Innovative Financial Instruments for Natural Disaster Risk Management

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Foreword

Natural disasters that result in catastrophic losses of human lives and property catch the world's attention every year. The familiar scenes of death and destruction lead one to wonder how such devastation can ever be remedied. Yet such incidents occur and the rescue, relief and reconstruction efforts are well documented.

However, the public rarely, if ever, will know or understand how the damages from natural catastrophes are recuperated or reconstruction is actually financed. This report explains the various mechanisms and financial instruments used to share the risks associated with covering these losses.

Torben Andersen provides us with an in-depth explanation of how losses due to catastrophes are insured and who absorbs the costs of compensating the insured assets. This is an insider's primer on insurance, reinsurance and new capital market instruments that make it possible to continue to respond to the impacts of recurrent natural disasters.

The Inter-American Development Bank's Sustainable Development Department is undertaking further studies in the areas of financial planning and risk transfer that will help understand disaster risk transfer instruments that provide financial protection for the private and public sectors in Latin America and the Caribbean. The Bank's current action plan on natural disaster risk management emphasizes such issues as risk identification, mitigation measures, risk transfer and disaster preparedness. As part of the overall Bank strategy for comprehensive risk management, this document specifically focuses on new financial mechanisms and opportunities for catastrophe risk transfer.

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Contents

Executive Summary

Natural forces such as earthquakes, hurricanes and landslides often leave human and economic losses in their wake. Such hazards are considered natural disasters when they lead to extremely large losses, which typically is the case when they affect densely populated areas. They are not very frequent, but their effect on economic life can be devastating, and the aftermath calls for a painstaking reconstruction process. However, many developing countries take few precautions to lessen the impact of disasters and local insurance markets are unable to satisfy the risk financing requirements. As a consequence, the human costs of natural disasters are unevenly borne by the poorest countries in the world.

In the absence of well functioning local insurance markets, postdisaster rehabilitation depends on other funding sources. Often, local governments and foreign charities step in to assist in the recovery process, but this aid tends to reduce incentives to engage in prevention and insurance. In addition, postdisaster financing requirements can often divert funds from public capital budgets and disrupt long-term development investments.

The most common natural disasters in Latin America and the Caribbean are caused by flooding, hurricanes and earthquakes. The frequency and severity of these events are rising because people are settling and building in more exposed regions. Changes in climate patterns are also a contributing factor. Exposure to natural disasters is exacerbated by poor housing, weak building codes, lack of urban planning, and other problems related to land use planning. Much can be done at the national level to mitigate the economic effects of natural disasters by eliminating the above named potential problems. However, even the best risk management approaches leave residual exposure that may benefit from coverage through various risk financing arrangements.

In the absence of an effective insurance market, the government often becomes the *de facto* financier of postdisaster rehabilitation efforts. Alternatively, governments can encourage the local insurance industry to engage in risk financing arrangements through insurance pools that, in turn, may cover higher exposures in the global reinsurance and capital markets. This study takes a closer look at how this type of international risk financing scheme might be developed.

During the past decade, catastrophes have periodically strained the insurance industry's capacity to provide catastrophe risk insurance. Hence, new instruments were introduced to transfer and finance catastrophe risk exposures, such as catastrophe risk swaps and contingent capital and risk-linked securities that are placed through the global capital market. These instruments provide new risk financing opportunities for developing countries.

The first capital market instrument linked to catastrophe risk (called a catastrophe bond and, more commonly, a *cat-bond*) was introduced in 1994. . Risk-linked securities transactions have since become common; total cat-bond issuance is estimated at around US$6 billion. Other financial instruments provide outright funding commitments to recuperate economic losses from catastrophes. These contingent capital instruments have amounted to some US$8 billion.

Successful use of risk transfer instruments depends on the ability to effectively estimate the amount of risk involved. Based on calculations of risk and estimated loss impact, reinsurance companies and investment banks can assess the implied risk profile of insurance contracts and risk-linked financial instruments. The information may also help develop parametric insurance contracts that use "triggers" (such as earthquake magnitude, sea level rise or wave height, rainfall, etc.) to objectively indicate when damages would have to be covered.

Several issues need to be considered when choosing between different types of risk transfer instruments, including moral hazard, adverse selection and basis risk. *Moral hazard* takes place when the insured party neglects preventive measures after the risk transfer contract has been signed and resorts to excessive reporting of losses. *Adverse selection* takes place when the covered party uses inside knowledge about the insured exposure to obtain more favorable terms from the company issuing the risk transfer policy. *Basis risk* occurs when the measurement basis in the insurance contract differs significantly from the actual losses incurred as a result of the insured event. These factors influence the applicability of different risk transfer instruments.

This report summarizes various risk management approaches, which are not necessarily mutually exclusive. International agencies such as the IDB can help affected countries to put them to use in various ways, as explained below.

- *To cover catastrophe risk exposures in individual investment projects*. A project-based approach to manage catastrophe risk through mitigation or risk transfer, such as insurance, will reduce specific project exposures, but does not necessarily lead to better risk management practices across the country and the region.

- *To facilitate country risk management plans and establish cover for higher catastrophe risk layers*. Countrywide risk management plans would help mitigate risk and arrange risk transfer cover. The lower level risk layers identified by the government could be covered by tax-funded calamity funds as the main source for short-term disaster relief and rehabilitation. Cover for higher risk layers could be obtained through various risk transfer arrangements in the international financial markets, e.g., cat-bonds, risk-swaps, contingent capital, etc.

- *To establish national insurance pools*. These could be supported by mandatory insurance policies, if needed, and local insurance companies could act as national sales agents to support local market involvement. This would require that the government take stringent initiatives in risk mitigation, such as enforcing effective property registration and building codes. The insurance pool could cover parts of the higher risk layers in international financial markets through reinsurance contracts, risk-linked securities, contingent surplus notes, etc.

- *To combine risk exposures across several countries*. This could be achieved by pooling the catastrophe risk exposures across the region in order to provide a natural first line of risk diversification that also engages local primary insurance companies in the development of regional insurance markets. It might also provide scale economies to risk financing arrangements in the international financial markets.

Introduction

Natural disasters can cause immense damages to people, their productive assets and the overall economic infrastructure of entire regions. This may have adverse effects on economic development when catastrophic natural events strike densely populated areas with high concentrations of economic assets.[1] The pattern is recognizable across the world, but the economic effects have been most pronounced in developing countries where human and social vulnerability is high.[2] Due to better risk mitigation and insurance coverage the socioeconomic consequences are generally less dramatic in developing countries.

Several factors increased the concern for human and economic exposure to catastrophe risks. Climate patterns seem to be changing in ways that affect the frequency of disastrous natural events (such as hurricanes, windstorms, flooding, mudslides, etc.). In addition, economic assets are, more often than not, being built in exposed regions (Kleindorfer and Kunreuther, 1999). This combination of higher event frequency and an extended exposure to hazards increases the potential damage of natural catastrophes and poses a real challenge to sustainable economic development. In this scenario, the poorest population groups are often the most vulnerable to natural catastrophes (Charveriat, 2000). Low-income groups suffer significant casualties because the live in poor housing whose construction quality is low. Moreover, economic rehabilitation is further strained by the inadequacy of emergency shelters, health care facilities, and other such services.

Despite the growing concern about environmental risk exposure, less than one fourth of all losses emanating from natural disasters around the world are insured. Most insurance against the economic effects of natural catastrophes covers only private assets in developed countries, while the developing countries are left largely without committed financial coverage even in the private sector (Sigma 2, 2000; Guy Carpenter, 2000). Public assets, especially in large economies, are typically covered at the governmental level

The insurance environment in Latin America and the Caribbean has some fundamental weaknesses. For example, poor (or absent) enforcement of building codes and property titles and inadequate urban planning impede the viability of property insurance contracts. This means that basic and affordable property insurance policies are unavailable to the mass market, which is a prerequisite to achieving higher insurance coverage and lower premiums in the region. It is not foreseeable that the primary local insurance capacity in the region will be able to provide for substantially increased catastrophe risk coverage in the short run. At the same time, global insurance companies are gradually expanding their activities in Latin America and the Caribbean (Sigma 4, 2000).

Global insurance companies are expanding their activities to emerging markets, but focus mostly on the attractive high-growth life insurance market that provides relatively wealthy, high net worth individuals with future retirement income.[3] Therefore, most of the people and assets that are exposed to catastrophe risks have no financial coverage. Given this reality, it may be worth considering a more proactive use of alternative catastrophe risk transfer mechanisms.

[1] Natural events occur without any human interference and as such represent "acts of God." However, natural disaster risk is a function of two factors: the events and vulnerability. Purely man-made disasters such as terrorist attacks are not considered in this paper.

[2] In many cases, the official reporting of catastrophic events in developing countries does not provide estimates of the economic losses they cause. Hence, the statistical information on global catastrophe losses tends to underrepresent the true economic impact in developing countries.

[3] Life insurance premiums in Latin America typically range between 0.6 and 0.9 percent of gross domestic product (GDP) and grow by 10 to 25 percent per year. In contrast, nonlife insurance premiums typically range between 0.6 and 1.3 percent of the GDP and grow by 3 to 7 percent per year. This compares to nonlife indemnity insurance premiums in the United States of around 3 to 3.5 percent of the GDP.

Developing countries remain highly exposed to natural catastrophes, leaving them at the mercy of the philanthropic capacity of the international community when disasters strike. This situation appears less than optimal from economic, social and political perspectives, and inspires the search for alternative risk management techniques that may fuel ongoing poverty reduction efforts.

This report presents a general assessment of the potential for catastrophe risk transfer. It analyzes different ways in which risk transfer can take place, be it in the form of conventional reinsurance contracts or the newer derivative instruments and risk-linked securities. It also aims to evaluate the future potential for a combination of conventional insurance approaches and new alternative risk management instruments that can help provide financial coverage for catastrophe risk exposures.

Natural Disasters and Catastrophic Losses: Trends and Recent Developments

A natural disaster typically refers to an extreme event caused by a natural force or hazard, which overwhelms the response capability within a geographical area and seriously affects social and economic activity. Hence, a natural catastrophe can be defined as a natural force that causes many casualties and large economic losses. If insurance coverage is involved, these losses may threaten the solvency of individual insurance companies (Cutler and Zeckhauser, 1999).

Risk exposure associated with natural catastrophes is generally characterized by low frequency and high impact. However, the level of impact is very uncertain. Natural hazards are often categorized as windstorms, flooding, earthquakes, drought and wildfires, cold waves and frost, and other events such as hail and avalanches. Official registration of natural catastrophes requires a cutoff point determined either by a minimum number of casualties[4] or a minimum aggregate economic loss associated with the catastrophic events.[5] This enables comparable trend analysis of the statistical recordings over time, even if at times the data may provide somewhat conservative estimates of the true economic losses.

The highest insurance loss derived from a natural catastrophe remains the damages inflicted by Hurricane Andrew in the United States in 1992, which caused total losses of US$19 billion (measured in 1999 dollars). The enormous claims associated with this event exceeded the capital reserves of several engaged insurance companies and caused their collapse (Kunreuther, 1996). But, the insurance community realized that if the hurricane had taken just a slightly different path through the more populous areas of Miami, the total loss could have been two or three times higher. This realization had a sobering effect on the catastrophe risk insurance market and inspired the search for alternative ways to transfer catastrophe risk.

This potential increase in claims on catastrophe insurance contracts does not appear coincidental given that eight out of the ten most costly insurance losses from natural catastrophes (measured in constant 1999 dollars) took place within the last 10 years (see Table 1).

While the frequency of certain catastrophic events appears to be on the rise, the severity of the losses from natural disasters is also increasing. A major reason is that more and more people are living and building economic assets in areas that generally are more exposed to these hazards. The combination of a higher population density and infrastructure that is more exposed to natural hazards increases the severity of the resulting loss. This is not just a phenomenon characterizing loss exposure in the developed economies, it also captures the essence of the current situation in developing countries where new urban developments and infrastructure investments are similarly exposed to the effects of natural catastrophes.

Types of Natural Disasters

Almost 70 percent of all insured losses from natural catastrophes during 1999 resulted from windstorms, including hurricanes, typhoons and winter storms (Table 2).

Similarly, around 70 percent of the natural disasters in Latin America and the Caribbean occurring

[4] Casualties usually refers to the human death toll or the number of people missing or unaccounted for in connection with a natural disaster. In some instances it may also refer to the number of people affected by an incident, e.g., the number of people becoming homeless, being exposed to physical injuries, etc.

[5] For example, in their reporting of catastrophe losses for 1970-1999, *Swiss Re* uses a threshold value for total losses of US$66 million calculated in 1999 prices. The losses ascribe to specific catastrophic events comprising the total impact from all environmental factors, e.g., wind damage, flood wave, etc. This definition ignores smaller disasters that in the aggregate may seriously affect community welfare over time.

during the period 1970-1999 were meteorological, such as rainfall and hurricanes, whereas the remainder originated in geological phenomena, e.g., earthquakes, volcanic eruptions, etc. (see Figure 1).

