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CATASTROPHE-LINKED SECURITIES AND CAPITAL MARKETS: DRAFT REPORT

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For further information please contact Mr. Timothy Bishop [Tel: +33 1 45 24 84 66; Fax: +33 1 44 30 63 08; Email: timothy.bishop@oecd.org].

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CATASTROPHE-LINKED SECURITIES AND CAPITAL MARKETS: DRAFT REPORT

1. Introduction[1]

Catastrophe-linked securities provide a mechanism for the transfer of catastrophe risks to capital markets, and may provide an additional layer of protection to traditional insurance and reinsurance arrangements or serve to reduce reliance on these arrangements. Catastrophe-linked securities may also create opportunities for the transfer of catastrophe risks that are currently not covered by insurance markets. As capital markets have a potentially huge capacity to absorb catastrophe risks, catastrophe-linked securities may enhance the ability of the financial system, and economic actors more broadly (including governments), to manage the costs of natural catastrophes.

Catastrophe-linked securities appeared in the aftermath of Hurricane Andrew in 1992 in the belief that the capacity offered by the traditional reinsurance market and the retrocession market would shrink. The Chicago Board of Trade launched futures and options contracts with payouts linked to the U.S. industry catastrophe losses. Securitisation of catastrophe risk[2] in the form of catastrophe bonds appeared soon thereafter with the first offering of catastrophe (CAT) bonds in 1994.

According to Guy Carpenter, CAT bond risk capital outstanding[3] was US$13.8 billion at the end of 2007, a 63 percent increase over US$8.5 billion in 2006, and nearly three times the US$4.9 billion outstanding at the end of 2005. As of year-end 2007, CAT bond risk principal composed 8 percent of the estimated property limits globally and 12 percent on a U.S.-only basis.[4] Alternative financing structures for CAT risks such as sidecars became increasingly popular as risk financing tools for insurance companies in the wake of Hurricane Katrina in 2005.

CAT-linked derivatives instruments have recently re-emerged, after a period of quiet in derivatives market following the CBOT's failed attempt in generating insurer and investor interest in exchange-traded derivatives. Three futures exchanges -- the New York Mercantile Exchange, the Chicago Mercantile Exchange, and the Insurance Futures Exchange Services – have re-introduced

[1] This paper was prepared, in large part, by Prof. Richard MacMinn and Prof. Sylvie Bourriaux of Illinois State University. Members of the High-level Advisory Board and the Secretariat contributed to its drafting.

[2] The term "securitisation" is used in a very broad sense in this paper to mean the conversion of (credit, interest-rate, catastrophe, etc) risks into marketable securities (e.g., bonds, derivative instruments).

[3] Total risk capital outstanding is the total bond principal at risk in the market, irrespective of issuance year (see *The Catastrophe Bond Market at Year-End 2007: The Market Goes Mainstream*, Guy Carpenter, LLC, 2008, p. 6).

[4] Ibid, p.3.

exchange-traded CAT-linked futures and options contracts. Each exchange is capitalising on a perceived larger appetite for CAT-linked products by investors and an ever increasing need for risk transfer by insurers and reinsurers.

The High-level Advisory Board to the International Network on the Financial Management of Large-Scale Catastrophes, with the support of the Insurance and Private Pensions Committee and the Committee on Financial Markets, has followed these developments and identified the role of capital markets in the financing of large-scale natural catastrophes as meriting policy attention among OECD and non-OECD countries. The Advisory Board considers that CAT-linked securities may provide a useful tool in the financial management of large-scale catastrophes by providing an alternative risk transfer instrument for insurers and other entities like governments and corporations seeking to transfer CAT risks, and thus enhancing the capacity of these entities to bear such risks. The Board expressed particular interest in identifying possible impediments to the growth of CAT-linked capital market instruments and considering possible solutions, if any.

This report intends to assess the potential role of capital markets in financing recovery from large-scale natural catastrophes, develop a better understanding of CAT-linked instruments -- including the drivers and impediments to their further growth -- and identify technical and other issues relating to the future growth of CAT-linked securities markets. While it is predicted that these markets will continue to grow, the current financial crisis suggests the need for caution in developing CAT-linked instruments and markets.

The report is divided into five sections. Section two identifies the problem by describing the nature and costs of catastrophic risks and the ability of insurance and reinsurance to absorb and transfer these risks. This section investigates the role that capital markets might play in the direct transfer of catastrophe risks, whether as a substitute for, or complement of, insurance and reinsurance. The section also provides a framework for analysis by reviewing the growth of securitisation and identifying key drivers accounting for its growth. Section three provides an overview and analysis of CAT-linked securities and derivatives. The evolving structure of CAT-linked instruments, and the role of pricing and credit ratings, are considered in this section. Section four notes the key drivers and impediments to the development of CAT-linked securities, using the framework for analysis developed in section two. Section five reviews issues relating to the future growth of CAT-linked securities. The final section offers some recommendations.

2. Nature of the problem and potential role of capital markets as a solution: framework for analysis

a) Nature of natural catastrophe risks, their economic costs, and losses absorbed

Insurance markets provide the means for individuals and organisations to transfer the risks of loss to insurers who pool the pure risks and, via the law of large numbers, make the unit loss more certain and the distribution less risky. The law of large numbers relies, however, on the independence of risks in the pool. Some perils abrogate that independence despite reinsurance because the spatial correlation of risks diminishes the effectiveness of the insurer's

geographic diversification. Reinsurance does allow the insurer to transfer risk to an entity with a more geographically diversified pool of risks, but reinsurance capacity is finite and any attempt at retrocession[5] simply chases a diminishing capital capacity.

i) Existing system for the transfer of catastrophe risk

The property-liability insurance industry faces risks that may be characterised as high frequency, low severity and as low frequency, high severity. The high frequency, low severity risks in its books of business (e.g., automobile collision losses) may represent serious financial risks to the insured but are small risks to the insurer and industry. These risks can be characterised as independent, so that the law of large numbers applies; given a large number of independent risks, the law of large numbers shows that the average risk becomes fairly predictable. By pooling such risks in its books of business, insurers can charge premiums that reflect the average loss plus expenses plus a risk-bearing premium. The industry's equity capital may be expected to cover any adverse deviation in losses.

By contrast, the low frequency, high severity risks in its books of business (e.g., home owner's property loss due to a hurricane), while representing the same serious financial risks to the insured, also create large risks to the insurer and the industry. Such catastrophic (CAT) risks are more difficult to manage. The low frequency makes predictability problematic and, given the occurrence of a CAT event, the risks in a book of business may be highly correlated. Hence, the law of large numbers, which makes pooling an effective management tool in the high frequency, low severity case, becomes ineffective and less appropriate in the low frequency, high severity case. The equity capital of the insurer and the industry may not be able to cover a large CAT risk.

To gain an historical perspective, Figure 1 shows the dollar costs of the worldwide catastrophic risks both natural and man-made from 1970-2007. The North American losses are quite large; it is instructive to compare those insured losses with the capital capacity of the insurers.

Figure 2 shows the historical development of U.S. policyholder surplus (PHS), which is a gross measure of the property-liability insurance industry's ability to meet its obligations. It reached a local minimum in 2002 but has risen steadily since then to reach a half trillion U.S. dollars in the third quarter of 2007.

While the surplus is instructive, viewing CAT losses as a proportion of the surplus allows us to roughly gauge the ability of the U.S. insurance industry to absorb losses resulting from these large events. Figure 3 shows that the proportion of CAT losses has risen to 15 percent or above only twice in the last thirty years; the last time it did so was due to Hurricanes Katrina, Rita and Wilma in 2005.

[5] Retrocession is the reinsurer's reinsurance; the retrocession transfers part of the reinsurer's risks to other reinsurers or insurers.

Figure 1: World Natural and Man-Made Catastrophes (Source: Swiss Re, 2008)[6]

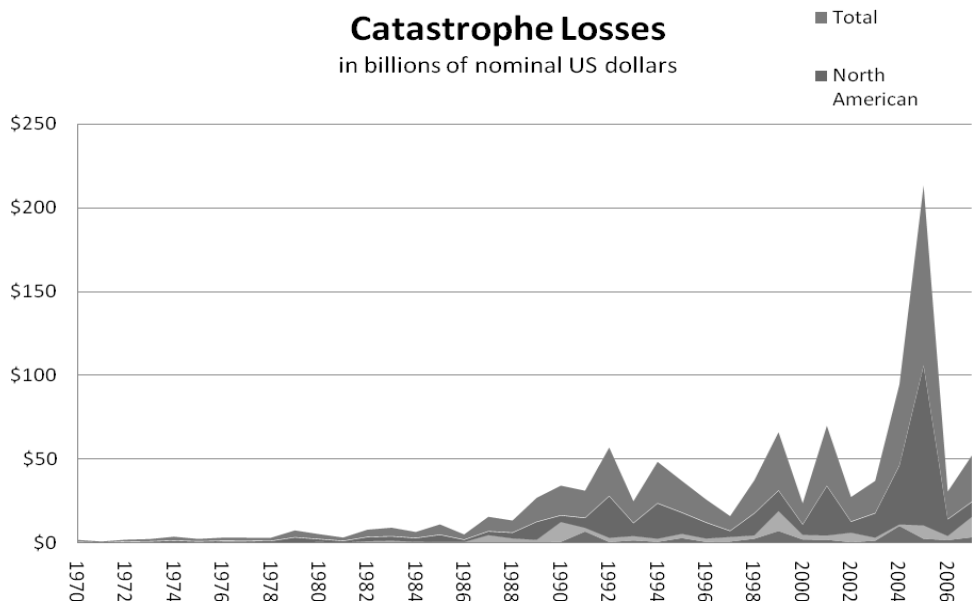
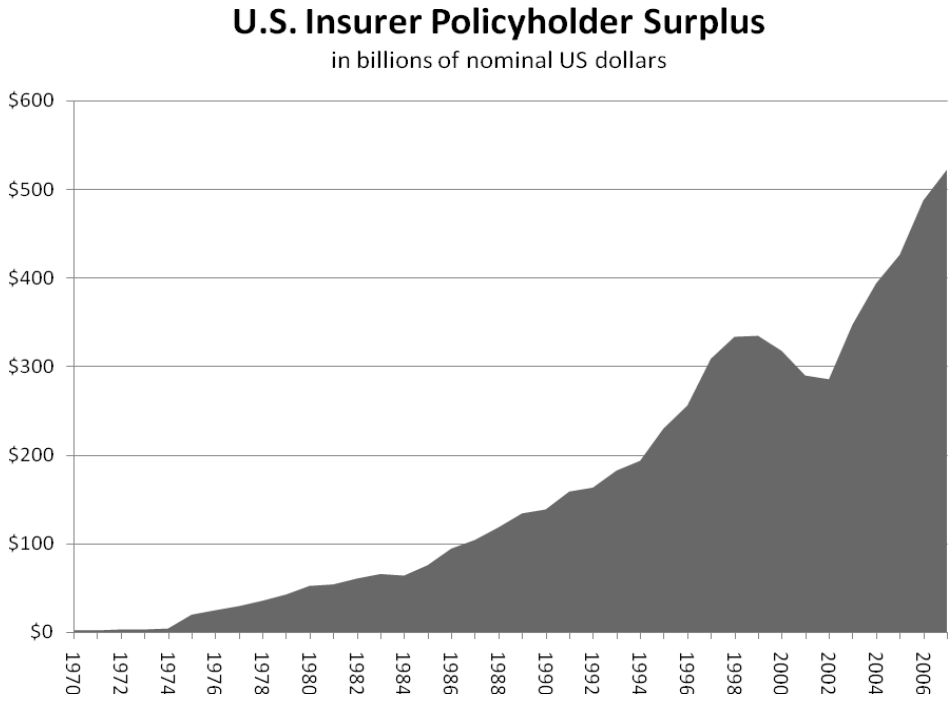


Figure 2



Source: A.M. Best, ISO, Insurance Information Institute

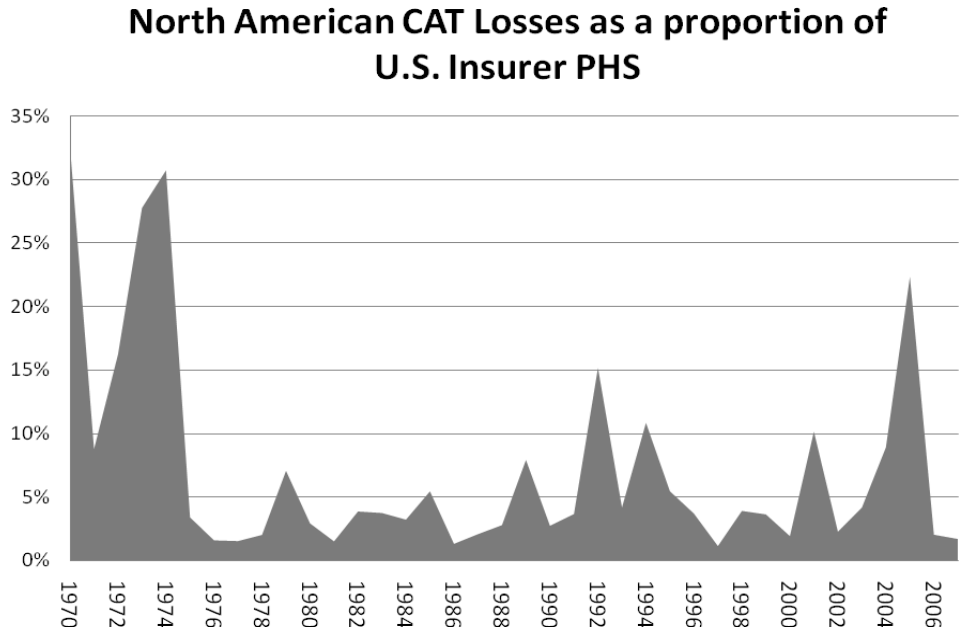
[6] The total losses also include losses from Africa, Antarctic, Australia and Oceania, South America, worldwide and space.

While the last spike reached over one fifth of the surplus, a substantial portion was reinsured or covered by capital market instruments, i.e., 44 – 53 percent by reinsurers and 1 - 3 percent by capital markets.[7] The 44 to 53 percent would amount to a US$20.7 to US$24 billion dollar loss to reinsurers. If the loss were covered solely by U.S. reinsurers, then it would amount to between 30 and 35 percent of their surplus.[8] While these numbers are rough approximations, they are large relative to the available U.S. reinsurer surplus.

ii) Pricing and capacity dynamics

The reinsurance market is subject to cycles and reinsurance premia were rising before Hurricane Andrew in 1992. The further increase in reinsurance prices after Andrew is shown in Figure 4, which depicts the Guy Carpenter Reinsurance Rate Online (ROL) index from 1990 through 2007.[9] The cycles of hard followed by soft reinsurance markets are well known but have not been adequately explained by insurance or financial market theory.[10]

Figure 3



Source: Swiss Re, A.M. Best, ISO, Insurance Information Institute

[7] See *Hurricane Katrina: Analysis of the Impact on the Insurance Industry*, Tillinghast, October 2005

[8] This is based on an estimated US$68 billion in U.S. reinsurer PHS in 2005. See *Property/Casualty Insurance Financial and Hurricane Update*, 2006, Insurance Information Institute.

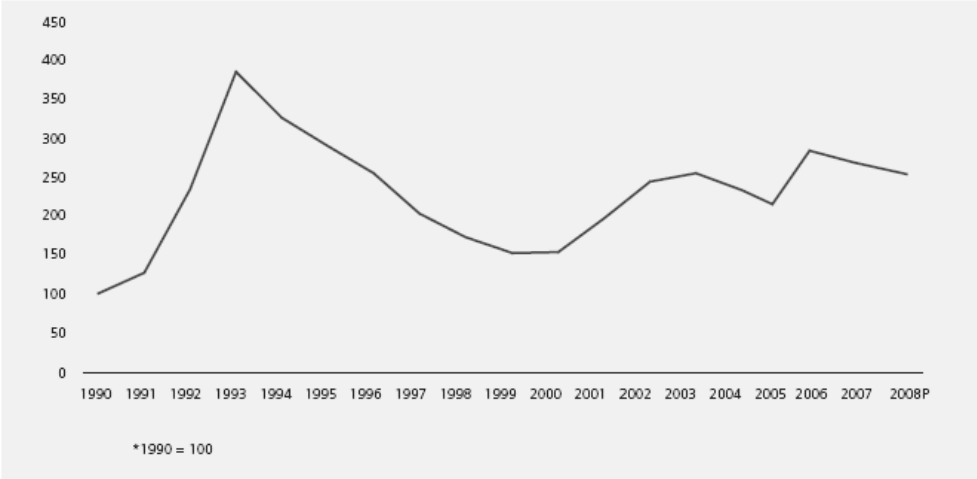
[9] Reinsurance Rate Online (ROR) is defined as the premium divided by the indemnity.

