THE TRANSFER OF CATASTROPHE EVENT RISK TO THE CAPITAL MARKETS OVER THE 1990s: AN ANALYSIS OF THE PROCESS

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ABSTRACT

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In 1992, hurricane Andrew was responsible for insured losses of US$19 billion in Florida. In 1994, the Northridge earthquake caused damages amounting to US$14 billion in California. At that time, a shortage of capital available from the insurance and reinsurance industries to sustain catastrophe losses was both anticipated and feared. The capital markets readily offered alternative vehicles through which catastrophe risk began to be transferred, thus initiating a convergence with the insurance market. This paper aims at gathering information relevant to the understanding of the process of the transfer of catastrophe event risk to the capital markets. First, it reviews the events that brought about emphasis on catastrophe risk management. Then, it dedicates attention to the peculiarities of catastrophe risk, before examining the design and evolution of the catastrophe derivatives themselves. Finally, a proposition for empirical research on the relationship between catastrophes and capital market returns is made. Furthermore, it is suggested that the theory of contagion in international finance would constitute an interesting framework for the analysis the relationship between catastrophe risk derivatives and other assets within a portfolio.

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SNEAK PREVIEW

"If a $50 billion catastrophe were to occur in the US, approximately 25% of the capital of the primary and reinsurance industries would be wiped out. A loss of this magnitude would be a devastating blow to the insurance industry. To the capital markets, however, such a loss is almost routine. It has been estimated that the total value of the capital markets is $19 trillion, and that the average daily standard deviation of the market is $133 billion. Thus what is needed is an efficient instrument through which the funds of the capital markets can be funnelled to the insurance market."

-Michael S. Canter, Joseph B. Cole, and Richard L. Sandor

"Securitization is a small piece of a much bigger pie: the convergence of capital markets and insurance and reinsurance markets. The big issue strategically is the following: Insurance has historically been purchased as asset value protection. The selling of insurance is really risk management, and risk management is the management of capital. What you're doing when you're buying insurance is you're managing capital and you are part of the corporate financing decision. This means that we need to begin to think about insurance and reinsurance in the context of the overall corporate financing process going on within a company. This is a much bigger picture and a much bigger issue."

-Kevin R. Callahan, CEO, Aon Capital Markets

""Convergence" has many implications that will penetrate every aspect of the insurance and reinsurance industry, as we now know it. No one entity of the converging services providers will dominate or be replaced by the others; however, no one will be unaffected!"

-Ken Hague, Senior Vice President, Aon Re Canada

There can be no risk transfer without risk management. There can neither be risk management without risk awareness. In the early 1990s, several financial scandals involving derivative financial instruments made the headlines and gave a wake-up call to the world about the existence of and the need for proper management of financial risk, mostly market and operational risks. Academia reacted to this momentum by producing a growing body of literature on the motivations driving corporate risk management. In turn, regulators began requiring increased disclosure of derivatives positions and trading motivations. Furthermore, accounting rules were revised to keep the pace with the evolving financial management tools used by corporations. Paradoxically, the same derivatives that were involved in major bankruptcies were viewed as integral parts of risk management programs designed to grant corporations the ability to pursue the normal course of operations by staying out of bankruptcy.

The insurance industry is particularly well suited to illustrate the importance of bankruptcy risk management. By definition, insurers are in the business of managing risks. Insurers pool the risks from large numbers of individuals and companies for a fee; they retain part of the risks; they cede the amounts they do not wish to retain to reinsurers; and, should the insured individuals or companies suffer certain losses, insurers indemnify them. However, two events disrupted this equilibrium in the United States. In 1992, hurricane Andrew caused US$19 billion in insurance losses in Florida, and the Northridge, California earthquake in 1994 was responsible for damages amounting to US$14 billion. As a result of these catastrophes, enough number of insurance companies went bankrupt for the very offering of catastrophe insurance to be questioned.

Reinsurance supply contracted at a time it was most needed. The small size of the capital available from the insurance and reinsurance industries to sustain catastrophe losses was contrasted against potential losses from catastrophes, and a shortage of capital to meet the requirements of a super catastrophe was anticipated and feared.

Because catastrophes are not traded assets, the usual way to transfer catastrophe insurance risk at the time was through insurance and reinsurance policies. In order to allow for capital market participation in catastrophe risk transfer, derivatives on catastrophe insurance losses were first listed in 1992. However, trading did not take off quickly, as several difficulties were observed both regarding the timeliness of and the availability of data on catastrophe insurance losses, and on the length of the history available. The fact that catastrophe risk is more of an event risk than a market risk made catastrophe derivatives peculiar and the design of pricing models for catastrophe securities complicated. In addition, catastrophe derivatives were confronted by internal and external trading and holding hurdles, which slowed their development.

In terms of contract design, traditional reinsurance contracts feature among the various catastrophe risk transfer solutions. Due to the need for special catastrophe solutions, the reinsurance industry also began offering alternative risk transfer solutions, or contracts that cater to both catastrophe underwriting and financial risks. At the same time, the exchanges listed futures and options on catastrophe insurance losses. Parallel to those developments, a private market for catastrophe risk developed. The private market offers mainly catastrophe bonds, but also swaps and options.

The common denominator amongst the different catastrophe risk vehicles is the trigger on which the derivatives base their values. So far, three types of triggers have been used. First, catastrophe insurance loss indices were constructed and used for the options and for some bond issues. Even in the case where no moral hazard from the companies whose losses are included in the index is possible, computational delay is one of the principal problems observed with the indices, along with the basis risk for companies seeking to hedge their own exposure. Triggers based on a specific company's losses, indemnified-based triggers, resolve the problem of basis risk, but exacerbate the potential for moral hazard. Furthermore, they can only be used for private transactions, as they would not be applicable to listed derivatives. Finally, parametric triggers made their appearance. Parametric triggers are based on independent and immediately observable data such as the magnitude and location of an earthquake or the intensity of a hurricane.

Given the young age of the catastrophe derivatives market, this paper first reviews the events that brought about emphasis on catastrophe risk management, then dedicates attention to the peculiarities of catastrophe risk, before examining the design and evolution of the catastrophe derivatives themselves. Finally, a proposition for empirical research on the relationship between the occurrence of catastrophes and capital market returns is proposed. Furthermore, it is suggested that the theory of contagion in international finance would constitute an interesting framework for the analysis the relationship between the returns on catastrophe risk derivatives and the returns on other assets within a portfolio.

FROM RISK AWARENESS TO RISK TRANSFER

DERIVATIVES DEBACLES

"Much like airplane disasters, derivatives have created much anxiety as news of spectacular losses have been splashed across headlines."

-Philippe Jorion

At one point, a large number of people perceived derivative financial instruments as monsters with a built-in ability to wreck havoc firms that used them. This perception originated from the public disclosure of several derivative-related losses over a short period of time. While the losses were not purposely sought after, in the end they served two important purposes. First, they brought about change in the regulation of derivative financial instruments. Second, they stimulated a rich stream of academic research in risk management.

Against this backdrop, we will briefly introduce the events that turned into "derivatives debacles"[1]. Jorion [1997] estimates the cumulative losses involving derivatives over 1987-1995 to US$16.7 billion. Table 1 lists the principal debacles. We will not attempt to provide detailed account of all the derivatives losses of the early 1990s. Rather, we will limit our presentation to the Metallgesellschaft, Orange County and Barings

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[1] Credit for this expression belongs to Kuprianov [1995].

situations, for these three scandals provide a good illustration of the general difficulties associated with derivatives.[2]

TABLE 1. DERIVATIVES DEBACLES

Affected Entity	Country	Type of Derivatives	Loss
Orange County	United States	Reverse floaters and reverse repos	US$1.64 billion
Showa Shell Sekiyu	Japan	Currency forwards	US$1.58 billion
Kashima Oil	Japan	Currency forwards	US$1.45 billion
Metallgesellschaft	Germany	Oil futures	US$1.34 billion
Barings Bank	England	Stock index futures and options	US$1.33 billion

Both Jorion [1997] and Kuprianov [1995] analyse the Metallgesellschaft loss. In 1993, MG Refining and Marketing, the US subsidiary of the German oil company, adopted a new sales strategy. They negotiated contacts with their clients that locked-in the price of over 180 million barrels of oil for delivery over the ten forthcoming years. This quantity compares with eighty-five days of Kuwait's national output. Contemporaneously, MG Refining and Marketing's management decided to hedge their long-term commitment in the financial markets. Since oil futures typically trade with maturities less than three years, it was impossible to buy one single contract to hedge the ten-year exposure. Instead, management decided to roll over three-month futures. In late 1993, oil prices began to drop and the margin calls on the long futures reached levels that made Metallgesellschaft's German management uncomfortable. They decided to fire their subsidiary's managers, to liquidate the futures positions at a US$1.34 billion loss, and to

[2] However, the interested reader will find a comprehensive gathering of links to information on financial scandals at the following URL: http://www.ex.ac.uk/~RDavies/arian/scandals/classic.html.

terminate the contracts with the clients. This story illustrates the problem of maturity mismatch between a physical commitment and a futures contract. The greater the gap, the greater the susceptibility to margin calls over time. When going forward with such a strategy, it is important to make sure that the company will be able to financially sustain the periodic cash strains, and that top management is aware of and in agreement with the embedded commitments.

On December 1, 1994, the news of Orange County, California's, local government fund bankruptcy once again put derivatives in the spotlight[3]. The assets under management in that fund totalled US$7.5 billion. Orange County Treasurer, Robert Citron, was in charge of the portfolio at that time. He decided to borrow US$12.5 billion through reverse repurchase agreements, using the US$7.5 billion as collateral. This provided him a total of US$20 billion that he chose to invest in reverse floater agency notes with an average maturity of four years. Had the notes been straight floaters, they would have paid more interest as the US interest rates went up. However, because their coupon is structured as the difference between a fixed rate and a floating rate, reverse floaters pay less in such situations. The February 1994 rate hike resulted in margin calls on the reverse repurchase agreements. However, given the sudden decrease in the value of the notes, the fund could not meet the collateral payments and thus defaulted. The county lost US$1.64 billion. The lesson from this story is not that derivatives are "bad" instruments. The issue is rather one of disclosure and control. In this case, the manager of a county fund leveraged the assets in the fund and took directional derivatives positions, while

[3] Jorion [1997] describes the Orange County situation.

practically no one else was aware of the transactions. Clearly, before these events took place, the county did not enforce a strict risk management policy.

Another bankruptcy involving derivatives and an individual who was given considerable leeway and whose actions were not closely monitored was declared just a few months after Orange County's. On February 26, 1995, Barings Bank accumulated a loss of US$1.3 billion and went under[4]. One trader, Nicholas Leeson, operating from Singapore, exposed the bank to US$7 billion by transacting on Nikkei 225 stock index futures in Singapore and Osaka. Although management in London believed that Leeson was arbitraging the two markets, he was long futures, thus making the bet that the Nikkei would rise. Unfortunately, from New Year 1995 to February 24, 1995, it fell 12.65%. To further aggravate the situation, Leeson had sold both calls and puts on the Nikkei 225 futures. He was short straddle, which meant that he could only profit from stability, and that volatility could cause him unlimited losses. Swings such as that of January 23, 1995, when the Nikkei 225 lost 5.6% in one day, were doubly hurtful. Leeson's strategy did not pay and, at one point, he could not hide his losses anymore. Barings' management only discovered the true nature of Leeson's activities when it was too late. In this case, like in Orange County's case, lack of control was a main reason behind the losses. In banks, the trading function is supposed to be completely separate from the back office record keeping functions. In Singapore, Leeson was both a trader and in charge of the back office, which enabled him to hide his losses. It is now common practice for banks to have a back office to process the trades, an independent middle office to double-check

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[4] Jorion [1997] describes the Barings bankruptcy.

that positions comply with internal risk management policies, and a front office, which is separate and consists of the traders. Such a segregation of functions could have prevented the occurrence of Barings' bankruptcy.

The large derivatives losses of the early 1990s gave a wake up call to many people. Sad as they were, the derivatives debacles introduced risk management as an important discipline and caused major changes in regulation. In the next section, we will see the steps taken by regulators when it became apparent that corporate disclosure of derivatives activity and that taxation rules on derivatives were not following the pace of derivatives themselves.

DERIVATIVES REGULATION

"The unifying theme behind these reports and regulations is an increasing emphasis on risk management."

-Philippe Jorion

Since 1990, the Financial Accounting Standards Board (FASB) has been giving increasing importance to the treatment of derivatives[5]. Regulating derivatives was not an easy task, for although a regulation appeared necessary, the spirit of the regulation was not unanimously agreed upon. The tenants of full disclosure were in favour of the mark-to-market of derivatives in all cases, while their opponents preferred moderation and insisted on laws that would recognise instead of distorting the economics of using derivatives as hedges. In this section, we will study the evolution of the regulation of financial derivatives, as well as the specific case of insurance derivatives.

To begin with, FASB issued FAS No.105 in March 1990 to require disclosure about derivatives. As of June 15, 1990, all American listed companies were to disclose, in their financial statements, the following items about their financial instruments carrying an off-balance sheet risk of accounting loss:

- The face, contractual or notional amount of the contracts;

[5] Appendix 1 presents information on selected Financial Accounting Standards Board (FASB) statements related to derivatives, insurance, reinsurance, and securitisation. This information is reproduced from the statement summaries displayed on the FASB Internet site as of July 15, 2000. Information is also reproduced from the National Association of Insurance Commissioners (NAIC) Internet site.

- The nature and terms of the instruments, a discussion of credit and market risks incurred, cash requirements related to the position held and related accounting policies;
- The accounting loss that would be sustained in the event of counter party default;
- The collateral required on financial instruments, and
- The level of concentration of credit risk.

To complement that list, FAS No.107 was issued in December 1991. It stated that all entities reporting after December 1992 must disclose the fair value of their financial instruments, or, at least relevant information in order to estimate that value.

A greater step towards transparency was taken in October 1994 with FAS No.119. Depending on their total asset size, large American firms were to disclose, as of January 1994 (small firms as of January 1995):

- The amounts, nature, terms of the derivatives instruments that are not subject to FAS No.105, because they have no off-balance sheet risk of accounting loss;
- The distinction between instruments held for trading and other purposes, as well as the gains and losses, which must be recognised in the earnings, and;
- The purpose of use of derivatives and the method for reporting them in the financial statements. If the purpose is to hedge anticipated transactions, the transactions must be explained, related to the classes of derivatives used, the amount of hedging gains or losses deferred, and the transaction that results in recognition of deferred gains or losses.

The changes imposed by FAS No.119 were highly controversial, for they obliged companies to tell the world how and why they used complex tools, thereby revealing their aptitude to managing risk adequately. At this point, no quantitative information about market risk was required.

The Securities and Exchange Commission approved a set of rules, on January 28, 1997, which also required increased disclosure. The annual reports published from 1998 on should contain three new additions:

1. A table with information about fair market value, about contract terms, and information to estimate the future cash flows of market risk sensitive instruments;
2. A sensitivity analysis that expresses the potential earning losses, the fair values, or the cash flow from those instruments related to selected hypothetical changes in market conditions;
3. A value-at-risk analysis that expresses potential losses in earnings, fair values, cash flows or market risk sensitive instruments that would result from various market movements.

The FASB issued FAS No.133 as an extension of this matter in June 1998. Starting June 15, 1999, statement 133 requires all entities to recognise all derivatives as either assets or liabilities at fair market value in the statement of financial position. The main improvement with this statement is that gains and losses are accounted for depending on the intention behind their use. By design, the value of instruments used for hedging the fair values of assets or liabilities or of cash flows is expected to vary contemporaneously with the changes of such assets, liabilities, or cash flows. FAS No.133 allows that recognition for accounting purposes. In practice, FAS No.133 was difficult to implement and its application was deferred by the issuance of FAS No.137 in June 1999. One year later, in June 2000, FAS No.138 was issued as a second amendment to FAS No.133. It was effective immediately. With FAS No.138, the accounting for derivatives is done with the same goals as with FAS No.133, except that some practical constraints have been alleviated.

To understand the importance of hedge accounting, one can think of the following: If you lose $1 on a sale and make a $2 profit on the subsequent sale, your net profit is $1. But if you cannot account for your loss and your gain in the same period, you have to report the $1 loss today, and the $2 profit later. This basic example illustrates how accounting rules can distort economic results. The same effects are observed in a greater scheme of things. The problem is that, no matter how economically valuable a transaction is, if tax and accounting laws distort the results, chances are it may not occur. Discrepancies between the intended goal and the reported results of derivatives use for corporate risk management practices were observed with FAS No.119 and attenuated with FAS No.133. However, in the case of reinsurance and insurance derivatives, regulation has not yet matured to reach the same result, although it is evolving towards that direction.

Kramer and Heston [1993], a few years before issuance of FAS No.133, acknowledged the importance of regulation in corporate risk management financial transactions. According to them, hedging will be ineffective and will result in distortions when accounting and tax results are not consistent with the economics of the transaction. They make a case regarding accounting requirements, in that their distortion effect can discourage hedging. They remark that hedging and risk management work as business or investment tactics, but only to the extent that the economics of a transaction are reflected in the tax results. For this to happen, gains and losses must be reported in the same taxable period, which allows for a timing match. Under this rationale, it makes sense to hedge only when it is possible to anticipate the tax consequences of hedging and to develop a hedging strategy that acknowledges these consequences. Current regulation embraces hedge accounting, which allows the gains and losses on derivatives to be accounted for in the same period as the fluctuations in the value of the asset or liability hedged.

Johnson and Swieringa [1996] explain that hedge accounting is different from regular accounting in that it is oriented towards the income statement and seeks to make the changes on the hedged item recognised in earnings in the same reporting period as those on the hedging instrument. Although hedge accounting respects the economics of a hedging transaction, it is costly and requires the creation of additional records. As a practical solution, Johnson and Swieringa [1996] postulate that an alternative to hedge accounting would be to eliminate the recognition and measurement differences between financial instruments, and to recognise them all at fair value. However, Moffett [1995] explains that, when hedging instruments are required to be mark-to-market, hedging may result in an increased variability of reported earnings per share. The only way for managers to eliminate these effects is to practice delta hedging, which is a costly strategy. According to Benston [1997], banks, derivative vendors, corporate derivative users, and accounting professionals defend hedge accounting, while regulators and academics have preferred fair value accounting.

The case of insurance, reinsurance, and their derivatives warrants separate consideration, for customized laws regulate their activities. Currently, Standard and Poor's [2000] explains that, for insurance options and other derivatives not based on an insurance company's direct losses, the derivatives are treated as an investment transaction. Their cost is accounted for with other investment expenses, and their payoffs under miscellaneous investment income. In other words, non-indemnified insurance derivatives do not affect insurance companies' underwriting profits and ratios. This implies that after incurring a loss, an insurer that protected itself with index-based derivatives will post higher net underwriting losses and combined ratio than an identical insurer covered with reinsurance. In the absence of a loss, the opposite result would be observed. The Insurance Services Office (ISO) [1999] explains that, in this case, the risk-based capital calculations implicitly require that an insurer using catastrophe derivatives should hold more capital than an insurer using reinsurance. This illustrates how regulation favours reinsurance over indexed-based derivatives when losses are suffered.

The securitisation of insurance risk is arguably slowed down by current regulation. Laurenzano [1998] proposes that regulators should be encouraging the securitisation of insurance risk and the alternative risk transfer market (the participation of the capital markets in the insurance industry). To quote Laurenzano [1998]: "Regulators must recognise capital markets initiatives like securitisation and derivatives instruments as acceptable, even desirable, risk transfer mechanisms for insurance companies, and establish favourable accounting rules designed to encourage this market." This would be accomplished if insurers were allowed to securitise their own risks, for example by issuing catastrophe bonds directly, while recording the bond proceeds and the interest expenses through their underwriting accounts. The opinion of Standard and Poor's [2000] regarding this matter concurs: "for financial strength rating purposes, a properly structured bond serves the same function as a program of reinsurance." Standard and Poor's [2000] further expects clarification of this topic to lead to a greater use of insurance securitisation, even in those lines that are not currently affected by capacity constraints.

The American Academy of Actuaries [1999] says that "while cosmetic in nature, the current accounting treatment is a factor in the use of index-based insurance as a risk transfer mechanism." This is one reason why the National Association of Insurance Commissioners (NAIC) formed a securitisation working group in 1998 with the purpose of evaluating the regulatory changes that would be needed in order to support capital market alternatives to insurance and reinsurance. The NAIC is currently developing a legislation that will support fully funded loss indemnity-based transactions, thereby reducing the need for special purpose vehicles that up to date have been used by ceding companies to account for securitisation transactions as reinsurance. The NAIC is also investigating the appropriateness of allowing underwriting treatment for index-based insurance and reinsurance derivatives, which would follow FAS No.133. This legislation bears the name of the Protected Cell Company Model Act.

The Protected Cell Company Model Act was adopted on December 6, 1999. According to Maurice [1999], the main reason for this proposed law is because special purpose vehicles used to issue catastrophe bonds have become very popular and are all located offshore[6]. The law would allow the deals to be home grown. O'Leary [1999] mentions that, up to date, only Illinois and Rhode Island have allowed catastrophe risk to be securitised within their territory. For example, the Illinois Department of Insurance allowed the Insurance Exchange (INEX) and its members to offer domestic catastrophe bonds. In April 1999 Kemper Insurance Co through AON Capital Markets completed the first domestic-based securitisation. The private placement effectively transferred US$ 100 million Midwestern earthquake risk. This is progress, but much remains to be done in that area.

In addition to affecting the treatment of reinsurance when compared to insurance derivatives, regulation distorts market equilibrium between reinsurance and insurance industries. Currently, reinsurance prices are not regulated, whereas insurance prices are highly regulated. This is not a small matter. Watson and Osborne [1999] say that the

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[6] The section "Trading and Holding Constraints" introduces the concept of special purpose vehicles.

parties involved in a reinsurance transaction are usually all sophisticated, which is why reinsurance contracts do not require state insurance regulatory approval. Reinsurers thus benefit from the possibility of developing custom products for catastrophe, foreign exchange, residual asset value or weather risks. Cummins, Lewis, and Phillips [1998] say that, following hurricane Andrew in 1992 and the Northridge earthquake in 1994, reinsurance rates rose by 150% in some cases. However, to increase their own rates in a comparable manner, insurers needed to seek regulatory approval. Even though they submitted their requests to state insurance commissioners, insurers were not granted that right. This means that if another catastrophe occurs in Florida or California, insurers will likely not be as covered by reinsurance as they would otherwise like to be, given that they keep charging the same premiums but they must pay more for reinsurance.

Regulation also discriminates between different types of reinsurance covers. Before EITF[7] 93-6 in 1993, there used to be accounting advantages to treaties (automatic reinsurance). Now, on the other hand, insurance risk cedents must account for the positive balances of their experience accounts in spread loss treaties as assets and, conversely, they must treat negative accounts as liabilities in the balance sheet.

As for finite reinsurance products, Swiss Re[8] identifies the economic costs of unnecessarily restrictive regulation as:

1. The amplification of the cyclical nature of the insurance market;
2. The exacerbation of the problem of non-insurability;

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[7] EITF is the Emerging Issues Task Force, which is related to the Financial Accounting Standards Board.

3. The discrimination against good risks;
4. The reduction in incentives for cautious underwriting and appropriate settlement;
5. The inhibition of long-term relationships between primary insurers and reinsurers;
6. The impairment of efficient price formation; and
7. The creation of obstacles to the insurance industry's access to the capital markets.

This section showed the changes in regulation brought about by the derivatives debacles of the early 1990s. At first, the lack of disclosure on derivatives was addressed and considerable information was required to be rendered public. Next, the distortion between the economics of a transaction and the reported effects of the transaction was lessened with the recent adoption of hedge accounting. Finally, this section addressed the status of insurance derivatives, highlighting that their regulation is evolving and that issues regarding US-based securitisation deals are being solved. The next section focuses on academia's efforts to explain the motives behind hedging and risk management programs.

[8] Sigma No.5/1997.

RISK MANAGEMENT THEORIES

"Risk management is asking what might happen the other one percent of the time."

-Richard Felix, Chief Credit Officer, Morgan Stanley

The bases of modern finance theory, market efficiency and diversification, do not set grounds for risk management. The concept of market efficiency, in Stulz' [1996] view, teaches us the lesson that any attempt to earn higher returns usually implies bearing large risks. Market efficiency should therefore discourage corporations from creating exposures to financial market risks. Similarly, Stulz [1996] affirms that diversification should discourage firms from hedging their operating financial exposures, since, for the most part, corporate financial exposures represent risks that can be diversified directly by shareholders. Therefore, dedicating corporate resources to risk reduction is justified only if not doing so would expose the corporation to real costs. Furthermore, if markets are efficient and if all investors are able to hold perfectly diversified portfolios, then all risks are being shared and efficiently held, and there is no need to worry about them. We can all dedicate our time to more important issues.

However, the derivatives debacles evidenced the importance of risk management, and the following evolution of derivatives regulation showed that this was indeed an issue to take seriously. Furthermore, scholars have dedicated considerable efforts to find evidence that corporations seek risk management solutions and to enunciate theories to explain their motives. Although all the theories do not apply to the same extent to catastrophe risk management, if we understand the importance of managing risk, any risk, we will understand even better why insurance companies care about catastrophe risk. Furthermore, some reinsurance solutions, broadly called alternative risk transfer, aim at managing more than catastrophe risk, and the roots of this new tangent can be found in the arguments that follow.

There are two main motives for setting forth risk management programs. The first motive, the minimisation of the variance of firms' cash flows, comprises agency costs, asymmetry of information, and market imperfection theories. The second motive, the reduction of downside risk, is dealt with subsequently.

Firstly, Stulz [1984] advances that hedging decisions benefit managers personally due to the existence of an agency relationship between managers and shareholders. Managers act in such a way as to maximize their own expected lifetime utility, which is not necessarily consistent with shareholders' best interests. Since managers' income is dependent on short term variations in firm value, usually in a proportional fashion, they will be inclined to use risk management as a way to maximize their utility, and to design active hedging policies. For risk management to be consistent with firm value maximization, it is imperative that management incentives be in line with shareholders'. Smith and Stulz [1985] pursue in the same direction as Stulz [1984] and demonstrate how management compensation contracts are a determinant of firms' hedging decisions. They advance the explanation that, often, compensation is related to firm value, and that because hedging changes the distribution of the firm's payoffs, it also changes that of the managers' expected utility. If managers own a significant fraction of a firm, then the firm is expected to hedge more, as the manager's end-of-period wealth comes closer to a linear function of firm value. A criticism to this argument is expressed in Froot, Scharfstein, and Stein [1993]. Their concern is that Stulz [1984] relies on the assumption that managers face significant costs when trading on their own account, and that otherwise they would not need to involve the firm in their hedging activities. They identify as a weakness the fact that Stulz [1984] does not include corporate transaction costs into his analysis, which has the implication that firms will hedge fully, up to the point where the variance of the stock price is minimised.

In the specific case of insurance, Mayers and Smith [1982] find that corporate demand for insurance is affected by the agency conflicts between managers and shareholders, i.e. insurance purchase is a function of management decision power. They propose that insurance will usually be purchased if the present value of the reduction in bankruptcy costs exceeds the present value of the contract's loading fees. However, insurance demand is tied to conflicts of interest between shareholders and managers, and firms with high managerial discretion over the choice of hazard-reducing projects are more likely to purchase insurance.

DeMarzo and Duffie [1995] give further consideration to the risk management practices of managers whose primary motivation is career concerns. Because management wealth is tied to the perception of firm performance, and because accounting rules influence the reported firm performance, the accounting framework itself plays a role in management's hedging decisions. DeMarzo and Duffie [1995] show that the optimal hedging policy is dependent on the type of accounting information disclosed publicly. When the accounting effects of hedging decisions are a prime concern for managers, they might influence the type of hedging instruments used as well as the decision to undertake hedging in the first place. This analysis is based on the informational effect of hedging. Hedging is seen as a reducer of the noise in the firm's profits and as a means to increase the informational content of those reported profits. In the environment considered, it is through performance observations that shareholders learn about managerial competence and project quality. When hedging positions are required by regulation to be fully disclosed, shareholders' perceptions of managerial competence become more sensitive to the firm's performance, and wages become more variable, destroying the incentive for risk-averse managers to hedge. More precisely, if standard hedge accounting is applied[9], managers will want to fully hedge, but if they must provide separate accounts of hedging activities, they will tend to reject hedging.

Under asymmetry of information, managers are in a better position than shareholders to make decisions on corporate hedging decisions. Assuming that managers will act in shareholders' best interest, shareholders will prefer that management undertake a risk management program, even if the terms are not public. DeMarzo and Duffie [1991] posit that in circumstances where a firm, or its managers, possess proprietary information on the firm's own dividend stream of which shareholders are unaware, it is possible that the

[9] Under hedge accounting, if a derivative is considered a hedge of an asset or a liability, the gain or loss on the derivative is recognised in the same period as the gain or loss on the asset and liability. The economics of the transaction are therefore reflected in the results.

shareholders and the firm would benefit from the adoption of a risk management policy. Furthermore, it is sometimes optimal for all shareholders that risks be completely hedged, particularly when there is asymmetry of information. Managers possess proprietary information, and the reason why they cannot disclose it to shareholders is either that the information is of strategic importance to the firm or that it would be very costly to inform shareholders of the details. As a result, shareholders are unable to hedge on their own account, which is why they might approve that managers do so.

