Securitization

Global Markets Research

Deutsche Bank Securities

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Catastrophe Bonds:
Opportunities for Issuers and Investors

Asset Backed Securities Research

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Introduction and CAT Bond Characteristics

Overview of Market

Approximately fifty catastrophe-linked bonds, popularly known as "CAT bonds", have been issued since 1996. These are bonds typically issued by insurers or reinsurers whose payouts are tied to natural disasters such as hurricanes, earthquakes, windstorms or temperature extremes. Virtually all CAT bonds to date have been issued on a floating rate basis, concentrated in the Ba/BB rating range and having a spread to LIBOR commonly in the 400-600 basis point range. The proceeds of a typical CAT bond are invested in a very high quality and liquid investment pool, but the credit rating is based upon the probability and severity of loss resulting from the natural disaster, much like a corporate bond rating. If a qualifying loss event occurs, the CAT bond investor will experience a loss of some or all of the principal and/or coupon upon the accelerated redemption of the bond. Upon redemption, the investment pool is liquidated and any qualifying loss is reimbursed to the issuer, thus reducing the investor's payout. If no loss event occurs, the CAT bond returns interest and full principal to the investor.

About $6 billion of insurance exposure has been transferred from underwriters in the insurance and reinsurance markets to CAT bond investors in the capital markets. The steady issuance (around $1 billion per year) testifies to the continuing benefits of such transfers and contributes to the growing liquidity of these instruments. The advantages have become even clearer in the past few years due to, among other factors, uncertain availability of traditional insurance/reinsurance sources for issuers, the uncorrelated nature of CAT bond returns versus corporate default experience, and new parametric structures which further enhance the bonds' transparency to investors. The latter is a particularly attractive feature in light of recent high profile corporate "wrongdoing" and accounting fraud.

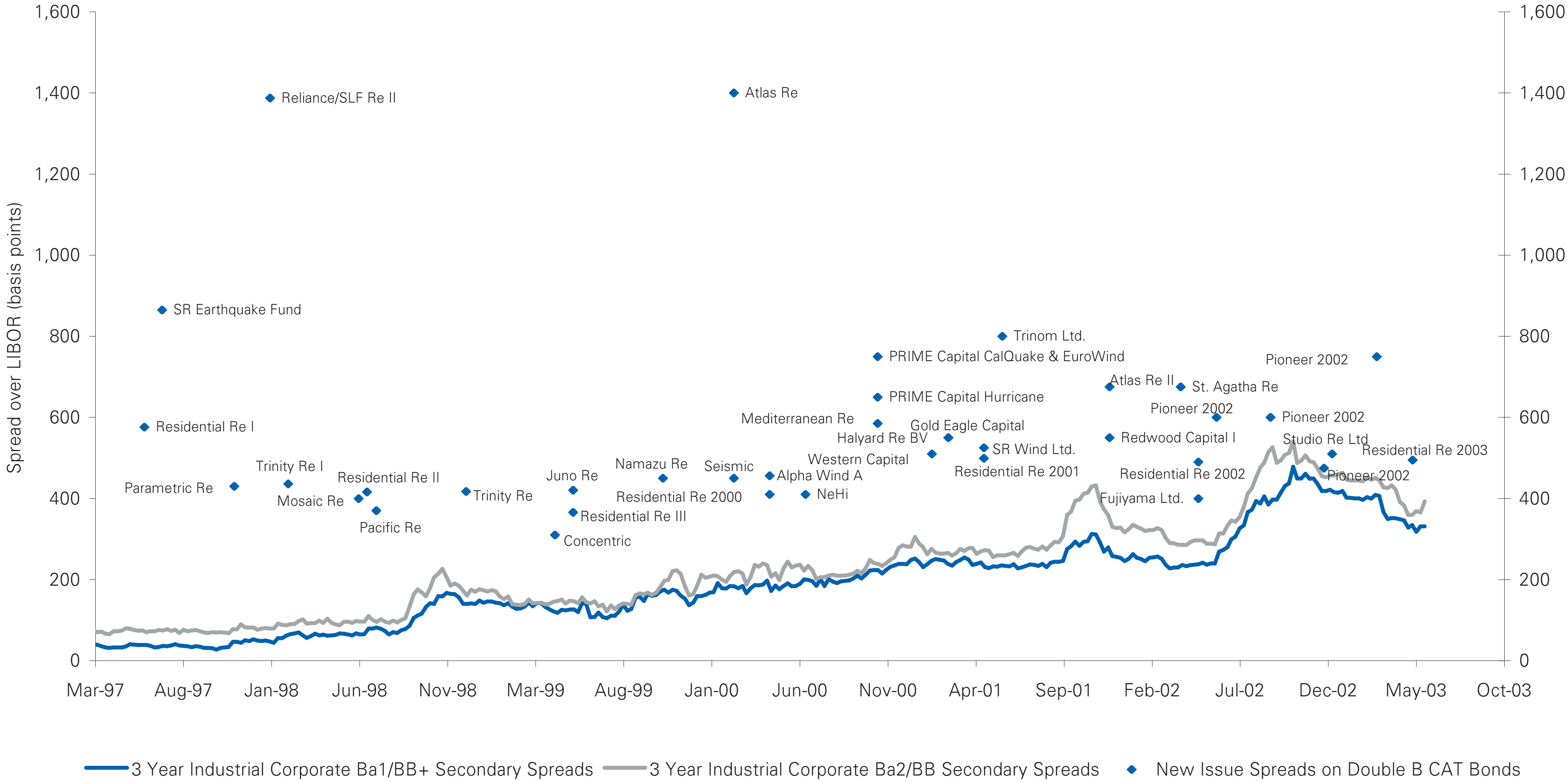
Investor Considerations

CAT bonds present investors with a number of distinguishing characteristics that can make them an attractive portfolio addition. These include spread pickups (historically), diversification, transparency of results, and vetting by independent third parties.

- **Spread Pickup**
  Spreads on CAT bonds have historically been considerably wider than comparably rated corporates, though recently the spreads have converged somewhat. Exhibit 1 shows double-B quality CAT bond spreads versus double-B three-year corporate bond spreads since 1997. Loss experience on CAT bonds or related structures has been limited to only three issues (Reliance/SLF Re IV, Kelvin and George Town Re), and the losses have been less severe than the typical 60-70% loss for defaulted corporate bonds. (See Appendix I for a detailed list of CAT bond issuances and related structures.[1])

[1] The CAT bonds in the main table of Appendix I include only bonds triggered by natural catastrophes or weather events and for which actual funding was raised. This is followed by a list of related CAT structures.

Exhibit 1: Double-B CAT Bond Spreads vs. Double-B Corporate Spreads



Source: CAT Bond Spreads from Lane Financial, LLC; Corporate Spreads from Bloomberg

- **Diversification**
  CAT bonds provide diversification to traditional fixed income investors. Corporate defaults are expected to have essentially no correlation with the loss behavior of CAT bonds, which are linked to defined geological and weather events. (The exceptions would be for specific corporations adversely affected by the covered catastrophe or natural disasters large enough to affect an entire economy). In addition, there are diversification possibilities across CAT bonds, as correlation between different types of locales or catastrophes is essentially zero.

- **Diversification Benefits in CDOs**
  In recognition of the highly specific risks securitized in CAT bond transactions relative to other assets, the major rating agencies have indicated they would consider treating specific CAT bonds as separate "industries" in their respective risk diversification metrics. To qualify as a unique industry category, the CAT bond potential losses must have little correlation with all other industry categories, including insurance. This favorable treatment, in combination with historical spread pick-up, may make CAT bonds attractive candidates to enhance returns of CDOs.

- **Transparency**
  CAT bonds target the investor's exposure to the occurrence of a specified natural disaster, and utilize collateral arrangements to eliminate exposure to any credit risk of the SPV sponsor (i.e., the ultimate issuer). The payment mechanism is very visible. If a triggering event occurs, it is publicly known. The event is evaluated by an independent third party and, if it meets predetermined criteria, the issuer receives a payment. If it does not meet the criteria or if no event occurs, the investor is repaid in full at maturity. As a result, the CAT bond is more transparent than a corporate bond, which is exposed not only to the underlying financial returns of the issuing company, but also the risk of management wrongdoing and reporting problems.

- **Non-Binary Payment Structure**
  The loss payout structure for the majority of CAT bonds is graduated according to the severity and particular location of the catastrophic event. This means that, even in the unlikely event of a loss, an investor is not automatically exposed to complete loss of principal.

- **Involvement of Independent Rating and Risk Modeling Agencies**
  CAT bonds are rated by the major rating agencies, which compare CAT bond risk to corporate bonds with equivalent expected losses. These expected loss parameters are developed after detailed analysis by an independent, established catastrophe risk modeling agency. The involvement of these third parties helps ensure the integrity of loss estimates and comparability with similarly rated corporate bonds.