Table 1 - The 10 Most Costly Insurance Losses (1970 to 1999)
[US$ millions at 1999 prices]

Country	Event	Year	Loss
USA	Hurricane Andrew	1992	19,086
USA	Northridge earthquake	1994	14,122
Japan	Typhoon Mireille	1991	6,906
Europe	Windstorm Daria	1990	5,882
Puerto Rico	Hurricane Hugo	1989	5,664
Europe	Windstorm Lothar	1999	4,500
Europe	Storms and floods	1987	4,415
Europe	Windstorm Vivian	1990	4,088
USA	Hurricane Georges	1998	3,622
Japan	Typhoon Barth	1999	2,980

Source: Swiss Re, Natural catastrophes and man-made disasters in 1999, *Sigma* 2/2000

Table 2 - Insured Catastrophe Losses in 1999
(US$ millions)

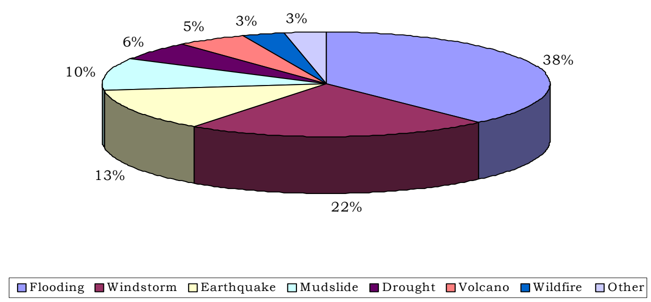
	Insured loss	Percentage
Windstorms	17,036.5	69.7
Earthquakes	3,100.0	12.7
Floodings	1,298.1	5.3
Droughts, forest fires	0.0	0.0
Coldwaves, frost	1,330.0	5.4
Other	1,676.4	6.9
All catastrophes	**24,441.0**	**100.0**

Source: Guy Carpenter and Company, 2000.

Note: According to information assembled by *Swiss Re* for 1999, the reported economic and insured losses in emerging and developed markets were distributed as follows:

[*US$ millions*]	Economic Losses	Insured Losses	Percent insured
Emerging markets	58,400	3,700	6.3
Developed markets	39,800	20,700	52.0
Total	98,200	24,400	24.8

Figure 1 - The Most Common Natural Disaster Events (1970 to 1999)
(Latin American and the Caribbean)



Source: Charveriat, 2000.

The most costly catastrophic events in Latin America and the Caribbean were the Mexico City earthquake in 1985, with estimated losses of around US$6 billion (in 1999 dollars), and the El Niño-related flooding in Argentina, Peru, and Ecuador in 1998, causing comparable damage. However, a number of hurricanes have also caused severe damages. Damages from Hurricane Mitch in five Central American countries reached close to US$6 billion. Hurricane George caused US$2 billion in damages in the Dominican Republic.

Demographic shifts and associated increased in population density in areas such as coastal regions have increased the region's vulnerability to catastrophic events. Urban areas are more vulnerable to natural disasters because of the greater concentration of people and economic assets. The main causes for such vulnerability are poor housing, weak building codes, lack of urban planning, and insufficient infrastructure. This means that poorer countries are more exposed to the disruptive social effects of natural catastrophes and tend to experience more fatalities and severe economic damages on a per capita basis.

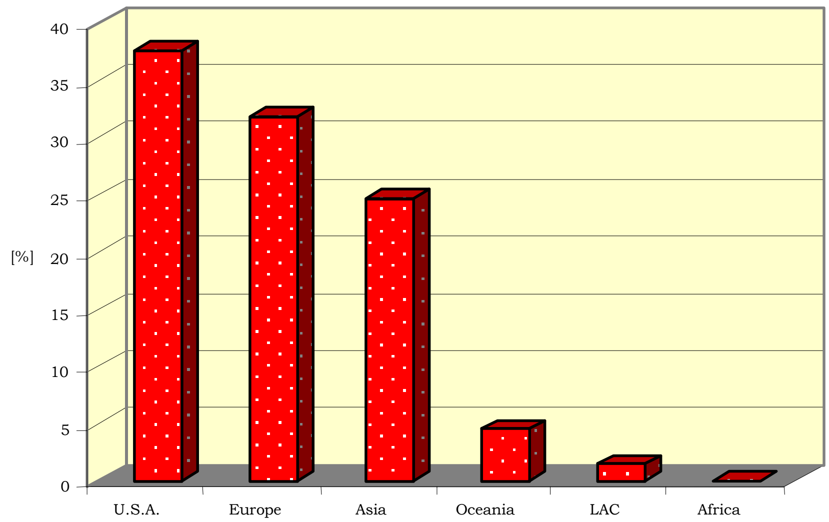
Global Distribution of Losses

Total estimated economic losses from all natural catastrophes around the world were close to US$100 billion in 1999. However, the insured losses from these catastrophic events only amounted to around US$24.4 billion (about 25 percent of the total). This significant undercoverage in the insurance market is partly ascribed to the fact that public infrastructure investments in large economies are largely self-insured at the state or federal level. However, the underinsurance is also explained by the fact that there is very little insurance coverage for the private and public sectors in developing countries despite the fact that many of the natural disasters occur in these regions. According to data collected by Swiss Re, Latin America and the Caribbean accounted for approximately 1.5 percent of all damages insured in 1999 (see Figure 2). Only Africa presented a lower insurance coverage (zero percent).

Approximately 80 percent of the most costly insured losses from natural catastrophes occurred in developed countries in 1999. However, the severity of the catastrophes, as indicated by the number of fatalities, was considerably lower in the developed countries compared to those taking place in developing countries (see Table 3).

During 1999 more than 95 percent of the total human death toll was a result of natural disasters in developing countries. However, these countries account for a very small percentage of the total insured losses. These statistics highlight the fact that the social effects of natural catastrophes in emerging markets can be extremely high (Table 4).

Figure 2 - Distribution of Insured Damages by Region in 1999



Source: Swiss Re, *Sigma* 2/2000.

Table 3 - The 15 Largest Insured Catastrophe Losses in 1999

Country		Event	Insured loss US$ million	Victims
France	*Developed*	Storm	4,500	80
Japan	*Developed*	Typhoon	2,980	26
USA	*Developed*	Hurricane	2,360	70
France	*Developed*	Storm	2,200	45
Turkey	*Emerging*	Earthquake	2,000	19,118
USA	*Developed*	Tornados	1,485	54
Taiwan	*Emerging*	Earthquake	1,000	3,400
Australia	*Developed*	Hailstorm	982	1
USA	*Developed*	Storm	755	39
USA	*Developed*	Storm	575	0
Denmark	*Developed*	Storm	500	20
Venezuela	*Emerging*	Flooding	400	50,000
USA	*Developed*	Hailstorm	390	0
France	*Developed*	Flooding	382	29
Switzerland	*Developed*	Flooding	320	7

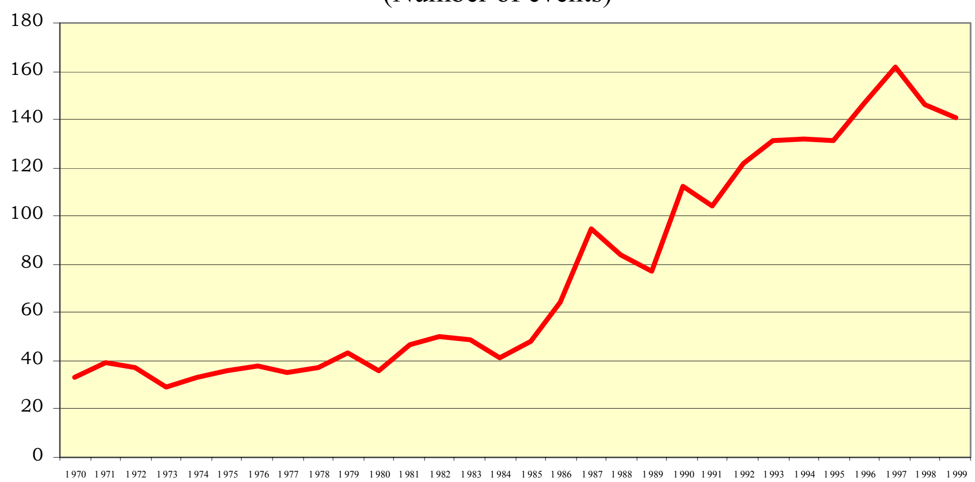
Source: Swiss Re, Sigma 2 (2000)

Table 4 - The 15 Worst Catastrophes in 1999
(in US$ million)

Country		Event	Victims	Insured loss
Venezuela	*Emerging*	Flooding	50,000	400
Turkey	*Emerging*	Earthquake	19,118	2,000
India	*Emerging*	Cyclone	15,000	100
Taiwan	*Emerging*	Earthquake	3,400	1,000
Mexico	*Emerging*	Flooding	1,300	0
Colombia	*Emerging*	Earthquake	1,185	100
Turkey	*Emerging*	Earthquake	834	0
Pakistan	*Emerging*	Cyclone	751	0
China	*Emerging*	Flooding	725	0
Vietnam	*Emerging*	Flooding	662	0
India	*Emerging*	Flooding	411	0
India	*Emerging*	Flooding	307	0
India	*Emerging*	Coldwave	275	0
Philippines	*Emerging*	Flooding	265	0
USA	*Developed*	Heatwave	217	53

Source: Swiss Re, Sigma 2 (2000).

Figure 3 - Frequency of Catastrophic Events Between 1970 and 1999
(Number of events)



Source: Swiss Re, Sigma 2 (2000)

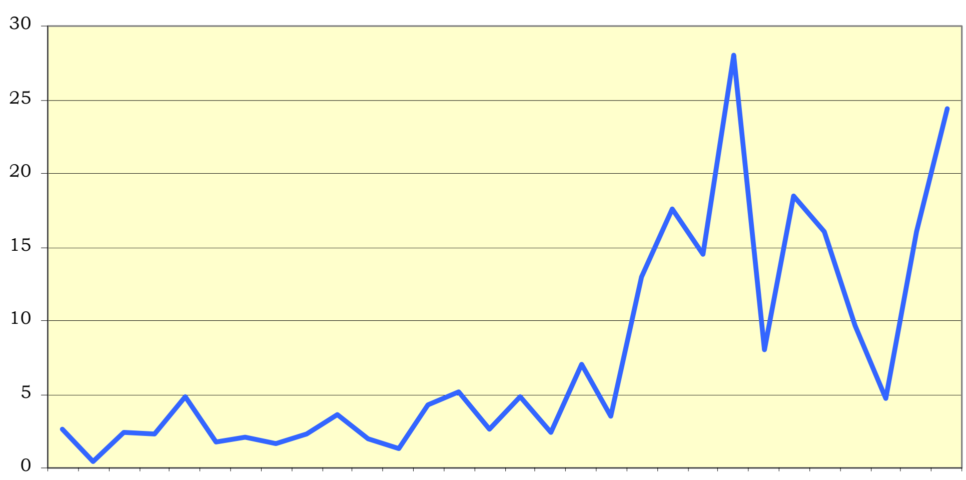
Trends

The frequency of catastrophic events appears to have increased significantly over the past fifteen to twenty years (see Figure 3). Even though the selection criteria used to identify natural catastrophes are adjusted for inflationary price effects, more of these events were registered in recent years. Measured in terms of casualties, i.e., dead and missing victims, 1999 was the fifth worst year on record (Sigma 2, 2000). However, due to continued population growth this may not indicate a definitive increase in the frequency of natural disasters. A certain portion of that increase may also be explained by the fact that a number of natural disasters previously went unreported because their economic and social impacts were limited. As population density increases, what may previously have gone unnoticed is now registered as a catastrophic event.

There is some evidence of increased exposure to windstorms. Intense rainfall and flooding events associated with El Niño, which was caused by changes in sea temperatures across the Pacific Ocean, have contributed to this trend (Swiss Re, 1998). Evidently, the combination of population growth, increased urbanization and an expanded economic asset base led to a significant increase in the size of insured losses. Moreover, the annual variation in natural catastrophe losses increased considerably, thereby possibly increasing the unpredictability of exposure to catastrophe risk (see Figure 4).

Our understanding of the complex relationships that influence global climate patterns remains incomplete. However, it is often possible to determine the potential catastrophe losses within appropriate statistical confidence intervals. This capability is important to the development of new risk transfer instruments. Whereas catastrophes are highly uncertain, the use of computerized modeling techniques that simulate the effects of a large number of weather scenarios makes it possible to estimate the potential economic impacts of natural events in different regions.

Figure 4 - Insured Catastrophe Losses Between 1970 and 1999
(US$ million in 1999 prices)



Source: Swiss Re, Sigma 2, 2000.

The Market for Catastrophe Risk Transfer

The basic idea underlying primary insurance is that the insurer assumes aggregate risk exposures for events that are independent of each other and therefore can be diversified. The insurance companies act as financial intermediaries that aggregate the risk faced by the insured population and thereby diversify their risk exposures across large portfolios of individual insurance customers.

Primary insurance companies may feel that they have accumulated risk exposures that are too large in particular insurance policies and within certain geographic regions. In such cases they can sell a portion of their policies to other primary insurers and purchase other policies from their peers in the industry. By trading portions of different insurance portfolios across entities operating in the industry, the insurance companies further diversify their risk exposures across types of policies and geographic regions. This is the basic reinsurance principle that has been refined in the global reinsurance market. Several large insurance companies engage solely in this kind of reinsurance on a global scale.