Agency conflicts are also present in the shareholder-bondholder relationship. One of the first agency costs that could be alleviated through risk management is identified by Myers [1977] as the under-investment incentive. Smith and Warner [1979] suggest that the under-investment problem is one of the important sources of conflict between bondholders and shareholders, along with dividend increase and investment decrease, issuance of additional debt of same or higher priority, and substitution of projects that increase firm's variance rate.

Myers [1977] describes the under-investment problem as follows: Firm value reflects an expectation of continued future investment. In fact, a significant part of many firms' market values is derived from assets to be acquired in the future, or from the present value of future growth opportunities. However, when there is risky debt in its capital structure, a firm will sometimes pass up valuable investment opportunities whose net contribution to firm market value would be positive. It is the very existence of debt that alters the firm's actions in some circumstances and creates situations in which management is bound to make sub-optimal decisions. For example, when debt matures after the firm makes an investment decision, if the benefits of that investment are expected to accrue to debt-holders, shareholders will prefer for the investment not to be made. Ex ante, this phenomenon reduces firm value and consequently shareholders' wealth.

Possible solutions to the under-investment problem, such as rewriting the debt contract, renegotiating the debt contract, shortening debt maturity, mediation, and imposing restrictions on dividends are suggested by Myers [1977]. Although Myers [1977] does not mention risk management, others have, based on his work. Mayers and Smith [1987] explicitly make a case for the use of insurance to control the form of the under-investment problem related to property/casualty losses. Those losses induce option-like features in firm's assets because their value is dictated by the cost of future replacement investment. In this case, insurance as a risk management tool can help reduce the under-investment problem.

Another stream of risk management incentives arises from market imperfections such as expected costs of bankruptcy, taxes, external finance contracting costs, and firm size. The theories pertaining to market imperfections apply to catastrophe considerations, mainly because catastrophes can make external finance very costly. Catastrophes can also bankrupt an insurer, and a reinsurer, for that matter. This is why we examine reduction in the expected costs of bankruptcy, an often-cited benefit to risk management.

Warner [1977] studies the role of bankruptcy costs in capital structure choices and shows that they are relevant, because the percentage decline in market value of equity is greater than the percentage decline in debt value when a firm declares bankruptcy. Smith and Stulz [1985] point out that the lower the expected costs of bankruptcy, the higher the expected payoffs to the firm's claimholders. Therefore, if the firm's value is lower than the value of its debt, the bondholders receive an amount worth the firm value minus the transaction costs of bankruptcy. If, on the other hand, the firm's value is higher than the value of the debt, the shareholders receive the firm value, minus taxes and minus payments to bondholders. This makes a case for transaction costs of bankruptcy to induce widely held corporations to manage their risks. In fact, hedging reduces the variance of the firm's future value, thereby reducing the probability of positive bankruptcy costs. In that sense, hedging benefits shareholders. However, hedging also increases firm value and operates a transfer of wealth from shareholders to bondholders, which means that shareholders must be provided an incentive to hedge.

A similar conclusion is found in MacMinn [1987], who affirms that the expected costs of bankruptcy constitute an incentive for firms to insure and shift the risk to an insurance company, reducing the probability that the firm will be the one having to incur those costs. However, insurance increases debt value and decreases equity value. Therefore, a market-value-maximizing firm has no incentives to insure. Furthermore, it is not necessary for a company to manage risks if these operations do not affect the payoffs that investors can achieve by diversifying their own portfolio, but, if it can alter the payoffs, e.g. by diminishing bankruptcy costs, then the company should insure.

Smith and Stulz [1985] present the argument that risk management programs are influenced by the tax schedule. They make the following hypotheses:

- The effective marginal tax rate is proportional to the company's pre-tax value;
- Hedging reduces the variance of the firm's pre-tax value;
- If the cost of hedging is small, the expected corporate tax liability decreases and the expected post-tax firm value increases;
- Costless hedging increases firm value as does incomplete hedging;
- If there are economies of scale in transaction costs, the firm will completely hedge.

This allows them to say that under a convex statutory tax function, the tax-reducing benefits of hedging increase if the function that leads after-tax income becomes more concave. This implies that convexity in the tax function directly induces firms to hedge.

Froot, Scharfstein, and Stein [1993] discuss the issue of the costs of external financing. Given the interaction between investing and financing decisions, their analysis shows that risk management might be a pre-requisite to optimal investments. In particular, they illustrate how optimal risk management strategies can be designed by building on capital market imperfections theories. They say that if external sources of finance are more costly to a firm than internally generated funds, there is a benefit to hedging. In this sense, hedging adds value because it serves as a means to ensure that the firm has sufficient internal funds available to take advantage of attractive investment opportunities when they arise.

Froot, Scharfstein, and Stein [1993] point to another type of under-investment problem, the case where, without hedging, firms find it too costly or impossible to raise external finance. They present two conditions that must be met for hedging to be beneficial: Marginal returns on investment must be decreasing and the level of internal wealth must have a positive impact on the level of optimal investment. This leads them to state that hedging is determined by the interaction of investment and financing considerations. In their optimal contracting model, they state that if there are no dead-weight costs to external finance, the firm undertakes investments efficiently. If there are dead-weight costs, however, the firm under-invests because an increase in investments necessitates an increase in debt and raises the probability of bankruptcy. This implies that firms with increasing marginal costs of external finance should fully hedge their cash flows. Froot, Scharfstein, and Stein [1993] also examine changing financing opportunities. They point out that negative shocks to a firm's current cash flows might make it more costly to raise outside money, under which circumstances it might make sense for the firm to hedge more than normally. An optimal hedge ratio allows the firm to fund its investments while reducing the need for borrowing at times when external finance is most expensive.

Tufano [1998] cautions us against cash flow hedging that allows firms to avoid the dead-weight costs of external financing by setting their internal cash flows equal to their investment needs in the Froot, Scharfstein, and Stein [1993] sense. In Tufano's [1998] view, when agency conflicts exist between shareholders and managers, these hedging strategies can be used to reduce shareholder wealth, since they remove the discipline of external capital markets on managers.

Finally, firm size is presented as a determinant of corporate hedging decisions. Given Warner's [1977] finding that the transaction costs of bankruptcy are less than proportional to firm size, Mayers and Smith [1982] find that small corporations are more likely than large firms to hedge via the purchase of insurance in order to reduce the probability of incurring bankruptcy costs. However, Booth, Smith, and Stolz [1984] and Block and Gallagher [1986] present a rationale for larger firms to hedge more, because of scale economies in information and transaction costs of hedging.

We have seen the arguments in favour of risk management to minimise fluctuations in the value of firms. Hedging to reduce agency conflicts, to diminish taxes and expected costs of bankruptcy, to avoid the under-investment problem, and to avoid the negative effects of firm value fluctuations on managers' compensation, are ways that pursue one single purpose, which is to minimise the variance of firms' cash flows. The remainder of this section presents a different angle under which risk management programs can be constructed. It studies downside risk.

Downside risk reduction appeared at a later stage than variance minimisation in the risk management literature. Miller and Leiblein [1996] present a model of risk-return relations in which risk is conceptualised in terms of downside outcomes, rather than variance. They examine the results of many surveys of managers' perception of risk, and concluded that risk, for managers, has a meaning much closer to that of failure to perform at an aspired level, that is the materialisation of downside outcomes, than to performance variability, which includes both upside and downside outcomes. Stulz [1996] also notes that although the primary theoretical emphasis of risk management is on reducing cash flow variability, in practice, large companies make greater use of derivatives than small firms, even though small firms have more volatile cash flows and have a more restricted access to capital. According to Stulz [1996], many companies appear to be using risk management for other purposes than variance reduction, as can be seen by the greater popularity of selective hedging than full-cover hedging.

Stulz' [1996] proposed goal for risk management is the elimination of costly lower-tail outcomes. Such strategies are designed to reduce the expected costs of financial distress while preserving the ability to exploit any comparative advantage in risk bearing. They are comparable to the purchase of well out of the money puts. Viewed this way, risk management could be used to change capital and ownership structures, to increase debt capacity and to facilitate larger equity stakes for management. At times, firms have a comparative advantage in bearing certain financial risks, and they must determine the role played by risk management in the exploitation of such an advantage. This implies that risk management may enable firms to take on more risks than they would in its absence. That said, a company's ability to prevent its operating activities from being affected by potentially large trading losses depends not only on its risk management policy, but also on its capital structure and general financial health. However, Stulz [1996] warns that, if the costs of making an erroneous bet can be substantial for the firm, then management should not let its views affect the hedge ratio. In the case of a firm already in financial distress, introducing new sources of volatility through risk management will raise the probability of upper-tail outcomes that are capable of rescuing the firm. Stulz [1996] maintains that "with as a primary goal for risk management the elimination of lower-tail outcomes, it is possible for a company to increase its volatility while also limiting the probability of a bad outcome that would create financial distress." He also adds that "focussing on lower-tail outcomes is fully consistent with managing longer-term economic or competitive exposures, as opposed to the near-term transaction exposures that most corporate risk management seems designed to hedge." Stulz' [1996] supports the concept of risk management as an insurance strategy rather than as a hedging tool.

Stulz [1996] also presents risk management as a substitute for equity capital. The idea is that the more the firm hedges its financial exposures, the less equity it requires to support its business. Risk management is therefore a way to increase debt capacity, which is why Stulz [1996] says that it is advantageous only to the extent that equity is more expensive than debt, and that hedging decisions should be made contemporaneously with capital structure decisions. Furthermore, for a firm with too much equity capital, risk management may not be useful under the status quo, but it can help to increase leverage and allow the firm to profit from tax advantages. Finally, increasing leverage can also strengthen management incentives to improve efficiency. A remark that corroborates this statement is made by Scholes [1998], who observes cases in which risk management is used to reduce the level of equity and in which some firms that would otherwise have gone public end up remaining private.

Up to this point, this section overviewed the broad theories for risk management. It will now discuss how they apply to the specifics of the insurance industry. In an empirical study, Cummins, Phillips, and Smith [1996] examine the risk management process going on within insurance companies. They find that insurers have become more sensitive to their risks because of FASB statement 115 that requires mark-to-market accounting for fixed income securities available for sale or held for trading purposes, and because of FASB statement 119 that requires disclosure of the purpose of derivatives activity. With data obtained from schedule DB of annual statements of US insurers that report to the NAIC, they find that 12% of life insurers, 7% of property/casualty insurers and 12.5% of groups and unaffiliated single insurers used derivatives in 1994. The authors have found that hedging activities are different for life and property/casualty insurers. Life insurers use more interest rate and foreign exchange derivatives, and property/casualty insurers use more equity options and foreign exchange derivatives. Portfolio composition for property/casualty insurers includes more stock than life insurers'. Life insurers prefer CMOs[10], private placement bonds, real estate and mortgages. Publicly traded bonds are widely held by both. However, the average maturity of life bond portfolio exceeds that of property/casualty bond portfolio.

Cummins, Phillips, and Smith [1998] pursue the 1996 study of insurer risk management behaviour and find evidence consistent with the fact that insurers tend to view reinsurance and derivatives as complements. In other words, they use the two types of hedging devices to deal with different risks. A second important finding of this study is

[10] CMOs are Collateralised Mortgage Securities, or securities guaranteed by underlying mortgages.

that insurers are motivated to use derivatives to reduce the expected costs of financial distress, which is inferred by the fact that their decision to use derivatives is inversely related to their capital-to-asset ratios, both for life and property/casualty insurers.

Cummins, Phillips, and Smith's [1998] recognition of the importance of the reduction of the costs of financial distress is particularly important for the current paper. The minimisation of the variance of a firm's cash flows to achieve a reduction of the costs of financial distress is closely related to the management of downside risk. Both these incentives to risk management ultimately seek the avoidance of bankruptcy. In the remainder of this paper, we focus on catastrophe risk. Catastrophes have provoked insurer bankruptcies in the past. For example, in the aftermath of hurricanes Andrew and Iniki in 1992, a record 63 property/casualty insurers went bankrupt.[11] Cummins, Phillips, and Smith's [1998] findings imply that the risk of bankruptcy caused by catastrophes features among the primary preoccupations of insurance companies. With this background information in mind, the next section will introduce natural catastrophes and their impacts.

[11] Insurance Services Office [1999].

CATASTROPHES IN A NUTSHELL

"On the other hand, at USD 150 billion, total [insured and non-insured worldwide] losses [from catastrophes in 1995] reached an exceptionally high level; half of the total amount of losses were due to the Kobe earthquake."

-Swiss Re

In this section, we explore the basics of catastrophes. We obtain comprehensive information on worldwide catastrophes in research published by the Swiss Reinsurance Company. A first distinction must be made between natural and man-made catastrophes. Swiss Re[12] defines natural catastrophes as events that are caused by natural forces and falling into one of six categories: flood, storm, earthquake, drought and bushfire, cold and frost, and other. In turn, man-made catastrophes, also called technical catastrophes, are major events that could not occur in the absence of human activity. Man-made catastrophes can be divided into seven categories: major fires and explosions, aviation disasters, shipping disasters, road and rail disasters, mining disasters, collapse of buildings and bridges, and miscellaneous[13].

The Property Claims Service (PCS) in the United States tracks all catastrophes. PCS has set a threshold for an event to be considered a catastrophe. In 1949, the minimum dollar amount of damages caused had to be at least US$1 million, which was raised to US$5

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[12] Sigma No.3/1998.
[13] An example of miscellaneous man-made catastrophes would be a major hacker attack on the World Wide Web.

million in 1982, and US$25 million in 1997. For the same periods, the average insurance claim was respectively US$137, US$1,500, and US$2,500[14].

Catastrophe losses have gained importance over the 1990s. The increased importance of catastrophes is corroborated by Swiss Re's Sigma studies, which began in 1970. To that effect, Table 2 presents information on the distribution of world catastrophe losses in 1999[15]. We notice that nearly half of the catastrophes occurred in Asia, but that only 24% of total world insured losses are attributed to that region. In contrast, the American continent was home to 25% of world catastrophes, while 39% of insured losses were incurred on this continent. Swiss Re's breakdown for 1999 insured losses, totalling US$28.4 billion, is US$24.2 billion caused by natural catastrophes and US$4.2 billion by man-made disasters. This figure is small compared to total losses of US$100 billion. Table 3 is adapted from Sigma[16] and provides a perspective of that breakdown for the most recent years.

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[14] Kerney [2000].
[15] Sigma No.2/2000.
[16] The information is gathered from Sigma No.2/1996, No.3/1997, No.3/1998, No.1/1999, and No.2/2000.

TABLE 2. REGIONAL DISTRIBUTION OF WORLD CATASTROPHES IN 1999

Region	Percentage of Total Number of Catastrophe Occurrences	Percentage of Total Number of Catastrophe Victims	Percentage of Total Insured Losses
Europe	15.3%	1.3%	31.3%
America	24.5%	51.4%	39.4%
Asia	46.0%	46%	24.1%
Africa	11.3%	1.3%	0%
Oceania	1.5%	0%	4.1%
Oceans/Space	1.2	0%	1.1%
World Total	100%	100%	100%

Source: Sigma No.2/2000.

TABLE 3. DISTRIBUTION OF WORLD-WIDE CATASTROPHE LOSSES FROM 1995 TO 1999

Year	Total World-wide Catastrophe Losses[1]	Total World-wide Catastrophe Insured Losses	Total World-wide Natural Catastrophe Insured Losses	Total World-wide Man-made Catastrophe Insured Losses
1995	150.0	14.6	12.4	2.2
1996	50.0	13.2	8.8	4.4
1997	28.8	6.7	4.1	2.6
1998	65.5	17.5	14.0	3.5
1999	100.0	28.4	24.4	4.2

[1] All losses in this table are presented in US$ billion.

Source: Sigma No.2/1996, No.3/1997, No.3/1998, No.1/1999, and No.2/2000.

Furthermore, Swiss Re releases a list of worldwide catastrophes and related losses once a year. Table 4 reproduces this list, which features the most severe catastrophe insurance losses from 1970 to 1999[17]. The most costly catastrophes for insurance were hurricane Andrew, which caused US$19 billion in insured losses in 1992 and killed 38 people, and the Northridge earthquake in California, which caused insurance losses of US$14 billion and 60 deaths. From this table, an increase in the annual number of major catastrophes over the last years is apparent. This is attributed to both the increased availability of information and to the fact that the density of population is increasing along with insured assets in catastrophe-prone areas[18].

TABLE 4. THE FORTY MOST COSTLY INSURANCE LOSSES BETWEEN 1970 AND 1999

Insured Losses[1]	Victims[2]	Date[3]	Event	Country
19,086	38	Aug/24/1992	Hurricane Andrew	USA
14,122	60	Jan/17/1994	Northridge earthquake in Southern California	USA
6,906	51	Sep/27/1991	Typhoon Mireille	Japan
5,882	95	Jan/25/1990	Winter storm Daria (hurricane)	Europe
5,664	61	Sep/15/1989	Hurricane Hugo	Puerto Rico
4,500	80	Dec/25/1999	Winter storm Lothar	Europe
4,415	13	Oct/15/1987	Autumn storm and floods	Europe
4,088	64	Feb/26/1990	Winter storm Vivian (hurricane)	Europe
3,622	600	Aug/20/1998	Hurricane Georges, flooding	USA, Caribbean
2,980	26	Sept/22/1999	Typhoon Bart hits south Japan	Japan
2,831	167	Jul/06/1988	Explosion on Piper Alpha Offshore oil rig	Great Britain
2,716	6,425	Jan/17/1995	Great Hanshin earthquake in Kobe	Japan
2,360	70	Sept/10/1999	Hurricane Floyd: East Coast, Bahamas, Caribbean	USA et al.
2,307	59	Oct/04/1995	Hurricane Opal	USA
2,200	45	Dec/27/1999	Winter storm Martin	France et al.
2,027	246	Mar/10/1993	Blizzard over the East Coast	USA
2,000	19,118	Aug/17,1999	Earthquake in Izmit	Turkey
1,909	4	Sep/11/1992	Hurricane Iniki	USA

[17] Sigma No.2/1996, No.3/1997, No.3/1998, No.1/1999, and No.2/2000.
[18] Sigma No.3/1998.

1,789	23	Oct/23/1989	Explosion at Phillips Petroleum	USA
1,733	-	Sep/03/1979	Hurricane Frederic	USA
1,708	39	Sep/05/1996	Hurricane Fran in the South-east	USA
1,696	2,000	Sep/18/1974	Tropical cyclone Fifi	Honduras
1,648	116	Sep/03/1995	Hurricane Luis	Caribbean
1,575	350	Sep/12/1988	Hurricane Gilbert	Jamaica
1,485	54	May/03/1999	Tornadoes in the Mid-West	USA
1,477	500	Dec/17/1983	Snowstorms, frost	USA
1,4767	26	Oct/20/1991	Forest fires which spread to urban area, drought	USA
1,461	350	Apr/02/1974	Tornadoes in 14 states	USA
1,398	31	Aug/04/1970	Hurricane Celia	USA
1,393	-	Apr/25/1973	Flooding on the Mississippi	USA
1,380	-	May/15/1998	Thunderstorm with hail damage (MN, IA)	USA
1,350	63	Oct/17/1989	Loma Prieta earthquake	USA
1,305	12	Sept/19/1999	Typhoon Vicki	Japan
1,263	46	Jan/05/1998	Cold spell with ice and snow	Canada, USA
1,247	21	May/05/1995	Wind, hail, flooding	USA
1,198	100	Jan/02/1976	Storms over north-western Europe	Europe
1,113	20	Aug/17/1983	Hurricane Alicia	USA
1,100	3	Oct/26/1993	Forest fires which spread to urban area, drought	USA
1,099	40	Jan/21/1995	Storms and flooding in the north of Europe	Europe
1,067	28	Feb/03/1990	Storm Herta (hurricane)	Europe

[1] Insured losses are expressed in US$ million, at 1999 prices, and exclude liability losses.

[2] Victims include dead and missing people.

[3] The date corresponds to the occurrence date for single-day events or to the beginning date for several-day events.

Source: Sigma No.2/1996, No.3/1997, No.3/1998, No.1/1999, and No.2/2000.

For the period spanning from 1970, Swiss Re also presents the forty worst catastrophes in terms of fatalities. It is noteworthy to observe that, of the forty most costly insurance losses, only the Great Hanshin Earthquake in Kobe and the Earthquake in Izmit concurrently appears in the list of the most fatal catastrophes. This seems due to the fact that the deadliest catastrophes primarily strike countries where insurance is not a developed practice. For example, the worst catastrophe in terms of victims was a tropical cyclone that went through Bangladesh on November 14, 1970, killing 300,000 people, for which no insurance loss was recorded. This further illustrates the importance of distinguishing between total losses and insured losses due to catastrophes.

This concludes our introduction to catastrophes. We have seen that they strike relatively often, but in different locations, that they cause large losses, that losses suffered by the insurance industry are fairly small compared with total losses, but nevertheless that insurance losses are reaching levels high enough to threaten insurers with bankruptcy. We established that catastrophes produce an impact that cannot be ignored. The next section puts the effects of catastrophes into perspective and identifies the different stakeholders in catastrophe situations.

STAKEHOLDERS IN CATASTROPHE SITUATIONS

"Although each country faces a different set of hazards and has a different set of institutional arrangements, the common thread is how to offer greater protection to potential victims. There are a set of key stakeholders, each of whom has their own set of objectives and concerns, that need to be considered when designing a set of financial arrangements to provide them with protection after a major disaster occurs."

-David C. Croson and Howard C. Kunreuther

There are numerous stakeholders in catastrophe situations. Each and everyone is affected in a different way and is able to seize different opportunities. We organize this section around Croson and Kunreuther's [1999] list of the stakeholders: homeowners and businesses at risk, insurers, reinsurers, investors, and the government. These entities are all affected by primary catastrophes, and they further play a role in the convergence of insurance and financial markets for transferring catastrophe risk.

The first category of people affected by catastrophes is composed of homeowners and businesses that stand to see their belongings physically destroyed by, and end up insolvent from, a catastrophe. They are willing to pay today what they consider a relatively small amount for insurance in order to avoid a large loss of wealth in the wake of a catastrophe. Unfortunately for them, while they can seek to minimise the financial damages they incur, they are not in a position to take advantage of a catastrophic situation, i.e. they cannot be short catastrophe risk[19]. As Froot [1999][20] remarks, there is no upside for them from the fact of a catastrophe not occurring. As far as this category is concerned, the market for catastrophe risk is incomplete.

Insurers form the second group of stakeholders at risk. Catastrophes pose a real threat to their businesses. The law of large numbers works out fine as a way of balancing insurance risk portfolios for most risks, but catastrophes induce correlation among losses. This is due to the fact that a catastrophe typically affects a whole neighbourhood at the same time. Many insurance companies do not want to underwrite catastrophes anymore, especially in areas such as Florida and California, because of the losses incurred through hurricane Andrew in 1992 and the Northridge earthquake in 1994, amounting to US$18.6 billion and US$13.7 billion, respectively. Premiums at the time were based on actuarial estimates of historical losses and, due to the extreme nature of those two catastrophes, were considerably below the amounts necessary to respond to the damages caused by these events[21]. In fact, prior to 1989, the insurance industry had not suffered a single loss exceeding US$1billion[22]. The impact of Andrew was such that, as previously mentioned, in 1992, 63 property/casualty insurers went bankrupt[23]. It seems as though at some point catastrophe losses crossed a line that made them uninsurable to insurance companies, and there was a definite shortage on the supply side of the insurance market after the big catastrophes of the 1990s. Jaffee and Russell [1997_b] note that, in California, insurance

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[19] Shiller [1993] studies a similar problem with respect to the individual real estate market and proposes the creation of a futures market for real estate that would enable homeowners to hedge against real estate price meltdowns.
[20] NBER Working Paper # 7287.
[21] Johnsson [1998].
[22] Bantwal and Kunreuther [1989].

companies which provide homeowner coverage are obliged to offer earthquake protection. After the 1994 quake, 93% (in terms of market shares) either stopped offering home coverage altogether or imposed strict limits on the policies. In Florida, where there is a legal impediment to exit, between 1992 and 1995, average insurance rates in and around Miami increased 65%. This leads them to say that "in many states public officials now take it for granted that if catastrophe insurance is to be available at all it must be provided by a public agency."

Given those premises, insurers' response to catastrophes can be twofold: they can either use traditional methods or they can turn to capital market solutions. For those wanting to use traditional methods, Croson and Kunreuther [1999] set forth two choices:

1. To raise premium to rule out insolvency even under the worst case scenario;
2. To accumulate surplus capital to pay for the losses.

Croson and Kunreuther [1999] describe the problem with the first option as follows: "If a catastrophe will create insurer insolvency, and policyholders will not be fully paid, the expected value of the insurance policy decreases and hence the policyholders' willingness to pay for coverage. If the insurer charges lower premium to generate demand, then its chance of insolvency increases even further, thus reducing insurance demand even further. This downward spiralling of premiums and upward spiralling of insolvency risk may eventually produce a situation where the insurer would prefer not to offer this type of coverage at all because it cannot cover its marketing and administrative costs. The

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[23] Insurance Services Office [1999].

market will thus fail to clear, as an indirect consequence of the insolvency risk, leaving consumers uninsured against moderate-level risks as well as catastrophes." This reasoning holds equally true for the demand for reinsurance.

Jaffee and Russell [1997a] address the problems with the second option when they remark that the difficulties with catastrophe insurance are peculiar and they are distinct from the traditional adverse selection and moral hazard problems. The bigger issue is the "mismatch between the size of the actuarially fair premium that can be collected in a given year and the size of a mega-loss that might occur in any year." The issue of being able to accumulate cash is a major problem in catastrophe insurance. Jaffee and Russell [1997_b] argue that "to be viable a private insurance market must solve an inter-temporal problem of how to match a smooth flow of annual premium receipts to a highly non-smooth flow of annual loss payments." To that effect, Cummins, Lewis, and Phillips [1998] remark that the insurance industry fails at time diversification, especially with respect to the capital it should have available at any point in time to cover catastrophe losses. Capital is too costly for them to always have enough on hand to guarantee that they will avoid bankruptcy. Jaffee and Russell [1997_b] highlight reasons why insurance companies are limited with respect to the amount of capital they can accumulate to prepare for catastrophes:

- Accounting rules, FASB statement 5A for that matter, prevent insurance companies from setting aside capital surplus to pay for future catastrophe losses.

- Taxation laws warrant that retained earnings be taxed as income in the year in which they are classified as retained earnings and that interest earned on them also be taxed, which discourages the accumulation of capital.
- Take-overs will likely be undertaken due to the agency costs associated with surplus cash or to myopic investor behaviour.

Because traditional risk management methods tend to be impracticable, insurers might want to look at securitisation or other capital market solutions. Doherty [1997] identifies four options available to them for catastrophe risk management:

1. Asset hedge: Owning an asset that protects against the risk of another asset, such as catastrophe options.
2. Liability hedge: Having a liability, such as catastrophe bonds, that provides against the risk of an asset.
3. Post-loss equity recapitalisation: Either issuing new equity following a loss, but the price will be diminished because of the loss, or purchasing a put option on a firm's own stock, such as a CatEPut exercisable when a predefined catastrophe strikes.
4. Leverage management: Reducing the level of leverage when needed to reduce conflicts between creditors and stockholders.

Let us ask what distinguishes between a loss that can be insured and one that cannot. We find some help in a Swiss Re[24] list that identifies basic principles that must be met by a risk for it to be insurable:

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[24] Floods – an insurable risk? [August 1998].

- There must be a large number of people at risk for a risk community to be built;
- The insured victims must experience financial need as a result of the event;
- It must be possible to assess the expected loss;
- There must be randomness at two different levels: the event must occur at a random, unpredictable moment, and the very occurrence of the event must not be influenced by the policyholder;
- With planning, the risk community must set aside sufficient means to cover upcoming losses;
- The threat exposure must be similar for the whole community, so must the financial needs resulting from materialisation of such a threat.

Parallel to that list, Jaffee and Russell [$1997_{a \text{ and } b}$] insist that the reason for the failure of the private catastrophe insurance market will be found outside the traditional insurance adverse selection and moral hazard problems. The failure is rather a consequence of the discrepancy between the size of a catastrophe loss than can occur in any year and the size of the premium pool that can be gathered in a given year. In other words, the insured risk is too large and the probability of loss is not susceptible to precise actuarial calculation. Those factors demonstrate directly how catastrophes challenge the conditions listed by Swiss Re.

In Canada, Guy Carpenter [1999] highlights the peculiarity that 90% of the population lives within 100 miles of the US border. This makes a very wide country where relatively few losses from catastrophes are reported, because there are more chances of catastrophes striking uninhabited regions. Hail and floods are the most frequent catastrophes striking the country, and private insurance companies generally only cover flood losses to commercial properties, not residential. Table 5 reports on the three largest catastrophes in Canada, all of them having occurred in the last decade.