[10] There have been notable explanations of cycles but none that are fully acceptable, e.g., see Cummins, J. D. and J. F. Outreville (1987). "An International Analysis of Underwriting Cycles in Property-Liability Insurance." Journal of Risk and Insurance 54(2): 246-62, Winter, R. A. (1994). "The Dynamics of Competitive Insurance Markets." Journal of Financial Intermediation 3(4): 379-415, Cummins, J. D. and P. M. Danzon (1997). "Price Shocks and Capital flows in Liability Insurance." Journal of Financial Intermediation 6: 3-38, Lai, G. C., R. C. Witt, et al. (2000). "Great (and not so Great) Expectations: An Endogenous Economic Explication of Insurance Cycles and Liability Crises." Journal of Risk and Insurance 67(4): 617-652.

iii) Possible limitations of insurance markets: insurability of natural catastrophe risks and capacity of the insurance and reinsurance industry

Insurance and reinsurance markets are well suited to independent risks that can be pooled. Natural catastrophes generate highly correlated risks and therefore challenge the typical notion of an insurable risk. This has become increasingly important as the size of the CAT losses has risen so dramatically this century. The capital capacity of the insurance industry has increased as evidenced by Figure 2, but that increased capacity does not necessarily represent an efficient use of financial resources.

Figure 4: Guy Carpenter Reinsurance World ROL Index



Source: The Catastrophe Bond Market at Year-End 2007: The Market Goes Mainstream, Guy Carpenter & Company, LLC, 2008

Transferring CAT risks to the capital market, however, does allow these risks to be divided and borne by investors at a price appropriate for the risk bearing involved. In fact, financial market theory does quite clearly show that hedging risks in capital markets can reduce volatility and create value. Although the amount of CAT risk that has been transferred to the capital market is still quite small, Figure 4 suggests that it has dampened the cycle in the reinsurance markets. CAT-linked securities decrease the volatility of insurer or reinsurer earnings by providing capital when it is needed, i.e., when a catastrophe triggers a payout; these securities also provide multi-year coverage at a known premium and this may dampen the rise in premium in a hard market as well as the fall in premium in a soft market.

b) Stages of evolution and maturation of securitisation of risk in capital markets: framework for analysis

Some lessons can be drawn from past experiences of securitisation of risk in capital markets in order to assess the possible roles of capital market instruments in the transfer of catastrophe risks. In addition, reflecting on the conditions for growth and liquidity of markets like the mortgage-backed and asset-backed security markets, the credit derivatives market, and, to a lesser extent, the weather derivatives market, helps to identify key drivers and impediments to the future development of the CAT-linked securities market. The following examination of past experience with securitisation provides a framework for analysis that will facilitate our understanding of the growth and evolution of CAT-linked securities.

Securitisation dates back to the early 1970's when a U.S. government sponsored agency called the Government National Mortgage Association (Ginnie Mae) pooled mortgage loans and sold single-class mortgage backed securities (MBS) collateralised by that pool of loans. Other federal agencies, the Federal Home Loan Mortgage Corporation (Freddie Mac) and the Federal National Mortgage Association (Fannie Mae), followed suit in the early eighties but instead issued multiple classes of securities against the pooled mortgages in order to access investors with various risk tolerances more efficiently. Financial institutions started issuing their own collateralised securities soon thereafter. Non-agency (private) MBS issuance surpassed agency MBS issuance for the first time in 2005 with US$1.191 trillion and US$966 billion issued respectively (FDIC Outlook, fall 2006).

Securitisation soon expanded to asset-backed securities (ABS) and collateralised debt obligations (CDO). ABS typically refer to the securitisation of pools of homogeneous assets like account receivables. CDO, which appeared in the late eighties, are more complex instruments. They became – until the recent financial crisis -- a crucial component of securitisation in the mortgage and credit markets. Broadly speaking, we define a CDO as a pool of debt contracts housed within a special purpose entity (SPE) whose capital structure is sliced and resold to investors. "Cash flow" CDO are collateralised by a portfolio of outstanding debt issued by a range of companies, while "synthetic" CDO are not collateralised by actual bonds but by more complex credit arrangements like swaps. Examples of cash flows CDO are MBS or credit-linked notes. Examples of synthetic CDO are CDO collateralised with credit default swaps or other types of credit derivatives.

Finally, securitisation of weather risk began in 1996 with an over-the-counter derivative contract between Aquila Energy and Consolidated Edison. The appearance of weather derivatives contracts just preceded the issue of CAT-linked securities such as CAT bonds. Weather derivatives were somewhat unique in securitisation markets in that they were usually not based on portfolios of pooled individual risk, but on indices of more independent measures of weather risk like indices of temperatures or snowfalls for a specific location.

The U.S. securitisation market experienced tremendous growth in the past twenty-five years. In the mortgage security market alone, issuance of mortgage-related securities, including agency and private MBS and collateralised mortgage obligations (CMO) totalled US$2.04 trillion in 2007, up from US$1.99 trillion in 2006 (SIFMA, February (2008)). In the credit markets, the International Swap Dealer Association (ISDA) has estimated the amount of notional value in credit derivatives to be about US$54.6 trillion in mid-2008. The notional amount of CDO remains unknown but is widely estimated to be in the multi-trillions. Finally, the weather derivatives market has grown very rapidly, but still remains smaller with an estimated US$32 billion in notional value of contracts (futures and over-the-counter derivatives) for 2007-2008 (Weather Risk Management Association).

i) Key drivers to initial market development

Historically, some common factors contributed to the initial development of securitised capital market instruments:

- ***Need for additional market capacity and need for transferring risk***: Securitisation in the MBS market allowed banks to move loans off their balance sheets by selling them to outside investors. This technique enabled them to grant more loans and, in the process, transfer mortgage-related risks (interest risk, default risk and pre-payment risk) to risk-takers. The same motivation accounted for the securitisation of credit risk via credit derivatives and weather-related risks via weather derivatives and for CAT risks via insurance-linked securities.

- ***Investor appetite for diversified risk***: Hedge fund managers, money managers, and other institutional investors provide services to their clients in the form of portfolios of securities. These services require the selection of assets and construction of portfolios. Institutional investors view assets from the perspective of what they contribute to the portfolio; if an asset has an expected return as least as great as the existing portfolio and a return uncorrelated with the portfolio then received financial theory shows that such an asset should be included in the portfolio (Samuelson 1967). Uncorrelated assets allow institutional investors to diversify their asset portfolios. Hence, institutional investors seeking uncorrelated assets provided the demand for securitised risks.

  Securitisation helps in the pooling of individually illiquid assets into portfolios and in the subdividing of these assets into classes of securities. This process allowed investors to participate in previously illiquid markets and helped them further diversify their asset portfolios.

- ***Development of methodologies for risk assessment***: U.S. rating agencies like Standard & Poor, Moody's and Fitch Ratings unquestionably played an important role in the development of securitisation by developing methodologies to evaluate the risk embedded in securitised instruments. Securitisation is a complex procedure, and investors rely heavily on risk ratings for the selection of securities in their portfolios. While U.S. ratings agencies have been under fire lately, allegedly for flawed ratings of mortgage CDO structures, their role remains crucial in securitisation.

  As discussed below, the role of credit rating agencies and catastrophe modelling firms in assessing the financial burden of natural catastrophes on an insurer's book of business has been invaluable to the CAT-linked security market.

- ***Government initiatives aimed at facilitating market growth***: The MBS market, in particular, may not have expanded as quickly as it did if the U.S federal government and federal agencies had not contributed to its development at the outset. The role of Ginnie Mae, Freddie Mac, and Fannie Mae in mortgage-backed securities issuance, and in providing liquidity in the secondary market, was critical for the development of securitisation and remains crucial. Rosen (Rosen 2007) reports that Fannie Mae and Freddie Mac accounted for 44 percent of MBS issued in 2006; the remaining 56 percent issued was packaged by financial institutions in the private sector.

- ***Legislative and/or regulatory factors***: Elul (Elul 2005) argues that legal factors and government regulation were also important drivers of securitisation. For instance:
  - Securitisation helped in lowering banks' regulatory capital requirements. For instance, the demand for credit derivatives by banks was spurred largely by the 1988 Basel Accord, which mandated that large commercial banks maintain a minimum amount of surplus, based on the amount of (credit, operating and interest) risks in their balance sheet. The banks realised that they could transfer the credit risk of borrowers to entities not subject to bank capital requirements, while retaining at the same time the ownership and revenue from such loans.
  - Pension fund, mutual fund, and hedge fund regulations (or lack thereof) may explain the credit enhancement and tranching techniques embedded in some securitised products, which broadened their appeal. In the U.S., pension and mutual funds can be heavily regulated in their holdings of low-rated asset-backed securities, while hedge funds are lightly regulated in their investments. Security tranching into high-rated senior tranches and low-rated junior tranches helped in circumventing the regulatory framework applicable to pension funds and mutual funds. Hence, tranching expanded the breadth of the market by enabling the participation of additional institutional investors.

ii) Market evolution

While the securitisation of mortgage, credit, and weather risk is currently experiencing difficulties in light of the financial crisis, the evolution of this market in recent years and its features are worth noting as a point of reference:

- ***Increased complexity in design of capital structures***: Increased complexity is observable in the design of capital structures. For instance, the securitised mortgage market has evolved from simple pass-through securities to CMO to CDO. In the credit markets, cash and synthetic CDO issuance now surpasses the size of the credit default swap (CDS) market. As noted in an FDIC outlook (2006), "much of the complexity of securitisation stems from the introduction of new types of collateral used in the underlying asset pools". This leads to less homogeneity in the underlying collateral and possibly makes the pricing of these securities more difficult.
- ***Refinement of risk-return profiles***: The tranching of securities into highly rated senior debt and low-rated junior debt has helped to refine the risk-return profiles of CDO and attract a larger base of investors. Banks, pension funds, and insurance companies are likely to invest in AAA-rated securities in the senior securitised tranches, while hedge funds and other specialised funds are more focused on the equity portion of a CDO and on lower-rated tranches.
- ***Further advances in technology and modelling***: Further advances in technology and modelling have contributed to public acceptance of securitised products. As noted by the FDIC (2006), "technological

advances in cash flow modelling, data processing and data availability will continue to play and integral role in the innovative market for securitisation". Market participants can now model more accurately the timing and amount of irregular cash flows (such as late payments, defaults, recoveries, prepayments) from an underlying asset pool in a securitisation deal. Data vendors like Bloomberg or Reuters even post their proprietary pricing models on their terminals for use by investors.

- ***Growth of index-based securitised instruments***: The proliferation of index-based securitised instruments has likely contributed to increased liquidity and trading. This development is currently notable in credit markets; a report from the British Bankers Association in 2006 indicated that credit default swaps (CDS) on indices had surpassed CDS on single names as the dominant product type. Mengle (Mengle 2007) notes that the issuance and trading of index-based products has grown rapidly to the increased acceptance of indexes such as, for instance, the Dow Jones iTraxx credit indexes. These indexes are subject to transparent rules and help to standardise CDS structures. He also notes that, since 2004, dealers in credit markets have promoted liquidity in the trading of index-based CDS. Such measures include the development of master confirmation agreements11 and commitments to make markets with tight bid-offer spreads.

iii) Conditions for market growth and liquidity in securitised markets

Based on this description of securitisation, the conditions for market growth and liquidity in securitised markets can be identified (beyond the basic driving factors of demand for securitised risks on the part of investors and hedgers, and the desire on the part of originators and other parties to transfer these risks):

a. Organised regulatory framework, government support, and conducive regulatory and tax environment

Securitised markets function better and gain public acceptance if they operate under some organised regulatory framework, provided either by government supervision or by self-regulation, that is aimed at protecting market participants and fostering efficiency. For instance, in the credit derivatives markets, the ISDA, the self-regulatory arm of swap dealers, routinely helps to settle trade disputes and counterparty default issues. Exchange-traded derivative instruments, like the CME weather derivatives or the credit index event contracts, benefit from the management of default and recovery by the exchanges' clearing corporations.

In addition, government participation in, and backing of, securitised markets provide a major stimulus. For instance, the U.S. federal government greatly facilitated the development of the mortgage securitised market by backing issuance of Ginnie Mae mortgage-backed securities. And, while Fannie Mae and Freddie Mac securities are not explicitly backed by the full credit and faith of the

[11] A master confirmation agreement is "…a contract in which all the terms that have to be agreed to only once by the parties are established for a single product group (such as European/North American single credit default swaps). That allows only the terms that change with every trade, called the transaction supplement or "short form," to be automated and confirmed"
(see http://www.dtcc.com/news/newsletters/dtcc/2006/jan/master.php).

U.S. government, it unlikely that U.S. regulators would let these institutions fail in the event of financial problems, as demonstrated by recent developments in which the U.S. Treasury has publicly indicated the need to sustain the solvency of these mortgage institutions and has injected capital to support these institutions.

A conductive legal and tax environment also favours securitisation, as demonstrated by the U.S. experience. For instance, in the mortgage market, CMO issues first faced complex tax, accounting and regulatory obstacles. The U.S. tax reform act of 1986 included the Real Estate Mortgage Investment Conduit tax vehicle that solved most of these legal issues.

b. Organised market framework

Securitised markets also function better and gain public acceptance if they operate under an organised market framework. Market infrastructures can be improved through collective actions by market participants.

The credit derivative markets recently benefited from such collective actions. The rapid growth of CDS outpaced the development of infrastructure necessary to clear and settle these transactions. Post-trade processes were largely manual and by early 2005, credit derivatives dealers had huge backlogs of unconfirmed trades. Dealers and asset managers acknowledged the problem and moved to adopt the Depository Trust and Clearing Corporation Deriv/Serv electronic confirmation service. As a result, the number of CDS confirmations outstanding thirty days or more declined by 92 percent between September 2005 and December 2006 (Kroszner 2007).

c. Standardisation

Standardisation enhances market liquidity and helps investors manage their portfolios more efficiently. Credit derivatives, for instance, are characterised by a higher degree of standardisation than other types of over-the-counter (OTC) derivatives. Market participants have widely used the relatively standardised ISDA Credit Swap Master Agreement as a blueprint for credit derivatives transactions. The standardisation of such agreements decreases the costs of initiating and trading credit default swaps. In a presentation made at a 2007 credit market symposium, Federal Reserve Governor Kroszner noted that the bid-ask spread for single-name investment grade CDS were 10 basis points or less at the time of his speech.

As noted above, transactions in index-based CDS have grown dramatically in the past two years. Their 'popularity' stems from the fact that they provide, by means of indices, investors with new tools for taking on, hedging, and managing credit risk in their portfolios. In the previously mentioned presentation, Kroszner (2007) estimated that the bid-ask spread for investment grade credit index-based transactions was at most two basis points at the time of his speech.

Finally, the growth of the weather derivatives market in recent years is almost exclusively due to increased trading volume in OTC index-based derivatives and in index-based futures and options contracts at the Chicago Mercantile Exchange.

d. Market transparency

Market transparency also enhances market liquidity. Transparency in some securitised markets (mortgage-backed securities and credit default swaps) has improved in recent years, while some other markets have remained opaque.

In the U.S., the mortgage-backed security market has benefited from a regulatory change that took effect in 2002 and which enhanced transparency. Security dealers must now report almost all corporate bond trades to the National Association of Securities dealers (NASD) within 15 minutes; the NASD then immediately reports the trade to the market via data vendors like Bloomberg or Reuters.

The prices of many credit derivatives, including single-names or index-based CDS and credit index tranches, are also widely reported to services like Bloomberg and Reuters. On the other hand, more complex credit derivatives like CDO tranches remain largely illiquid and opaque.

e. Diversification of market participants

Diversification of market participants is a key driver to market growth. This point is well supported in the credit derivatives market.