Until the mid-1990s, the reinsurance market was the only way available to transfer risk exposure associated with natural catastrophes. Primary insurance companies provide comprehensive insurance policies on homeowners' properties, industrial facilities, agricultural crops, automobiles, etc. As long as the insured catastrophe exposure remains within reasonable monetary boundaries, the insurance market works well. However, exposure to natural disasters is relatively infrequent and may have very high one-time losses. Individual policy risks from natural disasters are highly correlated within geographic areas, which makes them difficult to diversify through portfolio aggregation in a given country.

The transfer of some of these excessive catastrophe risks to the reinsurance market reduces the direct impact of losses on the insurance companies and diversifies the catastrophe exposure among participants in the global reinsurance market. The reinsurance market has evolved over many years on the basis of long-term business relationships and partnerships built on mutual trust between established reinsurance companies. Hence, a reinsurer would feel reasonably confident that excessive losses incurred on an unfavorable contract for catastrophe insurance in one period would be compensated for in subsequent periods by engaging in new, more favorable contracts. In this way the insurance industry has been able to cope reasonably well with the uncertainty of natural disasters. This approach imposes relatively low legal and administrative costs on the reinsurance process, provides a high degree of contract flexibility, and has shorter lead time when arranging reinsurance covers. However, as global catastrophe risk exposure increases, this practice is slowly changing.

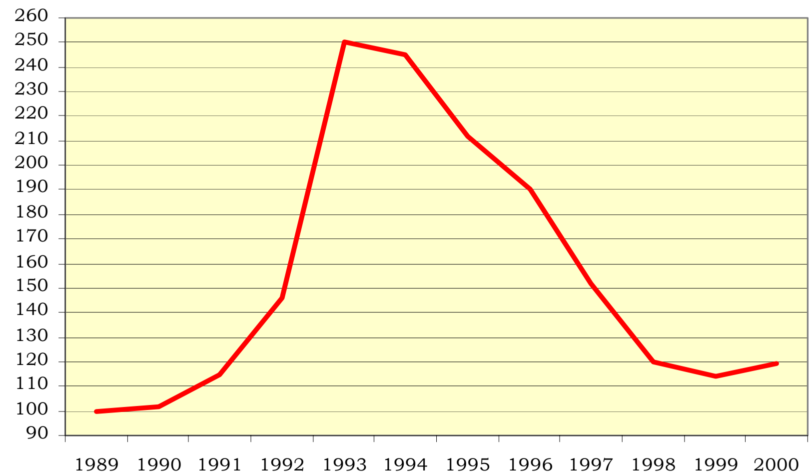
Capacity and Price Development

Prices for catastrophe reinsurance have followed a cyclical pattern (see figure 5). Reinsurance premiums rose dramatically in the aftermath of Hurricane Andrew in 1992. In subsequent years (1995-1999) the market eased considerably, to the extent that some reinsurers undercut the market and charged negative prices. Then again, prices are firming up again as a result of severe windstorm losses claimed in 1999 (Standard and Poor's, 2000; Guy Carpenter, 2000; Sigma 2, 2000). [6]

The cyclical nature of reinsurance prices indicates that the implied uncertainty is influenced by the experiences of immediate losses resulting from significant catastrophic events. Severe losses threaten the solvency of marginal reinsurance companies and drain the accumulated reserves of well-capitalized reinsurance companies. Conversely, during longer periods with relatively low

[6] Whereas the recent terrorist attack on the World Trade Center in New York relates to a man-made disaster, the total losses, which are estimated at around US$30 billion, will strain the entire reinsurance industry and tighten reinsurance prices in general.

Figure 5 - The Development of Catastrophe Reinsurance Prices
Rate on line (ROL) 1989-2000 (Index: 1989 = 100)



Source: Guy Carpenter, 2000.

losses, the reinsurance companies accumulate capital reserves that allow them to pursue a more aggressive price behavior. The amount of accumulated reserves, and hence the general capacity of the industry, seem to influence periodic pricing trends in the reinsurance market. Whereas cyclical prices are influenced by the uncertainty associated with mega-catastrophic exposures, the level of uncertainty of some disasters may be alleviated by the introduction of more accurate climate models and meteorological forecasting techniques. A higher degree of transparency in catastrophe insurance contracts and the use of standardized catastrophe risk measures may help reduce the implied uncertainty and increase pricing efficiency.

Financial Risk Management Alternatives

As conditions for the reinsurance of catastrophe risk exposure continued to tighten in the mid-1990s, there was a search for alternative financial structures to transfer catastrophe risk. With a finite reinsurance capacity, insurance companies looked toward the large global capital market for takers of catastrophe risk exposures.

It is difficult to provide an exact estimate of current capacity in the global catastrophe reinsurance market. The market consists of conventional reinsurance contracts and mutual agreements among primary insurers that are difficult to quantify. It is scattered across many countries and is represented by different types of reinsurance contracts, e.g., proportional property treaty, property per risk, and facultative treaties (Guy Carpenter, 2000). The global property catastrophe reinsurance market is estimated at approximately US$75 billion.[7] Given that potential one-time losses could reach this amount (disasters of the type of Hurricane Andrew, for example) there appears to be a need for alternative sources of risk transfer, particularly for higher risk layers (see Appendix for a description of risk layers). The capital market constitutes one such alternative.

The size of the global capital market has been estimated at around US$30 trillion, with the U.S. market accounting for more than a third.[8] The

[7] This estimate indicates the limit from the ground up (FGU), i.e., it includes both the retention by primary insurers and the additional upper limits covered in the global reinsurance market. Hence, the measure indicates the total insurance amount available to cover property losses from catastrophic events. The estimate is based on the major reinsurance markets in the United States, Canada, Japan, Australia, the United Kingdom, Germany, Switzerland and France.

[8] These numbers are from a study by the U.S. General Accounting Office, which ascribed the U.S. share of the global market for traded stocks and bonds at approximately US$13

dominant share of the market is comprised of corporate equity with the remainder consisting of treasuries, mortgage-backed securities and corporate bonds. The securities traded in the global capital market are exposed to sizeable price volatility, currency fluctuations and default risks. A typical daily change in the market value of traded stocks and bonds in the U.S. market could amount to US$125 billion.[9] Accordingly, capital market investors are familiar with sizeable shifts in fortune and should be able to absorb large potential losses associated with natural catastrophes that match the capacity of the reinsurance market. Losses associated with catastrophe risks are largely uncorrelated with the return on securities (Sigma 5, 1996; Goldman Sachs, 2000). That should make disaster risk-linked financial assets attractive to institutional investors with diversified portfolios because it improves the risk/return profile of their investments.

The first capital market instrument linked to catastrophe risk was placed in the capital market in 1994 when Kover, a captive of Hannover Re, issued a US$85 million catastrophe bond linked to worldwide property losses due to catastrophes.[10] Since this inaugural transaction, many other risk-linked securities transactions have followed, amounting to a total coverage of around US$6 billion. The market for disaster risk-linked securities is now well established.

Financial Derivatives

Several new risk transfer mechanisms were introduced in the early 1990s to manage catastrophe loss exposures. The Bermuda Commodities Exchange introduced futures and options contracts based on the Guy Carpenter Catastrophe Index (GCCI).[11] The Chicago Board of Trade (CBOT) opened for trading in quarterly futures and options contracts based on reported catastrophe losses. There is no natural underlying catastrophe asset, so the CBOT contracts were based on the quarterly losses reported by the Insurance Services Office (ISO).[12] In 1996, CBOT introduced new futures and options contracts based on the catastrophe index established by Property Claims Service (PCS).[13] The introduction of financial futures and options contracts based on different loss indices offered primary insurance and reinsurance companies, as well as large corporations, alternative and relatively flexible ways to hedge their catastrophe risk exposures.

The Catastrophe Risk Exchange (CATEX) was established in early 1996 as an Internet-based business-to-business exchange for all types of insurance contracts and related risk management products. CATEX does not trade standardized futures and options contracts but provides a technology platform that allows multinational institutions to post particular insurance needs to a wide international audience of insurance and reinsurance companies. It also allows insurance companies to post their specific needs to re-sell catastrophe risk exposures and for reinsurance companies to post their selling needs.

A plethora of derivatives has emerged as the markets expanded throughout the 1990s. Some of these derivatives are related to catastrophe risks. The derivatives for energy market comprise futures, options and swap agreements on different energy prices such as crude oil (e.g., Brent crude, crude oil light sweet, etc.), refined products (e.g., unleaded gasoline, heating oil, etc.), natural gas

trillion. By comparison, the market capitalization of all equities quoted on the New York Stock Exchange amounted to US$12 trillion in 1999.

9 The historical volatility of the stock market corresponds to a daily change in market value of approximately 1 percent, whereas the daily fluctuation in bond returns is closer to 0.7 percent. Hence, the expected daily change in the market value of all liquid U.S. securities is around US$125 billion.

10 The transaction excluded coverage in the United States and Japan. Insurance coverage was triggered by actual loss indemnity.

11 The index measures the insured property losses in different regions of the United States (Midwest, Northeast, Southeast, Florida, Gulf) caused by hurricanes, winter storms, thunderstorms, tornadoes and other "atmospheric perils." The GCCI is reported for two semiannual periods, January-June and July-December, and calculates both current and aggregate event losses for the two periods. The index indicates the ratio of losses over insured values.

12 The contracts were based on the reported paid losses of 22 insurers deriving from windstorm, hail, flooding, earthquake, and riots as registered by the Insurance Service Office (ISO).

13 The PCS Index contracts cover nine geographical indices for catastrophe losses in the Northeast, Southeast, East Coast, Midwest, West, California, Florida, Texas and national.

(e.g., Henry Hub), electricity (e.g., Palo Verde, California/Oregon border, etc.), and credit risk for energy investments (e.g., credit spread options, default swaps, etc.). Energy prices are sometimes correlated with different meteorological and economic events (temperature swings, rainfall) and disruptions in economic activity. Economic risk indicators (such as credit spreads) also bear some relationship to catastrophic events, particularly when credit spreads reflect exposed industries (such as agribusiness, utilities, etc.).

Capital Market Instruments

Since the 1980s, asset securitization has grown in importance as an attractive funding alternative for banks and finance companies. The asset securitization technique uses the cash flows generated from a portfolio of indigenous financial assets to support the issuance of securities that often are of higher credit quality than the originator of the financial assets (Blum and DiAngelo, 1998; Fabozzi, 1998). The resulting higher credit rating provides this financing alternative with a lower cost of funding and offers issuers the opportunity to arrange favorable off-balance sheet financing.

For many financial institutions (e.g., commercial banks) stringently enforced capital requirements restrict the ability to extend new loans. Hence, for banks with a high loan origination capacity, asset securitization provides an attractive financing opportunity. The asset securitization technique is best applied to financial assets with relatively stable and predictable cash flows (e.g., mortgages, automobile loans, credit card debt, etc.). The largest securitization market in the United States is the market for mortgage pass-through securities, where the cash flow from portfolios of mortgage loans is used to service the issuance of securities.

The development of the market for mortgage-backed securities has become more sophisticated with the introduction of derivative instruments, such as *collateralized mortgage obligations* (CMO) with different tranches (fixed rate, floating rate, reverse floaters, etc.) and stripped mortgage-backed securities with different classes of principal-only (PO) and interest-only (IO) payment structures. The successful development of a mortgage-backed securities market in the United States was enhanced by a favorable regulatory and federal tax regime. The Tax Reform Act of 1986 exempted the special purpose vehicle (SPV), referred to as a real estate mortgage investment conduit (REMIC), from any tax obligations on interest income (Roever, 1998). Instead, the residual holders of the mortgage payments are liable to pay income tax. Without this favorable tax treatment the market for mortgage-backed securities would not have been as successful.

As the reinsurance market for catastrophe risks tightened during the 1990s, the asset securitization technique was transposed to the reinsurance market (Litzenberger et al., 1996; Froot et al., 1998). However, in this instance the purpose was not to obtain favorable funding, but to transfer catastrophe risk exposures to investors in the capital market. Through the issuance of catastrophe risk-linked bonds, generally referred to as *cat-bonds*, the issuer (typically an insurance or reinsurance company) was able to obtain coverage for particular exposures (e.g., property damage, auto liability, etc.), in case of predefined catastrophic events, such as windstorms, hurricanes and earthquakes. The new catastrophe risk transfer opportunities have primarily been exploited by insurance and reinsurance companies as a way to obtain complementary coverage in the capital market (Standard and Poor's, 2000).

A *cat-bond* (catastrophe bond) is typically structured around a special purpose vehicle (SPV), an independent legal entity typically established in a tax favorable jurisdiction[14] (ISO, 1999; Standard and Poor's, 2000; Goldman Sachs, 2000). The SPV issues the cat-bonds and receives an up-front payment from the investors buying the securities. The SPV then engages in an insurance contract with the primary insurer who is selling part of its portfolio and pays an insurance premium for the entire insurance period, or on a periodic basis,

[14] There currently are a number of tax issues related to the establishment of SPVs to furnish catastrophe risk transfer in the United States. Most SPVs have been established in Bermuda, the Cayman Islands or in Ireland since they allow reinsurance companies to establish the SPVs as separate entities with zero or favorable tax status. The National Association of Insurance Commissioners is working on a proposal that will allow the establishment of similarly protected SPVs in the U.S. market.

(e.g., monthly or quarterly) as a percentage of the insured amount.