TABLE 5. THE THREE LARGEST CATASTROPHES RECORDED IN CANADA

Date	Type	Location	Economic Damage	Insured Loss
January 1998	Ice Storm	Quebec, Atlantic	C$1.5 billion	C$1.4 billion
July 1996	Flood	Saguenay	C$1.0 billion	C$0.2 billion
September 1991	Hail	Alberta	C$0.3 billion	C$0.3 billion

The 1998 ice storm is still fresh in our memory. It is believed to have developed as a result of El Niño. Swiss Re Canada[25] draws an insightful picture of the ice storm in an insurance context. The facts are that the ice storm in Canada and the USA lasted from January 4 to 12, 1998 over eastern Ontario, south-eastern Quebec, and north-eastern USA. The degree of severity of an ice storm is dependent on 1) how much ice accumulates, 2) where and how big the affected area is, and 3) how long the storm lasts. Montreal received 100 millimetres of freezing rain. Swiss Re estimates that the damages from the storm ranged up to US$2 billion, from which US$1.2 billion was insured. The storm was the third most costly world insurance loss in 1998, after hurricane George, which cost US$3.5 billion, and storms and hail in Minnesota and Iowa, which cost US$1.3 billion.

[25] Swiss Re Canada, Le grand verglas de 998.

On any given year, it is impossible to forecast the losses due to extreme catastrophes. Two thirds of the insured damages (about C$1 billion) caused by the ice storm were supported by the reinsurance industry, while insurers' share was one third.[26] To put this amount into perspective, let us compare with the reinsurance premiums received in Canada in 1998, which amounted to C$1.3 billion. The Canadian market on its own would not have been able to pay for all the losses. Due to their international structure, reinsurance companies could gather the necessary funds to indemnify the insurance companies in a timely manner. As a matter of fact, the first reinsurance payment was made in March 1998, and each week claims were paid as they came in. A gap of about fifteen to thirty days, sometimes less, occurred between the moment the insurers paid their clients and the time the reinsurers paid the insurers. This timeliness was important because it granted insurers the necessary liquid funds to indemnify their policyholders quickly – a necessity during such a crisis.

Although individual claims from the Ice Storm were small in size, there were over 840,000[27] of them, which compares to the number of claims related to hurricane Andrew. At the time of settling the claims related to the ice storm, it was found that some policies were not very clear on what was to be indemnified and what was not.[28] Furthermore, social and political pressure on insurance companies was intense. For instance, in many cases homes were not damaged by the storm but, as a result of the storm, the owners incurred additional expenses because they could not use their homes to pursue basic

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[26] This paragraph is inspired by a conversation held in November 2000 with Mr. Pierre Martel, Vice President of Swiss Re Canada.
[27] Conseil d'assurances du Canada [1998], p. 15.
[28] Swiss Re Canada, Le grand verglas de 98.

activities such as sleeping or eating. It was indeed dangerous to stay in a cold powerless house after the storm. Was that to be covered by insurance? On January 13, 1998, the Quebèc Prime Minister publicly strongly recommended that people living in non-heated homes leave them and seek refuge with friends or relatives, or in community camps organised in the affected cities. This was considered by the insurance industry as an evacuation order, and was necessary for recognition of the fees incurred by people whose property was not damaged.

Reinsurers are the third party at stake in catastrophe situations. They are better equipped than insurers to deal with catastrophe losses because their portfolio is international, thus more balanced. A Swiss Re study[29] estimates that, in 1997, total purchases of catastrophe excess of loss reinsurance amounted to US$52.9 billion[30], a 31% increase from 1994. From all the covers purchased, 35% were attributed to the USA. However, catastrophes also present a major threat to reinsurers. At the beginning of the 1990s, when the insurance industry experienced a shortage, there was also a perceived shortage of reinsurance supply, which could in turn have induced bankruptcies in the insurance market. Cummins, Lewis, and Phillips [1998] state that "The unavailability of capacity for large catastrophes has a number of serious effects on the viability of insurance markets and the ability of society to respond to a major disaster."

[29] Sigma No.7/1997.

[30] The countries included in this study were Australia, Japan, Belgium, Germany, France, the UK, Italy, the Netherlands, Israel, South Africa, Canada, the USA, and Mexico.

According to Pierre Martel, Vice President of Swiss Re Canada[31], the occurrence of a catastrophe provides reinsurers with increased information that they incorporate in their pricing models. Therefore, the very occurrence of a catastrophe influences reinsurance prices from that moment on, and the shift towards higher levels is permanent. However, demand is not affected to the same extent, since the public reacts immediately after a catastrophe by demanding more insurance, but reverts to its pre-catastrophe behaviour after a few months. To that effect, Froot, and O'Connell [1997] find that catastrophe reinsurance prices increase considerably following a catastrophe: supply decreases and demand increases. They estimate elasticity of demand to be between –0.2 and –0.3, while elasticity of supply is more in the order of 7. They find evidence that supply is highly sensitive to reinsurers' cost of capital. For a given contract, supply is reduced when the "variance of losses under the contract is greater" and when "the covariance of losses under the contract with the loss distribution of the reinsurer's portfolio is greater", i.e. the contract's contribution to total losses increases.

Reinsurance is not a new business. To put it in historical perspective, it existed as far back as 1370, when the oldest contract known to feature reinsurance characteristics was signed in Genoa, Italy[32]. The first reinsurance companies were subsidiaries of insurance companies whose business they were designed to protect. Cologne Re, founded in 1852 in Cologne, Germany, is known to be the first independent reinsurance company[33].

[31] This statement is inspired by a conversation held in November 2000 with Mr. Pierre Martel.
[32] Swiss Re, An Introduction to Reinsurance [1996].
[33] Weeks [1989].

Today, reinsurance is written either by direct writers, through reinsurance brokers or by in-house reinsurance departments of insurers[34].

The reinsurance industry has radically changed over the past decade[35]. In the mid 1980s, the US was the theatre of the insurance and reinsurance casualty crisis. The courts recognised long-tailed losses for asbestos and environmental issues, implying that insurance companies had to honour old policies for which they had not set aside reserves. In other words, this retroactivity was not foreseen when the original pricing of the risks was effected. The natural catastrophes of hurricane Andrew in 1992 and the Northridge earthquake in 1994 are the two main initiators of the reinsurance industry's structural change towards consolidation through mergers and acquisitions in the 1990s.

Here we must open a parenthesis to present Lloyd's of London, which was affected by the same crisis as the other reinsurers[36]. Part of the fundamental insurance vocabulary is attributed to the beginnings of Lloyd's. In the seventeenth century, Edward Lloyd's coffee shop served as an encounter point for wealthy merchants who shared the risk of loss of ships. To do so, they would write down how much risk they wanted to accept on a line, and write their names below. This is how the insurance industry started underwriting lines. However, Lloyd's is not a pure insurer nor a reinsurer, but rather a market through which reinsurance and insurance contracts are concluded. Lloyd's was particularly hit by the property/casualty crisis and had to undergo a thorough

[34] American Re [1998].
[35] Sigma No.9/1998.
[36] Sigma No.9/1998.

restructuring in order to survive. Upon restructuring, Lloyd's real capacity was only two thirds of what it used to be. Its share of world reinsurance was down to a mere 3% in 1996, from 6% in 1992.

Lloyd's was organised as an exchange in 1688[37], and as such it is an organisation that provides underwriting syndicates a location to gather and market their policies. Lloyd's Act 1871 is an Act of the Parliament that regulates the entity. It was last modified in 1982 when it granted Lloyd's self regulation right. It gives the Council of Lloyd's governance power of Lloyd's.

In 1998 the American National Association of Insurance Commissioners (NAIC) audited Lloyd's and their report sheds some light on the structure of the Lloyd's market. Participants to Lloyd's are as follows (figures as of January 1998):

- Members: 7,260 individuals and corporations bringing underwriting capital to the market.
- Member agents: 19 members guiding other members in the selection of syndicates.
- Managing agents: 66 agents hiring the underwriters and overseeing the syndicate operations.
- Main syndicates: 155 syndicates comprising different members.
- Registered brokers: 187 brokers grouped in 120 combinations bringing the business to the market. Business can only be brought to Lloyd's through its brokers.

[37] Weeks [1989].

- The Corporation of Lloyd's: providing the syndicates with facilities, authorization, administrative infrastructure and accounting rules.
- The Council of Lloyd's: providing the regulatory structure and the market operating rules.

Being a member of Lloyd's has always been a prestigious status reserved to British men. In the late 1960s, women and foreigners were allowed to become members due to an increased need for capital. Individual members have unlimited liability, and corporate members' liability is limited by their net worth. Corporate members were only admitted in 1994. All members must deposit assets in a trust. Many, not one, syndicates underwrite most of insurance and reinsurance policies. Non-Lloyd's insurers, called the company market, jointly underwrite many policies.

From 1988 to 1992 Lloyd's lost US$12.9 billion, or US$461,000 per member. Four major problems were identified:

1. London market excess of loss spiral: Inadequate internal control led to a concentration of high levels of risk. Layers were underwritten, reinsured and retroceded within very few syndicates, and as claims arose, they hurt each other in a domino effect. Reserves were too low.
2. Catastrophes: From 1988 to 1992, Exxon Valdez, Piper Alpha and hurricane Hugo affected Lloyd's all at once.
3. Environment: Long-tailed liability claims in the US were made for asbestos, pollution, and health exposure on contracts dating back decades.

4. Inappropriate capital requirements: Some members did not have sufficient capital to underwrite the risks they did.

In 1995 the Council of Lloyd's set forth its reconstruction and renewal program, whereby all non-life liabilities incurred prior to 1992 were reinsured under a single contract with new Equitas Reinsurance Limited for a premium of US$21 billion. Equitas Reinsurance Limited retroceded all its liabilities to its subsidiary Equitas Limited.

End of parenthesis.

The reinsurance industry currently exhibits a highly concentrated structure. In 1997, the four largest professional reinsurers accounted for 30% of world market shares. If we consider the top ten reinsurers, the Bermuda market and Lloyd's, the figure almost reaches 50%[38]. Noonan [June 1999] reports on one example of the concentration trend. In June 1998, Berkshire Hathaway Inc. announced it would acquire General Re for US$22 billion. General Re viewed this move as an opportunity to no longer need to respond to investors' demands in terms of quarterly figures. As the new owner, Berkshire Hathaway understands the business General Re is in, and is expected to let it make appropriate economic decisions with increased flexibility, without regards to short-term effects. A first example of this is that General Re is reducing its use of retrocession to a level it deems appropriate, even though earnings may become more volatile.

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[38] Swiss Re, La réassurance mondiale connaît une vague de concentrations, Sigma No.9/1998.

Standard & Poor's list of the leading providers of non-life reinsurance in the US for 1997 also provides information regarding the credit ratings of reinsurers, which we reproduce in Table 6. We observe that the pattern in the USA is similar to that of the rest of the world, in that over half of the reinsurers are rated A or above.

TABLE 6. REINSURERS' CREDIT RATINGS

Rating Category	200 Largest Non-Life Reinsurers (U.S.)	All Reinsurers (Worldwide)
AAA	11%	8%
AA	24%	25%
A	42%	31%
BBB	17%	23%
BB	5%	10%
B	1%	3%
CCC	0%	1%
Total Rated	**100%**	**100%**

This overview of the reinsurance industry established that there are a few, but important, reinsurers in the world. Most of these companies are high quality from a credit standpoint, and they provide a high value-added product. The first effect of the large catastrophes on reinsurers has been to shake up the industry. Then, reinsurers developed the alternative risk transfer market and took active part in the CAT bond market, both of which will be discussed later in this paper.

Investors are the fourth category of stakeholders at risk from catastrophes. They are concerned with the risk/return relationship of their investments. Not much is said about them in the literature. Catastrophes could present an opportunity for them. The peculiarity of catastrophe risk is that it does not appear to be historically correlated with market risks, such as interest rates, commodity prices, or foreign exchange rates. Introducing a catastrophe component into a portfolio could diversify it, so long as the instrument used to transfer the catastrophe risk does not, by design, introduce correlation. To date, few investors have capitalized on the opportunity presented by catastrophe risk. This can be seen in the illiquidity in the catastrophe options market, and in the secondary market for catastrophe bonds. One reason for that, regarding the options, is that an investor who is not an insurer or a reinsurer could only take speculative positions in the options, and this might mean taking on a very large risk. In the case of catastrophe bonds, they are issued as restricted securities only available to a selected few qualified institutional buyers. Furthermore, and this applies to both the bonds and the options, the absence of rigorous pricing models makes the risk of the securities difficult to gauge. Since most institutional investors must respond to internal risk management criteria, they cannot always freely buy such securities. In the future, as catastrophe-linked securities pricing models are developed and empirically tested, they will become available to all investors, and liquid markets are likely to develop.

The government is the last party affected by catastrophes. In cases where catastrophe risk is deemed too large to be insured, state intervention might be the only solution. Cummins, Lewis, and Phillips [1998] remark that the Federal government is able to diversify risk across time because of its superior borrowing power. Its cost of capital following a catastrophe would comparatively increase much less than would the cost for an insurance company facing bankruptcy. An example of such action is the Clinton government proposed Federal excess-of-loss catastrophe reinsurance contracts, which would be offered to private insurers and reinsurers. They would be structured according to an index of insurance industry losses and available in the US$25-50 billion layers, which is above those of the current private market. There would be annual auctions of the contracts. A minimum price would be set to ensure that the programme is self-supporting in terms of expected values. The contracts would be the equivalent of a long call that pays off when losses exceed US$25 billion and a short call that pays off when they exceed US$50 billion. The insurers would receive compensation in the US$25-US$50 billion layer, but would retain losses above US$50 billion. At the end of 1999, this program was still being developed, and had not gained unanimous acceptance. State intervention in private sector matters is often controversial. Brostoff [1999] reports the words of Scott E. Harrington, a professor at the University of South Carolina and a member of the Shadow Insurance Regulatory Committee: "There is no need for a federal reinsurance program at this time, let alone one that would substantially displace private sector coverage".

Up to this point, we have explored the motives for risk management set forth by academia, we have examined the legislative framework within which risk management evolves, and we have gone through an overview of what catastrophes are and how they play a role in the insurance-reinsurance universe, affecting homeowners, investors, and governments. We have set the bases of the transfer of catastrophe risk. In the coming section, we investigate the peculiarities of catastrophe risk as opposed to financial market risks.

PECULIARITIES OF CATASTROPHE RISK

EMERGENCE OF EVENT RISK

"The actuarially-fair premium for a 100-year disaster is meaningless if the 100-year disaster occurs in year 2 and bankrupts the reinsurer. Thus, even if a differential exists between the reinsurer's targeted economic return and the ceding insurer's required return, the risk premium required by the reinsurer for high risk lines may make reinsurance unaffordable for the primary insurer."

-J. David Cummins, Christopher M. Lewis, and Richard D. Phillips

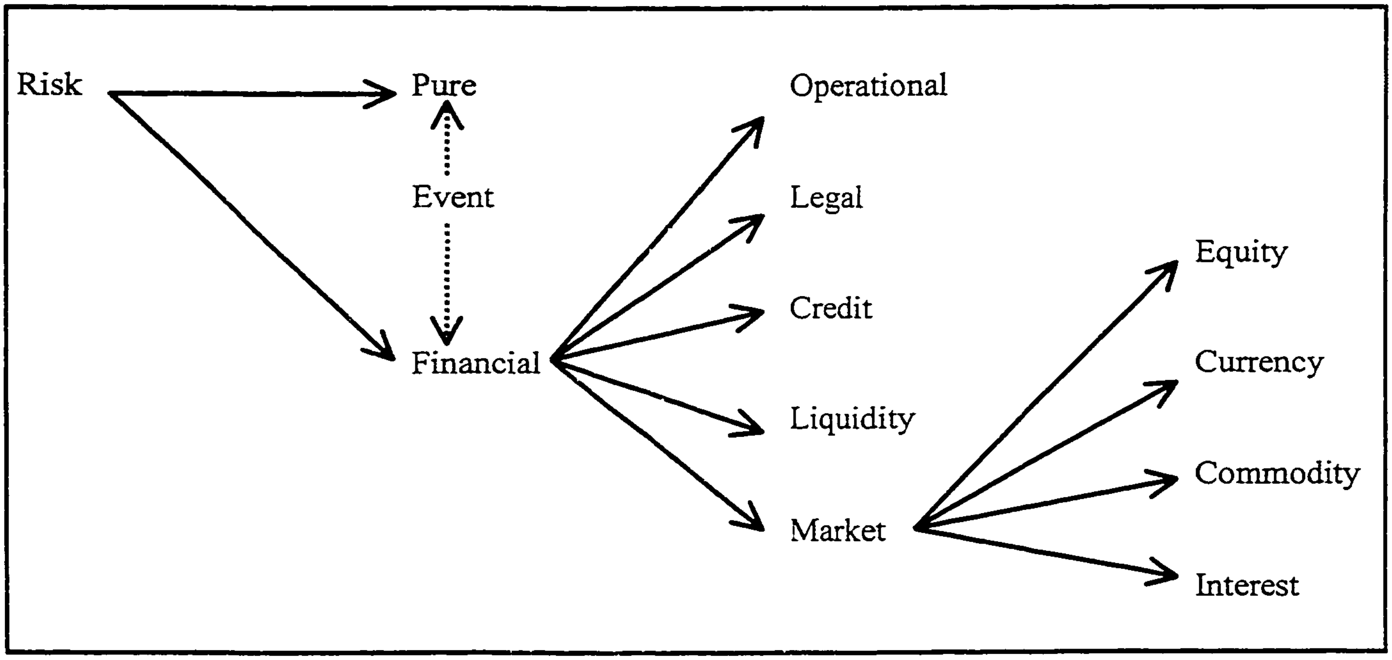
Catastrophe risk is different from all other types of risks. Catastrophe risk does not exhibit the same behaviour as stock prices or interest rates. The very nature of catastrophes renders the creation of financial derivatives on catastrophes peculiar. This sections classifies the types of risks and explains where catastrophe risk fits in.

We propose a classification of risks in Figure 1[39]. A first distinction is made between pure (insurance) risks and financial risks. Financial risks include operational risk, which is the risk corporations face from their internal organisation. Lack of control would fit into this category, and an illustrative example of the materialisation of unmanaged operational risk would be Barings' bankruptcy. Legal risk is also a financial risk and is defined as the possibility that a contract signed by a company might be found illegal. If insurance companies had securitised their policies directly, under current legislation the

[39] Adapted from Simons [1996].

contracts would have been deemed illegal. Credit risk is counter party risk. This is most often associated with swaps. In the event of default on a swap, one party is owed money and the other party is unable to honour its due. Liquidity risk originates from illiquid markets. For example, an investor owning 40% of the stock of a small cap company will have trouble selling all his shares on the open market at one precise moment. The last category of financial risks are market risks. Market risks refer to the fluctuations in the value of assets due to equity prices changes, interest rates movements, foreign exchange fluctuations, and commodity price variations. Market risks are mostly managed using value-at-risk models and stress testing scenarios.

FIGURE 1. A CLASSIFICATION OF RISKS



The main contrast between market risk and pure risk is that market risk is symmetric while pure risk is asymmetric. For each fluctuation in the value of an asset due to market risk, an investor being long will experience the opposite profit or loss as an investor being short. Furthermore, even considering only the investor who owns the asset, market risks will translate in gains on some days and in losses on other days. On the other hand, pure risk, which is typically insurable, only has a downside. Catastrophe risk falls into this category. When a hurricane wipes out a house, no one benefits. When a hurricane does not destroy a house, no one benefits either. In other words, when hurricanes cause destruction, the net effect to society is a loss.

Event risk affects both financial and pure risks. Event risk causes discrete disruption in continuous processes. For options pricing, Merton [1976] dealt with event risk by introducing the possibility for discontinuous stock returns in the Black and Scholes [1973] differential equation, in a process called jump diffusion. Henderson [1999] builds on Merton [1976]. In a study of sudden currency devaluation, Henderson [1999] explains that, in cases where event risk is important, asset returns do not follow a lognormal random walk. Instead of approaching event risk with arbitrage or CAPM arguments like Merton [1976], Henderson [1999] argues that the holders of assets that are likely to exhibit sudden and drastic drops in value are likely to care about more than only the expected returns due to the jumps and are expected to demand a jump risk premium, which is embedded in an implied jump probability, since they can hardly diversify event risk. The application of that argument to CAT bond pricing might explain why they typically trade at a premium.

To illustrate the manifestation of event risk on the stock market, let us consider the daily fluctuations in the price of one stock. The price will react to news. Each quarter earnings announcements are likely to cause changes in the price. However, a totally unexpected announcement, such as a take-over, can cause a large jump and disrupt the path of the stock price. From that point on, the price is not only influenced by regular factors, but also by the market's perceptions regarding the likelihood of the acquisition. Similarly, catastrophes occur almost at random and very scarcely, but their magnitude is so great that they change the existing dynamics in the insurance risk portfolios.

In one way, because catastrophes are event risks, they are difficult to manage. Their high-risk low-frequency distributions stem from the unknown. This is one reason why the securitisation of catastrophe risk is so peculiar. In addition, securitisation usually involves traded assets, but catastrophes are not traded assets. There is no market price for catastrophes until the moment they materialise. These considerations open the way to the next section, which focuses on the availability of data regarding catastrophes and models to price them.

DATA AVAILABILITY AND PRICING MODELS

> *"The ability to assess extreme quantiles and probabilities accurately translates into ability to manage extreme financial risks effectively... The problem ...[in] the present context is that for estimating objects such as a "once every hundred years" quantile, the relevant measure of sample size is likely much better approximated by the number of non-overlapping hundred-year intervals than by the number of data points. From that perspective, our data samples are terribly small relative to the demands we place on them."*
>
> *-Francis X. Diebold, Til Schuermann, and John D. Stroughair*

To price a stock option, we need information regarding the underlying stock price distribution. Similarly, to price catastrophe insurance derivatives, we need to know how the underlying catastrophe behaves. Then we can infer the prices of derivatives, regardless of the type of derivatives. It does not matter whether we are trying to price a bond, an option, or a futures. The real difficulty is defining the catastrophe occurrence, or the losses it produces upon occurrence, depending of the type of trigger used in the derivatives[40]. This section discusses historical and forward-looking simulation approaches to catastrophe distribution quantification.

Diebold, Schuermann, and Stroughair [1998] investigate the possibility of using extreme value theory (EVT) to fit the distribution of past catastrophe data. With EVT, instead of using all the data comprising a distribution, a model is fitted to the survival function, that

[40] Shiller [1993] discusses the issues related to building an index to reflect the value of non-traded assets, in the context of real estate property. A parallel can be made with indices on insured losses from catastrophes.

is, the tail, using only extreme event data. Applying EVT has the conceptual advantage that the estimation method focuses on the tail, which is the object of interest, instead of focusing on the center of the distribution. However, the EVT literature assumes that data are independent and identically distributed, which might not apply to catastrophe distributions. Diebold, Schuermann, and Stroughair [1998] warn of the difficulty of estimating very low-frequency events when we only possess short time samples. Although EVT alone might not be sufficient, it remains driven by powerful theory and might be used in conjunction with graphical analysis of empirical survival functions.

Moore [1999] studies the problem of small sample size for catastrophe distribution estimation. He suggests that difficulties in estimation arise from the small size of the population of catastrophes itself, and that the jackknife and the bootstrap techniques could help solve the problem. The jackknife technique consists of reestimating the distribution parameters successively, each time leaving one observation out. This will create several samples of the same size, and each observation will be excluded only once. Alternatively, the bootstrap technique draws one observation out with replacement. The samples estimated are the same size, but the observation that is left out is chosen at random. Moore [1999] applies this methodology to two data sets. First, he uses adjusted historic loss ratios based on Property Claims Service estimated losses from 1956 to 1994. Second, he examines insured damages from hurricanes from 1949 to 1993[41].

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[41] The steps used by Moore [1999] in applying the bootstrap and jackknife techniques are as follows:

1. Using maximum likelihood, fitting a distribution to catastrophe data and determining a vector of distribution parameters.
2. Perturbing the estimates of the parameters using the jackknife and bootstrap techniques.
3. Using estimated distributions to simulate the payoffs of the derivatives.

Moore [1999] finds that parametric fits to sample data for tail estimation using the jackknife or bootstrap techniques to perturb the data leads to wide variation in the estimations. There can therefore only be little confidence in the statistical accuracy of resulting prices or loss estimates. The bootstrap technique leads to better error estimates than the jackknife does, but its implementation is more costly. The fact that the standard errors of derivatives prices are large and that there is a lack of unequivocal tests to differentiate among pricing estimates directly affects the premium on reinsurance contracts or catastrophe options with strike prices deep in the tails.

Moore [1999] discusses the impact of his findings on catastrophe insurance derivatives. His words are: "for comparing the spreads commanded for hurricane bonds to actuarially-fair spreads under a lognormal assumption, the capital market demands a spread of 7-8 times the maximum likelihood estimate of fair value, or one in excess of 2.5 times the 99th percentile of the fair value spread." Although his estimates are wide, Moore [1999] does not believe that they can explain such spreads. Given that, even when market spreads are compared with the 95th or 99th percentile of actuarially-fair loss estimates, there is still additional charge paid for the transfer of risk, Moore [1999] expresses the possibility that the very design of the securities be flawed. One example of a flaw applies to catastrophe insurance index-based derivatives. In fact, the price of the

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4. Calculating the expected value and standard deviations of the derivatives prices using the jackknife and bootstrap techniques.
5. Repeating the previous steps for other securities and other distributions.
6. Computing t-stats using estimates of expected values obtained by simulation and jackknife standard errors to compare alternative distribution assumptions.
7. Using bootstrap estimates to characterize the empirical distribution of security price estimates.

underlying index is often not known at maturity, but only after maturity. Schön, Bochocchio, and Wolfram [1998] question whether prices are set realistically and whether catastrophe derivatives are truly cheaper than reinsurance.

Another reason for the high premiums might be that investors and issuers are not risk neutral. This is brought up by Froot and O'Connell [1997] and can be derived from our theoretical section on the reasons for risk management, especially in the theories on the costs of bankruptcy and reorganization, the cost of internal versus external funds, and the convexity of the tax schedule. Those are enough to allow us to infer that reinsurers are risk averse, and insurers alike. Therefore they are willing to pay more than risk neutrality would suggest to avoid certain risks.

On the other hand, Bantwal and Kunreuther [1999] believe that spreads in the CAT bond market are too high to be explained by standard financial theory or risk aversion. Important factors are ambiguity aversion, myopic loss aversion and fixed costs of education. There would also need to be a major catastrophe occurring so people would see how outstanding CAT bond issues react, and then they would be less reluctant to buy them.

Still on the topic of design, there is a major obstacle common to all catastrophe risk transfer products, and perhaps more obvious in the case of options. Cummins, Lewis, and Phillips [1998] put it this way: The arbitrage arguments underlying option-pricing models do not apply to the jump processes that characterize catastrophe losses. When asset prices can jump, markets are incomplete and jump risk cannot be hedged. Cummins, Lewis, and Phillips [1998] argue that the risk of loss from catastrophes is probably unsystematic. This is precisely what Henderson [1999] referred to when he ascertained that it would be expected for securities affected by event risk to trade at a jump risk premium. Therefore, to price the contracts, we need to estimate the loss distribution and its expected mean and to add a risk premium and an expense loading. Although there is historical data available on catastrophe losses, it must be used with caution, since systemic changes occur through time, since loss frequency and magnitude can be altered, and since past losses might not be appropriate for forecasting future losses. The main factors that we must adjust for when using historical data are the price levels in the economy and the amount of property at risk.

Computer simulations are an alternative to fitting a distribution to historical observations. Standard and Poor's[42] has reviewed the models of three companies specialized in meteorological and geophysical modeling: Applied Insurance Research, EQECAT, and Risk Management Solutions. These companies simulate the effects of earthquakes and hurricanes using proprietary data. Little information is publicly known about their models, except that they are recognized by Standard and Poor's. Emphasizing the difference between different perils, Levin, McWeeney, and Gugliada [1999] consider that it is best to be more conservative when rating earthquake securitisations than windstorm securitisations, because science is more developed to quantify windstorm than earthquake

[42] Standard and Poor's [2000]

risk. Their belief is that a 1-in-250 year earthquake event is consistent with a 1-in-100 year windstorm.

Swiss Re[43] emphasises the importance of determining the maximum possible loss that can result from a single event, and the difficulty of doing so for earthquakes, storms, and floods. For example, while "normal" risks such as a fire can affect one or a few buildings, a hurricane can destroy entire cities. Furthermore, the frequency of fires in a portfolio of buildings is relatively high and balanced, but the frequency of hurricanes or other natural catastrophes is low even for a diversified portfolio. This implies that the law of large numbers does not apply to natural catastrophes and that premium calculations for such rare events tend to underestimate the magnitude of those events when they do occur.

Ermoliev, Ermolieva, MacDonald, and Norkin [1998] explain that catastrophes are rare events that produce highly correlated insurance claims that are dependent on the exact location of the catastrophe. Therefore, catastrophe simulation needs to factor in the amount of coverage at a precise geographical location. This is exactly one of the main difficulties with the available data: although there might be information on catastrophes for a given region, the information is not often available for a given neighbourhood. To achieve catastrophe modelling, Ermoliev, Ermolieva, MacDonald, and Norkin [1998] suggest the use of adaptive Monte Carlo simulations. This would allow the development

[43] Périls de la nature et sinistres catastrophiques [1989].

of non-smooth stochastic techniques that could incorporate the spatial and temporal dependences of the losses.

