Chapter 7

Overview and Analysis of CAT-linked Securities

7.1. Overview of CAT-linked securities

The following provides a brief description of some of the CAT-linked securities that have been issued or traded in capital markets:

a) CAT bonds

A CAT bond is a high-yield bond that contains a provision that may cause the principal or interest payments to be delayed or lost to investors in the event of a specified loss such as a hurricane or earthquake. The CAT bond provides the insurer with fully collateralised multi-year cover for well-defined risks on an excess of loss basis.

As an illustrative example, the sponsor (i.e., the risk bearing entity that wishes to transfer CAT risks to capital markets), creates a special purpose vehicle (SPV). The purpose of the SPV is to provide loss protection to the CAT bond investors and sponsors.[1] The sponsor pays a premium to the SPV that issues bonds to qualified institutional investors and uses the proceeds of the sale plus the premium to purchase highly rated short-term investments such as Treasury notes. The SPV also enters into an interest rate swap to convert the periodic investment income from the short term investments to LIBOR, makes the periodic coupon payments to investors, and ultimately repays the principal upon maturity unless a loss occurs before maturity that triggers loss payments to the sponsor.[2] As mentioned, the collateralisation provisions of CAT bond structures have been tightened in 2009: most recent deals impose strict prudential rules on how the collateral is invested, feature daily mark-to-market accounting on the collateral accounts and "top up" requirements in the event that asset values fall below par. These new structures also feature improved transparency and easier access to information on the underlying assets, as well as contractual mechanics to facilitate the replacement of the swap counterparty or to unwind the transaction in case of default, with a view to better protecting the interests of investor and sponsor.

b) Catastrophe collateralised risk obligations (CROs)

In a CRO, an SPV managed by a risk manager assembles a portfolio of risks consisting of traditional reinsurance and CAT-linked securities. The SPV then issues multiple tranches of notes and a tranche of equity that successively attach upon exhaustion of the previous layer. CRO offerings, like CAT bonds, are fully collateralised.[3] Investors in a CRO immediately benefit from portfolio diversification in insurance risk.

c) CAT-linked derivatives

While the first attempt to launch exchange-traded CAT-linked futures and options failed due to lack of attention and low liquidity, there have recently been attempts to revive a derivatives market. Over-the-counter instruments such as the Deutsche bank-sponsored event loss swaps or the NYMEX, the CME, and the IFEX exchange-traded futures and/or options contracts are examples of more recent innovations in CAT-linked derivatives. Below is a brief description of these products.

i. Event loss swaps

Although there is little publicly available information on OTC CAT-linked derivatives, Deutsche Bank has sought to make two-way markets in what it calls event loss swaps. The Deutsche Bank event loss swaps, in their current form, work like credit default swaps. The buyer of event loss protection pays an upfront premium to the seller of the protection who must then pay the full notional value of the swap contract if industry-wide insurance losses breach a pre-agreed upon trigger. Features of the Deutsche Bank swap transactions are as follows:

- The swap contracts cover a one-year risk period and are sold in notional US$5 million amounts, with the buyer upfront premium being expressed as a percent of the notional amount.
- The swaps contracts cover windstorm and earthquake risks in the U.S. with thresholds levels set at US$20 billion, US$30 billion, and US$50 billion for hurricanes and tornadoes, and at US$10 billion and US$15 billion for earthquakes.

ii. NYMEX CAT risk index futures and options

The NYMEX contracts are standardised futures and options contracts co-developed by NYMEX and Gallagher Re (now Aon Re). The contracts settle against indices of industry losses estimated by the Property Claims Services ("PCS"). The indices are computed and maintained by Gallagher Re. NYMEX offers the futures contracts in the open-outcry and the options contracts on the GLOBEX electronic venue. The NYMEX clearing corporation also offers clearing services for index-based options traded off-exchange.