The British Bankers Association 2006 report on credit derivatives shed some light on the diversity of participation in this market. In 2000, banks and securities firms were dominant in 2000 and represented over 80 percent of credit protection buyers and 60 percent of credit protection sellers. By 2006, their participation had declined to about 60 percent of buyers and 44 percent of sellers. Recent new participants in the market included insurance companies, which tend to be active sellers of credit protection, and hedge funds, which tend to function as both buyers and sellers of credit protection. In 2000, hedge funds represented 3 percent of buyers and 5 percent of sellers, but in 2006, they had grown to 28 percent of buyers and 32 percent of sellers. Pension fund and mutual fund participation in credit derivatives remains at 1-2 percent as buyers and 2-4 percent as sellers.

It is important to note that, for the most part, the complexity of securitised structures in all markets makes them suitable investments only for investors with knowledge of complex financial transactions, notably institutional investors who actively manage credit or mortgage portfolios. These investors typically have access to sophisticated analytical tools unavailable to individual investors. This explains why only qualified institutional investors are active (and are permitted by regulation to be active) in most securitised markets.

iv) Impediments

Asymmetry of information among participants in securitised markets, combined with heterogeneity of pooled risks, may be an impediment to market growth, as demonstrated by the recent crisis in particular. Securitisation of risk becomes more successful when the capital structure provides an equal playing field in terms of information between risk transferors and risk takers. However, asymmetry of information combined with heterogeneous pools of risks may prevent risk takers from confidently assessing and pricing the underlying risk in various securitised structures, and may either deter some of them from

participating in these markets or cause them to take flight at the first hint of trouble in a securitised structure.

Asymmetry of information often leads to adverse selection and moral hazard. In the context of securitisation, adverse selection refers to the fact that, without a full ability to monitor a risk transferor's portfolio of risks, the risk transferor may securitise the most unattractive part of its portfolio. Moral hazard arises when the entity that transfers individual risks or a portfolio of risks no longer has the incentive to reduce risk.

Some index-based capital market structures may alleviate asymmetry of information problems, as long as the components of the index are not subject to possible manipulation. A good example of a non-manipulable index can be found in the weather derivative market. Most weather derivatives are based on an index of heating degree days (HDD) or cooling degree days (CDD), which are provided by an independent entity, the U.S. National Weather Service. In the credit market, Dow Jones is an independent firm that calculates and monitors both the CDX index (consisting of the risk of 125 North American investment grade firms) and the iTraxx index (consisting of the risk of 125 Euro-based investment grade firms).

In mortgage and asset-backed security markets, MBS or ABS structures tend to bundle homogeneous pools of assets such as mortgages or receivables with similar characteristics and generally idiosyncratic risk[12] is well diversified within the pool. Consequently, diversified and homogeneous pools of assets can be valued based on default probabilities that draw on the historical performance of similar asset pools (FDIC, 2006).

In contrast, in credit markets, some complex CDO structures can be collateralised by a relatively heterogeneous pool of risks, such as different types of bank loans, corporate debt, different types of derivative instruments, or even other CDO. Both systematic[13] and idiosyncratic risks remain important in the pool performance and valuing these pools on the basis of historical default probabilities may be inadequate because of the idiosyncratic risks remaining in the pool.

To its credit, the CDO market is moving toward more sophisticated valuation models, but these models are only accessible to "extremely sophisticated" institutional investors. The recent losses borne by large investment banks in complex CDOs backed by pools of sub-prime mortgage and credit risks show that even sophisticated investors are not immune from this problem.

c) Possible roles of capital markets and capital market instruments in the transfer of catastrophe risks

CAT risks are large relative to the capital capacity of reinsurers, and insurers have historically transferred a significant proportion of their property, including their CAT risk, to reinsurers. Bob Hartwig, President of the Insurance Information

[12] Idiosyncratic or nonsystematic risk is that risk which is inherent in a company or industry; it is also often called diversifiable risk.

[13] Systematic risk is that risk which is inherent in the market; it is also often called market or non-diversifiable risk.

Institute, has noted that global reinsurers absorbed 20 percent of the four 2004 hurricane losses and 45 percent of the 2005 hurricane losses – which were themselves more than twice the cost of the 2004 storms. As coverage in high-risk areas increases, the capital capacity of reinsurers becomes more limited and generates the need for either higher limits on instruments such as excess of loss reinsurance or additional capital capacity at the right price. CAT-linked securities provide a means of managing this risk by transforming pure risks into speculative risks and then transferring these speculative risks to capital markets, which have a potentially huge capacity to absorb catastrophe risks.

i) Complement or substitute to reinsurance

Excess of loss reinsurance or retrocession is often written in layers. The lower layers are associated with greater historical frequencies and thus are more predictable than the higher layers. This system allows insurers and reinsurers to select coverage and to separate the higher frequency lower severity from the lower frequency higher severity; equivalently, the excess of loss coverage allows insurers and reinsurers to separate extreme CAT risks from other risks. The lower layers consist of those risks that can be expected to be effectively and efficiently pooled, and rely both on the law of large numbers and better diversification. The higher layers constitute the CAT risks where predictability is more of a problem.

In the higher layers, there is some reason to view reinsurance or retrocession and CAT-linked securities as *substitutes* if the capital capacity of the insurer or reinsurer is sufficient to eliminate its credit risk. The pricing of each type of instrument should determine whether reinsurance or CAT-linked securities dominate the market. As the credit risk of reinsurers is strained by additional coverage of the higher layers, however, there is more reason to view the instruments as *complements*. Additional reinsurance requires more capacity and one way to achieve that capacity is via CAT-linked securities. There are, of course, other ways to create additional capacity, such as through IPOs and sidecars. New reinsurers entered the market in the aftermath of Katrina; new sidecars were also developed in the wake of Katrina.

As discussed below, it is not expected that CAT-linked securities will provide a substitute for traditional insurance for businesses and other large insurance customers unless the CAT risks are substantial (i.e., are not insurable from the perspective of an individual insurance company).

ii) Potential size of demand

The demand for CAT-linked securities is growing with the size of the CAT losses. Evidence has already been provided on the dramatic increases in the worldwide CAT losses as well as the U.S. CAT losses in the past decade. The CAT bond market has also gained speed. Between 1997 and 2006, there were only 89 transactions for a total of $15.35 billion issued. In 2007, $13.8 billion of CAT risk was securitised in the form of bond issues, compared with $8.5 billion in 2006.

Both insurers and reinsurers (and other actors such as governments) may, for a number of reasons outlined below, wish to make use of CAT-linked securities (such as CAT bonds and CAT-linked derivatives) for risk transfer purposes. For investors, there may a significant, longer-term demand for CAT-linked securities such as CAT bonds given their potential benefits for portfolio diversification.

3. Overview and analysis of catastrophe-linked securities

a) Overview of catastrophe-linked securities

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

i) 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.

The insurer or reinsurer, also called the sponsor, creates a special purpose vehicle (SPV). The purpose of the SPV is to provide loss protection to the insurer or reinsurer. The insurer or reinsurer pays a premium to the SPV, 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 insurer or reinsurer. See Annex 1 for the structure of a CAT bond.

ii) 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. An example of a CRO is Gamut Re that had a $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, industry loss warrants, and CAT bonds. Investors in a CRO immediately benefit from portfolio diversification in insurance risk.

iii) 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 New York Mercantile Exchange (NYMEX), the Chicago Mercantile Exchange (CME), and the Insurance Futures Exchange Services (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.

a. Event loss swaps

Although there is little publicly available information on over-the-counter CAT-linked derivatives, we note that Deutsche Bank has recently begun 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 $5 million amounts, with the buyer upfront premium being expressed as a percent of the notional amount.
- The swaps contracts cover windstorm and earthquakes risks in the U.S. with thresholds levels sets at $20 billion, $30 billion, and $50 billion for hurricanes and tornadoes, and at $10 billion and $15 billion for earthquakes.

b. 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 $10 million. For instance, cumulative loss estimates of $25 billion translate into a 2,500 point index. One index point is worth $10.
- NYMEX currently offers futures and options contracts on three regions: National, Florida, Maine to Texas (excluding Florida)

c. 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 $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.

d. IFEX event-linked futures

IFEX is a subsidiary of the Climate Exchange plc. Group and operates via the Chicago Climate Futures Exchange trading platform. The IFEX launched event-linked futures (ELF) contracts linked to U.S. tropical wind in September 2007 and will soon offer ELF contracts on other catastrophe zones and perils. 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 $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 $10 billion to $50 billion, in increments of $10 billion.

iv) Other instruments

a. 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 is 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 viewed as a derivative contract when it is triggered only by an industry loss. A.M. Best[14] has recently drawn analogies between the basis risk associated with non-indemnity triggered CAT bonds with that of ILWs.

b. 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. See Annex 2 for a diagram outlining the structure of the sidecar.[15]

b) Size and growth of the catastrophe-linked securities and main features

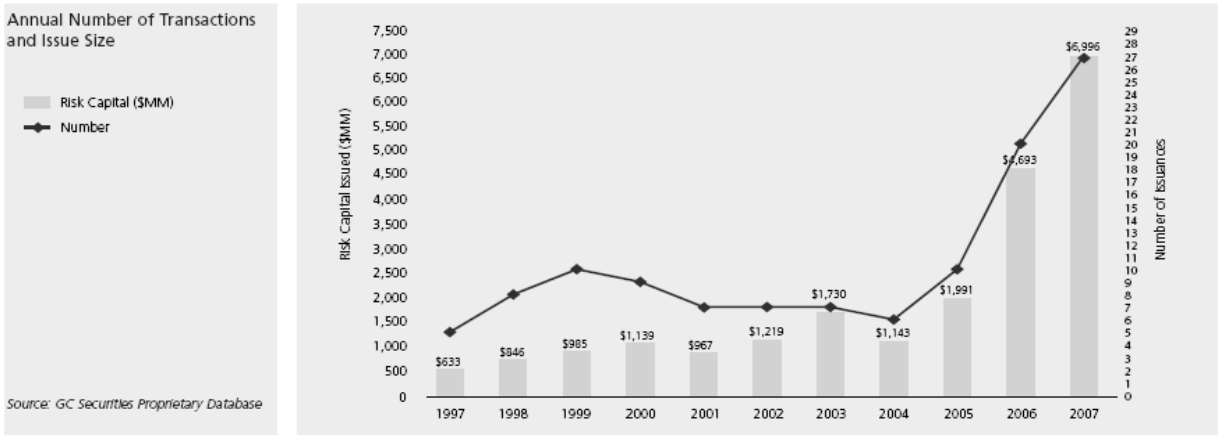
From 1997 through 2007, 116 CAT bond transactions were completed for a total of $22.4 billion issued. One of the most important measures of market size is the total risk capital outstanding; that measure showed record growth in 2007. At year-end, there was more than $13.8 billion in outstanding principal and that represented a 62 percent increase over year-end 2006 which had also been a record. The annual issuance totalled

[14] See A.M. Best's Press Release: "A.M. Best formally harmonises the basis risk evaluation of CAT bonds and ILWs", April 8, 2008.

[15] As sidecars are not, strictly speaking, capital market securities, they will not, for the purposes of this report, be explored further, except as a basis for comparison (e.g., in sub-section 4c)ii)).

almost $7 billion in 2007, which was 49 percent greater than the issuance in 2006 of $4.69 billion and 251 percent more than the issuance in 2005 of $1.99 billion. The number of transactions also set records in the last three years. The transactions are summarised in Figure 5.

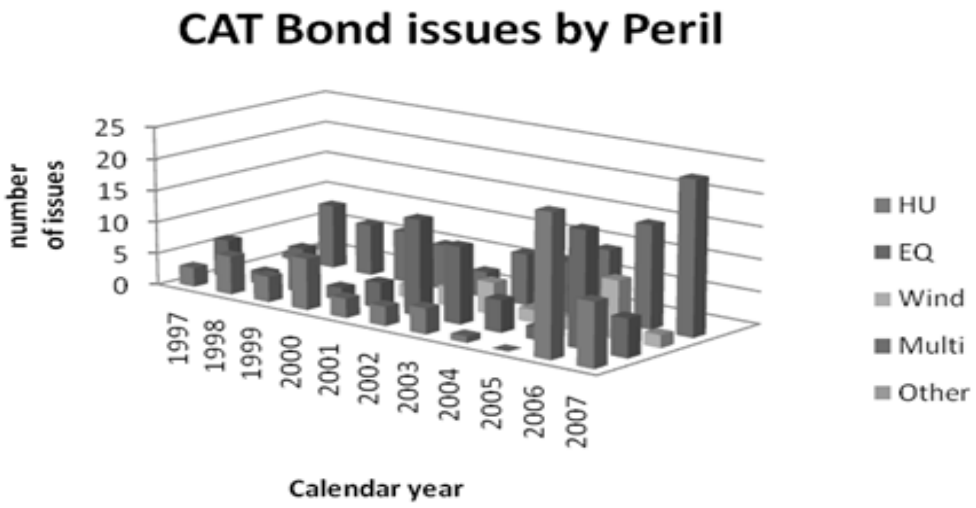
Figure 5: CAT Bond Transaction History



The sidecars issued in 2005, 2006, and 2007 represented $2.246 billion, $4.393 billion, and $1.762 billion, respectively.

Figure 6 provides a historical sketch of CAT bond issues by peril. 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. Hurricane, earthquake, and wind 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. Other perils such as flood would seem to fit this description but, in the U.S., this peril is covered by the government.

Figure 6



Source: Goldman Sachs

i) Triggers

The trigger on CAT-linked securities and derivatives 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.[16]
  - 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.
- **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 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 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 triggers.
- **Model**: 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.

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

- 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; use of this trigger was on the decrease with an exception and reversal in 2007. 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 random difference 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 Figures 7a and b for an historical sketch of trigger use. Both Figures 7a and 7b show more use of the indemnity trigger in 2007 than had been the case in earlier years. Note, however, that, in 2007, the State Farm $1.1 billion Merna offering accounted for almost half of the year's indemnity trigger offerings. Without it, indemnity-triggered structures amounted to only $1.2 billion, compared to $1.8 billion for PCS industry loss triggered securities. The trade-off between basis risk and moral hazard is discussed in greater detail below in the discussion on impediments to the growth of CAT-linked securities.

Figure 7a: Proportion of issue value (in $ millions) by year and trigger type

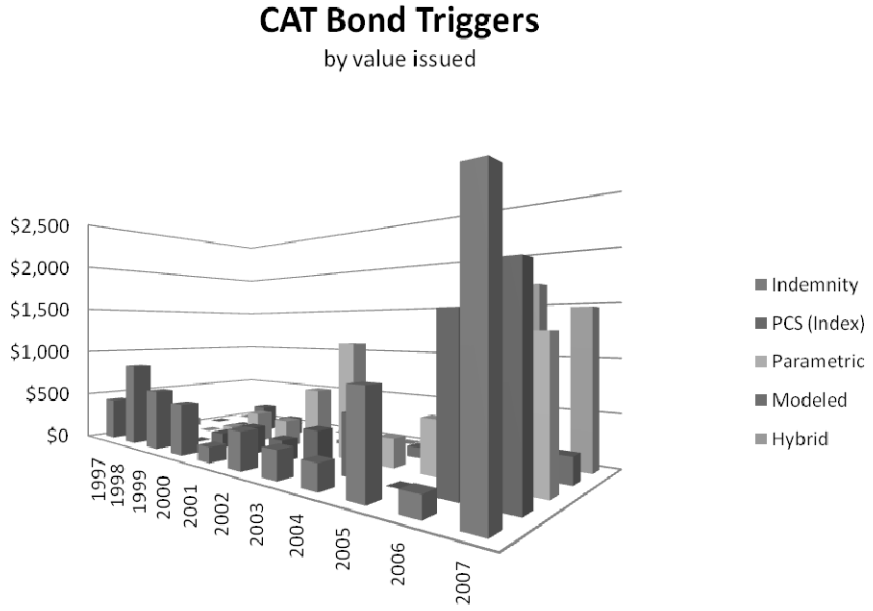


Figure generated from data in *The Catastrophe Bond Market at Year-End 2007*, Guy Carpenter & Company, LLC, 2008

ii) 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 A.M. Best 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 US 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.