In addition to the exact location of a catastrophe, climatic changes might be difficult to incorporate in models. Swiss Re[44] points out that climatic anomalies resulting from El Niño modify the probability distribution of natural catastrophes. These anomalies remain one of the many factors that affect the size of related losses, due to the fact that local weather during an extreme event, which greatly influences the losses, is not dependent on El Niño. A succinct but relevant discussion about El Niño is found in Sigma No.3/1998. Firstly, we learn that this phenomenon causes a transfer of warm water from the Indonesia/New Guinea to the Latin America area of the Pacific Ocean. As a result, the sea surface temperature around Latin America rises by 5°C to 6°C. From this transfer of water currents result intensive tropical precipitation and wind changes. El Niño occurs every three to six years in varying degrees of intensity and lasts one or two years, before being reversed by La Niña. Swiss Re warns that current knowledge does not enable us to attribute major past losses to El Niño, nor to produce reliable future El Niño loss scenarios. Nevertheless, we need to remain aware of El Niño.

This section showed that data on catastrophes and catastrophe losses is not widely available. The length of the historical series is often not long enough for modelling purposes and the geographical precision is unsatisfactory. Pricing methods based on historical data need to adjust for these data difficulties using resampling techniques. The

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[44] Sigma No.3/1998.

stationarity of data is also an issue for computer simulations. Weather is seasonal, it might have long-term trends, and insurance portfolio composition is affected by different population growth rates in different locations. Data and pricing issues are still very important fields of research, and improvements are necessary to the evolution of catastrophe derivatives. The next section discusses a second factor that must change for the market for catastrophe derivatives to mature: security trading and holding constraints.

TRADING AND HOLDING CONSTRAINTS

> *"The SEC adopted Rule 144A, which establishes new rules covering the buying and reselling of restricted securities. Restricted securities are exempt from SEC registration requirements and cannot be traded on the public markets. Rule 144A was issued in order to improve the liquidity and efficiency of the private placement market by giving more freedom to institutional investors to trade securities. ... For firms registered with the SEC or a foreign company providing information to the SEC, financial statements need not be provided to buyers."*
>
> *- William J. Lucchesi, The CPA Journal Online*

At present, the market for catastrophe insurance derivatives is still at a developmental stage. This section discusses the current hurdles to the development of this market. They include the costly process for issuing catastrophe bonds, the restricted status of the securities, which impedes their trading, and institutional constraints to holding such securities. Furthermore, the lack of empirical evidence on the behaviour of catastrophe risk securities implies that the potential results of portfolio strategies might be difficult to assess beforehand.

Issuing CAT bonds has been costly up to now partly because US legislation did not allow insurers to securitise their policies directly. With the adoption of the Protected Cell Company Model Law, the National Association of Insurance Commissioners is favouring on-shore insurance securitisation deals. However, before the year 2000, for regulatory and taxation motives, structured catastrophe risk transactions were all done through offshore special purpose vehicles (SPV). The concept behind a SPV is similar to the concept underlying captives. A captive is "an insurance or reinsurance vehicle that belongs to a company or group that is not active in the insurance industry itself, and it mainly insures the risks of the parent company[45]." A list of captives can be found on www.captive.com. Examples of single-parent captives are as diverse as AT&T's American Ridge Corporation, Caterpillar's Caterpillar Insurance Co, Hallmark Cards' H.C. Insurance Company, Pfizer's Kodiak Company Limited, and McDonald's McDonald's Quality & Safety.

The number of captives in the world is estimated to be 4,000, of which 3,000 belong to a single parent[46]. The remainder are group captives, rent-a-captives and protected-cell captives. Group captives belong to several companies who pool their resources. Rent-a-captives were created by reinsurers. They set up an account and charge administration fees, in return for which the company can use the account to clear premiums, claims and investment proceeds. By renting, the company does not need to put down its own capital. SPVs, also called protected cells, are used to transfer insurance risk to the capital markets. Rent-a-captives are the fastest growing segment of the captive market[47]. At the end of 1997 there were estimated to be over 40 rent-a-captives. Premium paid to captives and rent-a-captives are tax-deductible. In the offshore countries where captives are incorporated, underwriting reserves benefit from favourable tax treatments. Finite-risk

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[45] Sigma No.2/1999.
[46] Bowers [February 1999] and Sigma No.2/1999.
[47] Bowers [February 1999].

products or multi-line/multi-year solutions offer many of the same advantages as captives.

Swiss Re New Markets[48] describes the role of SPVs in CAT bond issues. SPVs are structured as a trust licensed as a reinsurer, usually in Bermuda or the Cayman Islands. They issue bonds to investors and simultaneously provide reinsurance to the insurance company. The SPV is only created to handle that single issue. Levin, McWeeney, and Gugliada [1999] reiterate that SPVs are centrepiece to the majority of structured insurance transactions. They believe that, although SPVs to date have been tailor-made for single transactions, it is not impossible to think that they might become multi-transactional in the future. Currently, SPVs accept the excess risk from an insurer. The potential reinsurance that is recoverable from the SPV becomes an asset for the insurer. That asset can be sold or securitised. It is the SPV that raises the funds in the capital markets, just as with standard structured finance. The raised funds are used, in all or in part, to secure the reinsurance contract between the SPV and the insurer. The capital market investors in catastrophe bonds receive a coupon that originates from the premium paid by the insurer to the SPV for its reinsurance coverage. In the case where a trigger event materialises, coupon payments and principal repayment might be stopped. The bonds sometimes are issued in more than one tranche. The senior part of the issue is not at risk, and part of the proceeds from the issue are invested in treasury securities, usually ten-year zero coupons. If the trigger is exceeded, on the protected part of the issue,

[48] Insurance-Linked Securities [1999].

investors are usually fully repaid but the maturity of the bond is extended. In the case of the tranche that involves full risk transfer, investors stand to lose it all.

In the summer of 1998, a new type of company appeared in Bermuda: the transformers. Booth [1999] mentions that Goldman Sachs has its own transformer, Arrow Re, and Lehman Brothers has created Lehman Re. Transformers act as intermediaries between insurance companies, investors and reinsurers. Banham [2000] describes the transformers' goal as to be a conduit on such a broad scale that a liquid market for large investors will develop. So far, transformers have securitised political risk, property/casualty exposure, foreign exchange exposure, and life insurance. They contribute to a streamlined process; they act as universal SPVs; and they are licensed to underwrite both insurance and reinsurance. Furthermore, transformers decrease the difficulties associated with legal, accounting and regulatory issues.

Setting up SPVs and getting a rating for CAT bonds has proven to be costly. McDonald [1999] estimates the fees of the first CAT bond issues at up to 75 basis points in investment bankers' fees and US$1 million in legal expenses. Now they range around 25 basis points and US$100,000. On the issue of rating, Levin, McWeeney, and Gugliada [1999] say that in some cases, Standard and Poor's rating for a catastrophe bond considers only the principal payment, in which case the rating is followed by the letter r, for restricted. Issuing CAT bonds will be less and less costly as a learning curve effect takes place. The fact that home-grown deals are encouraged is also likely to diminish the costs of setting them up. However, so long as they are restricted securities, the secondary market will not develop.

As a matter of fact, the first CAT bond buyers have been rather sophisticated[49]: life insurers, money managers, mutual funds, hedge funds and some property/casualty insurers. This does not imply that ordinary investors are not interested in those securities, but, as Moore [1999] explains, most of these securities, to date, have been Section 144a offerings, i.e. restricted to qualified institutional buyers that "acting for their own account or the accounts of other qualified institutional buyers, that in the aggregate own and invest on a discretionary basis at least US$100 million in securities of issuers that are not affiliated with the entity" or "any dealer registered pursuant to section 15 of the Exchange Act, acting for its own account or the accounts of other qualified institutional buyers, that in the aggregate owns and invests on a discretionary basis at least US$10 million in securities of issuers that are not affiliated with the dealer, provided that securities constituting the whole or a part of an unsold allotment to or subscription by a dealer as a participant in a public offering shall not be deemed to be owned by such dealer". CAT bonds are therefore still limited to institutional traders.

Even qualified buyers might run into internal hurdles regarding CAT bond trading and holding. Some classes of institutional portfolio managers, like pension funds, are typically very limited regarding the asset classes they can invest in. Since CAT bonds are more likely be associated with junk bonds than blue chips, internal rules based on credit

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[49] McDonald [1999].

ratings might reject them from portfolio inclusion. Even if credit rating is not an issue, institutional buyers might not be allowed to hold an asset that they cannot price or mark-to-market on a daily basis. This is a concern given the relatively thin secondary market trading of CAT bonds, and the absence of transparency on market pricing. Furthermore, in the absence of a generally recognised model for CAT bond pricing, the theoretical value cannot easily be calculated.

An example of institutional buyers who may be confronted with hurdles regarding the holding of catastrophe derivatives is banks. In 1975, the Basle Committee on Banking Supervision was formed with the purpose of ensuring "the international convergence of supervisory regulations governing the capital adequacy of international banks"[50]. In 1988, the Basle Committee issued the Capital Accord, which provided the member countries with guidelines in measuring the regulatory capital of banks mainly based on credit risk. In 1996, the Basle Committee amended the Capital Accord to include market risks as a determinant of regulatory capital. Market risk signifies the risk of losses in banks' on- and off-balance-sheet positions due to movements in the market prices of equity, interest rates, foreign exchange, and commodities. The objective of that amendment was to provide an explicit capital cushion for the price risks that banks are exposed to as a result of their trading activities. Practically, this implies that international banks must perform daily value-at-risk calculations on their trading portfolios, using a 99th percentile one-tailed confidence interval, applying a minimum price shock of ten

[50] As of January 1996, the Basle Committee comprised representatives of central banks and supervisory authorities of the following countries: Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, The Netherlands, Sweden, Switzerland, United Kingdom, and the United States.

trading days to market prices, and using an observation period of a minimum of one year. The value-at-risk measure computed by banks is the starting point in calculating the capital charge that must be applied to each bank. In order to compute value-at-risk, one essential step is to be able to price each security in a portfolio. In the case where no prices are available, or no pricing model exists, marking-to-market a security will be challenging. For this reason, one can think that banks from the member countries of the Basle Committee might have internal policies restricting the trading of such securities, in the category of which catastrophe derivatives arguably fall. Until a liquid market for catastrophe derivatives develops, until pricing models and data are widely available, we cannot expect banks to widely hold those derivatives.

If catastrophe insurance derivatives are costly to issue, if there are external and internal hurdles to trading them, if their behaviour is not well understood, why are they widely perceived as so promising? The high spreads they offer over other securities and the fact that they respond to a real capacity need are definitely valid reasons. Finally, their ever improving design is without a doubt another key factor. The next section presents the evolution of the catastrophe risk transfer contracts.

CATASTROPHE INSURANCE DERIVATIVES CONTRACT DESIGN

LESSONS FROM MORTGAGE-BACKED SECURITIES

> *"Over the past few years, the financial community has created an entirely new class of security that bridges the gap between the insurance industry and the capital markets. These ... CAT bonds ... have been used mainly by insurers to create a financial hedge against the cost of catastrophe losses. However, the techniques involved can be adapted for other insurance risks, much as the entire class of CAT bonds can be viewed as merely an evolution from asset-backed securities and other asset securitization transactions."*
>
> *-Alan M. Levin, Patricia E. McWeeney, and Richard Gugliada*

Over the past few decades, financial instruments have increased in sophistication. Product instigators have learned from the failures of the past and built on the successes, thus not needing to go through the complete learning process all over again. This is exactly the role played by mortgage-backed securities (MBS) in the introduction of catastrophe insurance derivatives. In this section, we will first review the history and peculiarities of the MBS market, of which Table 7 draws a list of the most important dates. Then, we will see how catastrophe insurance derivatives developed and incorporated features from MBS.

TABLE 7. KEY EVENTS IN THE EVOLUTION OF THE MBS MARKET

Date	Event
1938	Creation of Fannie Mae.
1968	Creation of Ginnie Mae.
1968	Ginnie Mae issues the first MBS.
1970	Creation of Freddie Mac.
1971	Freddie Mac first issues participation certificates.
1978	Wall Street opens its first mortgage security department.
1979	The Federal Reserve Board raises short-term interest rates in October.
1981	Congress attempts to save S&Ls and allows them to sell off their mortgages.
1981	Fannie Mae first issues MBS.
1983	The Securities and Exchange Commission allows private pass-through issuers to register securities backed by "blind pools" if the issuer can commit to obtain a specified rating and provide reasonable information about the future pool underlying the prospectus.
1983	The Federal Reserve Board amends regulation T and allows private pass-through to be used as margin collateral.
1983	The first collateralised mortgage securities (CMOs) are issued.
1984	The Secondary Mortgage Market Enhancement Act improves the marketability of mortgage-related securities rated AA or above, making them legal holdings for thrifts, federally chartered banks, and state-regulated financial institutions.
1986	The Tax Reform Act adds to the types of securities that can be issued. This Act exempts from separate taxation, under certain conditions, the entity distributing the cash flow and it reduces the tax benefit from investing in mortgages and induces S&Ls to sell them.

The Great Depression and the measures that were taken to recover from it gave rise to a secondary market for mortgages[51]. First, the Federal Housing Administration (FHA) was created to provide insurance against default on fixed-rate, level payment, and fully amortised traditional mortgages, addressing credit risk. Second, in 1944, the Veterans Administration (VA) also began insuring mortgages. Next, the Federal National Mortgage Association (Fannie Mae) was given the responsibility to create a liquid secondary market for the mortgages insured by FHA and VA. To do so, Fannie Mae was provided a credit line with the Treasury; hence it could buy mortgages to make a market even in tough times.

In 1968, due to little success, Fannie Mae was divided into two parts: Fannie Mae and Ginnie Mae. Ginnie Mae, the Government National Mortgage Association, was created to support the FHA and VA mortgage market using the full backing of the US government. It did so by guaranteeing securities issued by private entities. A pool of mortgages collateralised those securities. In 1970, Fannie Mae was granted the right to purchase mortgages that were not insured by the FHA or the VA. The Federal Home Loan Mortgage Corporation (Freddie Mac) was also created in 1970 to support non-insured mortgages, but also those insured by FHA and VA.

Freddie Mac and Fannie Mae, instead of guaranteeing securities already packaged and backed by mortgages, bought the actual mortgages, pooled them, and issued their own securities backed by them, called mortgage pass-through securities. These two agencies

[51] Fabozzi [1998], Chapter 24.

are sponsored by the government, while Ginnie Mae is the only one to offer a guarantee carrying "the full faith and credit" of the US government. Ginnie Mae is part of the US Department of Housing and Urban Development. Agency pass-through securities are associated with Ginnie Mae, Fannie Mae and Freddie Mac. They account for 98% of the pass-through securities on the market. Most of them come from Ginnie Mae.

In Liar's Poker, Michael Lewis [1989] gives an insider's description of how mortgages evolved to be a traded product, and what role regulation played in making all that happen. According to Lewis, the first mortgage security department on Wall Street was created in 1978. Back then, home mortgages were mostly issued by the Saving and Loans, and that industry benefited from considerable support from the US government. A disruptive event occurred in October 1979, when the Federal Reserve Board raised short-term interest rates. The Saving and Loans were invested long-term, but they borrowed short-term to finance the mortgages. A side effect of the rate hike was that, from 1980 to 1983, 962 of the 4,002 existing Saving and Loans collapsed.

To quote Lewis[52], "Lights began to flash on the mortgage trading desk [at Salomon Brothers] in October 1981, and at first no one knew why. On the other end of the telephone were nervous savings and loan presidents from across America … desperate to sell their loans. … There were thousands of sellers and no buyers. Correction. One buyer." This was the direct result of a government effort to save the Saving and Loans. Congress voted an act that allowed a tax break to Saving and Loans who sold their

[52] Lewis [1989], p. 103.

mortgages. For a moment, there was only one trading desk equipped to buy mortgages. At that point in time that desk was buying the mortgages directly, not a security backed by them. They got stamps by the FHA and then issued bonds against the mortgages and sold them. However, those bonds were tough to sell. The reason was that "You couldn't predict the life of a mortgage bond. It wasn't that prepayments were bad in themselves. It was that you couldn't predict when they would arrive. And if you didn't know when the cash would come back to you, you couldn't calculate the yield. All you could surmise was that the bond would tend to maintain its stated maturity as rates rose and homeowners ceased to prepay, and would shorten as rates fell and homeowners refinanced. This was bad. Though the conditions of supply had changed overnight in October 1981, the conditions of demand for mortgage securities had not. Mortgages indeed were cheap; they were plentiful, yet no one wanted to buy them[53]."

Thus, for investors, the timing and amount of cash flows associated with mortgages is uncertain[54]. Apart from pre-payment risk, mortgages also suffer credit, liquidity and price risks. Prepayment risk can materialise as either contraction or extension of the original mortgage length. This is the main factor underlying the advent of collateralised mortgage obligations (CMOs) in 1983. CMOs are derivatives that split mortgage pass-through securities into different tranches, or bond classes, with different prepayment risks.

[53] Lewis [1989], p.111.
[54] Fabozzi [1998], Chapter 23.

CMOs were invented in 1983, but it took them three years to become a dominant player in the mortgage market. CMOs were created by gathering guaranteed mortgage bonds into a trust that would pay interest to the owners. The owners were granted certificates of ownership, which is precisely what a CMO is. CMOs are typically divided into three slices. The owners of the first slice receive all principal repayments from the three slices in the trust. When they are entirely paid off, the same process starts with second slice holders. And the same occurs with the third slice. In comparison with a traditional mortgage bond, the first slice of a CMO has a shorter maturity, and the third a longer one. It then becomes possible to know within a certain range when an investor will get his money back. As a result, American pension funds went from having no money invested in mortgages at all in 1983 to owning close to US$30 billion in CMOs in 1986[55]. Now there were buyers and the market took off. In 1986 the Tax Reform Act reduced the tax benefit from investing in mortgages. This was just after the Saving and Loans crisis, when thrifts were very aware that they invested long term and lent short term, so as to have unbalanced portfolios. Both these factors induced them to start selling their mortgages while still servicing them for a fee[56].

Mortgages as a product have evolved through time. From the 1930s to the 1970s, they existed in only one form, that is with fixed rates, level payments and full amortisation. Improvements came later as a result of high inflation. Rates became adjustable, that is they were reset at fixed time intervals to reflect changes in market interest rates. Adjustable-rate mortgages were designed to include a periodic cap that could not be

[55] Lewis [1989], p.137.

exceeded at each reset and lifetime caps and floors that could not be exceeded over the whole life of the mortgage.

Now there are two main classes of mortgage derivatives[57]:

1. Multi-class mortgage securities: CMOs (collateralised mortgage obligations) and REMICs (real estate mortgage investment conduits).
2. Stripped MBS: IO/PO (interest-only/principal-only).

The way CMOs add value is by redistributing interest rate risk, prepayment risk and operational risk. This makes CMOs more attractive to hold than the underlying mortgages.

One of the intricacies of mortgage derivatives is illustrated with Z bonds, which are not to be confused with zero coupons. They have a coupon that is paid under the form of more bonds. "The cash interest earned by the Z bondholders is transferred to the tranche or tranches currently receiving principal in exchange for bonds. This has the effect of retiring the other tranches in the deal more quickly than would otherwise be the case. The outstanding principal amount of the accrual tranche grows at a compound rate. Once the bonds preceding the accrual tranche have been paid down, the Z bonds begin receiving both interest and principal in cash." There are also Jump Z bonds, which are structured so that the Z tranche moves immediately from the accretion to the pay-down

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[56] Fabozzi [1998], Chapter 23.
[57] Carron [1992].

mode, when a given trigger is activated. These are discount bonds and their yield increases when they jump.

Another type of CMOs are sequential-pay CMO bonds, from which each class will be retired at different points in time[58]. Planned-amortisation class (PAC) bonds within a CMO were first issued in 1987 to provide a more accurate predictability of payments, and included a principal repayment schedule. Non-PAC bonds are called companion bonds and are not protected against prepayment risk; rather, they absorb that risk from PAC bonds. The coupon on the securitised mortgage is lower than the interest paid on the original mortgage. The Public Securities Association (PSA) created a model for new CMOs and publishes a scale that specifies prepayment rates for each month from the pooling of loans to maturity expressed as annual rates. This benchmark allows for pass-through cash flow projections. Stripped MBS are created by modifying the pro rata distribution of principal and interest to an unequal distribution. The price/yield relationship of such securities can differ substantially from that of the original pool and so be used to hedge prepayment risk. Fully stripped MBS, or interest only and principal only securities (IOs and POs) were first issued in 1987.

Adjustable-rate mortgage (ARM) are so called because their coupons are adjusted for changes in an underlying index rates[59]. They have periodic and lifetime rate caps. Three variables determine whether ARM are popular in the market at a given point in time: the spread between fixed and adjustable mortgage rates, the absolute level of fixed mortgage

[58] Fabozzi [1998], Chapter 24.

rates, and the other available financing opportunities. Ginnie Mae and Fannie Mae have issued ARM pass throughs since 1984 and Freddie Mac since 1986. The underlying index is usually based on US Treasuries or selected bank rates. A spread is added to the underlying rate. This spread is called the ARM margin. To be traded on a "to be announced" basis, MBS must meet certain criteria. In the case of ARMs, only some Fannie Mae securities meet the criteria: they have a monthly coupon reset frequency, their net margin is 125bps and they have a life cap not inferior to 13%. To evaluate ARM securities on a relative basis, three measures are used:

- Net effective margin ("the yield spread over the security's current index rate that is required to discount all future cash flows back to the original price in a static interest-rate environment");
- Option-adjusted spread ("the average spread over the Treasury yield curve that an investor can expect to receive over the life of a security under many different interest-rate scenarios");
- Duration ("a measure of a security's price sensitivity to changes in interest rates")

Up to this point, we have seen that, at the beginning, the mortgage market in US was far from liquid. There was a strong imbalance between supply and demand. Everybody wanted to sell mortgages and nobody volunteered to buy them. This meant that the Saving and Loans were in deep trouble. The government was afraid of a bankruptcy domino effect, which meant that, being responsible for the losses, it would have had to pay a lot of money. In 1981, Congress allowed Saving and Loans to be saved, under the

[59] Biby [1995].

condition that they start selling their mortgages. In 1986, a law was enacted facilitating mortgage securitisation.

The MBS experience teaches us the lesson that investors do not like to invest in something that has an unpredictable behaviour. Investors need to be able to calculate the value of an investment in order to track their profits. As we will see, CAT bond issues are split into many slices, just like the CMOs, and this has occurred since the very inception of the CAT bond market. We will now discuss the development of the market for catastrophe insurance risk derivatives.

STRUCTURED INSURANCE RISK CONTRACTS

Swiss Re New Markets[60] estimates that, in 1997 and 1998 alone, structured transactions have added US$2 billion worth to worldwide insurance and reinsurance capacity. Compared to the US$125 billion worldwide reinsurance industry premiums in 1997, structured deals have a long way to go. However, if they succeed in improving the efficiency of insurance and reinsurance markets, they should succeed as a product. The five-year-old structured CAT risk transfer market is still in its infancy, yet it is seen as having a great potential.

Levin, McWeeney, and Gugliada [1999] present an evolution of the market for structured insurance risk transactions, which consist of nearly 50 deals to date. Their classification is presented in Table 8, incorporating ISO [1999] definitions.

TABLE 8. THE EVOLUTION OF THE MARKET FOR STRUCTURED INSURANCE RISK TRANSACTIONS

Ground-breaking Transactions
These were the early transactions. The most likely to be the first was concluded in 1995 by Nationwide Mutual Insurance Co and took the shape of contingent surplus notes. Contingent surplus notes are "notes that an insurer has purchased the rights to issue in the future to investors at pre-set terms in exchange for cash or liquid assets." Nationwide set up a trust that borrowed US$400 million in the capital markets, and then stood by to purchase a surplus note that Nationwide would issue upon incurring a catastrophe loss. The trust's capital was invested in AAA securities in the meantime. This deal is "the first publicly placed security in which the capital markets were allowed to invest, even indirectly, in specific insurance company catastrophe exposure."

[60] Insurance-Linked Securities [1999].

Hybrids
These transactions intended to bridge the gap between existing securities and to-be-developed-insurance securitisations. AON Capital Markets invented Cat-E-Puts. Catastrophe Equity Puts "enable stock insurers to sell shares of their stock to investors at pre-negotiated prices when catastrophe losses exceed the levels specified in the options." There was not yet true risk transfer. They are a form of contingent financing, in that they provide insurers with additional equity when catastrophes strike. In 1996 RLI corporation bought for US$50 million of those puts, in 1997 LaSalle Re and Horace Mann Educators Corporation each bought US$100 million.
Straight Securitisations
They began in 1996. Examples include Residential Re's CAT bonds sale of US$477 million to USAA in 1997 and SR Earthquake Fund Ltd.'s issue of US$137 million to provide reinsurance to Swiss Re also in 1997. In 1998, Trinity Re, Ltd. issued US$86.3 million to then provide reinsurance to Centre Solutions, and similarly Residential Re sold another US$450 million to reinsure USAA. CAT Bonds are "corporate bonds with special language that requires the bondholders to forgive or defer some interest or principal if actual catastrophe losses surpass a specified trigger amount. When that happens, the insurer or reinsurer that issued catastrophe bonds can pay claims with the funds that would otherwise have gone to the bondholders. And to the extent that bondholders forgive repayment of principal, the insurer or reinsurer can write down its liability for the bonds, boosting surplus and potentially staving off insolvency."

Portfolio Securitisations
They refer to the use of catastrophe issues by reinsurers to securitise part of their portfolios. The first occurrence was in 1996 by St. Paul Reinsurance Co for US$68 million. Swiss Re New Markets repeated the process several times through 1998.
Transformers
These appeared in 1998 when investment banks started setting up reinsurance companies in an attempt to sell more insurance risk to the capital markets and securitise the reinsurance portfolio. Such firms are Lehman Re of Lehman Brothers and Arrow Re of Goldman Sachs.
Modern Securitisations
Now bankers use sophisticated structured finance techniques for insurance securitisation.

As for the specifics of CAT bonds and other catastrophe insurance structured risk transactions, we have already pointed out that they are inspired by the mortgage derivatives. The first obvious resemblance lies in the fact that CAT bonds are usually divided into two to three slices, just like CMOs. In the case of CMOs, this was done to enable investors to approximate the timing of the cash flows they would receive. For CAT bonds, each slice has a different probability of default. This allows investors to determine above all if they will be paid back, and in some cases when, for the occurrence of a catastrophe might mean that principal repayment will be delayed a few years. The similarity is that each slice caters to a different set of investors, with different objectives and risk tolerance, and this segmentation makes the product easier to sell than if the issue were not subdivided. Information on the deals that have been concluded to date comes from many sources[61] and Appendix 2 presents comprehensive details.

Froot [1999][62] identified principles that should be followed in the design of CAT risk transfer:

1. Retention should be substantial so as to favour a better rating and enable more investors to buy in;
2. Layer of protection offered should not be too high;
3. Dollar amount of risk transfer should not be small;
4. Loss trigger should be beyond cedent control;

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[61] Sources of information on the transactions presented include Business Insurance [1999], Canter and Coles [1997], Euroweek [1999], The Financial Times [1998], Froot (NBER Working Paper #7286) [1999], Froot (NBER Working Paper #7287) [1999], Galli-Zugaro [1999], Insurance Accounting [1999], Insurance Service Office [1999], Lonkevich [1999], McDonald [April 1998], Noonan [1999], Swiss Re [Sigma No.2/1999], and The Wall Street Journal [October 26, 1999].
[62] NBER Working Paper #7287 [August 1999].

5. Loss trigger should be symmetrically transparent.

Croson and Kunreuther [1999] also present a list of guidelines:

1. Utilise scientific risk estimates;
2. Develop incentives to reduce moral hazard (deductibles);
3. Expedite settlement for catastrophic claims (importance of money from a policy is greatest when damage to property is greatest);
4. Link premium payments to non-catastrophic claims periods;
5. Employ capital market instruments to reduce credit risk (CAT bonds have none);
6. Customize risk transfer instruments to address basis risk.

We can see from those lists that traditional insurance problems, moral hazard and basis risk, are still issues with catastrophe derivatives. Standard and Poor's [2000] believe that, to the extent that ceding insurers retain significant exposures to the peril that underlies the derivatives, investors are unlikely to see atypical risk in the notes, such as the risk introduced by moral hazard. This brings us to wonder whether CAT bonds are more or less attractive than reinsurance for insurers. One fact is that since 1997 the overall demand for reinsurance has been falling, and consequently, so have reinsurance premiums, providing less incentive to issue CAT bonds, as explained by Roper [1999]. Because the product is new, companies like USAA still continue to issue the bonds, as they want easy access to the capital markets when reinsurance rates will rise. This indicates that CAT bonds are perceived as complements to reinsurance. Among the differences, Croson and Kunreuther [1999] note that CAT bonds provide insurers with one advantage over reinsurance: there is no credit risk, in that the cover is set aside in a trust. However, the contrary can be said with respect to basis risk. There is thus a trade-off between the bond's basis risk and the reinsurer's credit risk. As for the timing of payments, it is immediate with the bonds but there is a long delay with reinsurance. The costs of implementing each measure are different, the cost of reinsurance being the premium, and of the bonds the coupons.