The insurance contract typically provides the insurer with insurance coverage on an excess-of-loss (EOL) basis, which corresponds to common practice in the catastrophe reinsurance market. "Excess of loss" means that the insurer pays an amount in excess of the deductible and up to a maximum amount specified in the contract. Hence, the resold risk exposure may cover losses associated with a particular insurance layer between the deductible (called the *attachment point*) and maximum limit (called the *exhaustion point*) (additional details are available in the Appendix). The reinsurance price obtained through the risk securitization process should be related to the expected actual loss on the embedded catastrophe risk exposure.[15]

Supporting catastrophe risk analysis is critical to assessing the pricing of a risk-linked securities. The analyses are usually performed by specialized consultants that use advanced simulation models to estimate the probability that catastrophic events of certain magnitudes may occur and what the resulting insured losses will be.

The cat-bonds can use different formulas to trigger compensation under the reinsurance contract. Compensation can be triggered as a *loss indemnity* based on the actual insured losses incurred by the insured party. For the insured, this solution provides close to perfect coverage of losses. However, for cat-bond investors the solution is wrought with *moral hazard*[16] and *adverse selection* issues,[17] because there is no guarantee that the primary insurer will try to mitigate losses once the cat-bonds are placed, and as an insider, the primary insurer may know more about the catastrophe risk exposure than the investors buying the cat-bonds. The trigger could also be based on a defined *loss index* such as the Guy Carpenter Catastrophe Index or the PCS Index. This approach eliminates the risks associated with moral hazard and adverse selection because the index is well defined and cannot be manipulated.

However, a standardized index can expose the primary insurer to a potential *basis risk,*[18] if the actual losses differ materially from the underlying index. The triggers could build on *physical indicators* measuring the event magnitude in different ways (wind speed, wave height, rainfall, etc.). These measures are objective and can be more closely associated with potential catastrophe losses, and therefore may better accommodate the needs of both the insurance companies and the investors. A final methodology is to adopt a *parametric formula* as a trigger. (A parametric formula defines the parameters of the coverage. For example, the policy may require a 7.0 magnitude earthquake to 'trigger' coverage. Thus a 6.5 magnitude earthquake would not trigger the policy and there would be no coverage.) This hybrid approach can develop triggers that are closely associated with the insurer's exposure,[19] but at the same time are well defined, objectively measurable and can be analyzed.[20]

[15] In theory, the price of insurance coverage in the risk-linked securities market should correspond to the insurance rates offered in the reinsurance market. However, the experience so far has been that insurance coverage from the issuance of cat-bonds is somewhat more expensive than reinsurance contracts, partly because the methodology is relatively new and the SPV structures are rather comprehensive and costly.

[16] *Moral hazard* occurs when the insured party neglects preventive measures after the insurance contract has been signed and resorts to excessive reporting of losses.

[17] *Adverse selection* occurs when the insured party uses inside knowledge about the insured exposure to obtain more favorable terms from the insurance company issuing the policy.

[18] *Basis risk* occurs when the measurement basis in the insurance contract differs significantly from the actual losses incurred from the insured event.

[19] Of course there is no guarantee that a parametric formula will always match the insurer's exposure, but it does represent a way to develop formulas that minimize the basis risk based on objective measures of natural phenomena, which will effectively eliminate the moral hazard issue.

[20] A good example may be Tokio Marine's issuance of cat-bonds linked to Japanese earthquake risk. The company was in a situation where there was limited historical information to support reliable loss estimates, which is a problem in many regions outside the United States. The company would also like to establish a robust indicator or trigger that would enable the issuance of a long-term contract (up to 10 years). They solved the issue by letting the reinsurance cover written by the established SPV, Parametric Re, be triggered by the magnitude of earthquake activity in and around Tokyo as measured by the Japanese Meteorological Agency (JMA). The measures were divided into two grids reflecting an inner and an outer zone of Tokyo. For example, an earthquake registration of 7.1 in the inner grid would provide 25 percent coverage, whereas this registration in the outer grid would not lead to any cover. In other words, loss recovery is related to the intensity of the asset

Catastrophe Risk Swaps

The risk transfer characteristics of cat-bonds can be replicated through a mechanism called *catastrophe risk swaps*. In the risk swap the cedant makes fixed payments equal to the premiums paid in a cat-bond structure against receipt of claims compensation in case losses occur (indemnity basis). Just like the risk-linked securities, the catastrophe risk swap can be based on different types of triggers such as indemnity losses, loss indices, physical indicators, or parametric formulas. The potential benefit of the risk swap is that it can be established directly with a counter-party based on standardized swap documentation. This can be a faster and cheaper route to get risk coverage.

However, the risk swap entails a *counter-party credit risk,*[21] presumably on an insurance company or possibly a bank.[22] In other words, the insurance cover can only be realized if the swap counterpart is solvent when the trigger events occur. Hence, catastrophe risk swaps can increase flexibility when transacting in the conventional reinsurance market, but they impose additional credit risk exposures. This is in contrast to the risk securitization approach. Here the credit risk is very low because the proceeds from the bonds are placed in a trust fund as collateral for the underlying insurance contract. The risk-linked securities are placed among many institutional investors, which diversifies the risk exposure and provides access to a new source of catastrophe risk transfer.

Other instruments provide a cash reserve to cover catastrophe damages rather than find ways of transferring risk, and they can therefore establish financial contingencies in the capital market to fund the recuperation of future catastrophic losses. These instruments provide committed capital in case of catastrophic events through the issuance of common equity, preferred equity, or senior debt instruments (Colarossi, 1999, 2000).[23] Contingent surplus notes have been issued by a number of insurance companies for a total amount of approximately US$8 billion since the mid-1990s. The contingent surplus notes provide the holder, e.g., an insurance company, with the right to place notes with investors if certain catastrophic events occur. The holder of one of these contingent capital instruments will thus pay an annual premium as compensation for the put option that is embedded in the instrument.

structure in the two grids. An interesting aspect of this approach is that the grid structure permits some standardization because different trigger structures are based on the same magnitude measure.

[21] *For counter-party credit risk ,see next chapter*.

[22] There are formal regulatory limitations to the wider use of catastrophe risk swaps in most markets, with the exception of certain off-shore havens, because the swap agreements in many instances would be deemed insurance contracts that consequently could only be countered by chartered insurance companies.

[23] The contingent capital instruments are effectively put options that give the holders the right to place securities at a predetermined issuance price once a catastrophic risk trigger has been exceeded. These option structures are sometimes referred to as *knock-in* options, because they are effectuated after an independent trigger has been activated.

The Effectiveness of Alternative Instruments

The eventual choice of risk transfer mechanism is influenced by the characteristics of the financial instruments and their implications for moral hazard, adverse selection, basis risk and credit risk exposures.

Moral hazard may arise when coverage has been obtained for a particular risk (hurricane, flooding, etc.) based on previous losses. As a result, the property owner may no longer have a strong incentive to mitigate the size of future losses but would rather let a risk transfer policy cover any damages. The provider of the policy may not be aware of the degree of risk involved, or may subjected to excessive reporting of losses and thus could be adversely affected in case of a catastrophe (Grossman and Hart, 1983; Doherty, 1985). Risk transfer instruments that use an objectively determined index as the trigger for payouts will be less exposed to moral hazards because the contractual payments cannot be influenced by the user of the policy.

Adverse selection arises when the information held by the client and the provider of insurance coverage is asymmetric, for example, the party that wants to acquire coverage often knows more about the risk exposure than the company that is going to cover the risk (Rothschild and Stiglitz, 1976; Hillier, 1997). Hence, the party receiving the coverage may try to gain an advantage at the expense of the provider. As a consequence, the provider may charge a premium price to compensate for the uncertainty associated with the adverse selection issue. In either case, the outcome is an inefficient transfer of risk exposures.

The inverse situation may also arise, where the risk transfer provider knows more about the risk exposure than the hedger that is seeking cover. This can lead to "cherry picking" as the providing company only sells coverage to entities with a low risk profile while charging a higher price that reflects the full actuarial risk. Using well-defined and objectively determined triggers in the risk transfer instrument will normally circumvent the problem of adverse selection.

Basis risk arises from discrepancies between measures used in the risk coverage contract and the actual losses the instruments are meant to hedge. For example, if the value of the index (as determined by CATEX, PCS, etc.) that underpins the hedging instrument differs significantly from the value of the risk exposure it is intended to cover, the hedger will be exposed to a high basis risk. Instruments that use standardized indices will often have high basis risk, because it is difficult to apply a general measurement index to an individualized risk portfolio.

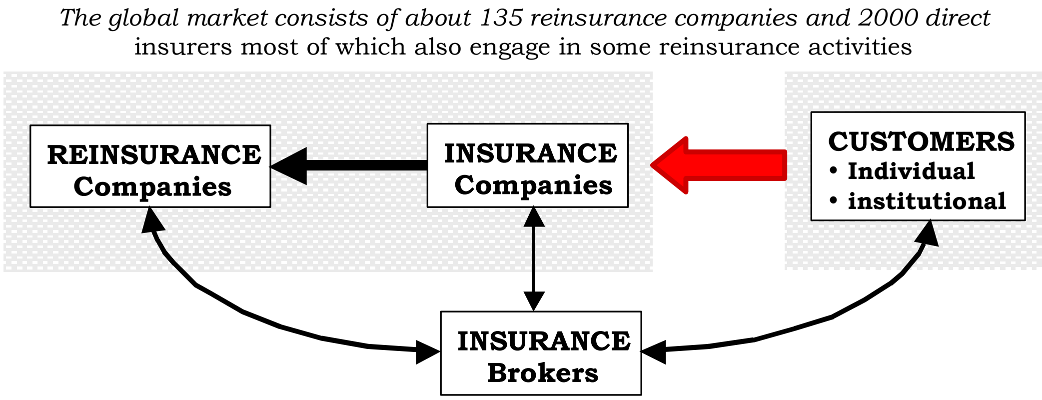
Finally, there are different *counter-party credit risks* associated with different hedging instruments. For example, catastrophe risk coverage obtained from insurance companies with a low credit standing may be unreliable. A natural catastrophe could jeopardize the solvency of the weakest insurance companies, which may even be bankrupted by the event. Conversely, the use of exchange-traded derivatives or the issuance of risk-linked securities in the capital market will circumvent the counter-party credit risk issue.

Reinsurance

The total amount of catastrophe exposure covered in the global reinsurance market (including total coverage up to the maximum excess-of-loss limits) is estimated at around US$75 billion (see Figure 6 for an overview and the Appendix for further explanations).

Although proportional reinsurance contracts for comprehensive property insurance and mutual reinsurance arrangements among primary insurers provide some additional coverage for catastrophe-related risks, the all inclusive market capacity

Figure 6 - The Conventional Insurance Market



for catastrophe reinsurance coverage is of a limited size and cannot be considered high compared to the potential risk exposures that can arise from a single catastrophic hurricane or earthquake. In extreme cases these catastrophic events might incur cumulative damages well in excess of US$75 billion in insured property losses (Sigma 7, 1997; Guy Carpenter, 2000). There appears to be a general consensus that the reinsurance market lacks cover for high impact mega-catastrophes.

This underinsurance situation is exacerbated as catastrophe risk exposures continue to expand due to economic asset build-up, population growth, demographic relocation to exposed areas, and changing weather patterns. This phenomenon is a partial reflection of *uninsurable risk*, as reinsurance companies retract from engagement in extreme event covers, but is also affected by the moral hazard and adverse selection issues associated with the risk-transfer arrangements.

As a result of the limited size of the current reinsurance market and the recurrence of large windstorm damages especially during 1998 and 1999, the catastrophe reinsurance market is became tighter and prices firmer (Standard and Poor's, 2000; Guy Carpenter, 2000). The availability and pricing of catastrophe reinsurance is highly cyclical and influenced by the recent loss experiences in the industry. One could ascribe the phenomenon to the myopic behavior of reinsurance companies, but there are also a number of regulatory constraints that prompt the behavior (Jaffee and Russell, 1997).

For example, current accounting rules prohibit insurance companies from assigning their accumulated capital surplus into irreversible reserves dedicated to cover specific future catastrophe losses.[24] This accounting practice, imposed by the Financial Accounting Standards Board, prevents prudent insurance companies from effectively smoothing the cash flows of premiums and claims over longer time periods. In addition, all retained earnings are considered taxable, and the U.S. Internal Revenue Service (IRS) appears to take a rather inflexible position, even when the retained earnings are earmarked as an accumulation to a capital reserve for future catastrophe losses. This obviously enforces the cyclical nature of reinsurance capacity.

Faced with the inability to insure certain risks in the aftermath of major catastrophic events, governments have regularly intervened to ensure the availability of coverage. In the United States, the Florida Hurricane Catastrophe Fund and the California Earthquake Authority are prime examples of government-induced insurance schemes. The state laws require homeowner insurers that operate in the respective states to purchase cover from the funds. The funds, in turn, may manage the aggregate exposure by forcing the insurance companies to cover the lower level risks on a mutual basis and by engaging in stop-loss treaties to

[24] These comments apply to existing practices in the U.S. insurance industry, whereas other rules may apply in other jurisdictions. The reference to U.S. rules is solely made to sensitize the readers to the importance of regulatory, accounting and tax regimes.

cover for higher level risk. It is noteworthy that the IRS has allowed capital accumulation in these government funds on a tax-free basis.