Figure 7b: Number of issues by date and trigger type

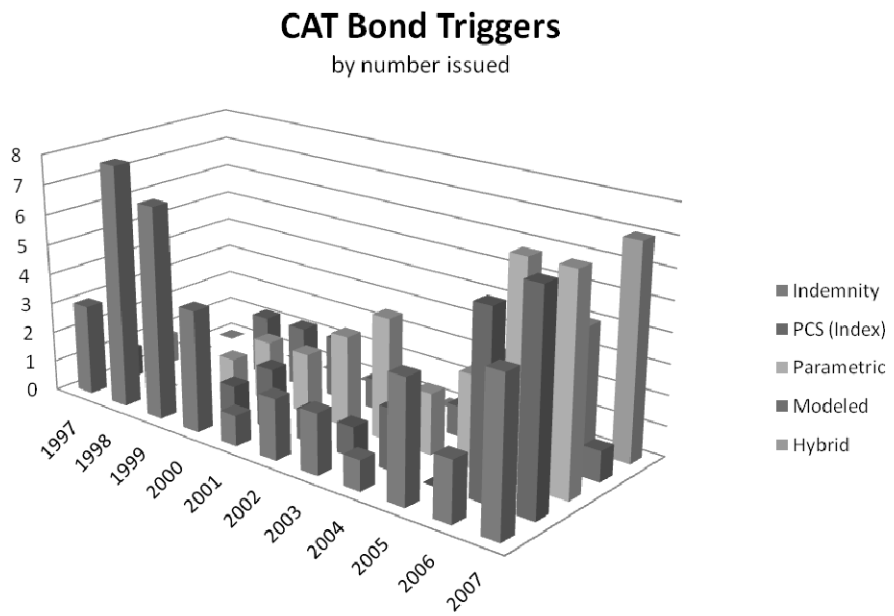


Figure generated from data in *The Catastrophe Bond Market at Year-End 2007*, Guy Carpenter & Company, LLC, 2008

iii) Credit ratings of catastrophe-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[17] that plots the bond issuer's loss against the probability of loss[18]. The credit rating agency may then ask that the model is 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. Figures 8a and b show the CAT bond ratings by issue value and year and by number and year, respectively. The figures show that the B and BB dominate in value and size historically. Only in 2007 did more highly rated CAT bonds reappear.
- **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.[19]
- **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; however, the dominance of BB and B issues has grown so that the non-investment grade plays a prominent role in the market both in terms of relative value and numbers. See Figures 9a and 9b for a historical sketch of CAT bond issues by credit rating. There was a return to AAA and other investment grade CAT bonds in 2007 due to more tranches in the issues that year.

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

[18] 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.

[19] 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.

Figure 9a: Proportion of issue value by year and rating

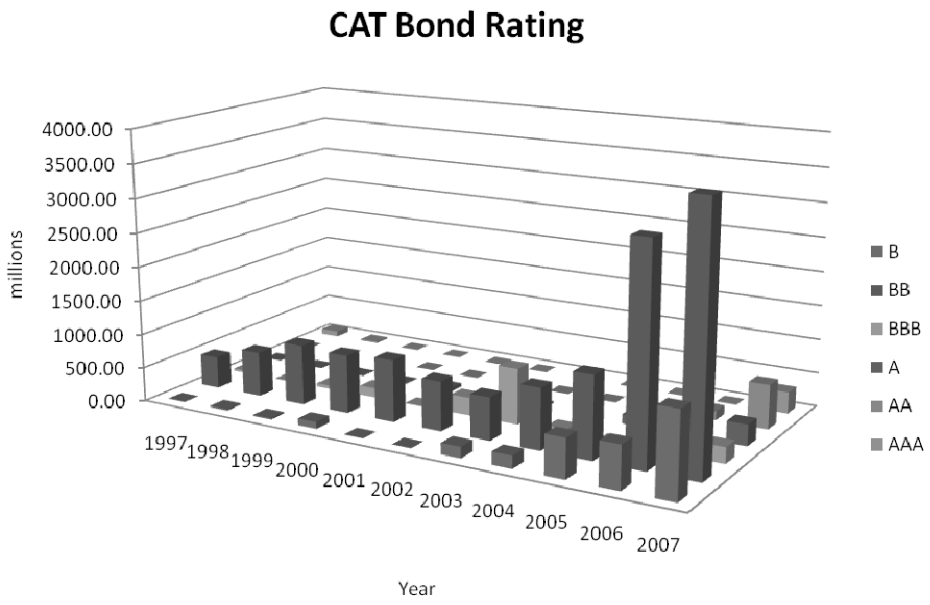


Figure generated from data in *The Catastrophe Bond Market at Year-End 2007*, Guy Carpenter & Company, LLC, 2008

Figure 9b: Number of issues by date and rating

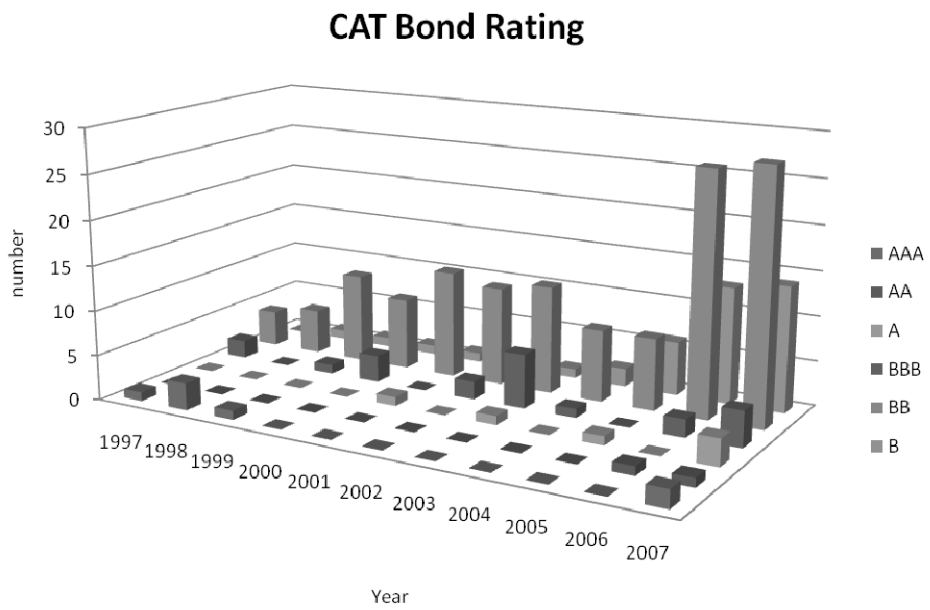


Figure generated from data in The Catastrophe Bond Market at Year-End 2007, Guy Carpenter & Company, LLC, 2008

iv) Pricing of catastrophe-linked securities

a. Theoretical considerations

The pricing of CAT bonds and other CAT-linked securities is perhaps the most investigated area of academic research in this area. 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 insurance-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 insurance-linked securities structures to the uncertainty associated with actuarial probabilities. On the other hand, Froot and Posner (Froot and Posner 2000) argue that the pricing of risks in CAT-linked securities structures, (and therefore the determination of risk premium spreads) is determined by reinsurer issuers that possess some market power due to their position as market makers.

Other research uses a financial approach to model CAT bonds and other insurance-linked securities structures. Vaugirard (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 & Pedersen (Cox, Pedersen et al. 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

As evidenced in Figure 10, from 2004 until May 2007, CAT bonds traded with a wider spread than similarly traded corporate securities. Markets 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. 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.

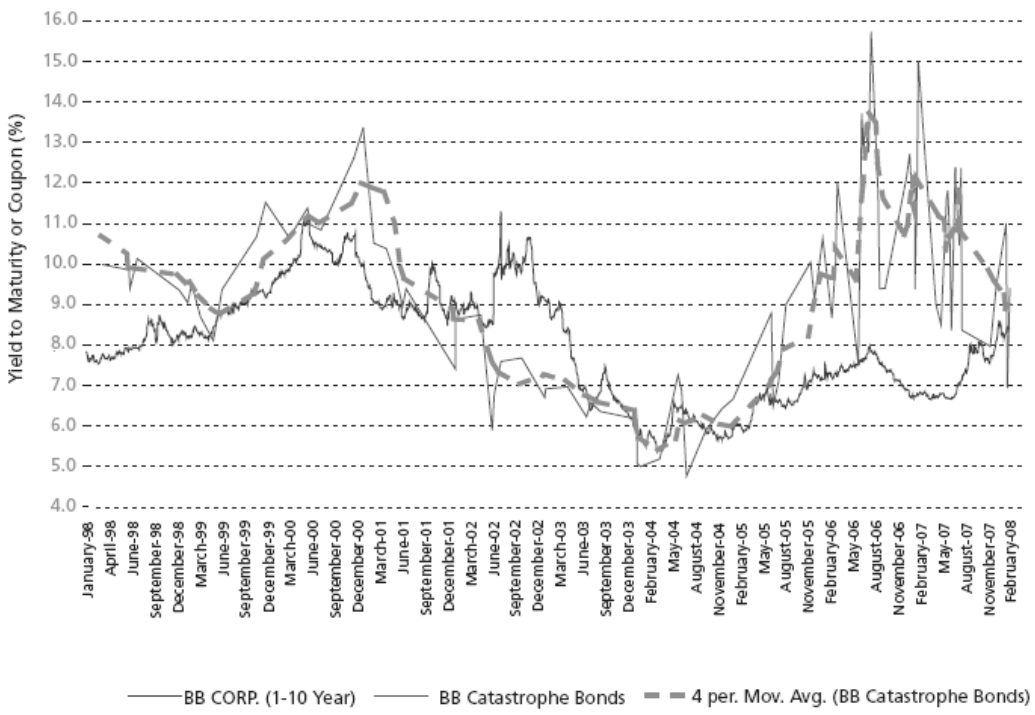
  Perception that the risk associated with CAT bonds may be more binary than that of corporate bonds (i.e., the perception that the loss is all or nothing).

- Willingness to pay a premium to acquire CAT bonds and other insurance-linked securities because the addition of these securities to their portfolios enhances diversification, i.e., see section below on CAT bonds as zero-beta assets.

Since May 2007, the difference between corporate bond spreads and CAT bond spreads has narrowed considerably, due mostly to the impact of the sub-prime mortgage meltdown on the pricing of credit risks. Guy Carpenter (2008) notes that corporate bond yields on BB-rated credits jumped significantly in the second half of 2007, compared to a relatively quiet first half of 2007. In the meantime, CAT bond yields continued to decline.

Figure 10: Comparison of CAT bond yields and corporate bonds yields (Source: Goldman Sachs)

FIGURE 9: CATASTROPHE BONDS vs. COMPARABLE CORPORATE BONDS 1997 TO 2007



- Cat bond prices are for individual issues (or in the case of multiples issues on a single day, a weighted average ROL based on risk capital) that have distinct characteristics affecting the bond's pricing. As a result, BB rated cat bond pricing appears more volatile when compared to the basket of corporate bonds reflected in the BB corporate index. To ameliorate some of the cat bond pricing volatility (which to a great extent is driven by idiosyncratic features of different issues) we have also taken a four observation moving average, in order to reduce noise and make it easier to recognize underlying pricing movement.

- In this year's report, Figure 9 includes only BB- rated catastrophe bonds and the corresponding corporate index. Of the 207 rated catastrophe bond tranches issued since 1997, 129 have been rated between BB-, BB or BB+. In the last three years, only five tranches have been rated BBB. Accordingly, we felt that data concerning BB securities was sufficiently representative of market dynamics and therefore keeping consistent with last year's report, we elected not to include BBB data in this exhibit.

- With respect to single day, multiple tranche issues, a weighted average ROL (based on risk capital) for the entire issuance was calculated.

- The "Gemini Re" transaction (issued 1/1/99) has been excluded from this exhibit because individual issuance characteristics made the pricing of this issue a non-meaningful data point.

- The "BB CORP. (1-10 Year)" data is taken from the Merrill Lynch BB Index (Corporates) Bloomberg Symbol: H5A1.

Sources: GC Securities, Bloomberg Financial Services, Inc.

GC SECURITIES

4. Key drivers of and impediments to the development of catastrophe-linked securities

a) Gap analysis

We can draw from observations made in section two of this report about the nature of natural catastrophe risks and their economic costs, the general conditions for market growth and liquidity in securitised markets and the possible roles of CAT-linked securities, to identify the key drivers and impediments to the development of the CAT-linked capital market.

i) General drivers

a. Demand for additional risk transfer capacity

Section two documents the need by insurers and reinsurers for additional risk transfer or risk financing capacity. Growing CAT bond issuance supports the statements made in that section: in 2007, many insurers already participating in the CAT-linked security market tapped the investment community again; for instance, Hartford, Liberty Mutual, SCOR and USAA executed their third, third, fourth and eleventh catastrophe bonds respectively. Allstate, Travelers and Chubb are among the major primary insurers who established shelf programs for the first time[20]. Also, in 2007, after a long absence from the CAT bond market, State Farm sponsored a $1.1 billion CAT bond. Finally, issuance of CAT-linked securities by reinsurers remains strong. Guy Carpenter (2008) estimates that reinsurer-sponsored transactions outpaced insurer-sponsored transactions 16 to 10 in 2007, as has commonly been the case throughout CAT bond market history.

When asked about future growth in the CAT-linked securities markets, some industry participants foresee demand for additional risk transfer capacity emerging from second-tier insurance companies, and from reinsurance companies that can synthetically "blend" their insurance clients' risk portfolios and transfer the blended risk to capital markets. Industry contacts also mentioned the possible role of state catastrophe pools that may securitise their extreme event risk rather than finance it with taxpayer money.

Finally, demand for additional risk transfer capacity and securitisation may emerge from countries that have huge exposure to catastrophe risks, a constrained financial ability to absorb the financial impacts of financial disasters, and/or an inexistent or inefficient reinsurance market infrastructure. A recent illustration is the newly established Caribbean Catastrophe Risk Insurance Facility (CCRIF). The CCRIF functions as a mutual insurance company controlled by participating Caribbean governments (with some support from donor partners and guidance from the World Bank). The CCRIF pools catastrophe reserves from participating governments, and transfers some of its natural disaster risks to reinsurance markets or capital markets via the use of CAT bonds.

b. Broader institutional base

As noted in section two of this report, diversification of market participants is a key driver of growth in securitised markets. In the last two years, the number of investors in the CAT-linked securities market has increased and diversified, as a result of a better understanding of the functioning of this market and of more sophisticated assessments of the financial impacts of catastrophe risks. The CAT bond market has a growing core of experienced investors including money managers, hedge funds, dedicated CAT funds, banks, reinsurers, life insurers, non-life insurers, and some money funds, (i.e., see figure 11a and 11b for a breakdown by investor group and country in transactions placed by Goldman Sachs in 2007).

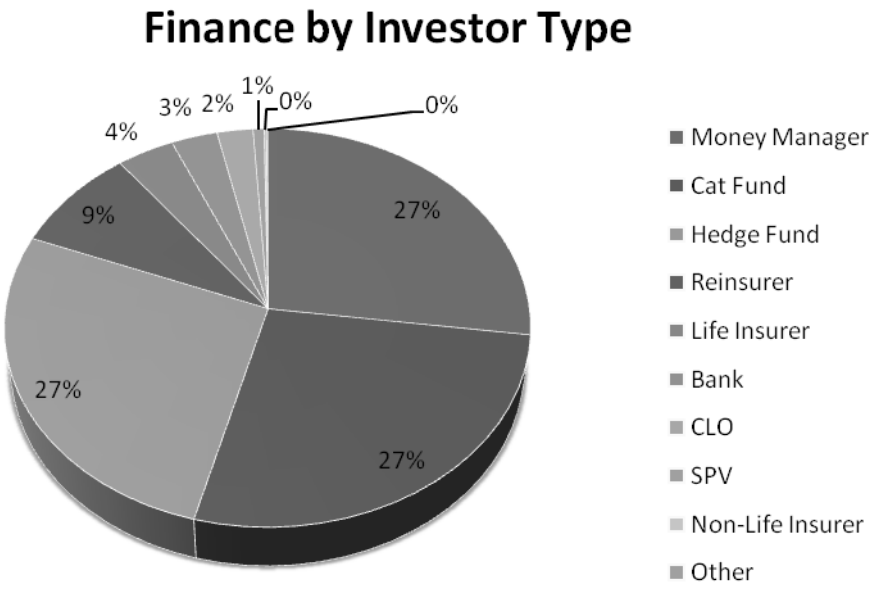
Since CAT bond structures trade over the counter, the secondary market is less transparent than the primary market and liquidity estimates vary considerably.

[20] Chubb announced the issuance of a US$200 million CAT bond on March 20, 2008.