Standard features of the NYMEX contracts are as follows:

- The futures and options contract prices are based on market (preliminary and subsequent) estimates of cumulative industry losses for catastrophes that occur during a calendar year. The contracts settle in cash at the end of March of the following calendar year.
- The Re-Ex index contains estimated losses from all perils identified by PCS except earthquake and terrorism.
- The Re-Ex index value is computed as the sum of cumulative industry loss estimates divided by US$10 million. For instance, cumulative loss estimates of $25 billion translate into a 2,500 point index. One index point is worth US$10.
- NYMEX currently offers futures and options contracts on three regions: National, Florida, Maine to Texas (excluding Florida).

iii. CME hurricane futures and options

In many ways, the NYMEX contract design mirrors that of the CBOT now-defunct instruments. The CME, on the other hand, adopted a radically different approach in the design of its hurricane futures and options. First, the CME products are one-peril instruments. Second, they settle against the Carvill Hurricane Index ("CHI"), which is based on the parametric features of a hurricane, such as maximum wind velocity and size (radius). Third, the CME futures and options expire as soon as an official hurricane makes landfall. The contracts settle in cash against the value of the CHI, which is immediately released after the hurricane landfall.

Other features are as follows:

- The CHI is expressed in points. One index point is worth US$1,000.
- CME currently offers futures and options contracts on five regions: Gulf Coast, Florida, Southern Atlantic, Northern Atlantic, and Eastern.
- The CME recently expanded its range of contracts to include seasonal aggregated futures contracts and options with a binary payout, i.e., either no payout or a full face value payout.

iv. IFEX event-linked futures

IFEX, a London-based insurance derivatives exchange, is a subsidiary of the Climate Exchange plc. Group and operates via the Chicago Climate Futures Exchange's trading platform. The IFEX launched event-linked futures (ELF) contracts linked to U.S. tropical wind in September 2007 and has offered ELF contracts on other specific U.S. seasonal hurricane risks. The futures contracts are designed to mimic industry loss warranties with a payout linked to "first event" of the year, "second event" of the year, and so on. The futures contracts settle against an industry wind loss as estimated by PCS and offer a binary payout of US$10,000 (when the industry loss amount reported by PCS equals or exceeds one of the applicable loss trigger levels) or zero. The applicable loss triggers levels for each listed event are currently US$10 billion to US$50 billion, in increments of US$10 billion.

d) Other instruments

i. Industry loss warrants

An industry loss warrant ("ILW") is an index-based instrument that can be structured either as an indemnity-based reinsurance contract or as a derivative contract. An ILW may be considered a reinsurance contract when: *(a)* the contract buyer suffers a loss; and *(b)* the industry suffers a loss over a specified threshold. However, it is generally viewed as a derivative contract when it is triggered only by an industry loss. A.M. Best[4] has recently drawn analogies between the basis risk associated with non-indemnity triggered CAT bonds with that of ILWs.

ii. Sidecars

A sidecar is a reinsurance company that is created and funded by investors, such as hedge funds, to provide capacity to a single insurer or reinsurer (commonly called the

sponsor) for its catastrophic losses. While CAT bonds allow insurers to transfer their property risk to the capital markets, sidecars are best described as tools that help insurers in financing any risk on their books, including property risks.

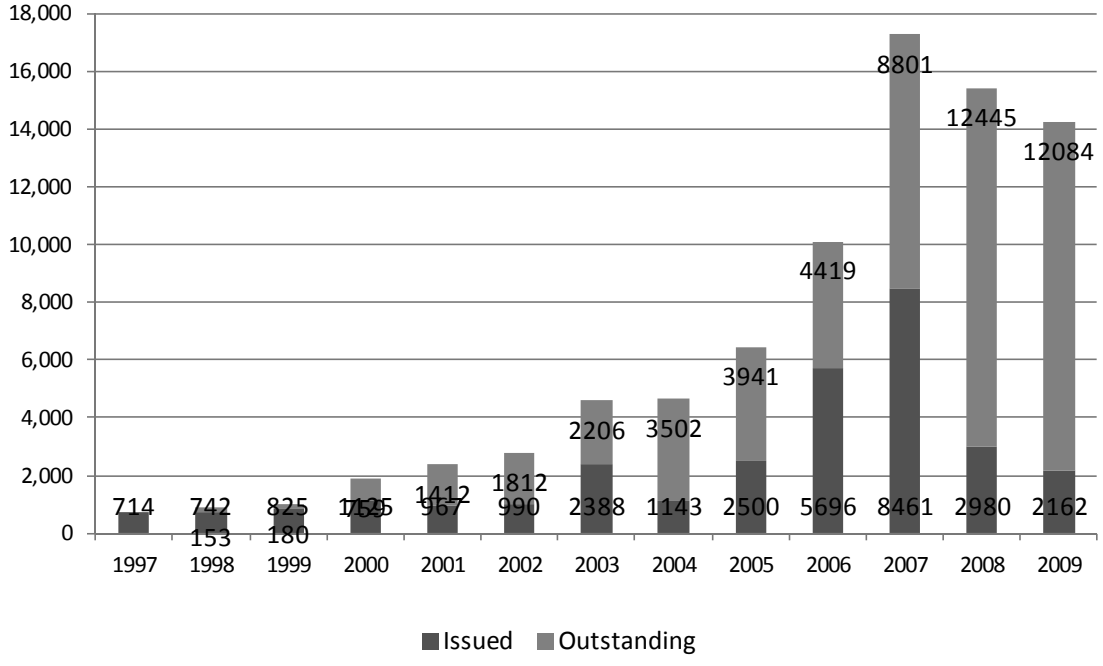
The structure of the sidecar is a reinsurance company created to provide quota share reinsurance protection to the sponsor via a quota share reinsurance agreement. The sidecar assumes a percentage of the sponsor's catastrophe risk in return for a percentage of the premium. The sidecar pays a ceding commission to the sponsor; the size of that commission increases in proportion to expected profitability. The sidecar accepts premiums and pays claims as a normal reinsurer. It also distributes interest and dividends to its shareholders. The sidecar usually has a lifespan of one or two years.[5]