In contrast to CAT bonds, Borden and Sarkar [1996] remark that the options might be more favourable for investors because the CBOT clearinghouse minimises credit risk. However, insurance companies face basis risk with the options, due to the use of the industry loss index.

The Federal Reserve Bank of New York [1996] denote a few characteristics that are common to insurance-based financial instruments:

- Liquidity risk: market liquidity, ability to trade quickly at a fair price, depends on volume and frequency of trades.
- Basis risk: cash flows from hedging instrument not perfectly correlated to those of hedged asset.
- Credit risk: counter party default.
- Adverse selection: seller has inside information about the true quality of its products, for example, the true level of risk of insurance policies.
- Moral hazard: one party can take actions that can affect the value of the transaction but the counter party cannot monitor these actions.

Table 9[63] summarises and compares all the alternatives for catastrophe risk transfer.

TABLE 9. A COMPARISON OF CATASTROPHE RISK TRANSFER VEHICLES

	Traditional commercial insurance cover	Captives	Finite Solutions	Multi-line/ Multi-year Products	Multi-trigger Products	Contingent Capital	Securitisation (private, trigger based on index or physical event)	Derivatives
Risk Carrier	(Re)insurer	Policyholder	Primarily the policy holder	(Re) insurer	(Re) insurer	Primarily the policyholder	Capital market	Capital market
Diversification mechanism	Portfolio	Portfolio/ time, depending on the type of risk	Emphasis on time	Portfolio/ time	Portfolio	Time	Portfolio	Portfolio
Duration	1 year	Variable	Multi-year	Multi-year	Variable	Variable	Variable	6-12 months
Credit risk for the insured	Exists	Slight	Slight	Exists	Exists	Exists	None	None
Suitability for individual portfolio	Yes, usual case	Yes, usual case	Yes, usual case	Yes, usual case	Yes, usual case	Yes, usual case	Limited, depends on the definition of trigger	Limited, depends on the underlying
Moral hazard from the insured	Yes	No	Limited	Yes	Yes	Yes	No	No
Increase of insurance capacity	Limited, cyclical	Dependent on policy holder's financial strength	Dependent on policy holder's liquid funds	Indirectly through more efficient use of capacity	Indirectly through more efficient use of capacity	Good potential, but still in infancy	Good potential, but still in infancy	Good potential, but still in infancy
Additional services	Yes	No	Yes	Yes	Yes	Yes	No	No
Suitability for holistic risk management	No	Yes	Yes	Yes	Yes	Yes	No	No
Suitability for protecting the balance sheet	Yes	Limited	Yes	Yes	Yes	Yes	Yes	Yes
Suitability for smoothing results	Limited	Yes	Yes	Yes	Yes	No	Limited	Limited

We will now turn to the catastrophe risk transfer vehicles. They feature traditional reinsurance, alternative risk transfer solutions, index-based derivatives contracts, which

[63] Reproduced from Sigma No.2/1999.

include options, futures, and bonds, indemnified derivatives contracts, which mostly consist of bonds, and parametric derivatives contracts, which also include catastrophe bonds, in addition to weather and energy derivatives.

TRADITIONAL REINSURANCE CONTRACTS

"Because managers of insurance companies purchase reinsurance at far above the fair price, they clearly must believe that risk management adds value."

-Kenneth A. Froot

This section introduces the types of reinsurance contracts. A formal definition[64] of reinsurance is: "a transaction whereby one insurance company ... agrees to indemnify another insurance company ... against all or part of the loss that the latter sustains under a policy that it has issued. For this service, the ceding company pays the reinsurer a premium." A complementary definition[65] is: "Reinsurance is the distribution through time and amounts of unpredictable losses". Reinsurance is most often provided to an insurer by more than one reinsurer[66]. There must be a contract between the insurer and each of the reinsurers. Usually, there is a main contract to which is attached a signing sheet for each reinsurer. These sheets contain the signature and the statement of the amount of the cover provided by the reinsurers. Each reinsurer is responsible for his own share, but not for the share of other reinsurers should they be unable to pay.

Reinsurance can be either proportional or non-proportional[67]. Proportional reinsurance is also called pro rata reinsurance. The basic principle behind proportional reinsurance is that the insurer cedes a percentage of a risk to the reinsurer. This percentage applies to

[64] American Re [1998].
[65] This statement was made by Mr. Pierre Martel, Vice President of Swiss Re Canada.
[66] Weeks [1989].

all losses and there is no retention level. In exchange, the reinsurer receives the same percentage of the insurance premium and is responsible for that percentage of losses. In proportional reinsurance, the reinsurer pays a commission to the insurer for the business that is brought to him. This indemnifies the insurer from part of the acquisition and administrative costs related to the risks ceded. The commission rate may be a flat rate of the premiums ceded, which is reasonable when the results are expected to be stable over many years. In addition, a commission can be set to be a function of the insurer's profits, in order to reward the insurer for sound practices. Alternatively, commissions may be dependent upon insurance results. This is called sliding scale commission, and is appropriate when results vary considerably from year to year.

The percentage principle doesn't apply to non-proportional, or excess of loss reinsurance. Excess of loss reinsurance bears a striking resemblance to a combination of options. When a loss occurs, the insurer is responsible for it up to a given retention point, after which the reinsurer pays all or part of the losses, provided a given cap is not exceeded. Above this level, amounts calculated as multiples of the line are ceded in pro rata form. E.g. the retention level is 1,000, the risk is 3,000, 2,000 is ceded, which corresponds to two lines [2,000 / 1,000][68]. In non-proportional treaties, the insurer must pay a premium to the reinsurer. In setting the premium to be paid to the reinsurer, no proportional principle is involved. The premium can be determined in three ways:

1. Flat premium: The premium if fixed for the cover.

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[67] Weeks [1989]. Note that American Re [1998] and Swiss Re, Questions of Reinsurance – A Short Guide [1998] contains similar descriptions and definitions.
[68] Example from American Re [1998].

2. Flat rate: The premium is a fixed percentage of the total premium generated by the insurer for the business covered by the treaty.
3. Variable or sliding scale rate: The premium depends on the performance of the portfolio under the treaty.

Whether a reinsurance agreement is proportional or non-proportional, it can be facultative or treaty[69]. Facultative reinsurance is decided upon and negotiated on a risk-by-risk basis. Treaty reinsurance is automatic reinsurance. It is effective from the moment an insurer takes on a risk. In quota share treaty, the reinsurer's share of the insurer's portfolio is fixed. The amounts of risks transferred and retained apply to each individual risk covered by the treaty. The insurer is committed to cede a percentage of each risk and the reinsurer is committed to accept them. We now give a brief overview of the different forms reinsurance can take.

In surplus treaty, the insurer sets a retention point, under which he keeps all the risks, and above which he cedes a fixed percentage. The reinsurer has three risks from surplus treaties:

1. The insurance company might retain the safest risks and cede the riskiest.
2. With respect to the quota share treaty, if a loss is due to the most hazardous risks, the reinsurer is likely to lose a greater share.
3. The size of the risks covered in surplus treaties is not constant, nor is the size of the losses.

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[69] Weeks [1989].

In a facultative obligatory treaty, the insurer is free to reinsure while the reinsurer must reinsure upon demand.

In a per risk excess of loss treaty, the treaty applies to each risk separately. Individual losses must exceed a pre-determined priority level before the reinsurer shares in the loss. If there are many small losses the sum of which exceeds the priority, the insurer gets nothing from the reinsurer. Per risk excess of loss treaties suit property risks.

In a per event excess of loss treaty, all losses stemming from a single event must exceed the priority for the reinsurer to indemnify the insurer. Both property and casualty risks can be covered with that type of treaty.

In a catastrophe excess of loss treaty, the ultimate net loss due to a catastrophe is covered, i.e. the loss that the insurance company must pay after it recovers amounts from all other reinsurance covers. In this type of treaty, any amount paid by the reinsurer to cover a loss directly affects the remainder of the cover, lowering it by this amount. It is possible to proceed to a reinstatement of the cover to its original level, which is generally done automatically and implies that the insurer will pay an additional premium to the reinsurer. There are many things a reinsurer must investigate before providing catastrophe reinsurance, starting with the concentration of exposure in a given area. For this he must quantify the size of the average risk in the area, the number of risks in the area, the number of risks subject to catastrophes, and the average underwriting loss per risk.

Catastrophe losses are considered as many losses that arise from the same event. The concept of a single event can be problematic. For example, in marine reinsurance one storm might last many days and affect two ships located in different geographic areas. For definition purposes, the centre of the loss area is identified on a map, a circle is drawn around it whose radius is previously agreed upon, and this circle defines the area within which losses pertain to the same event. A time limit to the length of the event is also agreed upon.

In a stop loss treaty, protection is offered to the annual results of a segment or the total of an insurer's business. The maximum loss is determined as a percentage of the annual premium income.

In the life business, excess of loss reinsurance is a scarce phenomenon. The main reason is that life insurance is provided on a long-term basis, while excess of loss reinsurance agreements last shorter time spans, usually a year. As a result, there is a mismatch between the original policies and the reinsurance, and should there be any pricing adjustments to reinsurance, the insurer is the one that has to bear the costs. There is however one emerging exception, that of excess of loss covers for a concentration of deaths arising from a single event.

Reinsurance is appealing to insurers for several reasons. American Re [1998], Weeks [1989] and Swiss Re [1996][70] describe the functions and advantages of reinsurance.

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[70] An introduction to reinsurance.

Table 10 presents those functions pairing them so that each line corresponds to one general idea.

TABLE 10. FUNCTIONS OF REINSURANCE

Weeks	American Re	Swiss Re
Capacity	Increases underwriting capacity for insurers	Enlarges the insurer's underwriting capacity
Resource protection	Provides insurers with protection against losses resulting from a catastrophe or against multiple large losses	Reduces the probability of bankruptcy due to a catastrophe
Stabilisation	Stabilizes insurers' operating results	Minimises fluctuations in balance sheet figures
Financing	Reduces the strain on insurers' surplus in periods of rapid premium growth	Increases the amount of capital by freeing equity that was reserved to cover risks
	Allows insurers to withdraw from a line of business, a geographic area or a production source	
	Helps insurers who enter new lines of business spreading the related risk until they are able to handle a greater share	
	Provides underwriting information to insurers new in some areas	

The Reinsurance Association of America [1998] explains how proportional reinsurance can increase insurance capacity. "When an insurance company issues a policy, the expenses associated with the issuance (taxes, agent commissions, administrative expenses) are charged immediately against the company's income, resulting in a decrease in surplus, while the premium collected must be set aside in an unearned premium reserve to be recognised as income over a period of time. This leads to decreased capacity because the more business a company writes, the more expenses must be paid from surplus, reducing ability to write additional business."

Weeks [1989] discusses the functions served by each type of reinsurance agreement. He notes that quota share treaties provide capacity in the same way they provide financing. Facultative reinsurance, surplus, and per risk excess of loss treaties all allow insurance companies to increase their capacity.

As for the resource protection function of reinsurance, reinsurance does protect capital, surplus, loss ratio, and investment positions.

An insurer seeking stabilisation in earnings can turn to[71]:

- Self-restriction, that is writing only small risks to keep a balanced portfolio;
- Coinsurance, or providing insurance with competitors, thus sharing strategic information with them;
- Reinsurance.

Reinsurance is arguably a preferable means to reduce earnings volatility. Weeks [1989] ascertains that non-proportional reinsurance is well suited to stabilisation purposes. In a working excess of loss treaty, for instance, claims are expected because of the low level

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[71] Swiss Re, Proportional and Non-Proportional Reinsurance [1997].

retention, and the insurer seeks protection against a higher-than-usual frequency of medium-sized losses. The surplus treaty is geared at the large-sized losses, and removing them serves as a stabilizing factor on results. Catastrophe excess of loss treaties do the same but for very large, extreme, losses that could bring an insurer on the verge of bankruptcy.

Weeks [1989] points out that proportional reinsurance is particularly suited as a means of financing for insurance companies. This occurs because part of the unearned premium, which is a liability, is borne by the reinsurer. Thus, reinsurance enables insurers to write more business than they would without this source of funds. The financing function of reinsurance can be compared to a bank loan or a participation in equity but without some of the constraints.

Quota share reinsurance presents several advantages as explained by Weeks [1989]:

- It is available as a form of standby financing;
- It involves less formalities and paperwork than going through with an IPO;
- It does not cause shareholder equity dilution;
- Its terms can be renegotiated;
- It can be used as a temporary source of funds while planning further long-term measures.

The associated disadvantages are:

- It implies ceding part of one's business;
- It might cost considerably more than traditional means of financing.

Weeks [1989] explains that all losses that occur during a treaty period are not settled during that period. There is generally an amount outstanding at the end of the period. They will be settled in the future and will be the responsibility of the reinsurer that was bound by the contract at the time the loss occurred. To prevent such a situation from happening, the old reinsurer can transfer the outstanding losses to the new reinsurer, by paying him an amount estimated to be representative of the losses in question. The insurer will then turn to the new reinsurer when it will claim those losses. This is called loss portfolio transfer.

This concludes the overview of traditional reinsurance forms. We now turn our attention to newer forms that involve the capital markets, alternative risk transfer, or ART.

ALTERNATIVE RISK TRANSFER

> *"Lack of insurance capacity and price volatility frustrate large organisations seeking stability in risk financing... Within the ART segment, this [reinsurance] capacity can be accessed via a captive insurer with a direct relationship to the net block of insurers and reinsurers. As such, the compressed relationship allows for an increased understanding of risk exposures between the underwriter and client and can, potentially, result in greater flexibility of cover."*
>
> *-Swiss Re*

Over the recent past years, the capital markets have experienced considerable changes. Many solutions have been offered to those who want to manage catastrophe risk other than by means of traditional reinsurance. Parallel to that, a new stream of reinsurance has emerged, ART, or alternative risk transfer[72]. Swiss Re [Swiss Re New Markets] lists the major companies which are involved in the ART market as AIG, Swiss Re, Zurich Re/Centre Re, Berkshire Hathaway, Allianz, and Axa.

Swiss Re New Markets [1998a] describes ART products as complements to insurance products, in that they are targeted at risks that traditional insurance is either unable or unwilling to accept. They would also be more efficient and cheaper than other financing means. Table 11 presents the similarities and differences between traditional catastrophe reinsurance and ART products, as extracted from Sigma No.5/1996. ART includes finite

[72] Swiss Re, Alternative risk transfer via finite risk reinsurance: an effective contribution to the stability of the insurance industry, Sigma No.5/1997.

insurance and reinsurance, and risk transfer via the capital markets[73]. The underlying concept of finite risk products is time spreading of risk for a single policyholder. This is different from traditional insurance that spreads the risks amongst people.

TABLE 11. A COMPARISON BETWEEN TRADITIONAL REINSURANCE AND ART

	Traditional Non-Proportional Reinsurance	Private OTC Placements	CBOT Insurance Derivatives	CATEX Risk Trading
Suitable for hedging individual portfolios (basis risk)	Yes, no basis risk	Yes, not necessarily basis risk problem	Yes, if high correlation with PCS indices, basis risk problem	No, only risk swapping
Suitable for homogenisation of uneven risk exposures	Yes	Theoretically, but not main purpose	Yes	Yes
Capacity	Large but still insufficient	Large potential, development just starting	Large potential, still little used	Small. only indirect capacity increase
Pricing/costs	Individual, high	Individual, variable	Via market mechanism, still relatively high	Via market mechanism, only transaction costs
Maturity	1 year	Variable	6 months to 1 year	1 year
Regulatory/tax treatment	Allowed, lowers capital needs	Still uncertain today	Only recognised as investment instrument today	Still uncertain today

Finite risk products cover underwriting and timing risks. These policies last for many years. Part of the premiums that do not contribute to loss settlement is paid back by the

[73] Swiss Re, Sigma No.2/1999.

reinsurer at the end of the contract, making the cost of the program dependent upon its own experience. The concept of time value of money is also applied. Interest earned on the premiums over the life of the policy is a factor in the premium itself. Finite contracts can be retrospective, i.e. cover losses incurred but not settled, or they can be prospective and related to anticipated losses. Examples of finite risk products include:

- Loss portfolio transfers in which the policyholder transfers outstanding claims reserves to the insurer. It is a retrospective form of insurance.
- Retrospective excess of loss covers: Includes losses that are incurred but not reported. There is no transfer of outstanding claims reserves. The policyholder pays the insurer a premium for the partial assumption of losses that exceed the reserves that are accumulated.
- Financial quota share reinsurance: Prospective policy in which the cedent transfers some of its premiums and stabilizes net claims costs.
- Prospective excess of loss covers: Spread loss treaty, a non-proportional reinsurance technique in which the policyholder pays premiums to the insurer, which are transferred to an experience account, in which they earn a specified interest rate.
- Integrated multi-line/multi-year products: One insurance programme for several lines of insurance. The liability limit of the provider and the deductible of the policyholder are both aggregated across all lines of insurance and contract terms.

Finite risk products have had a slow growth to date because of high transaction costs, credit risks, limited offering, traditional organisation of risk management and lack of accounting principle and tax deductibility clarity.

Swiss Re now provides integrated risk management solutions[74] to its clients, or reinsurance products which provide combined coverage for traditional insurance risks and financial risks. Examples of Swiss Re ART solutions are:

- IBIC: Investment-Backed Insurance Cover. This type of policy is multi-year and tailor-made.
- MACRO: Multiline, Aggregated, Combined Risk Optimization. Insurance and financial risks are hedged simultaneously.
- XENUM: Asset-backed financing concept. The client progressively sells to XENUM its receivables accruing from the goods/services it supplies. XENUM provides financing and takes care of risk collection.
- CAT bonds.

These examples show that ART, like proportional reinsurance, provides financing and contributes to the expansion of the primary insurance business.

Schön, Bochocchio, and Wolfram [1998] maintain that the main value added from integrated risk management solutions in comparison to traditional reinsurance is that they factor in financial risks. Their effect compares with that of a put option written on operating results. Separate insurance protection might lead to useless expenses due to over-hedging. Integrated risk management solutions may feature a single trigger that is activated when a combination of underwriting and investment losses is exceeded. They can also have double triggers, which must both be activated for a payoff to occur.

Usually one trigger is related to liabilities, while the second depends on investments, resulting in a cheap cover for rare events, a limit to downside risk, but no significant decrease in volatility.

A peculiarity of ART products is thus the inclusion of a long-term, conditional element in the contract. Financial reinsurance is a form of ART; it is a combination of banking and reinsurance products. Finite risk reinsurance is multi-term, and part of the profits accumulated over the term of the contract is reimbursed to the client. The initial premium is determined by factoring into the expected return on investments. Finite risk reinsurance combines both risk transfer and risk financing, which emphasises the time value of money.

Schön, Bochocchio, and Wolfram [1998] believe that integrated risk management products provide operating results coverage that are impossible to replicate using separate traditional reinsurance and/or investment hedging strategies. "Single-trigger integrated risk management solutions offer coverage if one predefined condition is fulfilled during the contract period. The treaty can be expressed as a stop-loss cover for several lines of business and financial positions. The loss ratio includes not only the traditional underwriting losses, but also additional loss ratio points resulting from the development of the insurance company's investment portfolio." Integrated risk management products are suitable for those who wish to limit the downside risk as well as the volatility of operating results.

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[74] Swiss Re New Markets, Integrated Risk Management Solutions – Beyond traditional reinsurance and

The uses of ART products are similar to those of traditional reinsurance, in that they allow for the stabilisation of reinsurance costs, the smoothing of results, the expansion of underwriting capacity, a partial protection against incurred but not yet reported claims, and balance sheet optimization. The innovation comes from the long-term, multi-year nature of the contract.

Recent innovation in the catastrophe line can be illustrated with BETA[75], Swiss Re's "high-excess. Multi-line, multiyear risk transfer product". The minimum limits of BETA are US$300 million for each of property and casualty exposure, for a maximum of US$600 million over three years. Sub limits are US$200-US$400 million for aggregate property and US$100-200 million for aggregate casualty. BETA is built using the attachment method[76]. Under this method, the existing mono-line reinsurance policies are bundled together and physically attached to a master agreement. The master agreement contains a pre-emptive term, a coordinating provision. In other words, the terms of the master agreement prevail in case contradictions are found in any of the mono-line policies. An alternative means of creating multi-line agreements would be to write a new contract from scratch and to include all the desired elements. This would cost more and take more time. Whichever method is used, once a final product is created, a single multi-line trigger must be set. This trigger encompasses all the underlying lines. This does not imply that the mono-line triggers are deleted, but that when such a trigger is

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financial hedging [1998].

[75] Swiss Re, Beta – A multiline, multiyear risk transfer product [1997].

[76] Swiss Re New Markets – Multiline multiyear agreements – A guide for the drafter and negotiator [1998].

exceeded, the reinsurer will indemnify the insurer provided the terms and conditions of the master agreement are also met.

Regarding the future of reinsurance, the industry is building on its traditional strengths, while innovating with solutions such as ART, as reinsurers' active involvement in the CAT bond market illustrates. We must not forget the fact that reinsurance is a client-oriented industry. Therefore, if insurance companies start asking their reinsurers for hybrid solutions that combine financial and reinsurance elements, the reinsurance industry will evolve consequently[77]. The next section studies the specifics of index-based catastrophe derivatives.

[77] This statement is inspired by a conversation with Mr. Pierre Martel, Vice President of Swiss Re Canada.

INDEX-BASED CONTRACTS

"The use of catastrophe bonds and indexes of insurer losses might enhance standardisation and transparency. This would reduce both insurer and reinsurer costs of capital and, simultaneously cut reinsurer market power, further lowering the costs of intermediated risk transfer."

-Kenneth A. Froot and Paul G.J. O'Connell

The principal distinction amongst catastrophe insurance derivatives lies in the definition of their trigger. Triggers to date have been based on indices, incurred losses, and parametric measures. Several reason why the index-based insurance derivatives appeal to insurers are set forth by the American Academy of Actuaries [1999]: The contracts offer supplemental reinsurance capacity; they allow for capital market participation; they favour transparency and potential transaction cost reduction; and they are integrated risk products. In this section, we study the characteristics of insurance loss indices, as well as the contracts that were created based on indices, such as catastrophe options and several bond issues.

The National Association of Insurance Commissioners asked the American Academy of Actuaries to provide them with technical assistance in understanding and measuring the effectiveness of index-based insurance derivatives for hedging insurance exposures. In their report, the American Academy of Actuaries [1999] provided a list of characteristics that made a good index, good meaning effective as a hedge. The list is as follows:

1. The index must be easy to understand;

2. It must be related to the loss process;
3. The timing of changes in value of the index must be consistent with the emergence of the loss process;
4. The index must not create moral hazard potential;
5. It must be possible to model the index;
6. The data required to construct the index must not be subject to manipulation, and
7. The index must be flexible enough to allow parties to customize their transactions.

Catastrophe risk securitisation does not eliminate moral hazard and basis risk, rather it is based on a trade-off between the two. This is where the choice of a trigger becomes crucial. If the instrument payoff is conditional on the company's own losses, there is no basis risk for the issuer, but moral hazard can be so great that there will be no market for the issue. On the other hand, industry-based indices will minimise adverse selection and moral hazard possibilities because they are based on transparent information. There are nevertheless advantages to the use of an index, in that the insurance company does not need to disclose information on its own book of business and the deal is clearer to investors.

This section will illustrate how the first series of indices used for options did not meet some important criteria, and how the second generation of indices constituted an improvement. Before getting into these details, we will emphasize the fourth point: The index must not create moral hazard potential.

Moral hazard occurs when, after entering a contract, one of the two parties is able to secretly affect the payoff of the contract in its favour. An example of moral hazard in insurance is given by Swiss Re [1993]: "Policies which cover losses caused by adverse weather conditions are open to abuse by insurance fraudsters. Of course, they are not able to single-handedly bring about natural phenomena in order to cause a loss, but they may see their occurrence as an opportunity to be taken advantage of. For example, upon hearing a storm warning on the radio, a policyholder might park his car –already in need of certain repairs- in the open so that the damage from hailstones, falling roof tiles or branches can be a good as possible..."

In the insurer-reinsurer relationship, moral hazard is also a factor. Suppose that a catastrophe has impacted simultaneously a large number of clients of an insurance company. For reasons such as preserving its good reputation, and because its knows that it can seek relief in its reinsurance policy, the insurer might be quicker and more generous than usual at settling the claims, passing on some of the costs to the reinsurer. However, according to Pierre Martel, even if moral hazard exists in the insurer-reinsurer relationship, it is insignificant. This is due to the fact that the reinsurance universe is composed of a small number of players, in which no one is the exclusive client nor supplier of anyone else, and in which frauds come out in the open very quickly. In cases where reinsurers would have to pay extra amounts as a result of moral hazard, they would pass the costs back to the insurers, who would also pass them back to the public, when establishing the new premiums for the next year.

With the insurance loss indices, moral hazard is already present simply because of the fraud that is characteristic in the insurance industry. However, the American Academy of Actuaries [1999] insisted on the index not creating the potential for additional moral hazard. Moral hazard could be created by the index if the companies whose losses are part of the index were able to influence the level of the index and at the same time transact on the derivatives from this index. That said, we will study the catastrophe options and see how they were affected by moral hazard.

The Chicago Board of Trade (CBOT) was the first institution to offer insurers, reinsurers, and investors the chance to manage catastrophe risk through exchange-traded index-based derivatives. In December 1992, CAT futures and options were introduced. In the catastrophe derivatives and securitisation vocabulary, CAT is often used as a convenient abbreviation of the full word. CAT futures and options were declared a failure when they proved inadequate at reflecting the losses from the Northridge earthquake in December 1994. They were then replaced by Property Claims Service (PCS) options, which have been trading on the CBOT since September 1995. A similar set of CAT options was introduced on the Bermuda Commodities Exchange and traded from November 1997 until August 1999. Although the CBOT PCS options have survived to this day, their success cannot be proclaimed loud and clear.

Vorm Christensen [1998] provides us with insight on CAT options and futures, and on why the PCS options are a more economically viable alternative. The underlying asset of CAT futures was the Insurance Service Office (ISO) index, and CAT options were written on the futures. The composition of the ISO index was the main reason attributed to the failure of the contracts. The index is defined using data from American insurance companies who report to the ISO on a quarterly basis. From about one hundred companies, the ISO selected a minimum of ten (other authors say 25) and computed the ratio of their reported incurred losses to their earned premiums.

Before a contract started trading, ISO made public the names of the companies to be included in the index and the volume of their premium. This was meant to render fluctuations in the index independent of variables other than expectations of insurance losses. However, this introduced the potential for moral hazard, since companies who were included in the index could try to manipulate it if desired. Aase [1995] says, to that effect, that to avoid the moral hazard problem, "It would be an advantage if it (the loss ratio index) had been a purely scientific index of some sort."

All contracts traded on a quarterly basis. For a March (Q1) future contract, the losses included were tied to events occurring either in January, February, or March. However, those losses could be reported until the end of June (Q2). Contracts settled on the fifth day of the month following the third quarter (Q3), i.e. October. Trading in this contract was allowed from the first day of the event quarter until the settlement date. The settlement value of the futures equalled US$25,000 * Min [ISO Index, 2].

A pertinent remark by Canter, Cole and Sandor [1996] is that although the ISO index was based on the losses of 25 companies which represented 23% of the property insurance industry, this index could not reflect the losses arising from the Northridge earthquake. This was so because the time it took to estimate the true loss from the earthquake was longer than the options' life. Indeed, the PCS estimate after 6 months was US$7.2 billion, but after 20 months it reached US$12.5 billion[78]. It took 20 months after the earthquake to get to the final evaluation of that loss. This was effectively the final nail in the CAT futures and options' coffin.

PCS options replaced CAT futures and options. Table 12, which is adapted from Vorm Christensen [1998], summarizes the major flaws of CAT options and futures with respect to information asymmetry, moral hazard, and reporting timeliness, and identifies ways in which PCS options solved those problems. With those considerations in mind, we are ready to take note of the material released by the CBOT on PCS options. The CBOT markets PCS options as a complement to reinsurance programs, as well as a way to indirectly invest in risks that are traditionally reserved to the property/casualty insurance industry. Alternatively, PCS options can be a tool for investors wishing to diversify their portfolios, as they are little or not correlated with stock and bond price changes. This also implies a potential for a new source of capital supply for catastrophe risk absorption.

The CBOT states that "with a hedging strategy known as a call spread, insurers and reinsurers can buy PCS option protection in layers – just as they would with aggregate excess-of-loss reinsurance." The CBOT also lists potential uses of PCS option call spreads as including:

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[78] Swiss Re New Markets, Insurance-Linked Securities [1999].