- **"Pure Play"**

  Through investment in CAT bonds, the investor has the ability to isolate exposure to a specific catastrophe event. By contrast, an investment in the securities of an insurance company forces the investor to accept a mixture of insurance risks, management risks, and investment portfolio risks.

- **Regulatory Treatment**

  Legal research has established that investors in CAT bonds will not be subject to insurance regulations in most US states and most major countries outside the US.

- **Accounting Treatment**

  Under US GAAP FAS 133, no separate accounting for the bond's embedded insurance component would be required, provided that the CAT bonds are of the parametric type where, by definition, the potential loss is tied to purely physical variables. Structured note accrual accounting would apply. (See Accounting Discussion section.)

- **Risk Factors**

  These include limited liquidity and "model risk." The limited liquidity is driven by several factors: (a) issuance amounts have been relatively small historically compared to corporates; (b) investors in the market have generally been limited in both number and investment size, though this is changing as more funds seek diversification opportunities; (c) there have been few market-makers to date. With respect to model risk, the attractiveness of CAT bonds depends on the robustness and transparency of the underlying probabilistic loss estimates for the particular catastrophic physical event. While these estimates are based on independent, expert analysis, there is risk (as is the case for any modeling predictions) that the model results may differ substantially from actual future outcomes. Historically, CAT bond spreads have been higher than comparably rated corporates as compensation for their more limited liquidity and perceived model risk.

Issuer Considerations

Catastrophe bonds bring considerable advantages to issuers, including offering an alternative source of insurance coverage, a means of avoiding credit exposure to insurers and reinsurers, and, in the case of multi-year issues, a way of "locking in" insurance premiums over several years.

- **Source of Capital for Insurers**
  For insurers and reinsurers, CAT bonds represent an alternative source of risk transfer capacity. The availability of reinsurance and the cost of insurance are cyclical, going through "hard" and "soft" pricing periods. When reinsurance is scarce and pricing is hard, the cedant (issuer) can tap the capital markets via CAT bonds instead of or in addition to the traditional sources.

- **Insurance Alternative for Other Issuers**
  While historically all but a handful of CAT bond issuers have been insurers and reinsurers, some corporations have issued directly. Two examples of such issuers are Universal Studios (Vivendi) with Studio Re, and Tokyo Disneyland (Oriental Land) with its Circle Maihama and Concentric transactions. (See Case Studies in Appendix II.) Another potential pool of issuers are sovereigns that face natural catastrophes on a recurrent basis, and whose economies are severely affected by these events. Disintermediating insurance companies in this way enables those issuers to directly benefit from the cost advantages of CAT bonds. Most recent CAT bonds have been issued with 3 or 5 year initial maturities, bypassing the pricing cycle typical of the traditional insurance market. Longer maturities are also possible, as there has been one 10-year issue to date.

- **Avoidance of Credit Exposure to Insurers**
  When CAT bond exposures are pre-funded through a standard SPV structure, the issuer (cedant) has minimal concern about insurance and reinsurance recoverables. Similarly, an alternative structure that may be considered is one where a double-A or triple-A third party corporation (instead of a SPV) would issue a CAT bond on behalf of the entity seeking insurance coverage, in which case the credit risk for recovery becomes that of the highly rated third party.

- **Accrual Accounting for CAT Bond Obligor**
  For CAT bond obligors (whether an SPV or a third party corporate) which are subject to US GAAP, parametric CAT bonds have a structure that avoids bifurcation of the embedded insurance feature under FAS 133. This allows for simple accrual accounting for the CAT bond obligor.

- **Contingent Structures**
  An issued and fully funded CAT bond may not meet every issuer's requirements for protection from catastrophic events. Structures in the form of an option to issue a CAT bond or trigger mechanisms that are contingent upon the occurrence of a prior event are two alternatives. Issuers retain the ability to obtain coverage at the time it is most needed but at reduced initial cost.

- **Risk Factors**
  For issuers, risk or cost factors for CAT bonds include: (a) with longer-term CAT maturities, the opportunity cost of missing out on unexpected soft periods in the insurance market; (b) the basis risk for parametric structures to the extent that the underlying parametric model does not accurately reflect actual losses incurred by the issuer; (c) the transactional costs involved with issuance (setting up the SPV structure, underwriting fee, modeling and rating agency fees, etc.), particularly for small issuance amounts.

The maturation of the CAT bond market, the ongoing need for corporations and sovereigns to source non-insurance industry coverage for catastrophe risk, and investors' demand for transparent, uncorrelated fixed income securities could drive an expansion of the CAT market beyond the traditional insurance participants on both the issuer and investor sides. In light of this opportunity, the purpose of this report is to provide a discussion of the principal conceptual and practical aspects of issuing and investing in CAT bonds. In particular, the report will address:

- Structure of CAT bonds, with a focus on the parametric type
- Roles of different parties, particularly modeling firms and rating agencies, in the issuance of CAT bonds
- Models for pricing CAT bonds
- A simple portfolio simulation model illustrating the potential advantages of adding CAT bonds to an investment portfolio
- Some highlights of U.S. GAAP accounting treatment

CAT Bond Basics and Structuring

Insurance and Reinsurance

Individuals and businesses manage their risk, at least in part, by purchasing insurance, which provides financial compensation for losses incurred. The insurance underwriter assesses the risk and establishes the price, or premium, paid by the insured to the insurer in consideration of covering his interests. Insurance companies are well equipped to manage the risk and potential losses associated with many kinds of claims, such as those arising from fires and automobile accidents. There exists a wealth of historical data associated with such losses that enable actuaries to determine, with a high degree of confidence, what future losses are likely to be.

Managing the risk from high-impact low-frequency events, such as major hurricanes and earthquakes, is much more problematical for insurance companies. The relative infrequency of such events and the resulting scarcity of historical loss data make it difficult to reliably estimate potential future catastrophe losses using standard actuarial techniques. Furthermore, a single hurricane or earthquake can cause widespread damage and affect large numbers of policies simultaneously, resulting in substantial payouts from insurance companies.

There are many ways of financing these “shock losses” to alleviate the disruptions they cause. They can be classified, however, under two broad categories: generating funds internally or transferring the risk. Companies can retain the risk and generate funds internally by maintaining additional liquid funds on hand, issuing debt, or issuing equity. In general, however, it is beyond the means of most companies to generate internally the amount of funds necessary to absorb catastrophic losses. Even if self-insurance is possible, it may not be an efficient use of capital. Even some sovereigns, particularly those in less developed economies, would feel significant fiscal pressure in the face of such catastrophic losses. By implication, supranationals such as The World Bank, which provide assistance to such economies, would also be under pressure in these circumstances.[2]

Consequently, to manage natural hazard risk, there is almost always some element of risk transfer. The most common form is reinsurance, where insurance companies transfer some or all of their catastrophic risk exposure to reinsurance companies.

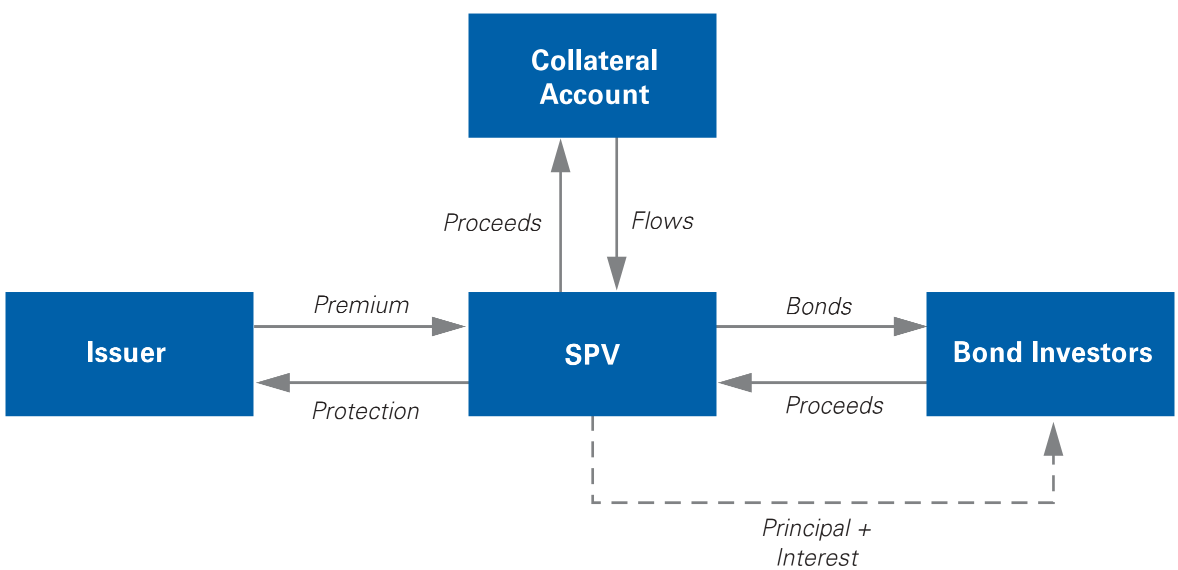
[2] In the US, an example of a state entity providing catastrophic insurance (through its participating member insurance companies) is the California Earthquake Authority (CEA), established in 1996. In 2001, the CEA ceded $100 million of earthquake risk through Swiss Re to Western Capital, an SPV which in turn issued CAT bonds to the market. A second example is the Florida Hurricane Catastrophe Fund, established in 1993 to provide additional reinsurance capacity in Florida for hurricane risk. The Fund collects premiums and reimburses insurers for a portion of their catastrophic hurricane losses. No CAT bond related to the Fund has yet been issued.