7.2. Market trends and analysis of the main features of CAT-linked securities

a) Size and growth of the market

One of the most important measures of market size is the total risk capital outstanding; that measure showed record growth in 2007, with new issuance exceeding US$8 billion (see Figure 7.1). At year-end 2007, there was more than US$17 billion in outstanding principal. The number of transactions also set records in that year.

Figure 7.1. **Risk Capital (for CAT bonds issued and outstanding, in US$ million)**



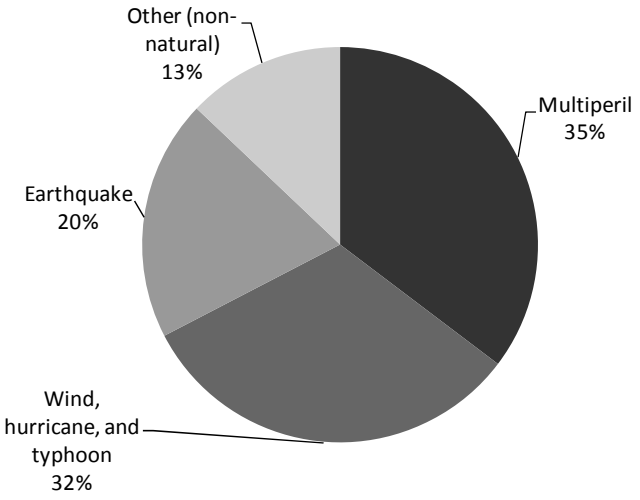
Source: Swiss Re Capital Markets, as of October 14, 2009

After this record-setting year, in 2008, new CAT bond issuance fell to US$2.9 billion (new and renewal capacity). Towards the end of the year, planned CAT bond transactions were postponed partly because of the impact of the global financial crisis on secondary

market spreads, and partly because of concerns over the effectiveness of the collateral protection mechanics embedded in CAT bond structures. The enhanced capacity and favourable rates in the traditional reinsurance market also contributed to this trend.[6] CAT bond issuance as of third quarter 2009 suggested that 2008 levels would be achieved.[7]

Figure 7.2 describes the non-life risks, by peril, that have been securitised through CAT bonds, including natural and non-natural risks. Natural hazards have, since 1997, largely been the risks securitised through CAT bonds. The multi-peril bond issues include combinations of the perils such as U.S. hurricane, California earthquake and European wind or U.S. earthquake, U.S. hurricane and Japanese earthquake and, in rare cases, property, launch, aviation and marine. Wind, hurricane, and typhoon, and earthquake, are the perils most often covered by CAT-linked instruments, whether individually or in multi-peril instruments. Indeed, the multi-peril CAT bonds have the most stable issuance history. These are perils for which more data exist, at least in North America, Europe and Japan; these are also perils that quite clearly violate the law of large numbers, making insurance coverage more difficult.