Most other developed countries with significant catastrophe exposure solve the issue of uninsurable risk through various types of government-induced funds. In France, flooding and earthquake damages are covered through a special program (*Catastrophe Naturelle* - *Cat Nat* for short), which is reinsured with a government-owned reinsurance company (*Caisse Centrale de Réassurance*, CCR). Insurance companies are allowed to establish tax deductible reserves for windstorm and natural catastrophes to smooth cash flows over longer time spans. Norway has established a national insurance pool (*Norsk Naturskadepool*), which is compulsory in all property insurance policies to cover residential and commercial property from damages associated with natural catastrophes. The Japanese Earthquake Reinsurance Company (JER) provides mandatory reinsurance cover for damages to residential property from earthquakes and volcanic activities.

Hence, there seems to be a general consensus that governments must play a central role in furnishing coverage for uninsurable risk. However, there is no agreement as to what the precise role of the government should be and to what extent involvement is required. It is argued that government-induced catastrophe reinsurance arrangements are needed because uninsurable catastrophe risks are mounting (as reflected in the potential for excessive losses).

Given that governments are generally assumed to have a low default risk, government-supported insurance schemes have easier access to risk capital than reinsurance companies, which are subject to bankruptcy risk. However, there is a downside to government guarantees. They encourage less solvent insurers to excessive expansion, write more insurance contracts and increase premiums to obtain cheaper up-front funding (Bohn and Hall, 1999). This would obviously destabilize the insurance market.

There have been other proposals for government intervention to cover the higher layers of catastrophe losses that otherwise would remain uninsured. For example, it has been suggested that the government could issue catastrophe call options to the insurance industry to cover excessive losses (Cummins et al., 1999). The government would receive a call option premium from the insurance companies from the sale of insurance policies as compensation for potential future payouts under the option contracts. This arrangement would expand capacity in the catastrophe reinsurance market without involving government entities in the day-to-day insurance business. The U.S. federal government already provides catastrophe insurance through disaster relief programs like the Federal Emergency Management Agency (FEMA) and various congressional appropriations. However, these arrangements may be less effective risk management approaches because they are prone to manipulation by political interests.

Despite the limited size of the catastrophe reinsurance market, there is additional appetite for new diversifiable risks such as catastrophe exposures in developing countries. The reinsurance industry is willing to extend alternative risk cover for catastrophic events in emerging markets. As long as the catastrophe risks are uncorrelated with the industry's existing economic and environmental liabilities, there will be an incremental insurance capacity because the new exposure can be diversified into the reinsurance companies' existing risk portfolios. Even if the reinsurance market seems to have a somewhat finite supply, there are good opportunities to obtain insurance cover for new alternative risk exposures.

Derivatives

The Bermuda Commodities Exchange suspended trading of its catastrophe futures and options contracts in 1999 due to sluggish trading volume over the preceding two years. The Chicago Board of Trade, the other futures exchange to offer catastrophe derivatives, has experienced dwindling interest in their contracts and is about to close trading. Trading in standardized exchange contracts has also failed because there has been insufficient interest and the trading volume has been unsatisfactory. Even though derivative instruments have been widely praised as promising alternatives for insurance companies to hedge their catastrophe risks (see Canter et al., 1996), there has not been sufficient market activity in the contracts to make them economically viable.

Numerous reasons can be suggested for the failing interest. Using the contracts to hedge catastrophe exposure is associated with substantial basis risk, which has provided a significant practical barrier to their use. Some studies indicated that standardized derivative contracts only cover somewhere between 60 and 80 percent of the underlying risk exposures (Major, 1999).

In recent years, catastrophe risk swap agreements in the over-the-counter market have emerged as a flexible and relatively simple way to obtain cover for catastrophe risk exposures. However, even though these instruments may provide hedgers with increased flexibility, they can be cumbersome to structure, and are generally difficult to unwind. In many cases, risk swaps are an alternative to the issuance of risk-linked securities, but they entail counter-party credit risk because the hedger depends on the other party to honor the swap in case of loss.

Risk-linked Securities

Given the significant size of the global capital market, there should be a good potential to issue risk-linked securities such as cat-bonds, contingent securities and cat-put equity instruments. Given that the returns from catastrophe risk exposure are fundamentally unrelated to the returns on commercial and market risks of conventional debt instruments, well-diversified investors can benefit from investment in risk-linked securities. Since the majority of traded securities are managed by large institutional investors, (e.g., mutual funds, life insurance companies, banks, etc.), there is a large potential investor audience for cat-bonds.

On this basis, there appears to be a good potential for transferring the uninsurable catastrophe risks back to the institutional investors in the capital market, and thereby providing an alternative way of diversifying cataclysmic risk exposure (figure 7).[25] Investors are increasingly familiar with the alternatives offered in the risk-linked securities market and the potential gains they can achieve on the risk/return profile of their invested portfolios.

The initial costs associated with these transactions were quite high because everything was tailored to the specific circumstances of individual issuers. However, cost savings are emerging from economies of scale as issuance practices have become increasingly standardized and transparent. Standardizing the deal structures, along with generalizing the triggers, could help reduce the cost associated with transaction analysis and increase market transparency. The triggers should be beyond the control of the insurer to avoid problems related to moral hazard and adverse selection. Hence, a major challenge in the ongoing development of the market is to create robust triggers that can be used across a larger number of transactions and be introduced as market benchmarks. (See Appendix for an in-depth explanation.)

The Bond Market Association, which counts all the major securities traders as its members, formed a market committee in the spring of 2000 to focus specifically on the promotion of risk-linked securities.[26] The committee works actively to increase investor knowledge about risk-linked securities, and to improve market transparency, integrity and liquidity by providing standards for disclosure, risk analysis, and secondary market trading.

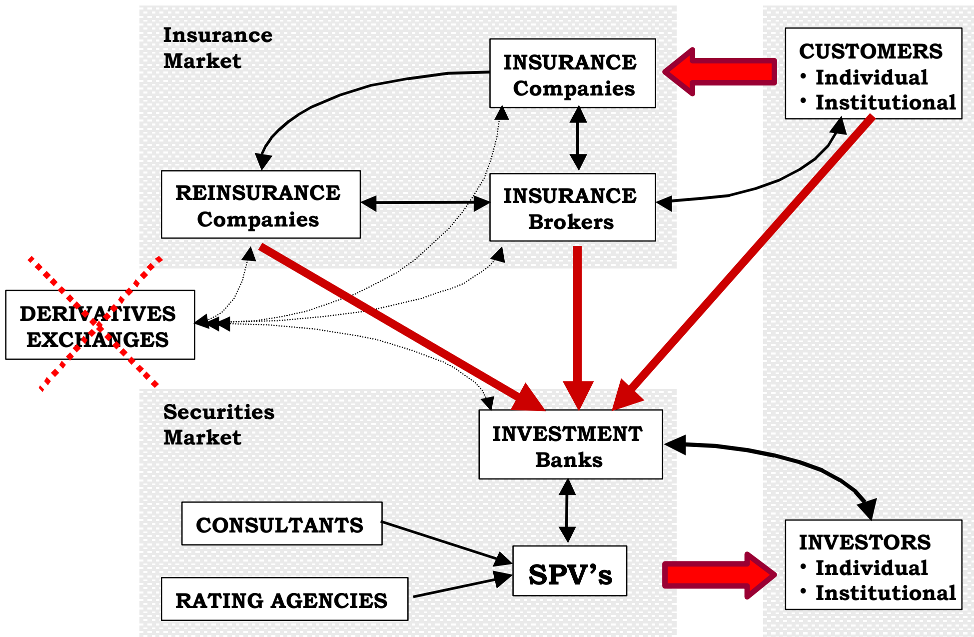
Although risk-transfer prices in the cat-bond market have traditionally been somewhat higher than conventional reinsurance contracts (Goldman Sachs, 2000), new diversifiable risks may be associated with more favorable relative pricing conditions.[27]

[25] Goldman, Sachs has simulated the return on the portfolio of outstanding risk-linked securities based on actual catastrophic events over the past 100 years (from 1900 to 1999), and found that the portfolio provided investors with a positive return in 98 out of the 100 years, leading to an average return of 10.8 percent per year. The two years of negative returns related to the San Francisco earthquake in 1906 and the Great Kanto earthquake in Tokyo in 1923. None of the risk-linked securities issued since the mid-1990s have experienced a negative return. [Note: cat-bonds are untested in this arena.]

[26] The committee was formed by the approximately 25 securities firms that presently deal in risk-linked securities.

[27] Triple-B rated cat-bonds have offered a premium of 100 basis points (bp) over triple-B rated corporate bonds with the same duration. Double-B rated cat-bonds have offered a re-

Figure 7 - Overview of the Market for Catastrophe Risk Transfer



The existing insurance coverage for catastrophe risk exposures in Latin America and the Caribbean is miniscule. Catastrophe reinsurance contracts predominantly cover assets in developed economies; indeed, only a small fraction applies to assets in developing countries. It is argued that insurance coverage is a demand issue given that some catastrophe insurance policies are sold throughout the region. However, things are more complex than that. Insurance coverage remains low for a number of reasons that are described below.

Insurance premiums are expensive for most people, and in the absence of formal requirements and economic incentives, there is no compelling urge to establish adequate insurance coverage on private property. In some cases the supply of insurance is highly selective due to severe moral hazard and adverse selection problems. The possibility of mitigating any risk factors for natural disasters is usually minimal, so property damages can often be considerably higher than expected. In other cases insurance companies havealmost no way of knowing the true risk exposures, and therefore may have withdrawn their insurance business altogether.

The economic impact of natural disasters is influenced by how often an event occurs and by the severity of the associated loss. Vulnerability to natural catastrophes can be reduced significantly by mitigating the risks in order to lessen the impact of disasters. This can be done, for example, through urban and environmental planning, resistant building structures, effective building codes and other such actions. (Kunreuther, 1996, 2001; IDB, 2000).

The economic vulnerability to natural disasters is exacerbated in Latin America and the Caribbean by the general underdevelopment of insurance markets, which provide little cover for catastrophe risks. Property insurance is generally limited to a very small and secluded segment of the commercial and public sectors, and to high net worth individuals.[28] The risk mitigation and coverage issues are obviously related. For example, establishing a

turn of between 100 to 300 bp above similarly rated corporate bonds. Single-B rated cat-bonds have offered between 300 to 800 bp above comparable corporate bonds.

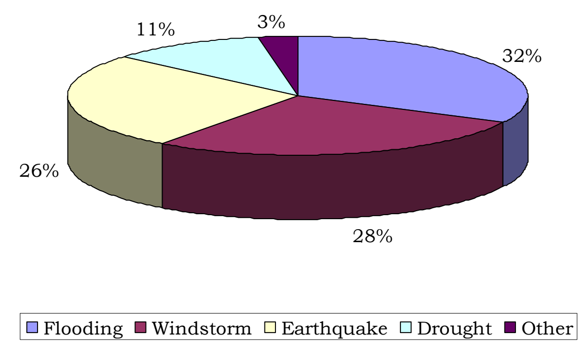
[28] For example, in Mexico recent estimates suggest that around 90 percent of the large industrial corporations and 50 percent of medium-sized commercial enterprises have some form of property and casualty insurance coverage, whereas the coverage among small business entities is only about 2 percent. Of the 8.3 million households that are deemed eligible for insurance contracts, only about 1.8 percent have actually obtained insurance coverage.

meaningful insurance industry is not possible without enforced building codes and urban planning. Therefore, effective catastrophe mitigation is a necessary condition for the development of viable local insurance markets.

Regional Needs

A variety of natural disaster exposures are prevalent throughout Latin America and the Caribbean. In general, Mexico, Central America and the islands of the Caribbean are primarily exposed to Pacific and Atlantic hurricanes and windstorms. Mexico and the countries of Central American have additional exposures in areas prone to earthquakes. Countries on the Pacific coast of South America, in particular, are exposed to storms, flooding and landslides caused by periodic El Niño episodes.[29] In terms of frequency, three types of natural catastrophe risk stand out in the region: flooding, windstorms and earthquakes. The economic losses associated with these natural disasters are generally highest in connection with each earthquake event and lowest in the case of individual flooding incidents. Therefore, these three natural phenomena have had an almost equal total effect as measured by their overall economic impact over the past 30 years (see Figure 8).

Figure 8 - Economic Losses Caused by Natural Disasters, 1970-1999
(Latin America and the Caribbean)



Source: Charveriat, 2000

[29] Other countries in Latin America are also affected by events related to El Niño, but not to the extent that those on the Pacific are affected.

Applications of New Risk Transfer Instruments

The cumulative losses caused by natural disasters in Latin America and the Caribbean during the past 30 years are estimated at around US$100 billion (Charveriat, 2000). However, natural disasters have increased in recent years. For example, losses from major natural disasters amounted to close to US$12 billion during 1998 and were primarily caused by flooding and hurricanes. In 1999, the losses from the Colombian earthquake and the Venezuelan flooding incidents alone were estimated at approximately US$5 billion.

The insurance-based catastrophe risk markets have a strong focus on windstorm exposures and a large number of the recent risk-linked cat-bond issues have covered hurricane exposure. Furthermore, meteorological observations of hurricane and related windstorm events are reasonably well covered, which makes it possible to estimate the catastrophe risk probabilities.