Insurance Risk Securities

CAT bonds are a recent alternative to traditional reinsurance contracts for corporates, governments and supranationals. A CAT bond is a bond whose eventual payout is tied to a catastrophic event such as an earthquake or hurricane. The coupon the investor receives from the issuer can be decomposed into the basic market interest rate (generally LIBOR) plus a spread. From the point of view of the issuer, the spread paid is essentially equivalent to an insurance or re-insurance premium. In a case where there is no catastrophic event, the investor receives the entire face amount of the bond at maturity. However, if there is a qualifying catastrophic event during the risk period, the investor will receive the original principal amount less any loss payments made to the issuer.

The figure below illustrates the typical structure of a CAT bond issued by a special purpose vehicle (SPV). The ultimate issuer is the entity seeking insurance coverage. It enters into a reinsurance agreement with a bankruptcy remote SPV set up for the purpose of issuing the CAT securities. The issuer pays a premium to the SPV in exchange for insurance. The investors, or noteholders, who purchase the securities provide the principal equal to the face amount of the reinsurance agreement. The investors receive interest payments based upon LIBOR plus a spread commensurate with the risk inherent in the reinsurance contract. Additionally, they receive the return of their principal investment less any loss payments that may be made. The funds raised from the sale of the CAT bond are held in a collateral account in the form of high-grade, liquid securities, to which interest rate or total return swaps may be applied. The securities are liquidated upon redemption of the bond, with the principal split between the amount due the issuer for loss payments, if any, and the residual going to the investor.

Typical CAT Securitization Structure



Source: Deutsche Bank

The issuer's qualifying losses can be quantified based on the trigger structure used for the bond. Although there are many variations, the two most representative structures are:

- **Parametric**
  Most recent CAT bonds apply this approach. If the defined event occurs, the loss on the bond is calculated using a set formula based on measurements of the event as determined by an independent third party expert. For example, measurements of an earthquake's magnitude or intensity at a specific location can be used to calculate losses on an earthquake bond. The advantage of this approach is a rapid payment to the issuer, and transparency and accuracy of measurements for the investor. Table 1 lists typical measurements for different categories of parametric bonds. The parametric table (for an earthquake-linked bond) might look as follows:

Example of Parametric CAT Bond Structure

Event Scale	Moment Magnitude	Loss to Investor	Estimated Annual Probability
Lowest Severity	6.5	0%	2.5%
Next Level of Severity	7.1	40%	1%
Highest Severity	7.7	100%	0.20%

- **Indemnity**
  Earlier CAT bond structures attempted to link bond losses to actual insured losses incurred, but these structures are now used by a limited number of issuers. For issuers, this structure results in long lead times for payments and to disclosure of their book of business and underwriting approach. For investors, there is uncertainty as to the accuracy of the loss calculation. Indemnity CAT bonds also raise other "moral hazard" concerns, though there is an attempt to address these concerns in structuring the transaction.

Table 1: Typical Loss Triggers for Parametric Bonds:[1]

Risk	Parameters	Intermediate Steps	Loss to Bondholders/Payment to Sponsor Occurs When…
▪ Hurricane	▪ Central pressure (CP) ▪ Landfall location in defined "gates"	▪ None	▪ CP is equal or below a specified trigger level defined in the offering circular ▪ Landfall is inside designated gate
▪ Earthquake	▪ Magnitude ▪ Spectral acceleration ▪ Epicenter in defined areas ▪ Depth	▪ None	▪ Magnitude is equal or higher than a defined trigger level ▪ Magnitude is equal or higher than a defined trigger level ▪ Location is within a defined area specified in the offering circular ▪ Depth is lower than or equal to a trigger level defined in the offering circular
▪ Windstorm	▪ Wind speed	▪ Creation of a wind index by aggregating observations from several recording stations.	▪ Index value is equal to or higher than a predetermined trigger level
▪ Temperature	▪ Accumulated temperature (degree days) in a defined region and in a defined period of time	▪ Creation of an temperature index, "CDD" or "HDD"	▪ HDD or CDD value is greater or lower than a predetermined value ("Strike")

Note: (1) The triggers are defined at the issuance of the bond. The measurement of the relevant parameters is made by independent reporting agencies on a continuing basis. These agencies hence determine the value of the parameters upon the occurrence of the triggering event.

Source: Deutsche Bank

Contingent Structures

The predominant form of CAT bonds has been fully funded transactions that provide coverage to the issuer immediately from the time of issuance. A qualifying event will result in a recovery by the issuer and a reduction in bond principal. However, certain issuers may be more focused on their ability to obtain coverage subsequent to the occurrence of an event, driven by concerns about the future liquidity of the insurance and reinsurance markets, or about increased premium levels. Two structures that have been successfully used to meet these issuer concerns are options to issue CAT bonds, and contingent triggers.

- Reliance/SLF Re III and Allianz's Gemini Re were structured as options to issue a CAT bond. The issuers paid a premium to the investors for their commitment to stand ready to purchase a CAT bond if the issuer chose to exercise the option. Such structures may involve conditions to be met prior to exercise (for example, a deductible involving the occurrence of one or more events), or exercise may be at the complete discretion of the cedant. These conditions can be tailored to meet the issuer's particular needs at a lower initial cost (premium) than a traditional CAT bond. Other structuring issues may involve the deposit by investors of a portion of the bond purchase amount as a good faith deposit. This deposit would be paid to the issuer if the investor chose not to extend liquidity following option exercise (for instance, if the investor believed that the issuer posed a strong default risk post-event).

- Contingent triggers have been used to provide coverage for subsequent events (Kelvin Ltd. and Trinom Ltd.) or to provide post-event liquidity (Circle Maihama). Kelvin's second event tranche was at risk of loss only after a loss had occurred to the first event tranche. Trinom's Class A-2 and Preference Shares pay a higher spread and were at risk only after an event had caused a loss to the Class A-1 notes. The spread on the Class A-2 and Preference Shares was significantly lower pre-event so that the issuer, Zurich Insurance, was able to obtain fully funded, second event coverage at a greatly reduced initial cost. No such adjustment was made to Kelvin's second event tranche but the spread paid over its term was relatively higher than in Trinom's contingent pieces. Circle Maihama was contingent on an event causing a loss to a related transaction, Concentric Re. The result was an extension in maturity of Circle Maihama as a general obligation of the issuer rather than an increase in spread (as in Trinom). The funds generated by Circle Maihama provided liquidity to the issuer (Tokyo Disneyland) to continue operation of the facility following an earthquake.

Key Parties in Catastrophe Bond Issuance

The issuance of a CAT bond involves a number of different parties. These include:

1) The entity (corporation, sovereign, or supranational) seeking insurance through a CAT bond structure.

2) The special purpose vehicle (SPV) set up for the purpose of issuing the securities.

3) The financial institution that structures and underwrites the transaction and markets the notes.

4) The modeling firm that evaluates the risk of loss, determines the probabilities of loss and evaluates the effect of potential events on the transaction.

5) The rating agencies that rate the notes.

6) Attorneys and accountants who may advise the issuer, the SPV and the investors on certain aspects of the transaction.

7) A custodian bank that manages the funds in the SPV, and makes interest and principal payments according to the terms of the supporting agreements.

8) For parametric structures, the reporting agency which verifies the magnitude and intensity of the triggering events.

Because of the unique role played by the modeling firm (party 4) in the transaction, and how its analysis factors into rating agency (party 5) considerations, we will examine the activities of these two parties in more detail.

Role of Modeling Firm

Critical to the process of issuing CAT bonds is the catastrophe modeling firm charged with quantifying the risk. This involves understanding the probability of default, of total loss, and the expected loss to the notes. For the issuer, it is very important that the payout from the bond bears a good relationship to the losses that the issuer incurs should the defined event occur. Both the issuer and the investor are concerned that the probabilities of loss are accurate so that pricing is appropriate. Therefore, fundamental to structuring and pricing a CAT bond is a reliable estimate of expected loss. Yet the infrequency of catastrophic events makes reliance on scarce historical loss data for estimating future losses a challenge. Furthermore, the usefulness of the loss data that do exist is limited as a result of changing property values, construction methods, and demographics.