Industry estimates of market participation range from scores to hundreds of investors. Figure 11a shows that the proportion of the capital raised by Goldman Sachs in 2007 came primarily from money managers, CAT funds and hedge funds, i.e., those groups financed approximately 81 percent of the CAT-linked issues.

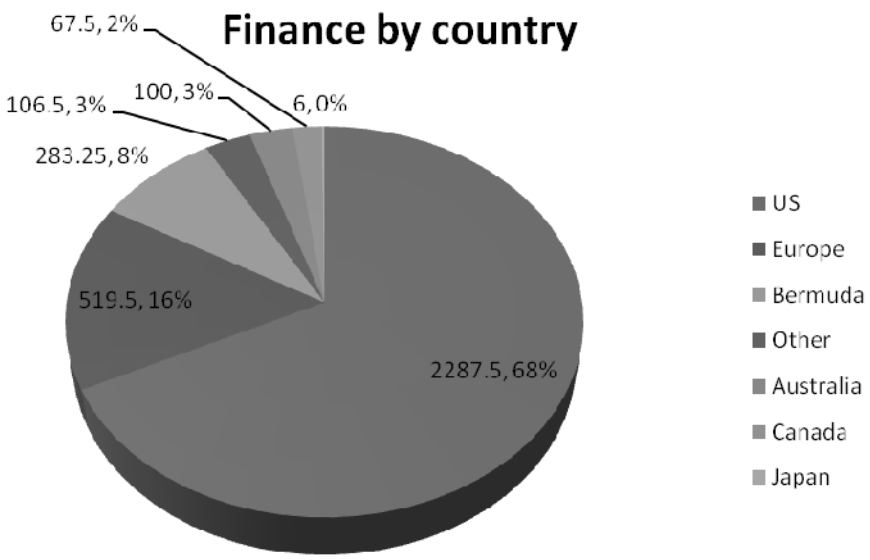
Finally, it is too early to predict the success of the CAT-linked derivatives markets. It is possible, however, that the proliferation of exchange-traded derivatives contracts has the potential of bringing a new category of investors into the market for catastrophe risks, like individual speculators or small trading firms like commodity pool operators.

Figure 11a: Investor base



Source: Goldman Sachs, May 2008

Figure 11b: Investor base by country



Source: Goldman Sachs, May 2008

c. Portfolio diversification benefits

Although CAT bond yield spreads have recently narrowed compared to traditional corporate debt spreads, CAT-linked securities have historically provided a favourable risk and return profile to investors and, more importantly, have provided them with a means of reducing portfolio risk.

More specifically, there is evidence that CAT bonds exhibit low correlations with other asset classes. For example, Froot (1995) estimates of the correlation coefficients between CAT exposures and other asset classes ranged from – 0.13 and + 0.21 but none were statistically different from zero[21]. The favourable risk-return profile of this class of securities demonstrates that the CAT-linked securities may be used to reduce the risk of a portfolio and increase its expected return. More recently, Heike and Kiernan (Heike and Kiernan 2002) have shown "that the addition of a small allocation of cat bonds to a BB high-yield portfolio, represented by the Lehman Brothers BB High Yield Index, reduces the portfolio's return volatility and boosts its expected return".[22] Hence, portfolio diversification provides a rationale for the growing investor base for this asset class.

The recent sub-prime mortgage and credit market crisis in U.S. financial markets further highlights the attractiveness of zero-beta assets, like CAT-linked securities, in

[21] See Froot, K. A., B. S. Murphy, et al. (1995). The Emerging Asset Class: Insurance Risk, Guy Carpenter. Also see Litzenberger, R. H., D. R. Beaglehole, et al. (1996). "Assessing Catastrophe-Reinsurance Linked Securities as a new Asset Class." Journal of Portfolio Management: 76-86.

[22] See Samuelson, P. A. (1967). "General Proof That Diversification Pays." Journal of Financial and Quantitative Analysis **2**(2): 1-13. Also see , MacMinn, R. D. (1984). "A General Diversification Theorem." Journal of Finance **39**(2): 541-50, which shows the conditions under which adding an asset to a portfolio will reduce the risk of the portfolio.

investor portfolios. Institutional investors have recently become re-acquainted with the dangers of holding securities collateralised with highly correlated assets and have shied away from mortgage-collateralised bonds or CDO, while turning to the CAT-linked market. This increased investor's interest partly explains the recent narrowing of CAT bond yields compared to yields on comparable traditional corporate debt (see Figure 10).

d. Advances in technology and modelling of catastrophe risk

As mentioned in section two, advances in technology and modelling also contribute to better public understanding and acceptance of securitised products. Today, thanks to advances in catastrophe modelling and risk assessment methodologies, both bond sponsors and institutional investors have a more sophisticated understanding of the financial impact of the risk embedded in various CAT-linked structures. In response to the financial impact of Katrina on the insurance and reinsurance industries in 2005, the leading CAT modelling firms, i.e., AIR, EQE and RMS, refined their modelling techniques to account for larger losses than those predicted. This increased awareness of potential losses has helped increase the search for capacity in the insurance industry and has driven sponsorship of CAT-linked securities. In addition, catastrophe modelling firms have reduced their wind prediction horizon to near-term probabilities, i.e., 5-year horizon as opposed to 25 -100 years.

The development of software technology aimed at facilitating the management of portfolio of catastrophe risks can also be observed. For instance, AIR has recently developed CATRADER®, a software tool that may appeal to both sponsors and investors in the CAT-linked securities market. In particular, according to AIR, the software provides investors with the ability to structure and evaluate securitised CAT transactions and enables the testing of portfolio optimisation strategies. RMS has also released a licensed software product "Miu" that allows investors and issuers to quantify and tailor a portfolio of catastrophe risk positions packaged in any form: catastrophe bonds, over-the-counter derivatives, sidecars, industry loss warranties, and various forms of reinsurance.

e. Competitive costs and pricing

The jury is still out on how costly CAT-linked securities are, from an issuance standpoint, compared to traditional reinsurance or industry loss warrants. In its report on managing large-scale risks, the Wharton Risk Management and Decision Processes Center (2008) notes that "from a single rate-on-line prospective, it is true that insurance-linked securities bear a higher cost than that of reinsurance or retrocession. However, there are exceptions for specific risks like higher tranches of retrocession and peak exposures in high-risk prone areas".

Typically, the one-time costs associated with issuing CAT bonds are higher than those that apply to regular debt securities. Most CAT-linked securitisation transactions have been structured via the use of SPVs that are generally based offshore. Although SPVs tend to simply operate trust accounts, there are significant transactions costs associated to the issuance of CAT bonds such as higher fees charged by rating agencies which devote more time and manpower in analysing CAT bond structures than regular debt structures, and fees charged by CAT modelling firms. Yet overall, the legal fees associated with issuing CAT bonds have declined with the increasing proportion of shelf registrations of insurance-linked securities, i.e., about 70 percent as estimated by Morton Lane (Lane and Beckwith 2007).

Indemnity-triggered bond transactions are generally (but not always) costlier than non-indemnity-triggered bond transactions. As noted by Guy Carpenter (2008), indemnity triggered bonds first require the payment of a higher risk premium to the investor relative to non-indemnity bonds. The size of the premium is a function of the type of business covered and the investors' confidence in the sponsor's underwriting, risk management, and loss and claims adjustment process. Second, there are additional costs embedded in indemnity-based structures resulting from disclosure requirements, the level of detail required on the underlying insured exposure in terms of nature and locations of the properties and their insurance coverages required to model the risk, and perceived legal exposure.

As noted above, the cost comparison between CAT-linked securities and traditional reinsurance may be unfair in that CAT bonds are multi-year programs that address credit risk and price volatility issues. Helfenstein and Holzheu (Helfenstein and Holzheu 2006)) argue that the multi-year nature of CAT bonds provides fixed-cost coverage over a multi-year period, while reinsurance premiums are much more sensitive to insurance cycles. CAT bonds also eliminate the risk of coverage and payment disputes. Swiss Re has also pointed out that catastrophe reinsurance claims for peak perils coincide with times of industry distress, while CAT bond proceeds are invested in highly rated securities, thus eliminating counterparty risk.

ii) General impediments

Each existing CAT-linked structure has its own weakness, which this report will describe. Overall, there are common factors that may have limited the growth and liquidity of CAT-linked securities and derivatives markets.

a. Trade-off between moral hazard and basis risk

As noted in section two of this report, securitisation of risk becomes more successful when the capital structure provides an equal playing field between risk transferors and risk takers. In the CAT-linked market, there could be a lack of "dual" coincidence of wants between the insurer and the investor. As explained previously, CAT-linked securities or derivatives may have a payout tied to indemnity or non-indemnity triggers (i.e., parametric triggers or industry loss triggers). Indemnity-triggered instruments appeal to sponsors because they reduce or eliminate basis risk.

On the other hand, non-indemnity based capital structures may be more attractive to an investor than indemnity instruments, as the use of an industry loss index trigger or a parametric trigger minimises moral hazard costs. Index structures also are likely to lower investors' costs in evaluating company-specific underwriting and financial results.

Company-specific capital structures, however, might be conducive to adverse selection and moral hazard. Adverse selection in the context of insurance securitisation reflects the fact that an insurer could securitise the most unattractive parts of its portfolio and keep the most profitable ones. Moral hazard relates to the fact that the insurer who transfers its risks to the investor via the capital market might no longer have an incentive to limit its losses.

Although relatively new in insurance markets, basis risk is well known in the financial markets, as it represents a risk inherent in all commodity and financial transactions

based on a standardised financial asset or commodity, or on an index of these. The issue per se is not the existence of basis risk, however, but its assessment and quantification. Once thoroughly quantified, if possible, basis risk in a financial transaction can be minimised and almost eliminated. For instance, it is common to use derivative instruments to eliminate basis risk in security or commodity portfolios via "over-hedging" or "under-hedging".[23]

The novelty here is that, with respect to CAT-linked securities and derivatives, it is much more difficult to assess the anticipated impact of a catastrophic event on an insurer's portfolio than to assess the market risk or interest rate risk of a specific security and to compare it to that of a standardised hedge instruments like a futures contract.

Can basis risk be handled in CAT-linked issues and does moral hazard still matter?

In a 1999 report commissioned by the National Association of Insurance Commissioners (NAIC), the American Academy of Actuaries argues that it is possible to statistically identify and measure the basis risk embedded in hedging transactions performed with index-based securities and derivatives.[24]

In addition, empirical evidence has supported the hedging effectiveness of non-indemnity instruments, despite the existence of basis risk[25,26]. However, these studies must be assessed with caution. Findings can vary based on the statistical method used, e.g., simulation models versus analysis of historical data, and on the source of basis risk embedded in a specific derivative transaction. Recent research has also focused on the benefits of index-triggered bonds in comparison with indemnity-triggered bonds. In a highly stylised model, MacMinn and Richter (2004) show that, under some circumstances, reinsurers who issue bonds to hedge against brevity risk (i.e., the risk of premature death) achieve greater shareholder value by utilising index-triggered securities instead of indemnity-based securities.

As noted above in this report, recent history in the CAT-linked securitisation market shows increased confidence by issuers of CAT bonds in index-based triggers; see Figures 7a and 7b for historical issuance of bonds by trigger type. Sponsors, with the help sometimes of reinsurance brokers, have spent a lot of time and resources understanding their exposures to basis risk. Meanwhile, investors have become increasingly comfortable with indemnity-based capital structures. Some of them now tend to recognise indemnity risk as another risk component in a transaction, provided

[23] The terms "over-hedging" and "under-hedging" refer to the process of transacting a higher or lower number of derivative contracts than the number that would be necessary for a company to perfectly hedge its exposure. Over-hedging and under-hedging examples using catastrophe insurance options can be found in the CBOT PCS catastrophe Options User's guide (1995, page 35-36).

[24] American Academy of Actuaries Index Securitization Task Force, "Evaluating the Effectiveness of Index-Based Insurance Derivatives in Hedging Property/Casualty Insurance Transactions" (American Academy of Actuaries, October 1999).

[25] See, for instance, Major, J. A. (1999). Index Hedge Performance: Insurer Market Penetration and Basis Risk. The Financing of Catastrophe Risk. K. A. Froot. Chicago and London, University of Chicago Press**:** 391-426. Also see Harrington, S. and G. Niehaus (1999). "Basis Risk with PCS Catastrophe Insurance Derivative Contracts." Journal of Risk and Insurance **66**(1): 49-82.

[26] A detailed discussion of the topic is beyond the scope of this paper. An overview and discussion of the regulatory and accounting treatment of insurance-linked instruments can be found in Bouriaux (2001).

that they have a sufficient grasp of catastrophe modelling techniques and a good level of comfort with bond sponsors. This explains why, in dollar issuance terms, the CAT bond market is now almost evenly split between indemnity versus non-indemnity triggered securities in terms of issuance.

Finally, while moral hazard exists in indemnity-based capital instruments, CAT bonds can be structured to minimise its impact. For instance, a structure involving co-insurance or payment of the premium upfront rather than in arrears may help to mitigate moral hazard.

b. Market fragmentation and lack of standardisation, and effects on market liquidity

In section two, it was noted that standardisation enhances market liquidity and helps investors manage their portfolios more efficiently. Yet, it was observed previously that, in issuance terms, the CAT bond market is almost evenly split between indemnity structures and non-indemnity structures. This partly explains the current fragmentation of the CAT-linked capital markets. In addition, and to a certain extent, CAT-linked capital structures seem to have become more complex with an evolution from fairly simple CAT bond structures, to CRO (reminiscent of CDO in credit markets), to sidecars[27]. However, secondary market liquidity generally increases as more standardised structures (i.e., structures with a payoff triggered by an index of pooled risks) appear in the capital markets.

It is interesting to note, in this respect, a new standardisation effort from a consortium of European reinsurers aimed at creating a neutral entity that would calculate, monitor, and publicly distribute industry indices that would track losses incurred from European wind risk and industry market exposures (based on CRESTA[28] zones).

c. Other factors that may be impairing market liquidity

The industry sources consulted in the context of this report indicated that secondary market activity in CAT bonds has largely improved in the last year; however, it is difficult to establish a reliable bond turnover to issuance ratio. Trading in CAT-linked exchange–traded derivatives has been very low. Described below are a few factors that may be impairing the growth in secondary market trading in these markets:

i. Inadequate cash market

Under SEC Rule 144A, CAT-linked securities can only be placed and traded among registered institutional investors. While the participation of institutional investors has diversified recently and now includes the so-called "alternative investors" (hedge funds and other private CAT equity funds), such diversification may or not be conducive to active secondary market trading. Hedge funds are notoriously secretive and are unlikely to add to market transparency by re-trading their bond holdings. On the other hand, as noted earlier in this report, there has been increasing participation of mutual funds in CAT-linked securities, which may help market liquidity and transparency. The opening of this market to sophisticated individual investors could generate trading interest since CAT-linked securities help investors in further diversifying their asset portfolios.

[27] It seems, however, that sidecars are popular structures in "hard" insurance markets and much less so in "soft" markets as evidenced by the dwindling amount of sidecar structures observed in 2007.

[28] Catastrophe Risk Evaluation and Standardizing Target Accumulations (CRESTA); see www.cresta.org.

Price transparency is crucial to secondary market trading. Low liquidity in CAT-linked securities may be explained by the absence of a true (electronic) trading platform open to any investor type. The CAT bond market is essentially an over-the-counter market with dealers firms and other investors communicating by phone or via e-mails. Data providers like Bloomberg or Reuters do not disseminate any price or yield information on CAT bonds. As a result, the CAT-linked securitisation market has suffered from a lack of price transparency.

Transparency in the underlying market is also crucial to secondary market trading. While some sophisticated investors know that insurance companies' historical loss records may not be extremely helpful in understanding and quantifying the risk associated with future catastrophe perils, other investors, including individual investors, value depth and frequency of market information. The lack of standardisation in insurance companies' catastrophe risk exposure records throughout the U.S. industry and the absence of public disclosure of such information may be impairing secondary market trading in U.S. catastrophe risks.

ii. Unfavourable accounting and tax treatment

As previously noted, almost all (U.S. and non-US based) sponsors have issued CAT bonds via the use of offshore SPVs. In the U.S., the use of offshore SPVs can be explained by the restrictive accounting treatment of CAT-linked securities and derivatives, the accounting guideline of the Financial Accounting Standard Board (FASB) for SPVs (called Variable Interest Entities or VIE in the FASB documents), and taxation issues.