Figure 7.2. **Risks Securitised Since 1997**[8]



Source: Swiss Re Capital Markets, as of October 14, 2009

b) Triggers

The trigger on CAT-linked securities determines the conditions under which payments are made to the sponsor. The generic trigger types are as follows:

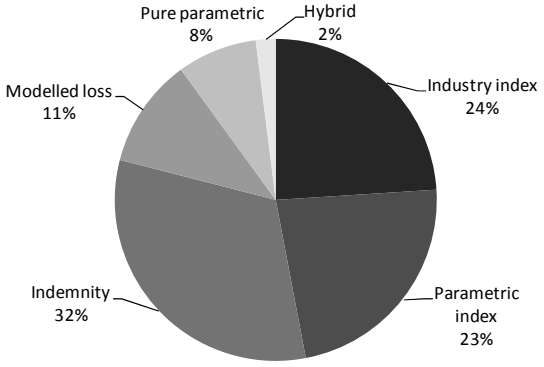
- **Indemnity**: The payouts depend on the sponsor's actual losses.
  - Advantage - This trigger eliminates basis risk.[9]
  - Disadvantages - This trigger requires costly disclosure by the sponsor, requires more detailed risk analysis by the modelling firm, and has a long recovery period for investors (of up to 18 months, due to the need for the sponsor to calculate loss claims), thus offering less liquidity for investors; this trigger may also introduce a moral hazard problem (see below), to the detriment of investors.

- **Industry index**: The payouts are triggered by the industry loss estimated by an agency that collates such information for CAT events.
  - Advantages - This trigger yields a more transparent process, protects insurer privacy, and eliminates the moral hazard problem.
  - Disadvantages - This trigger yields basis risk and a possible mark-to-market problem if the CAT-linked instrument is treated as a financial derivative as opposed to a reinsurance contract, as volatility may be introduced into the balance sheet and earnings.
- **Parametric**: The payouts are determined by well-defined parameters of a CAT event. Parametric structures have themselves evolved through two generations. First-generation parametric triggers ("pure parametric") were based on the broad parameters of the event – such as the magnitude and location of an earthquake (located within a defined area) or the intensity of a hurricane at landfall. Second-generation triggers ("parametric index") achieve a much better match with the actual loss by employing multiple windspeed recorders or earthquake strong motion recorders and weighting the values at each recording site into an index tuned to match the distribution of actual losses.
  - Advantages - This trigger also yields a more transparent process and a possibly more rapid verification process as well, allowing a transaction to be settled quickly (in weeks) after an event.
  - Disadvantages – Basis risk and mark-to-market risk, although these are significantly reduced in second-generation (parametric index) triggers.
- **Modelled loss**: The payouts are triggered by a model industry loss that is determined by running the parameters of the actual event through a modelling firm's database of industry exposures.
  - Advantages - This trigger may yield a rapid verification process. It also protects the privacy of the insurer.
  - Disadvantages - This process may be quite opaque, and yields basis risk and mark-to-market risk.
- **Hybrid**: The payouts are determined by a combination of two or more existing trigger types.
  - Advantages - This approach allows different triggers for different perils, or combinations of triggers, in order to reduce basis risk.
  - Disadvantages - The use of more triggers makes the process less transparent and more costly. Basis risk may remain as well as the mark-to-market risk.

The indemnity trigger has been the dominant form for CAT bonds because the payouts replicate reinsurance protection. The indemnity trigger requires the disclosure of details about the covered portfolio that make it more costly both to the insurer that would prefer to not to reveal the information and the investor who must digest the information. This trigger also generates a possible conflict of interest since the insurer may settle catastrophic claims in a way that is disadvantageous to investors; this is the well-known moral hazard problem.

The index, parametric, model, and hybrid triggers remove the moral hazard problem from consideration but may leave a basis risk problem. The imperfect correlation between the CAT-linked security payout and the insurer's loss represents the basis risk, e.g., for an index trigger, it is the difference between the estimated industry loss and the insurer's loss. See Figure 7.3 for an historical sketch of trigger use. The figure shows that indemnity triggers have been used the most frequently, followed by industry index triggers (e.g., PCS industry losses) and parametric index triggers. [10]

Figure 7.3. **Catastrophe Bond Trigger Breakdown (1997-2009)**



Source: Swiss Re Capital Markets, as of October 14, 2009 (percentages based on notional amounts)

c) Development of catastrophe loss models

Probabilistic catastrophe loss models have been crucial to the development of the CAT-linked securities market. The development of the CAT bond market was assisted by the general development and acceptance of second-generation catastrophe models that were first developed in the early 1990's and which became more generally accepted across the insurance and reinsurance industry by 1997 and in particular had become accepted by rating agencies for the assessment of capital adequacy requirements.