TABLE 12. COMPARISON BETWEEN CAT OPTIONS AND FUTURES AND PCS OPTIONS

CAT Options and Futures	PCS Options
Information Asymmetry	
The value of the ISO index at the end of the event quarter was published at the end of the following quarter, which introduced information asymmetry between companies participating in the index and those who were not. Companies in the index knew information on their own losses, and knew which percentage of the pool their premiums represented, and thus could estimate settlement value of the index with better accuracy than could others.	All investors, whether companies who report to American Insurance Services Group or not, receive the same information at the same time.
Moral Hazard	
A company who shorted a CAT futures was hoping for its value at expiry to be as small as possible. If that company was part of the index and suffered a big loss during the event quarter, it could delay its reporting until the next quarter, so as not to increase the index value and as to profit on the futures.	Surveys conducted by PCS after a catastrophe are not used as such to estimate insurance losses, and thus companies do not have the ability to influence results.
Reporting Delay Inadequacy	
The period over which losses were reported (Q1 and Q2) resulted to be too short to include all the losses when severe catastrophes struck. The March 1994 contract highlighted this problem. On January 17, 1994, the Northridge earthquake occurred. This should have lead to a high index value, but it did not because claims were slow in developing, and losses included in the index were lower than actual losses incurred in the first quarter of 1994. For an event occurring even closer to the end of the event quarter, the problem could be even more serious. Northridge proved that CAT futures could not be used to hedge against catastrophe losses.	The time between the beginning of the event period and final settlement is longer for PCS options. The fact that the index is not computed from actual claims also makes its estimation faster.

1. Filling the gaps in traditional reinsurance programs;
2. Adding short-term financial coverage before, during, or after a loss period;
3. Hedging retention levels;
4. Rebalancing the risk exposure of a book of business;
5. Geographically diversifying the risk exposure of a book of business;
6. Avoiding reinstating an entire reinsurance program.

Vorm Christensen [1998] acknowledges that PCS options resemble stop loss reinsurance contracts, but ascertains that there are some fundamental differences between reinsurance and financial contracts, which imply that they are not substitutes:

1. Price Determination: The buyers and sellers of PCS options do not know each other and prices are determined through auction markets. Reinsurance contracts are negotiated between two parties who know each other, and prices are not necessarily arbitrage-free.

2. Basis Risk: There is no basis risk in reinsurance contracts, as it is the insurer's own losses that are reinsured. However, with PCS options, there is no guarantee of perfect correlation of prices with any given insurer's losses.

3. Position Reversal: For those who want to reverse an option position, it can be done in one easy instantaneous step, just by buying or selling what was previously sold or

bought (assuming a liquid market). With reinsurance, cancelling a contract is not as simple.

4. Credit Risk: The clearinghouse eliminates credit risk for options, but in reinsurance contracts both parties are exposed to credit risk.

The characteristics of PCS options are numerous. The first one is the PCS index underlying the options. There are nine such indices, and they cover the following areas:

1. National: 50 States and Washington DC.
2. California.
3. Florida.
4. Texas.
5. Eastern: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland and Washington DC, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana.
6. North-eastern: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Washington DC.
7. South-eastern: Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana.

8. Midwestern: Oklahoma, Arkansas, Tennessee, Kentucky, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, Nebraska, Kansas, and Missouri.
9. Western: Hawaii, Alaska, Washington, Oregon, California, Nevada, Arizona, New Mexico, Utah, Colorado, Wyoming, Montana, and Idaho.

Quarterly contracts are available for the Eastern, South-eastern, Florida, Texas, National, North-eastern, and Midwestern indices. Annual contracts are available for California and the Western index, because earthquakes, the most common catastrophe in these areas, do not occur on a seasonal basis.

The loss period refers to the time during which a catastrophe must occur for the related insurance losses to be included in the index. Thus, the loss period for the contracts spans three or twelve months. It is followed by a development period. The development period corresponds to the time after the loss period during which PCS re-estimates the PCS indices. The PCS index value at the end of the development period will be used for settlement purposes, but it is possible that its estimates continue to change afterwards. Investors can choose a development period of six or twelve months for each purchased or sold option. Option expiry occurs at the end of the development period, and contracts can trade until this last day.

Only the events that qualify as catastrophes are included in the PCS indices. This means that total industry net insurance payment for personal and commercial property lines of insurance covering the following elements are included: fixed property, personal property, time-element losses, vehicles, boats, and related property items. There are exclusions to PCS estimates, which are losses involving: uninsured property, uninsured publicly owned property and utilities, agriculture, aircraft, property insured under the National Flood Insurance or Write-Your-Own programs, and loss adjustment expenses.

How do PCS loss estimates work? Although the PCS index value chosen for settlement is the value available at the end of the development period, there is no guarantee that the loss estimates will not change after that moment. As of 1995, the Chicago Board of Trade defines a catastrophe as "an event that causes in excess of US$5 million of insured property damage and affects a significant number of policyholders and insurance companies." PCS stands for Property Claims Services. It is a division of American Insurance Services Group. In 1949, catastrophes began to be assigned serial numbers and PCS has since been the responsible entity for estimation of insured property catastrophe losses in the US.

How does PCS compile its estimates? It uses a survey of insurers, its National Insurance Risk Profile and on-the-ground surveys. The surveys represent a minimum of 70% of the market based on premium-written market shares. The National Insurance Risk Profile involves an inventory of buildings and insured vehicles in each county. Combining this information, PCS approximates the number of insurable risks within the area affected by a catastrophe. The estimates factor in the expected dollar loss as well as the projected number of claims that will be filed. The first estimates are released on a preliminary basis within three to five days following a catastrophe and they do not pretend to predict an accurate dollar amount. PCS resurveys all losses for which the preliminary estimate is above US$250 million in insured property damage. Re-estimates are also conducted for all catastrophes that are considered to be uniquely characteristic, such as earthquakes, regardless of the initial loss estimate. The re-estimates are released within 60 days after the preliminary estimate. This process is repeated every 60 days until PCS feels confident that the full insured-loss has been estimated. Froot[79] [1999] criticises this approach, by saying that the use of surveys disables third parties from verifying the results, that reporting companies have sufficient leeway to manipulate the results, and that moral hazard is therefore not eliminated.

In terms of the reporting of the PCS index estimates, generally, PCS announces before 4PM that it will release a preliminary estimate or a re-estimate at 10AM Eastern Time the following day. If circumstances impede this release, rescheduling will be announced before 9:30AM, and the announcement is made after trading has closed for the day. American Insurance Services Group and its employees are under strict guidelines concerning loss estimate disclosure, and they may not do so prior to official disclosure. PCS faxes PCS loss indices to the CBOT by 2:30PM on each CBOT trading day.

PCS options come in two different sizes. There are small cap contracts, for losses from US$0 to US$20 billion and large cap contracts, for losses from US$20 billion to US$50 billion. The PCS Loss Index Value is equal to the PCS Options Cash Equivalent /

[79] NBER Working Paper #7287.

US$200, where the PCS Options Cash Equivalent is computed as the Industry Loss Equivalent / US$500,000. Examples of this calculation are presented in Table 13.

TABLE 13. RELATION BETWEEN INDUSTRY LOSS AND PCS INDEX VALUE

PCS Loss Index Value	PCS Options Cash Equivalent	Industry Loss Equivalent
0.1	US$20	US$10 million
1	US$200	US$100 million
20	US$4,000	US$2 billion
50	US$10,000	US$5 billion
100	US$20,000	US$10 billion
200	US$40,000	US$20 billion
250	US$50,000	US$25 billion
300	US$60,000	US$30 billion
350	US$70,000	US$35 billion
400	US$80,000	US$40 billion
450	US$90,000	US$45 billion
500	US$100,000	US$50 billion

Strike values are listed in multiples of 5. They range from 5 to 195 for small cap options and from 200 to 495 for large cap options. Premiums are quoted in points and tenths of a point. One point equals US$200. One tick equals one tenth of a point or US$20. The exercise type is European. On the expiration day, all in-the money options are automatically exercised. This is the day in which the settlement value of the PCS index is made publicly available. The last day of trading is the last business day of the development period. Trading hours are from 8:30AM to 12:30PM Chicago time, Monday through Friday.

The settlement for small cap contracts is made in cash and corresponds to the lesser of:

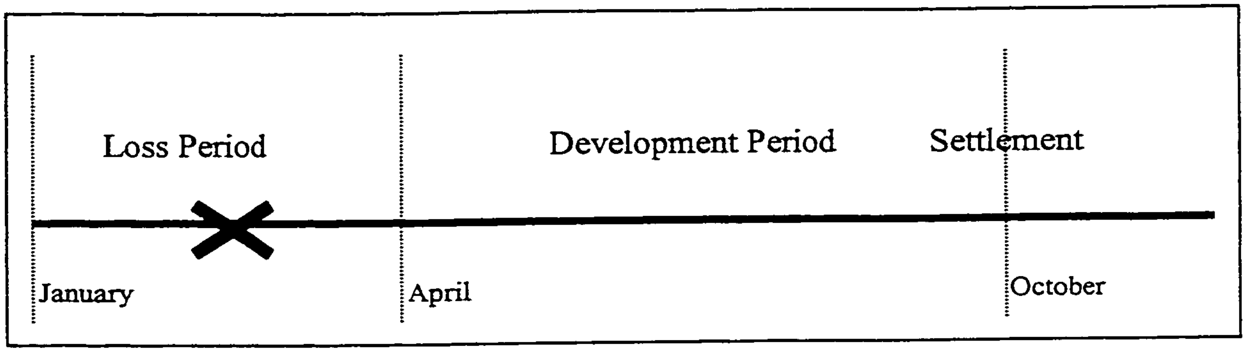
1. US$200 * settlement value of index;
2. US$40,000.

For large cap contracts, the cash settlement amounts to the lesser of:

1. US$200 * settlement value of index;
2. US$100,000.

Let us now work through a practical example of how one simple PCS call option works. Let us assume that we are January 1 and we are buying one March small cap PCS Florida call option with a strike of 50. The loss period ranges from January 1 to March 31. Further, we choose a six-month development period, which ranges from April 1 to September 30. Figure 2 illustrates the different dates. Now assume that, on March 1, a hurricane hits Florida. The settlement amount of the March small cap option will be affected by both the magnitude of the insurance losses attributed to the hurricane and the timing of the public disclosure of the losses.

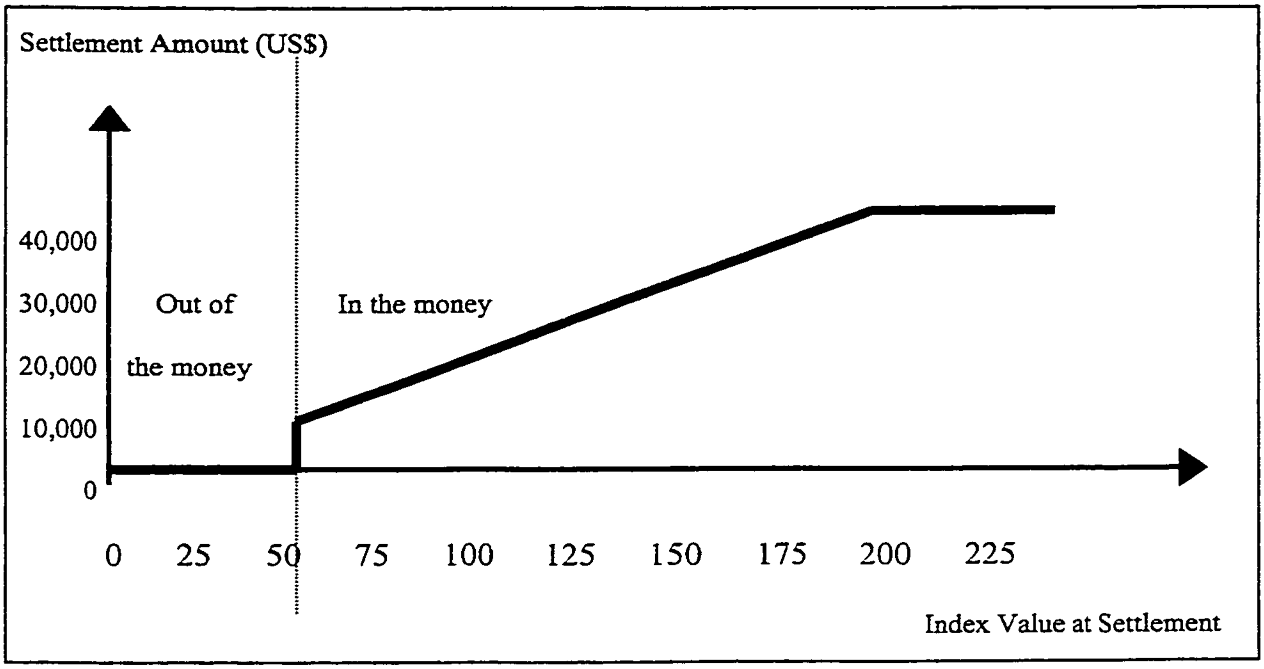
FIGURE 2. TIME LINE OF A PCS CALL OPTION'S LIFE



In any case, if industry losses at settlement are estimated below US$5 billion, which corresponds to the strike of 50, the option is out of the money and the holder receives no compensation. If industry losses are estimated at US$20 billion or above, the holder will receive a flat compensation of US$40,000. For all losses between US$5 billion and US$20 billion, the PCS index ranges between 50 and 200, and the settlement amount is calculated by multiplying US$200 by the index value.

It is important to underline that the development period of the purchased call ends September 30. Therefore, even if upward revisions are made to the index subsequent to September 30, there is no going back. However, had we purchased the same option with a twelve-month development period, the settlement amount we would receive on March 31 of the next year would factor in any adjustments to the value of the index over that additional six-month period. Figure 3 shows the payoff of that call option given different index values at expiry. The amounts shown do not include the premium paid at acquisition.

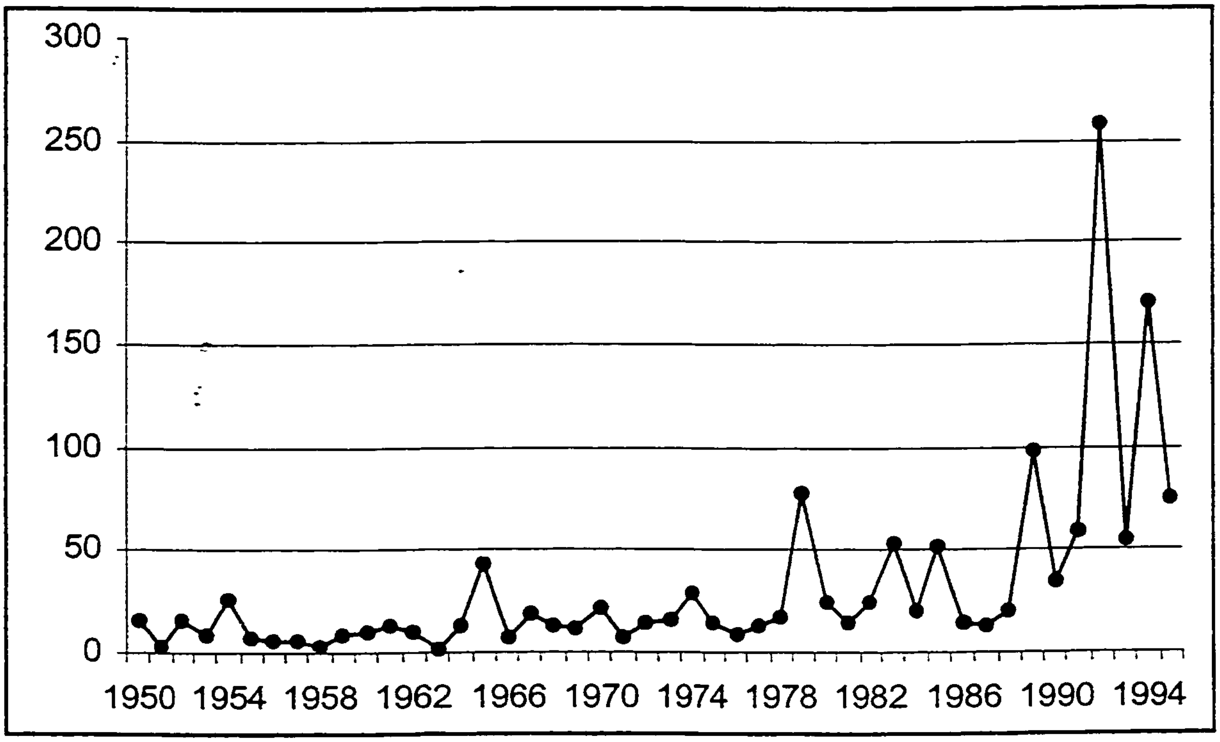
FIGURE 3. PCS CALL OPTION SETTLEMENT AMOUNT



If we had purchased a large cap call option instead of a small cap, the payoff schedule would have had the same shape, except for the index scale. The option would be in the money for index values starting at 200 (instead of 50). For values below 200, no money would change hands. Above 500, the settlement amount would be flat at US$100,000. In other words, whether the hurricane causes losses of US$50 billion or US$100 billion, each option would pay the same amount.

We present in Figure 4 the evolution of the PCS index prior to the launch of the PCS options. Data from 1950 to 1995 can be downloaded from the CBOT FTP website. Figure 4 shows how catastrophe-linked insurance losses dramatically increased, both in magnitude and in volatility, over the 1990s. This certainly was a reason to seek alternative ways to handle the risk related to those losses.

FIGURE 4. HISTORICAL RECONSTITUTION OF THE NATIONAL ANNUAL PCS INDEX (1950-1995)



The Chicago Board of Trade, in its user's guide to PCS options, provides information on the options and associated strategies to use them. The most common strategy is the call spread, because it can be designed to replicate aggregate excess-of-loss reinsurance agreements and layers of reinsurance.

There are three basic PCS options trading strategy outlined by the CBOT:

1. The first strategy are PCS option call spreads: A PCS option call spread is defined as the simultaneous purchase and sale of calls of the same expiration month with different strikes. "Buying the spread" means buying the call with the lower strike price and selling the call with the higher strike price. "Selling the spread" means the

contrary. Call spreads resemble layers of traditional non-proportional reinsurance, and the call strikes can be viewed respectively as the attachment and the exit point of reinsurance contracts.[80] Further description of call option spreads is found in Meyers. If an insurer wants protection in the $1 to $2 range of an index, it buys a call option spread. This means it buys a call with a strike of $1, e.g. for a premium of $0.20. Then it sells another call with a strike of $2 for a $0.10 premium. At expiry, if the index value is zero, both calls are worthless and unexercised. The investor keeps the $0.10 from the initial premiums difference. However, if the index were to settle at $3, then both options would be exercised. The investor would buy the index from the insurer for $2, and the insurer would buy the index from the investor for $1. The investor's loss would be:

Difference in premiums: ($0.20 -$0.10 = $0.10)

+ Difference in strike prices: ($1 - $2 = -$1)

= A loss of $0.90, which corresponds to the insurer's gain. As long as the index settles above $2, this result would be observed; the liability of the investor (the seller) is limited. The insurer has total protection for the above $2 layer. In the layer below $1, the insurer is not protected and the investor keeps the premium. Meyers views reinsurance as an option written on a catastrophe index, where the index is the insurer's losses.

2. PCS option strip transactions are the second strategy. PCS option strip transactions are simultaneous purchases or sales of a series of different quarterly options or option

[80] Swiss Re [Sigma No.5/1996].

spreads with the same strikes. The price for each quarter is fixed in this all-in-one package. Each quarter's losses become independent in that, if the index for one quarter exceeds the small cap limit, it will not affect the protection purchased for the remaining quarters. In reinsurance, there would need to be reinstatement and the purchaser would incur an additional cost.

3. The third strategy is called PCS option butterfly spread. PCS option butterfly spreads involve many calls or puts with the same maturity and different strikes. Buying a butterfly spread involves buying one option at a high strike price and one at a low strike price, and selling options at a middle strike value. Selling a butterfly spread means taking the opposite positions. This strategy enables reinsurers to rebalance their portfolios by exchanging one layer of risk for another. For example, if a reinsurer writes a cover at a high level, he can subsequently turn to the options and buy a call spread at the same level. If he wants to keep exposure at a lower level, he could also sell a call spread at that level. The two call spreads create the butterfly spread.

Up to this point we have seen how PCS catastrophe options work. Now, we will look at what does not work with them. Information found on the CBOT FTP site shows that from the inception of PCS options in September 1995 until September 1999, 17,040 spreads were traded, equivalent to US$8,678,842 in premiums, generating a capacity of US$88,987,000. This is relatively small compared to capacity provided by traditional means and CAT bonds. Furthermore, activity is relatively low these days. In the fourth quarter of 1999, only one trade (a spread) was recorded, which occurred on December 16, in the Midwest contract. The previous trade was dated September 17, 1999, and there were trades on only five different days during that month. Judging by these facts, it is obvious that PCS options are having some trouble. A main problem with those products is that the value of the underlying asset index at expiry, because of the way it is constructed and the time it takes to estimate, is only known after the fact. This can well be a cause of the absence of liquidity in the catastrophe market.

Jaffee and Russell [1997_b] expose another problem with catastrophe options: the difficulty to find people to bear the risk in the contracts. Vorm Christensen [1998] says that the main buyers of PCS options spreads are large insurance and reinsurance companies, while the sellers are investors and companies whose earnings are tied to catastrophes, such as building supply or construction firms. However, since bearing the risk in these options resembles the natural exposure of reinsurers (at least if call spreads are considered), and since general companies are not necessarily sophisticated users of derivatives, this would arguably leave speculators as the main source of alternate capital. However, even speculative capital is scarce when catastrophe options are used, which could be due to the following argument presented by Jaffee and Russell [1997_b]. "The Black/Scholes pricing argument is based on the fact that in a small amount of time the movement in the price of the asset on which the option is written is such that this price movement can be completely hedged with one other asset, the option itself." "The dynamics of catastrophe losses differ completely from the dynamics of stock prices. Catastrophe losses have sample paths which are usually zero, but which are sometimes very large. This creates a jump process with a very skewed distribution, even in a short period of time, so this risk cannot be fully hedged with only 2 assets. New and potentially far more complex option pricing theory needs to be developed for catastrophe options, and until this theory is established, it is unlikely that trading capital will flow into this market in any sizeable amount."

Before concluding on the catastrophe options, we must mention that they do not only exist on the CBOT, but they were also listed in Bermuda under a different form for a few years. Details about them can be found on the Bermuda Commodities Exchange web site. There are three types: Single loss CAT options, Aggregate CAT options and Secondary loss CAT options. Following are the peculiarities of each type:

- The single-loss CAT option is a cash-settled binary option (its payoff can either be zero or it can be US$5,000) based on the Event Guy Carpenter Catastrophe Index (GCCI) as published by IndexCo. The largest Event GCCI for a given region and risk period, if applicable, is multiplied by 10,000 for comparison against offered strike prices. The published Event GCCI measures a ratio of homeowners' loss damage as a result of the largest atmospheric loss events to respective insured value. Event GCCI are only produced for each of the ten largest events ranked by national damage rates as defined in the Index manual. It is possible for an Event GCCI not to be produced for a particular region and risk period, and an Event GCCI index value of zero would prevail.

- The secondary loss CAT option is a cash-settled binary option based on the Event GCCI as published by IndexCo. The second largest Event GCCI for a given region and risk period, if applicable, is multiplied by 10,000 for comparison against offered strike prices. The published Event GCCI attempts to measure a ratio of homeowners' loss damage as a result of the largest atmospheric loss events to respective insured value. Event GCCI are only produced for each of the ten largest events ranked by national damage rates as defined in the Index manual. It is possible that two Event GCCI not to be produced for a particular region and risk period, and a second loss GCCI index value of zero would prevail.

- The aggregate CAT option is a cash-settled binary option based on the Aggregate GCCI as published by IndexCo. The Aggregate GCCI for a given region and risk period, if applicable, is multiplied by 10,000 for comparison against offered strike prices. The published Aggregate GCCI measures a ratio of homeowners' loss damage as a result of all atmospheric losses to respective insured value.

There are common elements to the three types of options: The contact size is US$5,000 for each, the tick is US$0.01, the risk period covered are from January 1 to June 30 and from July 1 to December 31 each year, the exercise is binary: US$0 or US$5,000. There are five index-publishing dates:

1. Partial period: One month after the end of the risk period representing losses occurring only during the first three months of the risk period.
2. Full period: Four months after the end of the risk period.

3. First update: Seven months after the end of the risk period.
4. Second update: Ten months after the end of the risk period.
5. Third update: Thirteen months after the end of the risk period.

Strike prices are equivalent loss estimates of the GCCI multiplied by 10,000: 1,2,3,4,5,6,7,8,9,10,15,20,25,30,35,40,45,50,100,150,200,250,300,350,400,450,500,550, 600,650,700.

The buyer must post 100% of the premium in cash. The seller must post 100% margin in US$, US Treasuries, or a letter of credit to the BCOE for each contract sold: US$5,000 each.

The regions covered by the options are:

1. National: Continental United States, including Texas, Alaska and Hawaii.
2. Northeast: Connecticut, Delaware, Washington DC, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia.
3. Southeast: Florida, Georgia, North Carolina, South Carolina and Virginia.
4. Gulf: Alabama, Arkansas, Florida, Louisiana and Mississippi.
5. Mid/West: Arizona, California, Colorado, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Utah, Washington, Wisconsin and Wyoming.

6. State of Florida.

7. State of Texas (subject to availability of data).

All options can trade until settlement. At settlement, in-the-money options are automatically exercised and the holder is paid US$5,000 (calls). Out-of the money options expire. Settlement occurs the first time one of the following conditions is met:

- On the partial period publication date if the index value is greater than or equal to 110% of the strike price. If the index value is less than 110% of the strike price, settlement is extended to full period publication date.
- On the full period publication date if the index value is greater than or equal to 110% of the strike price. If the index value is less than 110% of the strike price, settlement is extended to the first update publication date.
- On the first update publication date if the index value is greater than or equal to 110% of the strike price. The options expire if the index value is less than 25% of the strike price. If the index value is less than 110% but greater than or equal to 25% of the strike price, settlement is extended to the second update publication date.
- On the second update publication date if the index value is greater than or equal to 110% of the strike price. The options expire if the index value is less than 50% of the strike price. If the index value is less than 110% but greater than or equal to 50% of the strike price, settlement is extended to the third update publication date.
- All remaining options either settle or expire at the third update publication date.

As a first comment on the structure of the BCOE options, we want to mention the difficulty of pricing an instrument whose maturity is not defined. Let us give details on the GCCI index used as underlying index for catastrophe options traded on the BCOE[81]. The GCCI index is a measure of the industry's losses in proportion of insured value (a ratio, not the magnitude of the losses). The index is available at zip code level, which is very suited for homeowner property insurance hedging. However, results are only available quarterly, and the index only covers homeowner losses, thus excluding commercial and industrial losses. Furthermore, being an index based on atmospheric catastrophes, the GCCI index excludes losses from earthquakes.

Incorporation of the exchange occurred on July 22, 1996. It is stated that "the BCOE is an entity owned and governed by its members. Members represent a variety of institutions, consisting of insurance and reinsurance companies, investment and commercial banks and trading firms, which will trade on the exchange for their proprietary accounts and on behalf of their customers. The BCOE is supervised by the Bermuda Monetary Authority."

Unable to find any information on actual trading at the BCOE, we sent a request for a history and documentation via E-mail to the BCOE generic address. On November 15, 1999, we were granted the following reply: "Trading was suspended on August 12th, 1999, until further notice. The Exchange is a private members only operation and no

[81] BCOE web page.

information regarding volumes is released publicly." This does not allow for a definite conclusion, but it would seem that success with these options was slight.

The attempts at transferring catastrophe insurance risk on an organised exchange made on the CBOT and the BCOE show that there are people with an interest in seeing the development of these products. The fact that the BCOE is member-owned indicates that the interest is genuine from the part of entities directly involved with this risk in the normal curse of their business. In other words, it is not a product that only exchanges wish to develop. However, it has now been eight years since this saga started, and it is still at a developmental stage. Many will point to these options as a failure.

The American Academy of Actuaries [1999] identifies the most important reason for the lack of interest in the catastrophe options among insurers as the potential for basis risk, the inexperience in managing basis risk, the availability of reinsurance at attractive costs, and the statutory accounting treatment. To manage basis risk, it is necessary to possess a model of both the index and the insurer's exposure in the occurrence of given events. With the options came a new form of risk transfer, a new product, a new terminology, a new methodology, and new learning was required.

We want to stress that these options were a first step towards the securitisation of insurance risk. Their success may lie in their failure, for they have given us the possibility to see what works and what does not.

The index-based CAT bonds had more success than the options. Given that an identical trigger leads to a different degree of success, perhaps the problem with the options was in the design. With the index, there is a possibility that late catastrophes will not totally be reflected at maturity of the derivatives. For options this is a true problem. For bonds, however, the fact that a certain compensation is received periodically by the means of coupons and the fact that maturity can be extended attenuate the situation.