The U.S. appears to be the only country that has specifically addressed the accounting and regulatory treatment of CAT-linked securities and derivatives, and of onshore SPVs. A summary of this treatment is provided below:

Regulatory accounting treatment of CAT bonds and exchange-traded CAT-linked derivatives: In the U.S., model law legislation adopted by the NAIC allows insurance companies to create a protected cell (i.e., an onshore SPV) and claim a somewhat favourable statutory accounting statement if the insurer sponsors an indemnity-triggered CAT bond via the protected cell. The accounting treatment is not quite as favourable as that of traditional reinsurance, because insurers can only claim such treatment if and when the bond trigger is reached and the sponsor is indemnified by the SPV. By contrast, under statutory accounting, an insurance company that buys traditional indemnity-based reinsurance can reflect the transfer of risk on its financial statements as soon as it agrees to the reinsurance contract.

The NAIC also adopted a Special Purpose Reinsurance Vehicle (SPRV) model law that allows any entity, i.e., insurer, reinsurer, insurance broker, or investment bank, to act as an onshore special purpose reinsurer and issue insurance-linked debt to back up a reinsurance program contracted by the ceding insurer. The model law also grants status of reinsurer for any entity that organises as an SPRV; in other words, any fully funded SPRV instrument meeting the requirements of the model law receives a somewhat favourable credit for reinsurance treatment.[29]

[29] A detailed discussion of the topic is beyond the scope of this paper. An overview and discussion of the regulatory and accounting treatment of insurance-linked instruments can be found in Bouriaux, S. (2001). "Basis Risk, Credit Risk and Collateralization Issues for Insurance-linked Derivatives and Securities." Journal of Insurance Regulation 20: 94-120.

The NAIC's accounting recommendations only apply to indemnity-triggered bonds. An insurance company that issues bonds with a non-indemnity trigger must account for these bonds just as a regular debt instrument.

From a regulatory accounting standpoint, the NAIC currently directs insurance companies that engage in insurance-linked futures and futures options transactions to report income from these transactions on a new Schedule DC of their statutory financial statements. The total reported income from Schedule DC must then be included in Aggregate Write-Ins for Miscellaneous Income. In other words, under the current statutory accounting rules, insurers who wish to transfer some of their underwriting risks to the capital markets via insurance derivatives cannot account for such transactions as part of their underwriting function.

FASB accounting guidelines: FASB has issued guidance under Generally Accepted Accounting Principles (GAAP) that has the potential to deter any corporate or insurance entity from sponsoring CAT bonds. In January 2003, FASB issued Interpretation No 46, Consolidation of Variable Interest Entities (FIN 46). FIN 46 introduces "variable interest entities" or VIE. If an entity like an SPV does not meet certain capitalisation requirements, it is deemed a VIE and may have to be consolidated into the balance sheet of the company that created it. In a comment letter addressed to the Government Accounting Office (GAO) and published in GAO report GAO-03-1033[30], the Bond Market Association notes that "such consolidation under FIN 46 would limit the appeal of catastrophe bonds because the proceeds of the bond offering would appear as additional leverage on the cedent's balance sheet".

Taxation: It appears that one major stumbling block to the wider use of onshore SPVs (i.e., protected cells) by sponsors remains that, under current U.S. tax laws, onshore SPVs do not receive a pass-through treatment similar to that afforded to mortgage-backed securities sponsors. In the mortgage market, the sponsoring entity is not taxed on the investment income from the trust account. The tax, instead, is being passed to the investor in the security.

d. Exchange-traded derivatives markets

It is important to learn lessons from the CBOT's experience in the mid-nineties. While the CBOT offered a trading venue for its CAT-linked futures and options, the rigid membership structure of the exchange created a barrier to entry for the risk cedent (the insurer), leaving the product to be traded among members who may not have had a great expertise or interest in pricing insurance contracts. In addition, the CBOT open outcry trading venue was clearly inappropriate for such products. Some of these problems are alleviated now that derivatives exchanges have demutualized and now offer electronic trading platforms open to all investor types. Yet, the NYMEX and CME derivatives instruments show minimal trading volume. The IFEX futures contracts also show low liquidity, but the presence of two market makers (Deutsche Bank and Swiss Re) may help.

A few reasons can be identified as why, to date, these instruments have failed to attract investor attention:

- Representatives of the CME and of Gallagher Re (now part of Aon Re),

[30] GAO-03-1033: "Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk", September 2003.

which co-developed the NYMEX contracts, attribute the lack of interest in exchange-traded derivatives to a quiet 2007 catastrophe season, and to a steep learning curve for both hedgers and speculators in these markets.

- The learning curve might be even steeper with the CME products that settle against a parametric trigger. Because of this, basis risk in the CME contracts might be harder to quantify. In addition, industry sources told us that it is very costly for investors to model a parametric trigger compared to an industry loss trigger (which only requires access to an industry loss exceedance curve, generally available from catastrophe modelling firms at an acceptable cost).[31] This prohibitive cost is likely to deter potential smaller investors, who otherwise might be willing to provide liquidity in the CME contract.[32]
- The current lack of trading activity in exchange-traded derivatives may be better explained by a more fundamental reason: in general, securitisation of markets starts with the development of standardised cash instruments (like CAT bonds). After liquidity occurs, derivatives are designed as tools to hedge exposure to the cash instruments. To date, there are little signs of standardisation in the CAT-linked security market. Each transaction is unique and cannot be standardised without significant basis risk. Consequently, there is no perfect easy hedging between the cash and derivative markets. This makes trading in the derivatives markets less attractive to potential holders of catastrophe bonds.
- That said, it should be noted that the currently listed derivatives have been designed not as "traditional" tools to hedge price risk, but more like over-the-counter instruments. For instance, IFEX designed its binary options to replicate industry loss warrants. As a result, these contracts may never be heavily traded and their success or failure should be more accurately measured with statistics on open interest rather than on trading volume.

b) Broader financial market considerations

According to industry sources that were consulted in the course of the preparation of this report, the current mortgage and credit crisis in the U.S. is having an unequivocally positive impact on growth of the CAT-linked capital markets. Some institutions now have a liquidity constraint, need to get cash out, and are selling their holdings in CAT securities. By doing so, they provide additional liquidity to a market that is clamouring for additional investment opportunities. Other investors are searching alternative opportunities to the credit and mortgage markets. In this context, the zero-beta asset argument works well, as institutional investors have become re-acquainted with the dangers of holding securities like asset-backed or credit-backed CDO collateralised with highly correlated assets.

[31] The industry sources consulted in the course of the preparation of this report estimate that some catastrophe modelling firms charge up to $200,000 for access to their entire capacities necessary to model a parametric index, while they off industry exceedance loss curves for about $20,000.

[32] The CME is in the process of revamping the design of its instruments. The exchange is introducing seasonal aggregated futures contracts and binary options. All futures and options contracts remain triggered by the Carville Index.

c) Considerations from the perspective of sponsors and investors

i) Sponsor perspective

a.Insurance/reinsurance sponsors

i. Supply considerations

The supply of CAT-linked securities comes primarily from insurers and reinsurers with a few examples of corporations and countries that have also sponsored these securities. Supply factors include the following:

- ***Pricing***: The price of CAT-linked security relative to the price of reinsurance or retrocession is a major determinant of supply, to the extent that one views CAT-linked securities and reinsurance or retrocession as substitutes.
- ***Volatility of reinsurance and retrocession prices***: The volatility of reinsurance and retrocession prices also impacts the market for CAT-linked securities. At larger volatility levels, the multiyear CAT bond gains a strategic advantage by providing coverage at a known price. Price stability in risk coverage enhances the insurer or reinsurer's ability to invest in new business or expand current business. This then allows the creation of value at an advantageous time that might not otherwise be possible.[33]
- ***Capital capacity***: Complementary capital capacity is also a determinant of supply. Reinsurers may aggregate CAT risks and, by doing so, gain some diversification benefits. Continued expansion, however, might require retrocession or other means to acquire the needed capital capacity to continue aggregating CAT risks. Retrocession is a very opaque means of acquiring capacity and is also a volatile market. CAT bonds, by contrast, provide a more transparent acquisition of additional capacity. This may benefit reinsurers by ensuring similar or higher credit ratings from rating agencies. Ratings perform an important function in the market by rendering an opinion on the solvency of the reinsurer. Without a high rating, the reinsurance company would have to stop writing new business.
- ***Modelling technology***: Finally, CAT modelling technology constitutes a major determinant of supply. This technology has continuously improved to allow the development of a more comprehensive treatment of all those components of loss that contribute to the overall loss exceedance curves that are the building blocks in the management of CAT risks.

More sponsors are now fully integrating CAT-linked securities into their overall risk management strategy rather than seeking capital market protection as a defensive or last resort tool. As pointed out by Guy Carpenter (2008), "the record market activity of 2007 demonstrates a fundamental shift in the perception of the capital markets as a risk transfer solution." Industry sources corroborate this view and observe an increased desire by sponsors to evaluate all risk transfers mechanisms equivalently. In 2007, several sponsors, who had until then avoided what they perceived to be costly

[33] Equivalently, the CAT bond solves a corporate underinvestment problem: see Froot, K. A., D. S. Scharfstein, et al. (1993). "Risk Management: Coordinating Corporate Investment and Financing Policies." Journal of Finance **48**(5): 1629-58, Garven, J. R. and R. D. MacMinn (1993). "The Underinvestment Problem, Bond Covenants and Insurance." Journal of Risk and Insurance **60**(4): 635-646, MacMinn, R. D. (2005). The Fisher Model and Financial Markets. Singapore, World Scientific Publishing.

CAT bond structures, issued CAT bonds, despite the fact that the reinsurance market was in a soft cycle.

As noted in this report, insurers and reinsurers may view CAT-linked securities as either substitutes or complements for reinsurance and retrocession, respectively. Each provides protection against CAT risks and so to an extent the notion of substitutes is appropriate and the price of the CAT-linked security must be compared to that of reinsurance or retrocession. The argument cannot, however, be pushed too far because the instruments are not homogeneous. Reinsurance and retrocession, for example, are typically single-year instruments and may be subject to varying degrees of credit risk. CAT bonds have become multiyear instruments; these bonds may be subject to basis risk but considerably less credit risk. Hence, the protection is comparable in principle but the manner in which the protection is provided is not.

Similarly, there is reason to view CAT-linked securities and either reinsurance or retrocession as complements. The retrocession market, for example, has cycles; in a hard retrocession market, a price comparison may be favourable for CAT-linked securities, but it must also be observed that reinsurers need another source of added capacity that allows for risk hedging. CAT-linked securities provide a new source of additional capacity and these instruments tap the far more liquid capital market. This additional source of capacity complements retrocession and offers a hedging mechanism that should dampen the cycles in reinsurance and retrocession markets. Note that Figure 4 shows less volatility in the ROL index subsequent to the introduction of rated CAT bonds in 1997, despite the occurrence of major natural catastrophes (e.g., Katrina) since that time.

ii. Advantages of catastrophe-linked securities over other financial instruments

Section three of this report provides a brief description of various types of CAT-linked securities (CAT bonds, CROs, certain types of ILWs) and derivatives (futures, options and swaps). All of these instruments, with the exception of sidecars, are risk transfer tools. Insurers or reinsurers may also use risk financing capital market instruments like contingent capital arrangements (CCA).

A CCA is an agreement entered into before any losses occur and enables an organisation to raise cash by selling stock or issuing debt at pre-arranged terms following a loss that exceeds certain thresholds. Examples of CCAs are contingent surplus notes or contingent equity. Contingent surplus notes are pre-arranged so that an insurer or reinsurer can immediately obtain funds by issuing surplus notes. In the U.S., one advantage of surplus notes is that statutory accounting allows an insurance company to account for these notes as policyholders' surplus rather than as a liability on its statutory balance sheet. This allows an insurer to increase its capacity to write business. Contingent equity is another way for an insurer to raise capital funds in the event of a large loss. An example of contingent equity is a catastrophe equity put option, which is a right to sell equity at a predetermined price in the event of a catastrophic loss.

CCAs were relatively popular in the mid-nineties, but insurers' and reinsurers' interest in these has waned recently. As noted by Figlewski (2002), "in most instances, financing cat event risk is not enough" if an insurer seeks to finance a loss that may be

potentially larger than the going concern value of an insurer.[34] In such situations, investors would not provide the needed contingent financing since securities, on arrival, would be worth much less than their purchase price. While it was argued earlier that CAT-linked securities can complement or substitute for traditional reinsurance, there is no doubt that insurance and reinsurance sponsors have tapped the CAT bond market to hedge against low frequency–high severity events.

iii. Perception of basis risk

The sponsor's perception of the basis risk embedded in CAT-linked transactions is also shifting. While sponsors generally prefer issuing indemnity bonds to non-indemnity bonds, they understand that their choice is a function of the cost-benefits of each trigger. As a result, sponsors have spent a considerable amount of in-house or sophisticated external resources understanding and quantifying their exposure to basis risk. They now weigh their choices of indemnity versus non-indemnity structures based on basis risk, pricing, and placement opportunities. It was observed previously that, in 2007, newcomers in the CAT bond market like Allstate and Travelers chose to issue non-indemnity bonds to ensure placement among investors. In the meantime, companies well known to investors, like USAA, or well organised like Chubb, have easily placed indemnity bonds. One oddity in this market is the choice made by State Farm to issue indemnity bonds that were costlier to place compared to non-indemnity bonds. State Farm may have easily tapped the investor base with a cheaper non-indemnity bond. It is possible that, as a mutual company, State Farm does not have to worry about efficient allocation of capital as much as publicly traded insurers.

b. Corporate/sovereign issuers

There have been very few corporate issuers of CAT bonds besides insurers and reinsurers. Tokyo Disney, Universal studios and Electricite de France are among a handful of corporations that have sponsored catastrophe-linked securities. Industry sources attribute such low interest to three factors:

- First, for most corporations, insurance costs are generally cheaper than the costs of transferring natural disaster risk via capital markets. Insurance pricing benefits corporate buyers because the insurer can pool and spread corporate risks.
- Second, while the pooling argument breaks down when peak risks arise, very few corporations around the world have peak risk exposures.
- Finally, FASB accounting guidelines may deter U.S. based corporations from issuing CAT-linked securities.

It was also noted earlier in this section that one source for the ongoing expansion and diversification in the sponsor base may lie in countries that have high exposure to catastrophe risks, a constrained financial ability to absorb the financial impacts of financial disasters, and/or an inexistent or inefficient reinsurance market infrastructure. Therefore, governments of such countries should investigate the extent to which CAT-linked securities would provide one of the means of hedging the risk of uninsured economic losses, especially for countries with inexistent, inefficient, or government-sponsored reinsurance markets.

[34] The going concern value of a company includes the liquidation value of a company's tangible assets as well as its intangible assets (i.e. corporate intellectual property, goodwill or brand recognition).

ii) Investor perspective

One key issue is the stability and long-term availability of capital market solutions to cover catastrophe risks. In other words, what are the conditions for investors to maintain and grow their appetite for CAT-linked securities?

a. Demand considerations

For the catastrophe-linked market to grow, the demand for CAT-linked securities must come from a increasing variety of investors. Demand factors include the following:

Risk-return profile: The risk-return profile of CAT instruments is a determinant of demand. All managers of institutional portfolios must decide whether to include an asset such as a CAT bond based on its expected return and its correlation. We have seen in Figure 10 that CAT bonds provide rates of return historically greater than similarly rated corporate bonds; hence the CAT instruments provide some excess return necessary for risk bearing. Corporate capital has always been present in the aftermath of a large disaster for the right risk-return profile.

For instance, in 1992, following the occurrence of Hurricane Andrew, a large injection of capital in the form of newly formed reinsurance entities in Bermuda was observed. Similarly, the occurrence of Hurricane Katrina provided the catalyst for growth in the CAT-linked securities market. Today, there are many dedicated CAT funds investing solely in CAT risks. Examples of such funds are: Stark Investments, Fermat, Nephila, Magnitar, Pulsar and Coriolis. Finally, hedge funds such as Citadel Investment Group, Fortress and JWM have focused on equity participation by investing in sidecars and other equity-related instruments.

That said, it is observed, however, that the most recently issued CAT bonds have tranches with ratings primarily in the B to BBB range. Lower ratings-higher yields securities may attract investors like hedge funds or CAT funds from a risk-reward standpoint, but may deter investors looking for A to AAA-rated securities. Investors in highly rated securities constitute the vast majority of investors in other securitised markets, such as the MBS or ABS markets.