The significant flooding resulting from the effects of El Niño constitute another category of catastrophe risk that clearly needs attention. The El Niño phenomenon is now relatively well understood, but it remains an important area in need of further research so that regional forecasts can become more reliable and losses are estimated more precisely.

Similarly, exposure to earthquake risk in the region is substantial and warrants further scrutiny. Earthquake-prone areas are fairly well identified and mapped, but more research is needed to assess the likelihood of different earthquake scenarios and the potential damages.

Risk Transfer Mechanisms

International reinsurance contracts and capital market transactions (such as cat-bonds and contingent capital) are viable risk financing arrangements that may help countries actively manage their catastrophe risk exposure. A less ambitious approach, which seems to be the one now being taken, is to gradually extend insurance coverage through continued development of local insurance markets. Accordingly, consideration of new risk transfer instruments must wait until local insurance coverage becomes sufficiently saturated. However, this approach takes time and, as a result, countries would be unable to take advantage of risk transfer opportunities available in the global market.

Attempts to combine the two approaches, including proposals made by the World Bank, suggest combining government-supported insurance pools with government issuance of cat-bonds in the local and international capital markets (Pollner, 1999; World Bank, 2000). A combination like this is currently being used in the Turkish Catastrophe Insurance Pool (TCIP) introduced in the wake of the earthquakes that affected the Istanbul area (Gurenko, 2000). Historically, insurance coverage for earthquake exposure has been very low in Turkey.[30] For one thing, the local insurance industry is relatively underdeveloped. It has insufficient underwriting standards, risk estimation, and management capabilities as well as low capital reserves to withstand potential claims. Inadequate construction and building standards combined with weak enforcement of building codes has increased earthquake exposure.

Prospects for expanding earthquake insurance coverage in Turkey was further hampered by government policies that provided replacement of dwellings almost free of charge, thereby obviating incentives to buy insurance policies. Recent earthquakes revealed these inherent market weaknesses and prompted the establishment of a government-backed insurance pool to cover uninsurable risks. Legislation establishing the Turkish Catastrophe Insurance Pool makes specific earthquake insurance policies compulsory. It also requires the enforcement of building codes and

[30] The penetration of earthquake insurance is estimated at approximately 2 percent outside Istanbul and 15 percent within the city. However, most of the insurance coverage applies to affluent residential customers and almost no coverage is obtained by, or provided to, low-income and middle-class households.

standards that reduce risk and eliminates government-subsidized loans to homeowners. The earthquake insurance policies are covered by TCIP and sold by local insurance companies.

The total exposure of this insurance pool is managed by a pool management company (*Milli Re*) established for the purpose. The TCIP provides coverage for total earthquake losses up to US$600 million. The World Bank funds the next risk layer if claims exceed the fund's financial reserves (determined by the premiums received from the insurance takers).[31] A large part of the next higher risk layer was ceded in the global reinsurance market, whereas the highest risk layer (up to a certain exceedance limit) was funded by the World Bank. Hence, the World Bank assumed a formal exposure to earthquake risk rather than granting post-emergency loans for disaster relief.

Earthquake exposure in Turkey is now considered and evaluated up front, which has a number of potential advantages. Local insurance companies are directly involved in the efforts to extend insurance coverage to the wider market. A substantial part of the risk exposure is covered by reserves accruing from the compulsory insurance premiums and commitments by pool members, so the World Bank is less exposed to situations where it has to reallocate its capital reserves to deal with unexpected funding ofdisaster relief. In turn, the World Bank has the opportunity to cover part of its risk exposure by engaging in risk transfer arrangements in the international financial markets in its own name.

Another approach to manage the economic effects of natural catastrophes is the use of public funds to recuperate losses when disasters strike. However, automatic support and subsidized lending for reconstruction purposes inevitably deplete government sources otherwise intended for long-term investment. That is, the resulting strains on the capital budget may jeopardize development projects and compromise economic growth.

[31] Coverage provided within the loss range, determined by the attachment point (deductible) and the exhaustion point (maximum coverage), is usually called a *layer*. A given insurance exposure can be divided into different layers, each of which may be covered by different insurance treaties and risk transfer mechanisms. See Appendix A for further details.

Social investment funds may provide valuable funding for immediate disaster relief. However, if used to support post-disaster reconstruction of economic infrastructure, the funding will come from resources that were originally allocated to social investment projects.

Special funds to support risk mitigation can help promote and finance important investments that reduce the vulnerability of the exposed economic assets (e.g., structural improvements in buildings, infrastructure, etc.). Risk mitigation and vulnerability reduction are important factors when trying to reduce the overall economic exposure to catastrophe risks and the costs of risk-financing arrangements.

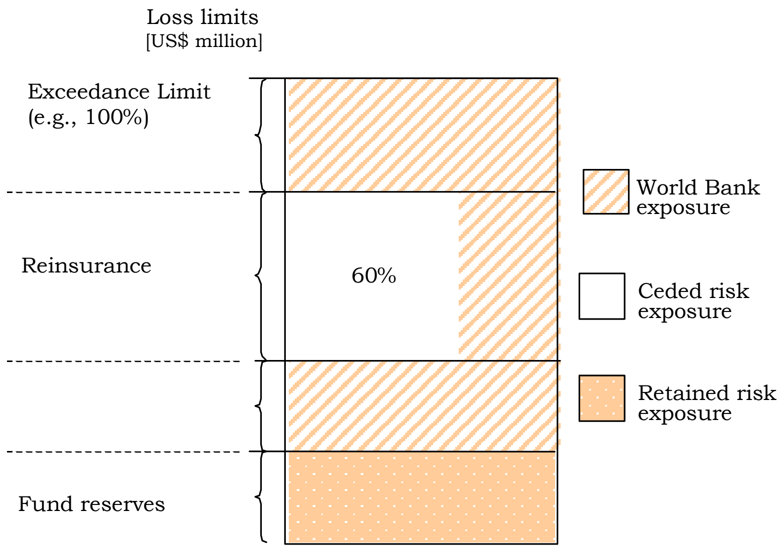
Government-funded calamity funds (e.g., Fonden in Mexico) were introduced as potentially effective ways to smooth the volatility of economic activity after natural disasters (World Bank, 2000). These funds are based on the principle that, as self-insurers, governments should reserve the funds to cope with disasters. However, if the funds remain undercapitalized subsequent payouts may jeopardize other long-term investment commitments.

A potentially negative effect of public commitments to cover direct economic damages from catastrophes is that they reduce the incentives to engage in commercial risk transfer contracts, as the government is expected to cover the losses. Therefore, any government-subsidized catastrophe insurance arrangements probably should require households and businesses to buy compulsory insurance. However, it is widely recognized that commercial insurers have a limited desire to cover the upper catastrophe risk layers; as a result, government-induced insurance pools are often established to cover these otherwise uninsurable risks (Guy Carpenter, 2000).

Risk Management Approaches for Latin America and the Caribbean

Four basic risk management approaches are relevant for Latin America and the Caribbean. It

Figure 9 - The Turkish Catastrophe Insurance Pool (TCIP)



should be noted that these approaches are not mutually exclusive.

- Covering and mitigating catastrophe risk exposures in investment projects.
- Facilitating country risk-management plans and establishing coverage for higher catastrophe risk layers.
- Introducing local insurance pools and excess-of-loss facilities to cover for uninsurable catastrophe risks.
- Monitoring and managing regional risk exposures on an integrative basis.

One way to reduce immediate catastrophe risk exposures across the region is to perform rigorous catastrophe risk analyses on all new investment projects, and then limit the identified exposure by enforcing stringent risk mitigation requirements. Any risks not already covered in the loan facilities and that exceed predetermined limits could be covered by tailored reinsurance contracts and risk swaps. This project-based approach to catastrophe risk management will reduce specific project exposures, but will not necessarily lead to better risk management practices across the region.

Another approach is to encourage governments to analyze their catastrophe risk exposures and develop countrywide risk management plans to ensure that the country is shielded from the adverse economic effects of worst-case catastrophe scenarios that otherwise would threaten economic development. This effort would help the countries engage in more effective risk mitigation efforts and arrange risk transfer cover that provides funding for post-disaster reconstruction needs. The lower level risk layers identified by the government could be covered by tax-funded calamity funds, which would be the main source of short-term rehabilitation and disaster relief. Cover for higher risk layers could be obtained through various risk transfer arrangements in the international financial markets (cat-bonds, risk-swaps, contingent capital, etc.).

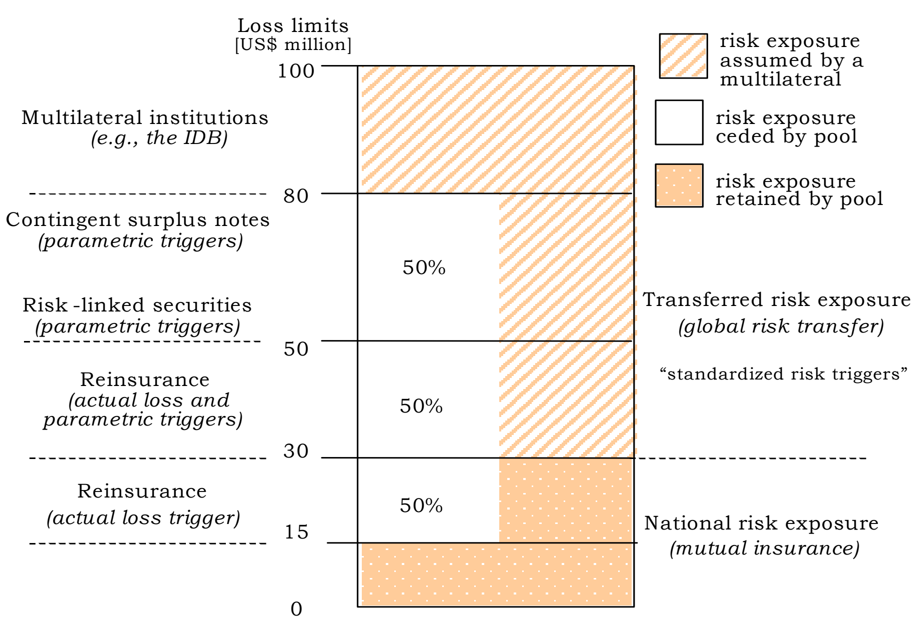
Yet another alternative would be to facilitate the establishment of national insurance pools that extend catastrophe insurance widely to all segments of the population and coverage for otherwise uninsurable catastrophe risks. The insurance pools could be supported by mandatory insurance policies, if needed, and local insurance companies could act as national sales agents to support local market involvement. Participating insurance companies could be engaged as mutual insurers of the lowest risk layers to reduce moral hazard issues associated with their role as insurance agents. These setups would require that the government take stringent initiatives in risk mitigation, such as enforcing effective property registration and building codes. The insurance pool could cover parts of the higher risk layers in international financial markets through reinsurance contracts, risk-linked securities and contingent surplus notes (Figure 10).[32]

Multilateral institutions such as the Inter-American Development Bank and the World Bank, may be able to support the establishment of insurance pools by facilitating different types of risk financing to the higher risk layers ceded by national insurance pools across the region. The multilateral institutions could participate in this process as structural advisors and financial intermediaries to the international markets.

It might be possible to combine risk exposures across several countries in the region and handle the aggregate exposure in a joint regional risk management company. Integrative arrangements of this type would have the potential benefit of pooling catastrophe risk exposure across the region. This would provide a natural first line of risk diversification that also engages local primary insurance companies in the development of regional insurance markets. It might also result in the creation of scale economies that foster risk-financing arrangements in the international financial markets.

The overall exposure to natural catastrophes could be analyzed on a regional basis so that the collective need for risk transfer arrangements is properly assessed. It could be advantageous to identify and map the major catastrophe risks that affect countries throughout the region and assess how aggregate risk-financing arrangements may be obtained more favorably in the wholesale market. It is possible to cover major catastrophe risk exposures in the international financial markets in ways that enable countries to use their financial resources more effectively and provide them with a better basis to pursue sustainable economic development.

Figure 10 – Example of an Insurance Pool with a Layered Risk Transfer Program



[32] See Appendix A for further details.

Conclusions

The frequency and severity of economic losses, especially from hurricanes, earthquakes, and El Niño-related flooding, appear to be on the rise across the region. The social and economic vulnerability of the countries of Latin America and the Caribbean is increasing dramatically and must be reduced through active risk management that leads to cost-effective mitigation efforts and takes advantage of new risk transfer opportunities.

One of the first important initiatives to be undertaken is to encourage prevention and mitigation efforts that reduce vulnerability to natural catastrophes. These include urban planning, enforced building codes, titling of properties and emergency contingency plans, among others. Since mitigation can only accomplish so much, there is also a need to improve preparedness in order to increase responsiveness and protect the poorest.
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Finally, reasonable risk financing arrangements should be established to allow for the fast and effective recovery of the economic infrastructure after a major disaster.

