity catastrophe bonds as parametric catastrophe bonds.) For rating agencies, parametric catastrophe bonds come with “basis risk” that must be considered in the Financial Strength Ratings (FSRs) of the companies sponsoring the bond issues. Basis risk, in the context of catastrophe bonds, generally reflects the possibility that a catastrophe bond may not be partially or fully triggered (for covered perils) even when the sponsor of the catastrophe bond has suffered a loss. This methodology discusses some of the factors that A.M. Best considers in estimating how much basis risk is inherent in catastrophe bonds and also helps A.M. Best determine how much reinsurance credit will be given to the insurance/reinsurance companies that sponsor catastrophe bonds with parametric triggers.

This report was written by Emmanuel Modu, managing director of the structured finance group of A.M. Best Co. (emmanuel.modu@ambest.com)

Key Considerations

A.M. Best's assessment of the basis risk in catastrophe bonds relies primarily on data and information obtained from the three leading peril modelers (AIR Worldwide Corp., EQECAT Inc. and Risk Management Solutions Inc.) and the insurance/reinsurance sponsors of the catastrophe bonds. A.M. Best accepts modeled losses from the peril modelers that reflect the most conservative trends in peril activities. A list of some of the items reviewed, evaluated or monitored to gauge basis risk of a catastrophe bond is as follows:

- **Independent Peril Modeler** — The level of involvement of independent peril modeling organizations. While some reinsurers bring great expertise in peril modeling, A.M. Best still values greatly the amount of objective analysis performed by independent peril modeling organizations.
- **Transaction Documents** — A.M. Best's review of the documents provided by the transaction's sponsor and service providers.
- **The specific peril included in the transactions** (e.g., U.S. earthquake, U.S. hurricane, European windstorm, Japanese earthquake, Japanese typhoon, etc.) — A.M. Best expects that the extreme high-severity perils such as earthquakes may give rise to higher basis risk.
- **Derivation of Index Share Factors** – the derivation of share factors (by state, by line, etc.) used to scale the industry losses to the losses of the sponsor. Company losses will be a fraction of industry losses, and the factors probably will vary according to the severity of the catastrophe.
- **Index Used** — the specific parameters/models used. If it is Property Claim Services¹ (PCS), for example, how will it be simulated? Historically, how adept have the peril modelers been in modeling the index?
- **Index versus Company Event Losses** – A.M. Best expects a table showing probability of the index or model losses falling short of company

(1) Property Claim Services (PCS) is a subsidiary of Insurance Services Office, Inc. PCS is the leading provider of information about property/casualty insurance, including statistical information (such as industry loss indicators), actuarial services, and a variety of insurance rating and underwriting services.



losses for a wide range of losses.

- **Business Composition** — the composition of the book of business being reinsured. Has the company been in business long enough to know the characteristics of the book of business it can acquire? If the composition of the book of business deviates from expectations, how will that change the company's basis risk indicators?

- **Factor Recalibration** — this reflects the adjustment of the Index Share factor to consider the changes in modeled risk or industry exposure.

- **Basis Risk Reevaluation** — A.M. Best expects that for multiyear catastrophe bonds, there will be a yearly evaluation of the basis risk, since the composition of the book of business may change over time.

Estimating Basis Risk

In reality, there are several levels of basis risk in parametric catastrophe bonds, and not all of them can be modeled with absolute precision. This modeling imprecision can be illustrated by a catastrophe bond with an industry loss-based trigger. The three general sources of basis risk with such a trigger are described below, along with the factors that may make them difficult to model:

1) *The Discrepancy Between the Reported Industry Loss and Actual Industry Loss* - As an example, suppose a reinsurer wants to use the reported PCS industry loss index as a trigger mechanism. This index probably would be approximated by total industry losses as modeled by the peril modelers. However, there is no assurance that modeled industry losses would equal reported PCS 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* - As an example, suppose the company loss is a derivative of the reported PCS industry loss. If the index share factors used to scale the industry loss to company loss are wrong, this produces yet another level of basis risk (sometimes called "secondary uncertainty")

that may not be captured by peril modelers.

A.M. Best's objective in estimating basis risk is to determine how much reinsurance credit should be given to parametric catastrophe bonds in the BCAR analysis which is an important element in assigning FSRs to insurance companies. One way to accomplish this objective is to use a "scorecard" approach by assigning 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 parametric catastrophe bond on the Probable Maximum Loss (PML), given the BCAR criteria (1-in-100 year PML for hurricane, and 1-in-250 year PML for earthquake), and give reinsurance credit based on the resulting "net" PML.