Estimation of the impact of natural catastrophes is done using stochastic simulation techniques. These models probabilistically generate the location, frequency of occurrence, and the primary characteristics of catastrophe events (whether meteorological or seismological), and apply mathematical functions that relate the intensity of the event to structural damage. (See Appendix III for a more detailed discussion of the catastrophe modeling process.) Catastrophe models provide scientifically-based loss estimates derived from the simulation of thousands of potential event scenarios, resulting in the complete range of potential annual aggregate and occurrence loss experience. The models are validated at every stage of their development by comparing model results with actual data from historical events, including claims data provided by clients and other insurance industry sources. The models are also validated and calibrated through the use of extensive post-disaster field survey data.

As discussed earlier, for parametric CAT bond structures, a loss to the investor is triggered by one or more objectively determined physical parameters of the peril, such as earthquake magnitude and location, or hurricane wind speed. From the point of view of the investor, the role of the modeling firm in this case is to estimate the probability of occurrence of such triggering events. Losses on the notes are not directly connected with the issuer's losses, thus eliminating any need for the investor to understand details of the issuer's business. The investor need only be concerned with the modeling firm's expertise in estimating event frequencies and intensities, rather than in its ability to judge the vulnerability of structures and estimate probable losses on some book of business.

From the point of view of the issuer, however, a full risk analysis of the company's exposures is essential to an understanding of the basis risk inherent in the structure. The modeler must work with the issuer in determining the most appropriate trigger -- one that mitigates, as much as possible, that basis risk. The modeler can also quantify the basis risk that the issuer chooses to retain.

The modeling firm presents the results of detailed sensitivity analyses and stress-testing to the rating agencies. The modeler is also involved in writing the offering memorandum, in which both the modeling methodology and model results are described in detail. Similarly, the modeler plays an educational role in "road shows" and other investor meetings, where the structure of the transaction and quantification of the risk is presented to potential investors. Modelers can also help investors understand the correlation between various CAT bonds in the market and thus help them diversify their CAT bond holdings.

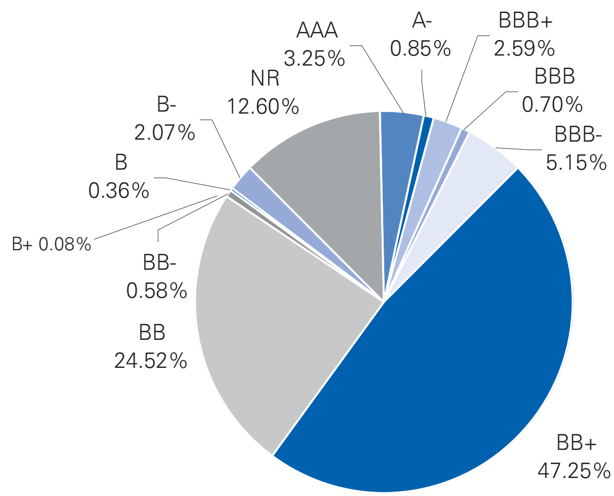
Role of Rating Agencies

Most, though not all, early CAT bonds were rated by the major rating agencies, and that trend has increased over time. Today, virtually all CAT bonds are rated. Early structures often had a highly rated senior tranche, one or more intermediate tranches, and an equity tranche, generally unrated. With experience and a better understanding of the universe of potential investors for these securities, structures have changed over time. Now, double-B tranches predominate, and the equity tranches are rated. One important factor in the move to a rated equity piece was the need to comply with off-balance sheet accounting requirements, although the recently issued FIN 46 for US GAAP changes the parameters going forward.

The process of arriving at a rating for a catastrophe bond is similar to that the rating agency follows for other securities, namely, assessing the risk of loss to an investor. The rating agency calibrates a CAT bond rating to the ratings on corporate bonds with similar expected losses. With CAT bonds, this assessment of expected loss focuses on the results of the independent modeling firm which determines the probability of any loss (attachment), the probability of a complete loss to the limit of the contract (exhaustion), and the most likely amount of loss (expected loss). The rating agencies then stress test these probabilities in their own models.

Rating Distribution of All Issued CAT Bonds

- Weighted by Principal Amount
- Rating at issuance
- Classified by S&P rating if rated by S&P, Moody's equivalent otherwise
- Includes all tranches of issued CAT bonds on p. 28 (Appendix I)



Source: Lane Financial, LLC

CAT Bond Pricing

Alternative Pricing Models

Developing models of CAT bond pricing is valuable to help estimate new issue pricing. CAT bonds can be divided into two components: a bullet bond, and an embedded insurance policy. The challenge in pricing a CAT bond arises from valuing this embedded policy. The policy has option-like characteristics, but is not appropriate for application of the Black-Scholes methodology, as the market for catastrophic risk is not subject to arbitrage (i.e. delta hedging). In addition, the distribution of CAT risk has particularly long "tails", and is more negatively skewed than is permitted in the Black-Scholes model assumptions.

Reinsurance price behavior is a useful proxy in pricing this embedded option. Reinsurance premiums are driven by conditional expected loss, probability of first loss, and load. Conditional expected loss (CEL) is the expected loss given that an event occurs. Probability of first loss (PFL) is the likelihood of this event occurring. Expected Loss, (EL) is the product of CEL and PFL. Load or expected excess return (EER) is the excess of premium over EL, and is compensation for covering unexpected losses. Rodney Kreps and John Major of Guy Carpenter & Company, Inc.[3] studied the behavior of reinsurance pricing and found a useful empirical relationship for the period studied (1999):

$$\text{Reinsurance Premium } P = EL + EER = 0.47 \times (CEL \times PFL)^{0.53}$$
$$= 0.47 \times (EL)^{0.53}$$
$$\text{where the general form is } P = \gamma \times (CEL \times PFL)^{\alpha} = \gamma \times (EL)^{\alpha}$$

The Kreps and Major model form (K&M) has proven to be quite a successful reinsurance formula in its application to CAT bond pricing. Another pricing formula, tailored specifically to pricing CAT bonds, was introduced by Lane Financial LLC (LFC). It seeks to explain the tradeoff that investors appeared to make between the frequency of loss and the severity of loss when pricing CAT bonds in the early days of issuance. Historical evidence reveals that the market assigns different spreads to bonds with identical expected losses, but diverging PFLs and CELs. For the same EL, investors accept a lower spread to reduce frequency of loss versus reducing severity. LFC's formula explains this tradeoff between frequency and severity of loss by following the same form as the Cobb-Douglas production function, an economic function that explains the tradeoff between capital and labor in theories of the firm. According to the LFC formula:

$$\text{Spread} = EL + EER = EL + \gamma \times (PFL)^{\alpha} \times (CEL)^{\beta}$$

As investors' tradeoffs between frequency and severity of loss may change over time, the parameters will change correspondingly and are re-estimated quarterly: γ, α and β estimates for 4Q 2002 are 28.17%, 40.59% and 19.34% respectively. The updated K&M model for 4Q 2002 is spread = $0.4937 \times (EL)^{0.471}$.

[3] Guy Carpenter & Company, Inc. is a subsidiary of Marsh & McLennan Companies.

Illustrating the Use of Pricing Formulas for New Issues

To illustrate the application of these various formulae, consider the issue price of Studio Re CAT bonds and shares issued at the end of December 2002. The parameters that were either disclosed, or calculated[4] were as follows:

Bonds	Probability of First Loss	PFL	1.38%
	Conditional Expected Loss	CEL	47.1%
	Expected Loss	EL	0.65%
Shares	Probability of First Loss	PFL	2.13%
	Conditional Expected Loss	CEL	80.3%
	Expected Loss	EL	1.71%

Using model fits as of 4Q 2002, the following spreads are projected:

	K&M Model	LFC Model	Actual Issue
Bonds	4.61%*	4.93%*	**5.10%**
Shares	7.26%	7.37%	**8.00%**

*Illustrative calculation:

K&M Model: $0.4937 \times (.0065)^{.471} = .4937 \times .0933 = .0461 =$ *4.61%*

LFC Model: $.0065 + [.2817 \times (.0138)^{.4059} \times (.471)^{.1934}] = .0065 + [.2817 \times .1758 \times .8645] = .0065 + .0428 = .0493 =$ *4.93%*

This demonstrates several features of the models. First, neither one is perfect. Both underestimated the eventual issue spread (in this example). Given the ultimate issue spread, the formulae indicated that Studio Re was "cheap" to investors, and, in fact, spreads narrowed on the Studio Re securities immediately following their issue.

In summary, no single agreed-upon CAT bond pricing model exists at the present time. However, several models seem to suggest reasonable price predictions. These can be useful guides to both issuers and investors.

[4] PFL and EL are given in the offering circular. CEL is simply EL divided by PFL.

Portfolio Diversification Benefits For Investors: A Simulation Model

Model Synopsis

Deutsche Bank has developed an in-house Monte Carlo simulation model which estimates the return and risk effects of adding CAT bonds to a portfolio of corporate bonds. The model generates expected return and various risk measures by sampling from the appropriate probability distributions over thousands of trials, over a multi-year period. From these metrics, it constructs efficient frontiers (representing portfolios that maximize return for a given level of risk). CAT bonds are shown to improve upon an efficient frontier consisting of only corporate bonds, due to their spread pickup, as well as their significant risk diversification benefits stemming from their lack of correlation with corporates (and each other).