There were three principal catastrophe modelling companies working in this area in the mid-1990's: Risk Management Solutions (RMS), Applied Insurance Research (AIR), and EQECAT, a situation that remains unchanged today. The first CAT models were developed for U.S. earthquake and hurricane and the expansion of the countries and perils securitised reflects the expansion and maturity of the models themselves to other territories and the acceptance of these models as being sufficiently mature as to be used for risk transfer. Inevitably, acceptance of the models for structuring and pricing reinsurance risk transfer, as a standard procedure within the insurance industry, has preceded the use of the same models for transferring risk to the capital markets.

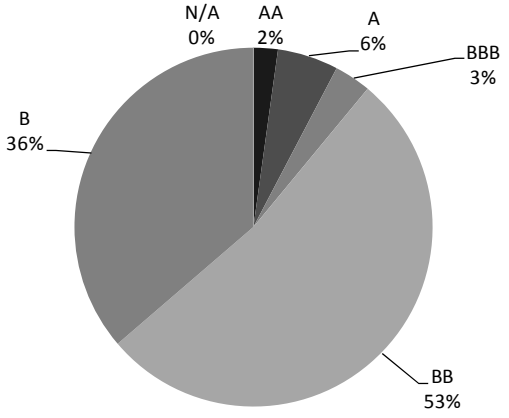
d) Credit ratings of CAT-linked bonds

U.S. credit rating agencies have also had an important role in the development of the CAT-linked securities market. Credit rating agencies rely on stochastic modelling undertaken by the CAT risk modelling companies to derive estimated loss statistics. Their rating methodology of CAT-linked securities typically focuses on the following factors:

- **Analysis of the issuer's insurance risk**: Credit ratings agencies rely on the input provided by catastrophe modelling firms in the form of a loss exceedance curve[11] that plots the bond issuer's loss against the probability of loss.[12] The credit rating agency may then ask that the model be stress-tested with different scenarios and assumptions. The trigger (or attachment point), once validated by the rating agency, is then applied to the exceedance curve to determine the probability of loss at the trigger point.
- **Evaluation of default risk**: Credit rating agencies compare the probability of catastrophic losses with the probability of default of corporate bonds estimated from historical data on corporate bond defaults, typically taking the probability of default from the loss exceedance curve and placing it in the relevant band. Figure 7.4 shows the distribution of ratings of outstanding CAT bonds (by number issued) at time of issuance. The figure shows that CAT bonds have been predominantly rated B and BB at issuance.
- **Terms and structure of the CAT bond transaction**: This includes the credit quality of the collateral placed in the SPV trust and the credit rating quality of the counterparty to the swap engineered by the SPV.[13]
- **Risk of the CAT-linked security sponsor**: This includes the sponsor's financial strength, length of time in business, history of sponsoring CAT-linked securities, management quality and other considerations.

Some CAT bond issues have been BBB-rated or higher; however, the dominance of BB and B issues underlines the prominent role played by the non-investment grade in the market.[14]

Figure 7.4. **Quality of Outstanding CAT Bonds**[15]



Source: Swiss Re Capital Markets, as of 14 October 2009

e) Pricing of CAT-linked securities

i. Theoretical considerations

The pricing of CAT bonds and other CAT-linked securities is perhaps the most investigated area of academic research in this field. Some research uses an actuarial

approach to model the yield paid on CAT-linked securities. The equilibrium models imply that disaster risk should yield an unbiased estimate of expected loss. This pricing approach, however, relies on the recognition that equilibrium models do not explain why yields on CAT bonds consistently exceed actuarially fair levels. Academics differ on the determinants of CAT-linked securities risk premium spreads. For CAT-linked instruments, the premium is most commonly determined as a fixed constant times the volatility of loss (other higher loss distribution moments, such that skewness, may also partly determine the premium spread). Others attribute high yields paid on CAT-linked securities structures to the uncertainty associated with actuarial probabilities.