Moreover, it is worth noting while individual and less sophisticated investors can, in theory, assume CAT via participation in mutual funds, only a few mutual funds, to date, specialise in natural disaster risk. While it seems obvious that both better price transparency and better transparency in the underlying risks are crucial to enhanced secondary market trading, the institutional community shows little interest in opening up the CAT-linked securities market to smaller or individual investors. In addition, the high costs of CAT risk assessment may be too prohibitive to some investor types.

Zero correlation: CAT-linked instruments, with returns uncorrelated to those of other financial assets, are particularly important in providing diversification benefits. Even if the CAT instrument yielded an expected rate of return equivalent to that of the investor's portfolio, the uncorrelated nature of the return on the CAT instrument would suffice to make it desirable. Current examples of institutional portfolios that have adopted catastrophe exposure as an asset in their overall portfolios are PIMCO, Fidelity and Pioneer Investments.

Modelling technology: Finally, technology in CAT modelling constitutes a major demand factor for CAT-linked securities. Investors need to trust CAT risk assessment methodologies developed by catastrophe modelling firms and credit rating agencies. As we have noted, the occurrence of Hurricane Katrina demonstrated some gaps in the complete modelling of all sources of catastrophe loss on a company's books of business, and motivated catastrophe modelling firms to revise their methodologies, including adjusting modelled activity rates to be based on the best estimate over the next five years, rather than on the average of history as previously employed. It also motivated credit rating agencies to refine their default rate grids.

b. Advantages of catastrophe-linked securities versus sidecars

As mentioned before, sidecars are limited-life special purpose entities that generally provide quota-share reinsurance exclusively to its sponsor. The sponsor (generally a reinsurer) creates a holding company. The holding company sells debt and equity to investors and invests the proceeds in an operating company, which puts the money in a trust that pays interest and profits to the holding company.

The growth in sidecar structures is essentially driven by hedge funds and other funds seeking equity ownership and looking for more control over what they are buying. Sidecars are very individually negotiated while CAT bonds are more pre-packaged investments available to a wider range of investors. As such, sidecars may have a limited appeal to a broader base of investors. In addition, it was observed that sidecars are more cyclical in that they are popular structures in "hard" markets and much less so in "soft" markets. Sidecars are short-term instruments that provide high rates of return to hedge fund investors during the hard reinsurance market cycle; they are typically structured after a CAT event when capital capacity has been depleted and additional capacity is necessary to maintain ratings and continue to sell reinsurance. The high rates provide the risk premiums necessary for speculators to participate in the hedge funds, and are more than a shareholder in a insurance or reinsurance company would receive since the sidecar is a pure play. Once it is no longer necessary for the insurer or reinsurer to pay the high risk premium for additional capital capacity, the sidecar may be folded up only to reappear in another hard market.

In contrast, CAT bonds are longer-term instruments that provide a higher rate of return typically than similarly rated corporate bonds (see Figure 10) but also provide somewhat less volatility than the sidecar. CAT bonds provide a risk that is uncorrelated with other capital market instruments and offer a means of reducing portfolio risk and increasing the investors' expected utility. As evidenced in section three of this report, investors have shown a healthy and sustained appetite for CAT bond structures.

d) Overall assessment of the sustainability of capital markets instruments as mechanisms for financing large-scale natural catastrophes

The analysis performed in the three previous sections of this report demonstrates the ability of capital market instruments to complement and sometimes substitute to other risk transfer mechanisms for financing large-scale natural catastrophes. 2007 marked a noted shift in insurers and reinsurers risk management strategies, and many of them now fully integrate capital market structures in their risk transfer or risk financing programs. The investor community has also increasingly embraced the diversification benefits of including catastrophe risk in their portfolios of assets. In 2007 and early

2008, most CAT bond issues were oversubscribed, which testifies to investors' appetite in this market.

Despite its proven benefits to both sponsors and investors and its recent growth, the CAT-linked capital markets could become much larger and much more attractive to both sponsors and investors if they meet certain conditions and requirements. The next section of this report reviews some technical and other issues regarding the future growth of the CAT-linked security market.

5. Identification of issues concerning the future growth of the catastrophe-linked securities market

The impetus for growth of the CAT-linked securities market must obviously come from both sides of the market. The sponsors' supply of CAT-linked securities is driven by a growing need for competitively priced capacity; the determinants of supply were identified in the previous section of this report. Investor demand for CAT-linked securities is determined by the risk and return of the instruments as well as the other factors identified in the previous section. The CAT-linked securities market can grow only if there are enough investors willing to absorb the increased supply of CAT-linked capital market instruments at the right price.

This section identifies some issues relating to the future growth of the CAT-linked capital market instruments.

a) Technical issues

i) Structuring/product design

Standardisation of capital market structures: A certain degree of standardisation in market capital structures is critical for the development of CAT-linked securities. It seems that, after a couple of years spent on introducing more complex instruments, CAT-linked securities market participants have come to the realisation that simpler CAT bond structures may remain the dominant form of CAT-linked securities. Despite the diversity of triggers, CAT bonds are more "standardised" than other capital structures as evidenced by the increased number of shelf registrations.

Triggers: Section four of this report documents the trade-offs between indemnity versus non-indemnity structures. In order for market transparency to increase and secondary market and liquidity to develop, non-indemnity structures should become the dominant form of CAT bonds. Non-indemnity triggers can be parametric or based on an aggregate of industry loss. There are clear trade-offs between both.

From the sponsor's standpoint, industry loss triggers tend to have less embedded basis risk than parametric triggers. Yet a bond or a derivative instrument triggered by an industry loss will not offer immediate payout to investors, as losses will develop over weeks and possibly months, especially losses resulting from large events like Hurricanes Andrew or Katrina. In addition, the methodology for collecting and aggregating insured losses may be deemed inadequate. For instance, some CAT-linked securities market participants feel that the existing industry loss triggers (i.e., PCS) are inadequate in their estimation of U.S. natural catastrophe insured losses. If so, then consideration should be given to the development of a new methodology for gathering industry loss and industry market exposure information for U.S. catastrophe losses.

As noted earlier, there is currently an effort by a group of European reinsurers aimed at creating a neutral entity that would calculate, monitor, and publicly distribute indices that would track insurance industry losses incurred from European wind risk. The methodology envisioned by the group in collecting industry loss data is similar to that used by PCS. PCS estimates industry losses by surveying U.S. insurers who had exposure in the disaster zone once the catastrophe occurred. It collects information on the number and average size of direct claims that an insurer expects to pay and aggregates this information across insurers. The European group would attempt to collate the same information, but based on industry loss and insured exposure numbers from disaggregated data collected by CRESTA zone, i.e., more at a U.S. county level.

Parametric triggers have always tended to be more attractive to sophisticated investors, who understand that the modelling for these triggers will involve significantly less uncertainty than for indemnity deals. It is easier for an investor to understand the basis of the modelling than industry loss triggers, in that they do not assess the insured exposure and vulnerability of the building stock, or undertake a comprehensive assessment of all the sources of loss, which are required to capture the financial impact of a natural disaster.

In addition, capital market structures triggered by parametric measures can be settled within weeks of a potential loss, unlike indemnity or industry loss deals that may take up to 18 months before the final loss is known. Even for the issuer, the advantage of the speed of settlement may be a significant factor in choosing a parametric structure. Also, by using second-generation parametric structures involving recorded measurements, it is possible to apply weightings to each instrumental value when constructing an overall index for the event to match the geography of the underlying portfolio of properties (and any localisation of vulnerability), so that it becomes possible to create an index that more closely matches the losses being modelled. This reduction of basis risk also makes such structures more attractive to the issuer. Second-generation triggers have been employed for issuing securitisations: in the US for California earthquake, in Japan for earthquake and typhoon wind, in the UK for windstorm and flood (using flood heights preserved on buildings within the construction of the index), and in Western Europe for windstorm.

Given the relative advantages of second-generation parametric structures, the main deterrent to their wider use, especially in developing countries, concerns the availability of a suitable dense network of hazard (wind speed, river height and earthquake strong motion) recording stations and, most importantly, recording procedures. There may, for example, be no guarantee that wind speed recorders will continue to record through intense tropical cyclones, because the equipment will have been dismounted and stored to protect it from damage. Also, it is common that the duration of battery power to cope with an inevitable loss of offsite power is insufficient to record through the passage of the storm. River flow gauges are often destroyed in extreme floods, and earthquake strong motion instruments also rely on batteries that require renewal every few months. Therefore, the expansion of second-generation triggers to new territories requires that government agencies of meteorology, hydrology and seismology (or even private companies in these areas) have appropriate standards regarding the installation and management of their networks of instrumental recorders.

There are three required components in this respect. First the choice of instrumentation and instrument siting must be sufficiently resilient to withstand the strongest potential hazard. Wind speed recorders designed to monitor wind speeds at airports, for example, are generally insufficiently robust to withstand a hurricane. Second, instruments should be spaced every 10-20 kilometres to ensure that the overall hazard field of an earthquake or windstorm is fully captured and that there is redundancy of observation (where a station fails to record). Third, there needs to be a maintenance guarantee for the equipment, batteries must be checked and replaced regularly, and the recording procedures tested to ensure they operate under all conceivable adverse conditions.

A government that chooses to support this level of instrumentation, recording, and reporting will provide the foundation for the use of second-generation parametric triggers in risk transfer. In particular, in the developing world, where information on property values, building types, and locations may be much harder to obtain, such risk transfer structures may provide the only effective way of designing a satisfactory risk transfer mechanism that does not suffer from a potentially large basis risk – as can be the case with first-generation parametric structures based only on earthquake magnitude or tropical cyclone intensity and track.

ii) Data-gathering and modelling of perils

One of the constraints on the development and expansion of the CAT-linked securities market has been the need to have a high quality CAT loss model for that region and peril. As the availability of such models has expanded since the late 1990s, so the range of countries and perils served by CAT-linked securities issuance has itself expanded. For example, the first European windstorm securitisation in 1998 was based on the availability of trusted second-generation CAT loss models for the peril. The decision for the risk modelling companies to build a CAT model for a new country and peril is based first on the commercial assessment that the insurance and reinsurance interest in that territory is of sufficient size to merit the investment. The quality of the model will then chiefly be determined by the depth and detail of the historical record and the availability of high quality information on recent loss data for calibrating vulnerabilities relevant to the local building stock. Inevitably, therefore, there are many developing countries and perils for which there is no CAT model, or a model considered too rudimentary to support issuing a CAT-linked security. In a developing country, without relevant institutions of meteorology and geology, there will also typically be far less actual monitored observational and historical data on which to base the model. CAT models only perform well if insurers are themselves able to collect high-quality data on the insured when they underwrite the risk, and in many territories the insurers themselves do not have the tools to collect such data.

As a result, issuance of CAT-linked securities may remain limited for some peril types and geographic areas because the available CAT models do not exist, or are not considered sufficiently robust. These problems will be particularly exacerbated for indemnity CAT-linked securities structures, as there will also likely be distrust of exactly what data has been available to be fed into the model for the analysis as well as exactly how claims management will be maintained in the aftermath of a major catastrophe. For this reason, parametric CAT-linked securities structures will be much more favoured for developing countries by CAT-linked securities rating agencies and investors.

iii) Market transparency

To date, the CAT-linked securities market has remained opaque to the general public. There is no public dissemination of bond offerings or prices as transactions occur over-the-counter. As noted in section four of this report, the CAT-linked securities market is likely to remain opaque if only open to qualified or institutional investors. This said, the institutions currently involved in the CAT-linked securities market might not perceive market opacity as an impediment to market growth because it is not an issue for them. They circulate lists of bond offerings and related pricing among themselves or their customers, as is common in the over-the-counter market. They can argue that information on bond offering and bond prices is available, but that it is not publicly disseminated.

Exchange-traded CAT-linked derivatives markets have also remained opaque, with the exception of the CCFE. The CME and NYMEX do not post price and volume information on their websites. Real-time price quote providers also do not carry this information. By contrast, the CCFE provides price and volume information on its website.

Opening access of the CAT-linked securities market to a broader base of investors would require public dissemination of offerings, prices, and other information related to the risk associated to investing in CAT-linked securities.

b) Other issues

In the past decade, the development of CAT modelling and the education of sponsors, investors, and rating agencies have provided the basis for and the expansion of CAT-linked securities markets. In noting the determinants of supply and demand in these over-the-counter markets, it was observed that it has become possible for insurers and reinsurers to extend the boundaries of what is insurable in a manner that allows the creation of value for their shareholders, and that institutional investors can also create value for their shareholders by participating in these markets. Hence, even in the absence of the regulatory stimulus that has caused growth in other markets such as MBS and credit derivatives, CAT-linked securities markets have grown, especially since Hurricane Katrina.

i) Government participation in the development of the market for catastrophe-linked securities

As noted in section two, some level of (federal or state) government participation may facilitate the growth of securitised markets. In particular, the MBS market may not have expanded as fast if federal and quasi-federal agencies had not contributed to its development at the outset. To date, government participation in the CAT-linked securities market has remained very limited. The newly established CCRIF provides a good but isolated example of possible government participation in the CAT-linked securities capital markets.

Consideration was given in the mid-nineties to having the U.S. Treasury possibly participate in the CAT-linked market. U.S. federal lawmakers considered passing the *Natural Disaster Act* in 1997. One provision of the Act called for the U.S. Treasury to carry out a program to auction self-funded excess-of-loss "reinsurance" contracts covering certain natural disaster perils. These contracts would have been standardised and re-tradable among insurers and other participants. The proposed *Natural Disaster Act* was never enacted.

Those governments that have a constrained financial ability to absorb the economic impacts of weather-related disasters could tap CAT-linked securities markets either by directly issuing CAT-linked securities (like the sovereign-backed Cat-Mex $160 million issued by the Government of Mexico in 2006) or by creating multi-governmental facilities similar to CCRIF. The latter would allow these governments to share the costs of reinsurance and the costs of the CAT modelling technology, and possibly transfer extreme event risks from the pooling facilities to capital markets via the issuance of CAT-linked securities.

Similarly, in some countries where private insurance and reinsurance markets are relatively well organised, individual state or federal governments could develop pools of reserves from individual insurers to cover extreme event catastrophes risks, and finance a portion of these pools via the issuance of CAT-linked securities, rather than via the use of taxpayer money.

In the U.S., for instance, after the Northridge earthquake and Hurricane Andrew in 1992, the states of California and Florida established catastrophe authorities to stabilise markets and maintain or increase capacity. In California, after Northridge, the state government formed the California Earthquake Authority (CEA) to provide residential earthquake insurance. Insurers that sell residential property insurance must offer their policyholders separate earthquake insurance. Insurers can offer a private earthquake policy but most choose the CEA policy. Only insurance companies that participate to the CEA can sell CEA policies. The CEA funds to pay claims come from premiums contributions from and assessments on member insurance policies, borrowed funds, reinsurance and the return on invested funds.

In Florida, after Hurricane Andrew, the state government established the Florida Hurricane Catastrophe Fund (FHCF) to act as a reinsurer for insurers that offer property/casualty insurance in the state. FHCF is financed by premiums charged to participating insurers, investment earnings, and emergency assessments on Florida insurance companies if needed. In both the Florida and California cases, the financing may not suffice in the event of an extremely severe disaster and both states have the flexibility to issue bonds. Instead of tapping taxpayer money, the CEA has regularly issued CAT bonds since 2000.

In Europe, insurance and reinsurance for natural catastrophes take various structures, from mandatory coverage with state-back guarantees (France) to complete private-sector coverage (Germany). A 2005 report from the U.S. Government Accountability Office (GAO) provides details on how six European countries (France, Spain, Switzerland, Germany, Italy and the United Kingdom) handle natural catastrophe risk. In France, for instance, coverage for natural catastrophes must be included in standard insurance policies. To cover natural catastrophe risk, insurers collect a government-determined premium surcharge from the private market and may reinsure with the Caisse Centrale de Reassurance (CCR), a state-backed reinsurer. CCR offers unlimited coverage that is guaranteed by the French Government. Again, in the event of a large disaster that may require more financing, the CCR could issue CAT-linked securities instead of relying on taxpayer money.

ii) Retail investor access to the catastrophe-linked securities market

This report has previously noted that a) only qualified or institutional investors have access to the CAT-linked securities market and b) only investors with a high level of

sophistication are likely to access the CAT-linked securities market and exchange-traded derivatives markets. However, facilitating access to the CAT-linked securities market to retail or individual investors (via secondary market trading or via mutual funds) may raise public policy issues, in light of investor protection objectives embedded in U.S. securities laws and in the recent *Markets in Financial Instruments Directive* in the European Union.