The model specifies spreads to LIBOR for all the corporate and CAT bonds. It incorporates the characteristics of actual CAT bonds, in terms of different possible loss levels and their corresponding probabilities of occurrence. The loss potential of corporates reflects probabilities of default based on transition matrices and recovery rate assumptions developed by rating agencies. The model also incorporates correlations among the bonds based on industry groups.

It is also possible using this model to incorporate additional constraints, such as having CAT bonds comprise no more than 10% of the total portfolio, or limiting non-investment grade bonds to no more than 25% of the portfolio. This flexibility is helpful in order to satisfy the eligibility criteria of some portfolio managers who might consider adding CAT bonds to their existing or future portfolios.

Generating the Simulation Paths

The simulation generates a multitude (typically at least 5,000) of "paths" of year-by-year cash flows for the corporate and CAT bonds, developed by sampling from the probability distribution appropriate to each bond. From the cash flows, internal rates of return (IROR), measured as a spread to LIBOR, are computed. A particular path therefore results in a set of returns for each bond for that path. For example, 5,000 paths for a portfolio of 10 bonds would result in 5,000 groups of 10 returns each. Since the bonds are assumed to be held to maturity (absent default for a corporate, or early redemption due to a triggering event for a CAT bond), a bond's return for a given path depends only on whether it survives or not for a given year. If it does survive a given year, the spread is earned and the bond moves on in the simulation to the next year.

For the corporates, the rating at the start of each year defines a set of probabilities for the possible ratings at the end of the year. These are mapped to specific threshold levels for a uniform normal distribution such that the probability of getting a random draw between successive threshold levels equals the corresponding rating transition probability. By assuming that a corporate's market asset value follows a normal probability distribution, the correlation effects between bonds in the joint probability distribution for each pair of bonds may be readily incorporated. The final rating states at the end of each year, including possible defaults, then correctly embed the bond correlation effects.[5] While there are many possible rating states for a corporate bond at the end of each year, the cash flow for a particular path depends only on whether a default has occurred or not. For example, for a 5-year corporate (with assumed annual coupons and defaults possible only at the end of each year), there is a total of 5 possible loss states (i.e., default in year 1, year 2,… ,year 5), plus the no-default case, for a total of 6 final IROR outcomes. As it is important to measure all returns over a common time horizon whether a default occurs or not, all intermediate cash flows are assumed to be reinvested at a specified rate until year 5. If the bond survives a given year, just the coupon is reinvested; if a default occurs, the coupon and recovery amount of the principal are reinvested. The IROR is then computed based on the probability-weighted terminal cash balance at the end of year 5.

For the CAT bonds, multiple states corresponding to the different loss levels are possible each year in the simulation, each of which will result in a different return for the path. For example, for 5 possible loss levels for a 5-year bond, the total number of return outcomes is 5*5 = 25 if a loss occurs, plus 1 for the loss-free outcome, for a total of 26 final IROR outcomes. As for the corporates, all intermediate cash flows are grown to the end of year 5 at the assumed reinvestment rate.

The overall portfolio 5-year IROR for a given path is simply the weighted sum of the individual IRORs, where each weight is the proportion of the total portfolio invested in that particular bond. By generating thousands of paths, a distribution of portfolio returns for a given set of weights is obtained. A standard optimization routine is then used to determine the "best" set of weights such that the objective function is met, maximizing expected return for a given level of risk. Risk may be measured either by the usual standard deviation of portfolio return, or on a specific percentile basis (e.g., the 5th percentile of the return distribution, such that only 5% of the outcomes have lower returns than the specified level).

[5] This methodology for modeling default correlation effects is based on an established approach that has been extensively discussed in many sources. See, for example, JP Morgan, CreditMetrics Technical Document (particularly Chapters 8 and 10), April 2, 1997, available on the RiskMetrics Group website at riskmetrics.com; KMV, "Porfolio Management of Default Risk", May 31, 2001; FitchRatings Structured Finance, "Default Correlation and its Effect on Portfolios of Credit Risk," February 5, 2003.

Illustrative Example

To simulate a representative diversified corporate portfolio, we created a hypothetical portfolio of 20 corporate bonds, each of 5-year bullet maturity and spanning 5 different industries. To this base portfolio, a 5-year CAT bond assumed to have zero correlation with the corporates was then added, for a total portfolio of 21 bonds. (The CAT bond is assumed to be linked to a catastrophe in a less developed region remote from the locale of the corporates.) The rating and spread characteristics of the portfolio are as follows:

Obligor	S&P Rating	Industry	Spread Over LIBOR
1	A	1	0.51%
2	A	2	0.51%
3	A	3	0.51%
4	A	4	0.51%
5	A	5	0.51%
6	A	1	0.51%
7	A	2	0.51%
8	BBB	3	1.16%
9	BBB	4	1.16%
10	BBB	5	1.16%
11	BBB	1	1.16%
12	BBB	2	1.16%
13	BBB	3	1.16%
14	BB	4	4.30%
15	BB	5	4.30%
16	BB	1	4.30%
17	BB	2	4.30%
18	BB	3	4.30%
19	BB	4	4.30%
20	BB	5	4.30%
21	BB	CAT	4%, 5% or 6%

The corporate spreads reflect Bloomberg five year industrial bond indices for the end of February 2003.[6] The corporate credit ratings are assumed to evolve each year over the 5-year horizon via the probabilities given in the S&P one-year ratings transition matrix (8 states, including default) as updated through 2002.[7] The recovery rate for corporates is taken to be 35%, independent of initial rating.[8] The correlation coefficient of the asset values of each pair of corporate bonds is assumed to be 50% if the pair is in the same industry group, and 40% between different groups.[9] Again, the corporates all have zero assumed correlation with the CAT bond.

[6] Spreads are for mid-single A, BBB, and BB indices versus the 5 year swap rate. Since February, the A and BBB spreads have widened slightly (as of 5/13/03) to 54 bp and 118 bp, respectively, while the BB spread has narrowed quite considerably to 365 bp. As the BB bonds are competing with the CAT at the high return end of the efficient frontier, using a relatively high spread for the BB versus current levels may be viewed as being conservative with respect to the potential benefits of the CAT at the present time. However, 430 bp for the BB spread is fairly close to the average BB spread over the May 2002 - April 2003 period, during which average spreads for the A, BBB, and BB indices were 51 bp, 123 bp, and 413 bp, respectively (12-point average computed from month-end Bloomberg data).

[7] See Table 8 in Standard & Poor's RatingsDirect Research, "Corporate Defaults Peak in 2002 Amid Record Amounts of Defaults and Declining Credit Quality – Hazards Remain," March 6, 2003.

[8] Moody's default studies indicate typical corporate recovery rates in the 30-40% range; see p. 20 of Moody's Special Comment, "Default & Recovery Rates of Corporate Bond Issuers - A Statistical Review of Moody's Ratings Performance, 1920-2002," February 2003.

[9] The FitchRatings Structured Finance report already cited indicates (p.2) that the average asset correlation between different industries is 40%. The study does not cite a statistic for the within-industry correlation, but this would be expected to be considerably higher; we conservatively assumed 50% for purposes of our analysis.

The CAT bond is modeled to have an annual probability of first loss (PFL) of 1.25%, and five possible, discrete loss buckets:

Loss to CAT Investor	*Assumed Annual Probability*
0%	98.75%
60%	0.40%
70%	0.30%
80%	0.20%
90%	0.10%
100%	0.25%
	100.00%

A probability-weighted loss calculation produces an expected loss (EL) for the above CAT bond of 95 bps. PFL and EL levels around 1% are typical for CAT bonds. This CAT bond was then analyzed assuming three different coupon spread levels of 400 bps, 500 bps, and 600 bps to understand what spread it would take to make the CAT bond an attractive addition to the portfolio. In this context, it is also interesting to consider the "breakeven spread", defined as the spread for which the probability-weighted internal rate of return in excess of LIBOR is exactly zero. This spread will be 95 bps for a CAT bond with the loss table above and a zero reinvestment rate; this breakeven drops to 88 bps for a reinvestment rate of 3%, 85 bps at 4%, and 83 bps at 5%. The assumed reinvestment rate in the present example is set at 4%.[10]

The model simulated 10,000 paths for returns on each bond, using the Monte Carlo simulation technique to generate the underlying correlated normal distributions discussed earlier. The efficient frontier is defined by the weights for each bond that maximize expected return for varying levels of standard deviation of return (the risk measure). While the optimization is performed utilizing 5-year return and risk metrics, the results are transformed back into 1-year equivalents for display purposes.[11] The efficient frontiers generated by the model for this example are shown below assuming no constraint on the proportion of the CAT bond in the total portfolio. In this unconstrained case, the addition of a CAT bond having a spread of 500 or 600 bps substantially enhances expected return for a given level of risk. At the highest risk level, the expected return increases from 2.85% in the portfolio having no CAT bond, to about 4.00% in the portfolio which includes the CAT bond having a 500 bp spread, an increment of 115 bps. The portfolio would consist entirely of CAT bonds at this highest risk/highest