A.M. Best recognizes the merits of both of these methods of estimating basis risk, and it

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Methodology

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has devised the following four-step process that incorporates both approaches and additional considerations that can not be quantified easily:

- 1) Calculate a score based on a scoring table and correlate the score to a reinsurance credit table.
- 2) Calculate a ratio based on 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, A.M. Best calculates a score based on Exhibit 1, the Basis Risk Scoring Table. This table describes A.M. Best’s internal scoring system for gauging basis risk. Each of the items in the scoring table is scored from 1 to 5 where 1 represents the least amount of basis risk.

While A.M. Best recognizes that it is not possible to capture all aspects of basis risk using this approach, the company believes it is useful as a relative measure of basis risk from transaction to transaction. The rest of the exhibits associated with the Basis Risk Scoring Table are described as follows:

- Exhibit 2, the Shortfall Table Example, shows the probability of a “shortfall” being greater than losses expressed as a percentage of the total principal amount of the catastrophe bond. A shortfall is defined as the amount by which the payout on the parametric catastrophe bond “falls short” of the sponsor’s loss (i.e. the modeled company loss). 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 the PCS industry index, the peril modeler readily 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:

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

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 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). Any insurer/reinsurer issuing a parametric catastrophe bond and working with one of the top three peril modelers should be able to provide similar data to A.M. Best.

- Exhibit 3, the Scoring-Based Reinsurance Credit Scale, is the reinsurance credit

table. A.M. Best adjusts for some of the modeling uncertainties, described earlier, that are associated with basis risk by imposing a maximum reinsurance credit of 90% (as shown on Exhibit 3).

- Exhibit 4 is an example of A.M. Best’s Scoring-Based Credit Calculation.

Scoring Procedures

The scoring mechanics for determining reinsurance credit are as follows:

- For each of the items in Exhibit 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 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 3).

Step 2 – Calculating the Capital Effectiveness Ratio And The Aggregate Capital Effectiveness Ratio

In Step 2, A.M. Best calculates a Capital Effectiveness Ratio and the Aggregate Capital Effectiveness Ratio, the components of which are supplied by the sponsor of the parametric catastrophe bond and its peril modeling agency. The

Exhibit 2 Shortfall Table Example

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

Exhibit 3 Scoring-Based Reinsurance Credit Scale

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

Exhibit 1
Basis Risk Scoring Table

Metrics	Scale*	Description	Weight																								
Shortfall	1 to 5	<p>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 parametric catastrophe bond.</p> <p>A.M. Best keys on the probability of a 50% shortfall. In the example shown in Exhibit 2, the probability of a shortfall being greater than 50% of the catastrophe bond's principal is 20% (as shown on the 2nd column in Exhibit 2 on the ">50%" row). This probability may vary from transaction to transaction depending on the structure of the bond.</p> <p>A.M. Best will request an exhibit similar to Exhibit 2 for all parametric catastrophe bonds. Based on the ">50%" shortfall line, A.M. Best will assign the appropriate score on the following table:</p> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>50% Shortfall</th> <th>Score</th> </tr> </thead> <tbody> <tr> <td>10%</td> <td>1</td> </tr> <tr> <td>15%</td> <td>2</td> </tr> <tr> <td>20%</td> <td>3</td> </tr> <tr> <td>25%</td> <td>4</td> </tr> <tr> <td>>=30%</td> <td>5</td> </tr> </tbody> </table>	50% Shortfall	Score	10%	1	15%	2	20%	3	25%	4	>=30%	5	35%												
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20%	3																										
25%	4																										
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Exhaustion Probability	1 to 5	<p>A.M. Best considers the exhaustion point in determining whether the parametric catastrophe bond should merit full capital relief, if any. Imagine a situation where the attachment probability is 5% and the exhaustion probability is nearly 0%. In this case, the full width 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, A.M. Best ranks the exhaustion probability in the following manner:</p> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Wind Probability of Exhaustion</th> <th>Score</th> <th>Quake 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	Quake 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%
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Peril	1 to 5	<p>Perils differ in terms of how much data is available for modeling probabilities of occurrence. In general, there is more data available for hurricanes than 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) U.S. 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 Modeler's Involvement in Basis Risk Analysis	1 to 5	<p>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.</p> <p>5) If basis risk analysis is done wholly by the sponsor with no input from an independent peril modeler.</p> <p>Scores from 2 to 4 will depend on the finer shades of distinction in this category as determined by A.M. Best.</p>	10%																								
Data Quality	1 to 5	<p>A.M. Best will ask each peril modeler for some generic indication on the different gradations of data quality used in modeling losses. For example, A.M. 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, content information, square footage, etc. Excessive use of default values in the models for primary and secondary characteristics of property is a clear cut indication of bad data quality.</p> <p>Information supplied by the peril modelers will be used to rank data quality from 1 to 5.</p>	10%																								
Certainty of Business Composition	1 to 5	<p>1) If historical data shows the type of business that is likely to be presented to the sponsor and the sponsor has a long track record. Stellar sponsor credibility is critical for this scoring category.</p> <p>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.</p> <p>Scores from 2 to 4 will depend on the finer shades of distinction in this category as determined by A.M. Best.</p>	10%																								