Several new risk transfer and contingent funding instruments are emerging that allow countries to modify their risk management profile to fit acceptable standards. The instruments include layered reinsurance contracts, risk-linked securities, catastrophe risk swaps, and contingent surplus notes. They do not represent either/or alternatives but constitute elements of complementary solutions that should all be integrated into a country's overall risk management strategy. The international financial markets have additional capacity for absorbing catastrophe risk exposures in Latin America and the Caribbean. The opportunity is there for the taking

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Appendix A
Technical Market Analysis of Financial Risks

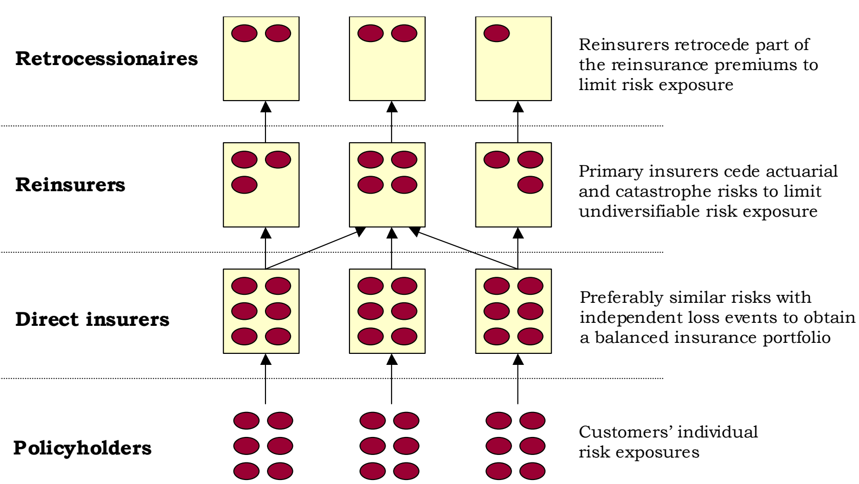
A Primer on Reinsurance Practices

Technically, the primary insurance companies are said to *cede* insurance business when they sell part of their policy portfolio to reinsurance companies. The share of the insurance portfolio that is retained in the primary insurance company is referred to as the *retention ratio*. The ceding insurance company may, in turn, buy part of the insurance policies that are ceded by other insurance companies. The reinsurance companies that buy insurance policies from primary insurers may sell, or *retrocede*, part of those insurance portfolios to other reinsurance companies, while the *retrocessionaires* in turn buy insurance portfolios from its peers in the reinsurance industry. Hence, the global reinsurance market provides additional diversification of risk exposures across the international insurance community.

An insurance portfolio is balanced when it consists of many policies covering similar events, the occurrence of which are independent of each other. In a balanced portfolio the loss ratio is reasonably predictablebecause Bernoulli's law of large numbers tends to prevail (although there can be wide discrepancies between expected and actual losses). Hence, the insurance companies manage their risk exposures by diversifying independent event risks in the insurance portfolio and ceding parts of the insurance policies to the reinsurance market.

In the case of catastrophe exposures, the risks posed by individual events are not independent of each other because all policy holders are affected when a natural disaster occurs. So, when disasters strike, property exposures cluster within certain regions and aggregate losses tend to be very large. The group of insurance policies that cover for catastrophe events does not reduce the insurance company's risk exposure through portfolio diversification. This makes it virtually impossible for an individual insurance company to carry the full exposure (i.e., they must cede catastrophe exposures into the reinsurance market). These potentially large risk exposures are redistributed further among the reinsurance companies through retrocession arrangements.

Catastrophe risks can threaten the solvency of individual insurance companies due to the overwhelming costs associated with covering economic losses of great magnitude. When catastrophe events severely threaten the stability of the entire insurance industry, they are referred to as



Adapted from Swiss Re, 1996.

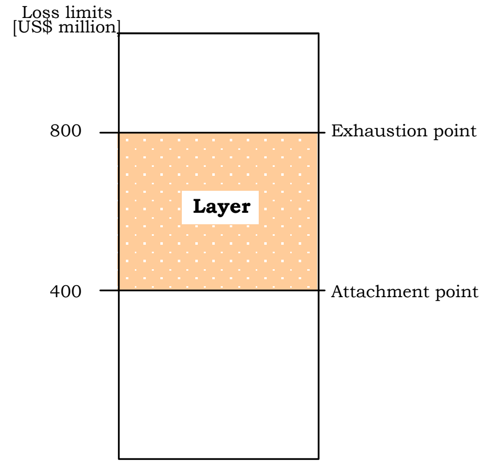
cataclysms (Cutler and Zeckhauser, 1999). In reality, these risks cannot be covered and constitute the so-called *uninsurable risks*, because reinsurance companies are not willing to commit their capital to cover these extreme exposures, even if the event probability is relatively low.

Well-balanced insurance portfolios are typically covered by obligatory *proportional* reinsurance treaties. Obligatory reinsurance commits a direct insurer to cede a share of all the written insurance policies to the reinsurance company. Large unbalanced risk exposures, such as catastrophe risks, are often ceded in the reinsurance market as facultative *nonproportional* treaties. Facultative insurance treaties provide coverage for individual risk factors, such as windstorms and earthquakes. Obligatory and facultative reinsurance treaties can be either proportional or nonproportional (Swiss Re, 2000).

In proportional reinsurance treaties, the direct insurer and the reinsurer divide all premiums and losses between them in accordance with a contractually determined ratio. In nonproportional reinsurance there is no predetermined division of premiums and losses. A nonproportional treaty typically defines a deductible and a net retention or attachment point, up to which the direct insurer will cover all losses. The reinsurance company is obliged to cover all losses in excess of the deductible up to a certain maximum amount, sometimes referred to as the *exhaustion point*.

Coverage provided within the loss range determined by the attachment point and the exhaustion point is usually called a *layer*. A given insurance exposure can be divided into different layers, each of which may be covered by different insurance treaties and risk transfer mechanisms.

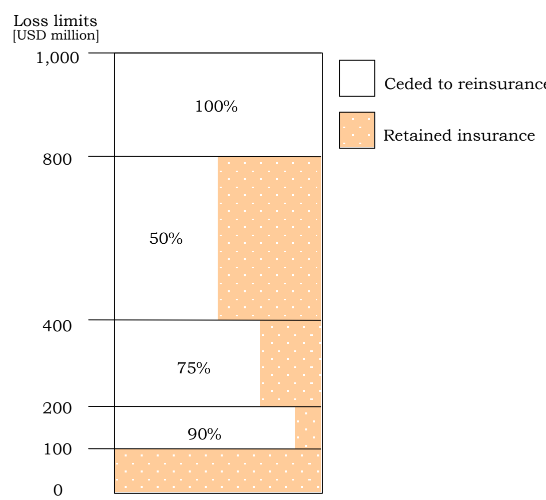
Catastrophe risk exposures are usually covered in nonproportional excess-of-loss insurance treaties (contracts), where the cedant (primary insurer) obtains insurance coverage from the reinsurance companies in case a catastrophic event leads to a loss in excess of the deductible, called the *attachment point*, and up to a maximum amount, called the *exhaustion point* (Canabarro et al., 2000).



The catastrophe risk exposures can be structured into a number of insurance layers defined by different attachment and exhaustion points. The insurance layers can be managed independently within the deductible and the contractual maximum, that is, different percentages of the individual layers can be ceded in accordance with the insurance company's overall capacity for different risk exposures.

The cost of reinsurance coverage is typically indicated by the rate-on-line (ROL), which is derived as the premium divided by the covered insurance limit (Froot, 1999; Guy Carpenter, 2000).

ROL = Premium/Cover limit



The Principle of Portfolio Diversification

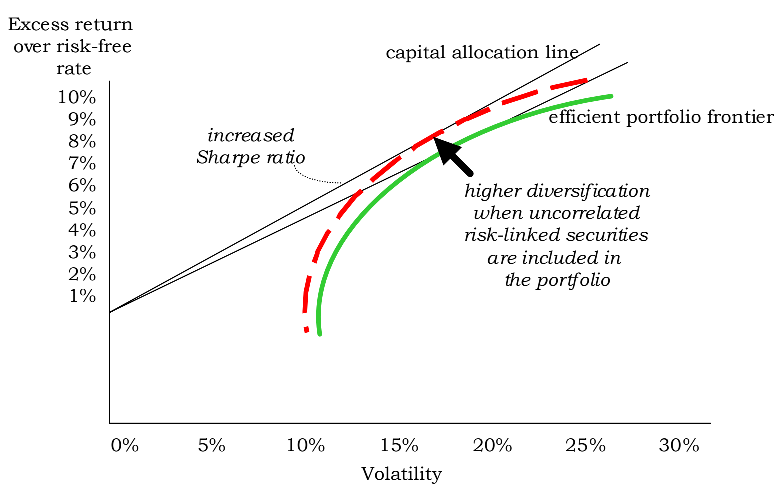
A portfolio of financial assets with less-than-perfectly correlated return characteristics (varying rates of return for different investments in the portfolio) will display a lower variation in the returns on the total invested portfolio. This effect is captured in the *efficient frontier*, which shows the risk/return characteristics for different combinations of financial assets in the portfolio. If a new financial asset class with uncorrelated returns is introduced into the portfolio, it increases the risk diversification capabilities, that is, the new efficient frontier will display lower return volatility (risk) for given portfolio returns. This allows the institutional investor to allocate invested funds between risk-free assets (treasury bills) and risky assets along a more favorable *capital allocation line* reflecting the potential for higher returns for a given level of financial risk. The *Sharpe ratio* expresses the implied risk/return trade-off.

The Catastrophe Call Spread

Traded catastrophe options contacts provide the holders with the right, but not the obligation, to acquire (*call*) or dispose of (*put*) an underlying catastrophe futures contract at a given settlement price at the expiration date (O'Brian, 1997). Hence, the hedgers gain added flexibility because they can exercise the option contracts under favorable circumstances, i.e., when they are *in-the-money*, and let them lapse if they are *out-of-the-money*. However, in order to buy an options contract, there has to be a *writer* of the option who is willing to assume and manage the (at times) substantial risks associated with option positions. The writer is obliged to honor the requests of the option holders, so there is no effective market without willing investors. Availability of both call and put options allows hedgers as well as investors to establish and manage positions in accordance with their particular views on the catastrophe reinsurance market. However, the option contracts must be very liquid to allow the involved parties to manage their option positions on an on-going basis.

The effectiveness of the hedges also depends on the extent to which the catastrophe loss indices that underpin the futures and options contracts covaries with the catastrophe exposure the hedger is attempting to cover. This might not be the case if, for example, the loss index covers property damages in the southeast and the property portfolio to be hedged is scattered across different geographic areas. The discrepancy between the price of the asset underlying the futures contract and the asset portfolio to be hedged is referred to as *basis risk*. In some instances, the basis risk may become so large that hedging is ineffective (Major, 1999).

In the early 1990s, the Chicago Board of Trade offered a catastrophe call spread option contract (Cummins and Geman, 1995). Like other financial futures these contracts were traded with quarterly settlement dates in March, June, September and December. A call spread option entails the simul-



taneous purchase of a call option at a lower strike price and the sale of a call option at a higher strike price. The combined long- and short-call option positions at a lower and higher strike price respectively is often referred to as a *bull call spread*, which provides the holder with the opportunity to hedge against catastrophe losses occurring at a range within the two loss ratios (strike prices). The establishment of such a spread position is usually cheaper than buying a single call option because it entails the simultaneous sale of a call option. The call spread option may be used by hedgers with a relatively strong market view to obtain cheaper risk coverage.

Insurance companies could hedge their catastrophe risks by buying futures contracts at the quoted price, which reflects the insured losses the market expects at contract maturity. They could sell the equivalent amount of futures contracts just before maturity to reverse the open futures position. If the insured losses turn out to be higher than expected as the contracts reach their expiration date, the futures contracts would be quoted at a higher price, and consequently the hedger would incur a capital gain from the futures transactions that compensate for the higher than expected losses incurred from the catastrophe exposure. In other words, the hedger would have been able to lock-in the catastrophe losses at the level expected by the market. The effectiveness of futures markets hinges upon the availability of investors willing to take the opposite position of hedgers, and manage the position risk throughout the life of the futures contact. In order to engage investors, the futures markets must be liquid, so investors are able to adjust invested positions when market outlooks change.

Structure of Risk-Linked Securities

The securitization of financial assets usually entails the creation of a new company. The financial assets are placed in this independent legal entity, called a *special purpose vehicle* (SPV) that will apply all the incoming cash flows from the financial assets to service payment obligations on securities issued by the SPV. Before the advent of asset securitization, U.S. banks kept all their mortgage loans on the balance sheets, which limited the ability to arrange new loans. As the three government-supported agencies—the Federal National Mortgage Association (*Fannie Mae*), the Federal Home Loan Mortgage Corporation (*Freddie Mac*) and the Government National Mortgage Association (*Ginnie Mac*)—started to buy the mortgage loans from banks and issue mortgage-backed securities, the market became more efficient through specialization. This development allowed banks to concentrate on loan origination and advisory services to individual and institutional borrowers, while the mortgage-facilitating agencies specialize in the securitization process and tailoring securities to investor markets.