In the U.S., both the Securities and Exchange Commission, which supervises issuance and trading of cash securities, options, and other over-the-counter derivatives, and the Commodity Futures Trading Commission, which supervises trading in futures markets, have, on an ongoing basis, enacted legislation aimed at protecting the individual customer. Yet individual investors often have access to securitised markets via secondary market trading or via mutual funds. For instance, GNMA mortgage-backed securities or mutual funds invested in mortgage-related instruments have been very popular among individual investors in the last twenty years. One could argue that these securities are attractive to retail investors because of their high credit quality, while most securities in the CAT-linked securities market are rated in the B to BBB range, possibly limiting the potential participation of individual investors.

This said, the current sub-prime mortgage crisis in the U.S. highlights the role of credit rating companies and their own fiduciary responsibility to investors. Credit rating agencies have been criticised lately for having overrated a certain number of MBS that, now, are in default. While these agencies have recently revised their methodology for rating CAT bonds and other CAT-linked securities, the sub-prime mortgage crisis and its impact on individual investors should constitute a wake-up call on the appropriateness of opening certain capital markets to such investors.

Besides credit ratings, there are other relevant non-institutional investor protection concerns. As mentioned previously, the assessment of risk in CAT-linked securities requires a high level of sophistication and an understanding of the nature and (non) predictability of catastrophe risks. Should catastrophe risk end up in the hands of individual investors whose investment decisions may be based on more traditional risk/return assessment measures than the ones used in CAT risks? Although CAT risks may be uncorrelated with other risks in an investor's portfolio, the nature of these risks makes measurement of the expected rate of return obscure simply because they are difficult to predict. Hence, it becomes difficult for an investor to distinguish an investment from a speculative plunge. The problem can become even more difficult when considering more than one CAT instrument because the nature of the instrument makes risk sensitive to spatial location as well as other characteristics that are not common in diversification decisions. These observations suggest that having an appropriate level of financial education and understanding of CAT risks is a pre-requisite for retail investor access to the CAT-linked securities market.

iii) Regulatory, accounting, and fiscal treatment

In consideration of the ongoing convergence of insurance and capital markets, comparisons between CAT-linked securities on the one hand, and traditional insurance and reinsurance on the other, should be conducted in a consistent, functional fashion. CAT-risk transfer instruments (CAT-linked securities and derivatives, insurance and reinsurance, and other ART instruments) should receive a regulatory, accounting, and fiscal treatment based on their relative merits and risks.

For instance, Bouriaux (2001) compares risk transfer alternatives offered by the capital and insurance markets based on the risks associated to each alternative: basis risk, credit risk, and collateralisation. She notes some inconsistencies in their accounting treatment. Generally, critics of a favourable accounting treatment for non-indemnity insurance-linked securities and derivatives argue that, unlike reinsurance, these instruments do not achieve full transfer of risk partly because of the existence of basis risk and partly because of the partially funded nature of some of these transactions (i.e., exchange-traded derivatives). Bouriaux points out that a) basis risk can be identified and quantified and b) that, in some instances, reinsurance transactions can be less than fully collateralised and funded and yet, in the U.S., the NAIC grants them a favourable accounting treatment.

The issue of the regulatory, accounting, and fiscal treatment of CAT-linked securities and derivatives should be revisited by governmental and regulatory bodies of countries interested in assessing whether there are any unnecessary impediments to the development of this market.

6. Recommendations (DRAFT)

In sections two and four of this report, what are considered to be the key drivers and the impediments to the growth of the CAT-linked security and derivative markets were documented. Some technical issues related to the structuring and design of these instruments, data gathering and modelling of perils, and market transparency were also investigated. Other issues were also identified.

It can be concluded, based on the analysis in this report, that the CAT-linked capital markets will continue to grow provided that certain concerns are addressed by sponsors and investors. The following actions may contribute to that growth:

1. ***Help encourage the creation of open national databases***

a. Encourage a greater level of detail and harmonisation in the parametric data collected and made available by national meteorological, seismological, and hydrological agencies on catastrophe events. For tropical cyclone in all regions, this data should not only include the central pressure and maximum wind speed of the storm at regular (typically 6 hourly) intervals along the track but also parameters related to the size of the storm. For earthquakes, earthquake maps of strong ground motion (employing strong ground motion data) should be developed as well as intensity maps. For floods, floods maps of the extent, height of flooding, etc. should be developed for all principal areas affected. Standardising these outputs across different agencies would help provide a more universal currency for the exchange of parametric information on catastrophes.

b. Encourage and sponsor national agencies of meteorology, hydrology, and seismology to install hazard monitoring equipment and recording systems able to capture the parameters of extreme events when they happen, at sufficient density of instrumentation and guarantee of recording that these readings can be employed for developing second-generation parametric trigger structures. Such structures, which may help to reduce basis risk, and are able provide settlement for a CAT-linked security within weeks of the occurrence of a catastrophe event (when contrasted with the 18 months or

longer required for an industry loss or indemnity deal) should be considered the future of the expansion of CAT-linked security issuance especially in second tier and developing countries in which it will not be possible, to collect sufficient information on exposures and losses, and where there may not even be an insurable interest (as with a government wishing to issue a bond to provide emergency funds in the aftermath of a catastrophe).

c. Aim to foster ways in which national insurance organisations, or other private agencies, help collect and harmonise insurance companies' market exposure data and provide a consolidated perspective of such data across the whole insurance industry in a territory. The gathering, harmonisation, and public dissemination of insurer market exposure data are crucial to quantify basis risk inherent to capital market structures with payouts triggered by an industry loss index. The wider availability of industry insurance data will help to bring confidence to using loss indices based on industry losses and also help insurers themselves understand the basis risk between their own losses and those of the whole market. (However, one should not underestimate the near impossibility of trying to compile this data across different companies, both because they may prefer to maintain confidentiality about information that they may consider relates to their business advantage, but also because in many countries the data actually collected and stored may be very limited. Hence, much industry insured data, as developed by CAT modelling companies, is modelled rather than compiled).

d. Assist in the creation and fostering of mechanisms to help track insurance industry losses resulting from a catastrophic event: In section four, it was suggested that standardisation in capital market structures is a key component in the growth of securitisation of catastrophe risk. Outside the U.S., there is little consistency in how catastrophe losses are aggregated, with some national insurance organisations in countries like Denmark or Japan providing this capability, while in other countries there is no agency able to obtain information from all insurers. As noted previously, some European reinsurers are considering the creation of a neutral entity that would calculate, monitor and publicly distribute indexes tracking insurance industry losses incurred from European wind. Such effort could also be expanded to other perils and countries.

2. ***Encourage transparency in the catastrophe-linked securities market:*** As noted in section five, the institutions currently involved in the CAT bond market may not perceive market opacity as an impediment to market growth. Yet the decision of opening access to a broader base of investors would require public dissemination of information, such as new bond offerings and secondary market information. Today, both Goldman Sachs and Guy Carpenter keep historical records of CAT bond issuance and details about each offering, but Goldman Sachs' records remains proprietary. Guy Carpenter posts historical information on catastrophe bond issuance on its website, with some details on each offering, but does not provide price or trigger information. There is also no public dissemination of secondary market price or volume information for catastrophe bonds.

   a. Make investment in CAT-linked securities public information. This would allow the assessment of not only the depth of the demand side but it would also allow that side of the market to be tracked, e.g., how many

CAT-linked investors are there and how does that change in response to the occurrence of CAT events.

b. Make the issuance of CAT-linked securities public information. Information similar to that currently available through sources such as Guy Carpenter plus price and trigger information should be provided. This would allow the supply side to be tracked.

3. ***For those governments with mechanisms to pool reserves from individual insurers or that have already formed a sovereign-backed reinsurance entity, consider whether it might be desirable and cost-effective to finance a portion of these reserves via the issuance of catastrophe-linked securities***. In section five, it was noted that, in the U.S., the CEA has already partially financed its earthquake exposure via the issuance of CAT bonds. Goverments (including state-level) could examine the appropriateness of using these tools or other risk transfer tools to transfer some of their CAT risk to capital markets. The securitisation of pooled risks within a country or state or across countries should be performed at competitive prices, that is, at high enough yields for investors to consider assuming the CAT risk. At the same time, however, governments must carefully evaluate the costs and benefits of such issuance and ensure the appropriateness of using CAT-bond securities.

4. ***Examine any unnecessary impediments to the development of catastrophe-linked securities market***. CAT-linked securities have, if placed within an appropriate regulatory framework, the potential to improve the financial management of CAT risks and bring benefits to capital markets. The regulatory, accounting, and tax framework for CAT-linked securities and derivatives should be carefully reviewed and compared with the framework for insurance and reinsurance as well as that of other securitised financial products in order to ensure that there are no unnecessary constraints on, or uncertainty in, the CAT-linked securities market. In this context, the nature and extent of the risk transfer provided by CAT-linked securities must be carefully examined and assessed.

5. ***Encourage research on areas worthy of further investigation***. For instance:

   a. The role of CAT-linked securities as diversification tools in asset portfolios requires more study. Section five of this report cited some research on the diversification benefits of CAT-linked securities. Further research is warranted as the market has greatly developed in the last two years, providing additional yield and return statistics. The impact of moral hazard on pricing indemnity-triggered CAT bonds, the quantification of basis risk in CAT-linked capital market structures, and the trade-off between basis risk and moral hazard all require further investigation. For instance, it may be valuable to develop a methodology on how to structure CAT-linked securities in order reduce both basis risk and moral hazard.

   b. The development of securities to hedge basis risk should be studied. To date, in non-indemnity based CAT-linked securities, very few market participants are willing to take the basis risk away from the sponsor. Research on this topic may be valuable to firms seeking a

"niche" in the CAT-linked securities market.

c. A policy report that investigates the appropriateness of allowing direct participation by sophisticated individual or retail investors in the market for CAT-linked securities is needed. In section five, it was observed that facilitating access to the CAT-linked securities market to (sophisticated) individual investors is likely to raise public policy issues in light of investor protection objectives embedded in U.S and European securities laws.

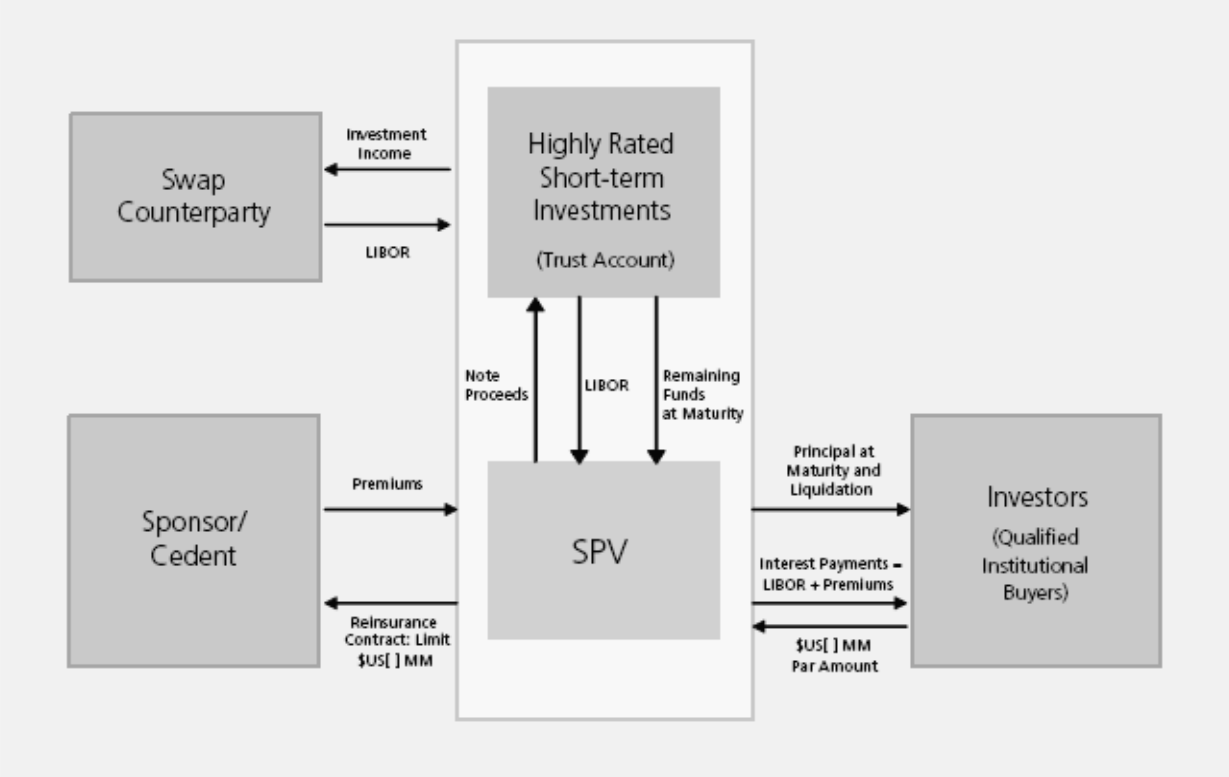
6. ***Encourage the development of education programs on catastrophe-linked securities***.

a. The demand and supply in the CAT-linked securities market depend on the education of potential investors and sponsors. The acquisition of the requisite education, i.e., knowledge to participate, in the market is one of the most important barriers to entry and so to growth.

b. An understanding of the CAT-linked securities market by governments and regulators is necessary for the establishment of an appropriate legal, regulatory, and tax framework for these securities.

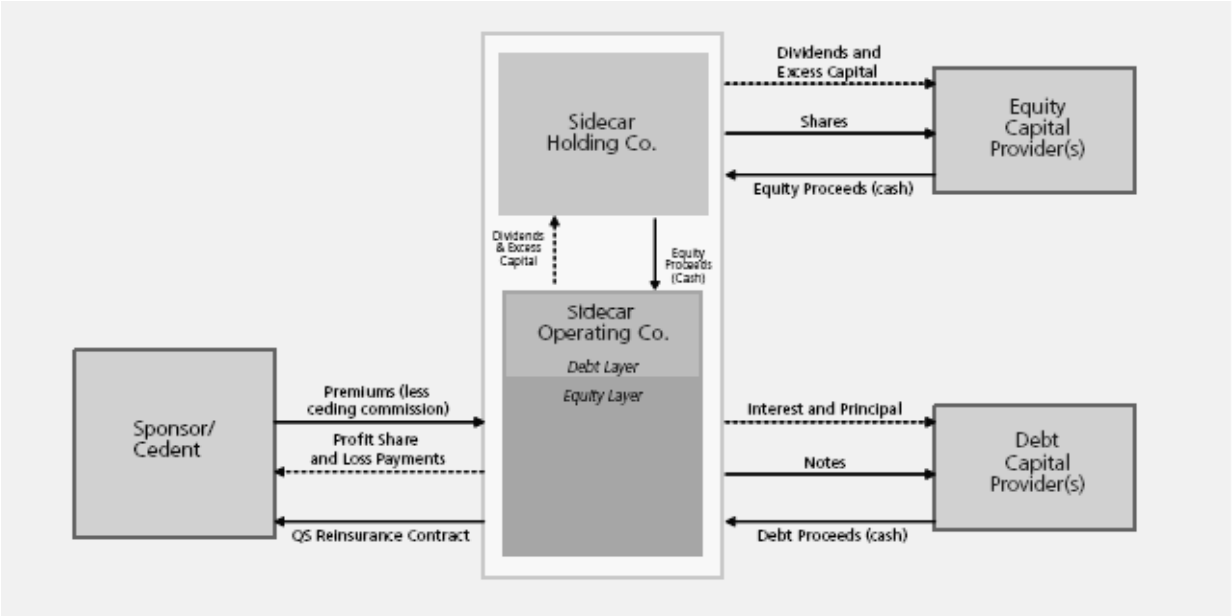
c. The structuring and pricing of catastrophe-linked securities with some emphasis on the trade-off between basis risk and moral hazard must be part of this education.

ANNEX 1: STRUCTURE OF A CAT BOND



Source: The Catastrophe Bond Market at Year-End 2006, Guy Carpenter & Company, LLC

ANNEX 2: STRUCTURE OF A SIDECAR



Source: The Catastrophe Bond Market at Year-End 2006, Guy Carpenter & Company, LLC

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