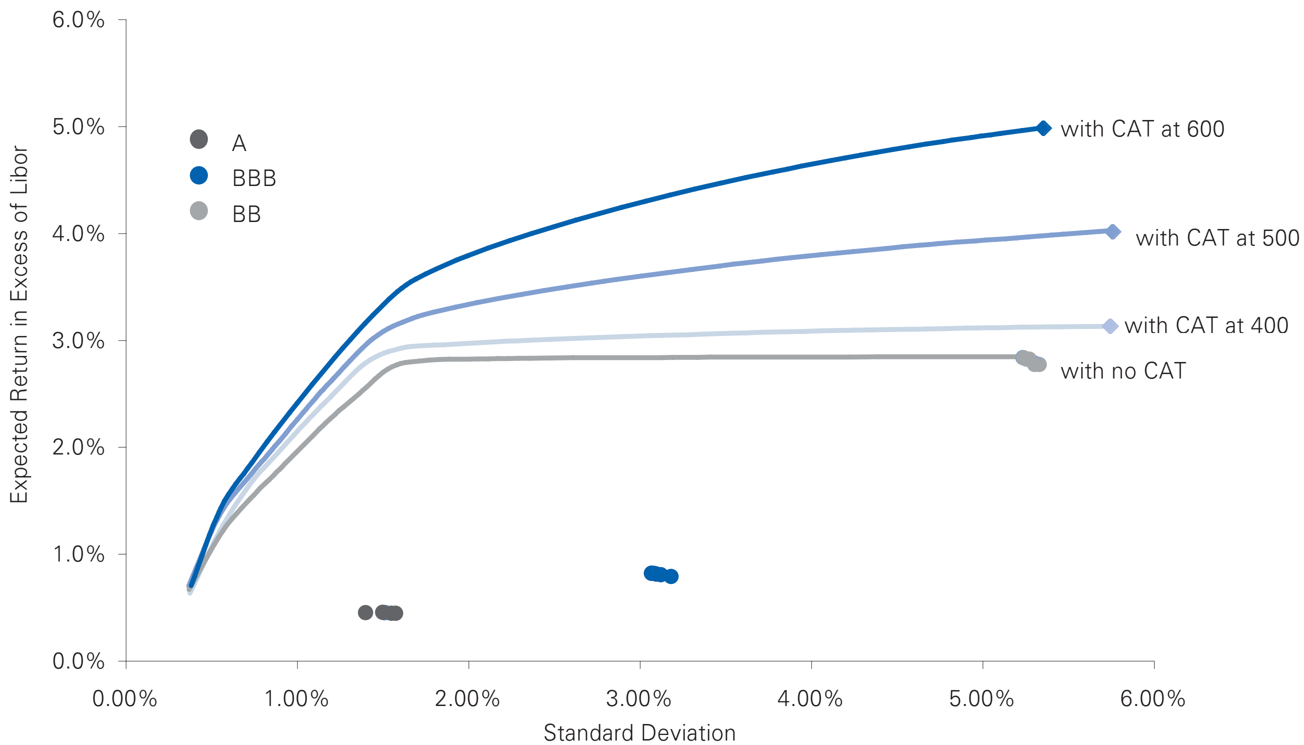
[10]Assuming the cash flows are invested at LIBOR flat, forward swap rates may be used to estimate the reinvestment rate. A rate of 4% approximates the time-weighted average of the current 4 year swap rate 1 year forward, 3 year swap rate 2 years forward, 2 year swap rate 3 years forward, and 1 year swap rate 4 years forward (3.3%, 3.8%, 4.2%, and 4.5%, respectively).

[11]The 1-year equivalent return is simply derived as the annual return which, when compounded for 5 years, produces the 5-year expected return. For the 1-year standard deviation, starting with each individual path's 5-year return, we derive the corresponding equivalent annual return and then take the standard deviation of this set. (Note that the average of the individual returns will not in general equal the 1-year equivalent return imputed from the 5-year expected return, due to compounding effects.) Alternative reasonable measures of 1-year standard deviation are certainly possible, as long as the metric is applied consistently. There is no perfect measure of dispersion for highly skewed distributions with long tails of low probability.

return point. With the CAT bond at the higher 600 bps spread, the incremental expected return grows about another 100 bps to 215 bps versus the no CAT portfolio, and again the CAT bond would comprise 100% of the portfolio. At the lower spread of 400 bps, the CAT bond adds about 25-30 bps at the high risk end, and once again constitutes the entire portfolio. To help benchmark the efficient frontier, the graph also displays the individual risk/expected return characteristics of the clusters of the A, BBB, and BB component bonds on a pure, stand-alone basis (no correlations with any other bonds).

If the CAT bond is constrained to be no more than 10% of the total portfolio, its incremental benefit versus the no CAT case is, as expected, considerably smaller. For spreads ranging from 400 to 600 bps, the pickup versus the no CAT bond portfolio ranges from about 5 to 25 bps.

Estimated Efficient Frontier with no constraint on CAT bonds



Source: Deutsche Bank

Selected Points (between minimium and maximum risk) on Efficient Frontier with CAT Spread = 500 bps

Portfolio Risk	0.37%	1.44%	2.44%	3.63%	4.74%	5.75%
Portfolio Return	0.70%	3.02%	3.47%	3.73%	3.90%	4.02%
CAT Bond Weight	1.3%	21.7%	54.0%	75.5%	90.4%	100.0%
A Corporate Weight	77.7%	0.0%	0.0%	0.0%	0.0%	0.0%
BBB Corporate Weight	15.1%	2.7%	0.0%	0.0%	0.0%	0.0%
BB Corporate Weight	5.9%	75.7%	46.0%	24.5%	9.6%	0.0%
Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Accounting Discussion

Highlights

Both CAT bond obligors and investors complying with U.S. GAAP need to consider the accounting for CAT bonds in light of recent developments for consolidation/deconsolidation in FAS 140 and FIN 46 as well as derivatives and hedge accounting developments in FAS 133 (and its Amendments, FAS 138 and 149). In the discussion below, the focus on the issuer side is restricted to the actual obligor of the CAT bond, whether it be an SPV or a direct issuance by a corporation or sovereign; we do not address the accounting standards for the contract between the cedant and the SPV when an SPV is employed. Further, as with application of any new accounting policy or standards, both issuers and investors should check with their own professional advisors before implementing any particular accounting treatment to ensure it is appropriate to the facts and circumstances at hand.

Implications of recent accounting developments are as follows:

- It appears unlikely that FIN 46 will be an obstacle for CAT bonds that are widely distributed across many investors.
- Parametric CAT bonds are exempt from bifurcation under FAS 133, and therefore the insurance component does not need to be marked to market by either CAT bond obligors or investors.
- For the investor, CAT bonds are regarded as structured notes, which results in some coupon interest being recognized in later periods.

Consolidation Concerns

Released by FASB in January 2003, FIN 46 is pertinent to the question of potential consolidation of an SPV structure issuing CAT bonds. If it is determined that the SPV fits the category of a Variable Interest Entity (VIE), it must then be tested to see whether there is any primary beneficiary exposed to the majority of its expected losses or, absent this, to the majority of residual returns. If there is no such majority position, no one needs to consolidate the VIE. However, consolidation would clearly be a concern for an investor exposed to more than 50% of the expected losses.

Embedded Derivative Exemption

In its discussion of derivatives, FAS 133 addresses hybrid securities with “embedded” derivatives that may need to be bifurcated. Parametric CAT bonds would be exempt from bifurcation under the weather contract exclusion [FAS 133 para. 10(e)], which does not classify as a derivative any contract whose payout is based solely on climatic, geological or other physical variables. The older indemnity CAT bond structures would also qualify for exemption from bifurcation under the exclusion for insurance contracts [para. 10(c)]. The critical requirement is that the benefit is paid to the entity buying insurance only when that entity is actually exposed to and incurs losses as a result of the catastrophic event . By contrast, CAT structures whose payout is based on an industry index of losses would require bifurcation [para. 192 example].

All European Union companies with listed stock must comply with International Accounting Standard Committee (IAS) standards by 2005. IAS 39 is similar to FAS 133 in most respects, although the treatment for CAT bonds is perhaps slightly less definitive. The IASB is currently addressing insurance contracts and is expected to issue new standards by 2004, which should help clarify how to handle CAT bonds.

Structured Note Accounting for Investors

While no bifurcation would be required for parametric CAT bonds under U.S. GAAP for investors, the accounting remains more complex than a straight accrual of the coupon on the bond into interest income. The bond would be treated as a structured note (EITF 96-12) since the principal is at risk due to the occurrence of certain catastrophic events. For a structured note, the retrospective interest method would be applied each period whereby an effective yield is calculated which equates actual prior cash flows and future expected cash flows (which would reflect the probability of losses) to the initial investment amount. As each period elapses and the bond survives, the expected cash flows get updated and a new effective yield is produced. The result for a bond that survives through maturity may be interest income in the beginning time periods somewhat lower than the coupon rate, but higher at the back end. The amortized cost of the bond also adjusts over the bond's life. It is usually assumed that the stated probabilities of catastrophic loss remain stable over time, and in that case, the investor can calculate up front the interest income to be recognized each year for any possible loss or survival outcome.