An example of an index-based CAT bond is SR Earthquake Fund, Ltd. Swiss Re New Markets[82] discusses the July 16, 1997 US$137 million issue. The coupon paid out to investors on the bond equalled the investment income plus the reinsurance premium, while the amount of principal that was repaid was dependent on insured earthquake losses in California over the two years of the bond. Were a late loss to occur and warrant estimation time, maturity might be extended. The issue involved a special purpose vehicle (SPV). It is the SPV who issued the US$137 million notes, and then entered a US$112.2 million reinsurance contract with Swiss Re. The index used was California's largest insured loss from a single earthquake over a two-year period as estimated by PCS. Class A-1 and class A-2 were rated investment grade (Baa3), with 60% of the principal at risk, and the remaining 40% invested in short-term Treasury notes. Class A-1 paid a fixed interest rate of 8.645% and A-2 paid Libor +255bps. Class B had 100% principal at risk, was rated Ba1 and paid a fixed rate of 10.493%. Losses for classes A-1, A-2 and B depended upon how much reinsurance the SPV must pay Swiss Re. Class was C unrated. It paid a fixed rate of 11.952% and would have lost all its principal if the largest earthquake caused insured losses in excess of US$12 billion. Table 14 is reproduced from Swiss Re New Markets [1999] and details the payout of the issue.

TABLE 14. DETAILS ABOUT THE RISKS IN THE SR EARTHQUAKE FUND ISSUE

PCS estimate	Classes A-1 A-2 % Principal Loss	Class B % Principal Loss	Class C % Principal Loss	Annual Probability of Loss of this Magnitude
US$12 Billion or greater	0%	0%	100%	2.40%
US$18.5 Billion or greater	20%	33%	100%	1.00%
US$21 Billion or greater	40%	66%	100%	0.76%
US$24 Billion or greater	60%	100%	100%	0.52%

The annual expected principal loss is A-1. A-2 : 0.46%

B: 0.76%

C: 2.40%

The coverage for Swiss Re is:

A-1 and A-2 principal US$62 million, coverage US$37.2 million;

B US$60 million principal, US$60 million coverage;

C US$14.7 million principal, US$14.7 million coverage;

This section covered the index-based form of contracting for insurance derivatives. It showed that index-based options have known little success and transferred insignificant amounts of risk. Although the use of the PCS indices introduces basis risk for the options, it is not the only cause behind their failure, since index-based bonds have

[82] New Perspectives – Risk Securitisation and Contingent Capital Solutions [1997] and Insurance-Linked

stimulated considerable demand. Perhaps standardised options simply do not work by design. The next section introduces indemnified contracts. These contracts eliminate basis risk, but this is at a trade-off with the inclusion of the potential for moral hazard.

Securities [1999].

INDEMNIFIED CONTRACTS

"Catastrophe bonds issued so far have been modeled on mainstream securitized products, but with a reinsurance angle. Instead of purchasing coverage from reinsurers, insurers set up a special-purpose reinsurance company. They then buy reinsurance from the special-purpose company, which in turn sells the notes to large investors. Return of the principal, interest or both on the notes is tied to the promise of repayment by the insurer--usually if the catastrophe costs do not exceed a predetermined threshold."

--Lee McDonald

The structure of indemnified-based catastrophe derivatives differs from index-based derivatives in that the trigger is based directly on the issuing company's own losses. The first CAT bonds were indemnified-based. They closely resembled reinsurance contracts in that they had no basis risk for the issuing insurers. However, moral hazard was an issue.

The most famous indemnified-based CAT bonds are USAA's. In 1996, USAA attempted a first issue, using a SPV called Residential Re, but it failed. Froot [1999][83] explains the reasons behind the failure. The first point was the lack of investor understanding of the issue. Second came the lack of rating agency criteria for CAT bonds. Third was the absence of regulator agreement that Residential Re note holders were not writing insurance to USAA. Fourth was the difficulty of finding the location to set the deal due to legal, regulatory and tax considerations. This deal took longer to structure than the original plan and became USAA 1997.

Levin, McWeeney, and Gugliada [1999] present interesting details about the 1997 Residential Re US$477 million catastrophe bond offering. The reinsurance treaty underlying that issue covered losses in excess of US$1 billion. The relevant probability is that of losses in excess of US$1 billion being incurred. It was estimated at 1.6% in this case, which corresponds to the probability of default on BB bonds. The principal of that issue was consequently rated BB. The coupon for that security was 576 basis points above the risk-free rate, which Levin, McWeeney, and Gugliada [1999] see as a sign that pricing was not efficient in this market at that time. They also note that the 1998 Residential Re issue traded at about 400 basis points above the risk-free rate, which would be an improvement but still a level above the premium for other BB securities at that time.

Moore [1999] also analyse the US$477 million USAA issue. Five remarks are made:

1. The size of the issue is considerable. The US$477 million raised provided US$400 of coverage to USAA against homeowner catastrophe.;
2. The structure is simple. The trigger is a single east coast hurricane of class 3 or higher;

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[83] NBER Working Paper #7286 [August 1999].

3. The investors receive a large premium. The principal tranche is protected and yields LIBOR + 273bps, whereas the junior tranche with its principal at risk yields LIBOR + 576bps;
4. There are significant coinsurance charges to USAA if triggered;
5. There was excess demand for the securities. Offers for the bond reported to be in excess of US$1.1 billion. This is considered very oversubscribed.

Moore [1999] calculates the rate-on-line of the issue to be about 7.13%. Similar coverage with reinsurance would warrant a rate-on-line of about 3.5% to 5%. This would imply a cost of over (7.13% - 5%)*($400M) = US$8.5 million just to use the capital market instead of traditional reinsurance. Details of these calculations are as follows:

1. Issuance fees:

A-1: US$868,000

A-2: US$3,131,800

2. Interest cost:

With LIBOR = 5.75% (as of 06/13/1997)

A-1: US$163,800,000 * (5.75% + 2.73%) = US$14,758,240

A-2: US$313,180,000* (5.75% + 5.76%) = US$39,178,800

3. Return on invested proceeds of issue:

With 1-year T-Bill =5.3275% (as of 06/13/1997)

US$476,980,000*5.3275% = US$25,411,110.

Where [(1) + (2) – (3)] / US$400,000,000 = 7.13% = Effective rate-on-line, with a +/- 0.25% estimated accuracy.

These costs were lower for subsequent placements. For example, Trinity Reinsurance paid a 182 bps spread for its protected tranche and 436 bps for its principal-at-risk tranche.

In the second USAA issue, there was no principal protected tranche and the premium was 420 bps. Given a 25% reduction in issuance costs, the rate-on-line was about 4.75%-5%. At the same time the price of reinsurance decreased by about 10%-15%. Thus the rate-on-line for similar reinsurance cover is about 4.25%. Capital market premium = 0.75% to 1%, or US$3 to US$4 million for US$400 million coverage.

Part of the capital market premium serves to compensate the absence of credit risk that fully capitalized reserves offer and that reinsurance does not necessarily offer. On the secondary market, there has been a drop in yield spreads from the earliest trades. For the 576 bps USAA tranche, the yield stabilized at around 440 bps. In addition, as exposure to risk decreases, with passage of time, it is observed that the yield falls.

This section focussed on one example of indemnified-based CAT bonds. There are many possible variants, such as bond options and basis swaps. The next section discusses parametric-based insurance derivatives.

PARAMETRIC CONTRACTS

"There are three major ways in which the default of a bond may be triggered: the specific underwriting loss of the insured; an independent index of insured events; or a non-insurance, physical index (such as the Richter scale). Of late, there has been a growing belief that the third trigger form of reset mechanisms represents the future of the market and the best possible option for investors attempting to quantify the risks."

-Jonathan Shann

Parametric-based insurance derivatives have gained popularity because their trigger is independent, transparent, and immediately observable. Parametric triggers include the magnitude of an earthquake on the Richter scale and the intensity of a hurricane on the Saffir-Simpson Index.

Lonkevich [1999] discusses two transactions completed by Oriental Land Company Ltd., the Tokyo-based owner and operator of Tokyo Disneyland in May 1999. The first noteworthy feature is that Oriental Land is not active in the insurance industry. Therefore, its CAT bond issues constitute self-insurance. Oriental Land securitised a total of US$200 million of earthquake risk.

Oriental Land used SPV Concentric Ltd. from the Cayman Islands for the first transaction. Concentric Re issued five-year floating rate notes for an amount of US$100 million. The notes pay Libor + 310 basis points semi-annually and are rated BB by

Standard & Poor's. They are due May 13, 2004. Investors stand to lose from 25% to 100% of the principal on notes depending on magnitude and vicinity of earthquake to Maihama. Actual property damages to Tokyo Disneyland form an eventual earthquake are not determinant of the notes structure.

For the second transaction, Oriental Land used Cayman Islands SPV Circle Maihama. Circle Maihama issued US$100 million of floating rate extendible notes. The notes are also due May 13, 2004, they pay a semi-annual coupon of Libor + 75 basis points, and they are rated A by Standard & Poor's. The extension provision would be used upon occurrence of an earthquake. In this case, Oriental Land would issue a five-year bond to Circle Maihama. For the first three years, Oriental Land would have no obligation to pay interest.

Following the parametric-based CAT bonds, a new type of parametric-based derivatives appeared recently: the weather instruments. Weather instruments are not directly insurance-linked, that is, they do not securitise insurance risk. However, we introduce them in this paper because they constitute a form of insurance that can be used by participants in all the industries that have weather-sensitive earnings[84]. Weather derivatives illustrate how parametric contracts can trade on an exchange with success, even though they do not securitize a traded asset. Furthermore, like insurance-related options, they require models that incorporate structural trends in the evolution of the underlying trigger. Their success contrasts with the failure of the PCS options.

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[84] Hague [1999].

Lancaster [1999] reports that the first purely weather-based derivatives appeared in the over-the-counter market around 1997. These products were demand driven, as a consequence of deregulation in the US electricity industry. Most of the early transactions were swaps. Keefe [1999] estimates the size of the US weather derivatives market at about US$3.5 billion in terms of exposure covered, and that weather-linked bonds could develop, which would be designed to protect sales and earnings when they are affected by a weather deviation from the norm. In addition to weather-linked bonds, other over-the-counter weather-linked derivatives include rain and snow precipitation swaps and options, as well as sunshine options.

Considine[85] believes that the first weather transaction was a weather option embedded in a power contract executed in 1997 by Aquila Energy. The OTC weather instruments are futures, swaps and options on futures on Heating Degree Days (HDD) and Cooling Degree Days (CDD). To quote Considine, "There are a number of drivers behind the growth of the weather derivatives market. Primary among these is the convergence of capital markets with insurance markets. This process is evidenced by the growth in the number of catastrophe bonds issued in recent years as well as the introduction of the catastrophe options that are traded on the CBOT. Weather derivatives are the logical extension of this convergence."

[85] Introduction to Weather Derivatives.

Considine explains that there is a reason the weather derivatives market was established in 1997: El Niño was particularly strong in the 1997-1998 winter. In fact, it was so strong that many companies feared a decline in earnings and decided to take protective financial measures. Dischel [November 1998] states that at the beginning, the market makers offered degree-days options specifically targeted at protecting energy sellers against declines in revenues. Considine highlight the fact that CDD and HDD options are similar to insurance policies, while futures are similar to swaps designed so that one party receives the payment if the degree-days exceed the strike over a period, while its counter-party receives it if it is below. The use of such contracts could be extended to the hedging of commodity price risk.

Dischel [November 1998] believes that the natural offsetting exposures to weather of different entities constitute solid grounds for a robust weather derivatives market. However, Dischel recognises that there are factors slowing the development of this market. First, there is a data difficulty, second, pricing models are scarce, third, accounting and regulatory rules are unclear, and fourth, potential end-users are slow to recognise the means they have.

How are weather options priced? The National Oceanic and Atmosphere Administration (NOAA) temperature database is a must. Historical series for 1979-1998 can be extracted from the database for Atlanta, Chicago, Dallas, New York, and Philadelphia, and distribution functions can be fitted to the data. However, the standard used by NOAA and other entities of the atmospheric community is different from the standard used to calculate HDD and CDD in the weather market, in that the weather market keeps one decimal in daily HDD and CDD, whereas NOAA rounds the figures out. Furthermore, each measuring station must be analysed. It may be a poor place to begin with, or the instruments might have changed through time, or have been moved a few feet, all of which introduce bias in the data.

The price of a weather option can be approximated with a Gaussian model if the average and the standard deviation of HDDs or CDDs in a given location are known. The price determinants are the standard deviation of the distribution, the distance of the option's strike from the mean value of the distribution, and the quantity of dollars per degree-day agreed upon in the contract. These determinants are not so simple to assess! Due to non-stationarity in climate, both its mean and standard deviation evolve through time. There are also trends in urbanisation that render old data less comparable to the current situation. Currently the cities for which HDD and CDD are measured and options are traded on the Chicago Mercantile Exchange (CME) are Atlanta, Chicago, Cincinnati, New York, Dallas, Philadelphia, Portland and Tucson.

Aquila Energy is a company that structures OTC ccntracts on rain, snowfall, wind, and other non-traded "commodities". Cao and Wei [1999] study weather contracts on temperature, rainfall, and snowfall in the OTC market. As an illustration of the fact that the specificity of the city is important, the analysis of data from Atlanta, Chicago, Dallas, New York and Philadelphia shows that standard deviations are larger for northern cities. However, the standard deviations of the monthly CDDs in the southern cities are larger.

Auto-correlation is characteristic of all data. There is a warming trend for all cities. To model daily temperature, one must respect its inherent features:

- Incorporate seasonal cyclical patterns;
- Allow for gradual changes in temperature;
- The daily variations must be around a "normal" average;
- Variations in winters must be larger than in summers;
- Global warming must be taken into account.

Thus a diffusion process would not be suitable.

Cao and Wei [1999] conclude that:

1. The market price of risk of the temperature variable does not seem to significantly affect the value of the derivatives. This might give some support to the industry practice of "using the risk-free rate in valuing weather derivatives without apparent justification."
2. One industry practice that seems flawed is the use of historical simulations to price weather derivatives, which most often over-estimates options prices.

On September 22, 1999, the CME started offering HDD and CDD futures and options on futures. The introduction of these contracts was motivated by the febrile over-the-counter activity in similar contracts. HDD and CDD indices are calculated on a monthly basis for selected cities and areas in the US. The CME defines a degree day as a measure of the deviation of one day's average temperature from 65 degrees Fahrenheit. The average daily temperature is calculated as the average of the maximum and the minimum temperatures observed between midnight and midnight. The benchmark of 65 degrees Fahrenheit is used in the utility industry. Formerly, it used to be the temperature at which people would turn their furnaces on. Now, it is observed that above 65 degrees Fahrenheit the demand for energy increases as people turn on their air conditioner, and below 65 degrees Fahrenheit, more energy is used for heating purposes. A HDD is a measure of how cold the temperature is relative to 65 degrees Fahrenheit, while a CDD is a measure of how hot. Here are the computation formulas:

- Daily HDD = Max [0; 65 F – daily average temperature]
- Daily CDD = Max [0; daily average temperature -65 F]

HDD and CDD indices are measured as the accumulation of daily HDD and CDD respectively over a calendar month, with US$100 attached to each HDD or CDD for the purpose of final cash settlement. Futures and options are listed for each of the twelve calendar months both on HDD and CDD. The options are European. One futures underlies each option. The price tick for an option is 1, and it is worth US$100. HDD and CDD indices are not calculated by the Chicago Mercantile Exchange, but rather by Earth Satellite Corporation. Trading in HDD and CDD futures and options is conducted 24 hours a day on Globex®2, the Chicago Mercantile Exchange's electronic system. This system offers price transparency and equal access to large and small traders. Further advantages are the absence of moral hazard and of a claims period.

This section has shown that parametric-based catastrophe insurance derivatives are superior to indemnified-based contracts, for they cannot be affected by moral hazard and are therefore more transparent. It also showed that, although there is bound to be basis risk associated with parametric-based contracts, the main advantage over index-based contracts is the timeliness of availability of information regarding the trigger. We further saw that parametric-based contracts, such as weather derivatives, could be standardised and exchange-traded. The next section of this paper is dedicated to the inclusion of a catastrophe risk component in the construction of a portfolio.

PROPOSED FRAMEWORK FOR PORTFOLIO CONSTRUCTION

CORRELATION BETWEEN CATASTROPHES AND FINANCIAL MARKETS

> *"Investors who buy the bonds take a chance that, during a particular period, a catastrophe won't strike the regions covered by the insurance firm(s) issuing the bonds."*
>
> *-Hedge Financial Products*

Catastrophe risk has been transferred to the capital markets for the last decade. Even though catastrophe derivatives are still perceived as fairly new, they are now part of the universe of securities available to portfolio managers. This section adopts the standpoint of portfolio managers and discusses the aspects of catastrophe derivatives that must be given extra consideration. Finally, it highlights more elements that further research can elucidate, thus contributing to a widespread use of catastrophe risk derivatives.

To include a catastrophe component in a portfolio, the first step would be to use the efficient frontier concept. This would mean finding the optimal amount of catastrophe component that could be added to an existing portfolio, minimizing the risk and maximizing the return. For this to be done, information about the correlation between the catastrophe derivatives and the existing portfolio is critical[86]. So far, studies have not

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[86] Note that the spatial and intertemporal characteristics of catastrophes must be taken into consideration. Several catastrophes should be studied in relation with the capital markets situated in their immediate geographic location.

reached an agreement on whether catastrophe risk is correlated with the financial markets.

One must distinguish between catastrophe risk and catastrophe derivatives. It is possible for the occurrence of a catastrophe to be uncorrelated with the financial markets, but for the derivatives written on that catastrophe to exhibit correlation. To that effect, Loubergé, Kellezi and Gilli [1999] make the important point that CAT bonds tend to have unconventional durations. Because of the option to extend the maturity of certain CAT bonds if a given catastrophe materializes, the duration of such a zero coupon CAT bonds is greater than their time to maturity. A CAT bondholder is implicitly long in a bond and short in a call. The call option gives the holder the right to buy in the catastrophe index at a predetermined price, whose price is a positive function of the interest rate. This renders the bondholder more exposed to interest rate rise risk, both through the long bond and the short call than a regular bondholder. Therefore, the authors believe that, although CAT losses are empirically uncorrelated with financial market returns, it is possible that CAT bonds display significant positive correlation with the financial markets.

Hoyt and McCullough [1999] investigate whether the PCS options are trading as zero-beta assets. They find evidence that the PCS options trade as zero beta assets. They use quarterly catastrophe loss figures for 1970-1995 and the SP500 stock index and bond markets returns. The correlation is found insignificant at the 10% level. There is no evidence that the traded PCS options are statistically significantly related to the markets' returns. This leads them to say that the options are behaving consistently with zero-beta assets behaviour, i.e. uncorrelated with capital markets movements. “Even with the low trading volume of PCS Catastrophe Insurance Options, the current price movements do appear to be uncorrelated with the overall movements in the market over the period of our study.” They conclude that their study supports the claim that PCS options are zero-beta contracts, and that they could be used for portfolio diversification. They mention catastrophe bonds as other potential zero-beta instruments. Their conclusion is: “This new generation of financial instruments based on catastrophe risk provides both an alternative to traditional catastrophe financing instruments such as reinsurance and a new outlet for investors wishing to better diversify their existing investment portfolio.”

Our belief is that more research on the topic is definitely warranted. Before investigating the correlation between catastrophe derivatives and the financial markets, the correlation between the occurrence of catastrophes and the returns on the financial markets should be examined. Although one example is not a proof, at this stage we would like to go back to the Barings bankruptcy studied in the derivatives debacles section of this paper and to the Great Hanshin Earthquake in Kobe mentioned when we introduced catastrophes. We saw that, in addition to being long futures, Barings was short in a straddle on the Nikkei 225. This position only paid when there was little or no volatility in the Nikkei. Without establishing causal relationships, we would like to state the following facts. There were 2,782 trading days between January 4, 1984 and January 22, 1995. The average daily standard deviation of the return on the Nikkei 225 over that period was 1.3%. On 23 occasions, standard deviations greater than three times 1.3% were observed, and on 21 occasions standard deviations were inferior to three times –1.3%. In other words, only

1.6% of the time in eleven years did the magnitude of the daily return on the Nikkei 225 exceed three standard deviations. On January 17, 1995, an earthquake affected Kobe and caused economic damage evaluated to be around US$75 billion in Japan. On January 23, 1995, the Nikkei 225 was down 5.6%, or 4.2 standard deviations. On February 26, 1995, Barings could not sustain its Nikkei 225 derivatives losses and announced its bankruptcy.

The purpose of the previous example was to highlight that, on one occasion, a severe catastrophe struck, and a few days later the stock market in that country exhibited an extreme shock. This, combined with other factors, affected a major portfolio dramatically. Fortunately, the portfolio was not long Japanese earthquake CAT bonds. Was the described situation due to total randomness? Or was there correlation between the earthquake and the stock market decline? We propose that this question be studied deeply, not only in this particular situation, but for a comprehensive list of catastrophes. Only after such an empirical study is conducted could we conclude on the correlation of catastrophes with financial markets.

CORRELATION BETWEEN CATASTROPHES DERIVATIVES AND FINANCIAL MARKETS

"...PCS options are a new, zero-beta asset class. The price movements of PCS options show no correlation with those of stocks and bonds. Stock and bond portfolios can thus use PCS options to diversify risk"

-Chicago Board of Trade

For portfolio construction, in addition to historical correlation, we have to ask the question as to what happens to a portfolio that holds catastrophe risk once a catastrophe strikes. Not only is the catastrophe-linked component likely to default, but the dynamics between the other components of the portfolio, that it the whole variance-covariance matrix, will be altered. This will make ex-ante optimal portfolios ex-post inefficient. This is what should be measured in an empirical study. There have been enough catastrophes lately for the aftermath of each of them on the companies in the affected geographical area to be studied. In terms of a framework for analysis, the area of research on contagion in international finance could serve as a starting point and be adapted to catastrophe situations.

Forbes and Rigobon [1999] discuss the theory of contagion in international finance. Stock market contagion is taken to mean that cross-market correlations increase during a period of crisis. This concept, adapted to catastrophes, would imply that the correlation between the returns on assets of a portfolio comprising both catastrophe derivatives and other securities, stocks for example, would increase as a result of the materialisation of a catastrophe. However, in international finance, Forbes and Rigobon [1999] explain that standard correlation coefficients are conditional on market movements over the period being studied, which means that, during a crisis, estimates of correlation are biased upward, and that the coefficients need to be adjusted.

Measuring contagion in the Forbes and Rigobon [1999] framework is done by comparing the correlation between two markets during a period deemed stable to the correlation during a period of turmoil. If there is a significant increase in the correlation during the period of turmoil, there is contagion. But if the level remains high without significantly increasing, there are strong real linkages between the two markets. This is called interdependence. Forbes and Rigobon [1999] maintain that "contagion implies that cross-market linkages are fundamentally different after a shock to one market, while interdependence implies no significant change in cross-market relationships."

Forbes and Rigobon [1999] enumerate three main mechanisms identified in work on international propagation of shocks:

1. Aggregate shocks affecting economic fundamentals of more than one country;
2. Country-specific shocks affecting economic fundamentals of other countries;
3. Shocks not explained by fundamentals.

Forbes and Rigobon [1999] explain that the third mechanism is contagion. By definition, contagion is treated as the residual, since it is meant to be what does not fit into mechanisms 1 and 2. In other words, there is the possibility to believe in contagion when in reality we are missing out on the real links between economies. Contagion is explained by many theories: multiple equilibrium, capital market liquidity, investor psychology, and political economy. All these theories reach the same conclusion: cross-market linkages during a crisis differ from linkages during stable periods. More particularly, the mechanism is strengthened during crises, and this is not due to real economic linkages. Contagion would be observed when there is a significant change in the variance-covariance matrix of returns during a turmoil episode.

With respect to the adjustments required to correlation estimates in contagion situations, Forbes and Rigobon [1999] explain that "The estimated correlation coefficient between x and y will increase when the variance of x increases even if the actual correlation between x and y does not changes. This standard, unadjusted correlation coefficient is conditional on the variance of x." When there is increased volatility, estimates of correlation will be greater than the true correlation, so there needs to be an adjustment for the increase in variance of x. Otherwise we will conclude to contagion when there is none. This leads Forbes and Rigobon [1999] to emphasize the fact that high cross-market correlations do not imply contagion, since stock markets also exhibit high correlation during periods of relative stability. In other words, international stock markets are highly interdependent, both in periods of stability and turmoil. They are closely linked due to fundamentals such as trade and other real economic factors. This is why a continued high level of interdependence after a crisis cannot be called contagion.

The application of the contagion theory to portfolios formed before a catastrophe would help us understand how the portfolio reacts to a catastrophe. We will illustrate by way of example a situation where such knowledge would be useful. Let us take the example of a bank. Banks must comply with much external regulation. Consequently, they have strict internal regulation. For risk management, they use value-at-risk analysis combined with stress testing scenarios. They must ensure that all the positions taken by their traders comply with the limits they have set. If one trader want to buy catastrophe derivatives, the bank will first want to know how much it stands to loose on the derivatives. Next, it will want to investigate the relationship between its other portfolios and the catastrophe portfolio. It is important for the bank to be aware of the impact one earthquake in Japan can have simultaneously on its catastrophe portfolio and its Japanese stock portfolio.

This section emphasized the importance of being able to quantify the relationship between capital markets, catastrophes, and catastrophe derivatives. We believe that much work remains to be done to establish the correlation between catastrophes and the capital markets, and catastrophe derivatives and the capital markets. Furthermore, we suggest that the theory of contagion be applied to catastrophe portfolios, thereby clarifying the behaviour of assets affected by catastrophes. Once these issues are resolved, we should expect to see more banks and other market operators trade more catastrophe derivatives, and their secondary market could become liquid.

POST MORTEM

Traditionally, the insurance market evolved separately from the capital market. Recently, however, these two markets began to converge. New hybrid securities were created that incorporated features from both industries. Catastrophe derivatives, indeed, are rooted in the capital markets, in which they are seen as a complex and innovative product. Yet, they can also be seen as a natural extension of reinsurance contracts. There have been many potential drivers behind the growth of catastrophe derivatives. Some will argue that the reinsurance industry was unable to face the eventuality of a super catastrophe and needed to be rescued by the capital markets. Others will rather maintain that the large catastrophes of the early 1990s stimulated the imagination of investment bankers and exchange executives and led them to create unsolicited derivatives. In studying the evolution of catastrophe derivatives, one must first recognise that its sources of information come from two separate universes, each with a different background and perspective on the same object of attention.

Given this duality, it is not surprising that the first attempts at trading catastrophe insurance risk derivatives on an exchange have known little success. In the reinsurance industry, each transaction is customized, not only to each client, but to particular aspects or sub-segments of a given exposure. On exchanges, the products are highly standardised and frequently traded. Yet, the listed catastrophe options derived their values from insurance loss indices whose values were not known in a timely fashion, a difficulty from the capital market community's standpoint, and the indices were built using industry-wide estimates, introducing basis risk for each insurance company considering them.

Against this backdrop, the absence of an accepted unifying framework justified this paper. At the early stages of this research, the author realised that very few of the available articles were published in academic journals. The bulk of the documentation on catastrophe risk either came from reinsurance companies or from finance professors' working papers. The objective driving the current paper was therefore to gather as much objective information as possible on the insurance, reinsurance, and capital markets separately, with respect to their treatment of catastrophe risk. It was attempted to provide a framework for understanding the parallel but converging trajectories of both industries, and to provide sufficient background information for empirical research on catastrophe risk.

Initially, this paper made the point that risk can only be transferred when the party incurring it is aware of it. This brought us to review the derivatives debacles of the early 1990s, the ensuing derivatives regulation and risk management theories, the advent of catastrophes causing ever-larger losses to the insurance industry, and the situation of the various stakeholders in catastrophe situations.

Next, we highlighted the peculiarities of catastrophe risk. The first element we discussed was the emergence of event risk, a risk that is best described as low frequency – high severity, which implies limited data and even more limited pricing models. Not surprisingly, the market for catastrophe risk derivatives is still thin, and many market operators face constraints when trading and wanting to hold those securities.

Then, we studied the various forms of contracting under which catastrophe risk is transferred. We presented mortgage-backed securities as an ancestor of catastrophe bonds, since mortgage-backed securities showed that highly complex securities could reach a stage of liquidity and maturity, provided it is possible to calculate their price transparently. We also studied traditional reinsurance contracts as tailored products to catastrophe risk, and alternative risk transfer products that were developed by the reinsurance industry to answer insurers' requests for tools that combined both insurance and financial risk transfer. Finally, we presented three broad classes of catastrophe derivatives, divided as index-based, indemnified-based, and parametric contracts. We hinted that parametric contracts were superior in design to index-based contracts, since the value of their trigger is unaffected by computation delay problems, and superior to indemnified-based contracts, in that they eliminate all moral hazard issues.

Which direction will the transfer of catastrophe risk take next? This is something that we cannot answer. However, we believe that catastrophe risk and catastrophe derivatives will keep on existing and having to be managed. Traditional risk management tools like value-at-risk might prove poor at dealing with catastrophe risk derivatives, given the fact that catastrophes are extreme events whose worse downsides fall beyond the scope of value-at-risk models. Furthermore, while stress testing scenarios are more suited to deal with extreme events, the absence of information on the response of catastrophe derivatives to catastrophe situations or other market shocks will make these scenarios difficult to assess.