Other research uses a financial approach to model CAT bonds and other insurance-linked securities structures. Vaugirard (2003) uses an arbitrage approach to value insurance-linked securities, which accounts for catastrophic events and interest rate randomness, notwithstanding the fact that markets are incomplete. Cox and Pedersen (2000) recognise that the pricing of CAT bonds requires an incomplete market setting and develop a pricing method based on a model of the term structure of interest rates and a probability structure for the catastrophe risk.

ii. Practical considerations

CAT bonds have, for some sustained periods over the course of their existence, traded with a wider spread than similarly traded corporate securities.[16] Market participants routinely attributed the wider spread to the following factors:

- Doubts by investors about the models used to predict loss probabilities, i.e. the estimated probability that a trigger will be reached.[17]
- The perception that the risk associated with CAT bonds may be more binary than that of corporate bonds (i.e., the perception that the loss is all or nothing).

Using a different benchmark, however, the cost of financing through CAT bonds – as measured by the coupon yield relative to the expected loss on the CAT bonds – appears to be in secular decline given growing capital market interest and expertise and increasing CAT-bond volume, with some suggesting that the critique of excessive spreads may no longer apply to the CAT bond market (Cummins, 2008).

Notes

1. The collateralisation of the risk capital underlying a CAT bond transaction provides investors and sponsors with protection: investors are protected against the default of the sponsor, so that interest income and the principal (at maturity) can collected, while sponsors with reinsurance arrangements with the SPV are assured of payment should the loss event(s) occur. As discussed on p. 5 and p. 19, collateral requirements have been recently tightened.
2. See GC Securities (2007), The Catastrophe Bond Market at Year-End 2006, p. 25.
3. An example of a CRO is Gamut Re that had a US$310 million bond offering in May 2007. Goldman Sachs was the lead underwriter of the offering. Nephila, a private

equity CAT fund assembled the portfolio of risks that includes traditional reinsurance, ILW, and CAT bonds.

4. See A.M. Best Press Release (April 8, 2008), "A.M. Best formally harmonises the basis risk evaluation of CAT bonds and ILWs".

5. As sidecars are not, strictly speaking, capital market securities, they will not, for the purposes of this report, be explored further.

6. See GC Securities (2009), Cat Bonds Persevere in Tumultuous Market .

7. More recent data from Guy Carpenter indicate that issuance of CAT bonds in 2009 in terms of risk capital and number of transactions exceeded 2008 levels. See GC Securities (February 2010), Catastrophe Bond Market Continues to Improve.

8. Other (non-natural) securitised risks include extreme mortality, automobile, industrial accident, credit reinsurance, and event cancellation.

9. Basis risk is the risk that the payoff on the catastrophe linked security will not match the sponsor's actual loss; such a difference can occur if, for example, the payoff on the CAT-linked security is determined as the average loss in the industry rather than the actual loss of the sponsor.

10. For a review of the role of indices in transferring insurance risks, see Swiss Re sigma (2009), The Role of Indices in Transferring Insurance Risks to the Capital Markets, n.4/2009.

11. The exceedance curve provides the probability of a loss of a certain size could occur this year.

12. Catastrophe modelling firms construct a loss exceedance curve by simulating thousands of hypothetical catastrophic event scenarios with varied geographical locations and event characteristics. The scenarios are then applied against the portion of the cedent's book of business covered by the bond.

13. As explained above, the SPV places the proceeds collected from the investors in the bond into a trust that invests in fixed-income securities. The SPV then swaps the investment earnings of the trust against a LIBOR rate minus a fixed spread.

14. The dominance of B and BB ratings is also observed when factoring in the notional value of CAT bonds issued. See GC Securities (2008), The Catastrophe Bond Market at Year-End 2007, Table 8, p. 28.

15. The ratings are those obtained at the time of issuance for each CAT bond. The distribution of ratings reflects a simple average (by number of CAT bonds), and is not weighted by notional value of the CAT bonds.

16. See GC Securities (2008), op. cit., Figure 9, p. 34.

17. After Katrina hit, the doubts were driven by a perceived under-estimation of losses; catastrophe modelling firms revisited their assumptions about hurricane activity rates, and property vulnerabilities, embedded in the CAT models that they had used to rate CAT bond offerings prior to the occurrence of the hurricane.