* 1 represents the lowest risk category, and 5 represents the highest risk category.

rest of this section describes both ratios and how they are calculated.

A.M. Best ultimately is interested in the extent to which the parametric catastrophe bond being contemplated is effective in providing reinsurance protection to the sponsor. To this end, A.M. Best will need the following aggregate exceedance curves for the company:

1) The base *aggregate* exceedance curve before adding the effect of the parametric catastrophe bond; and

2) The base *aggregate* exceedance curve after adding the parametric catastrophe bond.

Depending on the return period being targeted (e.g., 1-in-100 for hurricane, 1-in-250 for earthquake), A.M. Best will compare the PML based on the aggregate exceedance curve after adding the parametric catastrophe bond with the PML based on the aggregate exceedance curve before adding the bond. Specifically, A.M. Best will calculate the Capital Effectiveness Ratio for each catastrophe bond tranche as follows:

$$\text{Capital Effectiveness Ratio} = 90\% \times \left(\frac{\text{(PML Before Adding the Bond - PML After Adding the Bond)}}{\text{(Bond Principal Balance)}} \right)$$

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

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, A.M. 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, A.M. Best will calculate Aggregate Capital Effectiveness Ratios for the cumulative balance of the catastrophe bonds for each peril as follows:

$$\text{Aggregate Capital Effectiveness Ratio} = 90\% \times \left(\frac{\text{(APML Before Adding Bonds - APML After Adding Bonds)}}{\text{(Total Principal Balance of Bonds)}} \right)$$

Step 3 – Calculating the Absolute Reinsurance Credit

In Step 3, A.M. Best calculates the Absolute Reinsurance Credit. The Absolute Reinsurance

Exhibit 4

An Example of Scoring-Based Calculation (Calif. Quake)

Metrics	Score	Weight	Weight x 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 Value of: Weight x Score = 1.75.
 This Translates to Approximately 79% on the Scoring-Based Reinsurance Credit Scale (Exhibit 3).
 Assuming the Capital Effectiveness Ratio is 81%, the Absolute Reinsurance Credit = Minimum (81%, 79%) = 79%.

Credit is the maximum reinsurance credit to ascribe to the parametric catastrophe bond. The formula for the reinsurance credit of each individual catastrophe bond is as follows:

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

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 A.M. Best’s discretion) as follows:

$$\text{Absolute Reinsurance Credit} = \text{Aggregate Capital Effectiveness Ratio}$$

As an example of the calculation of reinsurance credit for a single parametric catastrophe bond covering earthquakes, assume that at the 99.6% confidence level (i.e. at a return period of 250 years), the PML before adding the effect of the parametric catastrophe bond is \$200 million, the PML after adding the effect of the catastrophe bond is \$65 million, and the principal balance of the bond is \$150 million. The Capital Effectiveness Ratio would be 81% (81% = 90% X [\$200 million - \$65 million] / \$150 million).

Step 4 – Other Considerations

Since an insurer’s or reinsurer’s book of business will change from year to year, so will the basis risk associated with the multiyear parametric catastrophe bond it sponsors. A.M. Best would like some indication of how the catastrophe bond sponsor intends to measure

basis risk changes as its business portfolio changes. In addition, A.M. Best is interested in 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. Finally, the risk-management personnel and practice of the insurer/reinsurer matter greatly to A.M. Best.



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