The securitization technique is also used to structure cat-bonds (catastrophe bonds). Here, the SPV uses the up-front proceeds from the bond issue less the issuance expenses to buy a securities portfolio with high credit quality and low interest rate sensitivity. The securities portfolio is placed in a trust account as collateral for the debt service payments due on the cat-bonds (Cook and Della Sala, 1998). The SPV is rated by a credit agency such as Standard and Poor's, Moody's Investor Services or Duff and Phelps Credit Rating. The roles of the trustee[33] and the rating agency are important in all asset-backed securities transactions. The presence of a low-risk collateralized trust account often provides the SPV with a relatively high credit rating.[34]

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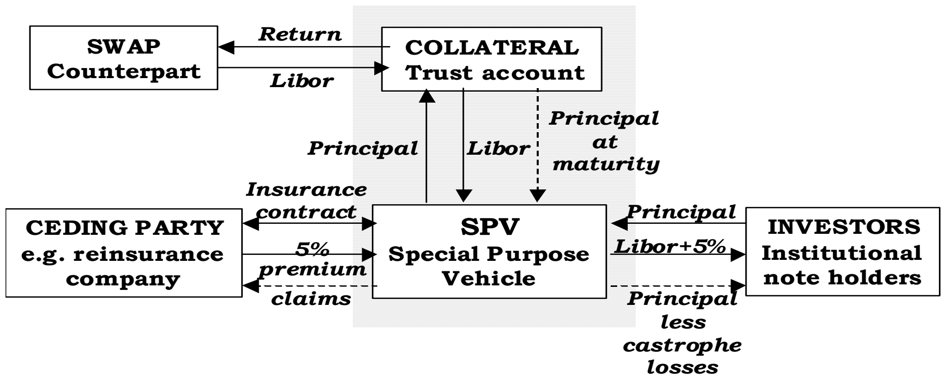
[33] In this case the trustee holds legal title to the assets deposited on the trust account. The trustee represents the interests of the cat-bond certificate holders who maintain a beneficial interest in the trust account, and typically incorporates a duty to monitor cash flows, investment funds, account reconciliation, etc.

[34] The SPV can issue different tranches of securities representing different risk classes. The risk-linked securities can be issued on a principal-protected basis, where only the interest coupons are at risk, or on a partial defeasance basis, where the interest coupons and only a part of the principal is at risk, or on a full risk basis, where both coupons and the whole principal are at risk. For example, the USAA cat-bonds are issued in two classes: Class A-1 bonds are issued as principal-protected securities, where approximately 53 percent of the principal is at risk at maturity, and Class A-2 bonds are issued as principal variable securities, where the full principal is at risk at maturity. The class A-1 bonds would earn a spread of 273 basis points above Libor,



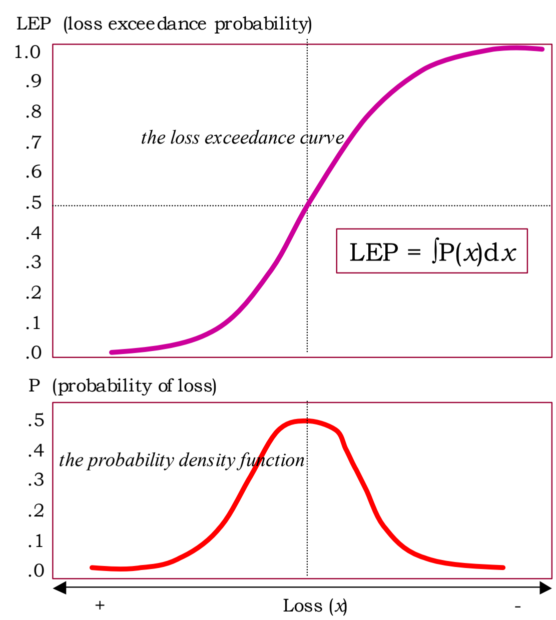
The SPV often engages in a fixed/floating interest rate swap agreement that converts the interest returns from the invested securities portfolio into monthly Libor-based floating rate payments. Thereby the SPV can issue the cat-bonds as floating rate notes that have limited interest rate risk. The investors receive a relatively high spread above the Libor rate as a compensation for the fact that they will only receive the principal back at maturity if the cedant (primary insurer) avoids incurring aggregate losses of a certain amount associated with the defined catastrophic events.

Assessments of the underlying catastrophe risks play a crucial role in informing the investors about the risk/return profile of the cat-bonds. A number of specialized consultants use advanced simulation models to estimate the probability profile of different catastrophic events. The consultancies include Applied Insurance Research (AIR) in Boston, Massachusetts, EQE International, Inc. in San Francisco, California, Risk Management Solutions (RMS) in Menlo Park, California, Tillinghast in Weatogue, Connecticut, and Weather 2000 located in New York City.

Measuring Catastrophe Risk Exposures

The implied uncertainty and, conversely, the stability of loss expectations influence reinsurance prices. Computerized risk modeling can help assess the stability of expected future catastrophic losses as indicated by the variance of the loss estimates. Hence, we should expect a positive relationship between the *exposure ratio*, calculated as the standard deviation divided by the mean loss estimate (σ/μ), and the reinsurance price for a specific catastrophe risk exposure.

The expected loss from natural catastrophes as indicated by the probable maximum loss (PML) is increasingly determined through the use of probabilistic computer models. The projected loss parameters are specified on the basis of historical data describing the natural phenomena, and detailed stipulations of the potential losses of different natural disaster scenarios (Major, 1999; Briys, 1999). The model simulations profile the risk exposure in the *loss exceedance curve* (Dong et al., 1996), indicating the probability that total catastrophe losses exceed specific aggregate values.



(Layered Reinsurance Program – Example)

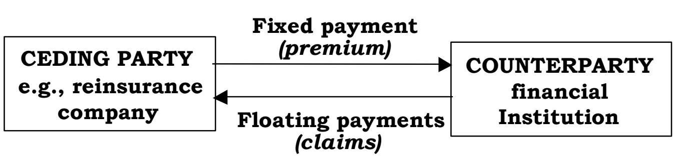
whereas the more risky class A-2 bonds would receive 575 basis points over Libor.

The model simulations describe the probabilistic catastrophic loss characteristics of individual reinsurance layers. The simulation output normally comprises three central pieces of information to characterize the catastrophe risk exposure:

- *Frequency of loss*: the likelihood that losses from the ceded insurance exposure will exceed the deductible (attachment point).
- *Expected loss*: the average product of the frequency and total losses along the loss exceedance curve between the deductible (attachment point) and the upper limit of the reinsured layer (exhaustion point).
- *Depletion loss*: the probability that total losses will exceed the upper limit of the layer (exhaustion point).

Structure of a Catastrophe Risk Swap

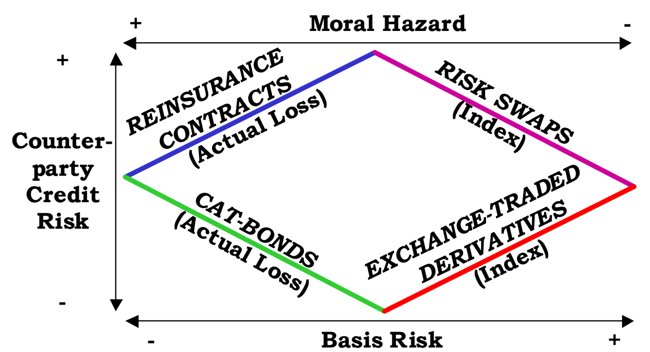
The counter-party to the risk swap receives fixed payments corresponding to the insurance premiums and provides variable payments to honor the claims experienced by the cedant.



Moral Hazard, Adverse Selection, Basis Risk, and Counter-party Credit Risk

The counter-party credit risk associated with *exchange traded derivatives* (i.e., futures and options contracts) is minimal because the exchanges normally mark positions to market on a daily basis and demand that clients maintain margin accounts to cover for their market exposures. Incidentally, the clearinghouse normally guarantees delivery of the contracts, so the counter-party credit risk is considered minimal.

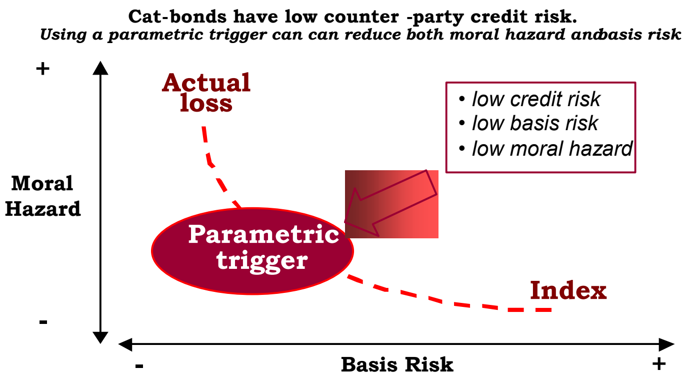
C*at-bonds*, i.e., risk-linked securities, carry little credit risk because they are collateralized and receive a relatively high credit rating. *Reinsurance contracts* normally have their risk cover based on actual losses and their indemnity claims have little basis risk, but are exposed to both moral hazard and counter-party credit risk. Exchange-traded derivatives such as standardized futures and options contracts potentially expose the hedger to a high level of basis risk, but moral hazard and counter-party credit risk exposures are low. *Risk swaps* are generally highly exposed to counter-party credit risk, whereas the level of moral hazard and basis risk depends on the trigger formula applied in the swap agreement. For example, if the swap is index-based, the level of moral hazard is low, and if the swap is triggered by actual losses, the level of moral hazard is high. The issuance of cat-bonds is associated with low counter-party credit risk, because the underlying insurance cover is collateralized in a trust fund, and the risk-linked securities are placed among a diverse group of institutional investors.



Adapted from N. A. Doherty, *Integrated Risk Management*, McGraw-Hill, 2000

From a counter-party credit risk perspective, the issuance of risk-linked securities is advantageous. However, the trade-off between instruments is also influenced by other factors like speed, flexibility and fee structures. When applying different triggers in the hedging instruments, the relationship between moral hazard and basis risk is not linear. The use of actual losses and indemnity claims as triggers is associated with high moral hazard and low basis risk, while the adoption of standardized indices is associated with low moral hazard and high basis risk, i.e., there is a trade off between these two triggers.

However, by using a parametric formula, where the trigger can be composed by a range of objectively measured indicators selected through extensive model simulations, it is possible to create a situation that simultaneously achieves low moral hazard and low basis risk. The concurrent reduction of these two risk elements is possible because the trigger is objectively determined (that is, it cannot be manipulated by the hedger) and the basis risk is low because the parametric formula can be construed to closely emulate the value development of the insured risk exposure. Since cat-bonds generally are associated with low counter-party credit risk, the issuance of cat-bonds based on parametric triggers appears to be a good alternative to conventional reinsurance contracts for catastrophe risk coverage.



The choice of financial instruments and the structures adopted to transfer catastrophe risk exposures should be based on an evaluation of the inherent risk elements of moral hazard, adverse selection, basis risk, and credit risk. The level of moral hazard and adverse selection bias is a function of the triggers adapted in the instruments. The two risk elements are founded in information asymmetries between the insurers and the insurance takers. Moral hazard relates to the *ex post* behavior of the insured party, as it can neglect risk mitigation once the insurance contract is in place. Adverse selection relates to the *ex ante* behaviors of both insurers and insurance takers. The insurance taker may exploit inside information about the risk exposure to obtain better terms than could be obtained on the basis of objective actuarial calculations, and insurers may exploit market insights and select insurance customers from the low exposure segments, while charging premiums based on overall market exposures.

The moral hazard and adverse selection issues are mitigated by the same underlying triggers across the different risk transfer instruments (see table below). Using index-based and parametric formulas as triggers can reduce or eliminate moral hazard and adverse selection issues, while the use of actual losses and indemnity claims as triggers retain these two risk elements. The choice of financial instrument determines the level of counter-party credit risk, as individualized reinsurance contracts and over-the-counter risk swaps entail high levels of counter-party credit risk, and the traded derivatives and risk-linked securities carry little counter-party credit risk. The level of basis risk is similarly influenced by the application of specific triggers. Adopting a value index as the trigger is associated with high basis risk, whereas use of actual losses and parametric formulas will reduce the basis risk. The choice of insurance trigger influences moral hazard, adverse selection, and basis risk across instruments. Credit risk differs across types of instrument regardless of the trigger. Market reception refers to the risk transfer structures that are considered to have the most favorable exposure to the inherent risk elements.

The last column, market reception, indicates the extent to which the specific characteristics of the risk transfer instruments are deemed to have high market receptiveness, i.e., are favorably exposed to the inherent risk elements and balances the exposures of both insurance takers and providers. Conventional reinsurance contracts are triggered by actual losses incurred from the underlying insurance portfolio or by the assigned risk layer. However, by adopting parametric formulas as triggers, the overall risk profile of the risk transfer mechanism can arguably be improved by simultaneously reducing moral hazard, adverse selection and basis risk, which should enhance the market reception of this specific risk transfer instrument. Cat-bonds and risk swaps related to catastrophe exposures in developing countries should be more attractive to institutional investors and counterparts if they use indices or parametric formulas as triggers because this reduces the issues of moral hazard and adverse selection.

Table – Risks Associated With Varying Risk Transfer Instruments

instrument \ risk	Moral Hazard	Adverse Selection	Credit Risk	Basis Risk	***Market Reception***
Reinsurance contracts :					
- Index	~	~	+	+	-
- Parametric	~	~	+	~	√
- Actual loss	+	+	+	~	√
Cat-bonds :					
- Index	~	~	~	+	√
- Parametric	~	~	~	~	√
- Actual loss	+	+	~	~	-
Risk swaps :					
- Index	~	~	+	+	√
- Parametric	~	~	+	~	√
- Actual loss	+	+	+	~	-
Exchange derivatives :					
- Index	~	~	~	+	-