Nevertheless, it is our belief that catastrophe derivatives are a growing segment of both the capital markets and the insurance and reinsurance markets. For this reason, we suggest that two questions be the object of further study. First, we think that the relationship between the occurrence of catastrophes and stock market returns in the areas affected by catastrophes warrants deep consideration. Second, we suggest the application of the contagion theory to the study of the reactions to catastrophes of portfolios that include both catastrophe derivatives and other assets. Work on these two different questions should help improving our understanding of catastrophe risk, and by way of consequence, the efficiency of its transfer to the capital markets.

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APPENDIX

APPENDIX 1 - SUMMARY OF SELECTED ACCOUNTING AND REGULATORY STATEMENTS

N°	Date	Content
FASB 5	03/1975	**Accounting for Contingencies** Accrual for general or unspecified business risks (reserves for general contingencies) are no longer permitted. Insurance companies cannot treat anticipated losses as a liability, i.e. catastrophe premiums cannot be isolated for catastrophe losses. Premium earnings are taxed at regular corporate income tax rates.
FASB 52	12/1981	**Foreign Currency Translation** Adjustment for currency exchange rate changes are excluded from net income for those fluctuations that do not impact cash flows and are included for those that do. Contracts, transactions, or balances that are effective hedges of foreign exchange risk will be accounted for as hedges without regard to their form.
FASB 80	08/1984	**Accounting for Futures Contracts** A change in the market value of an open futures contract is to be recognised as a gain or loss in the period of the change unless the contract qualifies as a hedge of certain exposures to price or interest rate risk. Immediate gain or loss recognition is required if the futures contract is intended to hedge an item that is reported at fair value. Effective for contracts entered into after December 31, 1984.

FASB 105	03/1990	**Disclosure of Information about Financial Instruments with Off-Balance-Sheet Risk and Financial Instruments with Concentrations of Credit Risk** All entities are to disclose the following information about financial instruments with off-balance-sheet risk of accounting loss: The face, contract, or notional principal amount. The nature and terms of the instruments and a discussion of their credit and market risk, cash requirements, and related accounting policies. The accounting loss the entity would incur if any party to the financial instrument failed completely to perform according to the terms of the contract and the collateral or other security, if any, for the amount due proved to be of no value to the entity. The entity's policy for requiring collateral or other security on financial instruments it accepts and a description of collateral on instruments presently held. Disclosure is also required regarding information about significant concentrations of credit risk from an individual counter-party or groups of counter-parties for all financial instruments. Effective for financial statements issued for fiscal years ending after June 15, 1990.
FASB 107	12/1991	**Disclosure about Fair Values of Financial Instruments** All entities are to disclose the fair value of financial instruments, both assets and liabilities recognised and not recognised in the statement of financial

		position, for which it is practicable to estimate fair value. Effective for financial statements issued for fiscal years ending after December 15, 1992, except for entities with less than $150 million in total assets in the current statement of financial position. For those entities, the effective date is for fiscal years ending after December 15, 1995.
FASB 113	12/1992	**Accounting and Reporting for Reinsurance of Short-Duration and Long-Duration Contracts** This statement eliminates the practice by insurance enterprises of reporting assets and liabilities relating to reinsured contracts net of the effects of reinsurance. It requires reinsurance receivables (including amounts related to claims incurred but not reported and liabilities for future policy benefits) and prepaid reinsurance premiums to be reported as assets. Estimated reinsurance receivables are recognized in a manner consistent with the liabilities relating to the underlying reinsured contracts. In order to be recognised as a reinsurance contract in a balance sheet or profit and loss account prepared in conformity with US GAAP, a contract must transfer a significant measure of both underwriting risk and timing risk, i.e. the timing risk alone is no longer sufficient[87]. Applies to financial statements for fiscal years beginning after December 15, 1992.

[87] Sigma No.5/1997.

FASB 115	05/1993	**Accounting for Certain Investments in Debt and Equity Securities** This statement applies to investments in equity securities that have readily determinable fair values and to all investments in debt securities. Debt securities that the enterprise has the positive intent and ability to hold to maturity are classified as held-to-maturity securities and reported at amortised cost. Debt and equity securities that are bought and held principally for the purpose of selling them in the near term are classified as trading securities and reported at fair value, with unrealized gains and losses included in earnings. Debt and equity securities not classified as held-to-maturity securities or trading securities are classified as available-for-sale securities and reported at fair values, with unrealized gains and losses excluded from earnings and reported in a separate component of shareholders' equity. Effective for fiscal years beginning after December 15, 1993.
FASB 119	10/1994	**Disclosure about Derivative Financial Instruments and Fair Value of Financial Instruments** This statement requires disclosure about amounts, nature, and terms of derivative financial instruments that are not subject to statement 105 because they do not result in off-balance-sheet risk of accounting loss. A distinction must be made between financial instruments held or issued for trading purposes and those held or issued for other purposes. Average fair value and net trading gains or losses for derivatives held or issued for trading purposes must be disclosed.

For derivatives held or issued for non-trading purposes, disclosure about the purposes and about how the instruments are reported in financial statements is required.

For entities that hold or issue derivatives and account for them as hedges of anticipated transactions, disclosure is required about the anticipated transactions, the classes of derivatives used to hedge the transactions, the amounts of hedging gains and losses deferred, and the transactions or other events that result in recognition of the deferred gains or losses in earnings.

Statement 105 is amended to require separation of information about financial instruments with off-balance-sheet risk of accounting loss by class, business activity, risk, or other category that is consistent with the entity's management of those instruments.

Statement 107 is amended to require that fair value information be presented without combining, aggregating, or netting the fair value of derivative financial instruments with the fair value of non-derivative financial instruments and be presented together with the related carrying amounts in the body of the financial instruments, a single footnote, or a summary table in a form that makes it clear whether the amount represents assets or liabilities.

Effective for financial statements issued after December 15, 1994, except for entities with less than $150 million in total assets. For those entities, effective for fiscal years ending after December 15, 1995.

FASB 126	12/1996	**Exemption from Certain Required Disclosures about Financial Instruments for Certain Non-public Entities – an Amendment of FASB Statement no. 107** Disclosures about fair value of financial instruments prescribed in statement 107 is optional for entities that meet all of the following criteria: The entity is non-public. The entity's total assets are less than $100 million on the date of the financial statements. The entity has not held or issued any derivative financial instruments, as defined in statement 119, other than loan commitments, during this reporting period. Effective for fiscal years ending after December 15, 1996.
FASB 133	06/1998	**Accounting for Derivative Instruments and Hedging Activities** Entities are required to recognise all derivatives as either assets or liabilities in the statement of financial position and to measure those instruments at fair value. The accounting for changes in the fair value of a derivative depends on the intended use of the derivative and resulting designation. For a derivative designated as hedging the exposure to changes in the fair value of a recognised asset or liability or a firm commitment, the gain or loss is recognised in earnings in the period of change together with the offsetting loss or gain on the hedged item attributable to the risk being hedged. The effect of that accounting is to reflect in earnings the extent to which the hedge

is not effective in achieving offsetting changes in fair value.

For a derivative designated as hedging the exposure to variable cash flows of a forecasted transaction, the effective portion of the derivative's gain or loss is initially reported as a component of other comprehensive income (outside earnings) and subsequently reclassified into earnings when the forecasted transaction affects earnings. The ineffective portion of the gain or loss is reported in earnings immediately.

For a derivative designated as hedging the foreign currency exposure of a net investment in a foreign operation, the gain or loss is reported in other comprehensive income as part of the cumulative translation adjustment. The accounting for a fair value hedge described above applies to a derivative designated as a hedge of the foreign currency exposure of an unrecognised firm commitment or an available-for-sale security. Similarly, the accounting for a cash flow hedge described above applies to a derivative designated as a hedge of the foreign currency exposure of a foreign-currency-denominated forecasted transaction.

For a derivative not designated as a hedging instrument, the gain or loss is recognised in earnings in the period of change.

This statement amends statement 52 to permit special accounting for a hedge of a foreign currency forecasted transaction with a derivative. It supersedes statements 80, 105, and 119. It amends statement 107 to include in it the disclosure provisions about concentration of credit risk from statement 105.

Effective for all fiscal quarters of fiscal years beginning after June 15, 1999.

FASB 137	06/1999	**Accounting for Derivatives Instruments and Hedging Activities – Deferral of the Effective Date of FASB Statement No. 133 – An Amendment of FASB Statement 133** Statement 133 is deferred.
NAIC 103	02/2000	**Statutory Issue Paper No. 103 - Accounting for the Issuance of Insurance-Linked Securities Issued by a Property and Casualty Insurer through a Protected Cell** Insurance–linked securities are fully funded corporate securities with special language that requires the securityholder to forgive or defer some or all payments of interest or principal if actual insurance losses surpass a specified amount, or trigger event. Should a triggering event occur, an insurer or reinsurer that issued insurance-linked securities can pay claims with all or a portion of the securityholder proceeds. To the extent that securityholders proceeds are at risk of loss, the insurer or reinsurer can write down its liability for the securities, and recognize a surplus benefit in an equal amount. Chapter 1 of the Accounting Practices and Procedures Manual for Property/Casualty Insurance Companies does not specifically address accounting for the issuers of insurance-linked securities issued through a protected cell. Financial Accounting Standards Board (FASB) Statement of Financial Accounting Standards No. 133 - Accounting for Derivative Instruments and Hedging Activities (FAS 133) dictates that these types of contracts would be accounted for as reinsurance. The purpose of this issue paper is to provide guidance for protected cells that

is consistent with the Statutory Accounting Principles Statement of Concepts and Statutory Hierarchy (Statement of Concepts).

The Protected Cell Model Act (included in its entirety in the Relevant Statutory Accounting and GAAP Guidance section) includes a complete listing of definitions used in this issue paper.

An insurance-linked security can be issued by the insurer through a protected cell for purchase by investors. A protected cell is retained within the insurance or reinsurance company and is used to insulate the proceeds of the securities offering from the general business risks of the insurer, granting an additional comfort level for investors of the securitized instrument. The insurance exposures that have been securitized by the insurance-linked security are attributed to the protected cell.

Under the terms of the security, the principal may be paid to the investor on a specified maturity date, with interest, unless a trigger event occurs. The proceeds of the security offering will collateralize (i) the issuer's obligation under an insurance or reinsurance agreement if a trigger event occurs and (ii) the issuer's obligation to repay the security if a trigger event does not occur.

If the trigger event takes place before a specified date, the issuer is relieved of some or its entire obligation to repay the securityholders, and the investor incurs a loss of some or all of its investment. The security must be issued with an indemnity trigger.

In an insurance-linked security, the insurer that originated the transaction has hedged its portfolio of insurance risks by transferring certain of those risks to the securityholders. Should the triggering event occur, the issuer would incur a loss that would be partly offset by the amount of liability to securityholders from which it is relieved. This issue paper provides statutory accounting guidance solely for indemnity triggered insurance securitization transactions conducted through a protected cell.

Accounting for Prefunded Insurance-Linked Securities for Business Attributed to the Protected Cell from the General Account

Activities such as sales, underwriting and contract administration, premium collection and payment of premium taxes, and claims processing are activities of the insurance company distinct from the protected cell and shall be accounted for as transactions of the general account.

Amounts paid to the protected cell for underwriting risks, which ultimately will be securitized by the protected cell, shall be reported separately as a reduction of written and earned premiums in the current period general account's statement of income. This premium is earned by the general account in accordance with Issue Paper No. 53 – Property Casualty Contracts–Premiums.

At the maturity of the protected cell all assets and liabilities of the protected cell are distributed based on the contractual agreement with the securityholders. If after this distribution assets still reside in the protected cell, these assets shall be attributed to the general account and recognized as an adjustment to surplus.

Insurance claim liabilities arising from past insurable events attributed to the protected cell account from the general account shall be accounted for as retro-active reinsurance as prescribed in Issue Paper No. 75 – Property and Casualty Reinsurance.

General account recoverables from the protected cell as a result of an indemnity based securitized event, shall be recognized separately as a reduction of gross losses and loss expenses incurred in the current period general account's statement of income. General account recoverables from the protected cell on unpaid reported and incurred but not reported losses and loss adjustment expenses shall be netted against the liability for gross losses and loss adjustment expenses in the general account's balance sheet. Recoverables from the protected cell shall not exceed the assets carried at fair value in the protected cell.

The general account shall include an aggregate write-in for the total assets and an aggregate write-in for liabilities of any protected cell which it maintains. Transfers to the general account due or accrued shall be reported on a net basis so that the asset and the liability totals of the general account are not overstated.

The protected cell annual statement is concerned with the investment activities and obligations relating to insurance-linked securities attributed to that protected cell. As a result, the protected cell statement shall report only the financial activities of the protected cell and shall not include general account expenses related to insurance activities which are recorded for in the general account.

The protected cell shall record premium income for transactions attributed to it by the general account as income reported in the protected cell's statement of income. This premium attribution is earned by the protected cell in accordance with Issue Paper No. 53 - Property and Casualty Premium.

The obligation from the issuance of the insurance-linked security are recorded as Funds Held Under Securitization Agreement, a liability on the protected cell balance sheet which is reported at its contractual or discounted value using a rate consistent with the invested assets of the protected cell. All protected cell assets shall be reported at fair value. Interest expenses payable to securityholders associated with the protected cell investment operations shall be deducted in the determination of net operating income of the cell. Net investment income and realized capital gains and losses relating to the investment operations of the protected cell are recorded as net investment income. Payables to the general account shall not exceed the assets carried at fair value in the protected cell.

Changes in both (i.) the fair value of the protected cell invested assets and (ii.) the protected cell contractual (or discounted) value of liabilities to investors shall be reported as an unrealized gain/loss in the equity section of the protected cell balance sheet.

When the trigger event occurs with respect to the underlying exposures attributed to the protected cell, the protected cell shall record the appropriate incurred losses in its current period statement of income. Correspondingly, the Funds Held Under Securitization Agreement shall be reduced and offset by gross losses incurred in the current period Statement of Income. The applicable funds to cover the subject exposure are then attributed to the general account via a balance sheet account, "Due to/from the General Account."

If the trigger event does not take place on or before the contractual maturity date, the protected cell repays the bond principal as prescribed in the debt contract by reducing Funds Held Under Securitization Agreement.

General Account

Prior to the adoption of formal blanks changes by the NAIC Blanks Task Force, the general account shall reflect all activities with its protected cells as an aggregate write-in in its statutory balance sheet and income statement. The general account shall also disclose in its notes to the financial statements the types and amounts of exposures /risks attributed to each of its protected cells.

Each protected cell of a protected cell company shall prepare and submit to all states where the protected cell company is licensed and the NAIC the following supplemental financial information:

a. Balance Sheet

b. Income Statement

c. Statement of Cash Flows

d. Investment Schedules as typically required for a property/casualty insurer

e. Schedule P

FASB 138	06/2000	**Accounting for Certain Derivative Instruments and Certain Hedging Activities - An Amendment of FASB Statement No. 133** FASB Statement No. 133, Accounting for Derivative Instruments and Hedging Activities, establishes accounting and reporting standards for derivative instruments, including certain derivative instruments embedded in other contracts, (collectively referred to as derivatives) and for hedging activities. This Statement addresses a limited number of issues causing implementation difficulties for numerous entities that apply Statement 133. This Statement amends the accounting and reporting standards of Statement 133 for certain derivative instruments and certain hedging activities as indicated below. -The normal purchases and normal sales exception in paragraph 10(b) may be applied to contracts that implicitly or explicitly permit net settlement, as discussed in paragraphs 9(a) and 57(c)(1), and contracts that have a market mechanism to facilitate net settlement, as discussed in paragraphs 9(b) and 57(c)(2). -The specific risks that can be identified as the hedged risk are redefined so that in a hedge of interest rate risk, the risk of changes in the benchmark interest rate would be the hedged risk. -Recognized foreign-currency-denominated assets and liabilities for which a foreign currency transaction gain or loss is recognized in earnings under the provisions of paragraph 15 of FASB Statement No. 52, Foreign Currency Translation, may be the hedged item in fair value hedges or cash flow hedges.

-Certain inter-company derivatives may be designated as the hedging instruments in cash flow hedges of foreign currency risk in the consolidated financial statements if those inter-company derivatives are offset by unrelated third-party contracts on a net basis. This Statement also amends Statement 133 for decisions made by the Board relating to the Derivatives Implementation Group (DIG) process. Certain decisions arising from the DIG process that required specific amendments to Statement 133 are incorporated in this Statement.

For an entity that has not adopted Statement 133 before June 15, 2000, this Statement shall be adopted concurrently with Statement 133 according to the provisions of paragraph 48 of Statement 133.

For an entity that has adopted Statement 133 prior to June 15, 2000, this Statement shall be effective for all fiscal quarters beginning after June 15, 2000, in accordance with the following transition provisions.

-At the date of initial application, an entity may elect to derecognise in the balance sheet any derivative instrument that would qualify under this Statement as a normal purchases or normal sales contract and record a cumulative effect of a change in accounting principle as described in paragraph 20 of APB Opinion No. 20, Accounting Changes. The election to derecognise may not be applied to only some of an entity's normal purchases and normal sales contracts and must be applied on an all-or-none basis. That election to derecognise a derivative instrument may be applied retroactively to the beginning of any fiscal quarter for which interim financial information or financial statements have not been issued.

-At the date of initial application, an entity must dedesignate the market interest rate as the hedged risk in a hedge of interest rate risk. An entity is permitted to designate anew the benchmark interest rate as the hedged risk in a hedge of interest rate risk.

-At the date of initial application, an entity may designate a recognized foreign-currency-denominated asset or liability as the hedged item in a hedge of foreign exchange risk pursuant to paragraphs 21 and 29 of Statement 133, as amended by this Statement. An entity may also designate inter-company derivatives that meet the requirements in paragraph 4(l) of this Statement (paragraphs 40A and 40B of Statement 133) as hedging instruments in cash flow hedges of foreign exchange risk when those inter-company derivatives have been offset on only a net basis with third-party derivatives. Any designations permitted by this subparagraph shall be made on a prospective basis.

APPENDIX 2 - LIST OF STRUCTURED CATASTROPHE INSURANCE RISK TRANSACTIONS

Issue Date and Maturity	Issuer	Underwriter	Product Type	Insured Perils	Issue Amount	Trigger	Coupon in bps	Default Probability	Comments
Prior to 1995 For 3 years	Normandy Re	-	Bond	-	US25M+	PCS Index	-	1%	Deal not closed
1995	Nationwide Mutual Insurance Company	-	Contingent surplus notes	-	US$400M	-	-	-	-
May 1996 For 20 months	AIG PX Re	-	-	-	US$10M	Index	0	25%	-
November 1996 For 4 years	California Earthquake Authority	-	Bond	California Earthquakes	US$1.5B	-	LIBOR+1075	1.27%	Failed and replaced with reinsurance from National Indemnity of the Berkshire Hathaway group

August 6 to December 31, 1996 + 6 months for development	ACE Ltd	Goldman Sachs	Bond	Hurricanes, Earthquakes USA	US$25M	PCS Index US$25B	6-month T-Bill + 550	1.34%	Unsuccessful, withdrawn
August 1, 1996 to July 1, 1997 + 6 months for development	USAA (United Services Automobile Association)	Merril Lynch	Bond	Hurricanes in Texas, Gulfcoast, East Coast of US	US$500M	USAA's Losses US$1B	1-month LIBOR + 300	1%	Unsuccessful, withdrawn
August 7, 1996 for 5 Month 6 months for development	CAT Ltd	Morgan Stanley	Bond	Hurricanes Northeast of US	US$50 M	CAT Ltd's Losses US$55M	672	1.10%	Unsuccessful
December 1996 Notes 11 years Preferred Shares 3 years	St. Paul Reinsurance Co Ltd	-	Notes and Preferred Shares	-	Notes: US$44.5M Preferred Shares: US$24M Total US$68M	-	Notes: 617 Preferred Shares: 1415	Various	SPV Georgetown Re from Cayman Islands

December 1996 For 5 years	Hannover Re	Citibank	Swap	Earthquake, Wind, in Japan, Australia, Canada, Europe, and Worldwide aviation	US$100M	Various PCS, Sigma	50% of profit	20%	-
February 28, 1997 For 3 years	Winterthur	Crédit Suisse First Boston	Bond	Hailstorms, Switzerland	CHF 399.5M	Number of insured vehicles damaged from a single hail storm or storm with winds in excess of 75 km/h in excess of 6,000 on one given day	225	No risk on the principal, but coupon is subject to trigger excess (20%)	Bond convertible into Winterthur equity

March 1997	Reliance National	SedgwickLane Financial	Bond	All perils affecting aviation, marine, satellite and worldwide property	US$40M	Various, Sigma	-	-	-
April 1997	Horace Mann	Aon	Contingent capital	-	US$100M	-	-	-	-
April 1997 For 16 months	Reliance National	Sedgwick Lane Financial	Note	Various risks	US$10M	Index	LIBOR+900	15%	-

June 1997	USAA	Merril Lynch	Bond	Homeowner	Tranche A-1	USAA's actual	A1-	A1- 0%	SPV
Tranche A-1 for		Goldman Sachs		losses from	US$164M	losses	LIBOR+273	Interest only is	Residential Re
1 year principal		Lehman		single	100% protected			at risk	from the
extendable 10		Brothers		hurricane, US	US$87M	A1- US$1B	A2 –	Rated AAAr,	Cayman Islands
years from				East Coast,	variable	A2- US$1B	LIBOR + 576	Aaa, AAA.	Tranche A-1
December 16,				Texas,	US$77M				raised
1998 to				Gulfcoast	protected			A2- 1%	US$86.8M risk
December 15,								Interest and	capital
2008.					Tranche A-2			principal are at	USAA
Tranche A-2 for					US$313M			risk, rated	coinsurance
1 year from					0% protected			below	20%
June 16, 1997					100% variable			investment	Protection for
to June 14,								grade BB, Ba.	80% of
1998.					Total size				US$500M layer
Extended					US$477M				in excess of
claims period									US$1B
from June 15,									No
1998 to									reinstatement
December 15,									
1998.									

August 1997	La Salle Re	Aon Re European Re Allianz, CNA	Contingent capital	CAT exposure, USA	US$100M	-	-	-	-
August 1997 For 2 years	Swiss Re	CSFB Swiss Re Capital Markets	Bond	Single California Earthquake	Tranche A: US$62M 40% Protected of which A1 US$42M A2 US$20M Tranche B: US$60M 0% protected Tranche C: US$15M 0% protected Total US$137M	PCS industry loss index A: US$18.5B, US$21B, US$24B B: US$18.5B, US$21B, US$24B C: US$12B	A1- LIBOR+519 A2- LIBOR+255 B- 864.5 C- 1049.3	A: 1%, Partial principal and interest at risk, rated investment grade B: 1%, Principal and interest at risk, rated below investment grade C: 1%, Principal and interest at risk, rated below inv estment grade	SPV SR Earthquake Fund from Cayman Islands Tranche A raised US$37.2M risk capital

December 1997 For 10 years	Tokio Marine & Fire	Swiss Re Capital Markets Goldman Sachs	Bond	Earthquake, Tokyo	Notes: US$80M, Ba2, fully exposed. Units: US$20M, Baa3, half exposed. Total issue US$100M	Magnitude of earthquakes around Tokyo	Notes: LIBOR+436 Units: LIBOR+206	Principal reduction depends upon trigger Notes 1.02% Units 1.02%	SPV Parametric Re from Cayman Islands Issue sold in North America and Europe
February 1998 For 9 months	Center Solutions I	Goldman Sachs Chase Securities Donaldson, Lufkin & Jenrette Zurich Capital Markets	Bond	Storms, Florida	US$83.57M of which A1 US$22.036M A2 US$61.533M	-	A1- LIBOR+182 A2- LIBOR+436	-	SPV Trinity Re

April 1998	Mitsui Marine & Fire	Swiss Re Capital Markets	Physical Trigger Swap	Earthquake, Tokyo	US$30M	-	LIBOR+375	-	-
April 1998	Hannover Re	Rabobank	Bond	Life, acquisition costs	DEM 100M	-	-	-	-
May 1998	Reliance National	Sedgwick Lane Financial	Optional Note	Various risk categories	US$20-40M	-	-	-	-
June 1998 For 11 months Extended claims period 6 months No defeasance of principal	USAA	Merrill Lynch Goldman Sachs Lehman Brothers	Bond	Hurricanes, US East Coast	US$450M	USAA own losses	LIBOR+416 Rated BB	0.52%	SPV Residential Re from Cayman Islands USAA coinsurance 10% Coverage 90% of one single event between US$1B and US$1.5

June 1998	CNA	Hedge Financial	Bond/swap	Storms, US Northeast Coast	US$90M	-	-	-	-
July 1998 For 5 years Extendable two additional years	Yasuda Fire & Marine	Aon Capital Markets Munich Re	Bond	Storms, Japan	US$80M	Trigger 1: Yasuda typhoon losses over US$1.2B (60B yen) Trigger 2: Losses from further typhoon over 70B yen.	LIBOR+370	-	SPV Pacific Re, Cayman Islands
July 1998 For 1 year	US F&G Re 1	Goldman Sachs EW Blanche Capital Markets	XOL Bond/swap	Wind + earhquake, USA	1: US$60M 2: US$60M	-	1: LIBOR+550 2: LIBOR+250	0.52%	SPV Mosaic Re
July 1998	US client	Axa-Paribas ARF	Option	Earthquake, California	US$21M	-	-	-	-

August 1998	XL Mid-Ocean	Aon Guy Carpenter Goldman Sachs Merrill Lynch Lehman Brothers	Swap	Earthquake, USA, Storms, Caribbean	US$200M	-	-	-	-
August 22 1998 for 1 year	Constitution Re	Swiss Re New Markets	Basis swap	Storms, USA East Coast	US$10M	Constitution Re losses over the year and Industry losses over the year	-	-	-
September 1998	US client	Axa-Paribas ARF	Option	Earthquake, USA	US$25M	-	-	-	-
December 1998	Allianz	Allianz Risk Transfer Goldman Sachs	Bond Option	Wind and hailstorms, Germany	US$150M	-	-	Principal and interest at risk for three years after trigger excess	SPV Gemini Re from Cayman Islands

December 1998	Center Solutions 2	Goldman Sachs Chase Securities Donaldson, Lufkin & Jenrette Zurich Capital Markets	Bond	Storms, Florida	US$54M	-	-	-	-
1998	Toyota Motor	Goldman Sachs	Bond	Auto residual value	US$566M	-	-	-	-
1998	Freddie Mac	Morgan Stanley Dean Witter	Bond	Mortgage loans	US$243M	-	-	-	-
1998	National Provident Institution	SBC Warburg Dillon Read Goldman Sachs Dresdner Kleinwort Benson	Bond	Liffe, embedded value	GBP260M	-	-	-	-

January 1999	US F&G Re 2	Goldman Sachs EW Blanche Capital Markets	Bond	CAT risks	US$50M	-	-	-	-
April 1999 For 3 years	Kemper Insurance Co	AON Capital Markets	Notes	Midwestern earthquake risk	US$100M	-	-	Rated BB+	SPV Domestic Inc, First domestic (Illinois) catastrophe risk securitisation
May 13, 1999 Notes for 5 years Floating rate extendible bond for 3, 4 or 5 years	Oriental Land	Goldman Sachs	Earthquake notes and Earthquake bond	Earthquake around Maihama	Notes: US$100M Bond: US$100M	Epicentre 10km from Maihama, Magnitude over 6.5 on Richter scale, or 50km and 7.1, or 75km and 7.6.	Notes: LIBOR+310, rated BB Bond: LIBOR+75	Investors lose from 25% to 100% of principal on notes notes depending on magnitude and location of earthquake	SPV concentric LTD, Cayman Islands, for the notes SPV Circle Maihama LTD, Cayman Islands, for the bonds

June 1, 1999 For 1 year Extendable claims period 6 months No principal defeasance	USAA	Goldman Sachs, Lehman Brothers, Merril Lynch	Bond	Single category 3, 4, or 5 hurricane in any of 20 pre-selected states or the District of Columbia	US$200M	USAA claims in excess of US$1B and less than US$1.5B from category 3, 4, or 5 storm on Saffir-Simpson Index	LIBOR+366 Rated BB	0.44%	SPV Residential Re from Cayman Islands
July 1999 For 3 years	Sorema SA	Merril Lynch AON Capital Markets	Notes, put and call options on notes	European windstorm, Japan typhoon, earthquake	US$17M	-	Annually adjusted rate	-	SPV Halyard Re BV, Netherlands
October 1999	Koch, Enron	-	Weather Bond	-	US$200M	-	-	-	-
November 1999 For 3 years	ACE Bermuda Insurance Ltd	-	Options sold to policyholders	Primary property	US$200M	-	-	-	-
December 1999 For 5 years, callable after 3 y at 101% of par	Gerling Globale Reinsurance Company	AON Capital Markets	Reinsurance notes	Japanese earthquake	US$100M	Portfolio index updatable every 6 months	LIBOR+450 Rated BB	-	Namazu Re Ltd, Cayman Islands