Illustrative example of retrospective interest method accounting:

Consider a highly simplified three year $100 million CAT bond, with a 10% annual coupon and 1% annual probability of the CAT event. If the CAT event occurs, assume a total loss of principal but final receipt of the coupon payment. The results for two example scenarios are shown below:

	Bond survives until maturity		**Bond has loss event in year 2**	
	Interest Income Recognized ($mm)	*Amortized Cost of Bond ($mm)*	*Interest Income Recognized ($mm)*	*Amortized Cost of Bond ($mm)*
Time 0		$100		$100
Year 1	$9.36	$99.36	$9.36	$99.36
Year 2	$10.00	$99.36	($89.36)	$0
Year 3	$10.64	$0		
Total	$30.00			

Source: Deutsche Bank

Appendix I: CAT Bond Issuance History

Catastrophe Bond Issues: 1996-2003*

(listed in reverse chronological order)

Issue Date	Issuer	Amount for All Tranches ($mm)	Largest Tranche by Principal Amount: Rating	Spread Over LIBOR (bp)	Expected Loss (bp)	Expected Excess Return at Issue (bp)
May-03	**Residential Re 2003 Ltd.**	$160	Ba2/BB+	495	48	447
March-03	**Pioneer 2002 Ltd.**	43	Ba3/BB+	750	131	619
December-02	**Pioneer 2002 Ltd.**	131	Ba3/BB+	475	129	346
December-02	**Studio Re Ltd.**	175	Ba2/BB+	510	65	445
September-02	**Pioneer 2002 Ltd.**	23	Ba3/BB+	600	128	472
June-02	**Pioneer 2002 Ltd.**	233	Ba3/BB+	600	128	472
May-02	**Fujiyama Ltd.**	70	BB+	400	67	333
May-02	**Residential Re 2002 Ltd.**	100	Ba3/BB+	490	67	423
April-02	**K3**	230	NA	NA	NA	NA
April-02	**St. Agatha Re**	33	BB+	675	114	561
March-02	**Redwood Capital II, Ltd.**	200	Baa3/BBB-	300	22	278
December-01	**Redwood Capital I, Ltd.**	165	Ba2/BB+	550	53	497
December-01	**Atlas Reinsurance II p.l.c.**	150	Ba2/BB+	675	90	585
June-01	**Trinom Ltd.**	162	Ba2/BB	800	111	689
May-01	**SR Wind Ltd.**	120	BB+	525	68	457
May-01	**Residential Re 2001 Ltd.**	150	Ba2/BB+	499	68	431
March-01	**Halyard Re BV**	17	BB-	550	22	528
March-01	**Gold Eagle Capital 2001 Ltd.**	120	Ba2/BB+	550	75	475
February-01	**Western Capital**	100	Ba2/BB+	510	55	455
November-00	**Mediterranean Re p.l.c.**	129	Ba3/BB+	585	22	563
November-00	**PRIME Capital Hurricane Ltd.**	165	Ba3/BB+	650	127	523
November-00	**PRIME Capital CalQuake & EuroWind**	135	Ba3/BB	750	133	617
July-00	**NeHi**	50	BB	410	70	340
May-00	**Alpha Wind 2000-A Ltd.**	90	BB+	456	63	393
May-00	**Residential Re 2000 Ltd.**	200	BB+	410	54	356
March-00	**Seismic Re**	150	Ba2/BB+	450	73	377
March-00	**Atlas Reinsurance p.l.c.**	200	BB+	1400	324	1076
November-99	**Namazu Re**	100	Ba2/BB	450	75	375
September-99	**Kelvin Ltd.**	44	B-	990	445	545
June-99	**Residential Re III**	200	Ba2/BB	366	44	322
June-99	**Juno Re**	80	BB	420	45	375
May-99	**Concentric Ltd.**	100	Ba1/BB+	310	41	269
May-99	**Halyard Re**	17	BB-	NA	NA	NA
March-99	**Domestic LLC**	80	NA	369	50	319
February-99	**Reliance/SLF Re IV**	10	NR	1441	1138	303
December-98	**Trinity Re 1999**	56	Ba3	417	77	340
July-98	**Pacific Re**	80	Ba3	370	97	273
June- 98	**Residential Re II**	450	Ba2	416	58	358
June-98	**Mosaic Re**	50	BB	400	53	347
February-98	**Trinity Re I**	84	Ba3	436	83	353
January-98	**Reliance/SLF Re II**	10	NR	1388	1106	282
November-97	**Parametric Re**	100	Ba2	430	70	360
July-97	**SR Earthquake Fund**	137	Ba1	865	68	797
June-97	**Residential Re I**	477	Ba2/BB	576	63	513
March-97	**Reliance/SLF Re I**	10	NR	1178	897	281
November-96	**Winterthur**	280	NA	225	45	180
July-96	**AIG Combined Risk**	10 (est)	NA	1416	1200	216
	Total Issuance	**$5,876**				

*Table includes only CAT bonds triggered by natural events and where actual funding was raised.

Spread, Expected Loss and Expected Excess Return are provided in basis points for the principal tranche (generally the largest). Quoted spreads are spreads over LIBOR.

Source: Lane Financial, LLC

Comments on Specific Transactions:

- Pioneer represents a MTN shelf registration; other transactions are either private placements or Reg. 144A private placements.
- Namazu Re was commuted early given the discontinuation of Gerling Globale Re.
- Kelvin carries a fixed rate of 15.70% which was a spread of 990bps over US Treasuries at the time of issue.
- Reliance/SLF I and AIG Combined Risks were issued at a discount.
- The Winterthur transaction was issued at 400 million Swiss Francs; US$ equivalent as of 3/03 is shown. The bond carries a fixed coupon of 2.25%; only the coupon is exposed to loss.

The following "related structures" are transactions that transfer catastrophic risk to the capital markets in a form other than an issued CAT bond: George Town Re (quota share); Reliance/SLF Re III and Gemini Re (options to issue CAT bonds); XL Mid Ocean (swap); and Circle Maihama (contingent post-event issuance)

			Largest Tranche by Principal Amount			
Issue Date	**Issuer**	**Amount for All Tranches ($mm)**	**Rating**	**Spread Over LIBOR (bp)**	**Expected Loss (bp)**	**Expected Excess Return at Issue (bp)**
May-99	**Circle Maihama**	$100	A	78	NA	NA
December-98	**Gemini Re**	150	[p]B3	822	361	461
July-98	**X.L. Mid Ocean**	200	NA	550	109	441
April-1998	**Reliance/SLF Re III**	20	NR	838	538	300
October-96	**George Town Re**	69	Aaa/AAA	1100	260	840

- George Town did not bear a coupon, rather it distributes available net income to investors; at issue the expected amount to be distributed was 11.00%. George Town was commuted early after St. Paul Re spun off Platinum Re.

Loss Experience:

As of May 2003, only two issued CAT bonds and one related structure have experienced a loss:

- Reliance/SLF Re IV experienced a 5% loss as a result of the French windstorms of 1999, reducing the coupon paid to investors from L+1441 bps to L+941 bps.
- Kelvin's junior tranche lost coupon and some principal due to adverse weather conditions in Winter 2000; the senior tranche was unaffected.
- George Town Re suffered an erosion of coupon and some principal loss due to several loss events over its life..

Source: Lane Financial, LLC

Appendix II: Case Studies

Studio Re Ltd.

A recent example of CAT bonds used in insurance industry disintermediation is the Studio Re Ltd. transaction. In December 2002 this SPV issued a total of $150 million notes and $25 million shares with a maturity of July 2006. The proceeds provide protection to Vivendi International in the event of earthquake damage to its Universal Studios facility in Southern California. Vivendi was only the second corporate issuer (see below) to bypass the insurance industry and go directly to the capital markets for casualty protection.

SPV	Amount	Rating	Spread Premium to LIBOR (bps)	Expected Loss (Annual)	Probability of 1st $ Loss (Annual)	Probability of Exhaust (Annual)	Expected Excess Return (Annual)	Conditional Expected Loss
Studio Re Notes	$150 mm	BB+/Ba2	510 bp	0.65%	1.38%	0.22%	4.52%	47%
Studio Re Shares	$25 mm	BB/B1	800 bp	1.71%	2.13%	1.38%	6.40%	80%

Source: Lane Financial, LLC

The payoff that Vivendi receives in the event of an earthquake is calculated using a special formula developed for the transaction. The formula is based on the location of the earthquake and the Spectral Acceleration (ground shaking) as measured by the US Geological Survey. If the index value as calculated by the formula exceeds the agreed minimum, Vivendi will receive a loss payment. Payments are graduated based on the index value, with the shares absorbing the first loss.

Concentric Ltd. and Circle Maihama

These transactions, in May 1999, were the first concrete example of disintermediation in the insurance securitization market. The bonds were issued by Oriental Land Company, whose principal business is the operation of Tokyo Disneyland.

Concentric Re provides Oriental Land with up to $100 million protection from the effects of a sizeable earthquake in and around the Tokyo Disneyland site. Upon the occurrence of such an event, Concentric will immediately make payment to Oriental Land. The exact payment is based on a synthetically constructed scale (i.e., an index payment).

Circle Maihama is a standby facility allowing Oriental Land to issue up to $100 million in general obligation debt under predetermined conditions even after an earthquake that affects Tokyo Disneyland takes place. Activation of Circle Maihama is contingent upon Concentric Re already having been triggered. The funds raised from the activation of Circle Maihama will be used as working capital for the continuing operation of the facility. The initial maturity of both transactions is May 2004 and Circle Maihama, if attached, may be extended an additional five years, but not beyond November 2007.

Loss payments for both transactions are based on the magnitude of an earthquake as calculated by the Japanese Meteorological Association (JMA) index of severity. Payments are graduated based on the value of the published index.

The figure below provides details of these two transactions. Note that no expected loss figures or probability of exhaustion are provided for Circle Maihama. This is due to the contingent character of this transaction and the fact that if issued, it becomes a conventional debt obligation of the company. As mentioned above, the trigger for issuing the notes is the occurrence of an event that triggers Concentric Re. If that occurs, then Oriental Land, through the facility of Circle Maihama, will issue notes with the proceeds used to maintain the operations of the company during the repair/rebuilding process. The note does not directly bear further risk of loss from an earthquake event; it merely calls for repayment in full at or before maturity. While outside factors could affect the ability of Oriental Land to make repayment at maturity, this constitutes a credit risk, not a direct risk of loss from a natural catastrophe.

SPV	Amount	Rating	Spread Premium to LIBOR (bps)	Expected Loss (Annual)	Probability of 1st $ Loss (Annual)	Probability of Exhaustion (Annual)	Expected Excess Return (Annual)	Conditional Expected Loss
Concentric Re	$100 mm	BB+/Ba1	310 bp	0.42%	0.64%		2.72%	65.63%
Circle Maihama	$100 mm	A/--	75 bp					

Probability of Circle Maihama activation is same as Concentric 1st loss probability; other probabilities not relevant.

Source: Lane Financial, LLC

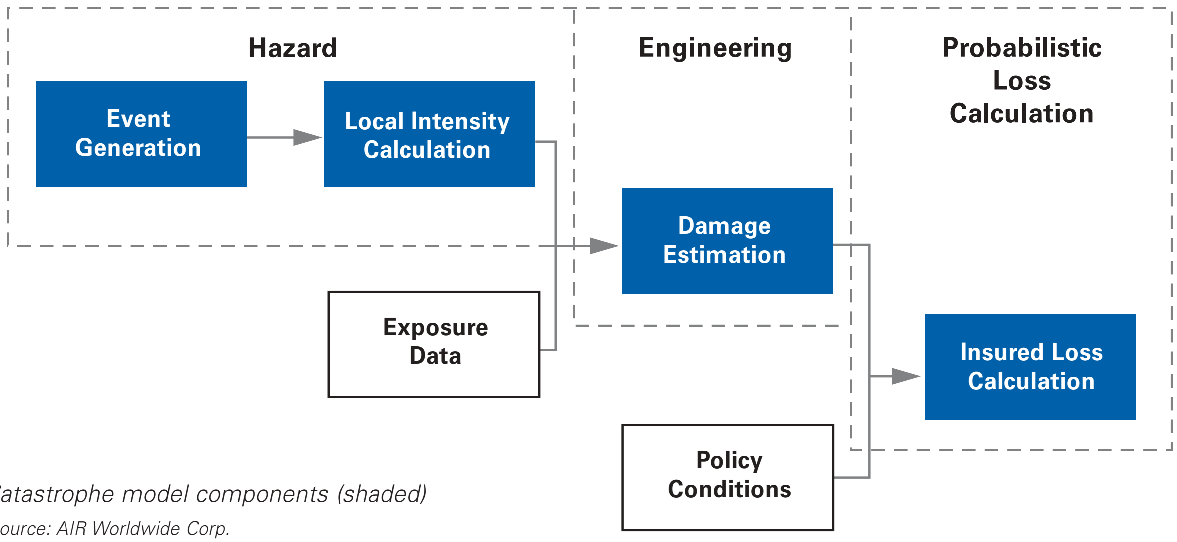
Concentric Ltd. and Circle Maihama are important transactions because they represent, respectively: (a) the first direct issue of CAT bonds bypassing the insurance industry, and (b) the use of a contingency structure.

Appendix III: Generic Desciption of Catastrophe Modeling Process

This section provides an overview of the component steps undertaken by a modeling firm in developing a typical catastrophe model.

Model Components

The primary components of the catastrophe model are illustrated below.



Catastrophe model components (shaded)

Source: AIR Worldwide Corp.

Event Generation

The first two model components address the hazard itself. Event generation answers questions about where events are likely to occur, how large or severe they are likely to be, and how frequently they are likely to occur. Most catastrophe modelers employ their own internal staffs of scientists, including meteorologists, seismologists, and geophysicists, who combine their knowledge of the underlying physics of natural hazards with the historical data on past events.

Local Intensity

Once the model *probabilistically* generates a potential future event, it propagates the event across the affected area. For each affected site, local intensity (in terms of surface wind speed, ground motion, etc.) is estimated. In this component as well as in the event generation component, detailed scientific and geophysical data and algorithms are employed to model the local effects of each simulated event. Windstorm models, for example, use high-resolution digital land use/land cover data to calculate surface frictional effects. Estimates of surface roughness dictate, in part, the behavior of ground level wind speeds. In the case of earthquake models, local soils affect the amplification of seismic waves.

For parametric CAT bonds, the relevant modeling from the investor standpoint stops at this point. For indemnity CAT bonds, which indemnify against insured losses, the next two modeling steps are also quite revelant for the investor. From the issuer's perspective, however, all four steps are critical even for parametric structures, as the issuer must understand and estimate the extent of its basis risk (the potential mismatch between actual losses and modeled payout) to appropriately design the parametric security.

Damage Estimation

The local intensities of each simulated event are superimposed onto a database of exposed properties. The damage estimation component then calculates the resulting monetary damage by applying mathematical relationships called damage functions. These capture the relationship between the intensity of the event, which varies by location, and the exposed buildings and contents.

The damage functions are region-specific and reflect local building codes and construction practices. They provide not only estimates of the mean, or expected, damage ratio corresponding to each level of intensity but, in addition, provide a complete probability distribution around the mean. Because different structures experience different degrees of damage for a given level of intensity, the damage functions need to capture this variability, referred to as secondary uncertainty.

Insured Loss Calculation

Insured losses are calculated by applying the specific policy conditions to the total damage estimates. Explicit modeling of uncertainty in both intensity and damage calculations enables a detailed probabilistic calculation of the effects of policy conditions.

Modeling involves the simulation of many thousands of potential events in accordance with their relative probability of occurrence. Probability distributions of annual aggregate and occurrence losses are estimated. Model output can also provide the probabilities of attachment for various reinsurance layers and therefore, in the context of CAT bonds, the probabilities that investors will suffer a full or partial loss of interest or principal.

Clearly, the quality of the exposure data is critical to the process. Considerable energy is typically spent by both the issuer of the CAT bond and the modeler to evaluate the data and determine whether it meets logic and reasonability tests.

Model Validation

As discussed in the main text, the models go through an extensive period of validation by the modeling agency. In the ratemaking approval process, various state insurance regulatory authorities have also validated the use of the models, as an increasingly important aspect of the rate filing process is the quantification and justification of the catastrophe risk component of proposed rates. Catastrophe modeling has come to play an instrumental role in bridging the information gap between insurance companies, on the one hand, and the various departments of insurance and their constituencies, on the other, about the nature and significance of catastrophe risk.

Florida, Louisiana, Hawaii and recently Texas have a model acceptability process. Probably the most extensive is that of the Florida Commission on Hurricane Loss Projection Methodology. This Commission was established in 1995, with the mission to "assess the effectiveness of various methodologies that have the potential for improving the accuracy of projecting insured Florida losses resulting from hurricanes and to adopt findings regarding the accuracy or reliability of these methodologies for use in residential rate filings." The Commission has established over 40 standards that need to be met before a catastrophe model is acceptable for ratemaking purposes in the State of Florida.

Finally, investors rely on the research and due diligence performed by the securities rating agencies, who subject the models to extensive scrutiny. The modelers present the results of detailed sensitivity analyses of all major components of the model. Modelers and experts hired by the rating agencies perform stress tests for model robustness.

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